Towards a Vocabulary to Implement Culturally Relevant Relationships Between Digital Collections in Heritage Institutions†

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Abstract: Cultural heritage institutions are publishing their digital collections over the web as LOD. This is is a new step in the patrimonialization and curatorial processes developed by such institutions. Many of these collections are thematically superimposed and complementary. Frequently, objects in these collections present culturally relevant relationships, such as a book about a painting, or a draft or sketch of a famous painting, etc. LOD technology enables such heritage records to be interlinked, achieving interoperability and adding value to digital collections, thus empowering heritage institutions. An aim of this research is characterizing such culturally relevant relationships and organizing them in a vocabulary. Use cases or examples of relationships between objects suggested by curators or mentioned in literature and in the conceptual models as FRBR/LRM, CIDOC CRM and RiC-CM, were collected and used as examples or inspiration of cultural relevant relationships. Relationships identified are collated and compared for identifying those with the same or similar meaning, synthesized and normalized. A set of thirty-three culturally relevant relationships are identified and formalized as a LOD property vocabulary to be used by digital curators to interlink digital collections. The results presented are provisional and a starting point to be discussed, tested, and enhanced.

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> *The Semantic web isn't just about putting data on the web. It is about making links so that a person or machine can explore the web of data. With linked data, when you have some of it, you can find other, related, data.*
>
> Berners-Lee 2006

1.0 Introduction

From a cultural standpoint, what are the relationships between the first edition of the *Don Quijote de La Mancha* by Cervantes Saavedra, which is in the collection of the Biblioteca Nacional de España and the etching by Pablo Picasso portraying Don Quijote and Sancho Panza, which is in the collection of MOMA—the Museum of Modern Art—in New York City? What might be the relationships between heritage objects of different collections that are being published according to linked open data (LOD) technologies? Such resources and many others belonging to the collections of different heritage institutions are now being published according to LOD technologies. They may be integrated into a unique and significant virtual resource that makes sense and contributes to cultural understanding. The facilities offered by LOD technologies enables digital objects of different collections to be mobilized by curators in specific domains such as art, culture, literature, history, journalism, education, scientific scholarly communication, travel and cultural tourism, etc., in order to create a new, unique, curated, digital resource, such as virtual exhibitions and educational resources.

Cultural heritage objects hold different types of relationships. A film may be inspired by a literary work, an etching becomes an illustration in an edition of a literary work, famous painters created the scenario and costumes of ballets or assembly plays. There are different versions of Da Vinci's *Mona Lisa* created by artists such as Marcel Duchamp, Andy Warhol, and Fernando Botero. In knowledge organization literature, such relationships are similar to associative relationships.

However, due to a long-time tradition of independent, self-contained collections and the adoption of different standards, the possibilities of interoperability between such diverse collections are beyond technological issues. In recent years, documentation as a domain has used conceptual models to identify, make explicit, standardize, and semantically integrate their objects. LOD technologies enable such semantic relationships to no longer remain within the scope of a specific collection's domain but rather within a wider scope of subject domains comprising heritage objects–and their digital representations—belonging to different collections.

A digital curator, with the aim of a formalized vocabulary of such relationships, could produce culturally rich virtual collections of archives, libraries, museums, and educational resources, accessible by anybody from anywhere, by exploring the increasing number of memory and cultural heritage collections now available throughout the web. These technologies enable a digital curator to discover and make sense of, or propose new, unforeseen, semantic relationships between digital cultural heritage objects belonging to different collections. Besides that, the implementation of semantic links using LOD technologies can achieve interoperability between digital collections.

What culturally relevant relationships may exist between digital objects of collections or fonds in archives, libraries, and museums? How can such relationships be discovered, identified, and classified? How can LOD technologies be used to implement such relationships as semantic links? How could such relationships be useful for art, history, or culture curators to annotate and enrich digital heritage objects?

This research aims to discuss and characterize such culturally relevant relationships, compiling an inventory and organizing them in a vocabulary. In this paper I expand upon and deepen the conclusions of previous work (Marcondes and Campos 2016; Marcondes 2018a; Marcondes 2018c). With this research I also aim to improve the usability of digital collections in archives, libraries, and museums, thus empowering heritage institutions. The paper is organized as follows: after the introduction, Section 2 describes the potential of publishing heritage collections as LOD; Section 3 reviews theoretical issues concerning relationships in knowledge organization, with a focus on associative relationships; Section 4 presents the materials and methods used, the assumptions related to precisely characterizing the objects being related and their digital representations, and develops a framework for the analysis of the relationships compiled; Section 5 presents the results—the thirty-three relationships found; and, Section 6 provides final remarks and conclusions.

2.0 Potential of LOD in heritage institutions

Since the publication of the Library Linked Data Incubator Group Final Report in 2011 (W3C Incubator Group Report 2011), LOD technologies applied to heritage digital collections in archives, libraries, and museums seem to have reached the first stage of maturity (Agenjo-Bullón 2015). These institutions, the GLAM–galleries, libraries, archives and museums–sector, have also been empowered by initiatives such as OpenGLAM (https://openglam.org/), which states as its mission "an initiative run by Open Knowledge that promotes free and open access to digital cultural heritage held by Galleries, Libraries, Archives and Museums." Reuse is a major issue when publishing digital heritage collections. When such collections are free and open access, they constitute input and raw material for creative industries, education, publishing, tourism, and other economic sectors. Indeed, there now are many successful experiences of publishing not only important collections encompassing archives, libraries, and museums, but also several LOD vocabularies (Zeng 2018).

Archives, libraries, and museums around the world are developing projects to publish their catalogs using LOD. Among the most significant are those of the Biblioteca Nacional de España (http://datos.bne.es), the British Library (http://bnb.data.bl.uk/), the Deutsche National Bibliothek (http://www.dnb.de/EN/Service/DigitaleDienste/LinkedData/linkeddata_node.html), the Bibliothèque Nationale de France (http://data.bnf.fr), the Europeana Library (https://pro.europeana.eu/page/linked-open-data), the British Museum (https://old.datahub.io/dataset/british-museum-collection), the Archives Hub (https://archiveshub.jisc.ac.uk/), and The American Art Collaborative Linked Open Data Consortium (https://americanart.si.edu/about/lod/aac.).

Among vocabularies published as LOD are the Library of Congress Subject Headings-LC Linked Data Service (http://id.loc.gov/authorities/subjects.html) and the Getty Vocabularies as Linked Open Data (http://www.getty.edu/research/tools/vocabularies/). LOD vocabularies are essential to assign semantics to published data. Besides that, in recent years Wikipedia, Wikidata, and DBpedia (Estermann 2018) have been playing a central role as data hubs, connecting cultural heritage collections published as linked data over the web.

According to Tim Berners-Lee (2006), LOD is not only about publishing data. Such technologies will achieve their full potential as the published resources became "interlinked." To take full advantage of LOD is not sufficient to publish heritage data according to LOD technologies. For many years, cultural heritage institutions have developed curatorial processes over the collections they oversee as continuous value-adding processes. These institutions are now beginning to publish their collections as digital objects over the web. Despite the advances of web catalogue archives, library and museum collections are still dependent on catalogue systems and technologies, which do not fully allow integration of their data with other resources available throughout the web.

Accordingly, LOD technologies allow the curatorial work done by memory and culture institutions to advance to a new level. The emergence of semantic web and LOD technologies enable cross-searching and the interlinking of digital objects belonging to different collections over the web, achieving interoperability between different collections (Zeng 2019). The LOD environment thus creates unexpected meaning and rich contextual networks, empowering the synergies of collections, their complementarities, and their educational and curatorial potentials.

LOD technologies are based on a simple descriptive data model comprising RDF (2014)—resource description framework—triples: the resource being described, the properties of such resources, and the values of such properties. Examples of archive, library, and museum objects described according to the LOD triple model can be seen in Wikidata (https://www.mediawiki.org/wiki/Wikibase/DataModel/Primer) items for the *Magna Carta* and *The Don Quijote* by Cervantes Saavedra and the *Mona Lisa* by Da Vinci. It comprises a simple, unified model through which archives, libraries, and museum objects can all be described. Such technologies enable direct publication of digital collections and their integration into the mainstream web. Many of these collections are thematically superimposed and complementary, having synergies not yet explored. Such technological facilities enable complementarity to be activated for the benefit of heritage institutions, culture, and education. According to Constantopoulos and Dallas (2007, 8)

> A study of current digital curation research and advocacy suggests that the scope of digital curation work needs to expand significantly, particularly as regards the goal of ensuring epistemic adequacy of information in yet unknown future contexts of use, and advances the view that validity and usefulness of digital information objects for "fitness for purpose" depends, crucially, on adequate knowledge representation.

The same authors claim (Constantopoulos and Dallas 2008, 5) that curatorial work includes "ensuring the ability to discover and access inter- and intra-domain associations and to overlay context dependent interpretations." Frequently these collections present culturally relevant relationships between their objects, like a book about a painting, drawings illustrating a literary work, a draft or sketch of a famous painting, a letter from an author commenting on a book or painting, or a contract to commission a sculpture or artwork, etc. With the publication of digital collections of GLAMs, the interlinking of such collections, a new curatorial activity, will produce richer and more comprehensive web resources.

Curatorial work is multidisciplinary, hard to delimit, personal, and authorial. Consider, for example, traveling exhibitions that have been exhibited in many countries such as *Leonardo Da Vinci: The Mechanics of a Genius* or *Human Bodies: The Exhibition*. Consider also how the exploitation of the curatorial potential of LOD technologies could enhance such exhibitions. They could be virtual exhibitions with a much broader reach, reaching far more people.

3.0 Relationships in knowledge organization

Research in information science and knowledge organization, especially in domains such as indexing languages, coordinated indexing systems, and information retrieval, gives special attention to relationships as keys for representing meaning (Khoo and Na 2006; Green 2001). The Relational Indexing proposal states (Farradane 1980, 267) that "a method of structuring terms from the vocabulary to express the meaning between words." Conventional thesaurus relationships are generally classified in paradigmatic and syntagmatic relationships. The paradigmatic relationships are the hierarchical relations that form the taxonomic structure paradigm of things in a domain. Associative relations are sometimes defined by exclusion of hierarchical or paradigmatic relationships. Marcia Lei Zeng (2005) defines them as: "This relationship covers associations between terms that are neither equivalent nor hierarchical, yet the terms are semantically or conceptually associated." Associative relationships are thus dubious and semantically inaccurate. They are also highly context dependent.

Tillet (2001) provides a taxonomy of the bibliographic relationships, mostly consolidated in the IFLA *FRBR* (1978) and *LRM* (Riva et al. 2017) bibliographic conceptual models. Conceptual models as the IFLA *FRBR* (1997) and *LRM* (Riva et al. 2017), the *CIDOC Conceptual Reference Model* (2014) and the RiC-CM (International Council on Archives 2016) provide richer sets of relationships.

The relationships we are looking for are relationships between heritage objects in collections belonging to heritage institutions as archives, libraries, and museums. *FRBR* and

its updated version, the *LRM*, have as their core the notion of work as "The intellectual or artistic content of a distinct creation" (Riva et al. 2017, 21). Rigorously speaking in terms of IFLA *LRM*/*FRBR*, they are relationships between items. But in the case of culturally relevant relationships they inherit the work to work, work to manifestation, work to item relationships as described and exemplified in IFLA (1997, 56) Chapter 5 and *LRM* (Riva et al. 2017, 64) Table 4.7. A fundamental distinction made in the *FRBR* model concerning the domain and range of a relationship is between "autonomous" and "referential" works, i.e., the grade a work is dependent-independent of another related work. We used this distinction in the analytical frameworks presented in Section 3.3.

Modern bibliographic description standards largely take advantage of relationships. The *Resource Description and Access* (Joint Steering Committee for Development of *RDA* 2015)—*RDA*—the bibliographic descriptive standard conceived to replace the *Anglo-American Cataloguing Rules, 2nd Edition Revised* (*AACR2*), gives special emphasis to relationships. Detailed descriptions of different types of relationships—those primary between work, expression, manifestation, and item, those to persons, families, and corporate bodies, those to concepts, objects, events, and places, those between those work, expression, manifestation, and item, those between those persons, families, and corporate bodies, and those between those concepts, objects, events, and places are provide in *RDA*'s sections five to ten.

BIBFRAME—Bibliographic Framework Initiative—the bibliographic description and exchange coding schema, built on the foundation of *RDA* and the successor of the MARC bibliographic format, largely takes advantage of LOD technologies to implement relationships and provide a richer context to bibliographic entities: "BIBFRAME provides a foundation for the future of bibliographic description, both on the web, and in the broader networked world that is grounded in Linked Data techniques" (Library of Congress).

4.0 Methodology

4.1 Material and method

Bibliographic and document sources about the patrimonialization and curatorial processes developed by archives, libraries, and museums were sought to supply definitions of concepts such as archives, collections, items, records, and cultural heritage objects. Conceptual models such as IFLA's (1997) *FRBR*, the *LRM* (Riva et al. 2017), the *CIDOC CRM* (*CIDOC Conceptual Reference Model* 2014), the EDM (Europeana 2017), the RiC-CM (International Council on Archives 2016) and vocabularies such as *ATT* (*Art & Architecture Thesaurus*) were examined as sources to identify possible relationships between objects. Use cases or examples of relationships between objects suggested by curators of archives, libraries, and museums or mentioned in literature, were also collected and used as examples of possible relationships; examples of forms used to collect use cases can be found in Appendix 1. Use cases and examples of relationships were also suggested by members of Europeana Tech and OpenGLAM mailing lists. Sites of exhibitions as *Leonardo Da Vinci: The Mechanics of a Genius* or *Human Bodies: The Exhibition* were also consulted.

The relationships thus identified were starting points to derive culturally relevant relationships. To each relationship a question was posed: How could this relationship be generalized to relate heritage objects belonging to different collections in archives, libraries, and museums? Among the relationships found in the different conceptual models, IFLA (1997, 56) Chapter 5 section 5.3 and *LRM* (Riva et al. 2017, 64) Table 4.7 proposes a set of important relationship cases to the development of culturally relevant relationships.

A framework to analyze and organize the collected relationships was also developed, based on the top-level relationship schema between entities of groups 1, 2, and 3 of the *FRBR* model. The *FRBR* model was chosen, because it is primarily oriented to objects (it is concerned with relationships between objects in library collections, the group 3 entities), while the *CIDOC CRM* and EDM are mainly event oriented. A deductive process based on such a framework, combined with an inductive process based on the cases collected, were used to reach the results.

4.2 Assumptions

What are the objects in collections of archives, libraries, and museums that we intend to relate to each other? According to Van Mensch (1992, 104), "The museum object is considered to be the basic unit of the museum working procedures." Van Mensch claims that "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."

Access through the web to collections of heritage objects presupposes their representation in digital formats. The digital objects that are published and interlinked throughout the web using LOD technologies are indeed artifacts, even if the original object it is based is a natural object (Marcondes, 2019). In this sense, they are social creations (Searle 1995). They are knowledge tools—artifacts—created on the foundations of archive, library, and museum methodologies and standards. They are complex digital objects, here called digital HO—digital heritage object, and, within the context of LOD technologies, identified by a unique identifier, along with metadata about both

the HO itself and its digital representations: digital images or copies of the physical object. Such metadata provide context and access points and enable the management of digital HOs in the digital environment. We consider the original physical heritage objects—HO—of *a priori* cultural relevance, as they are the result of curatorial processes developed by heritage institutions; their digital surrogates inherit their cultural relevance, forming a new collection or resource to be curated. A HO is a specific item in a heritage institution collection, in the senses of *FRBR* (1997) and IFLA *LRM* (Riva et al. 2017). Culturally relevant relationships interlink HO digital surrogates.

An important requirement is that culturally relevant relationships should be simple and intuitive as they are thought to be used by digital curators such as art, literature, and culture historians and critics, journalists, and educators in mind.

4.3 A framework to analyze relationships between cultural heritage objects

A framework is presented here along with its conceptual basis, developed to analyze the suggested and the compiled relationships. The framework consists of a table cross-relating heritage objects (HO) according to the type of heritage institution, archives, libraries, or museum heritage objects; line titles represent the domains, column titles represent the range of the relationships of the suggested use cases, and cells represent a specific relationship, as the relationship "inspired," between the novel *Iracema*, typically a library object (lHO) and the painting "Iracema„" a typical museum object (mHO, see Appendix 1). To these HO, "monuments" (monHO) was also added, as there are several suggested use cases that include relationships between archive, library, and museum objects with monuments. For analytical purposes, HO were subdivided into aHO, for archives digital heritage object, lHO for library digital heritage object, mHO for museum digital heritage object and monHO for museum digital heritage object. Such objects are related to other objects, namely agents (*FRBR* group two entities), concepts, events, time, and place (*FRBR* group three entities). See Table 1 below.

Each table cell contains a direct relationship from the entity represented by the specific line to the entity represented by the specific column. The entity in the cell line is the domain, and the entity in the column is the range of the relationship. For example, cell twenty-three represents a book in a library and an etching that illustrates it in a museum (lHO X mHO). As we ask for heritage institution curators to suggest cases of relationships between objects in collections of different heritage institutions, the framework we have developed reflects relationships where domain and range are objects in archives, libraries, and museum collections. HO, i.e., archive, library, and museum objects, may be further specialized into different types of objects as is usual in archive, library, and museum collections management. All relationships are also similar to associative relationships largely used in thesaurus theory and construction.

Within the scope of LOD technologies, a common feature is the use of multiple and specialized vocabularies (Zeng 2018). In LOD vocabularies, the domain and range of the relationships cannot be specified by the type of heritage institution as was done in the table just presented. For example, in the "documents" relationship (relationship ID: 0041), for the suggested case of Darwin's Beagle's expedition field notebook, the domain is an archive HO and the range, the species collected by him, is a museum HO. However, in many cases, a field notebook may belong to the collection of a library or museum. The previously mentioned table is just a tool for systematizing the case relationships collected. A requisite of vocabularies expressed as semantic web technologies that comprise classes of objects and the relationships among them is that the relationship specifications must include the domain and range.

Accordingly, a new classification of types of HO must be proposed that has as a basis in the "expression forms" of HO; domain and range are specified according to specific types of "expression forms" of HO, i.e, "how each object is expressed or manifested" to human senses. Such a classification is developed, inspires, and is used for similar purposes as edm:types and the IANA list of internet media types (https://www.iana.org/assignments/media-types/media-types.xhtml). However, the classification

	aHO	lHO	mHO	monHO	Agent	Concept	Events/Processes	Time	Place
aHO	11	12	13	14	15	16	17	18	19
lHO	21	22	23	24	25	26	27	28	29
mHO	31	32	33	34	35	36	37	38	39
monHO	41	42	43	44	45	46	47	48	49
Agent	51	52	53	54					
Concept	61	62	63	64					
Events/ Processes	71	72	73	74					
Time	81	82	83	84					
Place	91	92	93	94					

Table 1. Relationships between heritage objects.

of types of expression forms is applied not to the HOs' digital representations as the aforementioned ones but to the "original" HO. An expression form specifies the form in which an original HO is perceived by humans' senses: taste, sight, touch, smell, and hearing. The classification proposed has seven types of expression forms an HO may have: "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).

Although "expression form" is a consistent criterion, by definition, any digital HO is rendered in a digital format. Further discussion is needed regarding the correspondence of the expression forms proposed to digital formats. This decision is due to the complexity of the adoption of any of the existing classification of types of HOs, each of them having their pros and cons. A notorious lack of consensus and standards of types of heritage objects exists, and the adoption of such a classification would be polemic.

"Dependence" is a fundamental criterion to analyze and classify relationships. Are there several types of dependence? Following Guarino (1997), Guarino and Welty (2000b), and IFLA (1997) on "existential dependence" and "referential" and "autonomous" relationships, we question if any of the relata in the relationships found are existentially dependent on the other; are any of them dependent on the other in any sense? Searle (1995) discusses "subjective judgments," "observer-relative features" of reality, and features that are "ontologically subjective." Are both relata independent? Do any of the relata depend on a subjective judgment from their creator or from a third-party agent: a curator, a literary critic? Hessen (2000) notes that knowledge is always knowledge of something, a relation between an agent and an object; the agent is intended for the object. Within Dahlberg's (1992) concept theory, there are, among the formal relationships, intersections of relationships such as those relating objects that share at least one property.

To analyze and evaluate possible relationships provided by use cases or those collected in literature, each relationship is assigned a numeric identifier, is described, examples are given, and criteria are established; i.e., questions are asked as follows: do any of the relata existentially depend on the other? Is there an inverse relationship? Are there other types of relationships between the two types of objects? Are there similar relationships in other conceptual models, vocabularies, or ontologies?

5.0 Results and discussion

What are culturally relevant relationships? For the purposes of this work, they are relationships that contextualize and enhance the cultural comprehension of a heritage object. Here they are classified in direct relationships, such as between a book and a aquatint inspired on it (e.g., the previously mentioned work *Don Quijote de La Mancha* and the aquatint by Picasso portraying Don Quijote and Sancho Panza), and indirect ones, such the relationships between heritage objects and external entities such as between a book or a painting and its author (agent) or subject, or an painting depicting an event or process (the IFLA *FRBR* group one relationships to group two and three entities).

Such relationships may be directly or automatically derived from records in catalogs, according to established rules (Marcondes 2018b), such as between two books with common properties, i.e., the same title, as in the previous example of Don Quijote, or between a book and its author.

Yet, such relationships can also be authorial: different cultural experts and curators, such as art and literary critics, historians, educators, journalists, scholars, etc., discover, illuminate, evaluate, relate to, interpret, and show different points of view about historical facts or processes, historical characters, and artifacts, etc. While doing their job, these experts may find or propose authorial relationships between such entities not previously perceived by anyone else. The vocabulary was developed under the prerequisite that the relationships should be general and intuitive in order to be used by curators in annotating cultural heritage collections.

5.1 Criteria for analyzing the relationships.

From the theoretical basis used and from the use cases suggested and found in literature, emerged an initial set of criteria for the organization of the relationships. Such criteria are something like and inspired in what Guarino and Welty (2000a) call "meta-properties:"

- Cultural association (CA): when there is a relationship between two HOs or between a HO and another entity, established not by the creator of any of them, but by a "third-party agent," for example, by a curator, a literary or art critic. Cultural association means that the two HOs are existentially independent.
- Cultural dependence (CD): when two HOs have a relationship established by the creator of one of them; the creator of one HO intended for the other HO; the two HOs are both artifacts.

- Cultural independence (CI): when two HOs have a relationship established by the creator of one of them, the creator of one HO intended for the other HO, but

only one of the HOs is an artifact, whereas the other one is originally a natural object.
– Cultural dependence (CD): when two HOs have a relationship established by the creator of one of them; the creator of one HO intended for the other HO; the two HOs are both artifacts.
– Existential independence (EI): when the two HOs exist independently of each other.
– Intersection (IS): both HO share at least one common property, e.g., a common title or belong to the same culture or have the same artistic style, period, or are made of the same material or technique.

Another criterion that seems to define how two HO are related is the type of expression form. Accordingly, in many cases, the domain and range are specified according to HOs restricted to specific types of expression form.

5.2 Relationships identified

Based_on relationship	
Relationship ID: 0011	
Label	"Based_on"@en, "Baseado_em"@pt, "Basado_en"@es
URI	http://culturally_relevant_relationships.org/0011/
Description	This type of relationship presupposes an original, previous work, and another based_on work. It encompasses all kinds of pragmatic replicas or artistic copies, re-creations, revisits, and re-readings of a work; it is concerned directly with works in the *FRBR* model sense. A work is based on another if the based-on work carries at least one property of the base work: a book (lHO) that is based_on another (lHO): cell twenty-two; an artwork (mHO) that is the base for another mHO): cell thirty-three; a monument (monHO) that is the base for another (monHO): cell forty-four.
Domain	HO
Range	HO
Criteria	CD, the expression form of both the based_on HO and the base_for *HO* are the same.
Examples	Many works show literary influence of Hamlet (by Shakespeare), such as *Hamlet for Kids (Shakespeare Can Be Fun!)* by Lois Burdett; the design of Federal Hall in New York City is based_on the design of the Parthenon in Athens; the different based_on versions of Da Vinci's *Mona Lisa* by artists such as Dali, Botero, Andy Warhol, etc.
Similar relationships	The *FRBR* model has many types of work-to-work relationships such as, frbr:is an imitation of, frbr:is a transformation of, frbr:is an adaptation of; Getty att:pastiche
Inverse Relationship	Base_for, Relationship ID: 0012

Table 2. Based_on X base_for relationships.

Created_by relationship	
Relationship ID: 0021	
Label	"Created_by"@en, "Criado_por"@pt, "Creado_por"@es
URI	http://culturally_relevant_relationships.org/0021/
Description	The relationship between an intellectual, artistic, or technical work embodied in a HO and the agent responsible for its creation
Domain	HO
Range	Agent
Criteria	
Examples	Mona Lisa was created_by Da Vinci; *Guernica* was created_by Picasso; Ford Model T was created_by Ford Motor Company.
Similar relationships	dcterms:created
Inverse Relationship	Creator Relationship ID: 0022

Table 3. Created_by X creator relationships.

Design_or_procedure_for relationship	
Relationship ID: 0031	
Label	"Design_or_Procedure_for"@en, "Projeto_ou_esboço_para"@pt, "Proyecto_o_esbozo_para"@es
URI	http://culturally_relevant_relationships.org/0021/
Description	Relationships between architectural plans (aHO) and a monument (monHO): cell 14; between an artwork (mHO) and their preparatory sketches (mHO): cell thirty-three.
Domain	HO
Range	HO
Criteria	CD
Examples	The architectural plans of MAC Niterói—Museum of Contemporary Art—and the monument itself; the preparatory sketches and Guernica by Pablo Picasso; the preparatory sketches and the "War and Peace" panels by Brazilian artist Candido Portinari at the United Nations headquarters, New York.
Similar relationships	
Inverse Relationship	Design_or_procedure, Relationship ID: 0032

Table 4. Design_or_procedure_for X design_or_procedure relationships.

Documents relationship	
Relationship ID: 0041	
Label	"Documents"@en, "Documenta"@pt, "Documento"@es
URI	http://culturally_relevant_relationships.org/0031/
Description	The relationship between a field notebook and the objects it documents.
Domain	HO, with the type of expression form text_object

Documents relationship	
Relationship ID: 0041	
Range	HO, any type
Criteria	CI; the domain HO always has the type of expression form text_object.
Examples	Darwin's Beagle's expedition field notebook and the species collected by him.
Similar relationships	crm:P70 documents (is documented in)
Inverse Relationship	Documented_by, Relationship ID: 0042

Table 5. Documents X documented_by relationships.

Has_contribution_of relationship	
Relationship ID: 0051	
Label	"Has_theContribution_of"@en, "Teve_aContribuição_de"@pt, "haTenido_laContribuición_de"@es
URI	http://culturally_relevant_relationships.org/0051/
Description	The relationship between an intellectual, artistic, or technical work embodied in a HO and an agent, other than its creator, that made some contribution to its realization, or production; for example, the translator, compiler or organizer of a work.
Domain	HO
Range	Agent
Criteria	
Examples	Brazilian edition of the Hamlet by L&PM Editor Has_theContribution_of Millôr Fernandes as the translator. The Anthology of Medieval Literature Has_theContribution_of Rebecca Berg Manor as editor. Anthology of Medieval Literature. Rebecca Berg Manor (ed). Beautiful Feet Books, 2013. The Baptism of Christ by Andrea del Verrocchio, painting that belongs to the Uffizi Gallery Collection in Florence Has_theContribution of Leonardo Da Vinci; according to some art historians Leonardo painted the angel on the left of the picture
Similar relationships	dc:contributor
Inverse Relationship	Contributor, Relationship ID: 0052

Table 6. Has_theContribution_of X contributor relationships.

Has_subject relationship	
Relationship ID: 0061	
Label	"Has_Subject"@en, "Tem_Assunto"@pt, "Tiene_asunto"@es
URI	http://culturally_relevant_relationships.org/0041/
Description	Relationships between a book that has letters as a subject; between a book that has another book as a subject; between a book that has a monument as a subject; between a letter commenting on or describing a book and the book itself; between a letter commenting or describing an artwork and the artwork itself; between a book, a biography of a historical character (range agent).
Domain	HO entity having the type of expression form text_object
Range	HO, any external entitie
Criteria	CD; EI
Examples	La Joconde : essai scientifique / sous la direction de Christian Lahanier, as many other books, has as a subject, or describes, or analyses, Da Vinci's *Mona Lisa*; a letter from Brazilian writer Machado de Assis to his colleague Joaquim Nabuco commenting on the idea for a future book, *Ayres Memorial* (Jackson 1998); the book *Brunelleschi's Dome: The Story of the Great Cathedral in Florence* (King, 2008) has as subject the construction of Brunelleschi's Dome of Santa Maria del Fiori church; the book *Napoleon: a life*, by Andrew Roberts (2015).
Similar relationships	
Inverse Relationship	Is_subject_of, Relationship ID: 0062

Table 7. Has_subject X is_subject_of relationships.

Influenced relationship	
Relationship ID: 0071	
Label	"Influenced"@en, "Influenciou"@pt, "Influenciado"@es
URI	http://culturally_relevant_relationships.org/0051/
Description	Relationships between a work that influenced the creation of another work, according to someone. Or, the relationship between a work and the agent—artist, writer—that influenced it. This relationship is assigned by someone, an art or literature critic or historian.
Domain	HO
Range	HO, Agent
Criteria	CA, EI.
Examples	According to several literary critics, the work *Don Quijote* by Cervantes Saavedra influenced many others literary works; or the "List of works influenced by *One Thousand and One Nights*"; and "How Did Edgar Allan Poe Influence Literature"? One of the two HO is intended for the other or to an agent.
Similar relationships	crm: P15 was influenced by (influenced), didbpedia.org/ontology:influencedBy
Inverse Relationship	Influenced_by, Relationship ID: 0072

Table 8. Influenced X influenced_by relationships.

The formalization of the "influenced" relationship is a challenging issue. Here we documented the relationships of an HO that influenced other HOs, and an HO influenced_by an agent. It is usual in art and literature critics to say that an author or artist influenced others, as such a claim means that the works of an author or artist as a whole influenced the works of many others, as for example in the exhibition *Vermeer and the Masters of Genre Painting: Inspiration and Rivalry*. The latter would be a relationship between two agents, which is out of the scope of the relationships we are dealing with here. A cultural heritage cloud will integrate cultural heritage collections published as linked data with data hubs as Wikipedia, Wikidata (Wikidata:WikiProject Authority Control), DBpedia (Estermann 2018) and authority control databases (Klein and Kyrios 2013) such as VIAF (Agenjo-Bullón and Hernández-Carrascal 2018).

Inspired relationship	
Relationship ID: 0081	
Label	"Inspired"@en, "Inspirou"@pt, "Inspirado"@es
URI	http://culturally_relevant_relationships.org/0061/
Description	Relationship between a book which inspired a painting or drawing; between an artwork and a book. Relationships between two independent works with different authors.
Domain	HO
Range	HO
Criteria	CD; EI, both works may have the same or different expressions forms but they must have different authors.
Examples	Inspired is a loose relationship in comparison to influenced or based_on. The previously mentioned aquatint by Picasso portraying Don Quijote and Sancho Panza and the book *Don Quijote de La Mancha* by Cervantes Saavedra; or the romance *Iracema* by the Brazilian writer José de Alencar and a painting with the same title by José Maria Medeiros; or the Da Vinci's *Mona Lisa* and the romance *Mona Lisa Overdrive* by William Gibson (1997); or the romance *Buenos Aires Memorial* by Antonio Fernando Borges (2006) and the romance *Aires Memorial* by Machado de Assis, among many others.
Similar relationships	wikim:inspired, LRM21:is inspiration for; frbr:has a transformation/is a transformation of
Inverse Relationship	Inspired_by, Relationship ID: 0082

Table 9. Inspired X inspired_by relationships.

Is_illustrated_by relationship	
Relationship ID: 0091	
Label	"Is_Illustrated_by"@en, "É_Ilustrado_por"@pt, "Es_Ilustrado_por"@es
URI	http://culturally_relevant_relationships.org/0071/
Description	Relationship: between a book that is illustrated by a painting or drawing, or between a book that is illustrated by an agent
Domain	HO, type of expression form text_objects
Range	HO, type of expression form must be two_dimensional objects
Criteria	CD, ED, domain lHO has the expression form text objects, range mHO has the expression form iconographic, two_dimensional objects
Examples	Aristophanes' *Lysitrata* (1934), edited by the Limited Editions Club, which is illustrated by six signed etchings of Pablo Picasso; James Joyce's *Ulysses* (1999), edition illustrated by Henri Matisse's rare etchings.
Similar relationships	
Inverse Relationship	Illustrated, Relationship ID: 0092

Table 10. Is_illustrated_by X illustrated relationships.

Link_to_Agent relationship	
Relationship ID: 0101	
Label	"Link_to_Agent"@en, "Vinculação_a_Pessoa"@pt, "Vinculación_a_la_persona"@es
URI	http://culturally_relevant_relationships.org/0081/
Description	The relationship between a HO and an agent that this HO belonged, used or has some kind of relationship
Domain	HO
Range	Agent
Criteria	CA
Examples	The HMS Victory was the flagship of Admiral Nelson at "Battle of Trafalgar" on 21 October 1805.
Similar relationships	edm:HasMet
Inverse Relationship	Link_agent_to_object, Relationship ID: 0102

Table 11. Link_to_agent X Link_agent_to_object relationships.

Link_to_event_process relationship	
Relationship ID: 0121	
Label	"Link_to_Event_Process"@en, "Vinculação_a_Evento_Processo"@pt, "Vinculación_a_Evento_Proceso"@es
URI	http://culturally_relevant_relationships.org/0091/
Description	The relationship between a HO and an event or process in which this HO was present or has some kind of relationship
Domain	HOs
Range	Event_process
Criteria	CA

Link_to_event_process relationship	
Relationship ID: 0121	
Examples	The HMS Victory ship and the Battle of Trafalgar on 21 October 1805.
Similar relationships	crm: P12 occurred in the presence of (was present at), edm:HasMet
Inverse Relationship	Link_event_process_to_object, Relationship ID: 0122

Table 12. Link_to_event_process X Link_event_process_to_ object relationships.

Mentioned_in relationship	
Relationship ID: 0131	
Label	"Mentioned_in"@en, "Mencionado_em"@pt, "Mencionado_en"@es
URI	http://culturally_relevant_relationships.org /0111/
Description	This is the usual relationship between a HO that is mentioned in a document—a letter, an inventory, an exhibition catalog or a book.
Domain	HO
Range	HO, Expression form is text_objects
Criteria	CI, EI
Examples	A letter (602) from Vincent Van Gogh (1888) to his brother Theo, Arles, Tuesday, 1 May 1888, mentioning a drawing "Public garden and pond in front of the Yellow House." The painting "The Prodigal Son in the Tavern" by Rembrandt is mentioned in the Rembrandt catalog raisonné, by Christian and Astrid Tümpel (1986).
Similar relationships	dcterms:isReferencedBy
Inverse Relationship	Mentioned, relationship id: 0132

Table 13. Mentioned_in X mentioned relationships.

Part_of relationship	
Relationship ID: 0141	
Label	"Part_of"@en, "Parte_de"@pt, "Parte_de"@es
URI	http://culturally_relevant_relationships.org /0111/
Description	The relationship between a HO that is a part or a fragment of another HO.
Domain	HO, both having the same type of expression form
Range	HO
Criteria	CD
Examples	The angel playing an organ is part_of the Van Eyck's Ghent Altarpiece, housed in the Cathedral of St. Bavo, Ghent, Belgium.
Similar relationships	The crm:P5 consists of (forms part of), dc:isPartOf,
Inverse Relationship	Has_part, Relationship ID: 0142

Table 14. Part_of X has_part relationships.

Portrays relationship	
Relationship ID: 0151	
Label	"Portrays"@en, "Retrata"@pt, "Retrata"@es
URI	http://culturally_relevant_relationships.org /0121/
Description	The relationship between a HO and another HO, agent, event_process or place that HO portrays.
Domain	HO, type of expression form two_dimensional objects
Range	HO, agent, event_process, place
Criteria	CD
Examples	Several paintings made by French impressionist artist Monet portraying the Rouen Cathedral. The Louvre Museum has a portrait of Napoleon Bonaparte painted by Antonine Jean Gros.
Similar relationships	The crm:P62 depicts (is depicted by), edm:hasView
Inverse Relationship	Is_portrayed_by, Relationship ID: 0152

Table 15. Portrays X is_portrayed_by relationships.

Provenance relationship	
Relationship ID: 0161	
Label	"Provenance"@en, "Proveniência"@pt, "Procedencia"@es
URI	http://culturally_relevant_relationships.org /0131/
Description	The relationship between a HO and its place of creation
Domain	HO, any
Range	Place
Criteria	CA
Examples	The mask of Tutankhamun, now at the Egyptian Museum of Cairo, and Valley of the Kings, Egypt, where it was discovered. Duplicate objects or donations sent from an institution to another
Similar relationships	dcterms:provenance
Inverse Relationship	Place_of_provenance, Relationship ID: 0162

Table 16. Provenance X place_of_provenance relationships.

Similar_item relationship	
Relationship ID: 0171	
Label	"Similar_item"@en, "Item_similar"@pt, "item_relacionado"@es
URI	http://culturally_relevant_relationships.org /0141/
Description	The relationship between similar items, according to a collection curator
Domain	HO, both domain and range have the same type of expression form
Range	HO
Criteria	CA, IS
Examples	Similar items, as in museums in Israel.[1] Greek pottery from Greece and from south Italy.

Similar_item relationship	
Relationship ID: 0171	
Similar relationships	
Inverse Relationship	The relationship is symmetric

Table 17. Similar_item relationship.

A synthesis of the relationships proposed follows.

RELATIONSHIP	INVERSE RELATIONSHIP
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 Has_Subject
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: 0131 Mentioned_in	Id: 0132 Mentioned
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	

Table 18. Synthesis of the relationships proposed.

The final schema is shown in Figure 1.

5.3 Representation of culturally relevant relationships as LOD

As previously stated, the vocabulary of culturally relevant relationships was conceived to be used by cultural curators, even if a relationship is automatically generated from catalog systems. A known limitation of the RDF triple model is the lack of provenance information. In the case of the vocabulary of culturally relevant relationships, provenance information is the identification of the curator or the institution that proposed/assigned a culturally relevant relationship between two digital HOs, whether manually or automatically assigned.

There are several proposals to extend the RDF triple model to assign thrust, context, or provenance to a triple (Gandon and Corby 2010; Carroll et al. 2005). Wikidata uses qualifiers for its triples, and references for its statements in Wikibase, its knowledge base (Erxleben et al. 2014). One of such proposals is Named Graphs (Carroll et al. 2005). Among others, the authors propose a semantic web publishing vocabulary with entities as graph, warrant, and authority, aimed at extending the RDF model to ensure warranty and authority of a statement. Any implementation of the proposed vocabulary may consider and combine such extensions of the RDF model. We propose using such technologies to assign provenance to culturally relevant relationships. Here follows an example of the assignment of provenance information to a culturally relevant relationship realized as a named graph (the example is coded in TriG format (Carroll et al. 2005).

```
@prefix dc: <http://purl.org/dc>.
@prefix crr: < http://culturaly_relevant_relation-
   ships.org/>
@prefix foaf: <http://xmlns.com/foaf/0.1/>.
:r1 = { :http://datos.bne.es/obra/XX3383563 crr:Inspired
   :https://www.moma.org/collection/works/68157 }
:r1.1 = { :r1 dc:creator orcid: <https://orcid.org/0000-
   0003-0929-8475>
   :r1 dc:date :"20190417"}
:r1.1.1 = { :r1.1  foaf:name:" Marcondes"
            :r1.1  foaf:mbox
                   :<mailto: ch_marcondes@id.uff.br>
            :r1.1  foaf:homepage
                   :<http://www.professores.uff.br/
                     marcondes>  }
```

6.0 Concluding remarks

Regarding the HO-agents relationships, we opt to use relationship labels that express their semantics as clearly as possible, such as compiled_by, created_by, is_illustrated-by, instead of using created_by and a possible "Has_the-Contribution_of/Contributor" relationship as in the Dublin Core vocabulary; this last relationship does not express clearly the role of the agent as a contributor with respect to the HO. As previously stated, the proposed vocabulary of culturally relevant relationships is conceived to be used by cultural curators for annotating resources, so a clear semantic is an important prerequisite.

In this paper, a vocabulary of culturally relevant relationships is proposed between heritage objects (their digital surrogate: metadata, digital text and/or images) comprising heritage institutions collections. Such a vocabulary may be implemented using LOD technologies. The intended users of such a vocabulary are curators, cultural or literary critics, or scholars, in creating novel digital resources based on their authorial annotations. Such annotations comply with standards as the Open Annotation Data Model (http://www.openannotation.org/spec/core/).

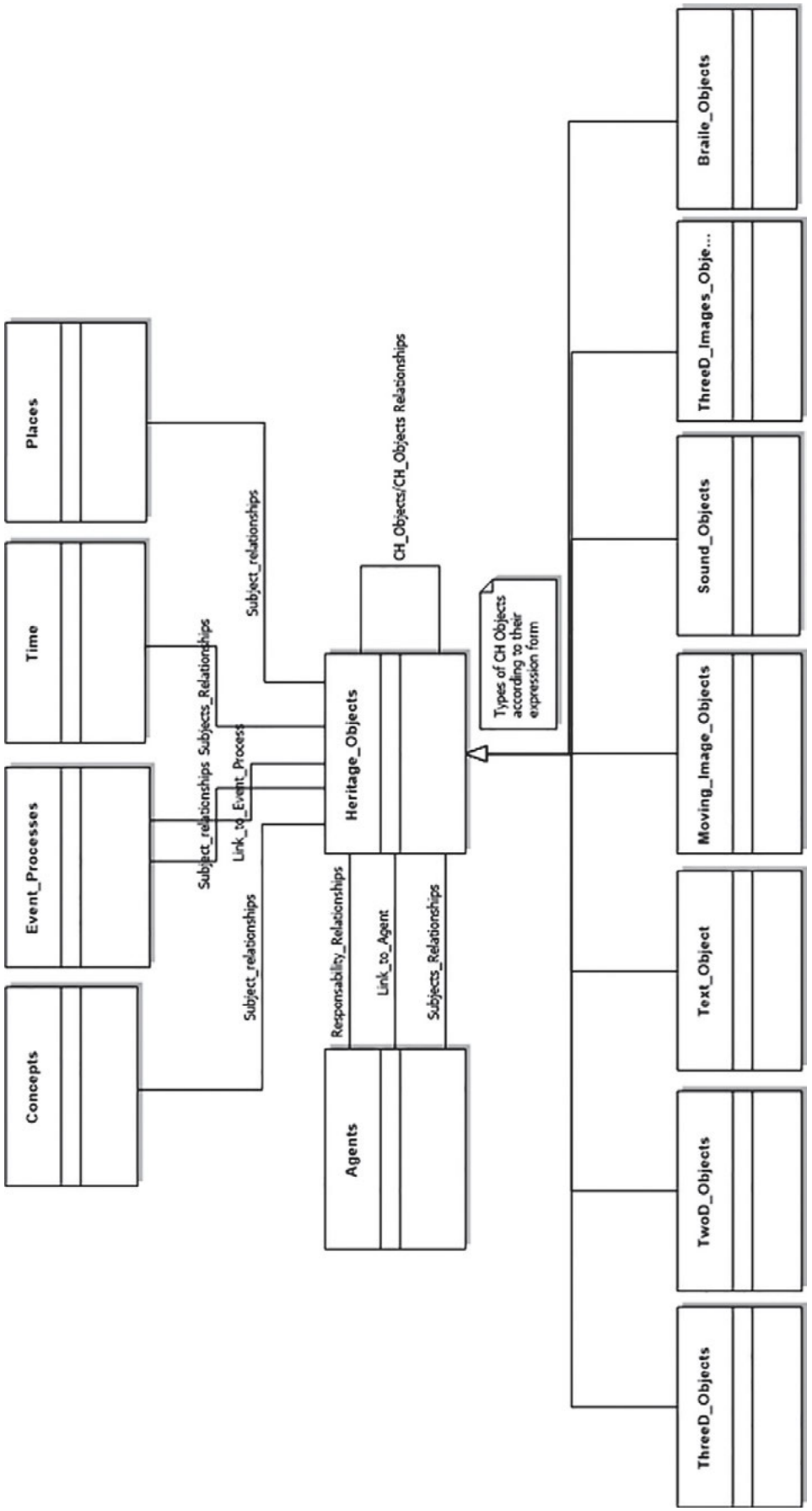

Figure 1. Final schema of the relationships found.

We envision as a possibility the use of the vocabulary of culturally relevant relationships as a web portal hosting LOD datasets of collections of several different heritage institutions. Through this web portal, curators can cross-search collections for culturally relevant objects, agents, subjects, events or periods of time, and places. Once they find what they consider a culturally relevant relationship between two entities, they can propose/assign such a relationship from the vocabulary. A curator can also save a set of such relationships as an authorial trajectory or roadmap to these collections, creating a virtual exhibition. Users can navigate through virtual exhibitions; heritage institutions can also enrich their LOD datasets with the relationships proposed by curators. The annotation of digital objects can be used as a target resource for enrichment processes of heritage collections (Europeana 2015).

The publishing of digital collections over the web opens new opportunities to heritage institutions. It enhances access, enables reuse, and achieves full integration of collections to the mainstream web, thus enlarging their reach and synergies. Such synergies can be exploited as culturally relevant relationships are established between the digital objects of these collections implemented as LOD links. The contribution of this article is to propose a vocabulary of culturally relevant relationships to provide semantics to such links. The interlinking of resources from different institutions provides rich contexts not available by OPAC technologies. The reciprocal implementation of LOD links between heterogeneous and distributed digital collections requires cooperation, coordination, and curatorial activities on a new level. It can also achieve interoperability, improve synergies and usability between collections, thus empowering and reshaping heritage institutions. This is ongoing research; the results presented and the schema proposed herein are provisional and a starting point to be discussed, tested, and enhanced.

A limitation of this research is that the relationships proposed are not yet validated as a whole as a vocabulary to be used by cultural curator in annotating digital heritage objects published as LOD. A next step is to create complex use cases and submit them to evaluation. An example of such a use case is "Botticelli 92 drawings" (that belongs to the collections of the Kupferstichkabinett Berlin and the Vatican Library) illustrating the Dante's *Divine Comedy* (see also the 1481 printed edition) which were commissioned by Lorenzo de Medici (which contract is in the collection of the Archivio di Stato di Firenze) (Watts 1995).

Note

1. Example suggested by Ram Shimony

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Appendix 1. Examples of use cases collected

Description of the USE CASE		
Suggested by: Angela Bittencourt	**Institution:** BN	
The painting *Iracema* by the artist José Maria de Medeiros, dated 1881, part of the collection of the National Museum of Fine Arts in Rio de Janeiro, was inspired by the novel of the same name by José de Alencar, first published in 1865, which has several copies in the collection of the National Library.		
RELATION/INVERSE RELATION		
Painting "Iracema," by the artist José Maria de Medeiros, 1881	WAS INSPIRED BY -> <- INSPIRED	Novel "Iracema," by José de Alencar, 1865
National Fine Arts Museum Collection		National Library of Brazil Collection

Description of the USE CASE		
Suggested by: Elenora Machado	**Institution:** SMU/SEC-RJ	
The novel *Dona Flor and her two husbands*, by Jorge Amado, is illustrated with engravings by the artist Carybé		
RELATION/INVERSE RELATION		
Novel *Dona Flor and her two husbands*, by Jorge Amando	IS ILLUSTRATED -> <- ILLUSTRATE	Engravings by Carybé

Appendix 2. Heritage Objects referenced

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