A curatorial model for digital heritage collections as linked open data and named graphs

Un modelo curatorial para las colecciones de patrimonio digital como datos abiertos enlazados y grafos con nombre

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Resumen

Un trabajo curatorial agrega valor al proporcionar una interpretación de dichos conjuntos de objetos, relacionando los objetos digitales patrimoniales entre sí y con otros recursos digitales, contextualizándolos, clasificándolos por tipología y brindando comentarios. Como tal, un trabajo curatorial es autoral. Se presenta una propuesta de modelo de curaduría de objetos patrimoniales digitales, con el objetivo de convertir el trabajo curatorial de colecciones de archivos, bibliotecas y museos en recursos digitales, permanentes, autorales y reutilizables. Actualmente, las colecciones de objetos patrimoniales se publican en la web como datos abiertos vinculados. El valor cultural y educativo del trabajo curatorial aumentaría si pudiera reutilizarse, como un catálogo de exhibición impreso. También se propone la implementación de dicho modelo utilizando LOD y tecnologías de grafos nombrados.

Palabras clave: Archivos. Bibliotecas. Museos. Colecciones. Trabajo curatorial. Modelos de patrimonio digital. Datos abiertos enlazados.

Abstract

Currently, collections of heritage objects are being published on the web as linked open data. A Curatorial work adds value by providing an interpretation of such sets of objects, relating heritage digital objects to each other and to other digital resources, contextualizing them, classifying them by typology, and providing commentary. As such a Curatorial work is authorial. A proposed model of curatorship for heritage digital objects is presented, with the goal of making the curatorial work on archives, libraries, and museum collections into digital, permanent, authorial, and reusable resources. The cultural and educational value of curatorial work would increase if it could be reused, like a printed exhibition catalogue. It is also proposed the implementation of such a model using LOD and named graph technologies.

Keywords: Archives. Libraries. Museums. Collections. Curatorial work. Digital heritage model. Linked open data.

1. Introduction

Since the 2010s, several projects for publishing collections from heritage institutions as Linked Open Data (LOD) have begun to appear. Projects such as those of Europeana (1), those of the National Libraries of Spain (2), France (3) and Germany (4), those of the British Museum (5) are well known, and, more recently, of archival institutions, driven by the emergence of the new conceptual model Records in Contexts (RiC-CM) (2021), such as those of the National Archives of Sweden (6).

The profusion of digital resources of interest to Science, Culture and Art now available over the web enlarges the possibilities of using such resources for cultural and educational purposes. Applications such as digital libraries, virtual museums and exhibitions, e-learning and distance learning platforms are similar since users interact with these applications according to previously defined procedures (browsing through resource access options, searching for information, and accessing and interacting with resources). The proper functioning of such applications, be they digital libraries (Candela et al, 2007), virtual museums (Klentien, 2022) or e-learning and distance learning (Samsuzzamanet al., 2012), (Tunde et al., 2015), require conceptual models (Campos, 2004) to integrate different resources into coherent and user-friendly systems.

Digital collections from archives, libraries and museums are an important input for digital humanities research (Zeng, 2019). Nowadays objects in heritage collections have been published and represented on the Web using LOD technologies. Such collections have high cultural value, as they result from curatorial processes carried out by the institutions that have kept them permanently, such as archives, libraries, and museums. Furthermore, these collections published as LOD are open, not constituting information silos. Their digital objects can be used by anyone and interlinked with other resources.

Such collections can serve as inputs for research, science, education and culture. Their organiza-

tion, both in traditional finding aids such as catalogs, thesaurus and classification schemas, and in devices driven by information technologies such as ontologies, poses challenges to Knowledge Organization (Dalberg, 2014), Knowledge Representation (Giunchiglia, Dutta and Maltese, 2114) and to Conceptual Modeling (Guarino, 2009).

Many of these collections have thematic intersections or are related to other resources also available on the Web. For the initiatives of publishing these collections to reach their maximum cultural and educational impact, their digital objects should be integrated and interrelated with each other and with other entities represented as digital resources, such as authors, themes, events, periods histories and places. LOD technologies allow this integration and interoperability to be achieved (Marcondes, 2021) creating new and unusual navigational paths. However, such is not given "a priori", but it requires curatorial work.

Relating heritage digital objects to each other and to other digital resources, classifying them by their typology and commenting on them is the result of a curatorial work *after* the publication of these collections as LOD. Such curatorial works can become permanent and reusable authorial resources in the form of curated virtual exhibitions, lectures, classes or collections.

This is ongoing research. The objective of this work is to develop a curatorial model for heritage collections (MIC) aimed at making the curatorial work into permanent, authorial and reusable resources. A use case implementation of such a model is also proposed using the LOD and named graphs technologies.

This article is organized as follows. After this introduction, where the research problem is established, the concept of curation of heritage collections, its phases and its role within the patrimonialization process discussed in section 2. Next, the current heritage models and the specifics of MIC are discussed in section 3. Section 4 presents, describes and discusses the proposed model. Finally, section 5 presents final remarks, conclusions and future works.

2. Digital curation of heritage collections

Today digital curation has a broad meaning encompassing activities from digital preservation to promoting access and reuse.

Heritage institutions such as archives, libraries, and museums play a vital role in curating collections of heritage objects and making these collections available to society for educational, cultural, and scientific purposes. Digital collections are

privileged material for the Digital Humanities (Zeng, 2019).

Being a heritage object is a cultural and value-added process that selects and separates objects from their original physical, functional, and cultural context and inserts them in a curatorial context: an archive, library, or museum. Such is the process of patrimonialization (7) where an object is selected, transferred from its original context, and brought to a heritage institution where its context is reconstructed. Within this new context, heritage objects are now witnesses and documents, representing or recording those aspects of the reality they came from (Van Mensh, 1992, 106), (Stransky, 1985, p. 98). Heritage objects are thus dual, they are primary objects (natural or man-made, or intangible) plus documents (Briet 2006)–descriptions of the primary object to add a semantic function and enrich its role as documents and testimony of natural, cultural, and social facts. As representations or symbols, i.e. documents, the properties assigned, added, or highlighted–their metadata (Qin and Zeng, 2020)–, during the curatorial process are dependent on the cultural, historical/social or scientific relevance of the specific object.

In other words, becoming a heritage object is a socially attributed characteristic (Searle, 1995), assigned to an object by an agent, a curator, on behalf of an archival institution, a library or a museum. This agent makes this decision based on the institution's collection policy and thus inscribes/lists the object in the institution's collection. The curator–be it an individual or an institution–thus performs an evaluation and decision-making process when carrying out the patrimonialization of a heritage object as stressed by Lima (2008, p. 36).

> […] valuer attribution, a judgment made by the cultural field that consigns it as an element with a differentiating character. And by distinguishing it in this way, it makes it 'special' and in a prominent position compared to other objects of the same nature, giving it a sense of exceptionality.

On the bases of such curatorial work developed by heritage institutions, others can be further developed. In the context of contemporary culture, a curator means, according to Gaskill (2011, p. 1), the professional in charge of collections in institutions who manage them, plans their exhibitions develop research to provide context.

LOD technologies allowed these collections to be published directly on the Web. Although heterogeneous, maybe represented using different metadata, conceptual models or vocabularies, LOD provides a unified data model. Once published, such collections are no longer limited to

the context of the original institutions that keep them; they can be combined with other entities represented on the Web such as authors, artists, themes, historical events, and places, in the ever-growing heritage interlinked "cloud", forming new and richer resources.

During the 20th century, curatorship in culture shifted its focus from collections to exhibitions (O'Neil, 2007, p. 15). Currently such exhibitions are gaining a global dimension. Examples are "Da Vinci: Mechanics of Genious" at the Science Museum in London, curated by engineer Jim Bennett, "Da Vinci" at the Louvre Museum, Paris, which was principally curated by Vincent Delieuvin and Louis Frank, and "Human Bodies", curated and catalogued by Prof. Gunther Von Hagens. With LOD technologies these exhibitions can now become new digital, authorial and permanent resources. Some of such are itinerant exhibitions that travelled by several countries, were visited by thousands of people, and were reassembled in different sites.

The instrument for disclosing and registering an exhibition is a catalog, a kind of special work. A catalog is a typical publication that permanently materializes the curatorship of a collection or exhibition. The content of an exhibition catalog are descriptions, analysis or comments about sets of heritage objects and why they are put together and related.

The Art History Research Guide (2023) of the University of Toronto Libraries stresses that

> Exhibition catalogues are a very important type of literature for Art History. They provide documentation relating to all the items displayed in a show at a museum or art gallery and they contain new scholarly insight by way of thematic essays from curators and academics.

According to the same source, a catalog may have the following structure:

> Now, exhibition catalogues often take the form of substantial books containing an introduction, essays, works shown, crisp colour images on glossy paper, a bibliography and sometimes an index.

An example of an online catalog, the British Museum catalogue, can be found at the following link: https://www.britishmuseum.org/research/publications/online-research-catalogues. The Guggheim Museum, New York, makes available digitalized versions of all its catalogs in https://archive.org/details/guggenheimmuseum. A guide on writing exhibition catalogs can be found at https://owl.purdue.edu/owl/subject_specific_writing/writing_in_art_history/museum_catalog.html. An example of a printed catalog, the one of the "Da Vinci" exhibition at the Louvre Museum, Paris, can be found at https://www.louvre.fr/en/what-s-on/exhibitions/leonardo-da-vinci#exhibition-catalogue.

In a catalog, a curator proposes a new look at that set of objects, contextualizes them, reveals new relationships–often unusual–between them, and proposes a narrative about those objects. Curating an exhibition is thus an authorial work. Therefore, the MIC aims somehow to mimic the structure and purposes of an exhibition catalog. It was developed based on the structure of the previously mentioned catalogs.

3. Current heritage models and the specifics of MIC

There are different conceptual models in the heritage domain as IFLA LRM, CIDOC CRM, BIBFRAME, EDM. Such models are declared as object-centred (Isaac, 2013, p. 12) or process/evento-centred (Isaac 2013, p. 15)

The aim of the CIDOC CRM is interoperability, i.e., "to allow exchange and sharing of information" (CRM Primer, 2012, p. 2) between heterogeneous data sources from different cultural heritage systems. It was designed to be implemented in RDF. It was conceived to model historical or cultural processes relating actors to heritage objects. In the CIDOC CRM no object is directly related to an actor, only through a process.

Another important remark is that the actor-event-object modelling used in the CIDOC CRM is quite complex and counterintuitive to be used by a curator. The CIDOC CRM also lacks a mechanism to provide a visiting sequence so useful within exhibitions.

The EDM–Europeana Data Model–, the conceptual model of the Euopeana Digital Library, is a quite complex model. Europeana is a data aggregator. It has to keep linked different representations of the same heritage object provided by different heritage institutions (using the ore:Aggregation property), as, for example, the metadata about the Da Vinci's Mona Lisa provided by both the Louvre Museum and the Joconde database (8), the catalog of objects of all France museums.

Within EDM, a heritage object may be related to persons, places, subjects, etc., that are part of its context, by two relationships: edm:isRelatedTo and edm:hasMet (Isaac 2013, p.13), depending if the modelling considers "object-centric" or "event-centric" approaches. The use of the EDM in such circumstances demands training and qualification by a curator.

Like the EDM, the MAP–Metadata Application Profile–, the conceptual model of the DPLA (DPLA Metadata Application Profile, 2017), the

Digital Public Library of America, also has to cope with different representations of the same heritage object provided by different partners.

The BIBFRAME–Bibliographic Framework–model is maintained by the US Library of Congress. It aims to provide the foundation for the future of bibliographic description, being an evolution of and resting on LC initiatives that date back to Project MARC in the 1970 decade. BIBFRAME was conceived to be serialized in RDF, being trivial the mapping of the bibliographic entity described in a MARC record–the Subject–of an RDF triple, the properties identified by MARC paragraphs/subfield codes–the triple's Predicate–, and the content of such paragraphs/subfield codes–its Object.

Descriptive information in BIBFRAME is organized in three levels of abstraction–Work, Instance, and Item–, somehow simplifying the four levels of abstraction of models as the FRBR and CRM. The majority of properties provided by the BIBFRAME are descriptive properties of bibliographic entities or relationships between entities of different levels of abstraction.

The models FRBR, its successor–the LRM– and BIBFRAME, all rest on modelling relationships between levels of abstraction of the bibliographic entities aimed at aggregating all corresponding items of a collection in information retrieval tasks. FRBR and LRM have four levels of abstraction: work, expression, manifestation, and item; BIBFRAME has three: work, instance, and item. All such models have also relationships between bibliographic entities and entities as agents, concepts, time, and space.

One could say that the MIC is an object centred model, but in a special sense. It is best described as a *relationship-oriented model*. It aims *not* to provide properties to describe heritage objects but to use the descriptions *already* provided by heritage institutions, possibly using other models, vocabularies or ontologies, and to comment and relate such heritage objects representations one with another. To the MIC the important is the IRI through what a digital heritage object and its representation, no matter the model or vocabulary used to describe it, may be accessed.

Digital representations of heritage objects from collections in archives, libraries and museums are its focus. Curators assemble together sets of heritage objects, create narratives and a visiting path across such objects, and make statements about them using the proposed standard provided by the MIC and the CRR Vocabulary. Such statements are implemented as RDF triples. Agents (actors), themes, historical events and places provide context to heritage objects, being

also related to them using the CRR. Whenever possible the MIC uses other metadata vocabularies such as DC, SKOS, Schema.org, etc.

The MIC, through the CRR Vocabulary, relates DHOs that are both in the sense of the FRBR and LRM (2017) models Instances and Works. The Da Vinci's Mona Lisa is both an Instance and a Work; the book "Mona Lisa: the history of the world's most famous painting", by Donald Sassoon is a Work with one (of several) Instance considered as a DHO within a case described with MIC. Such lack of ontological precision is a choice, aimed at making CRR intuitive and usable by curators without the need of any special training.

An item encompasses its expression, manifestation and work, but it, as a heritage object, has specific attributes of such levels of abstraction. MIC's main focus are the relationships between such digital heritage objects, with each other and with other entities, for example, that Da Vinci's Mona Lisa is 0012 Base_for the Dali's self-portrait as Mona Lisa, not that the last is a manifestation of the former in the sense of FRBR, LRM, and BIBFRAME models.

Several research projects have focused on modeling narrative as a sequence of events describing a specific theme or domain. In the sequel are discussed proposals that are more closely related to the MIC.

Mulholland, Wolff and Collins (2012, p. 748) proposed the CURARE ontology. It aims not to model a specific heritage object but a curatorial narrative that

> […] spans across heritage objects and have a meaning that does not necessarily reside in the individual heritage objects themselves.

CURARE distinguishes between the conceptual structure of a story as a set of events comprising story entities, a plot as an interpretation of such story as causal relations, and a curatorial narrative, i.e., how such story is expressed. For example, in an exhibition catalogue story entities may be comprised of individual heritage objects narratives, a description about an object. The distinction made by CURARE between the structural aspects of a story and its expression enables the modelling of different exhibition catalogs to the same exhibition when, for example, it is a traveling exhibition presented in different spaces.

HiCo, the Ontology of Historical Context (Daquino and Tomasi, 2015), aims at formalizing as RDF triples, authoritative statements about heritage objects, specifically textual works, encoded according to TEI standards; such statements form another work, an authorial interpretation of the

original text that adds context to it. The original work and its interpretation by a curator are linked together through an interpretative act.

The use of LOD technologies to develop narratives and arguments is described in Renda and Daquino (2023).

Meghini, Bartalesi and Metilli (2021) claim that Digital Libraries (DLs), especially in the Cultural Heritage domain, are rich in narratives about the objects they hold. The authors propose the NOnt –Narrative Ontology–to formalize narratives within the context of a digital library. NOnt is the base of a Narrative Building and Visualising tool offered as a facility to users of a DL.

Among the different conceptual models, the one that has many similarities with the MIC is the Wikidata Data Model (9). Like MIC it holds statements, in the form of RDF triples, about the entity being described by a Wikidata page. Like the MIC uses the CRR Vocabulary to standardize statements about heritage objects, the statements in the Wikidata use the Wikidata:WikiProject Ontology (10) as Subjects, Predicates, and Objects of their RDF triples. Like the MIC, any statement in the Wikidata Data Model may be supported by a reference.

4. MIC–The Integrated Model of Curatorship

By curating heritage objects from different institutions published on the web as LOD, a digital curator performs tasks such as: (a) querying collections, (b) selecting DHOs, (c) gather and classifying sets of DHOs, (d) relating objects with each other and with other relevant heritage entities, (e) commenting and making assertions on them, (f) justifying such assertions by citing bibliographic or document sources.

The MIC aims to support such a curator's tasks. Although such tasks are processual, the MIC aims to model, not such processes, but their *recording* as data.

The MIC has as its focus the curatorial work–CW –as an authorial narrative. A CW is a subclass or specialization of the IFLA LRM-E2 Work. The core of MIC are the relationships provided by the CRR Vocabulary. They relate digital heritage objects–DHO–to each other and with other entities that make up the Heritage environment such as Agents, Concepts/Themes, Time, and Space.

When performing a curatorial task, a digital curator also gathers and classifies sets of objects according to criteria such as having the same creator (Agent), their connection to the same event or period (Time), with the same Concept/Theme or

with the same R 013 DHO_type, provided by the TOP Vocabulary (Marcondes, 2019). Such types may be assigned by himself using the CRR relationship Id: 025 Has_type or by the institution that publishes the DHO.

The relationships provided by the CRR vocabulary were obtained from cases suggested by cultural curators or obtained from the literature, as described in Marcondes (2020). Many of these relationships have similar ones provided by other vocabularies or conceptual models. However, in many such cases, there are no inverse relationships which are important to provide curators with flexible and intuitive modes of relation heritage objects with each other and with other entities. The CRR Vocabulary was conceived to be intuitive and concise, releasing the curator from training and study to use it.

Just as a scientific article has a special format (The Writing Center, 2023), the MIC is a model for a specific literary genre, the exhibition catalog. The MIC Model addresses the unique structural features of such a genre. Among them is the specification of the exhibition sequence of DHOs that make up the exhibition, making explicit the Culturally Relevant Relationships between them and between them and other entities, commenting on each of such features, and making citations to support them.

The MIC has the following

- Entities: Curatorial Works, CRR Annotations, Digital Heritage Objects identified in the class diagram by the yellow color;

- External entities: Agents, Concepts/Themes, Space and Time (E02 Agents, E02 Concepts/Themes, E04 Time, E05 Space, identified by the blue color).

The core of MIC classes is identified by gray color. Curators and Publishers classes (E021 Curators, E022 Publishers), subclasses of E02 Agents; digital Curatorial Works class (E08 Curatorial Works), with the same attributes of a publication. An important class is the E080 Sequence which functions as a summary specifying the sequence of E083 Cw_sections and E09 CRR_Annotations that make up the Curatorial Work. E080 Sequence is implemented as a skos:OrderedCollection construct.

The two types of parts of a Curatorial Work are the (1 to many) Curatorial Work sections class (E083 Cw_section), textual parts of a Curatorial Work, and the (1 to many) Annotations (E09 CRR_Annotations) class, each referring, i.e., using the Web Annotation Vocabulary (2017)

oa:hasTarget, to a single Culturally Relevant Relation class (R01 CRR_rel-Types) or any Heritage_Web_Resource. The last may be any external entity mentioned in a Curatorial Work or even a Heritage Object, especially detached in the Curatorial Work. A Curatorial Work is complemented with the Documents class, cited in a Section or Annotation (E082 Documents).

Relationships were reified in the representation as a class diagram and treated as classes (R01 CRR, identified in the class diagram by the pink colour), subdivided into two subclasses.

1. DHO Relationships/External Entities (R 011 DHO/Extern_ent_rel_types) as between a DHO and its author (R021 Created_by), between a DHO and an eventual contributor–the same as the Dublin Core metadata dc:contributor–(R 0051 Has_Contribution_of), between an DHO whose subject is an external entity (R 0061 Has_Subject), between an DHO and an

agent that has influenced its creation in some way (R 0071 Influenced), between an DHO and an agent associated with it, e.g. between the pen–the DHO–with which Brazilian Princess Isabel signed the Golden Law (11) and Princess Isabel–the agent–(R 010 Link_to_ agent), between a DHO and its provenance as a place (R 0161 Provenance); and

2. DHO/DHO Relationships (R 012 DHO/DHO _rel_types), which can be seen in Figure 1. Some other relationships were used, as between DHO and external entities that are envisaged in other models or vocabularies, such as subject relationships between DHO and any of the external entities, authority/responsibility relationships between DHO and Agents, relationships such as dc:date (Dublin Core metadata vocabulary), between a DHO and the date assigned to it.
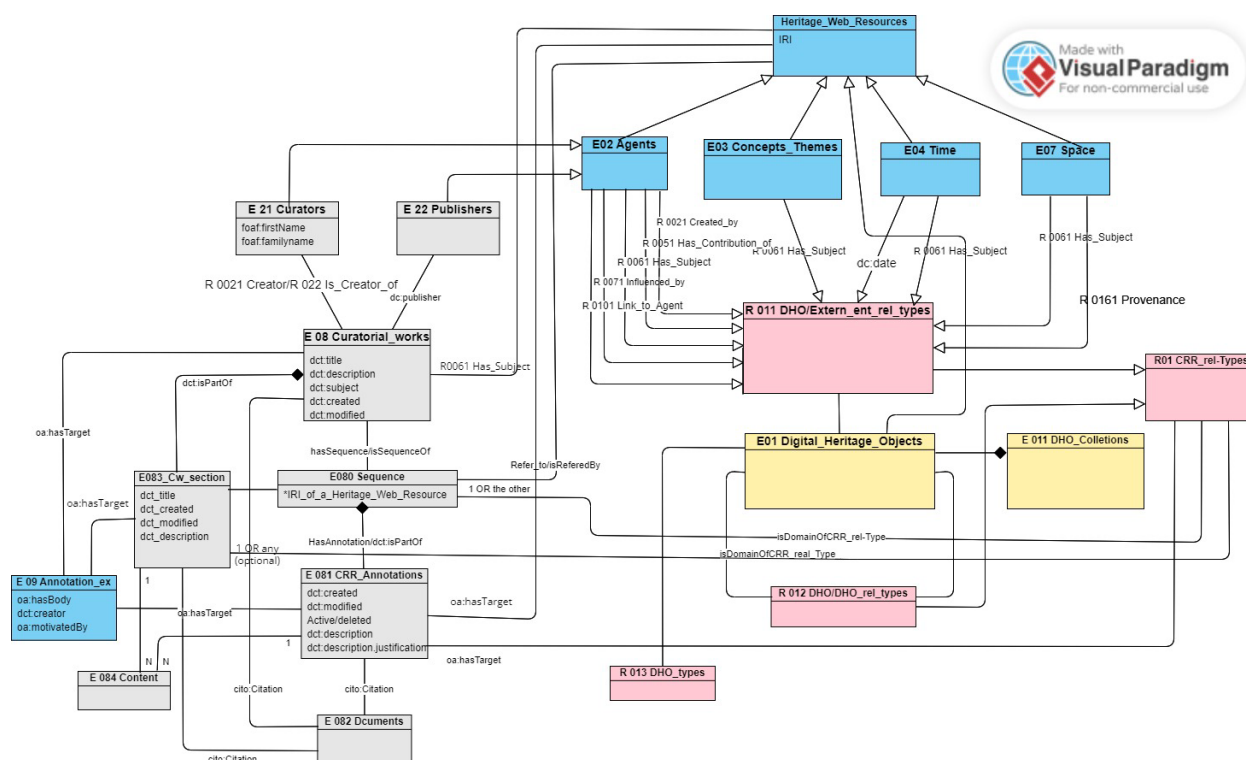

Figure 1. Class diagram of MIC

The attributes of the different classes of the MIC are only suggested and commented on when applicable.

In the proposed model, a CW has autonomy thus becoming a new document genre similar to an exhibition catalog. It becomes a subclass of a Work (FRBR, 1998; Riva et al., 2017; BIBFRAME, 2017) that has a Manifestation (FRBR, 1998; Riva et al., 2017) or Instance (BIBFRAME, 2017)

in a digital Item (FRBR, 1998; Riva et al., 2017), (BIBFRAME, 2017) with a specific IRI, where the author is identified, the digital Item is dated, and may contain other information that allow to identify their authorship and provenance.

An important issue in the work of a digital curator is to relate–by making links between them (Berners-Lee 2006)–DHO with each other and with other entities of interest to the culture represented

in the digital space. This is the purpose of CRR Vocabulary–Culturally Relevant Relationships (Marcondes 2020)–by providing a vocabulary to make these interrelationships. Using the CRR Vocabulary a curator could assert that the book "The Da Vinci Code", by Dan Brown, inspire–crr:0081_inspired–the film of the same name starring actor Tom Hanks, or asserts that the painting "Mona Lisa" by Da Vinci at the Louvre Museum served as the basis–crr:0012_base_for –the pastiche self-portrait of the Spanish painter Salvador Dalí portraying himself as the Mona Lisa. This case is illustrated in the Figure 2.

Figure 2. Da Vinci's Mona Lisa case as Linked Open Data

The CRR is implemented as predicates of a triple according to LOD technologies, having the URI of the DHO as the subject and the URI of another DHO or another entity as the object. The CRR is conceived to be intuitive e easy to be used by curators without the need of special training.

In the MIC, each CRR is treated as part of a CW, it is reified and becomes an annotation, receiving an IRI and also having its authorship and date recorded. Thus, a CRR_Annotation becomes an autonomous entity; it can be linked by citing another publication that justifies it and can receive other annotations as comments. It also has a status metadata, with two states, active/deleted, allowing the digital curator to review and modify a previously established CRR, so that readers can follow the changes made in the work. The MIC class diagram is presented in Figure 1. The CRR Vocabulary is described in Table I, on the right.

DHOs are digital representations of cultural heritage objects such as books, manuscripts, paintings, sculptures, artefacts in general, or manifestations of intangible culture or performing arts, such as a folk dance, a concert, or a ballet show, made permanent upon recorded and published on the Web.

Relationship	Inverse relationship
Digital Heritage Object to Digital Heritage Object Relationships	
Id: 0011 Based_on	Id: 0012 Base_for
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: 0071 Influenced_by	Id: 0072 Influenced
Id: 0081 Inspired	Id: 0082 Inspired_by
Id: 0091 Is_Illustrated_by	Id: 0092 Illustrated
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: 0171 Similar_item	
Digital Heritage Object to External entities relationships	
Id: 0021 Created_by	Id: 0022 Creator
Id: 0051 Has_Contribution_of	Id: 0052 Contributor
Id: 0061 Has_Subject	Id: 0062 Is_Subject
Id: 0071 Influenced	Id: 0072 Influenced_by
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: 0161 Provenance	Id: 0162 Place_of_Provenance

Table I. The CRR Vocabulary (version 2.0)

These cultural manifestations are typified in the TOP–Classification of Types of Cultural Heritage Objects–(Marcondes 2019), also incorporated into the MIC.

5. Implementing MIC with LOD and named graphs technologies

LOD are enabling technologies to cultural heritage. They enable the development by culture curators of narratives (Meghini, Bartalesi, Metilli, 2021) historically situated in Space and Time, involving digital resources representing specific themes, heritage objects, events, agents. All such entities can be represented, interlinked, recoverable, and accessed. In addition, LOD and N-Graphs technologies can made up several interlinked digital resources into standalone, authorial and permanent resources.

The model presupposes that: (a) the CW are represented according to LOD technologies; (b) that the DHO already exist as such, are published on the Web by the institutions that curate the objects that the DHO represent, such as archives, librar-

ies, museums and others; and (c) it is also assumed that the digital curator already knows or has been notified of the existence of these DHO that he will use in his CW.

Named Graphs is an extension of RDF model in which a name, an identifier, as a link, is assigned to a set of tripes (12) (Carrol, 2005). Thus, a graph can be identified and delimited, its navigation is not random, and can be planned according to an intended path. In addition, provenance and context information can be added.

The MIC is illustrated by a fictional case describing Da Vinci's Mona Lisa and its relations to resources describing Leonardo Da Vinci, the book and movie The Da Vinci Code, by Dan Brown, the Louvre Museum which holds the Mona Lisa, the Salvador Dali pastiche self-portrait as Mona Lisa, etc.

An implementation of MIC in a use case using LOD and named graph technologies is illustrated in the Appendix. Viewing Da Vinci's Mona Lisa graph through a browser can be seen in Figure 3 (using the GraphDB program).
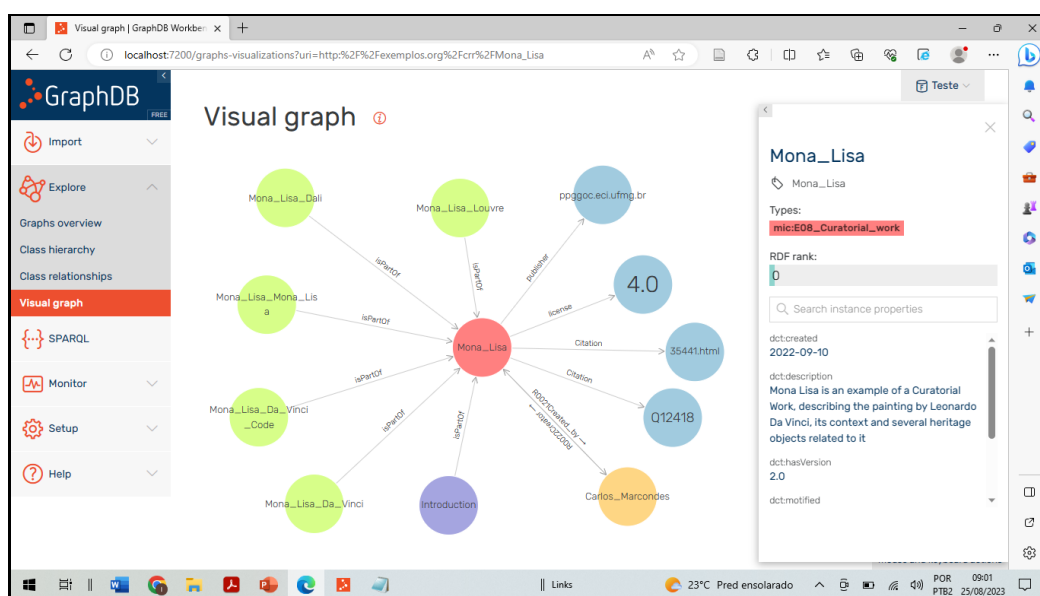

Figure 3. Viewing Da Vinci's Mona Lisa graph through a browser (using the GraphDB program)

5. Final remarks

To our best knowledge, there is no conceptual model in the heritage domain that addresses the modelling of a curatorial work. That is the aim of MIC.

This work outlined the MIC as a means of registering and making the work of digital curators autonomous and permanent by integrating digital objects from Heritage collections published on

the Web as LOD. To achieve these functionalities the MIC is implemented in RDF as a named graph. In this way, the curatorial work authorship of digital curators can constitute a new digital resource of educational and cultural value.

It is expected that the model will serve as a basis for the development of authorial tools for digital curation, or browsers through which users can browse DHOs, and curatorial works that integrate, annotate and comment on them.

The current version of the MIC can serve as a basis for the development of such applications.

As future developments, we intend to validate the MIC through new cases that represent significant curatorial works on Brazilian and global cultural heritage, load these cases into triple store and test the query possibilities using SPARQL. It is also intended to implement the MIC as a computational ontology.

Acknowledgments

Notes

(1) See https://pro.europeana.eu/page/linked-open-data.

(2) See datos.bn.es.

(3) See https://data.bnf.fr/.

(4) See https://www.dnb.de/EN/Professionell/Metadatendienste/Datenbezug/LDS/lds_node.html.

(5) See https://old.datahub.io/dataset/british-museum-collection.

(6) See https://groups.google.com/g/records_in_contexts_users/c/KZQXeodod9k/m/SQ5tblsPAAAJ.

(7) See https://www.igi-global.com/dictionary/educommunication-web-20-for-heritage/82076.

(8) See https://www.culture.gouv.fr/Espace-documentation/Bases-de-donnees/Fiches-bases-de-donnees/Joconde-catalogue-collectif-des-collections-des-musees-de-France.

(9) See https://www.mediawiki.org/wiki/Wikibase/DataModel/Primer.

(10) See https://www.wikidata.org/wiki/Wikidata:WikiProject_Ontology.

(11) See https://en.wikipedia.org/wiki/Lei_Áurea.

(12) See https://www.w3.org/2009/07/NamedGraph.html.

Appendix: Implementation of the MIC as LOD and Named Graph

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The coding of MIC as LOD and Named Graph, as follows, was validated by the IDLab Turtle validator, http://ttl.summerofcode.be/.

## A Curatorial Work relating Da Vinci's Mona Lisa with other heritage digital resources
@prefix dct:    <http://purl.org/dc/terms/> .
@prefix crr:    <http://exemplos.org/crr/> .
@prefix rdf:    <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix mic:    <http://exemplos.org/mic/> .
@prefix top:    <http://exemplos.org/top/> .
@prefix schema: <http://schema.org/>.
@prefix foaf: <http://xmlns.com/foaf/0.1/>.
@prefix skos: <http://www.w3.org/2004/02/skos/core#>.
@prefix cito: <http://purl.org/spar/cito/>.
@prefix wo: <https://www.wikidata.org/wiki/>.
@Prefix oa: <http://www.w3.org/ns/oa#>.
# Curatorial Work relating the Da Vinci Mona Lisa with other digital resources
<http://exemplos.org/crr/Mona_Lisa> a mic:E08_Curatorial_work;
   dct:title "Mona Lisa, an example of a Curatorial Work ";
   dct:description "Mona Lisa is an example of a Curatorial Work, describing the painting by Leonardo Da Vinci, its context and several heritage
objects related to it";
   dct:hasVersion "2.0";
   dct:created "2022-09-10";
   dct:motified "2022-09-13";
   crr:R0021Created_by <http://exemplos.org/mic/Carlos_Marcondes>;
   dct:license <https://creativecommons.org/licenses/by-nc-nd/4.0/>;
   dct:subject "Italian Renaissance";
   dct:subject "Paintining";
   dct:publisher <https://ppggoc.eci.ufmg.br/>;

## Citations in the Curatorial Work
# Mona Lisa in the Wikidata
   cito:Citation <https://www.wikidata.org/entity/Q12418>;
# Louvre Museum Catálog
   cito:Citation <https://www.boutiquesdemusees.fr/en/exhibition-catalogues/monna-lisa-exhibition-catalogue/35441.html>.

## Annotations
# Mona Lisa related to Leonardo Da Vinci
        mic:Mona_Lisa_Da_Vinci rdf:type skos:Concept.
# Mona Lisa related to The Da Vinci Code, by Dan Brown
        mic:Mona_Lisa_Da_Vinci_Code rdf:type skos:Concept.
# Mona Lisa related to the Salvador Dali pastiche self-portrait as Mona Lisa
        mic:Mona_Lisa_Dali rdf:type skos:Concept.
# Mona Lisa related to Louvre Museum
        mic:Mona_Lisa_Louvre rdf:type skos:Concept.

## Sections
# Introductory Section
        mic:Mona_Lisa_Introduction rdf:type skos:Concept.

## Sequence within the Curatorial Work
<Mona_Lisa_sequenceOfResources> rdf:type skos:OrderedCollection ;
  skos:prefLabel "Sequence of heritage web resources refering to Da Vinci's Mona Lisa"@en;
  skos:memberList <http://exemplos.org/mic/Mona_Lisa_Da_Vinci>.

        mic:Mona_Lisa_Introduction rdf:first <http://exemplos.org/mic/Mona_Lisa/Introduction>;
                rdf:rest mic:Mona_Lisa_Da_Vinci.
        mic:Mona_Lisa_Da_Vinci rdf:first <http://exemplos.org/mic/Mona_Lisa_Da_Vinci>;
                rdf:rest mic:Mona_Lisa_Da_Vinci_Code.
        mic:Mona_Lisa_Da_Vinci_Code rdf:first <http://exemplos.org/mic/Mona_Lisa_Da_Vinci_Code>;
                rdf:rest mic:Mona_Lisa_Dali.
        mic:Mona_Lisa_Dali rdf:first <http://exemplos.org/mic/Mona_Lisa_Dali>;
                rdf:rest mic:Mona_Lisa_Louvre.
        mic:Mona_Lisa_Louvre rdf:first <http://exemplos.org/mic/Mona_Lisa_Louvre>;
```

```
            rdf:rest rdf:nil .

# Mona Lisa
<https://collections.louvre.fr/en/ark:/53355/cl010062370> rdf:type schema:Paiting ;
   dct:type top:Painting;
   dct:title "Mona Lisa";
   dct:date "1503";
   crr:0065InColletion <https://www.louvre.fr>;
   crr:0131Mentioned_by_in <https://bnb.data.bl.uk/doc/resource/006946635>;
   crr:0012Base_for <http://www.studiolo.org/Mona/MONASV12.htm>;
   wo:P18 <https://commons.wikimedia.org/wiki/File:Mona_Lisa,_by_Leonardo_da_Vinci,_from_C2RMF_retouched.jpg> .

# Leonardo Da Vinci
<https://www.wikidata.org/entity/Q762> rdf:type schema:artist;
dct:title "Leonardo da Vinci";
wo:image:P18 <https://www.wikidata.org/wiki/Q762#/media/File:Francesco_Melzi_-_Portrait_of_Leonardo.png>.

# The Da Vinci Code book
<https://bl.natbib-lod.org/the-da-vinci-code-p1121681401307175/> rdf:type schema:Ebook ;
dct:type top:textual_documents;
dct:title "The Da Vinci Code, by Dan Brown";
dct:creator "Dan Brown".

# The Louvre Museum
<https://www.louvre.fr> rdf:type schema:Museum;
dct:title "The Louvre Museum";
wo:P18 <https://commons.wikimedia.org/wiki/File:Louvre_2007_02_24_c.jpg>.

# the Salvador Dali pastiche self-portrait as Mona Lisa
<http://www.studiolo.org/Mona/MONASV12.htm> rdf:type schema:Paiting;
dct:type top:Painting;
dct:title "Dali as Mona Lisa";
dct:creator "Salvador Dali";
wo:P18 <https://www.dalipaintings.com/self-portrait-mona-lisa.jsp#prettyPhoto[image1]/0/>.

# Carlos Marcondes
<http://exemplos.org/mic/Carlos_Marcondes> rdf:type mic:E21_Curator;
   foaf:family_name "Marcondes";
   foaf:first_name "Carlos";
   foaf:homepage <http://profmarcondes.ong.br> ;
   crr:R0022Creator <http://exemplos.org/crr/Mona_Lisa>;
   foaf:mbox <ch_marcondes@id.uff.br>.

## Annotations
<http://exemplos.org/mic/Mona_Lisa_Da_Vinci> rdf:type mic:E081_Annotation;
   mic:domain_resource <https://collections.louvre.fr/en/ark:/53355/cl010062370>;
   crr:0021Creator <https://www.wikidata.org/wiki/Q762>;
   dct:isPartOf <http://exemplos.org/crr/Mona_Lisa>;
   mic:A08_Content <http://exemplos.org/Text1>;
   #  The Wikidata paga of Mona Lisa
   cito:Citation <https://www.wikidata.org/wiki/Q12418>;
   dct:date "2022-09-10".

<http://exemplos.org/mic/Mona_Lisa_Da_Vinci_Code> rdf:type mic:E081_Annotation;
   mic:domain_resource <https://collections.louvre.fr/en/ark:/53355/cl010062370>;
   crr:0131Mentioned_by_in <https://bnb.data.bl.uk/doc/resource/006946635>;
   dct:isPartOf <http://exemplos.org/crr/Mona_Lisa>;
   mic:A08_Content <http://exemplos.org/Audio1>;
   dct:date "2022-09-10".

<http://exemplos.org/mic/Mona_Lisa_Dali> rdf:type mic:E081_Annotation;
   mic:domain_resource <https://collections.louvre.fr/en/ark:/53355/cl010062370>;
   crr:0012Base_for <http://www.studiolo.org/Mona/MONASV12.htm>;
   dct:isPartOf <http://exemplos.org/crr/Mona_Lisa>;
   mic:A08_Content <http://exemplos.org/Video1>;
   dct:date "2022-09-10".

<http://exemplos.org/mic/Mona_Lisa_Louvre> rdf:type mic:E081_Annotation;
   mic:domain_resource <https://collections.louvre.fr/en/ark:/53355/cl010062370>;
   crr:0065InCollection <https://www.louvre.fr>;
   dct:isPartOf <http://exemplos.org/crr/Mona_Lisa>;
   #  The Louvre Museum Catalog
   cito:Citation <https://www.boutiquesdemusees.fr/en/exhibition-catalogues/monna-lisa-exhibition-catalogue/35441.html>;
   dct:date "2022-09-10".

## Sections
#  Introductory Section
<http://exemplos.org/mic/Mona_Lisa/Introduction> rdf:type mic:E083_CW_section;
        dct:title "Da Vinci's Mona Lisa as seen by other artists";
        dct:creator "Carlos H. Marcondes";
        dct:isPartOf <http://exemplos.org/crr/Mona_Lisa>;
        dct:description  "The Da Vinci's Mona Lisa is the most famous painting of Occidental Art...";
        dct:description  <http://exemplos.org/any_text>;
        dct:date "2022-09-10".
```

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