Relations for Reusing (R4R) in A Shared Context:
An Exploration on Research Publications and Cultural Objects

Andrea Wei-Ching Huang and Tyng-Ruey Chuang
Institute of Information Science, Academia Sinica, Taipei, Taiwan.
{andreahg, trc}@iis.sinica.edu.tw

Abstract: Will the rich domain knowledge from research publications and the implicit cross-domain metadata of cultural objects be compliant with each other? A contextual framework is proposed as dynamic and relational in supporting three different contexts: *Reusing*, *Publication* and *Curation*, which are individually constructed but overlapped with major conceptual elements. A *Relations for Reusing (R4R)* ontology has been devised for modeling these overlapping conceptual components (*Article*, *Data*, *Code*, *Provence*, *and License*) for interlinking research outputs and cultural heritage data. In particular, packaging and citation relations are key to build up interpretations for dynamic contexts. Examples are provided for illustrating how the linking mechanism can be constructed and represented as a result to reveal the data linked in different contexts.

Keywords: citation, context, cultural heritage, curation, ontology, packaging, publication, R4R, research data, reuse, sharing

1. Introduction

A digital object *Y* curated in a digital museum, is a cultural object *Y* with metadata descriptions. This cultural object *Y* reused by an academic article is not a cultural object but a science object *Z* that can be viewed under different context perspectives. By a definition of Zimmermann et. al., "*when the contexts of two entities overlap and part of the context information become similar and shared*," a shared context emerges [1].

Embedded information has been well preserved and curated in research data repositories and in Libraries, Archives and Museums (LAM) databases, but has not been explored for their potentials in enriching each other's contexts. For instance, cultural objects are mostly preserved with metadata information, but part of the data may come from the outputs of research projects. As for research data, the interpretation of domain knowledge is professionally established from scholarly publications which are comprehend by articles' textual descriptions, or by supportive evidences like associated publications (i.e. data and code), and these supportive evidence may come from cultural objects curated in LAM collections. Thus, is there a shared context between these two domains that can serve for a common understanding? And, how can a shared context

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between these two help us enrich contextual information and make our data better? In practice, will linking data from scholarly publications to metadata-rich LAM collections foster contextualizing research outputs? Will linking data from LAM collections to research publications increase the reuse and the remix of cultural heritage for a broad range of disciplines? And, in particular, what kinds of relations exist, or need to be established for a shared context? Finally, how these relations can be represented?

In this study, we hope to contribute to open a new dialogue among researchers from across different communities who share a common interest in understanding the potential of data sharing and reusing accross different domains. In the meantime, three more recent developments provide the potential of relating data in a wide range of contexts: (1) An increasing development on data publication and citation principles which is participated vividly by research communities like CODATA[1] , Research Data Alliance (RDA)[2] and FORCE11[3]. At the same time, the opportunity that open science movement presents for research reproducibility is taken from joint publications of articles, datasets and software codes. (2) The choice of linked data approach for data publication in research domains such as the VIVO project [2] and Linked Science and Education [3]; in cultural heritage data, efforts like LODLAM community[4] and the Europeana project [4], or in specific library catalog cases in LIBRIS [5], Library of Congress [6], WorldCat Work of OCLC[5] are examples in which this trend is well-justified. (3) As an overlapping of data publication and citation, open science as well as linked data developments, cases like publishing semantic enriched articles [7], source code Linked Data repository [8], and the emerging code citation mechanism[6] are such examples just to name a few.

However, citations need context [9], linked data is not enough only for research data [10], and the lack of theory and "object-rich but resource-poor" problems are identified in cultural heritage domains [11]. Therefore, above mentioned developments with these problems have motivated us to the design of a contextual framework to disclose context by a systematic approach in the next section.

2. A Contextual Framework for a Shared Context

For modeling and representing contextual linking, we follow the operational definition of [1] for determining the design space of context models. The five essential contexts are time, location, individuality, activity and relations. And in specific to model the activity, we further adopt Courtright's theoretical concept of actors-in-context which combines a relational view on activities of users, information systems and information

[1] http://www.codata.org/task-groups/data-citation-standards-and-practices
[2] https://rd-alliance.org/
[3] https://www.force11.org/
[4] Linked Open Data in Libraries, Archives, and Museums (LODLAM): http://lodlam.net/
[5] http://www.oclc.org/data.en.html
[6] https://github.com/blog/1840-improving-github-for-science

existence that context not only shapes action but is also shaped by it [12]. Our framework consists three major parts: (1) three contexts relate actors' levels with associated activities as *Reusing, Publication* and *Curation*[7]. (2) a Representation-Preservation-Interpretation setting is established. (3) Nine contextual elements are derived and extended from a contextual study on cultural heritage objects, and are further adjusted to accommodate particular settings. Table 1 provides a summary of this contextual framework, and the following offers theoretical backgrounds in details.

Table 1: A Contextual Framework for relating Reusing, Publication and Curation Contexts

activity \ setting	Representation	Preservation	Interpretation
Reusing *(User Level)*	**Application** (VII) *(ex. Reusing Cases)*	**Authorization** (VIII) *(ex. Policy/Licence)*	**Utilization** (IX) *(ex. Citation or Packaging Relation)*
Publication *(Author Level)*	**Identification** (I) *(ex. DOI/URI/URL)*	**Physicalness** (II) *(ex. Article, Data, Code)*	**Intangibleness** (III) *(ex. Domain Vocabulary & Citation)*
Curation *(Curator Level)*	**Classification** (IV) *(ex. RRObject/RRPolicy)*	**Authentication** (V) *(ex. Metadata/Provenance)*	**Ontological Relations** (VI) *(ex. Domain-independent Ontology /Relations ontologies/ R4R ontology)*

(1) Three dynamic activity contexts: *Reusing, Publication* and *Curation.*

From session one, we realize the importance of modeling publication and reusing contexts. However, Contextualizing only for these two activities is not enough since this framework is also to assist system designers, developers and curators for their practices. Thus a third Curation level is added for two more reasons: (1) Zimmermann et.al [1] defines activity context as a context which decides to its current needs and covers current and future activities. In other words, curation activity not only determines current needs of curators but also future activities like publication or reusing. Similarly, the publication activity serves publication-now and reusing-in-the-future purposes. (2) As [12] indicates that technology has a dual role in context, technology variations depend on other contextual elements while at the same time technologies influence information practices. In other words, a shared context between *Reusing* and *Publication* emerges as a technical dimension for the *Curation*. In short, three activity levels are situated in a multiple, overlapping, and dynamic context because *Publication* involves both publication and curation activities, and *Reusing* involves reusing, publication and curation, while *Curation* cannot exist without considerations of two other activity contexts.

(2) A perspective setting: *Representation-Preservation-Interpretation*.

In considering theoretical issues for a contextual framework, a Representation-Preservation-Interpretation setting is established from Charles Sanders Peirce (1839–1914)'s triadic sign theory: {Representation, Object, Interpretant} that a sign constituents three basic parts with a relation that a something, Representation, brings its Interpretant sign determined or created by it, into the same sort of correspondence with its Object, as that

[7] Three activity contexts are italics with the first word capitalized.

the something (Representation) stands to the Object [13]. Here, we define a contextual setting as a sign with the triadic relation [13]:

- The **Representation** is a representation of the activity context setting itself, and is the form that the setting takes. For instance, in *Reusing*, the Representation is the application cases employed to determine a resource to be used by oneself or others.
- The **Object** is the entity to which the context setting points, refers or applies. In this study, it is the specific preservation object that the authors, users, and curators refer to. The original "Object" has been adjusted to the object preservation for "Preservation" to describe associated activities.
- The **Interpretant** of a contextual setting is the Interpretation that is made of the setting. In this study, the interpretation is taken from the view of [1] on Relations Context that context information captures the relations an entity has recognized to the others.

The triadic sign theory has been empirically applied as an analytical framework for dynamic and complex composition such as for social tagging [14] and semantic web [15]. Furthermore, according to Tim Berners-Lee's own words, the Semantic Web is "a fervent desire to implement some ideas of Charles S. Peirce"[8]. Thus, we use this triadic relation that has also influenced Resources Description Framework (RDF) data model (Subject-Predicate-Object) to some degrees, as a basis to construct the context model as a triadic setting: Representation-Preservation-Interpretation. In addition, [12] argues that contextual elements must be explicitly linked to particular information practices, and the variability must be distinguished among actors and contexts. Thus, contextual elements need to be constructed within the *Representation-Preservation-Interpretation* setting and three dynamic activity contexts: *Reusing*, *Publication* and *Curation*. Next, we will move to disclose what contextual elements are constructed.

(3) Nine contextual elements: eight dimensions about context and its role are suggested by Beaudoin as technical, utilization, physical, intangible, curatorial, authentication, authorization, and intellectual [16]. The eight dimensions were generated for digital preservation of cultural heritage. For more context needs in this study, we adjust and extend technical, curatorial and intellectual dimensions to identification, application, classification and ontological relations. Table 1 is summarizes this framework. Details of these nine contextual elements associated with specific contexts and settings are introduced by using cases to illustrate how they can be applied in session 4[9]. Thus, we brief here four new contextual elements that are different from Beaudoin's work.

(I) Identification is a representation for disclosing the Intangibleness of the physical objects. In this framework, it is a publication-level representation for disclosing the existence of article, data, or code that can be identified for publication. It is restricted

[8] http://www.w3.org/DesignIssues/CG.html

[9] See more possible scenarios for different contents http://guava.iis.sinica.edu.tw/r4r/examples/possible_scenarios_for_different_contexts

by the *Curation*, and can be potentially utilized for the *Reusing*. For instance, when publishing linked data, it requires using URIs as names for things, the URIs are curated in restrict rules of the curation activity, and can be potential utilized for *Reusing***.**

(II) Application is a specific result or application cases like remixing or reusing, a representation for determining the Utilization of the presence of Authorization objects like digital policy or license that concerns the needs of users for *Reusing*.

(III) Classification is a classifying representation brings relational interpretations for Authentication elements (ex. metadata or provenance). It is a curatorial-level representation since it is the main task for curators to curate metadata about datasets. And metadata is interpreted by domain ontologies in the *Publication*, but interpreted by domain-independent ontologies in the *Curation*. For instance, the catalogue metadata of European Union Open Data is available as linked data[10], and uses the Data Catalog Vocabulary (DCAT) [11] to classify seven basic classes for catalogue metadata[12].

(IV) Ontological Relations is an interpretation for Classification that represents authentication elements such as metadata or provenance at the curatorial-level. Since contexts are changeable, we extend Beaudoin's intellectual dimension [16] and focus on the construction of a fundamental relationships for dynamic contexts and a domain-independent ontology formation. For instance, the Fedora relationship ontology[13] is used to model partial and provenance relations that can be shared across in its Fedora Ontology. Similarly, R4R ontology is designed for such functions.

To sum up, in *Publication*, an Identification name (ex. URI) is published and brings the interpretation by the network linkages of Intangibleness (ex. a domain vocabulary or citation), which determined or created by it, into the same sort of relation to the Physicalness (ex. data), as that in which the Identification stands to the Physicalness. Similarly, the rules are applied for *Reusing*: Application-Authorization-Utilization as well as for *Curation*: the Classification-Authentication-Ontological Relations. In practice, this framework is a conceptual tool to help us establish relations if we want to use the shared context for modeling *Reusing* and *Publication*. Since these two contexts share *Curation*, according to [1] we should start to establish relations between these two by examining what major preservation objects can be found in the *Curation* context.

3. Relations for Reusing (R4R) Ontology

For a light-weight design purpose, R4R consists 15 terms only: 7 classes and 7 properties plus one exceptional property *Cites*. Figure 1 illustrates the conceptual model of

[10] http://open-data.europa.eu/en/linked-data
[11] http://www.w3.org/TR/vocab-dcat/
[12] Catalog, Catalog record, Dataset, Distribution, Concept scheme, Concept, and Organization/Person
[13] http://www.fedora.info/definitions/1/0/fedora-relsext-ontology.rdfs

the R4R, and a full specification can be accessed online[14]. In the following, we will brief the major structure, and discuss our modeling decisions. Two crucial components as individual class concepts are identified in this model, namely, Reusing Related Object (RRObject) and Reusing Related Policy (RRPolicy). RRObject distinguishes R4R's basic components of described targets, creating the unique identification of the related objects, from RRPolicy being packaged for more specific combinations of provenance and license. The primary consideration for designing R4R is that it should on the one hand being capable of describing the combination of RRObject and RRPolicy, while on the other hand still allowing to just represent RRObject alone without packaging the RRPolicy. This is a decision made from reasons:

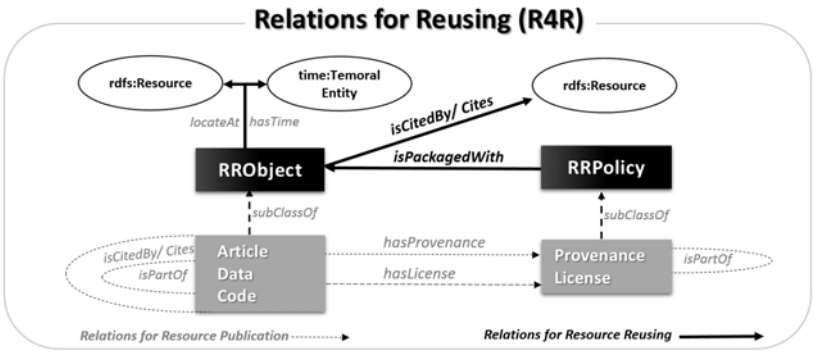

Figure 1: Relations for Reusing (R4R) Conceptual Model.

(1)Provenance and license concerns are not fully taken and implemented in existing practices, or have been curated as metadata in local curation that are not accessible or downloadable. Thus we use *hasProvenance* and *hasLicense* for relating local curation or for sharing publications. For *Reusing*, the context transitions occur, and according to [1], context attributes will change from one context entering another, thus Provenance or License, or both can be packaged with RRObject for reusing purposes. For such using of the relation, *isPackagedWith*, RRObject (article/data/code) and RRPolicy (provenance/license) are reachable and accessible for changing the original *Publication* and *Curation* contexts to a shift of the *Reusing* context.

(2) *isPartOf* and *isCitedBy/Cites* like *hasProvenance* and *hasLicense* that can relate internal relations within subclasses of RRObject (article/data/code). Meanwhile, these two relations can also be used for describing external relations. *isPartOf* describes partial relationships with temporal and spatial constraints. A *isPartOf B* only if A and B share the same time and location. This design helps to clarify relations of collections and items since temporal and spatial attributes of collections constrain item-level attributes. It also helps semantic publishing that one partial paragraph, session, chapter or even a sentence can be represented as an RRObject for article enrichments.

[14] http://guava.iis.sinica.edu.tw/r4r

(3) *isCitedBy* is distinguished *from Cites* for temporal constraints. Normally, when A *isCitedBy* B implies the publication time of A occurs before B. However, it is also possible that A and B are mutual-cited at the same time. For instance, two articles publishing in the same journal and citing each other are common research practices.

(4) Relations between Data and Code in current practice are sometimes *isPartOf*, sometimes *isCitedBy*, since dataset and code are quite often published together as Data. When Data and Code share the same temporal and spatial attributes, and data modelers wish to distinguish the two, it can be described as Code *isPartOf* Data.

(5) Citation is one of the most important traces to link contextual information from the original to many interpretations of the reused. In *Publication*, authors create their works by citing references as evidences/interpretations. In *Reusing*, afore mentioned publications become other's evidences/interpretations. As indicated by [1], when the activity (like citation) predominantly determines the relevance of context elements in specific situations, citation thus becomes one of our major interpretations for relations.

(6)Packaging relation in R4R is a relation between RRObject and RRPolicy. *isPackagedWith* is utilized only when *Reusing* occurs. It is a design specific to differentiate interpretations of metadata/provenance and license in different contexts. In *Publication*, metadata/provenance are curated for local preservation, and may be interpreted by domain vocabularies as a reflection of the author. In *Reusing*, metadata/provenance, and license are necessary components for Authorization and Authentication, therefore RRPolicy needs to be packaged to be able to be reused or remixed.

In sum, the design concept of R4R components are more toward modularity, in which components can be separated and recombined in different contexts, at different time. This is important because R4R wish to describe the future relations which will grow and evolve like future citations, provenance changed, or license policy changed.

So far we have dealt only with the contextual framework and the R4R ontology that reveal how context shared or changed can be modeled through establishing and explor-

Figure 2: A Data-Paper like publication in digitalarchives.tw

ing relations. But how a shared context between different domains like research publications and LAM collections help us enrich contextual information and make our data better? In the fowling, we will use R4R and different contexts to represent an example of interlinked data between research publications and a cultural object curated in LAM.

4. A Use Case from the Digital Archives Taiwan

Digital Archives Taiwan (digitalarchives.tw) consists collections of five million digitized cultural objects contributed by the largest memory institutions in Taiwan, and spanning various domains (history, art, biodiversity, geology, geography, ethnology, anthropology, etc.). The collection of Digital Archives Taiwan curated both in item and collection levels is indexed and catalogued through the Union Catalog (catalog.digitalarchives.tw) for data aggregation, representation, and citation. Figures 2 shows one item[15] that is published as a form which is similar to "data papers" (dataset descriptions for scientific research) or "nanopublications" (small units of publishable information with unique identifiers) [16]. Each item page constitutes: (1) The collection object and its basic information (Scientific Names and Vernacular Name); (2) Link to the original database; (3) Metadata Description; (4) Contact Information for Licensing; (5) Citation Information (bibliography and the unique URL). In addition, this item has an archive record ID, S010384, and it will be discussed in following sessions several times, thus we use daT(S010384) as a substitute name for this collection item[17].

The daT(S010384) has the Union Catalog metadata which uses Dublin Core for curation schema. The item also has a citation spec[18] and the license information is expressed by a contact information. The following shows how we use R4R in Turtle syntax to model this cultural object being curated and published in the Union Catalog. For *Curation*, daT(S010384) is being classified as RRObject (Classification) using R4R

```
@prefix dc:   <http://purl.org/dc/elements/1.1/> .
@prefix time: <http://www.w3.org/2006/time#> .
@prefix r4r:  <http://guava.iis.sinica.edu.tw/r4r#> .
@prefix :     <http://www.example.com/data#> .

:daT_S010384
    a r4r:data, r4r:RRObject ;
    r4r:locateAt :URI_S010384 ;
    r4r:hasTime  :t3 ;
    r4r:isPartOf :daT_Collection ;
    r4r:isCitedBy <http://www.plosone.org/article/#> .

:daT_Collection
    a r4r:data, dc:Collection ;
    dc:publisher "Digital Archives Taiwan";
    dc:provenance:daT_Metadata   .

:t3
    a time:Instant ;
    time:inXSDDateTime "2012-01-01" .
```

[15] http://catalog.digitalarchives.tw/item/00/61/e8/e2.html
[16] http://nanopub.org/wordpress/
[17] All figures presented in this paper are published with high-resolution gif files in the reference [25].
[18] http://digitalarchive-taiwan.blogspot.tw/2012/02/blog-post.html

ontology (Interpretation) to relate its metadata description (Authentication). For *Publication*, daT(S010384) is published using an R4R Identification that brings the Interpretation of Dublin Core and citation relations to it (Intangibleness). For a Shared Context, the relation is established by modeling daT(S010384) as subclass of RRObject (in *Curation* level) to be r4r:Data (Physicalness in Publication level), and using *hasTime* and *locateAt* to relate the Representation of two contexts, and prepare for the possible future *Reusing* emerging context.

A simple *Reusing* is presented by a citation relation. The daT(S010384) has been cited in a science articles' material and method session[19]. For a simple citation modeling, we can add this citation in local metadata using *isCitedBy* relation. The science paper may be benefited from this citation since the daT(S010384) is also curated under a catalog structure of domain knowledge interpretation from the international scientific standard of the biological classification: Domain/Kingdom/Phylum/Class/Order/..., as well as a hierarchy which includes the project information about the source organization and project details[20]. For a complex *Reusing*, these rich domain knowledge can be packaged for more application uses. For instance, we assume there is a digital plant atlas of natural museum in Europe, called PA. In their plant atlas, lacking of digital collection in Asia is one of major problems. PA finds that a plant specimen collection in Digital Archives Taiwan is proper for their uses. The first problem PA will encounter is the authorization of each digital item. The second problem is that they have to validate each item's collection and digital process for data quality. The third problem is that even each item in Digital Archives Taiwan is well documented and accessible through hyperlinks to original data repositories, PA does not want to manually click through all the links. Thus, if a machine readable and executable license and provenance are provided, not only PA but any other users can easily select, reuse or remix this digital collection. Taking daT(S010384) for example, the item can be modeled by provenance information using PROV-O ontology[21]. An example of this is described in [25].

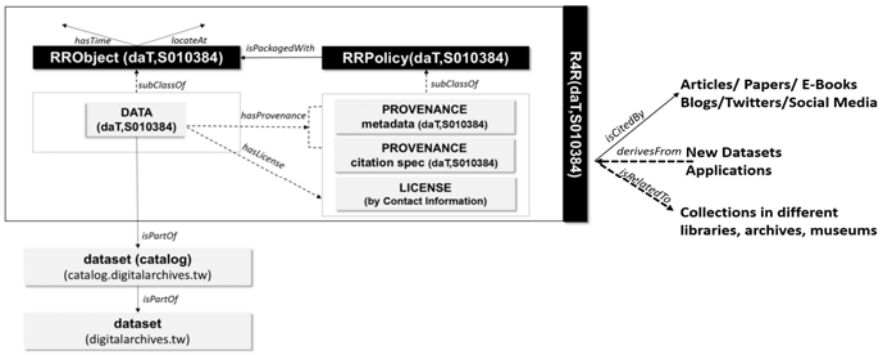

Figure 3. R4R for modeling one collection: daT(S010384)

[19]http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0077626#pone-0077626-g001

[20] http://guava.iis.sinica.edu.tw/r4r/examples/the_story_of_dat_s010384

[21] http://www.w3.org/TR/prov-o/

In short, when provenance or license is not ready to be packaged or not for releasing openly, we can use RRObject individually by publishing their unique identifications embedded with domain knowledge or citation interpretations through *hasProvenance* and *isCitedBy* to relate provenance information at the metadata level, and citation relations between article, data and code internally or externally. Once the RRObject is packaged with RRPolicy as R4R(daT,S010384), it is ready for other resources to connect and reuse by policy-aware tools for license like Semantic Clipboard [17], and by capturing provenance through ontology use like PROV-O at multiple layers [18]. It can also be easily used and relate to many forms of resources and from different domains. It can also be related to similar collections of other libraries, archives and museums; reused and recreated by other works. Or it can be embed in the package format of digital publishing like EPUB for E-books (see Figure 3).

5. Related Works

Although context modelling has been discussed in Artificial Intelligence literatures, the use of mathematical theory and logical formalization is beyond the scope of this paper. Instead, relations modeling that tries to classify linking structures in an attempt to make complicated relationships easier for semantic representation is most related to our work. For instance, the Fedora Relationship Ontology has been developed for representing object-to-object relationships in the Fedora architecture for complex object modelling [19]. And another useful example of relation representations supporting domain concepts interlinked by logical constrains is provided by the case of OBO Relation Ontology[22] in biomedical and life science. This ontology later influences the design of the Artifact Relationship Ontology (ARO) that has been designed specifically for comparing museum objects [20].

In addition, the Literature Object Re-use and Exchange (LORE) relationship ontology, a simplified version of IFLA FRBR is presented in [21] to facilitate reuse and exchange LAM collections for research purpose. Relations like authorship relations (i.e. creators, agents, or organizations), object attribute relations (metadata descriptions), or preservation and derivation relations are major concerns for LORE, and that results in more than one hundred relations are defined. Although many relation concepts of LORE are similar to R4R, it is taken from a bibliographic perspective. LORE uses its own definitions to represent similar and provenance information, while R4R recommend users to reuse SKOS[23], which can reference other concepts using a variety of semantic relationships, as well as PROV-O in the afore mentioned example. Most importantly, modeling compound and complex objects as employed in Fedora, Research Objects [10], and LORE alike is not the aim of R4R that takes the Shared Context for a design space, and aims to meet data publication, citation, and reusing for Open

[22] http://www.obofoundry.org/ro/
[23] http://www.w3.org/TR/2009/REC-skos-reference-20090818/

Science that needs to distinguish reusing, publication and curation for different contextual constructs. Table 2 is a summary of above mentioned relation ontologies, a full view of comparison can be accessed in [25].

Table 2: A Comparison of five relation ontologies

	Fedora	OBO/RO	LORE	ARO	R4R
Time	2005	2005	2009	2013	2014
Domain	independent	Life Science	Research	LAM	independent.
Concept		OBO Foundry /Other Biomed..	9 Classes from IFLA FRBR.	OAO+ Greek Vase Ontology	7 Classes
Relation	21 relations: (10 reverse)	13 relations : with logical definitions	133 relations: 63 reverse rel. +7 individual rel..	16 relations: classified by 5 levels	8 relations: (7 + 1 exceptional)
Location	---	V	V	---	V
Partial	V	V	V	V	V
Similar	V		V	V	SKOS
Provenance	V	V	V	V Open Annotation Ontology (OAO)	V PROV-O
Citation	---	---	V	---	V
Bundle	---	---	V	---	V
License	---	---	---	---	V
Compare	---	V	---	V	---
Definition	---	V	---	---	---

6. Conclusion

As responding to recent developments (Session 1) that have challenged research data, archival and cultural heritage communities for a contextual framework to support a dynamic and shared context environment, we have proposed a framework (Session 2), and to the establishment of an ontology, Relations for Reusing (R4R), that can facilitate the representation of contextual links between resources in diverse contexts (Section 3). In section 4, we use R4R for representing different contexts that can enhance semantic relationships of research publications and cultural objects when both are contextually linked. Section 5, related works are discussed and presented with a comparison on five existing relation ontologies that distinguishes the R4R from previous works.

The advantage of designing a new conceptual model to describe relations in a shared context is to ensure articles, datasets, software codes, provenance and license information can be treated as first-class contextual objects. At the same time, the module-like design of RRObject and RRPolicy can be practiced in isolation, and the unifying representation of their relations is semantically enough but not so structurally heavy-weighted that curators or researchers find it difficult to apply.

In sum, the daT(S010384) is a digital object with rich metadata descriptions being curated in *Curation* context. It is published as a cultural object Y, with unique identification, and being cited as a science object Z, interpreted by the citation relation for more professional interpretations. At the same time, the citing research can be benefited from the implicit information embedded in the institution's cataloging vocabularies for more

domain knowledge. Through the exploration of the Shared Context and R4R representation, the daT(S010384) now is capable to move from its traditional role and to "act as a citation of active knowledge" indicated in [22]. Creating knowledge out of interlinked data [23] is thus one step forward by packaging provenance and license for a policy-aware *Reusing* context. As a result, when data sharing needs not to remove the data's initial context but embedded in a shared context, the difficulty to interpret the reused data [24] may be expected positively through the use of the contextual framework and R4R ontology proposed in this study.

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