

# An Approach to Semantic Representation and Modeling in the Development of *De rerum natura* Digital Exhibition

Carlo Teo Pedretti<sup>1</sup>

Department of Classic Philology and Italian Studies, University of Bologna, Via  
Zamboni 33, 40126 Bologna, Italy  
carloteo.pedretti@studio.unibo.it

**Abstract.** The purpose of this paper is to present the implementation of *De rerum natura Exhibition* (DRN)<sup>1</sup>, a digital exhibition, with particular regards to Semantic Web technologies and design patterns which allow the seamless representation of heterogeneous contents and the creation of dynamic museal paths. In particular, this study presents the implementation solutions that have emerged during the development of a digital application concerning *Vedere l'Invisibile*<sup>2</sup>, an exhibition which follows Lucretius' *De rerum natura* and its reception in contemporary art. The peculiarity of the exhibition is the presence of heterogeneous data sources such as tangible or intangible cultural items (e.g. paintings, performances) and textual documents (e.g. *De rerum natura* and its translations). Starting from the aforementioned sources, the work explores modern technological solutions in order to deliver a system that can be both flexible in terms of requirements, reusable and ephemeral. Results show that by adopting a wrapper design pattern, a functional implementation of the system described above can be delivered without affecting original sources and successfully integrating different contents such as textual documents and cultural items through semantic technologies.

**Keywords:** digital exhibition · heterogeneous collections · Open Annotation · Semantic Web

## 1 Definition and Scope

The project revolves around the digitalization of *Vedere l'Invisibile*, an exhibition held in Bologna in 2017 with the shared efforts of scholars from different domains. The aim of the exhibition was to celebrate six centuries from the discovery of Lucretius' *De rerum natura* and specifically the influence it had on contemporary arts. In particular, *De rerum natura* exposes the principles of Lucretius' philosophy of nature, recurring to a number of images and metaphors

<sup>1</sup> <https://github.com/friendlynihilist/lucretius>

<sup>2</sup> <https://eventi.unibo.it/riscoperta-lucrezio>

that inspired crucial innovations in visual culture. While the marks left by the poem in Renaissance and modern art are known, its influence on contemporary art is somewhat left behind by scholars. Nevertheless, themes of *De rerum natura* – the caducity of nature, the frailty of knowledge and the disorientation of man inside an indifferent cosmos – have become central in our time and therefore it is not surprising that several original voices have tried to express them by means of different media. Contemporary vision of *De rerum natura* is declined through several media such as drawings, paintings, engravings, sculptures, films, music and performances. Moreover, the exhibition contains works and installations by several famous contemporary artists (Baj, Paolini, Mezzaqui etc.) and some of the most important Italian poetic translations (Sanguineti, Orelli, De Angelis) of *De rerum natura*. The exhibition is the result of an intense research activity that has involved philologists, art, science and books historians, offering the opportunity of dealing with an interdisciplinary project around an enthralling new theme.

DRN starts from these heterogeneous collections with the aim of creating an interactive digital exhibition using a modular framework and a light implementation of Semantic Web technologies. Differently from other exhibitions, *Vedere l'Invisibile* has been built around a specific literary work (Lucretius' *De rerum natura*) and its propagations in other domains. Therefore, *De rerum natura* influence upon other cultural heritage domains also maintains a primary importance in the design phase of the digital exhibition experience. Not only the final users should be able to discover works of art connected to or influenced by *De rerum natura*, but also the narrow bond between textual and artistic expressions should be described in an innovative and engaging way.

Several technologies have been employed in the development of the digital exhibition and in particular Omeka S<sup>3</sup> and TEI Publisher<sup>4</sup> have been employed for managing respectively digitalized tangible or intangible cultural items and textual documents. Furthermore, RDF(S)<sup>5</sup>, Web Annotation Data Model<sup>6</sup> and CIDOC CRM<sup>7</sup> have been employed in the creation of a data model for describing multi-layered, narrative paths designed by the curator.

Within this context, this study primarily aims at answering the following research questions:

- Is it possible to build a narration which involves heterogeneous data sources within the context of a digital exhibition without recurring to a vertical, silo approach?
- To what extent can an adapter design pattern be capable to process and represent information homogeneously, harmonizing contents and models?

Results show that by adopting a wrapper design pattern, a functional implementation of the system described above can be delivered without affecting

<sup>3</sup> <https://omeka.org/s/>

<sup>4</sup> <https://teipublisher.com/index.html>

<sup>5</sup> <https://www.w3.org/TR/rdf-schema/>

<sup>6</sup> <https://www.w3.org/TR/annotation-model/>

<sup>7</sup> <http://www.cidoc-crm.org/>

original sources and successfully integrating different contents such as textual documents and cultural items through semantic technologies.

## 2 Background and Significance

Temporary exhibitions are a traditional and successful cultural activity that art museums have sponsored for decades. As their name implies, the life-cycle of these events is ephemeral and short-lived. Nonetheless, the development of digital, online versions of exhibitions and their availability in time with extended features that cannot be replicated in a physical environment means that the impact of the adjective ‘temporary’ has started to fade [3].

Furthermore, the implementation of technologies and standards borrowed from other cultural domains, such as metadata and ontologies, signals the rise of a new era in terms of communication and dissemination of museal contents. Indeed, while Semantic Web technologies are used to connect and describe all sorts of data for business purposes, the vast cultural heritage domain in its heterogeneity has profited from implementing such technologies for archiving, curating and disseminating its objects, opening up to unprecedented possibilities [4].

In particular, apart from being an answer to the need of preserving the material counterpart, Semantic Web and Linked Open Data (LOD) have been used successfully in many domains to foster exploration and discovery of cultural heritage objects [2]. LOD brings the possibility of linking datasets from different cultural institutions, providing new horizons of interconnection and accessibility to the public. These practices have contributed to build a shared knowledge base that allows reusability through different applications and domains. Many ontologies and Knowledge Organization Systems (KOS) have been developed in order to exploit that knowledge base. On the other hand, the ontological heterogeneity of cultural heritage entities requires different approaches in terms of knowledge representation and data modeling [1].

Finally, as narrative can be identified as the distinctive feature of exhibitions with respect to other cultural institutions, the technologies described above should also serve the purpose of designing environments in which narrations and curatorial intents merge seamlessly into a constant dialogue between the items and the visitors of a collection.

## 3 Problems

Indeed, one obstacle in the development of digital exhibitions in general lies in the modeling and representation of the items that form the exhibition itself. In particular, DRN draws upon two radically different data sets: items (paintings, engravings etc.) and textual documents (transcriptions and translations).

Defining the relationships between items and literary works is not always linear and often involves hermeneutical efforts and precise choices in terms of granularity and serialization of data. In these cases, recurring to data silos or

vertical approaches in terms of information management inevitably leads to a lack of reusability and flexibility of the system.

Another challenge is represented by the nature of the items themselves. For instance, some items could be part of a larger set or belong to the same series (as in the case of Baj's engravings), while others are different versions of the same work (as in the case of Paolini's *Casa di Lucrezio*). For these reasons, modeling the exhibition should take into account meronymy, sequentiality and temporality.

Finally, an exhibition should avoid when possible passive fruition and therefore has to introduce mechanisms to enhance active discovery and browsing, both through advanced filtering, multiple views and dynamic paths.

These prerequisites have been taken into account in the preliminary phases of development of DRN by sketching both multiple possible views on the collections, and by designing a storytelling component that offers dynamic museal paths based on semantic relationship between items and collections.

## 4 Method

DRN aims to overcome lack of reusability and reproducibility by building a flexible framework that acts as a wrapper on top of sources. Moreover, it implements Semantic Web technologies consistently in order to manage heterogeneous sources without recurring to vertical approaches that will in return hinder its true potential. By acting as a wrapper, DRN aims to create a homogeneous space of fruition for the user, where information organization and management with regards to exhibition contents becomes independent from the actual sources.

Having taken into consideration the nature of the exhibition and its collections, DRN has been designed and implemented using a two-tier architecture, which is based on the separation of the data logic and the presentation logic, as shown in Figure 1 in the following page. In simple software architecture, the presentation layer or user interface layer runs on the client side while the dataset layer gets executed and stored on the server side. As such, there is no business logic layer or immediate layer in between client and server; in fact, the application logic is built in parallel with the presentation layer. The frontend framework manages both the presentation layer as well as the application logic, operating as an "ephemeral" wrapper on top of data sources, which it consumes for creating dynamic views. An adapter pattern design has been chosen primarily for lightness and flexibility.

Specifically, data is stored in two different repositories based on its format. Textual documents and fragments are XML-TEI encoded and stored inside an instance of TEI Publisher, an eXist-db application, that manages and publish TEI documents in HTML and other formats through an ODD file, based on the TEI Processing Model. Multimedia digital objects are mostly Dublin Core encoded and managed by Omeka S. These data sets are then exposed through a REST API as JSON-LD multi-dimensional arrays. Moreover, RDF models are stored in a quad store subsystem and dynamically parsed and extracted.

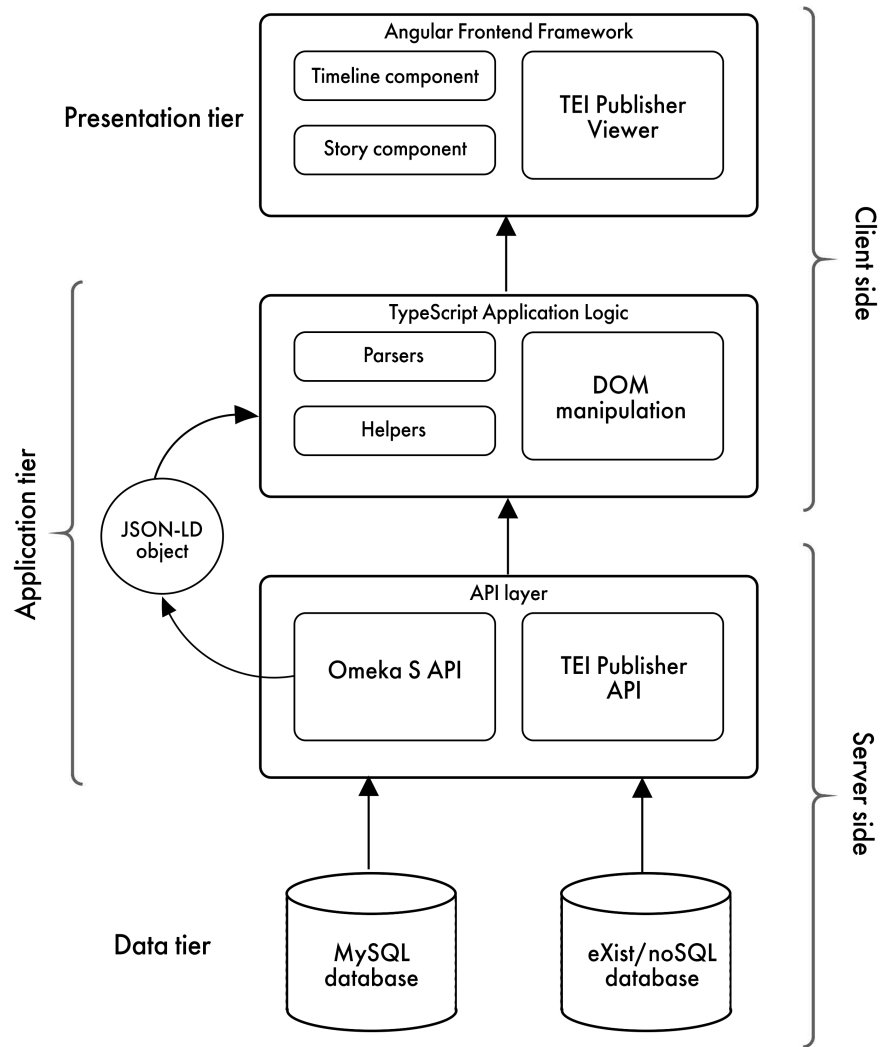


Fig. 1. DRN digital exhibition architecture model

The application logic is entirely made through Angular, and clustered in components such as helpers and parsers. Therefore, Angular manages both the application logic and the presentation layer. Helpers and parsers work as adapters for retrieving and transforming the various data formats (JSON-LD, RDF, XML) in order to be consumed and dynamically presented through the DOM. As stated before, one of the main goals of this digital exhibition is to create sophisticated museal paths based on semantic relationships between textual fragments and items of the collections. In order to do so, further technologies have been introduced to design and manage semantic relationships.

First of all, it is not always possible to embed metadata or annotations into documents as in the case of the literary works that compose this digital exhibition. In these scenarios, standoff formalisms support the separation between the document and its annotations. The Web Annotation Data Model has been developed by the Open Annotation W3C Community Group and provides a RDF-based approach for standoff annotation of web documents, serialized in JSON-LD. While Web Annotation has been designed to be used across different formats, the most common scenario is to connect text fragments to a single web resource.

The Web Annotation provides reified representation of annotated elements and their relative annotations: *Body*, *Target* and *Annotation* are discrete resources and can be further specified with more properties and relationships. `oa:hasSource` and `oa:hasSelector` can respectively define the resource from which the annotated element is refined from and the object of the relationship that describes the segment or region of interest within the source resource. Another crucial selector is the `oa:XPathSelector`, that uses XPath for identifying elements of an XML document (e.g. a DOM tree). In the case of the XML-TEI encoded documents used in DRN, the aim is to create a relationship between an item of the exhibition and a section of the XML-TEI document and successively between the XML-TEI document and the respective DOM counterpart.

Secondly, CIDOC CRM, as well as RDF(S), have been integrated in order to develop complex museal paths. In particular, as shown in Figure 2 in the following page, a given resource ("E73-Information Object") refers to ("P67-refers to") a *Target* that describes an item of the collection (`o:Item`) or an annotation (`oa:Annotation`). A given resource always has a type ("P2-has type"), a time-span ("P4-has time-span") and note(s) attached to it ("P3-has note"). Furthermore, a list or ordered collection of resources defines a topic ("E89-Propositional Object") that can contain named entities (`rdfs:seeAlso`) and interpretative note(s) attached to it ("P3-has note") that in turn can point to internal or external resources depending on the context. In this context, a topic offers information on a particular subject. For example, as shown later in this study, the topic named *Le acquaforti di Baj* presents curatorial notes regarding a series of engravings made by Enrico Baj. In turn, a collection of topics defines a story or (museal) *path* ("E89-Propositional Object").

As an example, *La peste d'Atene* is a path (a story) designed with the aid of curators and domain experts, presented as a succession of topics (enriched

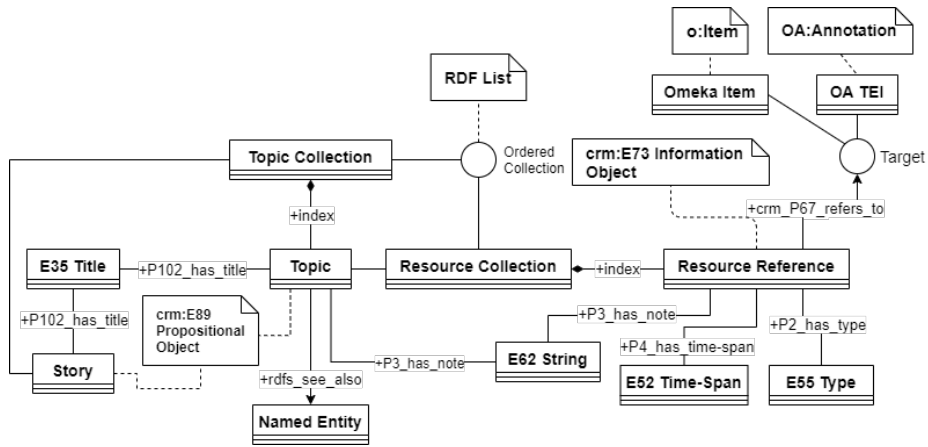


Fig. 2. UML diagram representing the data model

with interpretative notes). *La peste d'Atene* refers to the final part of *De rerum natura*. In addition to being philosophically fundamental within the Lucretian speculative system, the ending of *De rerum natura* bears dramatic suggestions which were inspiring for artists of the exhibition such as Enrico Baj and Teresa Procaccini, among the others.

By describing the model as a series of triples using CIDOC CRM and RDF(S), it is possible for example to refer a path to a collection of topics, using an RDF List. In particular, *La peste d'Atene* presents nine different topics:

```

@prefix ecrm: <http://erlangen-crm.org/150716/> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .

<http://example.org/story_1>
  a <http://erlangen-crm.org/150716/E89_Propositional_Object> ;
  ecrm:P102_has_title <http://example.org/storyTitle_1> .

<http://example.org/storyTitle_1>
  a ecrm:E35_Title ;
  rdfs:label "La_pest_e_d'Atene" .

<http://example.org/topicCollection_1>
  ecrm:P67_refers_to <http://example.org/story_1> ;
  rdf:_1 <http://example.org/topic_1> ;
  rdf:_2 <http://example.org/topic_2> ;
  [...]
  rdf:_9 <http://example.org/topic_9> .
    
```

A topic is defined by a title and a body. It could also contain references to Named Entities and interpretative notes:

```

@prefix ecrm: <http://erlangen-crm.org/150716/> .
@prefix ex: <http://example.org/schema#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .

<http://example.org/topic_1>
  a <http://erlangen-crm.org/150716/E89_Propositional_Object> ;
  ecrm:P102_has_title <http://example.org/topicTitle_1> ;
  ex:hasNamedEntity <http://example.org/Arturo_Schwarz> ;
  ecrm:P3_has_note <http://example.org/topicBody_1> .

<http://example.org/topicTitle_1>
  a ecrm:E35_Title ;
  rdfs:label "Le_<u>ac</u>queforti_<u>di</u>_Baj" ;
  rdf:value "Le_<u>ac</u>queforti_<u>di</u>_Baj" .

<http://example.org/Arturo_Schwarz>
  rdfs:seeAlso <http://viaf.org/viaf/54154160> ;
  a <http://example.org/Person> ;
  rdfs:label "Arturo_<u>S</u>chwarz" .

<http://example.org/topicBody_1>
  a <http://erlangen-crm.org/091125/E62.String> ;
  rdf:value "Nell'aprile_<u>del</u>_1958,_<u>Arturo</u>_<u>Schwarz</u>_pubblica_<u>De</u>_
  rerum_<u>natura</u>,_<u>una</u>_cartella,_<u>stampata</u>_in_51_<u>esemplari</u>,_<u>che</u>_
  raccoglie_36_<u>ac</u>queforti_<u>di</u>_<u>Enrico</u>_<u>Baj</u>[...]" .

```

Moreover, and most importantly, target items could also have references to textual parts of *De rerum natura*, as in this example:

```

@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix oa: <http://www.w3.org/ns/oa#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .

<https://137.204.168.14/lib/api/items/25> rdfs:seeAlso <TEI-
DRN:sez1/ann1> .
<TEI-DRN:sez1/ann1>
  a oa:Annotation ;
  oa:hasBody <https://137.204.168.14/lib/api/items/25> ;
  oa:hasTarget <TEI-DRN:sez1/ann1/trg> .

<TEI-DRN:sez1/ann1/trg>
  oa:hasSource <TEI-DRN:sez1> ;
  oa:hasSelector <TEI-DRN:sez1/ann1/trg/sel> .

```



```
<TEI-DRN:sez1/ann1/trg/sel>
  a oa:XPathSelector ;
  rdf:value "//*/*[position()>63_and_position()<79]/text()" .
```

In particular, OA annotations allow not only to annotate textual parts and associate them with items, but also to set up the core which made possible the realization of thematic paths. In the design pattern, annotations assume the dignity of an autonomous resource: in fact they are the contents of the exhibition.

As demonstrated above, the data model has been designed with a selection of well-known standards (CIDOC CRM and RDFS) in mind, and this allows to obtain a simple and light framework for describing the resources semantically. In addition, by not implementing a custom ontology, reusability and interoperability of the framework are pursued.

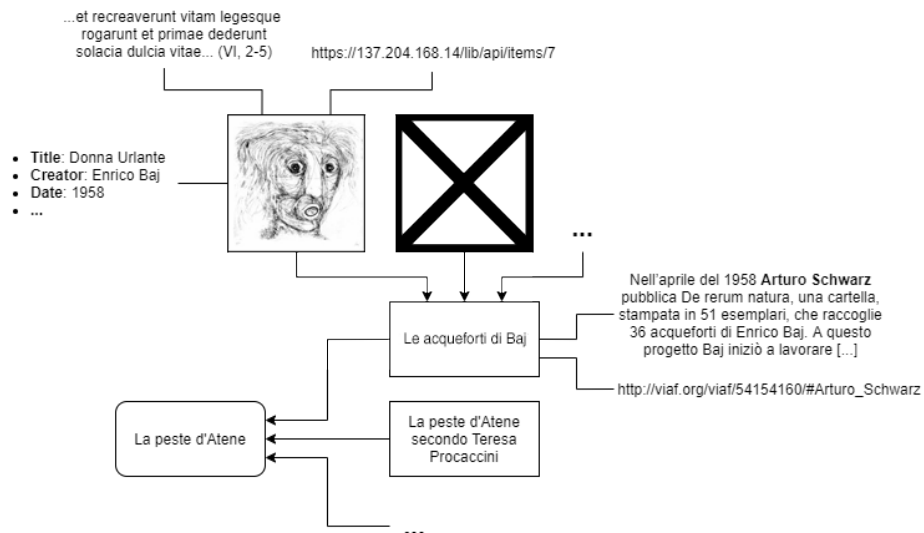


Fig. 3. An example with actual data from the digital exhibition

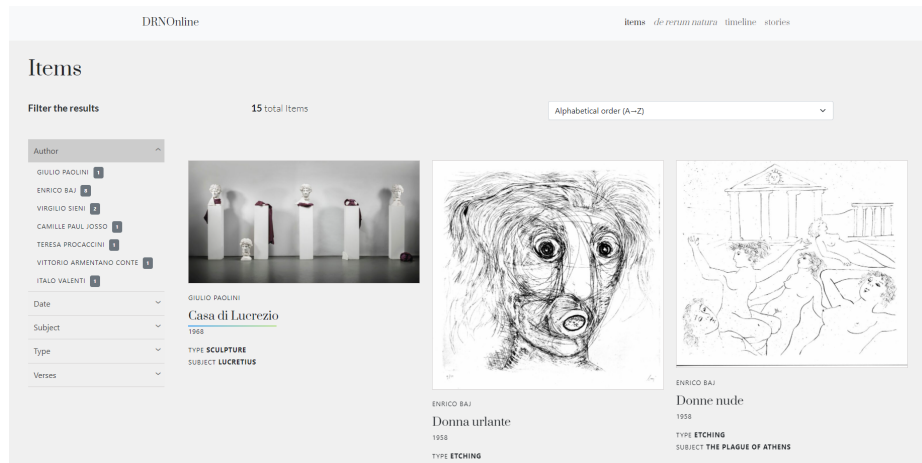
Figure 3 shows an implementation with real data from the exhibition. In the example, a collection of resources that refers to items and textual parts (e.g. *Donna Urlante* and other engravings from the series *Storie della morte* by Enrico Baj) defines the topic titled *Le acqueforti di Baj*, which is here presented accompanied by a critical text by the curator and a link to a Named Entity (Arturo Schwarz, the publisher of Baj's series of engravings about). *Le acqueforti di Baj*, along with other topics such as *La peste d'Atene secondo Teresa Procaccini*, defines a collection, which in turn determines *La peste d'Atene* as a path. Thus,

a path acts as an aggregator or container of resources and semantic relationships between data.

## 5 Results and Further Developments

The main goal of DRN digital exhibition was to offer customized museal paths based on semantic relationships between textual parts and items to the final users.

One of the limits that has been encountered in the generalization phase concerns the alignment between XML-TEI sources and the HTML presentation structure, due to the constraints imposed by the integration of TEI Publisher. In particular, a solution had to be implemented that would allow the TEI sources to integrate with the presentation layer without losing information on their structure. The answer was found using Web Annotation Model. Nonetheless, through the implementation process of the prototype, it has been shown that a wrapper approach (opposed to a vertical, silo-like approach) is not only achievable in this context, but also useful in order to build a narrative which involves different digital sources. In particular, the adapter design pattern has proved to be an optimal solution in order to represent information and harmonize heterogeneous contents with their models while leaving the sources untouched. In this way, reusability and interoperability have been addressed.

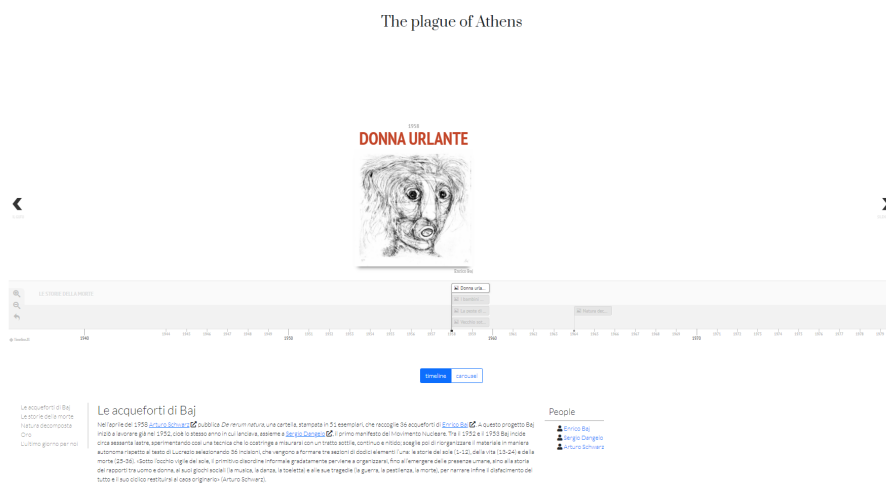


**Fig. 4.** An overview of the items collection from DRN digital exhibition

While this is not the focus of this work, a very brief overview of the presentation layer could prove useful in order to present a concrete application in the cultural heritage domain of the architecture presented above. The design of interfaces and browsing aids for digital collections is a crucial step for delivering

a successful user experience, even more so if considering that discovery is one of the most important elements in applications of this sort and "the interface [...] often a user's only point of contact with the collection" [5]. DRN interface has been designed following primarily Whitelaw's "generous interfaces" ethos as a principle capable of providing a critical perspective on the collection access point.

DRN is first and foremost a digital exhibition, thus the figurative element plays a central role in the presentation of its contents. Figure 4 shows the thumbnail preview of every item of the collection, which presents an overview on the individual elements, enabling identification at a glance. A filtering and facets system allows to refine the results employing item metadata. By clicking on a thumbnail, the user can enter the record page which contains media, metadata and, eventually, the verses significantly related to the item. Furthermore, by clicking on the verses, user is redirected to the TEI Publisher interface, in which corresponding verses are highlighted; also, a popover with the thumbnail and basic metadata of the related item appears.



**Fig. 5.** Story component view from DRN digital exhibition

Finally, Figure 5 shows the story component view. Stories are accessible through a dedicated voice in the navigation bar. After choosing a path (e.g. "The plague of Athens"), the user can navigate it both from a temporal point of view, by using the timeline, or by selecting the topics (e.g. "Le acqueforti di Baj" etc.) which act like chapters. Every topic is also connected to particular items of the collection and offers both internal (e.g. resources, textual parts) and external references (e.g. Named Entities connected to Authority Files).

Nonetheless, as this remains a prototype, further testing needs to be carried out in order to evaluate the effectiveness of the system in communicative terms.

In particular, it should be evaluated if this design pattern allows the visitors of the digital exhibition to reach a more thorough understanding both of the collection and its context.

From a technological point of view, added views can be implemented as further developments. In particular, a force-directed graph could be an optimal solution in terms of data visualization for representing relationships between institutional actors such as artists and curators by employing metadata and Semantic Web technologies.

To conclude, DRN digital exhibition proves that with flexible choices in terms of design implementation, an adaptive, reusable, ephemeral and disposable solution can be achieved, that allows heterogeneous contents and models to be described and represented harmoniously.

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