# Mismuseos.net: Art After Technology. Putting cultural data to work in a Linked Data platform

**Ricardo Alonso Maturana**
GNOSS
*Piqueras 31, 4th floor
E-26006 Logroño. La Rioja. Spain
+34 941248905
riam@gnoss.com

**María Ortega**
GNOSS*
mariaortega@gnoss.com

**Susana López-Sola**
GNOSS*
susanalopez@gnoss.com

**María Elena Alvarado**
GNOSS*
elenaalvarado@gnoss.com

**María José Ibáñez**
GNOSS*
mariajoseibanez@gnoss.com

## ABSTRACT

Mismuseos.net shows a case of consumption and use of Linked Data from museums and their valorisation in education, through innovative end-user applications, like facet-based searches, semantic context creation and navigation through graphs, which improve user experience. The search engine enables aggregated searches by different facets and summarization of results for each successive search. The solution is built on GNOSS, a semantic and social software platform.

MisMuseos.net gathers museum metadata from multiple Spanish Public Institutions, which includes seven Spanish Great Museums until now. It is a semantic Museum of Museums (a meta-museum) where users can browse over 17,700 pieces of art and 2,700 artists.

The project is a free access online solution available in the web address http://mismuseos.net.

## Categories and Subject Descriptors

**Information systems** - Data management systems - *Database design and models - Graph-based database models*

**Information systems** - Information retrieval - *Document representation – Ontologies*

## General Terms

Algorithms, Documentation, Standardization, Languages.

## Keywords

semantic solution, semantic end-user application, museums, education, linked data, cultural datasets, faceted searches, gnoss, meta-museum, semantic web

## 1. INTRODUCTION: DESCRIPTION OF THE PROBLEM

Libraries, Archives and Museums (identified by the acronym LAM) are the group of institutions that care for and preserve our culture. Therefore, they are the places of our collective memory, being known as the Memory Institutions. As such, they accumulate a huge amount of knowledge, contents and data.

When considering the potential of consuming and reuse LAM's open content, it leads us to Linked Open Data (LOD). Linked Open Data make it possible to move from the current web of documents with hyperlinks between web pages (links in hypertext documents written in HTML), to a Web of Data where data link and connect with other data [1], [2]. LOD contain a hidden graph, made up of nodes (entities) and lines (relationships) with enormous possibilities of discovering and knowledge. The software applications based on semantic web technologies allow computing those concealed relationships, and exposing the connexions that exist inside our collective memory graph (under some conditions).

In particular, a museum –says Wikipedia- "is an institution that cares for (conserves) a collection of artifacts and other objects of scientific, artistic, cultural, or historical importance and makes them available for public viewing through exhibits that may be permanent or temporary".[1] The more official definition given by ICOM (International Council of Museums) includes the purposes of the museum: "A museum is a non-profit, permanent institution in the service of society and its development, **open to the public**, which acquires, conserves, researches, communicates and exhibits the tangible and intangible heritage of humanity and its environment for the **purposes of education, study and enjoyment**. This definition is a reference in the international community".[2]

What do we know about data contained in museums in relation to the consumption of those data? According to ICOM, The World Museum Community, there are more than 55,000 museums in 202 countries [3], taking as reference the directory *Museum of the World* published by De Gruyter Saur [4]. Nevertheless, the data of the museums are distributed in those museums and countries, and those data are not connected.

The knowledge contained in these spaces, the relationships between works, authors, and between them and their periods or styles, has been an issue that has occupied art historians, artists themselves and many teachers for a long time. Unfortunately, it is actually impracticable to know all the possible relationships among all those entities without semantic computing. With the information contained in the current formats of knowledge representation, we cannot do interesting uses utilizing the capacity of the machines.

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[1] Museum, entry in Wikipedia, available online: http://en.wikipedia.org/wiki/Museum. [December 2013].

[2] Museum definition according to the ICOM Statutes, adopted during the 21st General Conference in Vienna, Austria, in 2007. Available online: http://icom.museum/the-vision/museum-definition/ [December 2013].

In fact, the knowledge representation model used by archivists, librarians and curators has not foreseen the use of those resources beyond the professional needs of each group. As a consequence, ontologies are deeply focused in solving problems and satisfying interest of these professional groups. On the other hand, there have been other groups, like researchers, teachers, business men, etc., who have valorised that kind of contents for other purposes, for instance educational or touristic ones.

Up till now, human intelligence has been what puts into contact entities with entities, generating interpretations and knowledge. But now Linked Data expresses the mechanical possibilities of discovering knowledge related to almost every domain of human interest and let us amplify our faculties for understanding.

Putting together all the resources of all museums would previously require that each work and each author had an URI, and therefore a unified and specialized underlying graph is required. If we could have it, we could make explicit all possible relationships between all entities.

So, the first part of the problem consists of building a Museums Micro Cloud of Linked, Clean and Curated Data with an underlying Specialized and Unified Graph.

Secondly, we wanted to connect cultural and educational worlds in a knowledge ecosystem. In other words, we wanted to valorise cultural information of our cultural heritage for educational purposes.

If we want to make that kind of Micro Clouds by using only ontologies and vocabularies that mimic the knowledge representation models of archivists, curators, etc., that aim is unachievable. This poses a particular problem of ontological engineering that we have addressed: the problem of building Hybrid Ontologies or extended ontologies; the problem of which is the method for doing that from a universal point of view and, at last, the problem of which is the nature of them.

Our project shows the way for overcoming the challenge of linking the resources of different museums, by making real that possibility for a group of Spanish Greatest Museums. We present a working solution (a final solution, not a prototype) that is open access.

MisMuseos.net gathers museum metadata from multiple Spanish public institutions. It is a semantic museum of museums where users can browse over 17,700 pieces of art and 2,700 artists. We currently have a collection of seven Spanish Great Museums (a meta-museum): Museo del Prado, Biblioteca Nacional de España Escolar (School National Spanish Library), Museo Reina Sofía, Museo Bellas Artes de Bilbao, Museo Sorolla, Museo de la Fundación Lázaro Galdiano and Museo del Greco. It works according to the standards of the Semantic Web and the principles of the Linked Open Data Web.

Mismuseos.net obtains the information about cultural goods from the Europeana dataset and the online collections of public Spanish museums. It also extracts and links data from additional datasets of the LOD cloud, either to supplement information or to generate enriched contexts: Dbpedia, Geonames and Didactalia (a GNOSS project with an index of over 56,000 open educational resources).

## 2. SYSTEM DESCRIPTION

### 2.1 Goals

The main goal of Mismuseos.net is to present a case of consumption of Linked Data from museums and their valorisation in education, through end-user applications. In more detail, the project is guided by the following specific goals:

- To put data to work: consume public datasets and information on museums to generate benefits for users and improve the user's experience.

- To link datasets both to enrich content and generate accurate contexts of information.

- To clean up, curate, unify, extend and hybridize data into a knowledge domain.

- To express all the data through a unified graph in the context of a specialized Micro Linked Data Cloud for culture and education (see Figure 1).

- To connect cultural and educational worlds in knowledge ecosystem through the development of Hybrid or Extended Ontologies thought for that purpose.
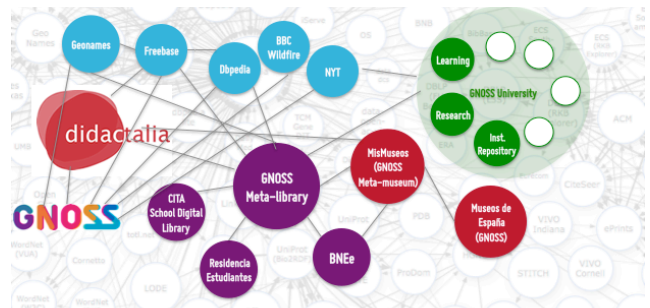


**Figure 1. Specialized Micro Linked Data Cloud for culture and education**

Mismuseos.net structures, organizes and makes available to you, in accordance with the principles promoted by the Linking Open Data Project, an extensive catalogue of artworks that museums publish on the Web. Moreover, it links the catalogue with other existing LOD educational knowledge bases allowing the generation of educational contexts related to cultural goods.

### 2.2 Motivation

The solution has been designed with an important focus in education. Although it is also applicable across multiple domains, a specific target group is the educational community (teachers, professor, students, scholars…) as this project connects cultural and educational worlds by offering educational content related to artworks and artist through the linking of their data.

Mismuseos.net can also have a direct use by professionals in the cultural area and 'museum consumers', such as museum curators, museum workers, researchers, visitors or just people interested in art that want to find information about museums, artworks and artists.

If we focus again in the use of Mismuseos.net with and educational sense, Mismuseos.net introduces elements of innovation in education.

Faceted search applied to cultural goods, such as the ones offered by a museum, can be used as a learning tool, since this type of search allow people to develop skills of exploration and discovery, while giving information about the results with refinement options (only filtering options with possible results are shown). Then, if we look for Velázquez's paintings in MisMuseos.net, the refinement options offered by the facets will show us that he was a painter of the seventeenth century and Baroque style.

Moreover, as explained above, MisMuseos.net uses the linking data possibilities of the semantic web to connect cultural content with related educational resources, which are presented as context information.

In addition, showing the results and contexts of a query in very specialized ways can be itself a formative or educational tool. Now, we can in some cases search on a map, but in the future the solution would allow doing that on timelines and other ways of presentation. For example, we could see 'Las Meninas' by Velázquez, together with some contemporary works and, besides, we could present these results on a timeline or on a map. In this last case, we could see the centres of art production in this period. Eventually, we could present the artistic style of the pieces of art on a map too, so that we could see the connection and transitions among them. Another possibility would be browsing through the authors' graph. For instance, we could see the contemporary artists of Velázquez, where they were painting, in which styles and techniques, and so on.

In conclusion, the connection between specialized fields of knowledge has not only an ontological solution, but also a solution based on the way the results are shown.

An ontological solution could be necessary for establishing the use of the results in terms of curricula, academic level, skills, subjects and this kind of didactic and pedagogic considerations. But navigating through a knowledge graph could be itself an educational experience.

Other direct advances or benefits for the educational and cultural community could come from:

- Extending the cultural graph with additional contexts through the connection to other cultural heritage resources of libraries and archives.

- Offering a semantic web publishing service to serve customized semantic web pages with selected data coming from mismuseos.net.

- Providing linked data or semantic contexts to third parties, putting your cultural information inside new platforms and spaces.

Other potential advances could be:

- Developing personalized cultural/educational assistants depending on the user preferences.

- Offering varied levels of specialized information using different views and searching tools for every kind of user, from kids and teachers to researchers;

- Promoting the development of new applications for your exposed linked data, from games to digital books.

## 2.3 Datasets used: Europeana (CER.ES collection), Dbpedia, Geonames and Didactalia (GNOSS)

Mismuseos.net uses several datasets and sources of information:

- Europeana dataset [5], specifically the data from the CER.ES collection;[3] the online collections of public Spanish Museums; and primary databases provided by certain institutions (Fundación Lázaro Galdiano and National Spanish Library). These data were used in order to obtain the information about cultural goods (pieces of art and museum information basically).

- Dbpedia [6], used to supplement the information about the author, such as biography or dates of birth and death, and extract information about the location of authors and museums.

- Geonames [7], in order to obtain the geolocation data of artists and museums, once we have obtained the names of the places from the primary source or from Dbpedia. This information will be used in the future to locate entities in a map view.

- Didactalia (www.didactalia.net), an index of over 56,000 educational resources on the semantic and social platform gnoss.com, linked to the museum's data to provide users with related educational content.

The museums included until now are the following ones: Museo del Prado, Biblioteca Nacional de España Escolar (School National Spanish Library), Museo Reina Sofía, Museo Bellas Artes de Bilbao, Museo Sorolla, Museo de la Fundación Lázaro Galdiano and Museo del Greco.

To sum up the process, we have followed the next basic steps to create the Linked Data catalogue 'MisMuseos':

1. We have obtained primary information of artworks and museum as explained above.

2. The primary information has been enriched, cleaned-up, normalized and extended when necessary. This phase has several points of interest from the end-user perspective. First, it allows us to show extended information about artists and museums directly in their corresponding web pages. Secondly, it widens the potential of linking data to generate significant related content or recommendations, for instance, contemporary artists, artists of the same artistic style, recommended museums, etc. Thirdly, it can contribute to the future generation of new ways of visualizing data and presenting results, for example in maps or timelines.

3. We have published the data in the online space of the project on the gnoss.com platform, so that we can consume the data and set up the end-user applications.

## 2.4 Presentation of the solution: general navigation in MisMuseos

We have prepared a general navigation through tabs that includes a homepage with content selection, a tab for the collection (pieces

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3 CER.ES is the Digital Network of Collections of Spanish Museums: http://ceres.mcu.es.

of art) and another one for artists (see Figure 2). In the future, we will also include a tab for museums.
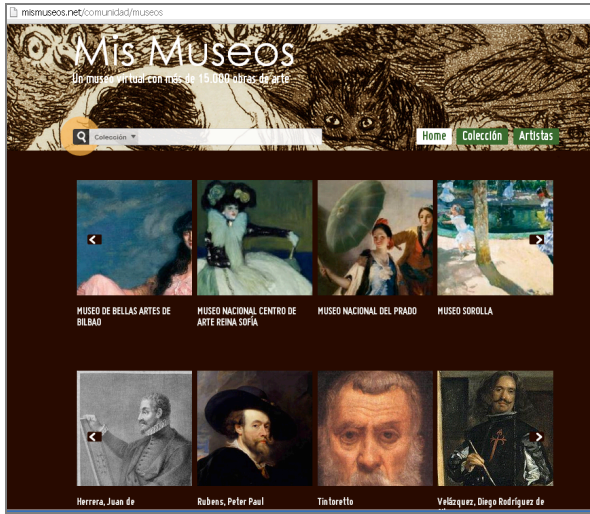


Figure 2. MisMuseos.net homepage

The previous entities (pieces of art, artists and museums) are represented on the platform with their specific ontologies thanks to the Semantic Content Management System of GNOSS using standard vocabularies if available.

## 2.5 Technology and featured applications

The solution has been developed on gnoss.com, a social and semantic platform with a deep focus on the generation of social knowledge ecosystems and end-user applications in a Linked Data environment. It includes faceted searches, recommendation systems and adapted contexts in education, university and enterprises. GNOSS could be conceived as a network of networks or a linked networks space oriented to using semantic technologies for data and service integration. Moreover, it has a wide range of configurable social tools, which have been mostly deactivated in the case of Mismuseos.net.

The featured applications in Mismuseos.net are: semantic content management system (SemCMS), faceted searches, contexts of significant information and semantic dynamic publishing.

### 2.5.1 Semantic Content Management System (SemCMS)

GNOSS has an engine for developing specific ontologies to represent knowledge objects, and, as a consequence, specific search engines if necessary. GNOSS SemCMS allows uploading an OWL file describing the concepts and relations within a particular knowledge domain, and it generates a semantic form with all the classes and properties represented in the OWL file. This semantic form includes also edition tools, in case data should be modified directly in the platform. The presentation and edition pages can be personalized.

MisMuseos.net makes use of the GNOSS SemCMS to express the ontologies for artworks, artists and museums. So, all the information in Mismuseos.net is available in RDF files (machine readable), as well as in the usual HTML format (for end-users). See Figure 3.
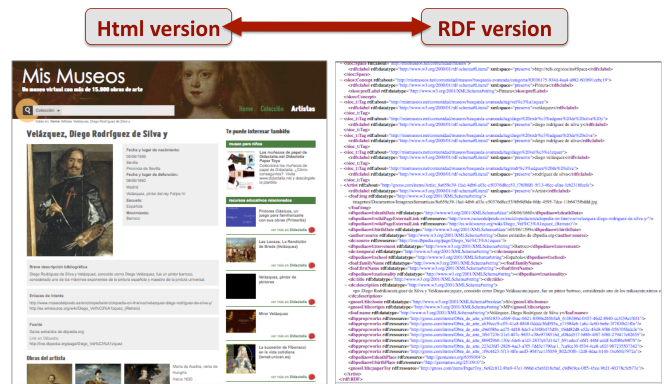


Figure 3. Html and RDF of a resource on MisMuseos.net

### 2.5.2 Faceted Searches

The usual search experience based on a text box to search, offers a list of results sorted by a theoretical relevance, which, in general, satisfies the user expectations. However, there are cases in which this operation is insufficient, often in searches of much value in specific environments (catalogues, business environments). What happens if the user does not know exactly what he is looking for? What tools does the user have to refine his search?

In recent years, the convergence of studies in the areas of Information Retrieval (IR) and Human Computer Interaction (HCI) has generated a specific study area, Human-Computer Information Retrieval (HCIR) [8]. It deals with information retrieval techniques that introduce human intelligence in the search process. Some of the ideas generated, which are already being applied in the most advanced search engines, are:

- Give responsibility and control on the search to the person. It takes effort, but the person will be rewarded.

- Not guess the intentions, but improve communication.

- Support refinement and exploration.

- Reply to a set of orderly and adequate results, which includes offering different presentation modes depending on the type of results: lists, mosaics, maps, timelines, etc.

- Extend the results and information with contexts, which are, in turn, results from other searches.

One of the concrete proposals is the use of faceted search engines as interface. Web sites like Amazon or eBay have been pioneers in the use of this type of interface. For its part, Google has introduced faceted search engines in specific areas, such as recipes or travel, but without summarization.

Following this approach, MisMuseos.net presents a faceted search engine based on the use of semantic web standards, given the greater expressiveness and extensibility of the data provided by those standards, and that they help to build more powerful, flexible and evolutionary search systems for human beings.

The faceted search engine of Mismuseos.net has been generated by its semantic graphs (RDF triplets); and it makes use of these graphs through reasoned or inference-based searches. It provides specific configurable facets for each item type. For instance, in the case of pieces of art, users can search by facets such as collection type (sculpture, drawing, painting, etc.), museum, key words, author, time period, art techniques, etc (see Figure 4).
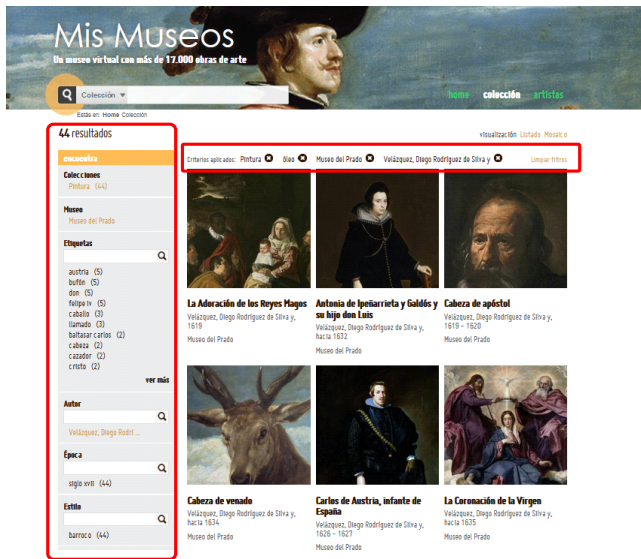
**Figure 4. Faceted searches in MisMuseos.net**

The search engine of Mismuseos.net meets the characteristics of faceted search engines:

- **Each possible value of a property can be an option of refining the search.** By selecting a search option, it allows you to filter the results in consecutive searchers, and therefore restrict the results to a manageable number of entries. For example, once you have searched for artworks on horses,[4] you have a list of artistic styles. Choosing one of them, Baroque,[5] 33 paintings would be obtained. Among these results, we note that one of the authors is Velázquez, which takes us to 3 paintings:[6] *recall and precision*.

- **It offers summarization of the results**, based on properties that specifically characterize the results shown, so that users can better understand how the results relate to all search facets. For example, if it is showing pieces of art, the properties could be author, museum, period of time, style, school, artistic technique, etc. The values are recalculated for every set of results in aggregated searches.

- **The refinement options offer only possible results,** avoiding incoherent search options. In the above example, you cannot choose Goya as author, as none of his works corresponds to the Baroque style. The possibility of

combining search options that return no results is a common defect of some search engines.

The faceted search system of MisMuseos.net offers exploration and discovery capability and can support the individual reasoning of users, without need for previous administration of all routes to reach content.

### 2.5.3 Contexts or related information: enriched content and navigation through graphs

One of the benefits that arise when machines understand the content and digital resources represented in accordance with the semantic web standards, is the potential to link data and generate meaningful contexts for given information. In MisMuseos.net we have taken advantage of this possibility to enrich the content and link educational content dynamically. We have set several contexts depending on the object or entity that the user is viewing, which offer dynamically generated content:

1**. Contexts for the entity 'piece of art'**: related works by the same artist and artworks within the same particular time period, artist information and related educational resources of Didactalia.

For example, if you are visiting the painting 'The Surrender of Breda' (also known as 'Las Lanzas') by Velázquez (see Figure 5),[7] in addition to all the details of the painting, you can access extra information within MisMuseos collection: other works by Velázquez, like 'Felipe IV' or 'Las Meninas'; works in the same period of time like 'The Rape of Proserpina' by Rubens and his workshop; connection to the Velázquez page in MisMuseos, or linked educational resources from Didactalia.net. Also, the tags of the resource are linked to Dbpedia entries, so in this example you can read information about the city of Breda.
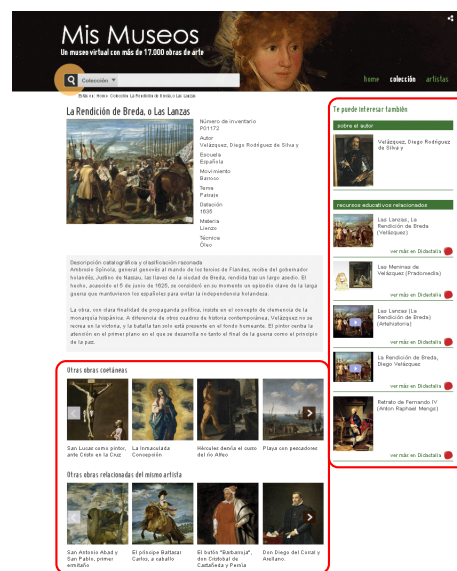


**Figure 5. Contexts for 'piece of art'**

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[4] See the search example for horse ('caballo' in Spanish) in: http://mismuseos.net/comunidad/museos/Colección?search=caballo.

[5] See the filtered search results for this example, Baroque ('Barroco' in Spanish) in: http://mismuseos.net/comunidad/museos/Colección?search=caballos&dbpedia-owl:movement=barroco.

[6] See the filtered search example in: http://mismuseos.net/comunidad/museos/Colección?search=caballo&dbpedia-owl:movement=barroco&dce:creator@@@foaf:name=velázquez,%20diego%20rodríguez%20de%20silva%20y.

[7] Resource available online in: http://mismuseos.net/comunidad/museos/recurso/la-rendicion-de-breda-o-las-lanzas/5385c9fe-b140-4684-9795-29775f8e4b32

2. **Contexts for the entity 'artist'**: artworks of the artist, contemporary artists, related paper toys and educational resources of Didactalia.

If you go on browsing through Velázquez and go to the author's website in MisMuseos.net, besides the basic information of Velázquez, you can follow his works (Las Lanzas, Mercurio and Argos, Mariana de Austria, etc.) and know what other artists painted at that time, like Rubens. Users can also download the Velázquez paper toy, or enter educational resources from Didactalia, like one to study the Fibonacci sequence through the paintings of Velazquez.

### 2.5.4 Semantic Dynamic Publishing

Mismuseos.net offers the possibility of serving subsets of its data in other web pages with their own design and way of presentation. This makes it possible, for example, the creation of a particular web for a specific museum only with its artworks (see Figure 6 with the example of the catalogue of the museum Fundación Lázaro Galdiano), or a thematic virtual museum, like Picasso Museum, regardless the museum that owns or exhibits the artworks.



**Figure 6. Semantic Dynamic Publishing example: collection of Fundación Lázaro Galdiano**

## 3.    PERFORMANCE AND USE

**Data usage and quality**

We have linked four data sources from the LOD cloud (Europeana, Dbpedia, Geonames and Didactalia); as well as other data sources that correspond to specific museums. The detail of the data sources is described in section 2.3.

We have reused the datasets of Europeana (CER.ES collection) in the case of the following museums: Museo Sorolla and Museo del Greco. Nevertheless, we have not simply included those data, but also enriched them with additional information.

We have created new datasets for some museums. In some cases we obtained the primary information from the public information published in the web pages of the corresponding museums (Museo del Prado, Museo Reina Sofía, and Museo Bellas Artes de Bilbao). In other cases, the information was provided directly by the organization that owned the data (Museo de la Fundación Lázaro Galdiano and National Spanish Library).

We represented the artworks and artists on the platform with their specific ontologies thanks to the semantic CMS of GNOSS following standard ontologies and vocabularies: CIDOC [9], FOAF (Friend-of-a-Friend) [10] and DC (Dublin Core) [11].

In addition, other vocabularies were included for representing the extended information and/or correlating datasets, for instance SIOC (Semantically Interlinked Online Communities) [12], SKOS (Simple Knowledge Organization System) [13], DBPROP [14] or GN (Geonames) [15].

**Performance**

The system runs stable and is scalable; it has a fast response time even with increasing user or content data. The precision and recall value of our facets interface is 1. When the number of results is too large to show all of them to the user in each facet (the interface and the user have a limited capacity), we restrict the results on the presentation view, so that depending on the facet, we show a limited list (tags), a navigable tree (thesaurus) or a list of ranges (number of comments).

Mismuseos.net has an average of 9,000 visits per month and the scalability can be checked through other projects running on our technology and much larger than MisMuseos.net. For example, www.didactalia.net serves up to 40,000 daily unique visits, or www.researchgroups.gnoss.com has over 2 million scientific publications in IT and a social graph of almost 500,000 authors.

We use several solutions to deal with increasing numbers of users and data. First, we horizontally scale our web and data servers, without going offline. Second, we distribute our data in many data servers, even dedicating one data server for just one graph, if necessary. Finally, we use cache systems to serve as fast as possible frequents queries, and pre-generated HTML code.

**Usability**

The application has been built considering general principles of web usability, such as the ones related to web structure and navigation, clear URLs, issues related to identity and information, searches, multimedia elements, web design, or compatibility in different browsers, among others. We have taken special care for the look & feel to present the information in a very attractive end user interface. We have paid special attention to how a faceted search should work from an intuitive point of view, and how contexts should be presented from an educational perspective.

## 4.    DISCUSSION AND CONCLUSIONS

We have presented the solution Mimuseos.net, a use case of consumption of cultural Linked Open Data in the LAM sector (Libraries, Archives and Museums). More specifically the solution uses museum data and revalorizes them for education. We have built a digital meta-museum (museum of museums) with 17,700 artworks and 2,700 artists from seven Great Spanish Museums, such as Museo del Prado or Museo Reina Sofía, among others. Mismuseos.net is an open software solution with end-user applications where visitors can find and explore information about artworks and artists through faceted searches; and also discover related information through semantic dynamic contexts: related artworks and artists, extended information about the authors and educational resources. The solution, built on the platform GNOSS, works according to the standards of the Semantic Web and the principles of LOD.

We have faced some challenges in this project. Our proposal consists of building a Museums Micro Cloud of Linked, Clean and Curated Data with an underlying Specialized and Unified Graph; and secondly, in connecting cultural and educational worlds in a knowledge ecosystem. This poses a particular problem of ontological engineering that we have addressed: the problem of building Hybrid Ontologies or extended ontologies.

The second challenge has been generating a scalable graph that can potentially integrate any Museum. Until now, Mismuseos.net includes a graph based on data from seven Spanish Great Museums; nevertheless the project is scalable to extend the collection with additional museums.

Thirdly, the datasets and data contained in them must be maintained.

Once the data were available for consumption in the platform, we wanted to develop uses and presentation of those data appropriate to each environment or user group. First, we have done it for visitors of Mismuseos.net. Then, we have prepared an example for the visitors of a specific museum, Museo de la Fundación Lázaro Galdiano, which generates a view with the subset of its data and a customized presentation (Semantic Dynamic Publishing).

Finally, one of the main focuses of the project was connecting cultural and educational worlds. Thus, we have linked Mismuseos.net data with educational resources data from Didactalia (a GNOSS project with an index of over 56,000 open educational resources). This relationship is shown to the user as contexts for information in both directions: when a user is visiting content in Mismuseos.net, he can find related educational resources from Didactalia, and from Didactalia resources he can see significant artworks coming from Mismuseos.net.

The evolution of the project would address some next steps. Mismuseos.net is a Spanish project, but we would like to develop the multilingual navigation and, as a consequence, the potential uses of the solution could aspire to international reach. Furthermore, we could also expand the collections with more museums and galleries enlarging the unified graph of the meta-museum.

**Links to the project**

The solution is available in www.mismuseos.net.

Some videos about MisMuseos project are also available: a presentation video (http://youtu.be/ESXjohOQNrA) and a video showing the navigation through the solution (http://youtu.be/l9QAYkda-io).

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