

LOD4Culture: Easy Exploration of Cultural Heritage Linked Open Data

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Abstract. LOD4Culture is a web application that exploits Cultural Heritage (CH) Linked Open Data for tourism and education purposes. Since target users are not fluid on Semantic Web technologies, the user interface is designed to hide the intricacies of RDF or SPARQL. An interactive map is provided for exploring world-wide CH sites that can be filtered by type and that uses cluster markers to adapt the view to different zoom levels. LOD4Culture also includes a CH entity browser that builds comprehensive visualization of sites, artists, and artworks. All data exchanges are facilitated through a CRAFTS API that translates REST API calls into SPARQL queries over multiple Linked Open Data sources, including Wikidata and DBpedia. Since March 2022, more than 1.1K users have employed LOD4Culture. The application has been mentioned many times in social media and has been featured in the DBpedia Newsletter and in the open data applications list of datos.gob.es.

Keywords: Cultural Heritage, Linked Open Data, data access, REST API, map visualizations, user interfaces

1. Introduction

Cultural Heritage (CH) is one of the most vibrant application domains of the Semantic Web (SW), as demonstrated by the two recent special issues on CH and SW in the Semantic Web journal [1, 2]. Institutions such as museums, libraries, or galleries invest substantial resources in the publication of their collections as Linked Open Data (LOD). Aggregators such as Europeana [3] contribute to consolidate CH digital resources in the LOD cloud. Moreover, cross-domain datasets like Wikidata and DBpedia provide an extensive coverage of the CH domain; in this regard, organizations such as the Smithsonian Institution are adapting their strategies to interlink their archives with Wikidata and other Wikimedia projects to increase their visibility [4].

All these efforts have crystallized in the creation of an emergent CH LOD cloud. Despite the availability of large amounts of CH content as LOD, its exploitation is challenging. On this subject, the primary concern in [5] is the remaining work in democratizing the use of CH LOD. [6] also raises this problem, giving as justification the lack of technical competencies in query languages and difficulties in understanding data models. Access to LOD is not a specific challenge of the CH domain, affecting the whole SW community [7–9]. This is especially problematic for web developers which are not familiar with SW technologies such as SPARQL, RDF, and OWL. Instead, this group of users is more used to Representational State Transfer (REST) [10] Application Programming Interfaces (APIs) and the JavaScript Object Notation (JSON) data interchange format [11]. Due to this, there are several proposals of API generators for LOD such as RAMOSE [12], OBA [13], or our previous work CRAFTS [14].

In this paper, we propose LOD4Culture, a novel web application that exploits CH LOD for tourism and arts learning purposes. The application offers an interactive map for exploring world-wide *CH sites* [15, 16], i.e. immovable heritage, typically buildings, monuments, historic places, museums, archaeological sites, etc. LOD4Culture also provides a browser of CH entities of different types (sites, artists, and artworks). Wikidata and DBpedia are employed as LOD sources, using a CRAFTS API to simplify data access. Contributions of this work include (1) the proposal of an interactive application based on CH LOD that can be enjoyed by lay users, and (2) a demonstrator of REST-based access to various LOD sources through a CRAFTS API that is especially meaningful to web developers.

The rest of the paper is organized as follows: Section 2 reviews existing proposals consuming CH LOD. Section 3 provides a technical description of LOD4Culture, including its requirements, its data sources, its architecture, its main functionalities, and implementation details. Section 4 reports about the impact of LOD4Culture so far. The paper ends with a discussion in Section 5.

2. Related work

The CH community is carrying out a tremendous effort in digitalizing their contents and publishing them as LOD. This is the case of individual institutions, such as Rijksmuseum [17]. To avoid fragmentation of CH datasets, aggregators like Europeana [3] provide single access to myriads of artworks. Studies such as [5, 6] survey some of the most relevant initiatives in CH data publication. Nonetheless, cross-domain community-based datasets like Wikidata and DBpedia are also a rich source of CH LOD. Indeed, Wikidata aims to establish itself as a central hub for data integration, data enhancement, and data management in the CH domain.¹

The availability of CH LOD has fueled the development of websites and portals for browsing and searching CH content. One example is the Europeana website² that includes faceted search over the Europeana Data Model.³ The Sampo series of portals [18] is another remarkable example in the CH field; its foundation is a collaborative publication model for CH LOD, embraced by several Finnish institutions. This model has been followed to publish CH datasets as LOD that can be browsed through portals like WarSampo.⁴

openArtBrowser [19] is an artwork browser that uses Wikidata as source. This application employs an offline batch process for extracting artworks from Wikidata, converting them to JSON objects, and uploading the output into a text-based search engine. openArtBrowser supports faceted search over the extracted artwork collection.

In our previous work we have proposed CasualLearn [20], a mobile application for CH education. It exploits a dataset of 10K geolocalized learning tasks that were generated from DBpedia, Wikidata, and the Open Data portal of Castile and León.⁵ CasualLearn tracks the physical location of learners to offer these tasks. For example, it may ask about the characteristics of the Gothic style when passing by a Gothic Cathedral. The application also includes an interactive mode for browsing tasks in a map view.

[6] addresses the challenge of CH LOD exploitation through virtual assistants (VAs). Their approach consists of a generator of VAs that can be employed with SPARQL endpoints. It enables users to pose questions in natural language through their smartphones. This approach has been tested in several case studies in the CH domain.

Beyond the aforementioned initiatives, the usage of CH LOD is still scarce [5]. [21] discusses the difficulties in creating CH LOD-based applications, requiring expertise in SW technologies not common among the CH community; moreover, it identifies a lack of tools for dealing with LOD to facilitate its exploitation in particular application cases.

¹https://www.wikidata.org/wiki/Wikidata:WikiProject_Cultural_heritage

²<http://www.europeana.eu/>

³<https://pro.europeana.eu/page/edm-documentation>

⁴<https://www.sotasampo.fi/en/>

⁵<https://datosabiertos.jcyl.es/web/jcyl/set/es/cultura-ocio/monumentos/1284325843131>

Table 1
Prefixes and namespaces employed in this paper.

Prefix	Namespace
dbo	http://dbpedia.org/ontology/
dbp	http://dbpedia.org/resource/
geo	http://www.w3.org/2003/01/geo/wgs84_pos#
owl	http://www.w3.org/2002/07/owl#
p	http://www.wikidata.org/prop/
psv	http://www.wikidata.org/prop/statement/value/
rdfs	http://www.w3.org/2000/01/rdf-schema#
schema	http://schema.org/
wd	http://www.wikidata.org/entity/
wdt	http://www.wikidata.org/prop/direct/
wikibase	http://wikiba.se/ontology#

3. Design of LOD4Culture

The analysis in Section 2 evidenced the existence of a deluge of CH LOD, although applications that exploit them are relatively scarce. This section describes LOD4Culture, a novel application targeted to lay users that consumes CH content for tourism and education purposes. The following subsections present the requirements, the employed data sources, the architecture of LOD4Culture, and further design and implementation details. Employed prefixes and namespaces are listed in Table 1.

3.1. Requirements

LOD4Culture is a CH application intended for tourism and education purposes that exploits LOD sources. Table 2 summarizes the main requirements for LOD4Culture. This application should provide two main functionalities: exploration of CH sites through an interactive map (FR0) and browsing of CH entities (FR1). The former functionality is purposed for discovering CH sites in an area of interest defined by the user. The scope should be world-wide and the map view should be adaptable to different zoom levels (FR2), thus allowing the exploration of small areas –showing a marker for each site, as typical in map applications– but also large ones, providing appropriate aggregating mechanisms to avoid cluttering the map view with too many markers. The application should allow the user to filter CH sites by a specific type (FR3).

With respect to browsing of CH entities, LOD4Culture should provide suitable visualizations (FR4) with the information available in the target LOD sources (labels, descriptions, images, locations, etc.). A CH entity may correspond to a CH site, an artwork, or an artist. Along a session, the user will typically navigate the map and then switch to the entity browser by selecting a site of interest. Entity browsing should be further facilitated by interlinking sites with their artworks, these with their creators, and so on (FR5). In addition, the application should include a textbox for searching CH entities by label (FR6).

Beyond the aforementioned functionalities, LOD4Culture has to comply with a number of non-functional requirements. First, the application should be portable to facilitate its usage in a wide range of devices, including mobile phones, tablets, and desktop computers (NFR0). Since prospective users are not necessarily fluent in Semantic Web technologies, LOD4Culture should provide a user interface that effectively hides RDF annotations or SPARQL queries from end users (NFR1). Furthermore, the application should be responsive in order to keep user engagement; this may be difficult to achieve with third-party services (especially SPARQL endpoints), but LOD4Culture should provide mechanisms to keep latency low (NFR2). Finally, the application should be localized to English and Spanish (NFR3).

Table 2
Requirements for LOD4Culture.

ID	Requirement
FR0	Exploration of world-wide CH sites through an interactive map
FR1	Browsing of CH entities (sites, artists, and artworks)
FR2	Map view adaptable to different zoom levels
FR3	Filtering of CH sites by type
FR4	Provide comprehensive visualizations of CH entities (labels, descriptions, images, locations...)
FR5	Facilitate interlinking of CH entities in the entity browser view
FR6	Support searching of CH entities by label
NFR0	Portable (mobile phones, tablets, and desktop computers)
NFR1	Effective hiding of RDF annotations and SPARQL querying
NFR2	Provide mechanisms to keep latency low
NFR3	Localized to English and Spanish

3.2. Data sources

LOD4Culture uses Wikidata and DBpedia as sources of CH LOD. Both datasets are well-known by the Semantic Web community; they are open and collaborative projects that are used in a myriad of applications by researchers and industry practitioners. While the scope of Wikidata and DBpedia is cross-domain, CH is well covered in both sources; lots of CH entities can be found from every place in the world and with very detailed annotations in many cases. CH entities are not uniformly annotated in Wikidata and DBpedia though; well-known items commonly include very rich descriptions, but not so popular CH entities are sparsely annotated.

Wikidata and DBpedia contain complementary information about CH entities. Wikidata includes very fine-grained annotations such as inception dates, creators, heritage designations, materials, architects, subelements, widths, heights... DBpedia shines at providing very thorough comments, Wikipedia categories, images, and mappings to Wikidata. Some CH entities include image annotations in DBpedia, but not in Wikidata –this is very typical of contemporary paintings, e.g. Picasso’s Three Musicians (check `dbr:Three_Musicians` in DBpedia and `wd:Q1113293` in Wikidata)–.

Interestingly, population completeness of CH entities is significantly higher in Wikidata than in DBpedia. As an example, querying the number of castles gives a value of 28,678 in Wikidata⁶ (members of `wd:Q23413` and its subclasses) and 4,845 in English DBpedia (members of `dbo:Castle` and its subclasses) in July 2022. With other classes of the CH domain, population completeness of Wikidata was systematically higher (4–8 times) than English DBpedia. For this reason, Wikidata is the main source of LOD4Culture, while English DBpedia is used as a secondary source, taking advantage of the Wikidata mappings already available.

Unfortunately, the Wikidata endpoint is not responsive enough for supporting the exploration of CH sites (FR0) with a low latency (NFR2). Listing 1 presents a typical query for fulfilling requirement FR0, but the Wikidata endpoint takes several seconds to answer it.⁷ Further tests with the custom geospatial box search extension of Wikidata⁸ did not serve to reduce latency below one second. In order to address this limitation, we set up a new dataset, henceforth named *CHsites*.

⁶Note that the query in Listing 2 also requires a heritage designation, a geolocation, sitelinks, statements, and a label in English or Spanish. This is why only 13K castles were extracted, as shown in Table 3.

⁷The latency of a similar query in the English DBpedia endpoint is one order of magnitude lower, i.e. hundreds of milliseconds, which is assumable for an interactive application.

⁸https://www.mediawiki.org/wiki/Wikidata_Query_Service/User_Manual

Listing 1: Query to the Wikidata endpoint for retrieving the number of castles in a bounding box with the following WGS84 coordinates: South 41°, North 42°, West -5°, East -4°.

```
SELECT (count(distinct ?castle) as ?nc) WHERE {
  ?castle wdt:P31/wdt:P279* wd:Q23413 ;
    p:P625/psv:P625 ?coords .
  ?coords wikibase:geoLatitude ?lat ;
    wikibase:geoLongitude ?lng .
  FILTER (?lat < 42)
  FILTER (?lat > 41)
  FILTER (?lng < -4)
  FILTER (?lng > -5)
}
```

CHsites contains the essential information about CH sites to fulfill functionality FR0 of LOD4Culture. This dataset was created by submitting a series of SPARQL CONSTRUCT queries to the Wikidata endpoint. Listing 2 shows the prototypical query for castles that retrieves labels, descriptions, and images for presentation purposes; types for supporting type filtering (FR3); geocoordinates and administrative territorial location for positioning; and sitelinks and statements for measuring CH site popularity. We decided to borrow terms from the DBpedia and W3C Geo ontologies –such as `dbo:thumbnail` instead of `wdt:P18`– because they are more mnemonic and easier to grasp than the corresponding Wikidata terms. More importantly, Table 3 includes the types of CH sites that were extracted using a trivial reformulation of the query in Listing 2. Note that the majority of the extracted CH sites require a heritage designation,⁹ the rationale of this is to prefer quality over pure quantity as the main purposes of LOD4Culture are tourism and CH education. The dataset was completed with the subclasses of the extracted types of CH sites and the geocoordinates of the administrative territorial locations.

Listing 2: SPARQL CONSTRUCT query for generating a graph of RDF triples about castles with a heritage designation from the Wikidata endpoint.

```
CONSTRUCT {
  ?site a ?type, dbo:Place ;
    rdfs:label ?lab ;
    schema:description ?desc ;
    wikibase:sitelinks ?sitelinks ;
    wikibase:statements ?statements ;
    dbo:thumbnail ?img ;
    geo:lat ?lat ;
    geo:long ?long ;
    dbo:location ?loc .
  ?loc a dbo:Location .
}
WHERE {
  ?site wdt:P31/wdt:P279* wd:Q23413 ;
    wdt:P1435/wdt:P279* wd:Q358 ;
    wdt:P31 ?type ;
    rdfs:label ?lab ;
    wikibase:sitelinks ?sitelinks ;
    wikibase:statements ?statements ;
    p:P625/psv:P625/wikibase:geoLatitude ?lat ;
    p:P625/psv:P625/wikibase:geoLongitude ?long .
  FILTER (lang(?lab) = "en" || lang(?lab) = "es")
  OPTIONAL { ?site wdt:P18 ?img . } .
  OPTIONAL { ?site wdt:P131 ?loc . } .
  OPTIONAL {
    ?site schema:description ?desc .
    FILTER (lang(?desc) = "en" || lang(?desc) = "es")
  } .
}
```

⁹Only museums, national heritage sites, and UNESCO World Heritage Sites did not require a heritage designation; in these cases the triple pattern `?site wdt:P1435/wdt:P279* wd:Q358` was removed from the corresponding SPARQL construct queries.

Table 3
Types of CH sites extracted from Wikidata.

Type of CH site	Wikidata term	# of extracted sites
Archaeological site	wd:Q839954	75K
Castle	wd:Q23413	13K
Factory	wd:Q83405	3K
Fountain	wd:Q483453	3K
Green space	wd:Q22652	6K
Monument	wd:Q4989906	73K
Multistorey building	wd:Q79146420	4K
Museum	wd:Q33506	35K
National heritage site	wd:Q45580643	1K
Neighborhood	wd:Q123705	2K
Office building	wd:Q1021645	10K
Palace	wd:Q16560	4K
Place of worship	wd:Q1370598	156K
Public building	wd:Q294422	11K
Square	wd:Q174782	1K
Tower	wd:Q12518	12K
UNESCO World Heritage Site	wd:Q9259	2K
Wall	wd:Q42948	16K

Table 4
Statistics of the CHsites dataset.

Item	Total
# of CH sites	521.3K
# of types of CH sites	4.4K
# of administrative territorial locations	87.4K
# of triples	5.3M

CHsites is currently published in a SPARQL endpoint¹⁰ using Openlink Virtuoso v07.20.3230. Table 4 provides some statistics of the dataset that were computed in July 2022. Noteworthy, geospatial queries such as the one in Listing 1 —slightly adapted to the ontologies employed in the CHsites dataset, as discussed above— are now performant, taking 100–300 milliseconds and thus serving to fulfill requirement NFR2.

3.3. Architecture

LOD4Culture is designed as a web application to facilitate portability (NFR0), allowing its deployment in multiple devices and platforms as a web browser is ubiquitous nowadays. Traditional web applications require full-page reloads from the server that negatively impacts performance. This limitation is addressed in single-page applications (SPAs), web applications that initially load a single web document and then update their body content with data from the server, resulting in performance gains and a more dynamic experience [22]. Given the latency requirement of LOD4Culture (NFR2), the SPA approach is embraced in this application.

¹⁰Endpoint URL <http://185.179.104.18:8893/sparql> and graph IRI <http://chsites.gsic.uva.es>.

Table 5
Routes exposed in LOD4Culture. Query parameters marked with * are required.

ID	Operation	Path	Query parameters	Description
R0	GET	/	–	Landing page of LOD4Culture
R1	GET	/app/	loc*, siteType	Map centered in loc with an optional siteType filter
R2	GET	/app/	type*, uri*	Entity of a specific type and a specific uri

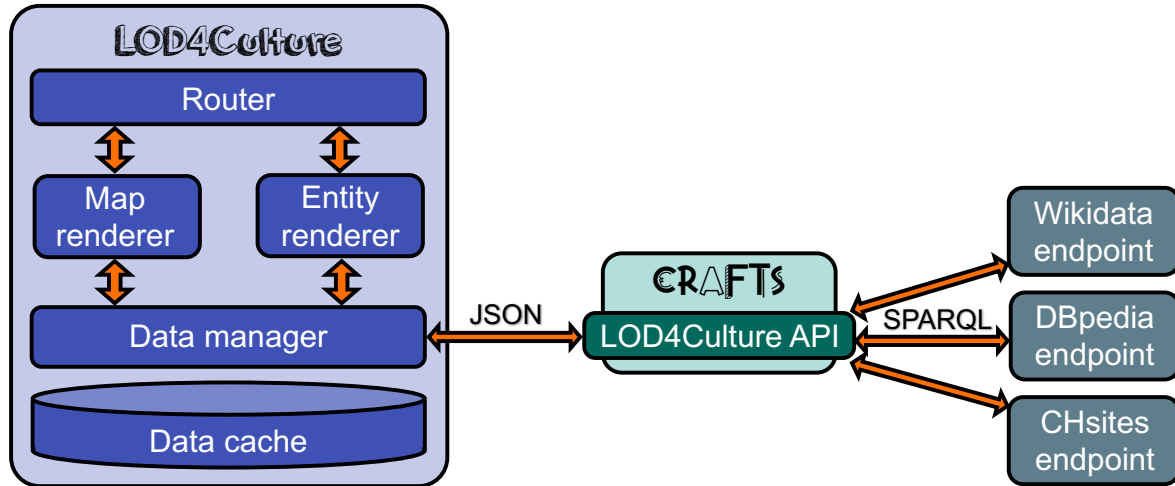


Figure 1. Architecture of LOD4Culture.

LOD4Culture exposes the routes in Table 5. R0 is a landing page that presents the application and includes links to R1 and R2. Route R1 corresponds to the interactive map functionality (FR0); *loc* is a required query parameter that refers to a specific position and zoom level with format *LAT, LONG, ZOOMz*,¹¹ while *siteType* is optional and sets a specific CH site type, e.g. <http://www.wikidata.org/entity/Q2977>, a cathedral in the Wikidata ontology. In this way, R1 can be used to specify the location of any place in the world, with a specific zoom level, and with an optional CH site type filter such as the route [/app/?loc=42.879958,-8.544381,15z&siteType=http://www.wikidata.org/entity/Q2977](#).

Route R2 is used to get a representation of a CH entity (functionality FR1). *type* is a required query parameter for setting the type of CH entity –allowed values are *Site*, *Artwork*, and *Artist*–. *uri* is also required, referring to a Wikidata entity. With this route design, R2 can be employed to specify arbitrary CH entities such as painter Picasso, [/app/?type=Artist&uri=http://www.wikidata.org/entity/Q5593](#), or the Spanish National Sculpture Museum, [/app/?type=Site&uri=http://www.wikidata.org/entity/Q1581475](#).

After embracing the SPA principles and defining the routes, the architecture of LOD4Culture can be designed; it is graphically depicted in Figure 1. The *Router* component is in charge of performing client-side routing. If the browser URL changes, the *Router* detects it and checks its validity. A valid URL has to follow one of the routes in Table 5, as discussed above. The *Router* dispatches R1-compliant URLs to the *Map renderer* and R2-compliant URLs to the *Entity renderer*. A *Renderer* updates the view according to the incoming request, i.e. the refreshed URL; in order to do it, a *Renderer* will make data requests to the *Data manager*. This component is in charge of gathering the necessary data by making calls to *LOD4Culture API*. Responses from the API are locally stored in the *Data cache* to minimize future exchanges. Indeed, the *Data manager* first checks the *Data cache* and in case of a miss will make a call to the API.

¹¹LAT and LONG assume WGS84 as a reference datum. ZOOM represents the zoom level in powers of two, typically ranging from 0 (the whole world is entirely represented in a tile) to 20 (~1 trillion tiles are needed to show the entire world).

Table 6
Sample calls to the LOD4Culture API.

ID	Call	Description
C0	/apis/chsites/query?id=countSitesInbox&lngwest=-5&lngeast=-4&latnorth=42&latouth=41	Count the number of CH sites in a specific bounding box
C1	/apis/chsites/query?id=countSitesInbox&lngwest=-5&lngeast=-4&latnorth=42&latouth=41&type=http://www.wikidata.org/entity/Q2977	Count the number of cathedrals (wd:Q2977) in a specific bounding box
C2	/apis/chsites/query?id=sitesInbox&lngwest=-5&lngeast=-4&latnorth=42&latouth=41&limit=1000	Get the representations of the CH sites in a specific bounding box (with a limit of 1000)
C3	/apis/chsites/query?id=sitesInbox&lngwest=-5&lngeast=-4&latnorth=42&latouth=41&type=http://www.wikidata.org/entity/Q2977	Get the representations of the cathedrals (wd:Q2977) in a specific bounding box
C4	/apis/chsites/query?id=mostPopularLocationInbox&lngwest=-5&lngeast=-4&latnorth=42&latouth=41	Get the most popular administrative territorial location in a specific bounding box
C5	/apis/chsites/resources?id=SiteType&ns=http://www.wikidata.org/entity/&nspref=wd&iris=wd:Q839954&iris=wd:Q23413	Get the representations of CH site types wd:Q839954 (archaeological site) and wd:Q23413 (castle)
C6	/apis/chsites/resource?id=Site&iri=http://www.wikidata.org/entity/Q160112	Get the representation of CH site <i>Museo del Prado</i> (wd:Q160112)
C7	/apis/chsites/resource?id=Artwork&iri=http://www.wikidata.org/entity/Q208758	Get the representation of painting <i>Las Meninas</i> (wd:Q208758)
C8	/apis/chsites/resource?id=Artist&iri=http://www.wikidata.org/entity/Q297	Get the representation of painter <i>Diego Velázquez</i> (wd:Q297)

LOD4Culture API is built with Configurable REST APIs For Triple Stores (CRAFTS) [14]. The case of LOD4Culture is quite suitable for using CRAFTS since it allows a highly flexible access over three different endpoints (Wikidata, DBpedia, and CHsites) that can provide a simple REST API exposing RDF resources and parametrized SPARQL queries, using JSON as interchange format, and caching SPARQL queries from the source endpoints. In other words, the use of a CRAFTS-based API serves to reduce the complexity of creating a LOD-based application such as LOD4Culture. This complexity is transferred to the creation of a configuration file that is used in a CRAFTS site for translating REST calls into SPARQL queries. [14] describes the elements of a CRAFTS configuration file, while the OpenAPI specification of CRAFTS is browsable (and actionable) at <https://crafts.gsic.uva.es/docs/>.

Appendix A depicts the configuration file of *LOD4Culture API*—essentially a JSON object with a collection of keys and values—. **apiId** contains the identifier of the API, **chsites**.¹² **endpoints** includes the information for accessing the three endpoints in LOD4Culture. **model** contains an array of the different RDF resources exposed by the API; each one defines mappings of RDF data to JSON by referring to datatype properties (**dprops**), object properties (**oprops**), and class membership (**types**). Finally, **queryTemplates** includes three parametrized SPARQL queries. Table 6 includes a comprehensive sample of the API calls used in LOD4Culture. They will be analyzed in the following two subsections that focus on the main functionalities of the application.

3.4. Navigating the map

The *Map renderer* is in charge of supporting the map navigation functionality (FR0), showing the CH sites in the map view using LOD as source (the CHsites dataset in this case, as discussed in Section 3.2). An interactive map is used for this purpose, supporting typical panning and zooming operations that are naturally supported for both point-and-click and touchscreen interfaces. The *Map renderer* carries out this task by handling R1-compliant routes. Upon an incoming request, the map view is centered in the location extracted from the browser URL, and with the indicated zoom level. Then, a rectangular grid, centered in point LAT=0, LONG=0, is employed to fill the map view; the cell side is configured to 9° for zoom level 4 and scaled to other zoom levels.¹³ While screen size of devices can vary a lot—compare the screen of a

¹²Note that this identifier was chosen before naming the application as LOD4Culture.

¹³As map applications typically employ a spherical Mercator projection, vertical sides of cells will look longer near the poles than near the Equator.

mobile phone with the one of a 27" widescreen monitor¹⁴–, a location at a given zoom level will always correspond to the same grid cell.

A grid cell is the unit of work for displaying CH sites in the map. After computing the grid, the *Map renderer* processes each cell autonomously. For every cell, a request is sent to the *Data manager* for gathering the necessary data from the CHsites dataset. The *Data manager* first obtains the number of CH sites by using query template `countSitesInbox` in Appendix A, parametrized with the bounding box of the cell and the optional CH site type filter –see sample calls C0 and C1 to the *LOD4Culture API* in Table 6–. The response is an integer value that is stored in the *Data cache* for future usage. If this value is between 1 and 10, it makes sense to plot a marker for each CH site in the map; thus, the *Data manager* will request the information about the CH sites by using query template `sitesInbox` with the cell bounding box and the optional CH site type filter as before (calls C2 and C3). The response now includes a list of CH sites with their geocoordinates, labels, number of sitelinks and statements, images and descriptions (check query template `sitesInbox` in Appendix A) –this answer is also cached, as any request to the *LOD4Culture API*–.

Once cell data is ready, the *Map renderer* will plot the corresponding markers in the map. Markers are 50 pixel-wide circles that embed an image of the CH site if available. As markers can still overlap, the popularity of a CH site is used to set the z-index CSS property¹⁵ of markers; in this way, more popular CH sites are placed on top of less popular ones. Popularity is computed using the following formula:

$$popularity_score = 3 * \#sitelinks + \#statements \quad (1)$$

popularity_score is a simple index that estimates the visibility of an entity through its number of sitelinks and the depth of its description through the number of statements. The *Map renderer* also employs this score for obtaining the most popular CH sites –a threshold of 100 that roughly corresponds to the 1% of all CH sites in the dataset– that are plotted with a “golden marker”.

If there are more than 10 CH sites in a cell, it is pointless to plot them all with markers since they will look cluttered in the map. This is especially relevant with low zoom levels (0–9) in which a cell can concentrate hundreds or even tens of thousands of CH sites –it is also quite inefficient to gather the information of all the CH sites in a very large area–. Instead, LOD4Culture will plot a single cluster marker with the number of CH sites in the cell. A simple approach for positioning a cluster marker is to use the center of the cell; however, the result does not look good as the grid division is too evident to the user and, worse, cluster markers may be positioned in awkward places, e.g. in the middle of the ocean. Instead, the *Data manager* will use query template `mostPopularLocationInbox` to find a more suitable location for plotting a cluster marker (call C4). This corresponds to the regional administrative location that contains more CH sites in the cell. Figure 2 includes several snapshots of the interactive map of LOD4Culture, illustrating the use of individual and cluster markers at different zoom levels.

In order to support filtering of CH sites by type (FR3), the *Data Manager* performs a bootstrapping routine for building the taxonomy of CH site types at launch time. API calls like C5 are used for this purpose, initially employing the full list of CH site types in Table 3. For a given CH site type such as `wd:Q23413` (castle), call C5 will retrieve its labels, number of members, and subclasses –check model element `SiteType` in Appendix A–. The *Data Manager* will recursively employ API call C5 with the found subclasses until the full taxonomy is built. Once computed, the *Site type* button in the top-left bar of the user interface (see Figure 2(a)) will be enabled. Upon clicking this button, the taxonomy of CH site types can be browsed (Figure 2(b)) or simply searched by using the provided text search box. The number of members of a CH site type is employed for sorting (Figure 2(b) shows *Place of worship*, the top CH site

¹⁴A large screen will be able to accommodate more cells than a small screen.

¹⁵<https://developer.mozilla.org/en-US/docs/Web/CSS/z-index>

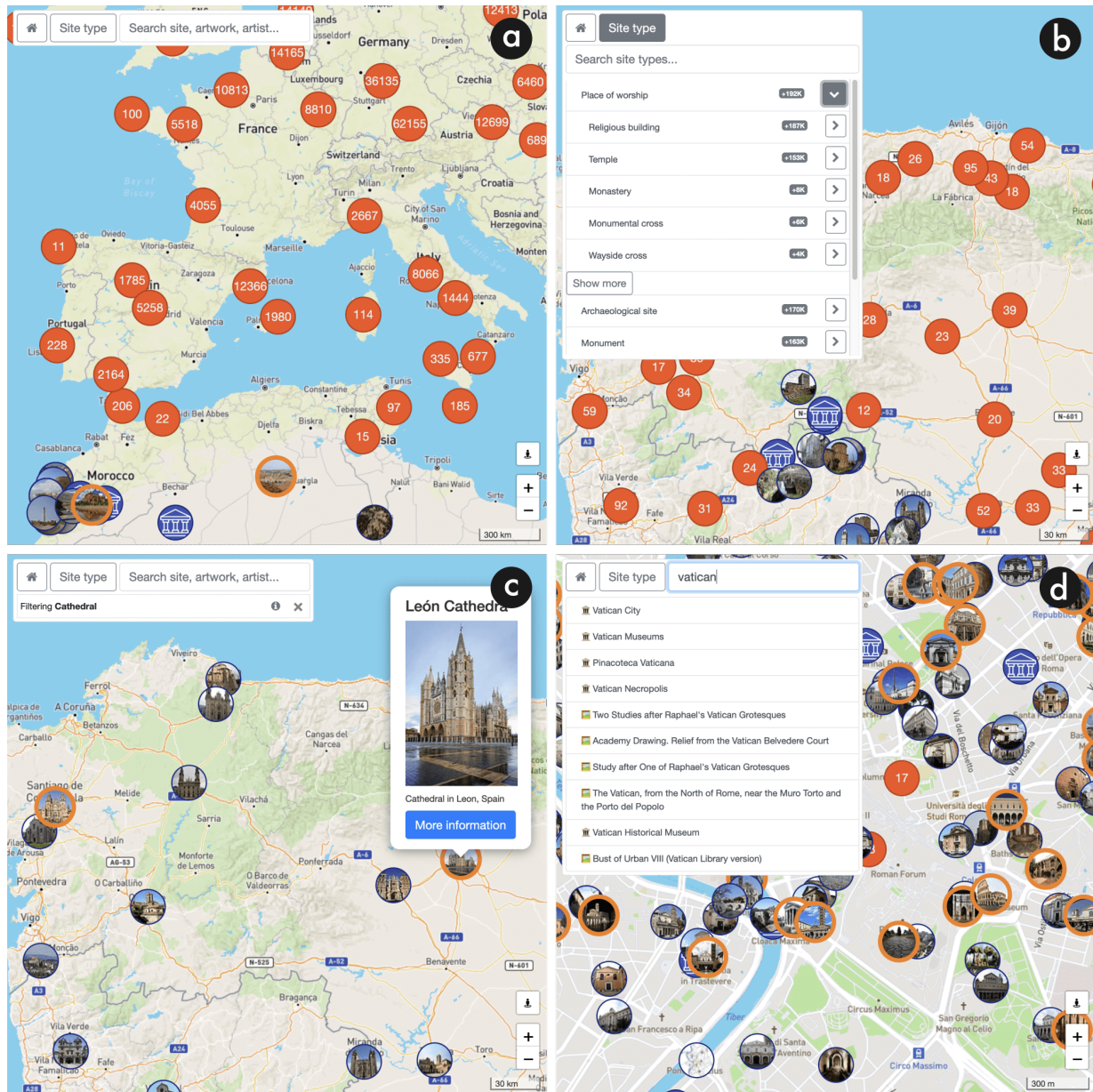


Figure 2. Snapshots of the map interface of LOD4Culture. (a) Route `/app/?loc=41.623655,3.801270,5z`: the map covers a very large area that includes South-West Europe and North Africa; cluster markers aggregating CH sites are shown in Europe and the Mediterranean coast of Africa, while single CH site markers are displayed in the rest of Africa. (b) Route `/app/?loc=42.757188,-6.908581,8z`: the map is positioned in the last part of the Way of St James (North-West Spain); cluster markers are positioned in the main cities of the view, while single CH site markers are plotted along the North-East border of Portugal and Spain; the taxonomy of CH site types is displayed in the top-left form. (c) Route `/app/?loc=42.757188,-6.908581,8z&siteType=http://www.wikidata.org/entity/Q2977`: the map covers the same area as (b), but only cathedrals are shown due to the type filter set in the top-left form; a popup of León Cathedral is displayed. (d) Route `/app/?loc=41.893061,12.482765,15z`: the map is centered in a tiny area, corresponding to the city center of Rome; the search textbox shows a list of 10 suggestions for input text *vatican* that are sorted by popularity and including a distinguishing icon to differentiate the type of CH entity.

type, and its subclasses also sorted –*Religious building* being the most populous–).¹⁶ Selecting a CH site type updates the browser URL with the `siteType` parameter set, triggering a validation of the new URL by the *Router* component. Then, the *Map renderer* will follow a new cycle for updating the map according to the new route.

3.5. Browsing CH entities

During a session with LOD4Culture, a user will navigate the map and may find a CH site of their interest, e.g. Cathedral of León in Figure 2(c). Alternatively, a user may use the search text box to find CH sites, artists, or artworks (FR6) –see Figure 2(d) for an example–. LOD4Culture supports browsing of such CH entities (FR1) that employ R2-compliant routes. Refreshing the browser URL will activate the *Router* that will validate the route and then dispatch the request to the *Entity renderer*. The functioning of this component is quite simple: it will extract the type and the entity IRI from the URL, and then make a request to the *Data manager* with these two parameters. The latter component will return a JSON object with the data about the requested entity that will be employed by the *Entity renderer* to create an HTML page (FR4). Figure 3 shows several snapshots of HTML pages of CH entities.

In order to answer an entity request from the *Entity renderer*, the *Data manager* will first look up the *Data cache*. In case of a miss, the *Data manager* will make an API call such as C6–8 with the type and entity IRI parameters. Therefore, all the complexity is translated to the authoring of the configuration file of *LOD4Culture API*. Specifically, three RDF resources from the `model` are exploited for this functionality; namely, `Site`, `Artist`, and `Artwork`. They all extend `DetailedThing` to reuse common properties: labels, descriptions, number of sitelinks and statements, types, images, and Wikipedia categories (see Appendix A). Configuring the extraction of this data is trivial in some cases, e.g. setting property `wdt:P18` for retrieving images from Wikidata, but some cases are more involved, e.g. all data obtained from English DBpedia makes use of property `owl:sameAs` for finding the corresponding DBpedia entity from the given Wikidata entity.

`Site`, `Artist`, and `Artwork` define their own properties, e.g. latitude and longitude WGS84 coordinates for `Site`. Figure 3(b) and Figure 3(c) shows that different data is retrieved depending on the entity type. Interestingly, `Site` and `Artist` are configured to extract lists of artworks pertaining to the site collection (through property `wdt:P276`) and created by the corresponding artist (through property `wdt:P170`), respectively. As some sites (and maybe some artists) host very large collections,¹⁷ a generous limit of 5,000 artworks is set, using equation (1) for sorting (check subelement `works` of `Site` and `Artist` in Appendix A). Moreover, contained artworks are configured with the `embed` flag and shaped as `LabeledThing`, so *LOD4Culture API* will first obtain the IRIs of the 5,000 most popular artworks and then retrieve their corresponding labels –this is sufficient for listing the collection of artworks through a paginated view with support for text search, as shown in the bottom part of Figure 3(b)–. Note that a browsing session is naturally supported by interlinking CH sites with their artworks, these with their creators and hosting sites, and artists with their artworks (FR5). Search of CH entities (FR6) is also supported through a search textbox, again using equation (1) for sorting –see Figure 3(d)–.

3.6. Implementation

LOD4Culture is coded in JavaScript; this programming language is the natural choice for developing web applications. The implementation effort has been considerably reduced by the usage of a number of

¹⁶Note that the counting of the CH site members shown in the application is an approximation. For performance reasons –there are more than 4.4K CH site types– only the direct members of each CH site type are retrieved (check model element `SiteType` in Appendix A). For a given CH site type the actual figure is obtained by summing the count of its direct members and all of its subtypes; thus, a single entity may be counted multiple times if it is a member of several CH site types. This is why Figure 2(b) shows 192K members for *Place of worship*, while Table 3 specifies 156K. Despite the figures shown in the application are imprecise, they serve for sorting in a performant way.

¹⁷For example, Wikidata includes more than 22K artworks in the collection of Metropolitan Museum of Art (`wd:Q160236`).

★ National Sculpture Museum

Museum in Valladolid, Spain

The Museo Nacional de San Gregorio (National Museum of Sculpture) is a museum in Valladolid, Spain, belonging to the Spanish Ministry of Culture. The museum has an extensive collection sculptural ranging from the Middle Ages to the 19th century from Region of Castile's churches that, at 19th-20th c., these were confiscated, and other particular donations, deposits or acquisitions of the state. During the Holy Week in Valladolid the museum gives 104 images (distributed in the corresponding pasos) to the processions for the brotherhoods.

Types

art museum monument national museum

Categories

Art museums and galleries in Spain Art museums established in 1842 1842 establishments in Spain


Bien de Interés Cultural landmarks in the Province of Valladolid Plaster cast collections

Sculpture galleries in Spain Herrarian architecture Museums in Castile and León Museums in Valladolid

Sources

Wikidata: National Sculpture Museum DBpedia: Museo Nacional de Escultura, Valladolid

Back Go to map f t



Basic information

Location Madrid

Country Spain

Architect Juan de Villanueva

Founded by Charles III of Spain

Year founded 1819

Heritage designations Bien de Interés Cultural

Visitors per year 3,497,345 (2019) 3,672,853 (2018) 2,696,666 (2015) 2,900,000 (2011)

Artworks

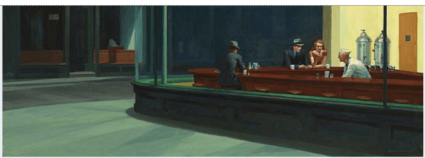
< > Page 1 of 500 Page... Go Search artwork...

Las Meninas

The Garden of Earthly Delights

The Third of May 1808

La maja desnuda



Artwork information

Created by Edward Hopper

Location Art Institute of Chicago

Genre genre art

Movement American realism

Year created 1942

Width 1,524m

Height 0,841m

Materials oil paint canvas

Main subject diner

Depicts cigarette coffeehouse stool window sidewalk

★ Leonardo da Vinci

Italian Renaissance polymath (1452–1519)

Leonardo di ser Piero da Vinci (15 April 1452 – 2 May 1519) was ar who was active as a painter, draughtsman, engineer, scientist, the fame initially rested on his achievements as a painter, he also becc drawings and notes on a variety of subjects, including anatomy, as and paleontology. Leonardo's genius epitomized the Renaissance compose a contribution to later generations of artists matched on Michelangelo.

Types

human

Categories

Ambassadors of the Republic of Florence Fabulists 1452 births 1519 deaths

15th-century Italian mathematicians 15th-century Italian painters 15th-century Italian scientists

15th-century Italian sculptors 15th-century people of the Republic of Florence 16th-century Italian inventors

16th-century Italian mathematicians 16th-century Italian painters 16th-century Italian scientists

16th-century Italian sculptors 16th-century people of the Republic of Florence Ballistics experts

Burials in France Italian Renaissance painters Italian Renaissance sculptors Italian Roman Catholics

Italian anatomists Italian caricaturists Italian civil engineers Italian military engineers Italian physiologists

Italian male painters Italian male sculptors Writers who illustrated their own writing

Italian Renaissance humanists Botanical illustrators Fluid dynamicists Leonardo da Vinci

Search: pिकास

- Pablo Picasso
- musée Picasso
- Museu Picasso
- Picasso Head
- Museo Picasso Málaga
- Picasso Museum
- Picasso Goes to Heaven
- Picasso's Studio
- Picasso-esque female head (Woman in hat)
- Pablo Picasso

Figure 3. Snapshots of the CH entity interface of LOD4Culture. (a) Extract of the visualization of CH site National Sculpture Museum –route /app/?type=Site&uri=http://www.wikidata.org/entity/Q1581475– showing label, short description, types and image from Wikidata; and long description and Wikipedia categories from DBpedia; source pages and social media buttons are also included. (b) Extract of the visualization of CH site Museo del Prado –route /app/type=Site&uri=http://www.wikidata.org/entity/Q160112– showing basic information, e.g. country, and a browsable list of the 5K artworks retrieved from Wikidata; clicking on an artwork will lead to a new CH entity in LOD4Culture, e.g. painting ‘Las Meninas’. (c) Extract of the visualization of artwork ‘Nighthawks’ –route /app/?type=Artwork&uri=http://www.wikidata.org/entity/Q83872– showing an image and a list of factual information; blue buttons link to other CH entities in LOD4Culture, e.g. artist Edward Hopper; gray buttons display modal windows with the corresponding source Wikidata or DBpedia pages. (d) Extract of the visualization of artist Leonardo da Vinci –route /app/?type=Artist&uri=http://www.wikidata.org/entity/Q762– showing label, short and long descriptions, types, and Wikipedia categories; the search textbox shows a list of suggestions for *pिकास*.

JavaScript libraries. Notably, the *Map renderer* relies on Leaflet¹⁸ for the interactive map. All mapping functionality needed in LOD4Culture is supported with this library through the use of markers, popups, map controls and interaction capabilities.

The user interface is built with Bootstrap¹⁹ to easily accommodate different browsers and screen sizes in a responsive way. The top-left bar of the map interface in Figure 2 uses Bootstrap components. The CH entity interface –see Figure 3– is entirely based on Bootstrap. For the creation of HTML pages, the *Entity renderer* makes usage of Mustache²⁰ templates –one for each type of CH entity–. In this way, the transformation of a JSON object into an HTML page is almost automatic. The utility functions of Underscore²¹ are employed for handling collection in all parts of the code. Lastly, usage of LOD4Culture is tracked with Google Analytics²².

LOD4Culture API is deployed on a test site of CRAFTS, accessible at <https://crafts.gsic.uva.es/apis/chsites/>. LOD4Culture includes a configuration file with the URL of this API along with a read token for accessing CRAFTS through Bearer authentication [23]. This file also contains access data to a Solr²³ text search server for retrieving CH entities by label (functionality FR6). Figures 2(d) and 3(d) shows how this functionality is integrated in the user interface.

Since LOD4Culture needs to be localized to English and Spanish (requirement NFR3), *LOD4Culture API* is configured to extract all labels and descriptions in these two languages. Moreover, the application includes a multilingual strings file with all the labels employed in the user interface. When LOD4Culture starts, it gets the browser language preferences to decide the session language that will be applied to every text shown.

The source code of LOD4Culture is available on GitHub.²⁴ A live version of the application²⁵ is openly available for anybody who wants to use it.

4. Impact of LOD4Culture

The test site of LOD4Culture²⁶ was launched in March 2022. We shared the application link with some colleagues and prepared several Twitter threads to promote LOD4Culture. One of these threads gain some visibility with more than 5.5K impressions and hundreds of engagements (likes, comments, retweets, etc.). Many of the interactions came from Semantic Web practitioners, CH experts, librarians, and organizations like Wikidata and DBpedia (the data providers of LOD4Culture), datos.gob.es (Spanish open government data site), Gobierno Abierto JCyL (regional open government data site in Castile y León), or Spanish Society for Scientific Documentation and Information (SEDIC).

As a result of this activity in social networks, we were contacted by DBpedia to feature a short community article about LOD4Culture in the DBpedia Newsletter of April 2022.²⁷ In May 2022, Universidad de Valladolid, our employer, released a press note about LOD4Culture,²⁸ while a Spanish newspaper published an article about this application.²⁹ In June 2022, datos.gob.es included LOD4Culture in its list of featured open data applications.³⁰

¹⁸<https://leafletjs.com/>

¹⁹<https://getbootstrap.com/>

²⁰<https://mustache.github.io/>

²¹<https://underscorejs.org/>

²²<https://analytics.google.com/>

²³<https://solr.apache.org/>

²⁴<https://github.com/guiveg/lod4culture>

²⁵<https://lod4culture.gsic.uva.es/>

²⁶See footnote 25.

²⁷<https://us9.campaign-archive.com/?u=9089abb541e9463749b7d284d&id=9976e75f69>

²⁸<https://comunicacion.uva.es/es/detalle/Los-Datos-Abiertos-Enlazados-permiten-a-un-profesor-de-la-UVa-crear-una-app-con-informacion-de-mas-de-500K-sitios-del-Patrimonio-Cultural-mundial/>

²⁹https://www.elespanol.com/castilla-y-leon/region/valladolid/20220504/profesor-uva-explorar-patrimonio-cultural-mundial-conocidas/669933259_0.html

³⁰<https://datos.gob.es/es/aplicaciones/lod4culture>

Table 7
Uptake of the test site of LOD4Culture.

Item	Value
# of users	1.1K
# of sessions	1.9K
Average time per session	2m 03s
# of page views	24.1K
% of landing page views (route R0)	15.0%
% of map page views (route R1)	78.0%
% of CH entity page views (route R2)	7.0%

Since traffic in the test site is tracked with Google Analytics, the uptake of LOD4Culture can be easily analyzed. Table 7 summarizes the collected data, obtained in August 2022. In a period of barely 5 months, more than 1.1K users have employed the application in 1.9K sessions (with an average time of 2 minutes and 3 seconds). Users mainly come from Spain (69.8%), Canada (9.9%), Germany (5.2%), United States (3.7%), and France (2.1%). They have viewed 24.1K pages, most of them corresponding to map page views. The employed devices include mobiles (51.7%), desktop computers (44.3%), and tablets (4.6%).

Tracked data also includes latencies of the pages served with LOD4Culture. A map page takes 1.5 seconds on average; the time elapsed in mobile devices is just 1.1 seconds due to small screens requiring less grid cells than desktop computers. In the case of CH entity pages, the average latency is 1.4 seconds.

5. Discussion

LOD4Culture is a CH LOD-based application that fulfills all the requirements in Table 2. LOD4Culture adheres to the REST principles of web design [10], so all the application state is encapsulated in the URL (see Table 5). As a result, URLs will refresh as a result of the user interaction, allowing them to be shared and ensuring that a URL will produce the same view regardless of the device employed.

The interactive map of LOD4Culture is arguably the most challenging part of the application, especially for accommodating different zoom levels (FR2). The solution devised is highly adaptable by partitioning the map view in a grid and by retrieving cell data in a two-step process: first requesting the number of CH sites in a cell, and then obtaining site data if it makes sense to plot it. In this way, network exchanges are reduced and client resources are not wasted by plotting hundreds or thousands of markers in a tiny area. In contrast, the browser of CH entities is much simpler, as the *Entity renderer* only has to produce an HTML page out of a JSON object.

The complexity of the application is greatly reduced by the use of a CRAFTS API. The interactive map only needs three template queries to gather the required data. Similarly, the CH entity browser just uses three RDF resources defined in the API model to fulfill its data needs (see sample calls C6–10 in Table 6). From the point of view of the application, it only sees JSON data and REST API calls. Behind the scenes, the CRAFTS API provides single access to three different endpoints by translating API requests into SPARQL queries. Despite this simplicity of use, the configuration file of LOD4Culture has been carefully crafted to match the needs of the application. In the case of template queries, this involves the selection of the prototype queries and then defining the parameters, e.g. the SPARQL query in Listing 1 is mapped to the `countSitesInbox` query template in Appendix A. Regarding RDF resources, the process begins with the identification of the object and data properties to be extracted; more fine-grained decisions can be made for embedding data or for setting additional restrictions –check the examples given in Section 3.5–. This process is entirely declarative and can be repurposed without requiring changes in the application or the sources, e.g. the limit of 5,000 artworks in a site collection can be set to something else or the sorting equation can be modified (check subelement `works` of `Site` and `Artist` in Appendix A).

Since LOD4Culture is an interactive application, we have taken special care to meet latency requirements (NFR2). We employ client-side caching along a user session to avoid duplicated requests to the API. Server-side caching in CRAFTS can benefit the whole community of LOD4Culture users, as well as data providers that will receive less traffic. In this regard, the use of a common grid with fixed lengths per zoom level contribute to make server-side caching more effective. Despite all these measures, latency is quite dependent on data providers. As discussed in Section 3.2, we had to set up our own dataset due to latency problems with Wikidata. Thanks to SW technologies, the burden to gather the data and upload it into a new endpoint was negligible and can be easily replicated.

All in all, LOD4Culture can be used for tourism and CH education purposes by lay users, i.e. without requiring knowledge of SW technologies. More than 1.1K users have employed the application in less than half a year. We have received very positive feedback through social media and the application has been featured in DBpedia Newsletter and in the open data applications list of datos.gob.es. Our future work includes user studies to better understand how they perceive LOD4Culture and which aspects can be improved.

Acknowledgements

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Appendix A. CRAFTS API configuration of LOD4Culture

```
{
  "apiId": "chsites",
  "endpoints": [
    {
      "id": "chsites",
      "sparqlURI": "http://185.179.104.18:8893/sparql",
      "graphURI": "http://chsites.gsic.uva.es",
      "httpMethod": "GET"
    },
    {
      "id": "wikidata",
      "sparqlURI": "https://query.wikidata.org/sparql",
      "httpMethod": "GET"
    },
    {
      "id": "dbpedia",
      "sparqlURI": "http://dbpedia.org/sparql",
      "graphURI": "http://dbpedia.org",
      "httpMethod": "GET"
    }
  ],
  "model": [
    {
      "id": "SiteType",
      "oprops": [
        {
          "label": "subclasses",
          "iri": "http://www.w3.org/2000/01/rdf-schema#subClassOf",
          "inv": true,
          "restrictions": [],
          "endpoint": "chsites"
        }
      ],
      "dprops": [
        {
          "label": "label",
          "iri": "http://www.w3.org/2000/01/rdf-schema#label",
```

```

1      "restrictions": [],
2      "endpoint": "chsites"
3    },
4    {
5      "label": "nindivs",
6      "iri": "http://www.w3.org/1999/02/22-rdf-syntax-ns#type",
7      "restrictions": [],
8      "inv": true,
9      "altResult": "count(distinct ?value) as ?nindivs",
10     "altVariable": "nindivs",
11     "endpoint": "chsites"
12   }
13 ],
14 "types": []
15 },
16 {
17   "id": "LabeledThing",
18   "oprops": [ ],
19   "dprops": [
20     {
21       "label": "label",
22       "iri": "http://www.w3.org/2000/01/rdf-schema#label",
23       "restrictions": [
24         "hint:Query hint:optimizer \"None\".",
25         "FILTER (lang(?value) = \"es\" || lang(?value) = \"en\")"
26       ],
27       "endpoint": "wikidata"
28     }
29   ],
30   "types": [ ]
31 },
32 {
33   "id": "Measure",
34   "oprops": [ ],
35   "dprops": [
36     {
37       "label": "value",
38       "iri": "http://wikiba.se/ontology#quantityAmount",
39       "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
40       "endpoint": "wikidata"
41     },
42     {
43       "label": "unit",
44       "iri": "http://wikiba.se/ontology#quantityUnit"><http://www.wikidata.org/prop/direct/P5061",
45       "restrictions": [
46         "hint:Query hint:optimizer \"None\".",
47         "FILTER (lang(?value) = \"es\" || lang(?value) = \"en\")"
48       ],
49       "endpoint": "wikidata"
50     }
51   ],
52   "types": [ ]
53 },
54 {
55   "id": "VisitorsPerYear",
56   "oprops": [ ],
57   "dprops": [
58     {
59       "label": "value",
60       "iri": "http://www.wikidata.org/prop/statement/P1174",
61       "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
62       "endpoint": "wikidata"
63     },
64     {
65       "label": "year",
66       "iri": "http://www.wikidata.org/prop/qualifier/P585",
67       "restrictions": [
68         "hint:Query hint:optimizer \"None\".",
69         "BIND (year(?value) as ?year)"
70       ],
71       "altResult": "?year",
72       "altVariable": "year",
73       "endpoint": "wikidata"
74     }
75   ],
76   "types": [ ]
77 }

```



```

1  },
2  {
3    "id": "LabeledThing-dbpedia",
4    "oprops": [ ],
5    "dprops": [
6      {
7        "label": "label",
8        "iri": "http://www.w3.org/2000/01/rdf-schema#label",
9        "restrictions": [
10         "FILTER (lang(?value) = \"es\" || lang(?value) = \"en\")"
11       ],
12       "endpoint": "dbpedia"
13     }
14   ],
15   "types": [ ]
16 },
17 {
18   "id": "LinkedThing",
19   "extends": "LabeledThing",
20   "oprops": [ ],
21   "dprops": [
22     {
23       "label": "sitelinks",
24       "iri": "http://wikiba.se/ontology#sitelinks",
25       "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
26       "endpoint": "wikidata"
27     },
28     {
29       "label": "statements",
30       "iri": "http://wikiba.se/ontology#statements",
31       "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
32       "endpoint": "wikidata"
33     }
34   ],
35   "types": [ ]
36 },
37 {
38   "id": "DetailedThing",
39   "extends": "LinkedThing",
40   "oprops": [
41     {
42       "label": "types",
43       "iri": "http://www.wikidata.org/prop/P31>/<http://www.wikidata.org/prop/statement/P31",
44       "embed": true,
45       "targetId": "LabeledThing",
46       "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
47       "endpoint": "wikidata"
48     },
49     {
50       "label": "image",
51       "iri": "http://www.wikidata.org/prop/direct/P18",
52       "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
53       "endpoint": "wikidata"
54     },
55     {
56       "label": "dben",
57       "iri": "http://www.w3.org/2002/07/owl#sameAs",
58       "inv": true,
59       "embed": true,
60       "targetId": "LabeledThing-dbpedia",
61       "endpoint": "dbpedia"
62     },
63     {
64       "label": "cats-dben",
65       "iri": "http://www.w3.org/2002/07/owl#sameAs",
66       "inv": true,
67       "embed": true,
68       "targetId": "LabeledThing-dbpedia",
69       "restrictions": [ "?value <http://purl.org/dc/terms/subject> ?cat ." ],
70       "altResult": "?cat",
71       "altVariable": "cat",
72       "endpoint": "dbpedia"
73     }
74   ],
75   "dprops": [
76     {

```

```

1      "label": "comment-dben",
2      "iri": "http://www.w3.org/2002/07/owl#sameAs",
3      "inv": true,
4      "restrictions": [
5          "?value <http://www.w3.org/2000/01/rdf-schema#comment> ?comment .",
6          "FILTER (lang(?comment) = \"es\" || lang(?comment) = \"en\")"
7      ],
8      "altResult": "?comment",
9      "altVariable": "comment",
10     "endpoint": "dbpedia"
11 },
12 {
13     "label": "desc",
14     "iri": "http://schema.org/description",
15     "restrictions": [
16         "hint:Query hint:optimizer \"None\".",
17         "FILTER (lang(?value) = \"es\" || lang(?value) = \"en\")"
18     ],
19     "endpoint": "wikidata"
20 },
21 ],
22 "types": [ ]
23 },
24 {
25     "id": "Site",
26     "extends": "DetailedThing",
27     "oprops": [
28         {
29             "label": "partOf",
30             "iri": "http://www.wikidata.org/prop/direct/P361",
31             "embed": true,
32             "targetId": "LabeledThing",
33             "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
34             "endpoint": "wikidata"
35         },
36         {
37             "label": "location",
38             "iri": "http://www.wikidata.org/prop/direct/P131",
39             "embed": true,
40             "targetId": "LabeledThing",
41             "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
42             "endpoint": "wikidata"
43         },
44         {
45             "label": "country",
46             "iri": "http://www.wikidata.org/prop/direct/P17",
47             "embed": true,
48             "targetId": "LabeledThing",
49             "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
50             "endpoint": "wikidata"
51         },
52         {
53             "label": "archStyle",
54             "iri": "http://www.wikidata.org/prop/direct/P149",
55             "embed": true,
56             "targetId": "LabeledThing",
57             "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
58             "endpoint": "wikidata"
59         },
60         {
61             "label": "architect",
62             "iri": "http://www.wikidata.org/prop/direct/P84",
63             "embed": true,
64             "targetId": "LabeledThing",
65             "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
66             "endpoint": "wikidata"
67         },
68         {
69             "label": "foundedBy",
70             "iri": "http://www.wikidata.org/prop/direct/P112",
71             "embed": true,
72             "targetId": "LabeledThing",
73             "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
74             "endpoint": "wikidata"
75         }
76     ]
77 },
78 {

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1      "label": "imageNight",
2      "iri": "http://www.wikidata.org/prop/direct/P3451",
3      "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
4      "endpoint": "wikidata"
5    },
6    {
7      "label": "imageInterior",
8      "iri": "http://www.wikidata.org/prop/direct/P5775",
9      "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
10     "endpoint": "wikidata"
11   },
12   {
13     "label": "imagePlanView",
14     "iri": "http://www.wikidata.org/prop/direct/P3311",
15     "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
16     "endpoint": "wikidata"
17   },
18   {
19     "label": "material",
20     "iri": "http://www.wikidata.org/prop/direct/P186",
21     "embed": true,
22     "targetId": "LabeledThing",
23     "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
24     "endpoint": "wikidata"
25   },
26   {
27     "label": "length",
28     "iri": "http://www.wikidata.org/prop/P2043/<http://www.wikidata.org/prop/statement/value-normalized/P2043",
29     "embed": true,
30     "targetId": "Measure",
31     "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
32     "endpoint": "wikidata"
33   },
34   {
35     "label": "width",
36     "iri": "http://www.wikidata.org/prop/P2049/<http://www.wikidata.org/prop/statement/value-normalized/P2049",
37     "embed": true,
38     "targetId": "Measure",
39     "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
40     "endpoint": "wikidata"
41   },
42   {
43     "label": "height",
44     "iri": "http://www.wikidata.org/prop/P2048/<http://www.wikidata.org/prop/statement/value-normalized/P2048",
45     "embed": true,
46     "targetId": "Measure",
47     "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
48     "endpoint": "wikidata"
49   },
50   {
51     "label": "area",
52     "iri": "http://www.wikidata.org/prop/P2046/<http://www.wikidata.org/prop/statement/value-normalized/P2046",
53     "embed": true,
54     "targetId": "Measure",
55     "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
56     "endpoint": "wikidata"
57   },
58   {
59     "label": "heritageDesignation",
60     "iri": "http://www.wikidata.org/prop/direct/P1435",
61     "embed": true,
62     "targetId": "LabeledThing",
63     "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
64     "endpoint": "wikidata"
65   },
66   {
67     "label": "visitorsPerYear",
68     "iri": "http://www.wikidata.org/prop/P1174",
69     "embed": true,
70     "targetId": "VisitorsPerYear",
71     "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
72     "endpoint": "wikidata"
73   },
74   {
75     "label": "works",
76     "iri": "http://www.wikidata.org/prop/direct/P276",
```

```

1      "inv": true,
2      "embed": true,
3      "targetId": "LabeledThing",
4      "restrictions": [ "hint:Query hint:optimizer \"None\".",
5                        "?value <http://wikiba.se/ontology#sitelinks> ?sitelinks .",
6                        "?value <http://wikiba.se/ontology#statements> ?statements .",
7                        "BIND ((3*?sitelinks + ?statements) as ?score) .",
8                        "FILTER NOT EXISTS {
9                            ?value p:P276 ?stloc .
10                           ?stloc ps:P276 ?iri ;
11                             pq:P582 [] .}",
12                        "FILTER NOT EXISTS {
13                            ?value p:P276 ?stloc .
14                           ?stloc ps:P276 ?iri ;
15                             pq:P585 [] .}"
16      ],
17      "orderBy": "DESC(?score)",
18      "limit": 5000,
19      "endpoint": "wikidata"
20  },
21  "dprops": [
22  {
23      "label": "inception",
24      "iri": "http://www.wikidata.org/prop/direct/P571",
25      "restrictions": [ "hint:Query hint:optimizer \"None\".",
26                        "BIND (year(?value) as ?inceptionYear)"
27      ],
28      "altResult": "?inceptionYear",
29      "altVariable": "inceptionYear",
30      "endpoint": "wikidata"
31  },
32  {
33      "label": "latWGS84",
34      "iri": "http://www.wikidata.org/prop/P625/<http://www.wikidata.org/prop/statement/value/P625>/<http://wikiba.se/ontology#geoLatitude>",
35      "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
36      "endpoint": "wikidata"
37  },
38  {
39      "label": "lngWGS84",
40      "iri": "http://www.wikidata.org/prop/P625/<http://www.wikidata.org/prop/statement/value/P625>/<http://wikiba.se/ontology#geoLongitude>",
41      "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
42      "endpoint": "wikidata"
43  }
44  ],
45  "types": [ ]
46  },
47  {
48      "id": "Artwork",
49      "extends": "DetailedThing",
50      "oprops": [
51      {
52          "label": "imageDbpedia",
53          "iri": "http://www.w3.org/2002/07/owl#sameAs</http://dbpedia.org/ontology/thumbnail",
54          "inv": true,
55          "restrictions": [ ],
56          "endpoint": "dbpedia"
57      },
58      {
59          "label": "partOf",
60          "iri": "http://www.wikidata.org/prop/direct/P361",
61          "embed": true,
62          "targetId": "LabeledThing",
63          "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
64          "endpoint": "wikidata"
65      },
66      {
67          "label": "creator",
68          "iri": "http://www.wikidata.org/prop/direct/P170",
69          "embed": true,
70          "targetId": "LabeledThing",
71          "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
72          "endpoint": "wikidata"
73      }
74      ],
75  }

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1      {
2        "label": "genre",
3        "iri": "http://www.wikidata.org/prop/direct/P136",
4        "embed": true,
5        "targetId": "LabeledThing",
6        "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
7        "endpoint": "wikidata"
8      },
9      {
10       "label": "movement",
11       "iri": "http://www.wikidata.org/prop/direct/P135",
12       "embed": true,
13       "targetId": "LabeledThing",
14       "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
15       "endpoint": "wikidata"
16     },
17     {
18       "label": "location",
19       "iri": "http://www.wikidata.org/prop/direct/P276",
20       "embed": true,
21       "targetId": "LabeledThing",
22       "restrictions": [ "hint:Query hint:optimizer \"None\".",
23         "FILTER NOT EXISTS {\n#quito localizaciones previas\n ?iri p:P276 ?stloc .\n ?stloc ps:P276 ?value ;\n pq
24         :P582 [] }",
25         "FILTER NOT EXISTS {\n#quito localizaciones puntuales\n ?iri p:P276 ?stloc .\n ?stloc ps:P276 ?value ;\n
26         pq:P585 [] }",
27         "FILTER NOT EXISTS {\n#quito paises\n ?value p:P31/ps:P31/<http://www.wikidata.org/prop/direct/P279>* <http
28         ://www.wikidata.org/entity/Q6256> }"
29       ],
30       "endpoint": "wikidata"
31     },
32     {
33       "label": "width",
34       "iri": "http://www.wikidata.org/prop/P2049/<http://www.wikidata.org/prop/statement/value-normalized/P2049",
35       "embed": true,
36       "targetId": "Measure",
37       "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
38       "endpoint": "wikidata"
39     },
40     {
41       "label": "height",
42       "iri": "http://www.wikidata.org/prop/P2048/<http://www.wikidata.org/prop/statement/value-normalized/P2048",
43       "embed": true,
44       "targetId": "Measure",
45       "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
46       "endpoint": "wikidata"
47     },
48     {
49       "label": "mass",
50       "iri": "http://www.wikidata.org/prop/P2067/<http://www.wikidata.org/prop/statement/value-normalized/P2067",
51       "embed": true,
52       "targetId": "Measure",
53       "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
54       "endpoint": "wikidata"
55     },
56     {
57       "label": "material",
58       "iri": "http://www.wikidata.org/prop/direct/P186",
59       "embed": true,
60       "targetId": "LabeledThing",
61       "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
62       "endpoint": "wikidata"
63     },
64     {
65       "label": "mainSubject",
66       "iri": "http://www.wikidata.org/prop/direct/P921",
67       "embed": true,
68       "targetId": "LabeledThing",
69       "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
70       "endpoint": "wikidata"
71     },
72     {
73       "label": "depicts",
74       "iri": "http://www.wikidata.org/prop/direct/P180",
75       "embed": true,
76       "targetId": "LabeledThing",

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1      "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
2      "endpoint": "wikidata"
3  },
4  "dprops": [
5      {
6          "label": "inception",
7          "iri": "http://www.wikidata.org/prop/direct/P571",
8          "restrictions": [ "hint:Query hint:optimizer \"None\".",
9              "BIND (year(?value) as ?inceptionYear)"
10         ],
11         "altResult": "?inceptionYear",
12         "altVariable": "inceptionYear",
13         "endpoint": "wikidata"
14     },
15     {
16         "id": "Artist",
17         "extends": "DetailedThing",
18         "oprops": [
19             {
20                 "label": "country",
21                 "iri": "http://www.wikidata.org/prop/direct/P27",
22                 "embed": true,
23                 "targetId": "LabeledThing",
24                 "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
25                 "endpoint": "wikidata"
26             },
27             {
28                 "label": "placeOfBirth",
29                 "iri": "http://www.wikidata.org/prop/direct/P19",
30                 "embed": true,
31                 "targetId": "LabeledThing",
32                 "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
33                 "endpoint": "wikidata"
34             },
35             {
36                 "label": "placeOfDeath",
37                 "iri": "http://www.wikidata.org/prop/direct/P20",
38                 "embed": true,
39                 "targetId": "LabeledThing",
40                 "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
41                 "endpoint": "wikidata"
42             },
43             {
44                 "label": "occupation",
45                 "iri": "http://www.wikidata.org/prop/direct/P106",
46                 "embed": true,
47                 "targetId": "LabeledThing",
48                 "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
49                 "endpoint": "wikidata"
50             },
51             {

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1      "endpoint": "wikidata"
2  },
3  {
4      "label": "works",
5      "iri": "http://www.wikidata.org/prop/direct/P170",
6      "inv": true,
7      "embed": true,
8      "targetId": "LabeledThing",
9      "restrictions": [ "hint:Query hint:optimizer \"None\".",
10         "?value <http://wikiba.se/ontology#sitelinks> ?sitelinks .",
11         "?value <http://wikiba.se/ontology#statements> ?statements .",
12         "BIND ((3*?sitelinks + ?statements) as ?score) ."
13     ],
14     "orderBy": "DESC(?score)",
15     "limit": 5000,
16     "endpoint": "wikidata"
17 },
18 ],
19 "dprops": [
20     {
21         "label": "dateOfBirth",
22         "iri": "http://www.wikidata.org/prop/direct/P569",
23         "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
24         "endpoint": "wikidata"
25     },
26     {
27         "label": "dateOfDeath",
28         "iri": "http://www.wikidata.org/prop/direct/P570",
29         "restrictions": [ "hint:Query hint:optimizer \"None\"." ],
30         "endpoint": "wikidata"
31     }
32 ],
33 "types": [ ]
34 },
35 ],
36 "queryTemplates": [
37     {
38         "id": "countSitesInbox",
39         "description": "Count the number of sites (variable \"count\") of an optional type (variable \"type\") in a bounding box
40             with GPS coordinates \"latnorth\", \"latsouth\", \"lngeast\", and \"lngwest\"",
41         "template": "SELECT count(distinct ?s) AS ?count WHERE {
42             ?s a <http://dbpedia.org/ontology/Place> ;
43             <http://www.w3.org/2003/01/geo/wgs84_pos#lat> ?lat ;
44             <http://www.w3.org/2003/01/geo/wgs84_pos#long> ?lng ;
45             rdfs:label [] .
46             FILTER (?lat <= {{latnorth}})
47             FILTER (?lat >= {{latsouth}})
48             FILTER (?lng <= {{lngeast}})
49             FILTER (?lng >= {{lngwest}})
50             {{#type}}
51             ?site a/rdfs:subClassOf* <{{type}}> .
52             {{/type}}",
53         "variables": [
54             "count"
55         ],
56         "parameters": [
57             {
58                 "label": "lngwest",
59                 "type": "number",
60                 "optional": false
61             },
62             {
63                 "label": "lngeast",
64                 "type": "number",
65                 "optional": false
66             },
67             {
68                 "label": "latnorth",
69                 "type": "number",
70                 "optional": false
71             },
72             {
73                 "label": "latsouth",
74                 "type": "number",
75                 "optional": false
76             }
77         ]
78     }
79 ]

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1      {
2        "label": "type",
3        "type": "iri",
4        "optional": true
5      },
6      "endpoint": "chsites"
7    },
8    {
9      "id": "sitesInbox",
10     "description": "Obtain sites (variable \"site\") of an optional type (variable \"type\"), their positions (variables \"lat\"
11                    \" and \"lng\"), their labels (variable \"label\"), their sitelinks (variable \"sitelinks\"), their statements (
12                    variable \"statements\"), their image (if exists, variable \"image\") and their descriptions (if exists, variable \"
13                    desc\") in a bounding box with GPS coordinates \"latnorth\", \"latsouth\", \"lngeast\", and \"lngwest\". This template
14                    query can be paginated with the optional parameters \"limit\" and \"offset\"",
15     "template": "SELECT DISTINCT ?site ?lat ?lng ?label ?sitelinks ?statements ?image ?desc WHERE {
16       ?site a <http://dbpedia.org/ontology/Place> ;
17       <http://www.w3.org/2003/01/geo/wgs84_pos#lat> ?lat ;
18       <http://www.w3.org/2003/01/geo/wgs84_pos#long> ?lng ;
19       <http://wikiba.se/ontology#sitelinks> ?sitelinks ;
20       <http://wikiba.se/ontology#statements> ?statements ;
21       rdfs:label ?label .
22       FILTER (?lat <= {{latnorth}})
23       FILTER (?lat >= {{latsouth}})
24       FILTER (?lng <= {{lngeast}})
25       FILTER (?lng >= {{lngwest}})
26       OPTIONAL { ?site <http://dbpedia.org/ontology/thumbnail> ?image .}
27       OPTIONAL { ?site <http://schema.org/description> ?desc .}
28       {{#type}}
29       ?site a/rdfs:subClassOf* <{{type}}> .
30       {{/type}}
31       {{#limit}}
32       LIMIT {{limit}}
33       {{/limit}}
34       {{^limit}}
35       LIMIT 1000
36       {{/limit}}
37       {{#offset}}
38       OFFSET {{offset}}
39       {{/offset}}",
40     "variables": [
41       "site",
42       "lat",
43       "lng",
44       "label",
45       "sitelinks",
46       "statements",
47       "image",
48       "desc"
49     ],
50     "parameters": [
51       {
52         "label": "lngwest",
53         "type": "number",
54         "optional": false
55       },
56       {
57         "label": "lngeast",
58         "type": "number",
59         "optional": false
60       },
61       {
62         "label": "latnorth",
63         "type": "number",
64         "optional": false
65       },
66       {
67         "label": "latsouth",
68         "type": "number",
69         "optional": false
70       },
71       {
72         "label": "type",
73         "type": "iri",
74         "optional": true
75       }
76     ]
77   }

```



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1      {
2          "label": "limit",
3          "type": "integer",
4          "optional": true
5      },
6      {
7          "label": "offset",
8          "type": "integer",
9          "optional": true
10     }
11 ],
12 "endpoint": "chsites"
13 },
14 {
15     "id": "mostPopularLocationInbox",
16     "description": "Obtain the location (variable \"loc\") with their coordinates (\"lat\" and \"lng\") in a bounding box with
17     GPS coordinates \"latnorth\", \"latsouth\", \"lngeast\", and \"lngwest\" with more sites in it (variable \"score\"),
18     \"template\": \"SELECT DISTINCT ?loc ?lat ?lng (count(distinct ?site) as ?score) WHERE {
19         ?loc a <http://dbpedia.org/ontology/Location> ;
20         <http://www.w3.org/2003/01/geo/wgs84_pos#lat> ?lat ;
21         <http://www.w3.org/2003/01/geo/wgs84_pos#long> ?lng .
22         FILTER (?lat <= {{latnorth}})
23         FILTER (?lat >= {{latsouth}})
24         FILTER (?lng <= {{lngeast}})
25         FILTER (?lng >= {{lngwest}})
26         ?loc ^<http://dbpedia.org/ontology/location> ?site .
27     }
28     GROUP BY ?loc ?lat ?lng
29     ORDER BY DESC(?score)
30     LIMIT 1\",
31     \"variables\": [
32         \"loc\",
33         \"lat\",
34         \"lng\",
35         \"score\"
36     ],
37     \"parameters\": [
38         {
39             \"label\": \"lngwest\",
40             \"type\": \"number\",
41             \"optional\": false
42         },
43         {
44             \"label\": \"lngeast\",
45             \"type\": \"number\",
46             \"optional\": false
47         },
48         {
49             \"label\": \"latnorth\",
50             \"type\": \"number\",
51             \"optional\": false
52         },
53         {
54             \"label\": \"latsouth\",
55             \"type\": \"number\",
56             \"optional\": false
57         }
58     ],
59     \"endpoint\": \"chsites\"
60 }
61 ]
62 }

```

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