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Social cohesion, Participation, and Inclusion through Cultural Engagement

D6.4 APIs Specifications

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4	AAU	AALBORG UNIVERSITET	Denmark
5	OU	THE OPEN UNIVERSITY	United Kingdom
6	IMMA	IRISH MUSEUM OF MODERN ART COMPANY	Ireland
7	GVAM	GVAM GUIAS INTERACTIVAS SL	Spain
8	PG	PADAONE GAMES SL	Spain
9	UCM	UNIVERSIDAD COMPLUTENSE DE MADRID	Spain
10	UNITO	UNIVERSITA DEGLI STUDI DI TORINO	Italy
11	FTM	FONDAZIONE TORINO MUSEI	Italy
12	CELI	MAIZE SRL	Italy
13	UH	UNIVERSITY OF HAIFA	Israel
14	CNR	CONSIGLIO NAZIONALE DELLE RICERCHE	Italy

Executive summary

SPICE is an EU H-2020 project dedicated to citizen curation of cultural heritage. To support citizen curation, the project research upon and develops an ecosystem of methods and tools co-designed by an interdisciplinary team of researchers, technologists, domain experts, and user communities.

In Work Package 6, we design and implement the formal semantics for an integrated socio-technical system for citizen curation. WP6, jointly with WP4, aims at devising a technical research infrastructure to integrate multiple knowledge graphs and ontologies, a linked data social media layer, interface components, annotation software, recommendation systems, data mining tools, and models/methods devised by the SPICE work packages.

In this deliverable, we report on the interim specifications for APIs that have been developed and used in SPICE.

Document History

Version	Release date	Summary of changes	Author(s) -Institution
V0.1	06/01/2022	Document structure preparation, template definition of APIs with instructions for contributors.	Enrico Daga (OU)
V0.2	13/03/2022	Collected information from partners	All partners
V0.25	29/03/2022	Introduction and formatting for consistency	Jason Carvalho (OU)
V0.3	07/04/2022	Code formatting, final API spec contributions, document structure revision	Jason Carvalho (OU)
V0.4	11/04/2022	Internal review	Luigi Asprino (Unibo), Pedro Gonzalez (PG)
V0.5	26/04/2022	Internal review comments incorporated	Jason Carvalho (OU)
V1.0	26/04/2022	Final version submitted to REA	UNIBO

Table of Contents

1 Introduction

SPICE is an EU H-2020 project dedicated to citizen curation of cultural heritage. To support citizen curation, the project research upon and develops an ecosystem of methods and tools co-designed by an interdisciplinary team of researchers, technologists, domain experts, and user communities.

In Work Package 6, we design and implement the formal semantics for an integrated socio-technical system for citizen curation. WP6, jointly with WP4, aims at devising a technical research infrastructure to integrate multiple knowledge graphs and ontologies, a linked data social media layer, interface components, annotation software, recommendation systems, data mining tools, and models/methods devised by the SPICE work packages.

In this interim deliverable, we describe progress of the APIs that have been developed for use within the SPICE project architecture and their specifications. These APIs are predominantly used by pilot applications to provide access to linked data, ontologies and reasoning services.

This will be followed by deliverable D6.8, detailing the final APIs specification and deployment.

The deliverable is structured as follows. For each API, this document introduces an overview of its intended purpose in relation to SPICE work packages and any relevant design methodology employed. This includes a report of how each API is currently being used within the SPICE project and, specifically, which pilot applications are making use of its features. Details of the technical underpinnings of the APIs are provided. Further background information on each API can be found in the dedicated deliverables. For each section, a guide for developers is made available that details the functions available within each API and how to use and configure them through the use of appropriate parameters. Example API requests and code snippets are also provided. The APIs detailed in this report are the **SPICE Linked Data Hub API**, the **User Model API**, the **Community Model API**, the **SPICE Semantic Annotator API** and the **Social Recommender API**. In addition, we include technical documentation of the Ontology server, query and reasoning services, which rely on Apache Jena[1]. Section 8 summarises and concludes the report.

2 SPICE Linked Data Hub API

2.1 Description of the system

The SPICE Linked Data Hub (LDH) was developed as a data infrastructure to support the acquisition and management of dynamic data from a variety of sources including: museum collection metadata and digital assets, social media events and user activities, systems' activities (e.g., recommendations, reasoning outputs), ontologies and linked data produced by pilot case studies.

The SPICE Linked Data Hub API is an instance of the API Factory software and underpins the functionality of the LDH Portal; the front-end web-interface component of the LDH. The LDH-API exposes a selection of REST-based user operations for creating, managing and consuming data as well as management functions which are used by the web portal for creating datasets and managing permissions. The API's position within the wider LDH system is shown in Figure 2.1.1

[1] http://jena.apache.org

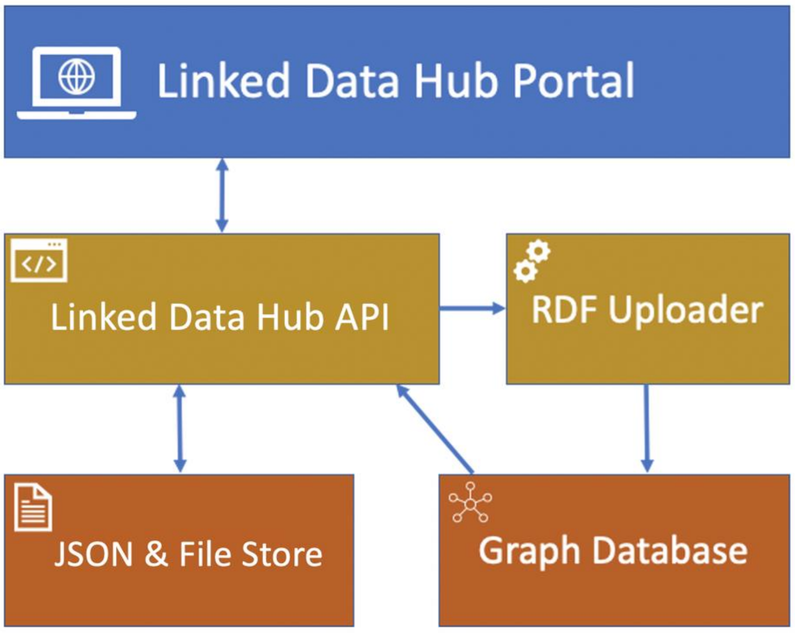


Figure 2.1.1: SPICE Linked Data Hub layout

As well as forming the technical backbone of the LDH portal, the LDH-API offers direct access to data storage and retrieval functions for SPICE application and pilot developers, through a series of REST endpoints. Full documentation on these API functions with example requests are included below in the *Guide for developers*.

The LDH-API operates primarily with JSON documents and makes use of MongoDB as its main data store. The LDH-API also supports storage and retrieval of files (binary and text-based) and associated metadata. Single datasets within the LDH can host a mixture of both JSON documents and binary files.

Parallel to the JSON data store is a graph database. All data within the LDH-API is also replicated into this graph database as RDF and made available through the API via read-only SPARQL queries.

2.2 Current applications and pilots

There are currently around 30 SPICE datasets accessible via the API that have been collected in the context of the following pilots:

- ***IMMA Viewpoints***
  IMMA Viewpoints is a mobile web application that encourages visitors to share their own response to artworks in the grounds of the Irish Museum of Modern Art (IMMA). The IMMA Viewpoints web application makes use of the LDH-API for file storage if artwork images and uses the JSON store for application configuration and the collection, moderation and review of user responses.

- ***IMMA Deep Viewpoints***
  Deep Viewpoints builds on the original IMMA Viewpoints prototype, making use of the IMMA Collection dataset stored on the Linked Data Hub. With Deep Viewpoints users can add artworks from the IMMA collection to their own personal collections. Deep Viewpoints has a separate dataset for storing data added by the users. This includes:
  - personal artwork collections
  - scripts and themes

- users and passwords
- data generated when a user undertakes a script (e.g. answers to questions)
- moderation status of contributions

- ***InSpice***
  A web framework for the creation of citizen curation activities within the different museums involved in SPICE. It proposes a template-based use model whereby museum curators can instantiate, manage and publish activities based on one of the templates provided by the framework. In this context, the LDH is used primarily as a storage, query and management space for the JSON files used to define specific instances of framework activities, as well as to access the various works and artifacts of the museums involved that already have an associated collection within the LDH.

- ***Hecht Museum – Student Experience***
  School students before, during and after a museum school trip at the Hecht Museum learn about their country's history and at the same time learn about the diversity of opinions regarding historical and national issues. Students learn to interpret museum artifacts according to their own personal views, reflect upon other students' opinions, connect their opinions with tangible artifacts at the museum, and perform citizen curation activities.
  The LDH infrastructure is used within this pilot for managing 5 major objects with basic CRUD (Create, Read, Update, Delete) operation: Users, User History, User Model Properties, User Generated Content and Sourced Content.

- ***Design Museum Helsinki – Pop-up VR Museum***
  The focus of the Design Museum Helsinki (DMH) Case Study is on developing the citizen curation methods by first gathering interpretations of DMH collection objects in workshops with selected end-user communities, namely senior citizens, remote dwellers, and asylum seekers (D7.3, pg33). An application known as the *Pop-up VR Museum* will be designed and accessible to audiences via portable VR headsets. Its users can access, interact, and engage with Design Museum Helsinki's collections.
  The experience of the Pop-up VR Museum is bound to be generative and dictated by a dynamic online repository of artefacts (3D models) and narratives (audio recordings and textual data) stored in the LDH. Mediators such as DMH staff, researchers, and members of affiliated institutions add artefact ontologies and narratives collected from end-user contributors to the LDH.

- ***GAM Game***
  The case study of the Gallery of Modern Art (GAM) in Turin, which addresses the inclusion of deaf people as target community, revolves around the notion of storytelling. Through the web app, called GAM Game, users can create short stories by collecting and sequencing the artworks from the museum collection, and add a personal response to each of the artworks in the story.
  The LDH infrastructure is used to manage three main entities in the interaction with the client:
  - User id and data, which include the links to the stories created by the user;
  - Stories, each including its own properties (date, title, etc.) and the list of links to artworks by which it is composed, and the user responses (stored in textual form) associated to each artwork in the story;
  - Artefacts, each accompanied by its metadata, which include both the ones extracted from the collection catalogues and the ones added by the sensemaking components (associated emotions, values, themes, etc.)

- ***Madrid - Treasure Hunt***
  The case study of the Natural Musem of Natural Sciences of Madrid (MNCN) revolves around treasure hunts in the museum. A treasure hunt consists of a series of searches guided by clues describing the object in the collection to be found. Once the object is found, the game provides relevant information related to it and may pose related questions.

  The LDH infrastructure is used in this pilot to manage a series of entities in its interaction with the client, such as user information, treasure hunt definitions, persistent application state information, artefacts referenced in treasure hunts and user responses and interactions.

2.3 Metadata

id	LDH-API
name	The Linked Data Hub API
description	The data API underpinning the SPICE Linked Data Hub. Supports reading writing and querying of JSON documents and binary files and querying of RDF data representations in SPARQL.
type	API
release-date	20/12/2021
release-number	v0.8.4 (main API) v0.1.6 (SPARQL addon)
work-package	WP4, WP6
pilot	ALL
keywords	JSON, RDF, SPARQL, REST
changelog	
licence	Apache Licence 2.0
release-link	https://github.com/mkdf/api-factory/releases/tag/v0.8.4 https://github.com/mkdf/api-factory-sparql/releases/tag/v0.1.6
image	
logo	
demo	https://api2.mksmart.org/ (access key required)
links	https://github.com/mkdf/api-factory/ (main code repository) https://github.com/mkdf/api-factory-sparql (SPARQL addon)
running-instance	http://spice.kmi.open.ac.uk
credits	Jason Carvalho (jason.carvalho@open.ac.uk); Enrico Daga (enrico.daga@open.ac.uk)
related-components	(reference other components' ids)

bibliography	

2.4 Guide for developers

The following is an overview of API functions. Full details on specific parameter usage are available via the LDH-API's live test interface at https://api2.mksmart.org/. Full OpenAPI specification is also referenced in the OpenAPI specification section below.

Access to and usage of the LDH-API is via API keys. API keys can be registered on the LDH web portal and assigned to specific datasets for either read, write or read/write access depending on the access control limitations set by the dataset owner. All API calls must be authenticated, using HTTP Basic Authentication, using the API key as both the username ***and*** password.

The API is made up of both user and management operations. Management operations are reserved for the creation and management of datasets, user keys and permissions. These management features are only available to API administrators and are also used as an interface to the API by the LDH web portal.

2.4.1 User operations

BROWSE

A read-only API endpoint for retrieving data. The endpoint provides options for paging, sorting,

filtering, field selection and complex database queries using MongoDB-style JSON queries.

Usage:

`GET /browse/{dataset-uuid}`

Parameters:

- `query` The filter query
- `sort` Specify fields on which to sort the data. Sort fields should be specified as a comma separated list. Data will be sorted in ascending order. To specify a field to sort in descending order precede that field with a minus ('-')
- `fields` Specify which fields to return. Fields should be specified as a comma separated list. Fields preceded with a minus ("-") will be excluded from the results. The "_id" field is always returned, unless explicitly excluded.
- `pagesize` Specify page size (defaults to a page size of 100)
- `page` Specify the page number of results to return (defaults to page 1)

Example request

```
curl -X GET "https://api2.mksmart.org/browse/123456789?sort=id&fields=id,value&pagesize=5&page=1" -H "accept: */*" -H "Authorization: Basic dGVzdDp0ZXN0"
```

OBJECT

The object endpoint is used for standard CRUD-style database operations; reading, writing, updating

and deleting. The HTTP method used (GET/POST/UPDATE/DELETE) defines which function is called.

Usage:

`GET /object/{dataset-uuid}` Retrieve documents from the dataset

Parameters

- `query` The filter query
- `limit` Limit the number of documents retruend (defaults to 100)

`POST/object/{dataset-uuid}` Create a new document in the dataset

`GET /object/{dataset-uuid}/{doc-id}` Retrieve a single document from the dataset

PUT /object/{dataset-uuid}/{doc-id} Update a document by ID

DELETE /object/{dataset-uuid}/{doc-id} Delete a document by ID

Example requests

Retrieve the most recent 5 objects from dataset 123456789:

curl -X GET "https://api2.mksmart.org/object/123456789?limit=5" -H "accept: */*" -H "Authorization: Basic dGVzdDp0ZXN0"

Post a new object to dataset 123456789:

curl -X POST "https://api2.mksmart.org/object/123456789" -H "accept: */*" -H "Authorization: Basic dGVzdDp0ZXN0" -H "Content-Type: application/json" -d "{\"_id\":\"1067\",\"attribute1\":\"42-a\",\"attribute2\":34.7}"

Retrieve object 1001 from dataset 123456789:

curl -X GET "https://api2.mksmart.org/object/123456789/1001" -H "accept: */*" -H "Authorization: Basic dGVzdDp0ZXN0"

Update object 1001 in dataset 123456789:

curl -X PUT "https://api2.mksmart.org/object/123456789/1001" -H "accept: */*" -H "Authorization: Basic dGVzdDp0ZXN0" -H "Content-Type: application/json" -d "{\"_id\":\"1067\",\"attribute1\":\"42-a\",\"attribute2\":34.7}"

Delete object 1001 from dataset 123456789:

curl -X DELETE "https://api2.mksmart.org/object/123456789/1001" -H "accept: */*" -H "Authorization: Basic dGVzdDp0ZXN0"

FILE

This API endpoint is used to manage binary files within a dataset.

Usage:

`GET /file/{dataset-uuid}` Retrieve a list of files for a single dataset

POST/file/{filename} Upload a new file

Parameters (supplied as multipart/form-data)

- `title` File title
- `description` File description
- `file` The binary file

GET /file/{filename}/{doc-id} Retrieve a single file

POST/file/{filename}/{doc-id} Update an existing file

Parameters (supplied as multipart/form-data)

- `title` File title
- `description` File description
- `file` The binary file

DELETE /file/{filename}/{doc-id} Delete a file

Example requests

Retreive a list of files for dataset 123456789

curl -X GET "https://api2.mksmart.org/file/123456789" -H "accept: */*" -H "Authorization: Basic dGVzdDp0ZXN0"

Upload a new file to dataset 123456789

curl -X POST "https://api2.mksmart.org/file/123456789" -H "accept: */*" -H "Authorization: Basic dGVzdDp0ZXN0" -H "Content-Type: multipart/form-data" -F "title=Image Title" -F "description=Image Description" -F "file=@myImage.jpg;type=image/jpeg"

Retrieve myImage.jpg from dataset 123456789

curl -X GET "https://api2.mksmart.org/file/123456789/myImage.jpg" -H "accept: */*" -H "Authorization: Basic dGVzdDp0ZXN0"

Update myImage.jpg in dataset 123456789

curl -X POST "https://api2.mksmart.org/file/123456789/myImage.jpg" -H "accept: */*" -H "Authorization: Basic dGVzdDp0ZXN0" -H "Content-Type: multipart/form-data" -F "title=New Title" -F "description=New Description" -F "file=@myImage.jpg;type=image/jpeg"

Delete image myImage.jpg from dataset 123456789

curl -X DELETE "https://api2.mksmart.org/file/123456789/myImage.jpg" -H "accept: */*" -H "Authorization: Basic dGVzdDp0ZXN0"

SPARQL

The SPICE Linked Data Hub API primarily operates with data in JSON format. However, all data that is pushed into the LDH is also replicated to RDF graphs so that it can be queried as linked data, using SPARQL. This API endpoint provides the facility to use read-only SPARQL queries against data stored within the LDH.

Usage:

/query/{dataset-uuid}/sparql

Parameters

- `query` The SPARQL query string (URL encoded)

Example request

This SPARQL query ...

SELECT * WHERE { ?s ?p ?o } LIMIT 5

... would be made on dataset 123456789 using the following HTTP request:

curl -X GET

"https://api2.mksmart.org/query/123456789/sparql?query=SELECT%20%2A%20WHERE%20%7B%20%3Fs%20%3Fp%20%3Fo%20%7D%20LIMIT%205" -H "accept: application/sparql-results+json" -H "Authorization: Basic dGVzdDp0ZXN0"

The results format can be chosen by passing an `Accept` header with the HTTP request. The following header values are supported:

- application/sparql-results+json
- application/sparql-results+xml
- text/csv
- text/tab-separated-values

2.4.2 Management operations

DATASETS

Used for managing datasets within the API.

Usage:

`GET /management/datasets` Retrieve a list of all datasets

`POST /management/datasets` Create a new dataset
Parameters (supplied in the request body):

- `dataset-uuid` The ID of the new dataset
- `key` The initial key to assign for use with this dataset which will be given read/write access. The key will be created if it does not already exist.

`GET /management/datasets/{dataset-uuid}` Retrieves a single dataset summary, including the number of documents in that dataset

Example requests

Retreive a list of datasets

curl -X GET "https://api2.mksmart.org/management/datasets" -H "accept: */*" -H "Authorization: Basic dGVzdDp0ZXN0"

Create a dataset with id 123456789 using key *key-001*

curl -X POST "https://api2.mksmart.org/management/datasets" -H "accept: */*" -H "Authorization: Basic dGVzdDp0ZXN0" -H "Content-Type: application/x-www-form-urlencoded" -d "dataset-uuid=123456789&key=key-001"

Retreive details for dataset 123456789

curl -X GET "https://api2.mksmart.org/management/datasets/123456789" -H "accept: */*" -H "Authorization: Basic dGVzdDp0ZXN0"

PERMISSIONS

Used for creating, assigning and managing key permissions on datasets

Usage:

GET /management/permissions Retrieve all permissions

`GET /management/permissions/{key}` Retrieve all permissions for a single key

`POST /management/permissions/{key}` Set/update permissions. If the key specified does not already exist, it will be created

Parameters (supplied in the request body):

- `dataset-id` The ID of the new dataset to set permissions on
- `read` Whether this key should have read permission – set to 0 or 1
- `write` Whether this key should have write permission – set to 0 or 1

Example requests

Assign key *key-001* read and write permissions to dataset 123456789

curl -X POST "https://api2.mksmart.org/management/permissions/key-001" -H "accept: */*" -H "Authorization: Basic dGVzdDp0ZXN0" -H "Content-Type: application/x-www-form-urlencoded" -d "dataset-id=123456789&read=1&write=1"

Assign key *key-001* read-only permission to dataset 123456789

curl -X POST "https://api2.mksmart.org/management/permissions/key-001" -H "accept: */*" -H "Authorization: Basic dGVzdDp0ZXN0" -H "Content-Type: application/x-www-form-urlencoded" -d "dataset-id=123456789&read=1&write=0"

Remove all permissions for key *key-001* on dataset 123456789

curl -X POST "https://api2.mksmart.org/management/permissions/key-001" -H "accept: */*" -H "Authorization: Basic dGVzdDp0ZXN0" -H "Content-Type: application/x-www-form-urlencoded" -d "dataset-id=123456789&read=0&write=0"

2.5 OpenAPI Specification

The LDH-API has been built with an OpenAPI specification. By doing so, a number of tools become available that can automatically interpret the specification and generate resources to speed up the use and adoption of the API by application developers. These resources include automatically web interfaces and automatically generated API clients in a number of programming languages.

The LDH-API uses a dynamically generated OpenAPI specification that is dependent on any addon modules that are currently being used. In addition to the core API software, the SPICE LDH-API also makes use of the optional SPARQL addon, as detailed in the API metadata table above.

A static version of the full OpenAPI 3.0.1 specifications in JSON format has been materialised for the purposes of this report, based on v0.8.4 of the main API software and version v0.1.6 of the SPARQL addon. These are available within the main API repository for the user operations and management operations in the following file locations:

/module/apif-core/view/apif/core/index/swagger-config-main.json

/module/apif-core/view/apif/core/index/swagger-config-management.json

The permanent link for the repository as of the release of this report is available here:

https://doi.org/10.5281/zenodo.6108050

3 User Model API

3.1 Description of the system

The purpose of the User Model (UM) is to store information about the user so that it can be reasoned about in uniform way, for use in the community model and the case study application. It can also be used to guide scripts and post-analysis.

The developer is exposed to a number of data objects (Users, User Properties, User Generated Content, User History) which can be accessed by basic CRUD (Create, Read, Update, Delete) functionality. The API provides examples how to derive User Model properties from user interactions and user-generated content.

For information about design principles see D3.1 and D3.3 documents

A typical scenario could be the following: content is shown to the user, s/he then writes something, this is analyzed by the Semantic Analyzer (cf. D3.2), the values derived are stored in the User Model for further use by the Community Model. To show the next bit of content the Social Recommender is used, (whose actions are based on the Community & User Models)

The User Model is currently used in the Hecht Case Study. It is used for two applications: 1) A student application which guides them through activities both prior to the visit, during the Museum visit and post the museum visit. 2) A teacher/researcher application which allow the teacher/researcher to examine the results and have some basic analysis performed

For more details see deliverable D3.3

3.2 Metadata

Id	UM-API
Name	User Model API
description	
Type	API
release-date	01/05/22
release-number	2.0
work-package	WP3
Pilot	
keywords	User Model, User Profile, REST
changelog	

Licence	Apache Licence 2.0
release-link	
Image	
Logo	none
demo	User Model Demo, Hecht Use Case
Links	
running-instance	
credits	Alan J. Wecker (ajwecker@gmail.com) Tsvika Kuflik (tsvikak@is.haifa.ac.il)
related-components	
bibliography	See D3.3

3.3 Guide for developers

In general, the flow is that the user interface (UI) stores a number of User History (UH) items, these can be used to create User Generated Content (UGC). These are analyzed by the Semantic Analyzer (SA) to create User Model Properties (UM). Alternatively, UM properties can be created directly from UH items.

See D3.3 for further detailed information.

user-controller

Usage:

`POST /api/v2/users2Create` - Create a new user. Note: ID should be anonymized

Parameters:

- No parameters

Request body

- **`User`** – see Schema (note: **`propertiesCount, ugcCount`**, **`userHistoryCount`** are not needed as they are derived values)

Returns

- OK – 200

`GET/api/v2/users2` - Get all users, sorted by name

Parameters:

- No parameters

Request Body:

- None

Returns

- **`200 – OK`** – Returns an array of Users

`DELETE/api/v2/users2Delete/{userid}` - Remove a user by userid

Parameters:

- Userid

u-history-controller

Usage:

`PUT /api/v2/uhistoryUpdate/{userid}` - Update a specific uhistory for a specific user

Parameters:

- `Userid`

Request Body:

- `UHistory`

`POST /api/v2/uhistoryCreate/{userid}` **- Add a new uhistory for a user**

Parameters:

- `Userid`

Request Body:

- `UHistory`

Returns:

- None

`GET /api/v2/uhistoryGetAllByUserid/{userid}` **- Get all properties for a specific user**

Parameters:

- `Userid`

Returns:

- `UHistory`

`GET /api/v2/uhistoryGetAllByPname/{pname} - Get all properties with a certain uhistory name`

Parameters:

- `Pname` - Property name

Request Body:

- None

Returns:

- `UHistory`

`GET /api/v2/uhistoryGet/{userid}/{pname} - Get a uhistory for a user with a specific name`

Parameters:

- `Userid`
- `Pname`

Request Body:

- None

Returns:

- Array of `UHistory`

`DELETE /api/v2/uhistoryDelete/{userid}/{pname} - Delete a specific uhistory for a specific user`

Parameters:

- **`Userid`**
- **`Pname`** – property name

Request Body:

- None

Returns:

- Array of `UHistory`

property-controller

Usage:

`POST /api/v2/propertyCreate/{userid}` **- Add a new property for a user**

Parameters:

- Userid: string
- Pname: string – property name

Request Body:

- Schema of Property

Returns:

- None

`GET /api/v2/propertyGetAllByUserid/{userid}` **- Get all properties for a specific user**

Parameters:

- **`Userid`**

Request Body:

- None

Returns:

- Array of `Property`

`GET /api/v2/propertyGetAllByPname/{pname} - Get all properties with a certain property name`

Parameters:

- **`Pname`** – property name

Request Body:

- None

Returns:

- Array of `Property`

`GET /api/v2/propertyGet/{userid}/{pname} - Get a specific property for a specific user`

Parameters:

- `Userid`
- `Pname` – property name

Request Body:

- None

Returns:

- `Property`

`DELETE /api/v2/propertyDelete/{userid}/{pname}` **- Delete a property for a specific user**

Parameters:

- `Userid`
- `Pname` – property name

Request Body:

- None

Returns:

- None

user-generated-content-controller

Usage:

`POST /api/v2/ugcCreate/{userid}` - Add a new User Generated Content for a user

Parameters:

- `Userid`

Request Body:

- `UGC`

Returns:

- None

`GET /api/v2/ugcGetByUseridAndName/{userid}/{ugcname}` - Get UGC for a specific user
Parameters:

- `Userid`
- `Ugcname` – ugc type name

Request Body:

- None

Returns:

- `UGC`

`GET /api/v2/ugcGetAllByUserid/{userid}` - Get all UGC for a specific user

Parameters:

- `Userid`

Request Body:

- None

Returns:

- Array of `UGC`

3.4 Schemas

User

source	String – Where was this info taken
context	String – Under what circumstances
id	integer($int64)
userid	string
password	string
ptype	String – participation type
role	String - (e.g. visitor, curator)
propertiesCount	integer($int64) - Derived number of user model properties
ugcCount	integer($int64) - Derived number of user generated content
getuHistoryCount	integer($int64) - Derived number of user history items

UHistory

source	string
context	string
id	integer($int64)
userid	string
pname	String- Property name
pvalue	String – Property Value

Property

source	String: From which ugc derived
context	application
id	integer($int64)
userid	String: from user db
pname	String: property name from ontology
pvalue	String: property value from ontology
datapoints	integer($int32)
origin	String: what artifact is this talking about

UserGeneratedContent

source	string
context	string
id	integer($int64)
userid	string
parentname	String- name of parent ugc if this is a comment to comment
parenttype	String – what type of media was parent
contentType	String – what is media type of this entry
ugcname	String – Generic Name of entry
ugcimage	String – If UGC contains image hled here
ugctags	String – User provided tags concerning ugc
ugcdesc	String – Written description of UGC passed to SA
ugcmeta	String – Explicit structured info by user about ugc

4 Community Model API

4.1 Description of the system

The Community Model API (CM-API) is the access point to the Community Model, which supports the social cohesion across groups, by the understanding of their differences and recognizing what they have in common. The community model is responsible for storing information about explicit communities that users belong to. Additionally, it creates the implicit communities inferred from user interactions and it computes the metrics needed to define the similarity (and dissimilarity) among group of users. The Community Model will support the recommender system in the variety and serendipity to the recommendation results, that will not be oriented to the typically popular contents or based on providing “more of the same” similar contents to the users (the so called, filter bubble) but to the inter-group similarities and the intra-group differences.

The CM-API exposes a set of REST-based operations for accessing information about implicit and explicit communities, as well as endpoints for operations related to similar and dissimilar communities. CM-API is also employed by the User Model to notify changes in user attributes and the creation of new user generated content. The CM-API acts as a façade that hides the modules that appear in figure 4.1.1

The CM-API primarily works using the community data stored in a Document Database implemented using MongoDB[2]. The access to this database is implemented using a Data Access Object (DAO) pattern[3], so it isolates the details for accessing the database. The information stored in the database is generated by the Community Model, described in Deliverables D3.3 and D3.5.

The CM-API is also responsible for supplying the Community Model with all the data about the users within the system. When a new user arrives at the SPICE infrastructure, the User Model notifies and provides the CM-API with the data provided by the user. Additionally, when a user contributes with interactions that are interesting according to the design of the SPICE case studies (interactions with museum items and concepts), the User Model will send these interactions to the Community Model using the CM-API. The Community Model is responsible for managing this new user data, updating the communities for the case study and store them in the database. This way, updated information about the communities will be accessible through the CM-API.

The CM-API will support the recommender system for accessing to the inter and intra group similarities and differences. CM-API will not be only used to know which communities a user belongs to, but also to retrieve de most similar o dissimilar communities to a given one. This information is not computed by the CM-API but created and stored by the community model and retrieved from the database.

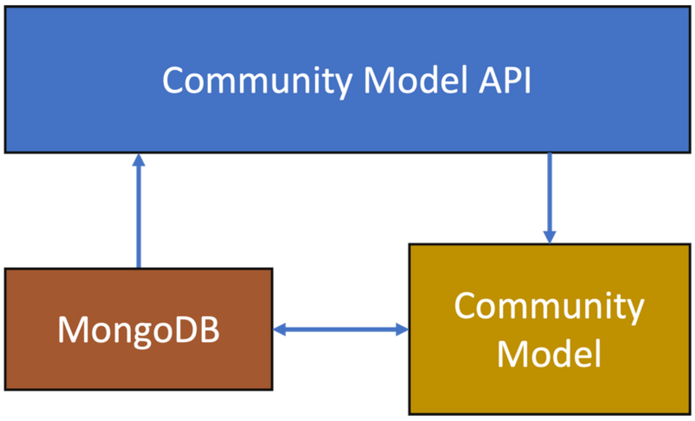


Figure 4.1.1. Overview of the CM-API infrastructure.

[2] https://www.mongodb.com/
[3] https://www.oracle.com/java/technologies/dataaccessobject.html

4.2 Metadata

id	CM-API
name	Community Model API
description	API for accessing data generated by the Community Model and for updating user data used by the Community Model for finding communities
type	API
release-date	01/03/2022
release-number	v.1.1
work-package	WP3
pilot	
keywords	Community detection, clustering, REST.
changelog	
licence	Apache Licence 2.0
release-link	
image	
logo	
demo	
links	https://app.swaggerhub.com/apis-docs/gjimenezUCM/SPICE-CommunityModelAPI/v.1.1 (Documentation) http://spice.fdi.ucm.es/ (Documentation) http://spice.fdi.ucm.es/v1.1 (API) https://github.com/spice-h2020/community-model-api (Main code repository)
running-instance	http://spice.fdi.ucm.es/
credits	Guillermo Jiménez Díaz (gjimenez@ucm.es), Jose Luis Jorro Aragoneses (jljorro@ucm.es), Belén Díaz Agudo (belend@ucm.es)
related-components	UM-API
bibliography	

4.3 Guide for developers

The following is an overview of API functions. Full OpenAPI specification is also referenced in the OpenAPI specification section below.

Source code repository contains a suite of integration tests that verifies that all the API functions are working correctly according to it OpenAPI specification.

The API is made up of three entry points with their corresponding operations:

4.3.1 Community operations

A read-only API endpoint for retrieving data about the communities.

Usage:

`GET /communities`

Access to a list of the all the communities in the community model

Parameters

None

Responses

A list with the communities contained in the community model. Every community is represented in an object with the following attributes:

- `id`: Unique id for the community in the community model
- `name`: Community name (for explicit communities)
- `explanation`: Community description (maybe empty). It can be computed by the explanation module from the Community Model or it can be provided by curators when defining explicit communities.
- `community-type`: Type of community (implicit or explicit). Implicit communities are computed by the community model. Explicit communities are provided by the user model.
- `users`: A list with the user ids who belong to the community.

Example request

```
curl -X GET "http://spice.fdi.ucm.es/v1.1/communities"
```

`GET /communities/{community-id}`

Returns information about a community

Parameters

None

Responses

An object with information about the requested community.

A response with status 400 is generated if the community model does not store any community with this community id.

Example request

```
curl -X GET "http://spice.fdi.ucm.es/v1.1/communities/621e53cf0aa6aa7517c2afdd"
```

`GET /communities/{community-id}/users`

Returns a list with the ids of the users who belong to a community.

Parameters

None

Responses

A list of user ids (cannot be empty).

A response with status 400 is generated if the community model does not contain any community with this community id.

Example request

```
curl -X GET
http://spice.fdi.ucm.es/v1.1/communities/621e53cf0aa6aa7517c2afdd/users
```

4.3.2 User operations

This endpoint provides GET/POST operations for requesting the communities that a user belongs to and updating data about user attributes and user generated content.

`GET /users/{user-id}/communities`

Returns a list with the communities that the user belongs to.

Parameters

None

Responses

A list of objects with information about the communities that the user belongs to (cannot be empty).

A response with status 400 is generated for invalid user ids.

Example request

curl -X GET "http://spice.fdi.ucm.es/v1.1/users/23/communities"

`POST /users/{user-id}/update-generated-content`

This service is employed to inform the Community Model about the User Generated Content (UGC) updated in the User Model.

Request Body

A list with UGC objects that represent the information about the user that will be added to the community model. Every UGC follows the schema provided by the User Model (User Generated Content Schema in section **Errore. L'origine riferimento non è stata trovata.**) is represented in an object with the following attributes:

- `id`: Unique id for the UGC in the user model
- `userid`: Unique user id
- `origin`: Unique id for the item or concept in the museum that this user generated content refers to.
- `source_id`: Unique id for the UGC that this content is derived from.
- `source`: Description about the UGC that this content is derived from.
- `pname:` Name of the property included in this UGC.
- `pvalue:` Value of the property included in this UGC.
- `context:` Context of the property included in this UGC.
- `datapoints`**:** Number of datapoint used to generate this UGC

Only (id, userid, origin, source_id, pname, pvalue) are mandatory required.

Responses

A response with status 400 is generated if the user-id in the url differs from any userid in the objects contained in the list in the body request.

If correct, an empty response with status 204 is generated.

Example request

- curl -d '[{"id":"12345","userid":"23","origin":"14294","source_id":"1893","source":"content desc","pname":"DemographicGender","pvalue":"F","context":"application

P:DemographicsPrep","datapoints":0}]' -H "Content-Type: application/json" -X POST "http://spice.fdi.ucm.es/v1.1/users/23/update-generated-content"

4.3.3 Similarity operations

A read-only API endpoint for retrieving information about similarity and dissimilarity between communities.

Usage:

`GET /communities/{community-id}/similarity`

Returns a list with the k most similar communities to the chosen one in the community model.

Parameters

`k`: Size of the result (k most similar communities).

Responses

A list with the similarity scores between the parameter community and the k-most similar communities, in descending order. Every similarity score is represented in an object with the following attributes:

- `target-community-id`: Unique id for the community parameter in the community model
- `other-community-id`: Unique id for another community in the community model
- `value`: Similarity value between the specified communities.
- `similarity-function`: similarity function employed to compute this similarity score.

A response with status 400 is generated if the community model does not contain any community with this community id.

Example request

```
curl -X GET
"http://spice.fdi.ucm.es/v1.1/communities/621e53cf0aa6aa7517c2afdd/similarity?k=
5"
```

`GET /communities/{community-id}/similarity/{other-community-id}`

Returns the similarity score between two communities.

Parameters

None

Responses

A similarity score object. The similarity score is always 1.0 if both communities are the same.

A response with status 400 is generated if the community model does not contain any community with any of the community ids contained in the URL.

Example request

```
curl -X GET
"http://spice.fdi.ucm.es/v1.1/communities/621e53cf0aa6aa7517c2afdd/similarity/72
1e53cf0aa6aa7517c2afdd"
```

`GET /communities/{community-id}/dissimilarity`

Returns a list with the k most dissimilar communities to the chosen one in the community model.

Parameters

`k`: Size of the result (k most similar communities).

Responses

A list with the dissimilarity scores between the parameter community and the k-most dissimilar communities, in descending order. Every dissimilarity score is represented in an object with the following attributes:

- `target-community-id`: Unique id for the community parameter in the community model
- `other-community-id`: Unique id for another community in the community model
- `value`: Dissimilarity value between the specified communities.
- `similarity-function`: dissimilarity function employed to compute this dissimilarity score.

A response with status 400 is generated if the community model does not contain any community with this community id.

Example request

```
curl -X GET "http://spice.fdi.ucm.es/v1.1/communities/621e53cf0aa6aa7517c2afdd/dissimilarity?k=5"
```

`GET /communities/{community-id}/dissimilarity/{other-community-id}`

Returns the dissimilarity score between two communities.

Parameters

None

Responses

A dissimilarity score object. The dissimilarity score is always 0.0 if both communities are the same.

A response with status 400 is generated if the community model does not contain any community with any of the community ids contained in the url.

Example request

```
curl -X GET "http://spice.fdi.ucm.es/v1.1/communities/621e53cf0aa6aa7517c2afdd/dissimilarity/721e53cf0aa6aa7517c2afdd"
```

4.4 OpenAPI Specification

CM-API uses a dynamically generated OpenAPI specification. A static version of the full OpenAPI 3.0.1 specifications in YAML format has been materialised for the purposes of this report, based on v1.1 of the CM-API. It is available within the CM-API repository in the following file location:

http://spice.fdi.ucm.es/openapi.yaml

5 SPICE Semantic Annotator API

5.1 Description of the system

Spice Semantic Annotator (SSA) is an annotation service for the semantic enrichment of textual contents, targeting user generated contents as well as descriptions of museum artifacts. The service is multilingual and supports English, Finnish, Hebrew, Italian and Spanish. It consists of a natural language processing pipeline that performs Sentiment Analysis, Emotion Detection and Entity Linking.

The process of semantic annotation is realized by a **Natural Language Processing Pipeline** that includes different analysis modules, each one responsible for annotating the document with respect to a specific aspect: sentiment analysis, emotion detection, entity linking. The overall process is exposed by means of standard **RESTful[1] APIs** and produces a JSON-LD[2] document as output. **JSON-LD** is a JSON-based serialization for Linked Data that can be seamlessly stored in the Linked Data hub of WP4.

SSA analyses textual contents collected from museum visitors interacting with the activities scripted in the interfaces (WP5) and realized for the different use cases (WP7). The service annotates contents with respect to the ontological models developed in WP6 and generates as output an RDF graph to be stored in the linked data hub developed by WP4. Such analysis puts the visitor at the centre by interpreting and then enhancing his point of view and contributes to:

- the process of defining profiles of each visitor in order to build Community Models (the profiles and models are generated by task 3.1).
- the design of an advanced recommendation engine (task 3.3)

The whole pipeline is designed following a **Microservice Architecture**[3] approach in order to isolate and decouple the different analysis modules implementing them with different technologies (e.g. Java, Python, R), and exploiting a wide variety of models and solutions available on the open source. The pipeline is deployed as a Microservice Architecture on a Kubernetes[4] cluster with the replication of the analysis components managed by KEDA[5].

- **Kubernetes** is an open-source system for automating deployment, scaling, and management of containerized components (e.g., Docker[6] images).
- **KEDA** instead is a single-purpose and lightweight component that can be added into any Kubernetes cluster and acts as a Kubernetes-based Event Driven Autoscaler; with KEDA it is possible to configure the scaling (up and down) of any container in Kubernetes based on the number of events needing to be processed.

Such architectural solutions were chosen in order to achieve horizontal scalability. In particular, we (1) increase the instances of a given component when the number of documents waiting to be processed exceeds a certain threshold and decrease their number when they go below the threshold. This approach allows us to **ensure service response time** regardless of the system workload and to r**educe economic and energetic costs** by dismissing computational resources when they are not needed.

The whole system is deployed to AWS[7] cloud resources, on servers located in the European region. The architecture and layout of the service is provided below in figure 5.1.1.

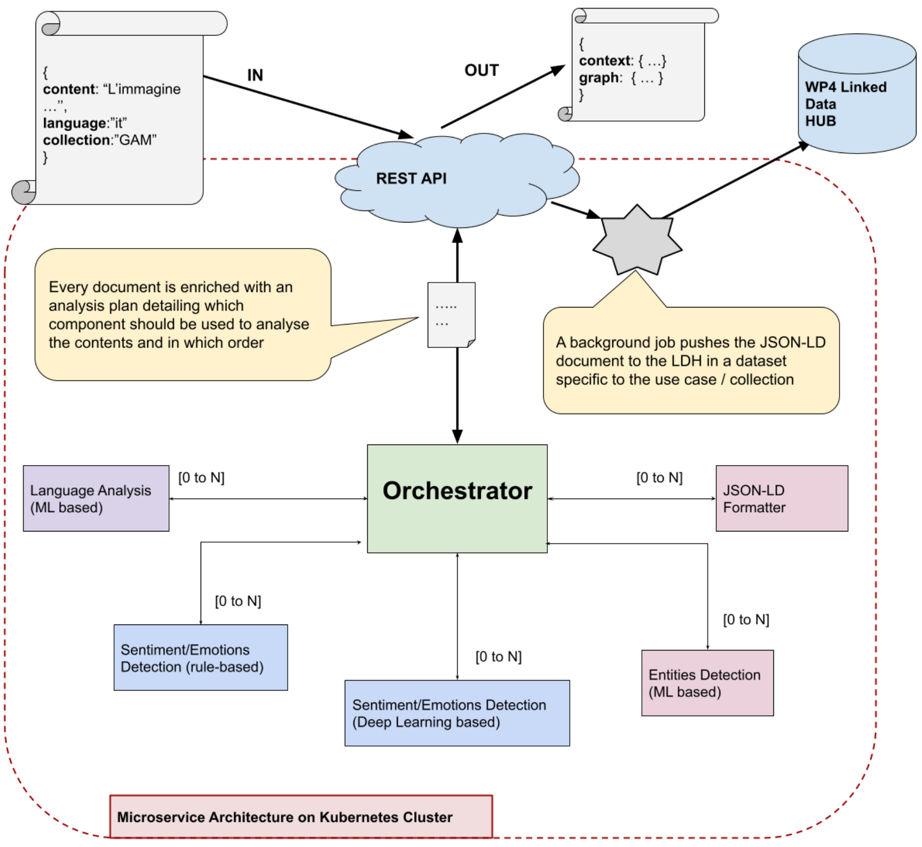

{
content: "L'immagine …",
language:"it"
collection:"GAM"
}
IN
OUT
{
context: { …}
graph: { … }
}
WP4 Linked Data HUB
REST API
Every document is enriched with an analysis plan detailing which component should be used to analyse the contents and in which order
A background job pushes the JSON-LD document to the LDH in a dataset specific to the use case / collection
Orchestrator
Language Analysis (ML based)
[0 to N]
JSON-LD Formatter
Sentiment/Emotions Detection (rule-based)
Sentiment/Emotions Detection (Deep Learning based)
Entities Detection (ML based)
Microservice Architecture on Kubernetes Cluster

Figure 5.1.1. SPICE Semantic Annotator Architecture

This section describes SSA API detailing about its input, output and usage. The service is exposed through standard REST API behind a Basic Authentication[18] scheme. The service can be accessed at the URL: `https://sophia42-demo.aws.celi.it/<LANGCODE>/spice/analysis`

`<LANGCODE>` is a path parameter and it is used to specify the language content, the supported values are:

- `en`
- `es`
- `fi`
- `it`
- `he`

The service can be accessed with:

∉ POST requests: accepting a json document as input, with the following properties:
  - `content`: *mandatory* - the textual contents to be analyzed
  - `ns_prefix`: *optional* - the prefix used for representing the textual content in the JSON-LD response document, default value is "`spice`"
  - `ns_uri`: *optional* - the URI of the ontology used for representing the textual contents in the JSON-LD document, default value is "`https://w3id.org/spice/resource/`"
  - `collection`: *optional* - a textual label representing the collection/museum/use case, default value is "`spice`"

5.2 Metadata

id	SSA
name	SPICE Semantic Annotator API
description	Final Version of SSA
type	Rest API
release-date	24/02/2022
release-number	1.0
work-package	WP3
pilot	
keywords	Semantic annotation of User Generated Contents
changelog	
licence	
release-link	
image	
logo	
demo	
links	
running-instance	
credits	Alessio Bosca (alessio.bosca@h-farm.com)
related-components	
bibliography	

5.3 Guide for developers

An example API request to SSA service API, using curl[19]:

```
curl --user USR:PWD[20] -X POST https://sophia42-demo.aws.celi.it/en/spice/analysis -H 'Content-Type: application/json' -d '{"content":"I love Picasso'\''s Guernica but I am absolutely terrified by the screaming horse!", "collection":"test"}'
```

SSA API request example via CURL

The same request expressed in python, using the popular requests[21] lib:

```
import requests

def testService(text: str, lang: str) -> object:
   r = requests.post('https://sophia42-demo.aws.celi.it/'+lang+'/spice/analysis',
                json={"content":text, "collection":"test"},
                auth=('USR', 'PWD'))
```

```
    print(r.json())

if __name__ == "__main__":
    testService("I love Picasso's Guernica, but I am absolutely terrified by the screaming horse!", 'en')
```

SSA API request example via Python

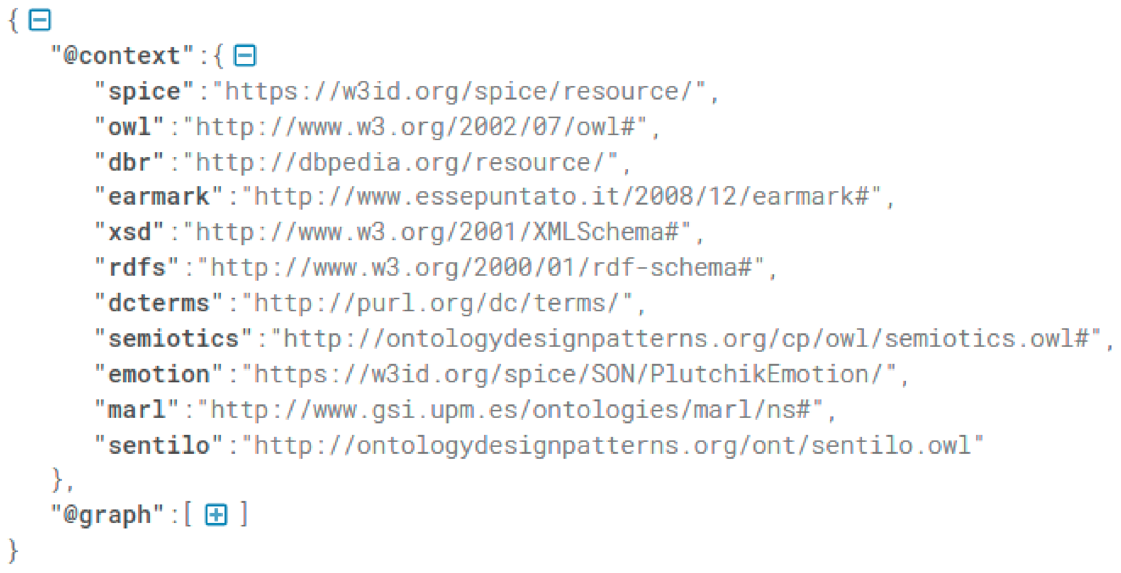
Please notice that USR and PWD **MUST** be substituted with a real authentication in order to access the API.

The Semantic Annotator exposes the NLP pipeline analysis results as a JSON-LD[22] document. JSON-LD is a method of encoding linked data using JSON. Linked Data is structured data which is interlinked with other data so it becomes more useful through semantic queries. It builds upon standard Web technologies such as HTTP, RDF and URIs. More details on the Linked Data Hub designed and deployed by WP4 can be found in **D4.1 *Linked Data server technology: requirements and initial prototype.***

The JSON-LD document contains two main sections:

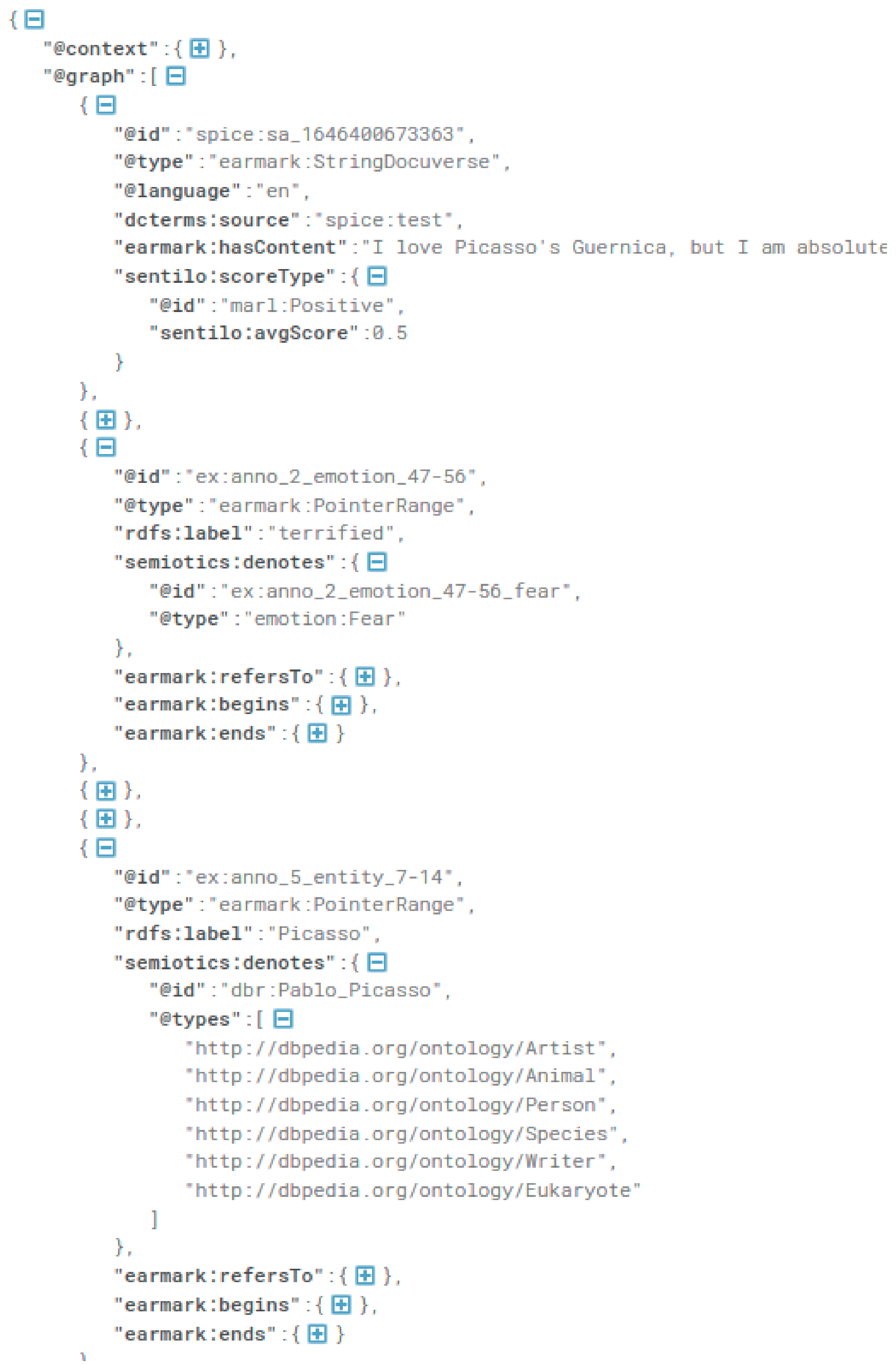
- **Context**: detailing the ontologies used to describe data along with their prefix (used for compact notations in the graph section)
- **Graph**: containing a set of RDF triples represented as JSON objects; in our case the textual contents along with some metadata, followed by a set of annotations referencing the textual spans that can be linked to an emotion, a sentiment value or an entity (within DBPedia knowledge graph)

The following image represents the service output for the input: "I love Picasso's Guernica, but I am absolutely terrified by the screaming horse!"



```
{ ⊟
   "@context":{ ⊟
      "spice":"https://w3id.org/spice/resource/",
      "owl":"http://www.w3.org/2002/07/owl#",
      "dbr":"http://dbpedia.org/resource/",
      "earmark":"http://www.essepuntato.it/2008/12/earmark#",
      "xsd":"http://www.w3.org/2001/XMLSchema#",
      "rdfs":"http://www.w3.org/2000/01/rdf-schema#",
      "dcterms":"http://purl.org/dc/terms/",
      "semiotics":"http://ontologydesignpatterns.org/cp/owl/semiotics.owl#",
      "emotion":"https://w3id.org/spice/SON/PlutchikEmotion/",
      "marl":"http://www.gsi.upm.es/ontologies/marl/ns#",
      "sentilo":"http://ontologydesignpatterns.org/ont/sentilo.owl"
   },
   "@graph":[ ⊞ ]
}
```

Figure 6.3.1. SSA JSON-LD output - @context section



```
{ ⊟
   "@context":{ ⊞ },
   "@graph":[ ⊟
      { ⊟
         "@id":"spice:sa_1646400673363",
         "@type":"earmark:StringDocuverse",
         "@language":"en",
         "dcterms:source":"spice:test",
         "earmark:hasContent":"I love Picasso's Guernica, but I am absolute
         "sentilo:scoreType":{ ⊟
            "@id":"marl:Positive",
            "sentilo:avgScore":0.5
         }
      },
      { ⊞ },
      { ⊟
         "@id":"ex:anno_2_emotion_47-56",
         "@type":"earmark:PointerRange",
         "rdfs:label":"terrified",
         "semiotics:denotes":{ ⊟
            "@id":"ex:anno_2_emotion_47-56_fear",
            "@type":"emotion:Fear"
         },
         "earmark:refersTo":{ ⊞ },
         "earmark:begins":{ ⊞ },
         "earmark:ends":{ ⊞ }
      },
      { ⊞ },
      { ⊞ },
      { ⊟
         "@id":"ex:anno_5_entity_7-14",
         "@type":"earmark:PointerRange",
         "rdfs:label":"Picasso",
         "semiotics:denotes":{ ⊟
            "@id":"dbr:Pablo_Picasso",
            "@types":[ ⊟
               "http://dbpedia.org/ontology/Artist",
               "http://dbpedia.org/ontology/Animal",
               "http://dbpedia.org/ontology/Person",
               "http://dbpedia.org/ontology/Species",
               "http://dbpedia.org/ontology/Writer",
               "http://dbpedia.org/ontology/Eukaryote"
            ]
         },
         "earmark:refersTo":{ ⊞ },
         "earmark:begins":{ ⊞ },
         "earmark:ends":{ ⊞ }
      }
```

Figure 6.3.2. JSON-LD output - @graph Section

In the LDH, a specific dataset for each museum is used to collect all users' generated content related to a specific use case. One of the parameters of SSA API consists of a label for the collection of the contents to be analysed. If the value of the collection parameter refers to one of the museum use cases, then the JSON-LD document is saved in a use case specific dataset, otherwise a fallback test dataset is used.

The following table details the museum specific collections along with the relative dataset UUID; the fallback test dataset details are also reported at the end of the table.

Collection - Museum Use Case	Dataset UUID in LDH
IMMA	b3631f48-2657-4cd3-96fa-4887c6e0c63a
GAM	810d60a6-c7be-4299-be2e-c86d988f58ad
HECHT	4125ba0c-adbe-4b0b-a2ff-3a5dde29d088
MNCN	2ae73c0c-84ad-416c-b17b-23032a75f0ef
DMH	514c5676-2560-47a9-bab4-76ff42eb0b83
test	85c109bb-6090-4110-9422-79303183fae5

6 Social Recommender API

6.1 Description of the system

The purpose of this component is to provide social recommendations of user generated content to aid in the implementation of the interpretation-reflection loop of WP2; primarily reflection. You can choose similar viewpoints by different communities to engender inclusion and use different viewpoints by similar communities to try and engender cohesion. The recommendations are based on similar and dissimilar views of topics and subjects and material from both similar and dissimilar communities. Views of the subject are collected by the Semantic Analyzer. This stored in the UM for use by the CM who generate similar and dissimilar communities which is then used by the SR to provide recommendations.

The API consists of a single call which attempts to do as much as possible for the developer in providing recommendations of user generated content. Communities can either be explicit or implicit

The idea is to give the script designer the possibility to find people who have common background but have either a different or same opinion or alternatively people who think alike but have a different or same opinion

A typical scenario is that a recommendation of user generated content (opinion, curation and so on) is requested. User generated content is chosen based on the analysis of the Semantic Analyser (similar or dissimilar) it is then filtered by content belonging to users of certain communities.

A prototype demo is incorporated in the *Hecht studentmgr* demo.

For more detailed information See D3.6.

6.2 Metadata

id	SR-API
name	Social Recommender API
description	Provide similar/dissimilar recommendations bases on similar/disimilar communities
type	API

release-date	1-5-2022
release-number	1.0
work-package	WP3
pilot	Hecht studentmgr
keywords	Social Recommender, De-polarization
changelog	
licence	Apache
release-link	
image	
logo	
demo	Hecht studentmgr
links	
running-instance	
credits	Alan J. Wecker (ajwecker@gmail.com) Tsvika Kuflik (tsvikak@is.haifa.ac.il)
related-components	
bibliography	See D3.6

6.3 Guide for developers

The API is called using a standard Spring Boot REST API call.

Recommendation-controller

Usage:

GET/api/v2/srecommend/{userid}/{subject} - Get recommendation for user

Parameters:

- `userid` - from UM
- `subject` - from use case ontology

Body:

- `rconfig` – see Schemas

Returns:

- `Recommendation` – see Schemas

6.4 API Schemas

RecommendationConfig

subjectSimilarity	String {SA –same as, DF –Different From, DK - Don't Care
communitySimilarity	String {SA –same as, DF –Different From, DK - Don't Care
numRecommendations	integer($int32)

explicitCommunities	[...]
implicitCommunities	[...]

Recommendation

ugcid	String {content id to retrieve}
explanation	String {Why this recommendation given}
entrancement	String {personalized enhancement why you might like this recommendation}

7 Ontology server, query and reasoning services

The ontology server in the SPICE technical infrastructure runs via a virtual machine instance, within the HPC4AI cloud infrastructure of the Department of Computer Science of the University of Turin (https://hpc4ai.unito.it/), and managed through the OpenStack console (https://www.openstack.org/).

The server has a total volume storage of 500GB, a RAM of 256GB, an availability of 8VCPUs (currently the SPICE virtual machine uses 4 VCPUs) and is equipped with the Ubuntu 18.04 operating system. It has an external IP address reachable by other services via HTTP. The SPICE Server hosts and integrates the following software components:

- OWL-API 5 (http://owlcs.github.io/owlapi/), a Java API and reference implementation for creating, manipulating, serialising OWL Ontologies and using OWL Reasoners;
- HERMIT (http://www.hermit-reasoner.com/), a standard ontology-based reasoner used to infer taxonomical and hidden relationships between elements from a knowledge base. The reasoner is called externally via the OWL-API;
- ONT-API 2.0.0 (https://github.com/owlcs/ont-api), a java library for converting the OWL and OWL 2 ontologies (with the materialized inferences obtained through reasoning) in RDF-like graph models stored as triples;
- JENA (https://jena.apache.org/index.html), an Apache framework for storing, manipulating and accessing RDF graphs.
- Fuseki 2 (https://jena.apache.org/documentation/fuseki2/index.html) a SPARQL server of the Apache family used to expose the Jena models (containing the inferred triples) to other services both via a public interface (available at this address: http://130.192.212.225/fuseki/) and via SOH (SPARQL Over HTTP): a set of server-independent command-line scripts for working with SPARQL 1.1 offering HTTP access to external services. Fuseki 2 is hosted in a Tomcat Server to be exposed and reachable on the Web. The overall architecture is illustrated in the figure 7.0.1 below.

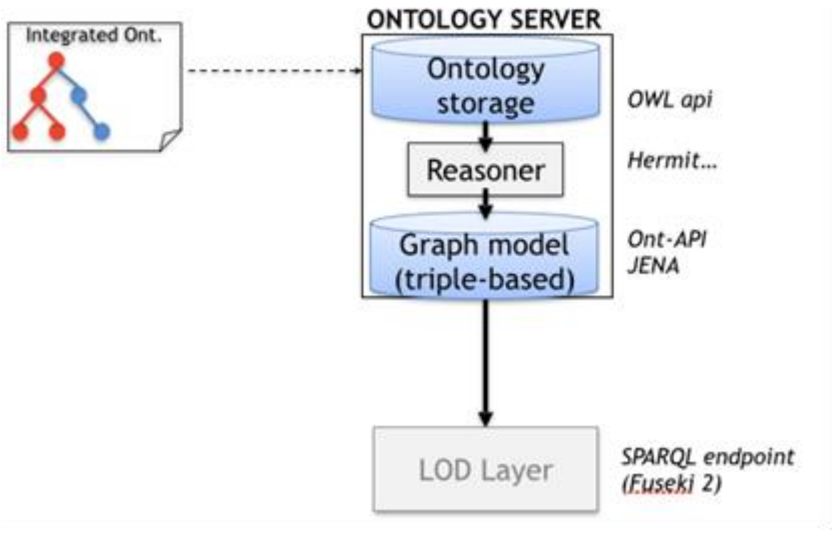


Figure 7.0.1. Overview of the components of the Ontology Server and Reasoning Architecture

This architecture implements the following workflow:

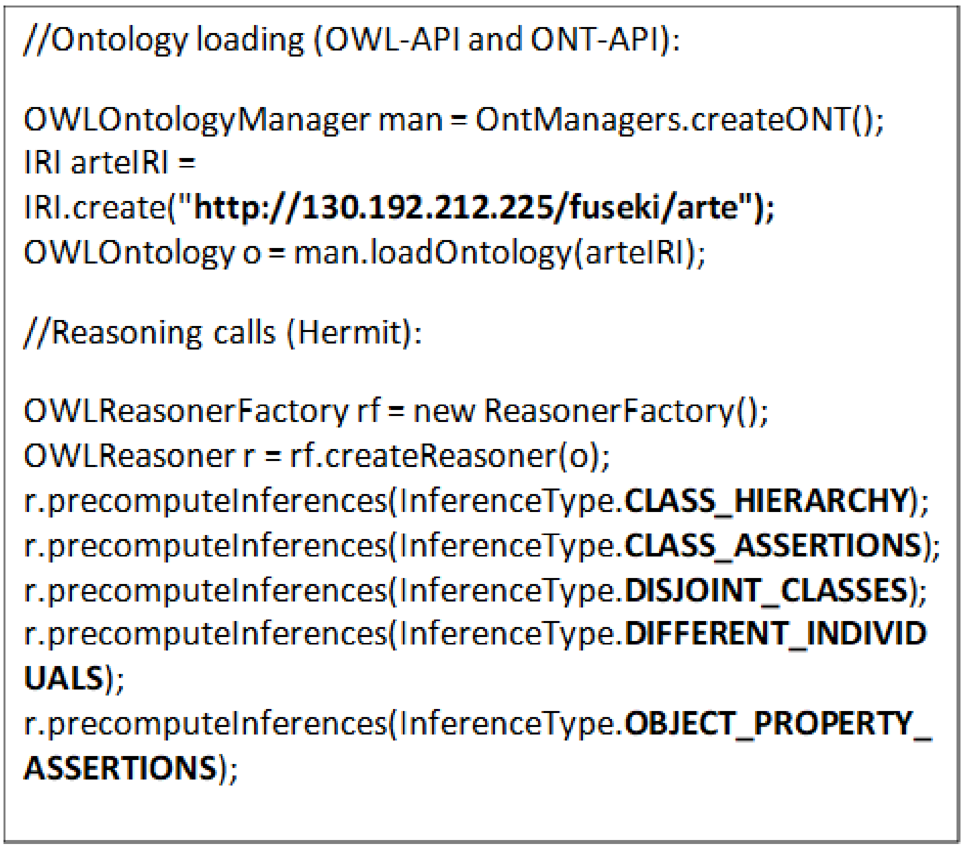
1. An OWL/OWL 2 ontology (or a network of ontologies) is uploaded to the Ontology Server via OWL-API[1].
2. All the triples that can be deduced by the loaded ontology, which form the so called "inferred ontology" are then derived by using a standard OWL reasoner (e.g., Hermit)[2].
3. The inferred ontology is then transformed to graph model (which is the format suitable for enabling querying via SPARQL). This is done by relying on the ONT-API framework, which transforms the inferred model into graph model compatible with Jena and Fuseki frameworks.
4. The model is automatically loaded in the Fuseki 2 SPARQL server available for querying at http://130.192.212.225/fuseki/

We will detail below, step by step, how the different components are integrated by using a running example about a toy knowledge base (called "arte") loaded, reasoned and exposed in a SPARQL endpoint as a turtle file (.ttl extension). The example will be discussed by providing the different pieces of code necessary to activate the different components (the overall code provided in the example is available in the final appendix).

7.1 Ontology Uploading and Reasoning calls via OWL-API (Steps 1-2)

An ontology, or a network of ontologies, can be uploaded to our ontology server via OWL-API as a file, or by using an external IRI pointing to an OWL ontology. Since the uploading procedure via file can only be done by the managers of the infrastructure (i.e., UNITO members) we have opted for the upload via an external IRI, that is reachable and directly usable by any user of the project. The IRI from which it is possible to upload the ontologies is: http://130.192.212.225/fuseki (the public address of the Fuseki 2 repository).

In the code shown below in figure 7.1.1, we show how an ontology stored at the IRI http://130.192.212.225/fuseki/arte (where "arte" is the name of the newly created dataset in Fuseki 2 storing the "arte.ttl" ontology) is loaded via OWL-API and how an ontological reasoner (e.g., HERMIT) is initialized by indicating the types of inferences we are interested in (e.g., CLASS_HIERARCHY, CLASS_ASSERTIONS, DIFFERENT_INDIVIDUALS etc.).



```
//Ontology loading (OWL-API and ONT-API):

OWLOntologyManager man = OntManagers.createONT();
IRI arteIRI =
IRI.create("http://130.192.212.225/fuseki/arte");
OWLOntology o = man.loadOntology(arteIRI);

//Reasoning calls (Hermit):

OWLReasonerFactory rf = new ReasonerFactory();
OWLReasoner r = rf.createReasoner(o);
r.precomputeInferences(InferenceType.CLASS_HIERARCHY);
r.precomputeInferences(InferenceType.CLASS_ASSERTIONS);
r.precomputeInferences(InferenceType.DISJOINT_CLASSES);
r.precomputeInferences(InferenceType.DIFFERENT_INDIVID
UALS);
r.precomputeInferences(InferenceType.OBJECT_PROPERTY_
ASSERTIONS);
```

Figure 7.1.1. Code excerpt for ontology uploading via external IRI and initialization of the reasoning procedures

7.2 Ontology Export as JENA Triple-based graph model (step 3)

In order to expose the reasoned ontologies in a format that is also accessible via SPARQL queries, it is necessary to translate the OWL / OWL 2 ontology/ontologies in a JENA graph model. This service is provided by the ONT-API library. In order to activate this translation, the following instruction (to be intended as a continuation of the code illustrated in figure 7.1.1) is provided:

```
Model model = ((Ontology(o).asGraphModel();
```

It allows to generate and store the JENA Graph Model as a JAVA object. It is worth noticing that the Model could also eventually be written into a file by providing this additional instruction:

```
model.write(FileOutputStream(new File(ReasonedArte.ttl)), “ttl”).
```

This possibility, however, is not currently used because it does not allow to automatically upload the JENA model to the external SPARQL server (that is, on the other hand, what we aim to do).

7.3 External Exposure of the Graph Model in a SPARQL Server (step 4)

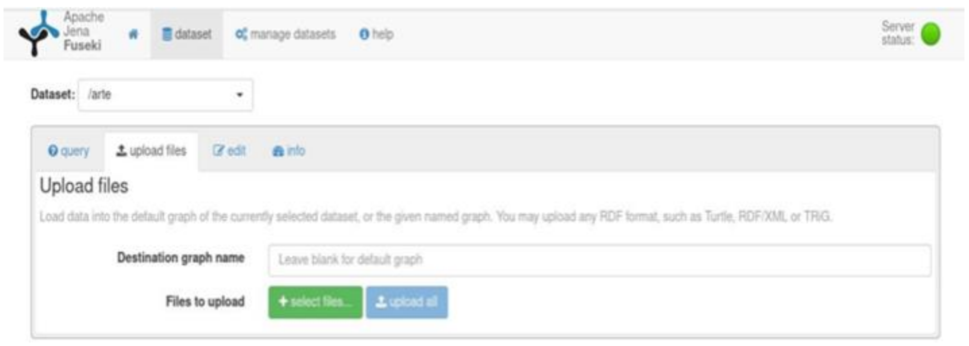
We upload the extracted JENA model to a Fuseki 2 SPARQL server. In Fuseki 2 it is possible to expose the JENA models as different datasets in two different ways: in a manual way and in an automatic fashion.

The manual upload can be done by using the **SOH function** (**S**PARQL **o**ver **H**TTP functions)[3] provided by Fuseki 2 or by manually uploading the file on the Fuseki 2 SPARQL graphical interface. SOH provides a set of Ruby scripts runnable from command line (therefore it is necessary to install Ruby in order to run them).

In our example, for what concern the use of the “UPLOAD” SOH command it is sufficient to provide the following PUT script to upload the file “ReasonedArte.ttl”:

```
s-put http://130.192.212.225/fuseki/arte default ReasonedArte.ttl
```

Alternatively, the file can be simply uploaded via the SPARQL graphical interface (see Figure 7.3.1), reachable at http://130.192.212.225/fuseki/arte

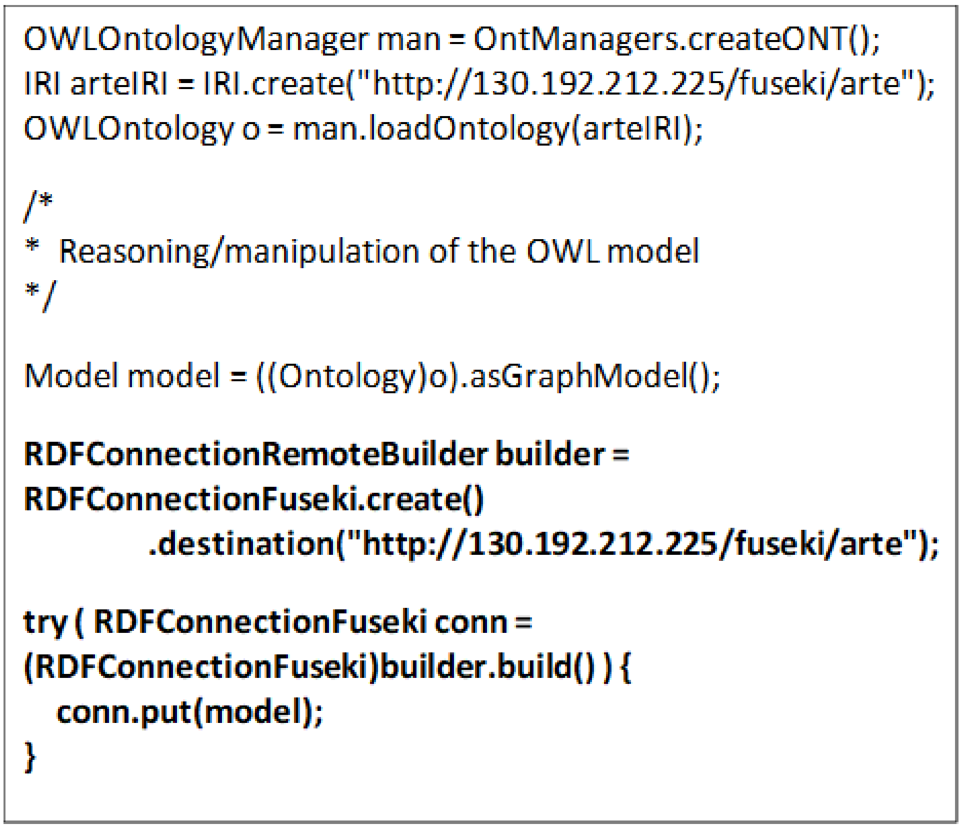


Load data into the default graph of the currently selected dataset, or the given named graph. You may upload any RDF format, such as Turtle, RDF/XML or TRiG.

Figure 7.3.1. SPARQL endpoint interface for the upload

As mentioned above, however, we decided to opt for a completely automatic upload of the JENA model Graph Model (containing the inferred ontology) in Fuseki 2 (at the scope of making it available such model via a reachable SPARQL endpoint).

In order to do that, we used the RDF Connection component of JENA API[4]. This process is obtained by the following instruction (in bold the new instructions with respect to the previous ones):



```
OWLOntologyManager man = OntManagers.createONT();
IRI arteIRI = IRI.create("http://130.192.212.225/fuseki/arte");
OWLOntology o = man.loadOntology(arteIRI);

/*
*  Reasoning/manipulation of the OWL model
*/

Model model = ((Ontology)o).asGraphModel();

RDFConnectionRemoteBuilder builder =
RDFConnectionFuseki.create()
        .destination("http://130.192.212.225/fuseki/arte");

try ( RDFConnectionFuseki conn =
(RDFConnectionFuseki)builder.build() ) {
  conn.put(model);
}
```

Figure 7.3.2. Automated export of the JENA Graph Model in the Fuseki 2 SPARQL Server via JENA API

This overall workflow allowed us to completely automate the connections between the ontology server and the SPARQL one. As already mentioned, we opted for an upload of the ontology via OWL-API through an external IRI. The external IRI provided to OWL-API resolves to the Fuseki repository reachable (in our example) at the address http://130.192.212.225/fuseki/arte. Once the ontology is loaded in OWL-API, it goes through the whole processes of reasoning, translation to JENA model, and automatic update of the Fuseki 2 repository without any manual intervention.

In the following we describe how to query and update (including inserts, deletes, updates) the Fuseki 2 exposed model by means of the services: SOH and RDF Connection. Query and update are also available through the graphical interface.

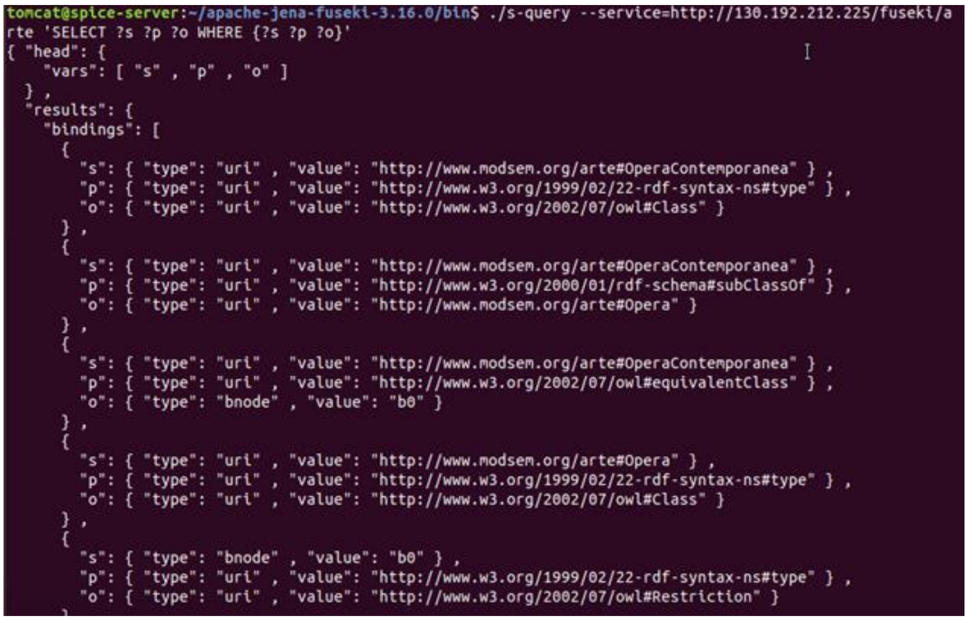
7.4 How to QUERY and UPDATE the exposed Fuseki 2 Model with SOH

In order to query the exposed Fuseki 2 Model via SOH, it is sufficient to use the scripting instructions provided here: https://jena.apache.org/documentation/fuseki2/soh.html.

For example: a simple query could be run via command line in the following way (see Figure 3.4.1 below).

[4] https://jena.apache.org/documentation/rdfconnection/

```
./s-query —service=http://130.192.212.225/fuseki/arte 'SELECT ?s ?p ?o W
HERE { ?s ?p ?o . }'
```



```
tomcat@spice-server:~/apache-jena-fuseki-3.16.0/bin$ ./s-query --service=http://130.192.212.225/fuseki/a
rte 'SELECT ?s ?p ?o WHERE {?s ?p ?o}'
{ "head": {
    "vars": [ "s" , "p" , "o" ]
  } ,
  "results": {
    "bindings": [
      {
        "s": { "type": "uri" , "value": "http://www.modsem.org/arte#OperaContemporanea" } ,
        "p": { "type": "uri" , "value": "http://www.w3.org/1999/02/22-rdf-syntax-ns#type" } ,
        "o": { "type": "uri" , "value": "http://www.w3.org/2002/07/owl#Class" }
      } ,
      {
        "s": { "type": "uri" , "value": "http://www.modsem.org/arte#OperaContemporanea" } ,
        "p": { "type": "uri" , "value": "http://www.w3.org/2000/01/rdf-schema#subClassOf" } ,
        "o": { "type": "uri" , "value": "http://www.modsem.org/arte#Opera" }
      } ,
      {
        "s": { "type": "uri" , "value": "http://www.modsem.org/arte#OperaContemporanea" } ,
        "p": { "type": "uri" , "value": "http://www.w3.org/2002/07/owl#equivalentClass" } ,
        "o": { "type": "bnode" , "value": "b0" }
      } ,
      {
        "s": { "type": "uri" , "value": "http://www.modsem.org/arte#Opera" } ,
        "p": { "type": "uri" , "value": "http://www.w3.org/1999/02/22-rdf-syntax-ns#type" } ,
        "o": { "type": "uri" , "value": "http://www.w3.org/2002/07/owl#Class" }
      } ,
      {
        "s": { "type": "bnode" , "value": "b0" } ,
        "p": { "type": "uri" , "value": "http://www.w3.org/1999/02/22-rdf-syntax-ns#type" } ,
        "o": { "type": "uri" , "value": "http://www.w3.org/2002/07/owl#Restriction" }
```

Figure 7.4.1. Query of the FUSEKI 2 server via terminal with the SOH scripts.

By using SOH it is also possible to upload/modify the Fuseki 2 model via command line. For example, it is possible to include additional information in our toy model about the artistic domain in the following way:

```
s-update --
service=http://130.192.212.225/fuseki/arte

'PREFIX : <http://www.modsem.org/arte#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-
syntax-ns#>
PREFIX xsd:
<http://www.w3.org/2001/XMLSchema#>

INSERT DATA {

        :LaVita rdf:type owl:NamedIndividual ,
              :Dipinto ;
       :haTitolo "La Vita"^^xsd:string .

   :PabloPicasso :creatoreDi :LaVita .
}
```

Figure 7.4.2. This simple instruction allows adding that "La Vita" (La Vie) is a painting by Picasso.

7.5 How to QUERY and UPDATE the exposed Fuseki 2 Model with RDF Connection

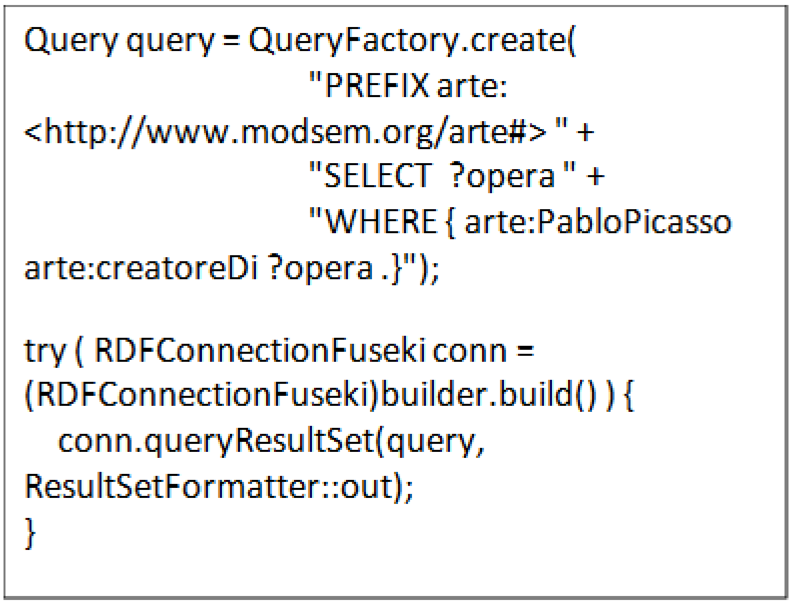
In order to use **RDF Connection** for both SPARQL query and Model Updates, we need to first establish a connection between the Fuseki 2 Server and the corresponding Model that we want to query/update. With the RDFConnection interface, SPARQL operations can be performed on Fuseki remote datasets.

In order to activate an RDF Connection, it is necessary to include the instruction mentioned above and used for the automatic upload of the JENA graph-model in Fuseki 2. The remote connection to the "arte" dataset is provided as follows:

```
RDFConnectionRemoteBuilder builder = RDFConnectionFuseki.create()
.destination("http://130.192.212.225/fuseki/arte");
```

Once the connection is established, it is possible to use RDF connection to provide SPARQL Queries and Model Updates on the Fuseki 2 Model.

For example: a query about the paintings of Picasso contained in the "arte" knowledge base can be executed programmatically in this way:

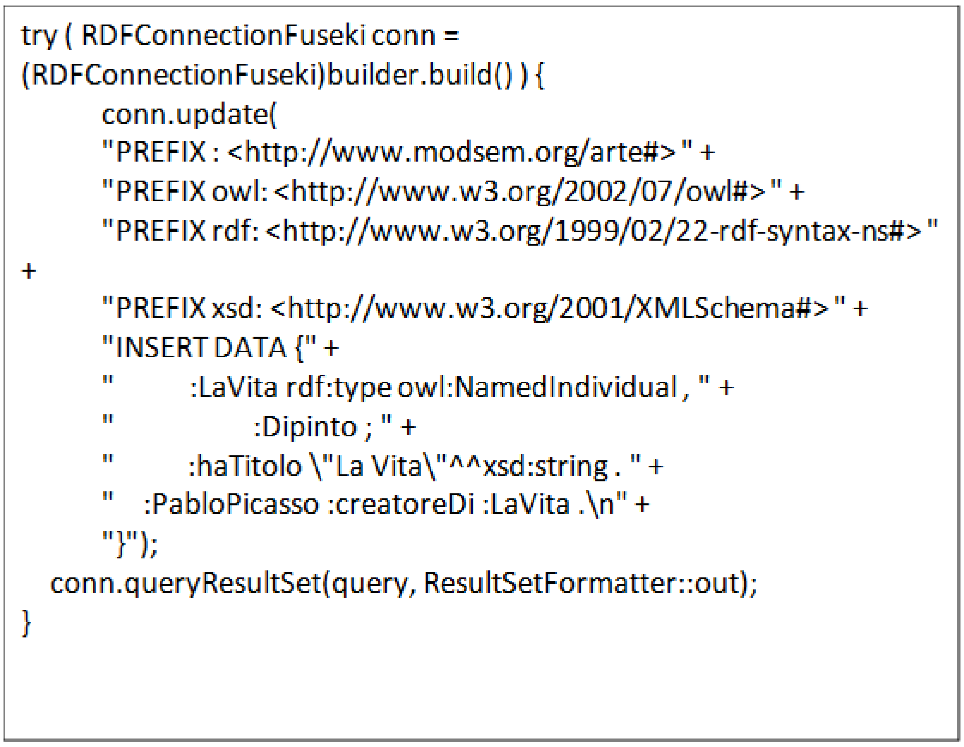


```
Query query = QueryFactory.create(
                    "PREFIX arte:
<http://www.modsem.org/arte#> " +
                    "SELECT  ?opera " +
                    "WHERE { arte:PabloPicasso
arte:creatoreDi ?opera .}");

try ( RDFConnectionFuseki conn =
(RDFConnectionFuseki)builder.build() ) {
   conn.queryResultSet(query,
ResultSetFormatter::out);
}
```

Figure 7.5.1. SPARQL query execution on Fuseki 2 from an external application via RDF Connection

Similarly, the knowledge base can be updated by adding new information in this simple way:



```
try ( RDFConnectionFuseki conn =
(RDFConnectionFuseki)builder.build() ) {
        conn.update(
        "PREFIX : <http://www.modsem.org/arte#> " +
        "PREFIX owl: <http://www.w3.org/2002/07/owl#> " +
        "PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> "
+
        "PREFIX xsd: <http://www.w3.org/2001/XMLSchema#> " +
        "INSERT DATA {" +
        "        :LaVita rdf:type owl:NamedIndividual , " +
        "                :Dipinto ; " +
        "        :haTitolo \"La Vita\"^^xsd:string . " +
        "    :PabloPicasso :creatoreDi :LaVita .\n" +
        "}");
   conn.queryResultSet(query, ResultSetFormatter::out);
}
```

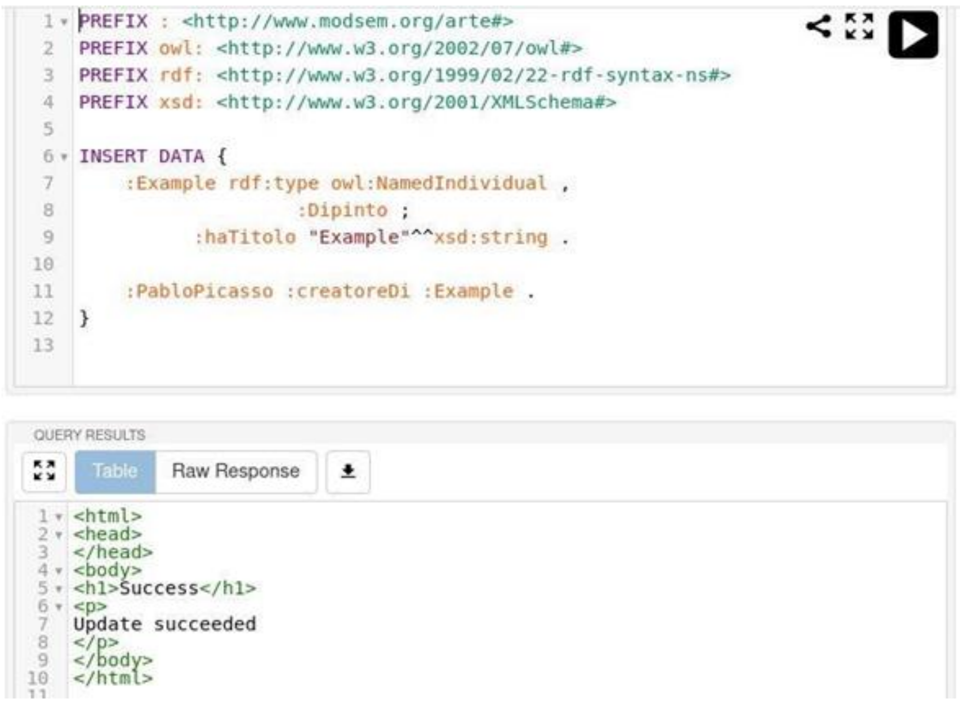
Figure 7.5.2. Knowledge update on Fuseki 2 from an external application via RDF Connection

Some insertions or deletions could be not compliant with the dictate of the ontological models. In case some inconsistent information is added, the OWL-API component (that loads the ontology from the IRI we are manipulating) can detect, using the launched reasoner, that the included information is inconsistent and should be modified or deleted.

7.6 Graphical Interface

The same query and update/delete commands described in the SOH and the RDF Connection can be run directly on the graphical interface of the Fuseki 2 SPARQL endpoint: http://130.192.212.225/fuseki (by selecting the repository “arte”).

For example, it is possible to update the Fuseki Model (e.g., by adding an additional painting by Picasso called “Example”), as exemplified in Figure 7.6.1 below.



```
PREFIX : <http://www.modsem.org/arte#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>

INSERT DATA {
    :Example rdf:type owl:NamedIndividual ,
                :Dipinto ;
          :haTitolo "Example"^^xsd:string .

    :PabloPicasso :creatoreDi :Example .
}
```

```
<html>
<head>
</head>
<body>
<h1>Success</h1>
<p>
Update succeeded
</p>
</body>
</html>
```

Figure 7.6.1. Model update in Fuseki 2 via the graphical interface

7.7 Source code

(Code illustrated in the running example, available at https://github.com/spice-h2020/SPICE-OntoServer)

```
//Ontology loading (OWL-API and ONT-API):
OWLOntologyManager man = OntManagers.createONT();
IRI arteIRI = IRI.create("http://130.192.212.225/fuseki/arte");
OWLOntology o = man.loadOntology(arteIRI);

//Reasoning calls (Hermit):
OWLReasonerFactory rf = new ReasonerFactory();
OWLReasoner r = rf.createReasoner(o);
r.precomputeInferences(InferenceType.CLASS_HIERARCHY);
r.precomputeInferences(InferenceType.CLASS_ASSERTIONS);
r.precomputeInferences(InferenceType.DISJOINT_CLASSES);
r.precomputeInferences(InferenceType.DIFFERENT_INDIVIDUALS);
r.precomputeInferences(InferenceType.OBJECT_PROPERTY_ASSERTIONS);

//Translation into Jena Model (Apache Jena and ONT-API):
Model model = ((Ontology)o).asGraphModel();

//SPARQL Graph Store Protocol "PUT" on remote Fuseki server (Jena RDF Connection)
RDFConnectionRemoteBuilder builder = RDFConnectionFuseki.create()
    .destination("http://130.192.212.225/fuseki/arte");
try ( RDFConnectionFuseki conn = (RDFConnectionFuseki)builder.build() ) {
    conn.put(model);
}

//Example of SPARQL Query on remote Fuseki server (Jena RDF Connection)
RDFConnectionRemoteBuilder builder = RDFConnectionFuseki.create()
    .destination("http://130.192.212.225/fuseki/arte");
Query query = QueryFactory.create(
            "PREFIX arte: <http://www.modsem.org/arte#> " +
            "SELECT  ?opera " +
            "WHERE { arte:PabloPicasso arte:creatoreDi ?opera .}");
try ( RDFConnectionFuseki conn = (RDFConnectionFuseki)builder.build() ) {
    conn.queryResultSet(query, ResultSetFormatter::out);
}

//Example of SPARQL Update on remote Fuseki server (Jena RDF Connection)
RDFConnectionRemoteBuilder builder = RDFConnectionFuseki.create()
```

```
    .destination("http://130.192.212.225/fuseki/arte");
try ( RDFConnectionFuseki conn = (RDFConnectionFuseki)builder.build() ) {
conn.update(
            "PREFIX : <http://www.modsem.org/arte#> " +
            "PREFIX owl: <http://www.w3.org/2002/07/owl#> " +
            "PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> " +
            "PREFIX xsd: <http://www.w3.org/2001/XMLSchema#> " +
            "INSERT DATA {" +
            "      :LaVita rdf:type owl:NamedIndividual , " +
            "                    :Dipinto ; " +
            "          :haTitolo \"La Vita\"^^xsd:string . " +
            "    :PabloPicasso :creatoreDi :LaVita .\n" +
            "}");
    conn.queryResultSet(query, ResultSetFormatter::out);
}
```

8 Conclusions

This document presented and described the APIs that have been developed for use within the SPICE project architecture. For each API we have detailed the specifications along with its intended purpose in relation to SPICE work packages and any relevant design methodology employed.

The report includes a user guide for each API, describing how pilot application developers can make use of the API's functions and how to make use of and customise API parameters where appropriate. Example API requests and code snippets are also supplied.

Many of these APIs are currently in a state of ongoing development. Where links to released versions and OpenAPI specifications are made available, these reflect the interim development status at the time of writing this report. Moving forwards into the third year of the project we will finalise the development of these technologies, making final releases and full specifications available in D6.8.