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SPICE
Social cohesion, Participation, and Inclusion through Cultural Engagement

# D6.2 Initial Ontology Network Specification

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| 13 | UH | UNIVERSITY OF HAIFA | Israel |
| 14 | CNR | CONSIGLIO NAZIONALE DELLE RICERCHE | Italy |

# Executive summary

The deliverable presents the SPICE Ontology Network (SON), whose main objective is to provide the ontological backbone for the representation of citizen curation activities.

The SPICE Ontology Network (SON) is the main outcome of the task T6.3 (Ontology network for citizen curation) of the WP6 work package.

In WP6, 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.

SON is an integration driver: it creates an interoperable space, where applications can interact with a shared semantics. SON enables software components to organise, exchange, query, interpret and reason over data collected or generated during the citizen curation activities.

SON empowers applications with knowledge level reasoning to support citizen curation activities. This enables, for example, the discovery and extension of latent sensemaking, and the automated inference of implicit (non-trivial) implications from the data shaped according to the SON, or aligned to it.

This is the first of two deliverables about the ontology network. In this document, we report on the initial ontology specification. This report includes: a brief overview of the principles and technologies the ontology network relies on, the design methodology applied for developing the ontology network, the ontological requirements gathered so far, the first prototype of the ontology network designed according to the collected requirements, and the protocol for testing and experimenting the ontology network in the context of SPICE case studies.

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# Table of Contents

# 1 Introduction

This deliverable presents the SPICE Ontology Network (SON), whose main objective is to provide the ontological backbone for the representation of citizen curation. As discussed in D2.1 (Initial methods for interpretation) *citizen curation* can be defined as "citizens applying curatorial methods to archival materials available in memory institutions in order to develop their own interpretations, share their own perspective and appreciate the perspectives of others". Moreover, SON enables software components to organise, exchange, query, interpret and reason over data collected or generated during the citizen curation activities. This document gives an overview of the ontology network, its underlying principles, and its modular component ontologies. The description provided here is complemented by the documentation available online at[1].

## 1.1 Work Package 6 Objectives

The SPICE Ontology Network (SON) is the main outcome of the task T6.3 (Ontology network for citizen curation) of the WP6 work package.

In WP6, 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.

SON is an integration driver: it creates an interoperable space, where applications can interact with a shared semantics. SON enables software components to organise, exchange, query, interpret and reason over data collected or generated during the citizen curation activities.

SON empowers applications with knowledge level reasoning to support citizen curation activities. This enables, for example, the discovery and extension of latent sensemaking, and the automated inference of implicit (non-trivial) implications from the data shaped according to the SON, or aligned to it.

## 1.2 Purpose of the Deliverable

This is the first of two deliverables about the ontology network. In this document, we report on the initial ontology specification. This report includes: a brief overview of the principles and technologies the ontology network relies on, the design methodology applied for developing the ontology network, the ontological requirements gathered so far, the first prototype of the ontology network designed according to the collected requirements, and the protocol for testing and experimenting the ontology network in the context of SPICE case studies.

## 1.3 Relations to other Project Activities

Figure 1 depicts the relations that exist between the work of the task T6.3 and the other project activities. There exists a mutual benefit between them. On the one hand, other tasks provide the ontological requirements (i.e., information deemed relevant by those activities) that feed the ontology design process. On the other hand, T6.3 activities define shared conceptualizations of the requirements that indicate how to specify relevant information with a shared format and semantics. In particular, the collection of ontological requirements has benefited from: i) methods and theories studied in WP2 and WP6; ii) application scenarios of WP3, WP4 and WP5, i.e., text annotation (WP3), recommendation system (WP3), linked data hub (WP4), interfaces for citizen curation (WP5); iii) data emerged from the case studies (WP7). The ontology network contributes to: i) the activities of the WP2 by formalising theories and methods so as to enable the computational operationalization of such methods; ii) it provides a common vocabulary for specifying the relevant information exchanged by the various components of the socio-technical system, thus fostering the syntactic and semantic interoperability among those components. A more detailed discussion about the relations to the other project activities is provided in Section 3.1.

[1] https://github.com/spice-h2020/SON

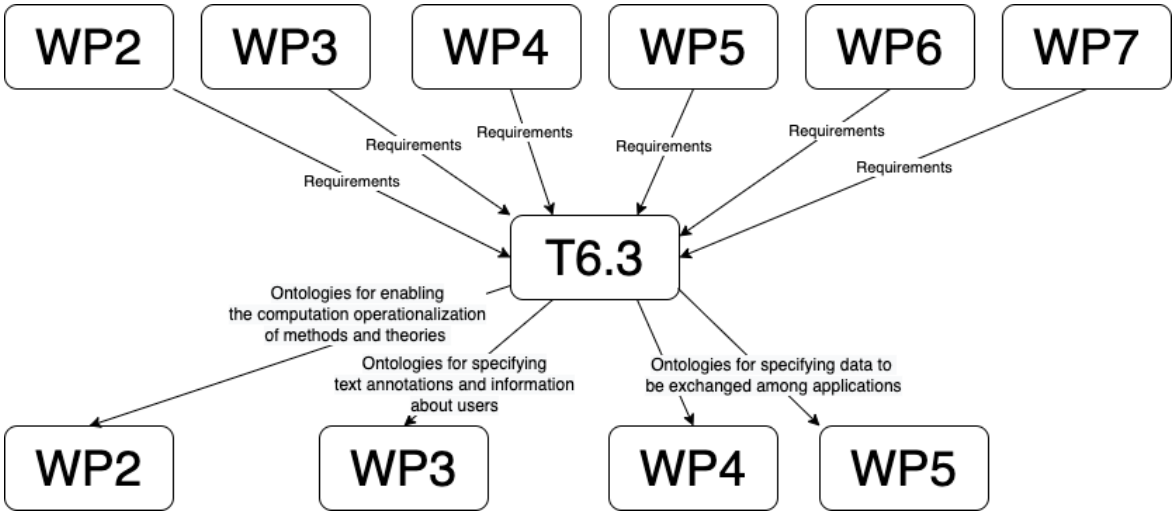



*Figure 1 Relation with the other work packages.*

## 1.4 Document Outline

The rest of the document is organised as follows. Section 2 provides some background on Semantic Web technologies and ontology design methods that have been adopted for developing the ontology network. It also explains the notation used in the paper. Section 3 gives an overview of the ontology network, the knowledge areas of which it is composed, an application scenario that describes how the ontology network addresses the information needs, the state-of-art-ontologies that have been reused in SON. Then, we devote a chapter to each Knowledge Area (KA) of the ontology network: Section 4 for the Curatorial KA, Section 5 for the Interaction KA, Section 6 for the Narrative KA, Section 7 for the Symbolism KA, Section 8 for the User and community KA, Section 9 for the Emotion KA, Section 10 for the interpretation KA. Each section describes the objectives and presents the ontologies used to represent the knowledge area.

# 2 Background

In this section we provide an informal description of the main concepts, techniques and methodologies on which our work relies on. These technologies are standard in the Knowledge Representation research area and lay the foundation of Semantic Web (a set of standards that aim at making web data machine readable). With these technologies at hand, SPICE applications become capable of publishing information on the Linked Data Hub (LDH), consuming this information with the SPARQL query language, and derive inferences by exploiting implicit knowledge derived by the ontologies or vocabularies used. This section aims at providing a reader with the minimal background needed for interpreting the content of the deliverable.

## 2.1 Ontology and Ontology Network in a nutshell

An ontology is an explicit specification of a conceptualization of a domain of interest [1]. An ontology network [2] is a collection of linked (also including import statements) ontologies that give a shape to a knowledge graph. An ontology network is a good practice for designing ontologies when they get very large and heterogeneous: their maintenance and validation is easier, and design work can be made modular and reuse architectural methods like in software engineering (notably, *design patterns*). Ontology networks aim at:

- Establishing a vocabulary of terms that may be used for exchanging data across information system;
- Formally defining the semantics of the terms;
- Specifying an interpretation of a domain of interest;
- Relating concepts/data/information.

Ontologies typically defines four kinds of entities: classes, properties, individuals and axioms. Informally, classes define sets of entities of a certain domain of interest (e.g., the class *Person* collects all the persons of the domain). A property defines a binary relation that connects two entities of the domain (e.g., the property *has brother* connects two persons having a brotherhood relationship). An individual is an entity of the domain (e.g., *Luigi Asprino*). An axiom specifies an assertion involving entities of the domain (e.g., *every man is a person*). Axioms enable automated reasoning, e.g., from the axiom *Luigi Asprino is a man*, the axiom *Luigi Asprino is a person* is automatically inferred. Axioms can be extremely elaborated and expressive, and can control the complexity of our assumptions, giving us also feedback on the consistency of our conceptualisation. For example, we may want to assume an axiom like *persons are not time intervals* (e.g., because time is an abstract entity, while persons are *located in* space-time). Now, if for any reason (the reason being a set of axioms that can be navigated within the knowledge graph), the reasoner can conclude (infer) that *Luigi Asprino is both a person and a time interval*, it will raise an exception of inconsistency, leading us to revise our own assumptions, or to correct a modelling error.

## 2.2 Semantic Web Languages: RDF, OWL, SPARQL

The Semantic Web is an extension of the Web that aims at providing a common framework so that data can be shared and reused across applications. Standardisation for Semantic Web is under the responsibility of World Wide Web Consortium (W3C). W3C standards for the Semantic Web mainly include: XML, RDF(S), OWL, and SPARQL. The foundation layer of the Semantic Web is the Resource Description Framework (RDF), a generic meta-model that allows the exchange of data by the means of a minimal graph-based structure. On top of that, specifications like RDF Schema (RDF(S)) and Web Ontology Language (OWL) permit to express logical constraints on the content of RDF graphs. With these set of technologies, systems are capable of publishing information on the WWW as Linked Data (LD), consuming this information with the SPARQL query language and the Linked Data Protocol (LDP), and derive inferences by exploiting implicit knowledge derived by the ontologies or vocabularies used. Figure 2 shows the Semantic Web stack of technologies as originally conceived and provides an overview of the standard technologies recommended by the W3C.

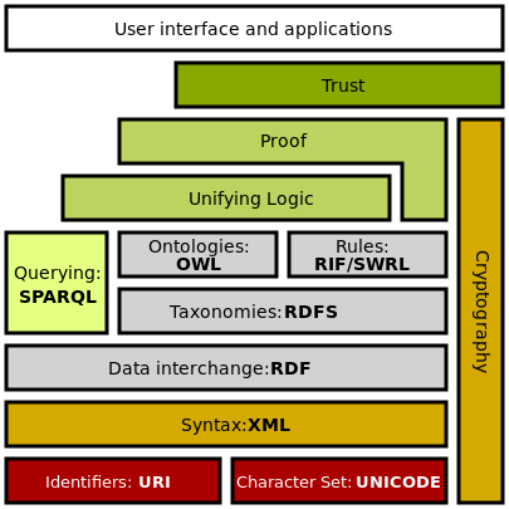



*Figure 2 The Semantic Web stack as originally conceived.*

However, a recent survey [3] showed how the Semantic Web evolved in the past 20 years. An updated version of the Semantic Web stack is showed in Figure 3. In the next sections, we provide a brief overview of the technologies of the stack that are relevant for the work presented in this document.

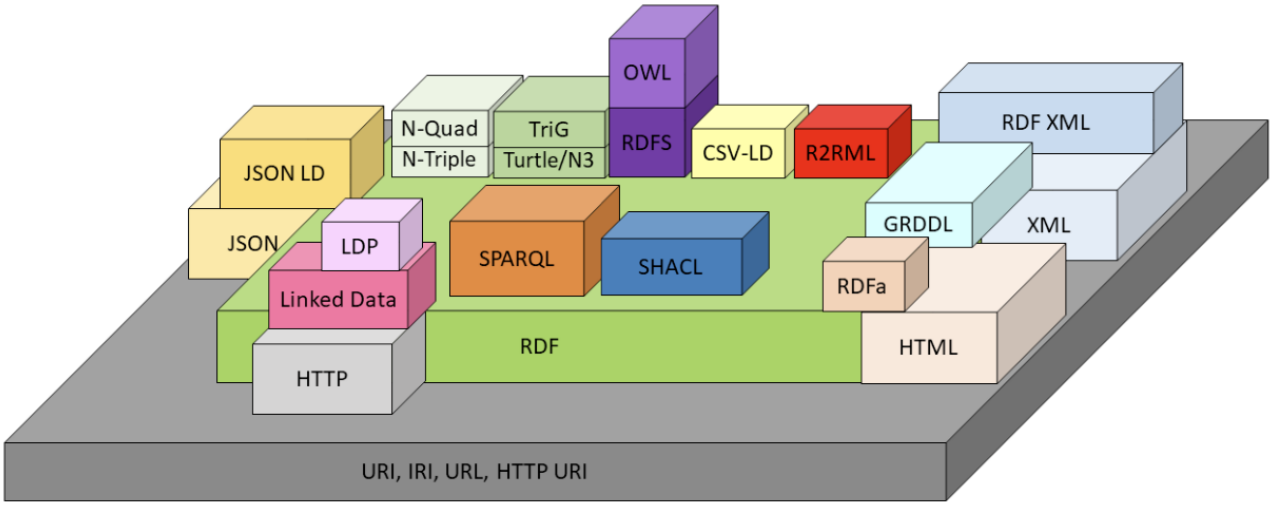



*Figure 3 An updated version of the Semantic Web stack.*

### 2.2.1 RDF and RDFs

Resource Description Framework (RDF)[2] is a W3C recommendation originally designed as metadata model, that is used as a general framework for modelling information. The basic construction in RDF is the triple <subject, predicate, object>. The subject and the object denote resources and the predicate expresses a relationship between them. For example, a way for representing the fact "The author of War and Peace is Lev Tolstoy" is

```
:War_and_Peace  :author  :Lev_Tolstoy
```

where `:War_and_Peace` and `:Lev_Tolstoy` are the Uniform Resource Identifiers (URIs) of two resources representing respectively the book titled "War and Peace" and the writer "Lev Tolstoy". The term `:author` represents the URI of the predicate "author", which is used to connect a book to its author. The

[2] RDF, W3C Recommendation https://www.w3.org/TR/rdf11-concepts/

RDF model can be seen as a graph where nodes are resources and edges are properties. Several serialisation formats of RDF are in use, including: TURTLE[3], RDF/XML[4], N-Triples[5] and JSON-LD[6].

RDF Schema (RDFS)[7] provides a data-modelling vocabulary for RDF data. RDFS is an extension of RDF that aims at providing basic elements for structuring RDF resources. It allows to define classes, properties, datatypes, and hierarchies of both classes and properties.

### 2.2.2 JSON and JSON-LD

JSON[8] is a data serialization and messaging format that uses human-readable text to store and transmit data objects. JSON-LD[9] is a JSON-based format that is used for specifying RDF data. The syntax is designed to easily integrate into deployed systems that already use JSON, and provides a smooth semantic lifting path from JSON to JSON-LD. It is primarily intended to be a way to use Linked Data in Web-based programming environments, to build interoperable Web services, and to store Linked Data in JSON-based storage engines. JSON-LD is adopted as shared syntactic format for the data to be exchanged among the software components that interact through the Linked Data Hub (cf. D4.1 – Distributed Linked Data Infrastructure).

### 2.2.3 OWL

The Web Ontology Language (OWL)[10] is a semantic markup language for defining, publishing and sharing ontologies on the World Wide Web. OWL allows to describe the meaning of terms in vocabularies and the relations between terms, and to group these into vocabularies or *ontologies*. OWL is part of the Semantic Web stack and it is complementary to JSON-LD, RDF and RDFS. In particular:

- JSON-LD provides a surface syntax for structured documents, but imposes no semantic constraints on the meaning of the documents;
- RDF is a data model for resources and relations between them. It provides a simple semantics for this data model;
- RDFs is a vocabulary for describing properties and classes of RDF resources, with a semantics for generalisation-hierarchies of such properties and classes;
- OWL adds constructs for describing properties and classes: among others, relations between classes (e.g. disjointness), cardinality (e.g. "exactly one"), equality, richer typing of properties, characteristics of properties (e.g. symmetry), and enumerated classes.

### 2.2.4 SPARQL

SPARQL[11] is a query language for retrieving and manipulating data stored in RDF format. SPARQL queries contain a set of triple patterns called *basic graph patterns*. Triple patterns are like RDF triples where the subject, the predicate, and the object may be variables (denoted by a question mark). A basic graph pattern matches a subgraph of the RDF data when terms from the subgraph can be substituted with the variables expressed in the query, and the result of the query is an RDF graph equivalent to the subgraph at hand. For example, the following SPARQL query retrieves pairs of books and authors:

```
SELECT ?book ?author WHERE {?book :author ?author}
```

## 2.3 Pattern-based Ontology Design

Developing ontologies is a challenging task and a number of methodologies for guiding the design process have been proposed over the years. Among the most effective methodologies, pattern-based approaches to ontology design enables an iterative, incremental, and test-driven ontology building process which is

[3] TURTLE, https://www.w3.org/TR/turtle/
[4] RDF/XML, https://www.w3.org/TR/rdf-syntax-grammar/
[5] N-Triples, https://www.w3.org/TR/n-triples/
[6] JSON-LD https://www.w3.org/TR/json-ld11/
[7] RDFs, W3C Recommendation https://www.w3.org/TR/rdf-schema/
[8] JSON https://www.json.org/json-en.html
[9] JSON-LD https://www.w3.org/TR/json-ld11/
[10] OWL, W3C Recommendation https://www.w3.org/TR/owl-ref/
[11] SPARQL, W3C Recommendation https://www.w3.org/TR/rdf-sparql-query/

streamlined by the adoption of a practical method that reuses Ontology Design Patterns as building blocks. The notion of "pattern" has proved useful in design, as exemplified in diverse areas, such as software engineering. Assuming that there exist classes of problems that can be solved by applying common solutions (like in software engineering), supporting reusability of the design specifications is compelling. To this extent, the *Ontology Design Patterns (ODPs)* have been proposed as modelling solutions to formally represent recurrent ontology design problems. ODPs are ontology components that can be used as basic building blocks of an ontology network. eXtreme Design (XD) is an ontology design methodology that supports the pattern-based approach. In SPICE. we adopted XD as methodology for the ontology design and we extensively reused ODPs. Sections 2.3.1 and 2.3.2 briefly introduce ODPs and XD, respectively.

### 2.3.1 Ontology Design Patterns

Ontology Design Patterns (ODPs)[4] is a technology that favours the reuse of encoded experiences and good practices. ODPs are modelling solutions to solve recurrent ontology design problems. ODPs can be classified in several types, namely: (i) logical, which typically provide solutions for solving problems of expressivity e.g., expressing n-ary relations in OWL; (ii) architectural, which describe the overall shape of the ontology (either internal or external) that is convenient with respect to a specific ontology-based task or application e.g. a certain Description Logic family; (iii) content, which are small ontologies that address a specific modelling issue, and can be directly reused by importing them in the ontology under development e.g., representing roles that people can play during certain time periods; (iv) presentation, which provide good practices for e.g. naming conventions.

### 2.3.2 eXtreme Design

eXtreme Design (XD) [5][6][7] is a family of methods and associated tools based on the application, exploitation, and definition of ontology design patterns (ODPs) for solving ontology development issues. XD principles are inspired by those of the agile software methodology called eXtreme Programming (XP). The main idea of agile software development is to be able to incorporate changes easily, in any stage of the development. Instead of using a waterfall-like method, where you first do all the analysis, then the design, the implementation and finally the testing, the idea is to cut this process into small pieces, each containing all those elements but only for a very small subset of the problem. XD is test-driven and applies the divide-and-conquer approach as well as XP does. Also, XD adopts pair design, similarly to pair programming. The main principles of the XD method can be summarised as follows:

- **Customer involvement and feedback.** In the context of SPICE a customer is anyone that intends to generate or access data by means of an ontology. Therefore, this includes: (i) the *museums* which are the data main data providers, (ii) the *citizens* that might want to access the data by means of the Linked Data Hub or generate and upload new content, (iii) or the other applications that might include the ontology in their busines logic. These kinds of customers should be involved in the ontology development and its representative should be aware of all parts of the ontology project under development. Interaction with the customer representative is key for favouring the explicit expression of the domain knowledge.
- **Customer stories and Competency Questions.** The ontology requirements and tasks are described in terms of small stories by the customer representative. Designers work on those small stories and, together with the customer, summarise them in Competency Questions (CQs)[8]. CQs will be used through the whole development, and are key elements as these must help the designer and customer in making explicit the unstructured, implicit knowledge.
- **Content Pattern (CP) reuse and modular design.** A development project is characterised by two main sets: (i) the problem space composed of the actual modelling issues that have to be addressed during the project which are called "Local Use Case" (LUC); (ii) the solution space made up of reusable modelling solutions, called "Global Use Case" (GUC), representing the problem that a certain ODP provides a solution for. If there is a CP's GUC that matches a LUC it has to be reused, otherwise a new module is created. An analysis of the possible strategies for reusing CP is provided by [9].

- **Collaboration and Integration.** Collaboration and constant sharing of knowledge is needed in a XD setting, in fact similar or even the same CQs and sentences can be defined for different stories. When this happens, it means that these stories can be modelled by reusing a set of shared CPs.
- **Task-oriented design.** The focus of the design is on that part of the domain of knowledge under investigation that is needed in order to address the user stories, and more generally, the tasks that the ontology is expected to address.
- **Test-driven design.** A new story can be treated only when all unit tests associated with it have been passed. An ontology module developed for addressing a certain user story associated to a certain competency question, is tested e.g. i) by encoding in the ontology a sample set of facts based on the user story, ii) defining one or a set of SPARQL queries that formally encode the competency question, iii) associating each SPARQL query with the expected result, and iv) running the SPARQL queries against the ontology and compare actual with expected results.

## 2.4 Syntactic Notation for describing ontologies and examples

### 2.4.1 Graphical Notation for ontologies

In this document, we adopt Graffoo [10][12] as graphical notation for OWL ontologies. Graffoo defines a graphical element for each kind of objects of an ontology. Specifically, all the ontological entities (i.e., ontologies, classes, properties, datatypes, and individuals) can be defined either as an IRI surrounded by angular brackets (e.g., <http://xmlns.com/foaf/0.1/Person>) or as with a shortened notation (e.g., foaf:Person, where foaf is the prefix associated to the namespace <http://xmlns.com/foaf/0.1/>). Graffoo defines two different kinds of graphical elements, i.e., blocks (or nodes) and edges. Blocks are used to define classes and class restrictions (yellow rectangles with solid and dotted borders respectively), datatypes and datatype restrictions (green rhomboids with solid and dotted borders respectively), individuals (pink circles with solid black border), additional axioms in Manchester Syntax for all those constructs that are not directly supported by a particular graphical element (light-blue and folded boxes). Arcs are used to define assertions (black lines ending with a solid arrow), annotation properties (orange lines beginning with backslash and ending with a dashed arrow), data properties (green lines beginning with an empty circle and ending with an empty arrow), and object properties (blue lines beginning with a solid circle and ending with a solid arrow).

### 2.4.2 Syntactic Notation for examples

The ontologies presented in this document will be also documented with usage examples. Each usage example defines the application scenario in which the ontology plays a role. Then, for each application scenario we provide a concrete RDF instantiation of the terms of the ontology. The instantiation is written either in Turtle or JSON-LD. Additional examples are available in the GitHub repository[13].

[12] Graffoo, https://essepuntato.it/graffoo/
[13] https://github.com/spice-h2020/SON

# 3 SPICE Ontology Network (SON) overview

In this section, we give an overview of the overall ontology network by focussing on the role of the ontology network in the project, a description of the design methodology, the overall skeleton of the ontology and a motivating scenario that shows how all the ontologies collectively cooperate for addressing an information need.

## 3.1 Role of the ontology network and relations with other work packages

The ultimate goal of the SPICE Ontology Network (SON) is to provide the ontological backbone for the representation of citizen curation activities, thus enabling SPICE "stakeholders"[14] to communicate with a common vocabulary and a formal semantics. Pragmatically, SON enables software components to consistently organise, exchange, query, interpret, and reason over data collected or generated during the citizen curation activities. In this section we provide a detailed description of the relations of the ontology network with the other work packages.

- **WP2.** The ontology network formalizes and enables the operationalization of the methods and techniques developed in WP2. In particular, the interpretation knowledge area (cf. Chapter 10) is devoted to the formalization of the concept of interpretation (cf. D2.1 Initial methods for interpretation). Moreover, ontologies within User and Community modelling knowledge area (cf. Section 8) aims at making the general concept of value (moral, cultural, social etc.) more explicit, to be able to reason formally on the impact that some user's value commitment, recognition and appraisal have in the interpretation - reflection loop process (cf. D2.2 Initial methods for reflection).
- **WP3.** The ontology network provides the user model (cf. D3.1 Prototype user and community modelling) with the information needed for classifying users according to their characteristics (e.g. moral values, cf. Section 8, or personal interests, cf. Section 3.6). The ontology network also provides the formal model and the terms for specifying text annotations (cf. D3.2 Prototype semantic annotator). Specifically, by reusing state-of-the-art ontologies, we designed a model for specifying textual annotations and a series of vocabularies of emotions that allow the semantic annotator to consistently represent which emotion is detected in a text (cf. Chapter 9).
- **WP4.** The ontology network shapes the data that will be shared through the Linked Data Hub (cf. D4.1 Linked Data server technology: requirements and initial prototype). Hence, it enables data to be shared with a common semantics and enables software components to effectively interoperate.
- **WP5.** The ontology network standardizes the way of communicating with interfaces (cf. D5.1 Preliminary interfaces for interpretation and reflection). Specifically, the curatorial knowledge area (cf. Section 4) defines a schema for data to be exchanged with applications supporting curatorial activities.
- **WP6.** The ontology network is the key enabler for data and software integration (cf. Task 6.2); knowledge exploration, sophisticated reasoning and sensemaking (cf. Task 6.4); mining and analytics of the curatorial scripts (cf. Task 6.5).
- **WP7.** The ontology network formalizes the data shared coming from the case studies. This process is commonly known as semantic lifting (i.e., the process of specifying data with terms having a shared semantics). An example of semantic lifting is described in Section 3.5.

## 3.2 Ontology Design Methodology

As we already mentioned in Section 2.3, the SPICE Ontology Network has been developed by following the eXtreme Design (XD) methodology [5]. In this Section, we describe how XD has been implemented for SPICE what instruments supported the design process.

Figure 4 depicts the ontology design process. Similar to the standard software development processes, the ontology design process begins with the collection of *user stories*. Users include museum professionals creating or managing data, developers and stakeholders reusing data in third party applications, and target

[14] With the term "stakeholder" we intend both group of people that are involved in the project and software applications.

users of final data (e.g. museum visitors). In order to gather user stories for SON, we set up the repository issue tracker[15]. Github issues also collect pointers to relevant work for addressing the issue (e.g. existing ontologies), examples, discussions about the knowledge requirement etc. thus becoming a container that can be referenced also as documentation of the ontology.

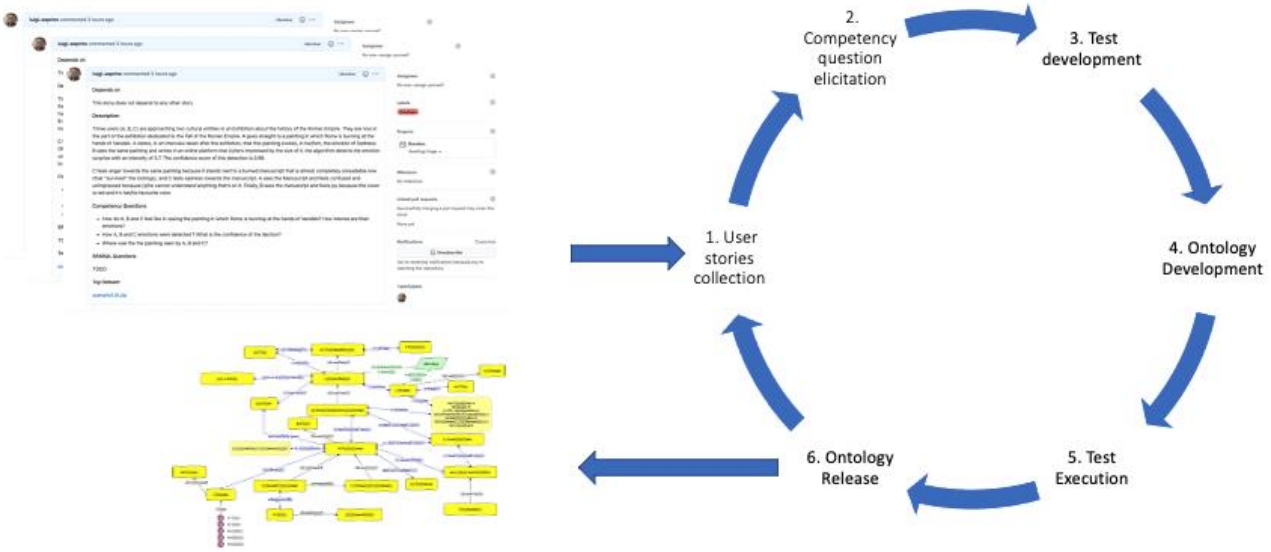



*Figure 4 Ontology Design Process*

The template for the collection of the user stories[16] is described in the following table.

| Field | Instructions for filling in the field |
|---|---|
| Depends on | Indicate other stories this story depends on. (You can simply mention the issue e.g. #1 or write that the story is independent from any the other scenarios). |
| Description | Provide a description of the story. |
| Source | Indicate the source document or the event in which this story has been defined (if any). |
| Competency Questions | Provide one or more competency questions the ontology shall be able to answer. In case that you want to fill this later, please write (TODO). |
| Ontology/Ontology Design Patterns Relevant for the scenario | Suggest a list of existing ontologies or ontology design patterns that can be used for specifying the scenario. |
| SPARQL Questions | Provide one or more SPARQL queries that express the competency questions. In case that you want to fill this later, please write (TODO). |
| Toy Dataset/SPARQL Endpoint | Provide the link to or upload a toy dataset that can be used for unit test. In case that you want to fill this later, please write (TODO). |

To date, we have collected 43 stories. Not all the fields are mandatory, meaning that users decide which fields to fill in when the issue is created or to postpone the compilation. Such an agile approach to the requirement collection let us to collect either proper stories or notes that can be refined in a later time.

[15] https://github.com/spice-h2020/SON/issues
[16] We use the terms story, user story, scenario and requirement interchangeably

We associated each user story with a set of knowledge areas (cf. Section 3.3). A knowledge area indicates the thematic domain of a user story. It is important to note that in this process the knowledge areas emerge directly from the stories. We remark that in knowledge engineering the user stories are commonly used for specifying requirements that an ontology has to address. Each requirement affects one or more knowledge domains and knowledge areas that aim at specifying such domains. The knowledge areas were gathered by applying an iterative generalization of the knowledge domains (a method similar to the Grounded Theory [11], which is a method often used in Social Sciences to extract relevant concepts from unstructured corpora of natural language resources).

In summary, the following operations were performed:

- For each user story we defined a set of unit tests, as defined according to the TESTaLOD methodology [12] and the OWLunit framework[17]. The test suite is available online at the following link[18].
- As soon as a critical number of stories of a certain knowledge area is collected, we proceeded with the development of the ontologies for that area.
- Once the ontology development process was completed, we ran the unit tests.
- Finally, if the ontology passes the tests, then a new release is issued, otherwise an additional development phase is needed to fix the ontology.
- Once that all the user stories of a knowledge area are addressed, the process can start another iteration from the collection of user stories.

## 3.3 Knowledge Areas

A Knowledge Area is a collection of ontologies of the ontology network that share a common theme. Even if knowledge areas are not logical elements of the ontologies, they provide us a mean for classifying requirements and developed ontologies, drawing a thematic overview of the ontology network useful to analyse at a higher level the interactions between the ontologies.

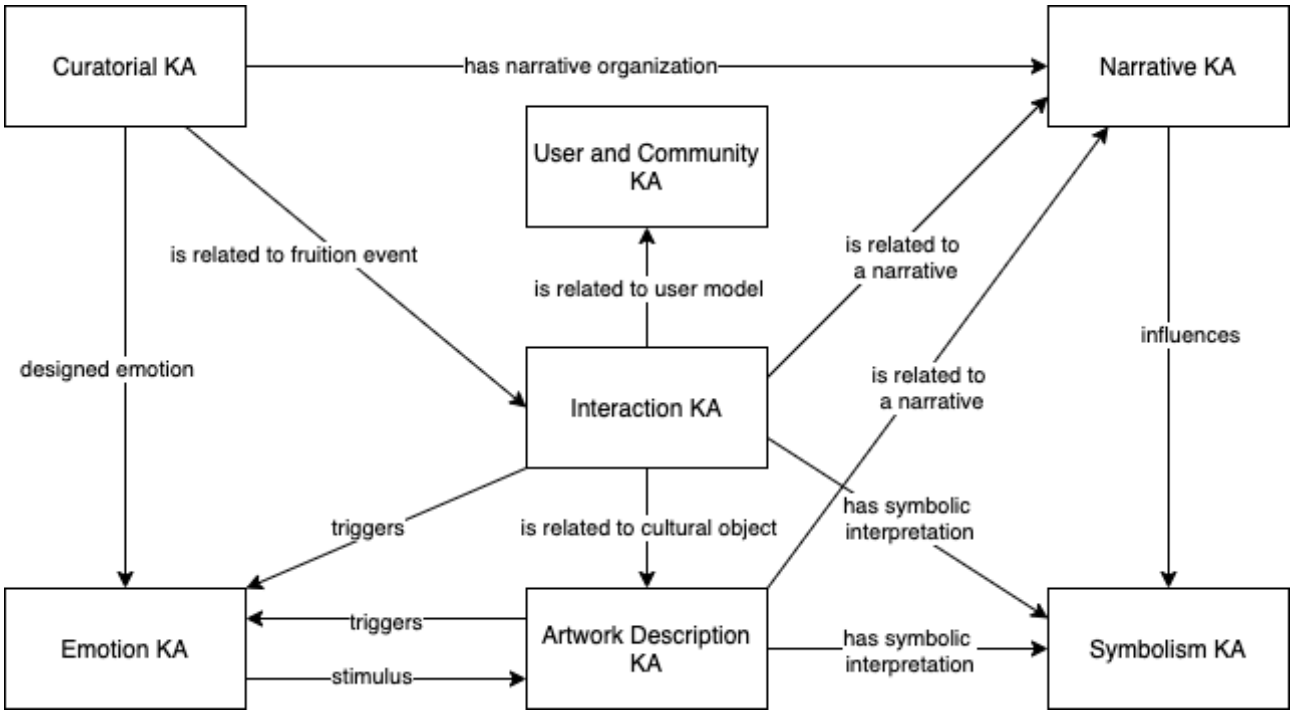



*Figure 5 The Knowledge Areas of SPICE Ontology Network*

[17] https://w3id.org/OWLunit
[18] https://github.com/spice-h2020/SON/blob/main/TESTING.md

Figure 5 shows the Knowledge Areas of the SPICE Ontology Network (identified so far) and how they are interconnected. The knowledge areas were selected by analysing the user stories collected during the first year and related to the work carried out in all the work packages.

In the following list we provide a brief description of the knowledge areas that will be discussed later in the document.

- *Curatorial Area* (cf. Section 4) models aspects related to the citizen curation of artefacts. The user stories for such area mainly emerged from WP4 (in particular from the activities related to the definition of a Manifest) and WP6 (designing of activities plans – i.e. scripts).
- *User and Community Area* (cf. Section 8) models the user information/profile. The User and Community Knowledge area emerged from the activities of the task WP2 and WP3 which aim at building models able to describe users' characteristics and interests.
- *Interaction Area* (cf. Section 5) models aspects related to the modality of the interaction; specifically, it aims at representing the interaction between the experiencer, the museum artefact, and the environment, by linking together different elements from all the other areas. The user stories for this area were identified in the context of WP6 (scripts also define the modality of the interaction of the users with the artworks).
- *Narrative Area* (cf. Section 6) covers information related to the contents and narrative elements represented by the artefacts (e.g. characters, actions); it also represents the narrative techniques adopted by curators when designing engagement activities. The user stories for the Narrative Knowledge Area were defined in the context of the WP6 (in particular, ontologies this knowledge area are intended to represent narrative defined by a curator for a script).
- *Artwork Description Area* (cf. Section 3.6) deals with metadata of the cultural objects. The user stories for this area emerged from the analysis of the data shared by the museums (cf. WP7).
- *Symbolism Area* (cf. Section 7) models the symbolic aspects of artefacts and the interpretation made by users. The user stories for this area were defined in the context of WP7 and focused on specifying the meaning of the artworks.
- *Emotion Area* (cf. Section 9) models emotions triggered by the interaction between users and cultural heritage objects. The user stories for this area were defined in the context of WP3 (cf. Semantic Annotator).

The next table briefly summarizes the ontologies composing the knowledge areas. For each ontology we indicate if it has been developed in SPICE or already exists. Ontologies are detailed in the next sections.

| **Knowledge area** | **Ontologies** | |
|---|---|---|
| | New | Reused/Extended |
| Curatorial Area | Scripting | Prov-O, P-Plan, Schema.org |
| User and Community | Values, Value Core, World Value Survey, Schwartz, Haidt | D&S, Framester, FrameNet |
| Interaction | Fruition Context | Affordance from the MARIO Ontology Network (extended) |
| Narrative | Narrative | |
| Artwork Description | | CIDOC-CRM, ArCo, Building Topology Ontology |
| Symbolism | Symbolism | |
| Emotion | Emotion, Emotion in cultural context, Ekman Emotions, Pluchick Emotions, Shaver Emotions, OCC Emotions | MARL Opinion Ontology, semiotics, earmark, POS |

## 3.4 Permanent URI of the ontology network

All the ontologies of the network have a persistent identifier. The identifiers of the ontologies fall under the namespace: https://w3id.org/spice/SON/ (prefix son:).

## 3.5 Motivating Scenario

To pragmatically drive the development of SON ontologies we co-designed a motivating scenario with the following partners of SPICE[19]:

- The GAM museum, which provided cataloguing data of 43 selected artefacts and curators' annotations (such as descriptions of narrative aspects represented in the artefacts, subjective emotional responses, and historical notes)
- All partners of SPICE providing technologies and data relevant to the scenario, namely: UNITO, which collected data during a citizen curation activity involving GAM collection of artefacts (D4.1); UNIBO, which developed a dashboard application for monitoring social media and citizen curation activities leveraging GAM data collections (D4.1); OU, which provides the infrastructure for storing and serving Linked Open Data and contributes to the design of citizen curation activities (also called *Scripting*) (D4.1); CELI, which provides REST services for annotating texts with sentiment and emotions (D3.2); UH, which provides requirements relevant to the modelling of users and communities (D3.1).
- All partners in SPICE that provided theoretical frameworks to model Citizen Curation and Social Cohesion aspects (D2.5), namely AAU and AALTO providing theoretical grounding for interpretation methods (D2.1) that can be translated into activities (artifact analysis, citizen curation activities)(D7.1) and initial approaches for the User and Community Knowledge Area concerning the interpretation-reflection loop (D2.1-2.2); UNITO, UNIBO and CNR providing theoretical foundation to the conceptual modelling activity (D6.1), both in ontologies content and structure (D6.5), in all the SON modules.

We describe the motivating scenario in natural language as follows (in squared brackets, we include a reference to the Knowledge Area to which the topic at hand pertains):

> *Curators of the Galleria d'Arte Moderna (GAM) of Turin select 43 artefacts as a testbed to foster and monitor citizen engagement in a number of activities. Museum curators provide cataloguing metadata of the artefacts [Curatorial KA], descriptions of narrative aspects depicted in the visual artworks (e.g., characters, actions, objects) [Narrative KA], and emotions that they believe the artefacts would elicit in the general public [Emotion KA].*
>
> *First, GAM collaborates with UNITO in designing a citizen curation activity called GAMgame that conforms to Scripting templates addressed in a dedicated SPICE working group (including GAM, UNITO, UNIBO, OU, UH) [Curatorial KA]. GAMgame is a web application that allows users to select pictures of the selected artefacts [Interaction KA] and share stories about those (including memories, opinions, emoji, hashtags) [Emotion KA]. Secondly, developers harvest existing social media contents wherein users share their opinions and images of the selected artefacts.*
>
> *Data collected from Social Media Platforms and GAMgame are enriched with machine-readable annotations on sentiment and emotions, through a REST service provided by CELI [Emotion KA]. Developers of UNIBO upload the data on the Linked Data Hub (provided by OU) and realize a dashboard where statistics on user-generated contents are provided to curators.*

In Figure 6, we provide an overview of the data model used to represent the scenario, including both terms of the SON ontologies and reused ontologies (further detailed in the following sections).

[19] Relevant deliverables where to find further information are indicated in between parentheses.

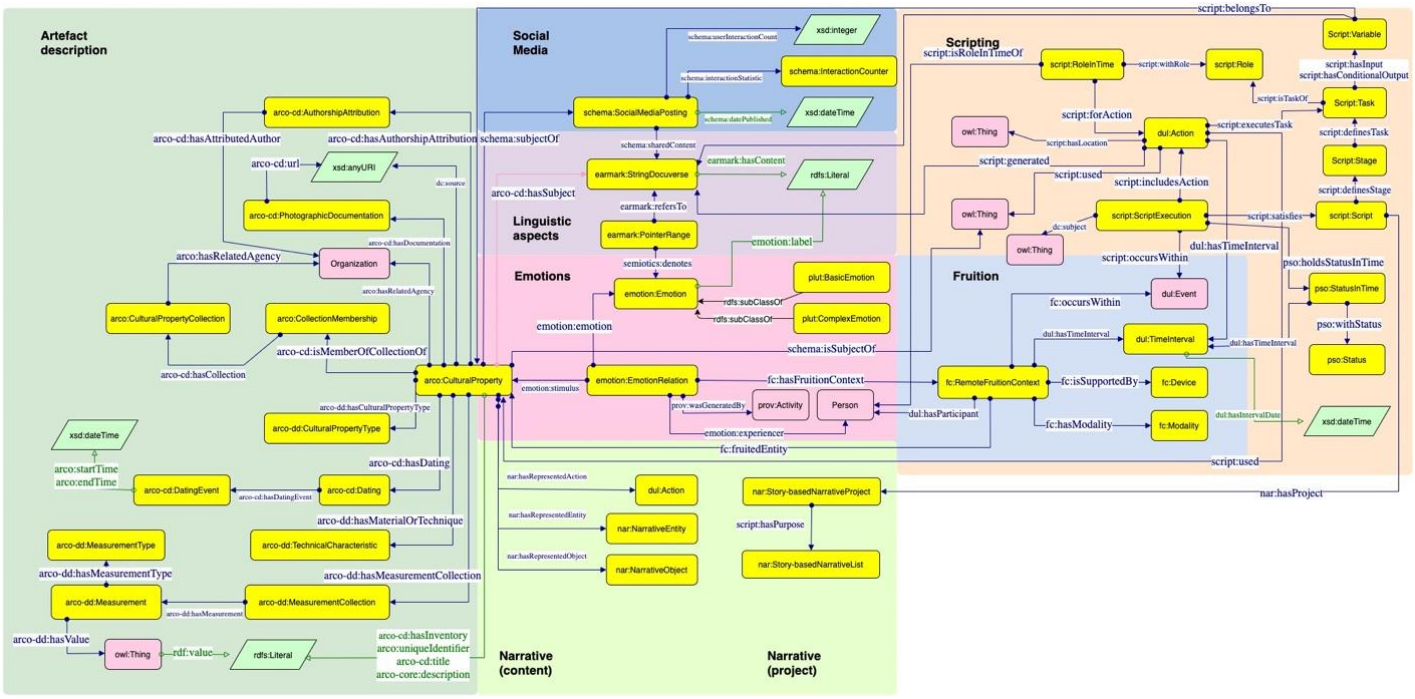



*Figure 6 Overview of GAM motivating scenario. An online version of the picture is available at the following link[20]:*

All terms required to represent the scenario are currently addressed in the SON Ontologies. Moreover, new ontologies not used yet in the motivating scenario but for which we plan a future application [see *Symbolism KA* and *User and Community KA*] have been included in the current release and were preliminarily evaluated.

## 3.6 Reuse of state-of-the-art ontologies

As already anticipated in the description of the methodology (cf. Section 2.3), XD maximizes the reuse of existing ontologies. This practice favours the interoperability and streamlines the ontology design process.

We remark that, in doing so, we benefitted of many ontologies developed in the context of past European research project.

Currently several existing ontologies have been reused to represent information relevant to knowledge areas. These include the following:

- **DOLCE+DnS Ultralite**[21] (DUL) foundational ontology. In the context of SPICE it is used as a backbone to guide the development of all the ontologies to support reasoning tasks. It is extended/specialised when needed. DUL is an OWL adaptation and extension of the DOLCE foundational ontology (originally expressed in S5 modal logic) [13], and Descriptions and Situations [14][15], which have been originally designed in the context of the WonderWeb[22] EU project.
- **PROV-O**[23], a W3C endorsed ontology. It is used to represent provenance of activities, such as the information related to data annotation. The P-Plan Ontology[24], an extension of PROV-O, is used to represent the template (scripting) and the execution of citizen curation activities.
- **CIDOC-CRM**[25], an ISO standard ontology for museum data. It is used as a reference for describing contents represented in a visual work (e.g. characters depicted in a painting).

[20] https://drive.google.com/file/d/1YtiQsZ9tD9DHuUoETOFG3Xxx6NLYA0RM/view?usp=sharing
[21] http://www.ontologydesignpatterns.org/ont/dul/DUL.owl
[22] https://cordis.europa.eu/project/id/IST-2001-33052
[23] https://www.w3.org/TR/prov-o/
[24] http://vocab.linkeddata.es/p-plan/
[25] http://www.cidoc-crm.org/Version/version-7.0.1

- **Schema.org**[26], a popular ontology founded by large companies such as Google, Microsoft and Yahoo. In SPICE it is used to describe web contents, such as social media posts.
- **ArCo [16]**[27], the ontology adopted by the Italian Ministry of Cultural Heritage is used to represent cataloguing data of museum artefacts.
- **MARIO Ontology Network**[28] is an ontology network for organising the knowledge of a social robot. It has been included in SON for describing affordance relations (cf. Section 5.2) and Tagging activities (cf. Issue 42[29]). The MARIO ontology network is one of the results of the H2020 Mario project[30].
- Several ontology design patterns (e.g. Situation[31], Time-indexed role[32] etc.) developed in the NeOn project and later by the Ontology Design Patterns community.
- **Earmark**[33], **Semiotics**[34] and **POS**[35] as reference models for specifying textual annotations (cf. Issue 30[36]).
- **Building Topology Ontology (BOT)**[37] is a minimal ontology for defining relationships between the sub-components of a building. For example, this model is relevant for describing the topological structure of an exhibition of artworks (cf. Issue 31[38]).
- **MARL Opinion Ontology**[39] is an ontology designed enables the annotations of sentiment (positive/negative) of portion of text (cf. Issue 43[40]).

Our approach to ontology reuse is detailed in [17]. In particular, the rationale of the ontology selection lies on a few solid grounds, namely:

- The availability of reused ontologies MUST be ensured beyond the end of the project. Therefore, reused ontologies MUST be either standard ontologies (e.g., W3C endorsed ontologies, ISO standards) or ontologies developed by trusty parties that can ensure the long-term availability of the ontology.
- Direct reuse (via import) SHOULD be endorsed for all the ontologies, to ensure consistency in reasoning tasks.
- When ontologies are extended or specialized, alignments between new terms and existing ontologies SHOULD be provided as part of the final ontology files or in dedicated alignment documents.

It's worth noting that, while terms from DOLCE, PROV-O, and CIDOC-CRM are aligned whenever applicable to new terms across the SPICE ontologies, Schema.org and ArCO are orthogonal to the SPICE Ontology network, meaning that terms defined in those ontologies are not specified (neither extended nor specialised) anywhere else. For the sake of completeness, we include here an exemplar of usage of these ontologies.

*Reuse of ArCo Ontology Network.* Common cataloguing metadata of museum artefacts (e.g., title, author, date) fall under the *Artwork Description Knowledge Area*. Such information can be represented according to terms belonging to the ArCo ontology network. In particular, we reuse the following modules:

- arco: (https://w3id.org/arco/ontology/arco)
- arco-core: (https://w3id.org/arco/ontology/core)

[26] https://schema.org/
[27] http://wit.istc.cnr.it/arco
[28] http://etna.istc.cnr.it/mario/mon/index.html
[29] https://github.com/spice-h2020/SON/issues/42
[30] http://www.mario-project.eu/portal/
[31] http://ontologydesignpatterns.org/wiki/Submissions:Situation
[32] http://ontologydesignpatterns.org/wiki/Submissions:Time_indexed_person_role
[33] https://essepuntato.it/2008/12/earmark#
[34] http://ontologydesignpatterns.org/cp/owl/semiotics.owl#
[35] http://www.ontologydesignpatterns.org/ont/fred/pos.owl#
[36] https://github.com/spice-h2020/SON/issues/30
[37] https://w3c-lbd-cg.github.io/bot/index.html#
[38] https://github.com/spice-h2020/SON/issues/31
[39] http://www.gsi.upm.es/ontologies/marl/ns#
[40] https://github.com/spice-h2020/SON/issues/43

- arco-cd: (https://w3id.org/arco/ontology/context-description)
- arco-dd: (https://w3id.org/arco/ontology/denotative-description)

In Figure 7 we show the main classes and properties of ArCo ontologies reused in the GAM motivating scenario.

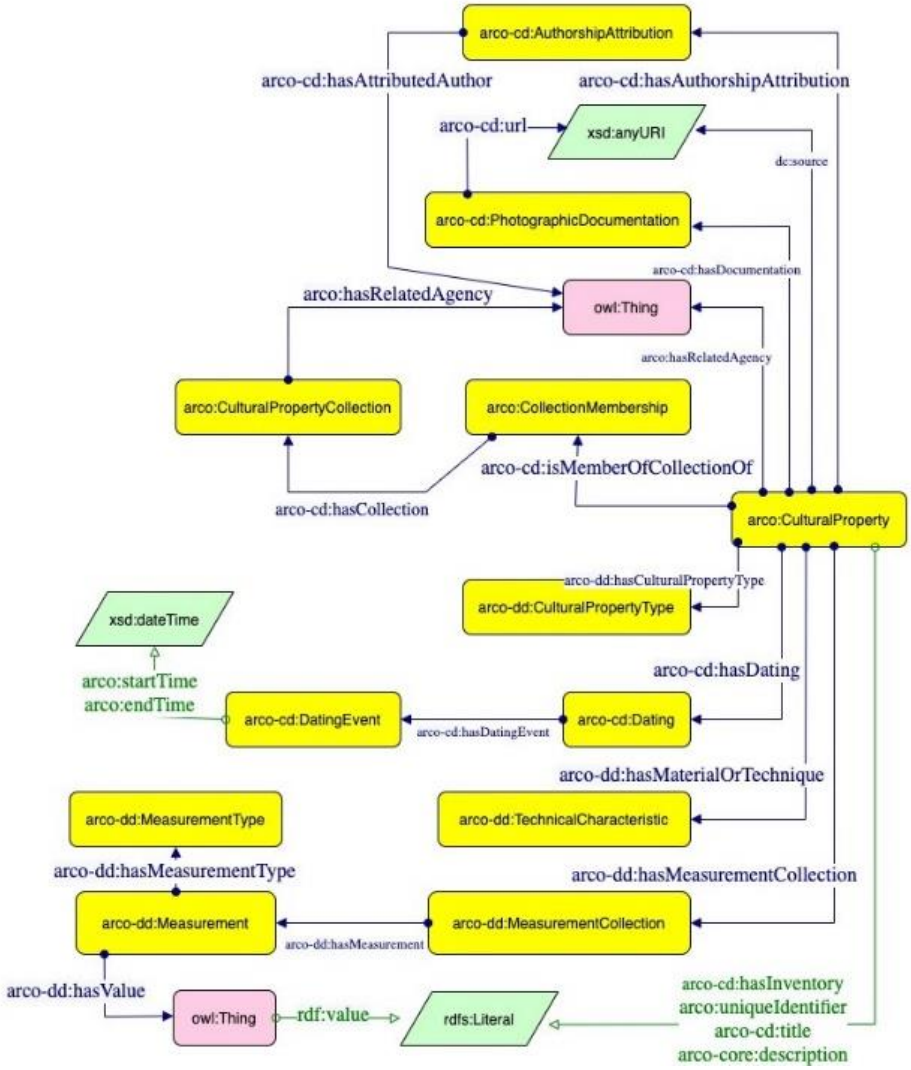



*Figure 7 Main classes and Properties of ArCO for describing museum artefacts*

An artefact can be described as an instance of the class *arco:CulturalProperty,* that is associated to the collection it belongs to (*arco:CulturalPropertyCollection*) and to its keeper (*arco:hasRelatedAgency*). Physical dimensions can be described as the result of a measurement (*arco-dd:Measurement*), while material and techniques are described as technical characteristics *(arco:TechnicalCharacteristic)*. Information that is subject to the cataloguer's interpretation or analysis, such as the authorship or the dating of the artefact, are associated to the artefact through dedicated interpretive events *(arco-cd:AuthorshipAttribution, arco-cd:Dating)* which can be further annotated with context information (e.g., sources, motivations). Images of the artefact can be recorded as instances of *arco-cd:PhotographicDocumentation*, and, if applicable, associated to an online image *(arco-cd:url)*. Lastly, identifiers *(arco-cd:hasInventory, arco:uniqueIdentifier),* titles *(arco-cd:title)*, and descriptions *(arco-core:description)* are recorded as free-text information.

*Reuse of Schema.org.* All the information related to web contents such as users' posts on Social Media Platforms, are described according to terms of Schema.org. In Fig. 8 we show an overview of terms belonging to Schema.org that we reused to represent social media interactions.

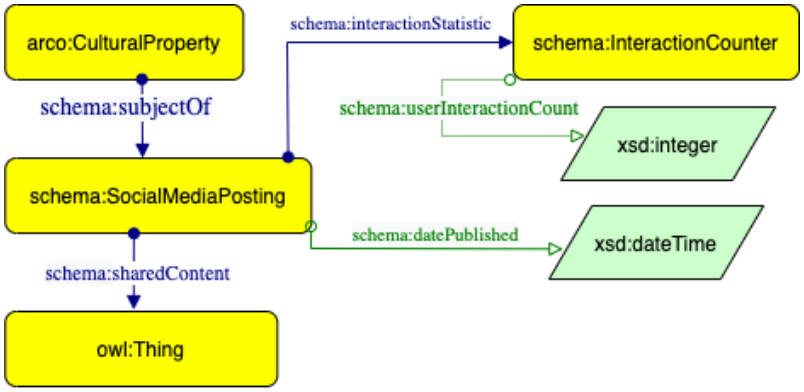



*Figure 8 Main Classes and Properties of Schema.org for describing Social Media posts*

A user's post is represented as an instance of the class *schema:SocialMediaPosting*, which is associated to its date of publication *(schema:datePublished)* and, if available, the number of likes the post received *(schema:interactionStatistic / schema:userInteractionCount)*. Contents, like images or text, are associated via the property *schema:sharedContent*. The artefact that is addressed in the post (e.g., depicted in a picture that is part of the post), is linked via the property *schema:subjectOf.* It's worth noting that we do not describe any information that allows one to identify the author of the post, and all data are anonymised.

# 4 Curatorial Knowledge Area

The Curatorial Knowledge area addresses all the aspects related to curatorial practices and citizen curation activities. Citizen curation activities are exhibitions or engaging activities wherein users interact with exhibits - according to an activity plan designed by museum curators (from now on called *script*) - and user-generated contents are selected to become part of the cataloguing data.

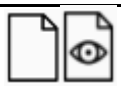
The description of the design and the execution of citizen curation activities includes innovative aspects that have only partially been addressed in existing ontologies. Therefore, a dedicated ontology module, i.e., the Scripting ontology, has been developed and aligned to existing ontologies whenever applicable.

## 4.1 Scripting ontology

### 4.1.1 Introduction

The Scripting ontology allows us to describe aspects related to the design and execution of citizen curation activities, including engagement activities with museum visitors, web applications for eliciting users' interpretations (e.g., via storytelling, question answering), and social media interactions. Design aspects relevant to citizen curation activities (i.e., the script), include stages, activities, roles, used and generated contents, and intended purposes. For instance, the following table exemplifies roles, activities, and stages included in an exemplar script. The script represents a generic engagement activity wherein visitors' stories are elicited by curators. While preparing the general activity, curators select artworks to be presented to visitors. In this stage, nobody else is allowed to intervene. When the script is running, visitors are grouped and tell a story about a selected artwork. Curators monitor the received stories, analyse them, and propose them to other visitors, which in turn can respond with another story or comment. When the activity is over, selected stories are shown to the public, which can explore different points of view about artworks.

*Table 1. Example of roles, activities, and stages related to a script.*

| **Role** | | **Activity** | **Stage** | | | |
|---|---|---|---|---|---|---|
| | | | Preparation | Running | Analysis | Presentation |
| Curator | | Select set of artworks |  |  |  |  |
| | | Monitor shared stories |  |  |  |  |
| | | Select shared stories |  |  |  |  |
| Grouped | Story giver | Tell story, specify recipient and indicate whether it can be shared with the curator |  |  |  |  |
| | Story receiver | Give response to received story |  |  |  |  |
| Public | | Explore shared stories |  |  |  |  |

A script can be separately described from its (multiple) executions (i.e. events wherein a pre-designed script is performed). The ontology allows to link executed activities and generated outputs (e.g., a user story generated during a question answer session with curators) to the originally intended scripting templates.

The aim is to provide all the terms required to validate the execution of a citizen curation activity over its original plan in an ontology-driven fashion. For instance, it is possible to validate whether a user consistently answered a question with a multiple value restriction, whether the user correctly responded to a task with an image rather than a text, or to quantify how many executions are completed.

In the context of SPICE, the scripting ontology is relevant to the following activities:

- Ensure consistency in the **design and representation** of citizen curation activities. The taxonomy of stages, tasks, roles, and types of user-generated contents supports the formal representation of scripts developed by museums (relevant to pilots in WP7).
- **Exchange** background information along with user-generated contents and annotations. Data contributed by users via the interfaces for citizen curation (developed in WP5) and annotated by means of dedicated REST APIs (provided by CELI, WP3) will be available for reuse according to specific privacy policies designed in WP4. Data will be shared along with all the information on the activities performed to elicit users' contribution (that is, the script and its execution) conforming to the Scripting ontology.

### 4.1.2 State of the art

According to Mulholland et al. 2012 [18], a script can be divided into sequential, temporal stages, each including a number of activities performed by agents with different roles in time. DOLCE and the P-Plan ontology both allow to represent the execution of workflows and plans as sets of activities (actions) executed according to an original description (tasks).

However, existing ontologies do not allow to specify (1) conditional sequences of tasks, (2) whether an input or output is mandatory or conditional, and (3) the type of expected inputs and outputs of activities. Therefore, there is no means to validate whether contents generated during a workflow execution respect the original plan and whether they belong to the same class as originally specified. For this reason, we extended prior work with new properties and by using punning[41] to represent the class to which an input/output must belong to.

### 4.1.3 Description of the ontology

The ontology and the documentation are available at: https://w3id.org/spice/SON/scripting. In the figure below the main classes and properties of the ontology are presented, including the alignments to DOLCE (dul:) and the P-Plan Ontology (p-Plan:).

[41] See https://www.w3.org/2007/OWL/wiki/Punning

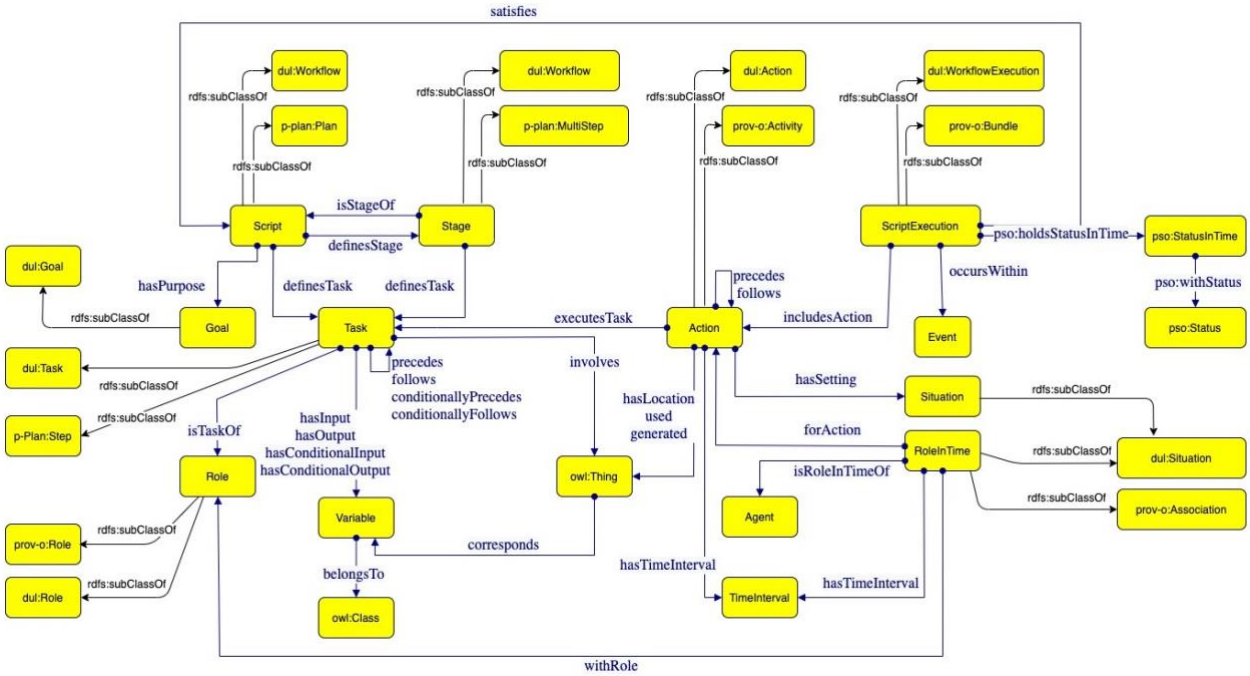



*Figure 9 Main classes and properties of the Scripting Ontology*

The class *Script* represents the designed citizen curation activities. Scripts can be linked to stages (*Stage*), which in turn are linked to the planned activities (*Task*). A detailed taxonomy of stages and tasks is also provided. For instance, the Task taxonomy includes classes such as *Selection, Design, Processing, Collecting,* which are in turn further specialized. Each execution of the plan (*ScriptExecution*) can be annotated with executed activities (*Action*). Actions can be described in terms of their setting (*Situation*), inputs (*used*) and outputs (*generated*), the event (*Event*) in which the action takes place, and the people and roles involved.

### 4.1.4 Example

**Motivating scenario.** *The script selected for the interaction between the user and a web application (the GAMgame) prepared by curators and scholars.* The objective of the activity is to elicit user stories [Goal: engagement, self-expression, storytelling] with respect to selected artefacts. Curators select pictures of artefacts from the GAM collection [Task: Selection of artefacts / Selection of multimedia contents] to be presented to users in random order every time [Task: Presentation of curatorial content]. Users pick 1-n pictures [Task: Selection of multimedia contents] and for each of them they may share: a text on a memory [Task: Free-text answering], a feeling, an emotion elicited by the picture [Task: Add emoticon], emojis, hashtags [Task: Tagging]. If the user chooses at least 3 pictures, the application recommends [Task: Recommendation] another picture to be included in the story. The recommendation is based on the analysis of the user story, e.g., narrative-based, emotion-based, random recommendation. Results of the script are currently under evaluation and enrichment. The user may accept the recommended picture or not. The script has been executed from 25th November 2020 to 30th March 2021.

**Competency questions.** The ontology allows to answer the following competency questions:

- **CQ1** What are the **stages** of the script?
- **CQ2** What are the **tasks** defined in each stage?
- **CQ3** What is the **purpose** of the script?
- **CQ4** What are the **agents' roles** involved in a task?
- **CQ5** What are the **input and outputs** of a task?
- **CQ6** What is the **next/preceding task** in a sequential script?

**Example in JSON-LD syntax.** A complete example of the scenario is available in section Appendix (13.1). Other example scenarios are available at https://github.com/spice-h2020/manifest.

# 5 Interaction Knowledge Area

The Interaction Knowledge Area aims at collecting ontologies representing the aspects related to the modality of the interaction. Specifically, it aims at representing the interaction between the experiencer and the museal artifact and environment, by linking together different elements from all the other areas. The Interaction Knowledge Area currently consists of two ontologies: the Fruition Context Ontology (presented in Section 5.1) and the Affordance Ontology (presented in Section 5.2).

## 5.1 Fruition Context ontology

The Fruition Context ontology aims at representing the modality and the context of someone's interaction with a cultural entity. Specifically, the Fruition Context expresses the event in which someone interacts with a certain cultural entity and it is related to the main aspects that a curator might want to track and analyse, such as: the modality of the interaction; possibly, the device used for interacting with the cultural entity; the time when such event occurs; the script or the exhibition in which the event occurs.

The main requirement that motivated the development of this ontology relies on the need of explicitly representing the interaction of a person with an artwork. The explicit representation of the interaction may be then referred by the information extracted or inferred by the recommender (cf. D3.1) or the semantic annotator (cf. D3.2). Additionally, fruition information enables mining of users' interests and habits (information relevant for the user and community modelling) or measuring the effectiveness of the scripts (cf. T6.5).

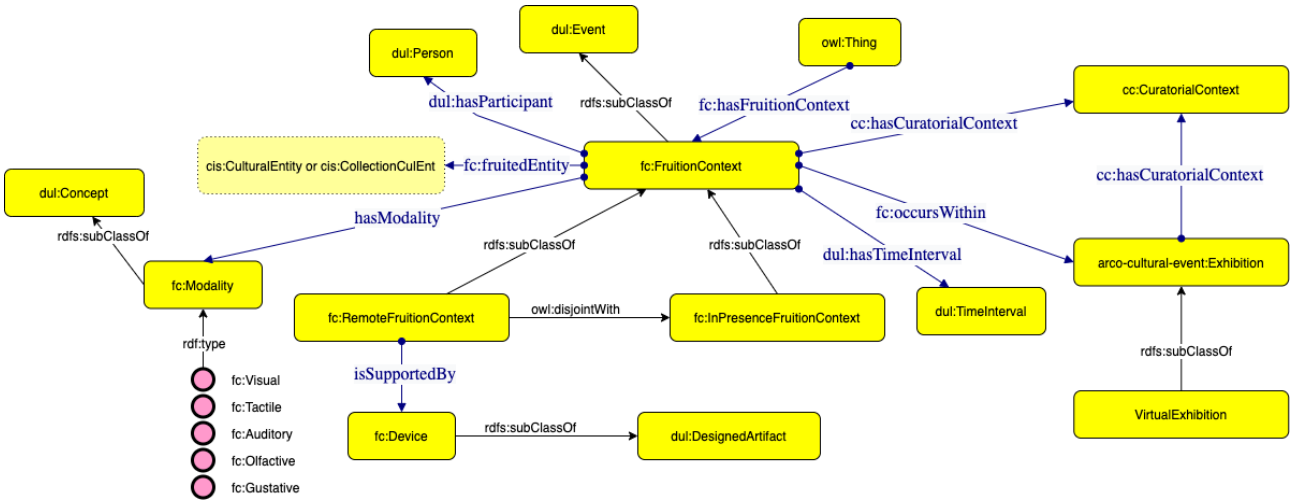



*Figure 10 The Fruition Context Ontology*

Figure 10 depicts The Fruition Context Ontology. The URI of the ontology https://w3id.org/spice/SON/fruitionContext/. The main class of the ontology is `fc:FruitionContext` which represents the fruition of a certain cultural entity (i.e. the fruited entity) by someone (i.e. the participant, a `dul:Person`), at a certain time (represented by a time interval, i.e. `dul:TimeInterval`), in the scope of a particular curatorial context. It is defined as subclass of `dul:Event`. It is specialized by: i) `fc:RemoteFruitionContext` which encloses all the fruition events in which the participants "virtually" interact with the cultural entity by means of some device (e.g. a smartphone); ii) `fc:InPresenceFruitionContext` which represents all the events in which the participants "physically" interact with the cultural entity. The ontology also enables us to specify the modality (i.e. `fc:Modality`) of a certain fruition event which is essentially the set of senses of the participants involved in the fruition event (e.g. the event has the visual modality in case that the participant can only see the cultural entity, tactile modality if they can touch the cultural object etc.). The ontology also the properties "has curatorial context" and "occurs within" that links the fruition context to the curatorial activities (i.e. the curatorial context) or the exhibition in which the fruition context occurs.

An example of usage of the Fruition ontology is provided in the motivating scenario (cf. Section 3.5).

**Competency questions.** The ontology allows to answer the following competency questions:

CQ1) What are the fruition events someone participated in?
CQ2) When a fruition event occurred?
CQ3) Does the user physically interact with the cultural entity? If not, what device supported the interaction?
CQ4) How a user interacted with a cultural entity?
CQ5) In which context a certain fruition event occurred?

## 5.2 Affordance ontology

In the design of cognitive agents (e.g. robots) behaviour selection is the process of deciding which action to execute at each point of time depending on the context in which the agent is situated. Many strategies have been proposed ranging from the purely reactive ones to the behavioural approaches. A number of behaviour-based approaches rely on the notion of Affordance. The concept of affordance has been introduced by Gibson [19] who devised a theory of how animals perceive opportunities for action. Gibson defined affordance as opportunity of actions. He suggested that the environment offers the agents (people or animals) opportunities for action. For instance, a door can have the affordance of "openability". These action opportunities are latent in the environment and independent from individual's ability to recognize them, but affordances are always dependent on agent's capability. For example, to a thief an open window can afford the "steal" action, but not so to a waitress who may simply be afforded by the "close" action if outside the temperature is too cold.

In the context of the H2020 MARIO project, this notion has been formalised as Ontology Design Pattern (ODP) [20]. Here, we briefly summarize the main ingredients of the pattern. The Affordance Ontology Design Pattern[42] extends the classical notion of affordance, which suggests that the physical objects (e.g., a door) offer the opportunity of performing an action (e.g., open). In fact, this ODP is designed by relying on the assumption that, not only physical objects, but also complex situations (e.g. the user want to listen to some music) afford actions (e.g. play music). A complex situation can be seen as the fulfilment at a certain time of certain conditions. These conditions may involve temporal aspects (e.g. lunchtime may afford the task remember the user to take the pills), the perception of certain physical objects, the receiving of a command (e.g. I want to listen to some music), or even the existence of certain state-of-affairs (e.g. the situation the user is sitting on a chair for a long while may afford the task entertain the user).

In SPICE, the notion of Affordance is also relevant for describing activities defined by a curator in a script. Specifically, it might be convenient for a curator designing a script (or parts of it) in a more flexible way without strictly imposing a sequence of actions for the user. The SON's Affordance ontology provides a general schema that allows the curator to define a set of stereotyped situations a user might be involved in and the actions that the user might perform in each situation.

The schema of the affordance ODP is showed in Figure 11. The ontology is inspired by the Affordance ODP but it adapts it for the SPICE requirements. The URI of the ontology is https://w3id.org/spice/SON/affordance. As in the Affordance ODP, the concept of affordance is defined as a relation connecting a description of a stereotyped situation (which in the case of the ODP is formalized as a Frame, here we generalize it as a `dul:Description`) with the tasks (`dul:Task`) that can be performed in that situation. The strength is a measure that indicates how much relevant is the performance of the task in such situation. In addition to the ODP, the ontology defines also a property "has effect" that is meant to specify the effect of the execution of a certain task, in other words, the property connects the tasks with its consequential stereotyped situation.

**Competency questions.** The ontology allows to answer the following competency questions:

CQ1) What are the tasks afforded in a certain situation?
CQ2) What are the effects of a given task?

[42] http://ontologydesignpatterns.org/wiki/Submissions:Affordance

An example of usage of the Affordance ontology is available online at[43].

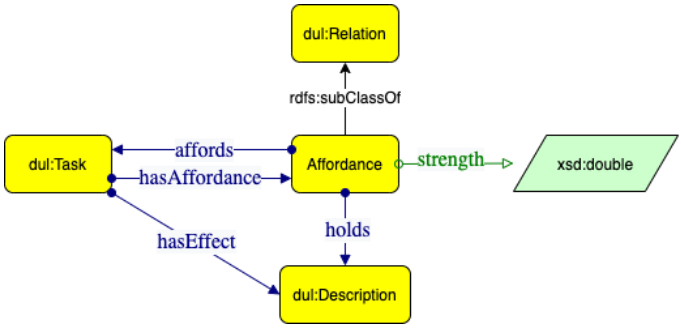



*Figure 11 The Ontology Affordance Ontology*

[43] https://github.com/spice-h2020/manifest/tree/main/hfm_scenario

# 6 Narrative Knowledge Area

## 6.1 Narrative Ontology

In SPICE, narratives are a primary medium for the expression of personal responses to artwork within the framework of citizen curation activities. In fact, the narrative format is implied by the use of narratives as part of the interpretation methods developed by WP2: consider, for example, the personal narratives elicited by an artwork, which may refer to biographic events of a person's life. In addition, narrative structures also lend themselves well to the representation of the events represented into, or evoked by, in artworks. This second case is relevant not only for narrative interpretation method, but also for the artefact analysis method, during which the content of an artwork is examined. For example, consider the following themes represented in Iconclass, the taxonomy of iconographic subjects designed for art. In this taxonomy, the subject described as "the Greeks rush to their ships" (id 94F22) clearly refers to an action (rushing to the ships), whose agent (the Greeks) is precisely identified; or, else, the one described as "Ariadne left behind on the island of Naxos" (95B(ARIADNE)61), where the specific location parameters of the event. If we consider, in the SPICE context, the collection of GAM, we can find examples such as "Studio per la morte di Leonida alle Termopili"[44] (The death of Leonidas at the Thermopylae), namely an artwork named after the event (of biographical type) it displays, or "Sirena" (Mermaid), described as "la Sirena ammaliatrice che trascina nella profondità marine la sua vittima" (the enchanting mermaid in the act of drawning her victim into the depths of the sea")[45]. Or, else, the event described through language may be found in the response, e.g., an annotation, added by a citizen to an artwork during a citizen curation activity: the dataset collected from the online responses to the artworks of the GAM contains references to specific actions and events -- often personal memories -- an example of which is the comment "(it reminds me of) when me and my friends were playing in the garden".

The purpose of narrative knowledge in SPICE is manifold. As described before, it has the function of describing the narrative elements contained in artworks and interpretations. An important requisite of the ontology is the representation of events as intentional actions carried out by characters, since this is a prerequisite for the representation of the emotional content of both artworks and citizen interpretations (see *Interactive storytelling and narrative methods* described in deliverable D2.1, Section 4.2): in appraisal models, in fact, the attribution of emotions relies on the accountability of the agents involved in the events to which they take part. While emotions can be associated with symbols (e.g. sadness to a skull) and moods may depend on aesthetic qualities such as colour (e.g. bright colours to elatedness), cognitive emotions such as pity or admiration imply an understanding of the situation from the point of view of the involved agents, including their motivations and values.

Representing the narrative content of artworks and of the interpretations of artworks provided by citizens is also relevant for the purpose of sensemaking, part of the Reflection phase in the Interpretation Reflection Loop (See D2.1 section 4.2, *Interactive storytelling and narrative methods*, and D2.2 section 4.1, *Narrative Identity*). Narrative elements, in fact, can provide a conceptual tool for comparing artworks and interpretations, as recommended by the methodological framework brough about by WP2, thus letting curators and citizen to explore the relations between them with the guidance of shared event types, characters, and so on (see 4.1.5 *Recommendations for SPICE*). For example, once a narrative event has been identified in an artwork, or in a set of artworks, the emotional response to it can be compared and become an element of reflection.

Given the role of narrative methods in SPICE, as described in D2.1, then, it is of primary importance to include in the ontology the knowledge about the structure of specific types of narratives, relevant for citizen curation, so that this information can be straightforwardly encoded in the narratives produced through the application of these methods. Examples of relevant narrative structures for narrative methods can be the biographical narrative (needed when personal memories are associate with artworks by curators or citizens, see D2.2,

[44] https://www.gamtorino.it/it/le-collezioni/catalogo-delle-opere-online-gam/studio-la-morte-di-leonida-alle-termopili-battaglia

[45] https://artsandculture.google.com/asset/la-sirena-sirena-abissi-verdi-giulio-aristide-sartorio/NQGGefC3eaZwLg

*Narrative Identity*), the chronological narrative (needed to account for the exposition of historical events, often represented in artworks), the thematic narrative (needed to represent the type of loose narrative created by using a topic as a red thread) or the dramatic narrative. Dramatic element, in particular, are often implied by the contrapositions displayed in artworks, where contrasts between characters are illustrated, or in biographic stories, where the overcoming of obstacles is staged, since elements of conflict are useful to gain the emotional engagement of the audience.

### 6.1.1 State of the art

Narratives constitute a cultural asset in themselves, especially when they are shared across ages and cultures. As such, they belong to the so-called Intangible cultural heritage[46], an abstract, human borne and mutable form of art that manifests itself through the representation of stories and characters in different contexts, from figurative arts to music and drama. As described in D2.2 (Cultural Narrative Identity, sections 4.1.1 and 4.1.2), narratives are also a means by which Cultural Narrative Identity is established in the Reflection phase of the Interpretation Reflection Loop.

The representation of narratives in semantic form has been addressed by a several projects in the last two decades, geared on the extraction of narrative structures from text and media, and possibly on the generation of stories. The pioneering Narrative Knowledge Representation Language (NKRL) project combines the use of markup for the encoding of the narrative content of text with the use of frames to represent the narrated story incidents [21] [16].

One of the first examples of model oriented to generation is the work of Gervás et al. [23]: inspired by the structuralist account of the tale provided by Propp [24], an OWL ontology of fairy tales is exploited to model different plot types and generate new tales by using a Case-Base Reasoning approach.

The OntoMedia ontology provides a media-independent model, designed to annotate the content of media objects in terms of characters, events, locations, etc., ranging from written literature to comics and TV fiction [25] [26]. Being an event-based description of the timeline of story incidents, with no interpretive intents, it does not cover the description of characters in terms of goals and intentions. TBA: BBC Story ontology. In a complementary way, the Story Intention Graph proposed by Elson [27] relies on the representation of the short-term characters' intentions to build an interpretive layer of a narrative text, but does not account for the causal sequences spanning long-term characters' intentions.

In the last decade a number of approaches have been developed for the formal description of narratives in cultural heritage activities and for enabling the exploration of museum collections. The StorySpace ontology [28] is an ontology of story aimed at supporting museum curators in linking the content of artworks through stories, with the ultimate goal of enabling the generation of user-tailored content retrieval (see also [29] ). For example, Mulholland et al. [29] describe a model of curatorial stories distinguishing story, plot and narrative. The Archetype ontology describes archetypal stories (e.g., heroic journeys) in terms of their shared symbolic meaning [30] [31]. Meghini et al.'s narrative ontology (NOnt) [32], developed within the EU Mingei project, provides a DL formalization of narratives, implemented as an extension of standard vocabularies in the field of cultural heritage (CIDOC CRM, FRBRoo, and OWL Time), and suitable to describe temporal processes through narratives, such the intangible knowledge about Craft Heritage. Damiano et al.'s Ontology of Drama, called Drammar [33], addresses the dramatic qualities of media, by proposing a formalization of drama mainly targeted at the study and annotation of dramatic qualities of narrative media [34], such as the element of conflict.

### 6.1.2 Description of the ontology

The Narrative Ontology (NO) developed in SPICE (available at https://w3id.org/spice/SON/NO/) is employed to describe both: 1) the narrative relations exhibited "within" a cultural entity (e.g. the representation of a certain action, story, character and their narrative connection, the narrative elements (listed also in the section of D2.1 on Interactive Storytelling and Narrative Methods: Story, Events, Character) and that can be used to group similar museum items sharing exhibiting similar narrative content; 2) the narrative relations

[46] https://ich.unesco.org/en/what-is-intangible-heritage-00003

projected "about" a cultural entity and used to define narrative projects (this aspect representing "the complementary part" of the scripts). These two uses are important to organize (according to a narrative structure) the data coming from the textual analyser in WP3, to group the cultural entities along narrative dimensions as proposed in the Interpretation Reflection loop developed in WP2 (see D2.1 and D2.2).

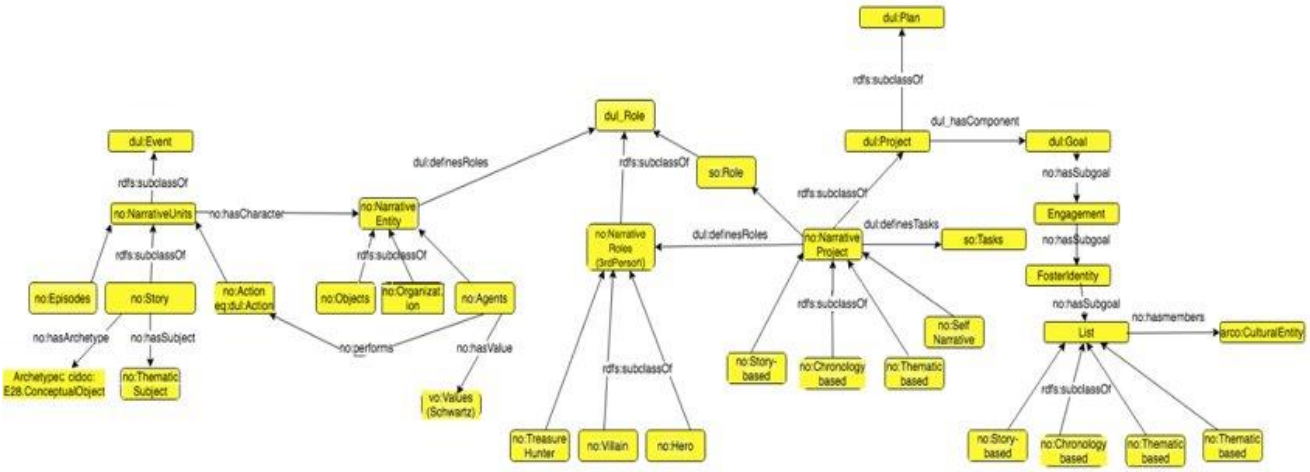



*Figure 12 Narrative Ontology Classes and Properties*

The ontology is aligned with DOLCE-zero http://www.ontologydesignpatterns.org/ont/d0.owl and, for the first modelling purpose (i.e. the "within" narrative modelling of cultural entities) describes the main components characterizing the represented stories in such cultural objects. In particular, following the specification provided by D2.1 (Section 4, *Interactive Storytelling and Narrative Methods*: Story (4.2.3), Events (4.2.4), Character (4.2.5)) this part of the ontology models: Events (specialized as Episodes, Stories or Actions), Narrative Entities (specialized as Objects, Agents and Organizations), Roles that can be played within an Event by such Narrative Entities, and Values that can emerge from such narratives (the modelling of Values is described in detail in the next sections).

The second narrative component modelled in NO (i.e., modelling the narrative "about" a cultural entity) takes into account that a "narrative" is a sort of organization principle around a set of cultural entities. It can be thought as a particular type of Plan (i.e. a Project) with its own Goals, Tasks and Roles assigned to the different participants. In this respect, the ontology defines Narrative Projects as an abstract characterization of a Plan in DOLCE-zero. It is worth noticing that, in DOLCE-zero, the class Plan has as subclasses Project and Workflow. While Project is the specialized class for the "Narrative", the class Workflow, on the other hand, is the overarching class of the Scripts in the Scripting Ontology. Narrative Projects and Scripts are, therefore, two different levels of description of the same plan.

Such narrative projects can be characterized by different constraints. For example: the Narrative Project of a curator could be to design an exhibition where all the cultural entities are grouped according to the Story the share or their Thematic Subject, their Chronological period etc. All these principles provide a way to constraint and group similar items together. The overall goal of such a project could be, for example, to foster the Engagement of the museum users. This goal can be achieved by means of many levels of subgoals where the ultimate one is represented by the definition of a list of cultural entities organized according to some narrative principles. The roles and the tasks involved for reaching such goals are assumed to be the same of the ones used in the Scripts (as above mentioned: Narrative Projects and Scripts are two sides of the same coin. An example in Turtle of the connections between the Narrative Ontology and the Scripts is provided at https://github.com/spice-h2020/SON/issues/40). Another assumption modelled in the ontology is that the planner of a Narrative Project (e.g., a curator in the example) could also decide to assign – for the project to unfold – some "narrative roles" to a particular group of users. For example: an exhibition could be designed by assigning 3rd Person narrative roles to the museum visitors (e.g. the role of a Treasure Hunter, a Villain, a

Hero etc.) and this role assignment would influence the kind of activities that this group of users can carry out during their fruition.

The competency questions of this ontology are:

CQ1) What are the events represented in Cultural Entity x?
CQ2) What are the stories represented in Cultural Entity x?
CQ3) Who are the Narrative Entities represented in Cultural Entity x?
CQ4) Are there other artworks representing the same story/events/actions/Narrative entities of the Cultural Entity x?

### 6.1.3 Example: the GAMgame

A curator of the GAM Museum decides to select a list of cultural entities from the GAM collection grouped according to a story-based principle (the items share or represent the same underlying story). Such items are shown via an APP to the users. Users can tag the artworks with emoji of with their own personal feelings. They can then select some of these artworks and create their “personal narratives” (e.g. providing their own organizational principles on the above-mentioned artworks). Such narratives can be shared with friends (thus starting an interpretation-reflection loop between citizens) or remain private. The museum curator can also analyse the produced personal narratives and such data-driven grouping can lead to a reflection about how the future narrative projects of the museum Users' interaction with museal items triggers different basic emotions in a user (e.g., Joy and Trust). The Plutchik's model automatically associates to the items triggering these emotions also the emotional concept Love (composed by those basic emotions).

The Turtle serialization of this examples is provided in the Appendix (13.2)

# 7 Symbolism Knowledge Area

The Symbolism Knowledge Area deals with the symbolic aspects of the cultural entities of SPICE. Symbolism is an umbrella term to address pre-iconographical, iconographical, iconological aspects of a work of art, along with meanings that take into account the cultural context of the artifact.

For instance, a painting represents a person turning away from a church (pre-iconographical recognition). That person could be identified as Apollo (iconographical recognition), and Apollo may be interpreted as a symbol of reason and intuition (iconological interpretation) [35]. The juxtaposition of reason and intuition, and the act of turning away from a church, when appearing in an Italian Enlightenment painting, might represent the general phenomenon to turn away from religious dogmatic ideals, typical of that period.

In SPICE we assume that the symbolic knowledge is relevant in both the authoritative descriptions museum professionals and the interpretations of the users considering the sphere of Cultural Semiotics explored in WP2 (Deliverable 2.2). The main objectives of this knowledge area are highlighting the differences and similarities in symbolic interpretation from users and museums and including the symbolic meaning of the artifacts in the parameters for a recommender system developed by WP3.

## 7.1 Symbolism Ontology

### 7.1.1 Introduction

In the context of SPICE, museal item are given an authoritative description that might contain symbolic notions. Following the promising results of the experiment in [36] ,these unstructured symbolic notions could be given a structure if encoded using an ontology. Moreover, the users' interpretations could as well contain symbolic elements and be encoded using the same ontology.

Due to the heterogeneous nature of the elements that are included in this ontology, it will be strongly correlated to the Narrative, Values, and Interpretation ontologies in the SPICE network.

In the future plans of WP3, there will be the development recommendation system for the users (Task 34), symbolic information encoded with this ontology could enrich this system.

### 7.1.2 State of the art

In [37] an ontological model is presented to describe the identification of an Iconographic Subjects according to specific recognizing elements. The ontology presented in this work is not currently available and there is only a test case to show how to use the ontology as an aid to subject identification.

In Wikidata, according to its data model[47], a work of art is linked to the elements that are depicted in it with the property P180 *depicts*. There is no distinction between elements of pre-iconographical, iconographical, or iconological level. There exist some qualifiers applied to that property, in particular P6875 *motif represents* and P4878 *symbolizes* that could potentially give more background information on the iconographic and iconological levels of a work of art but they are used respectively for 1 and 241 entities only. An example of a query that verifies this statement can be seen below[48]:

```
PREFIX wd: <http://www.wikidata.org/entity/>
PREFIX pq: <http://www.wikidata.org/prop/qualifier/>
PREFIX ps: <http://www.wikidata.org/prop/statement/>
PREFIX p: <http://www.wikidata.org/prop/>

SELECT distinct ?depicted ?depictedLabel  ?symbol ?symbolLabel
WHERE
```

[47] https://www.mediawiki.org/wiki/Wikibase/DataModel
[48] The query was run in Wikidata SPARQL portal (https://query.wikidata.org/)

```
{
  ?entity p:P180 ?P180node .
  ?P180node ps:P180 ?depicted .
  ?P180node pq:P4878 ?symbol .
  SERVICE wikibase:label { bd:serviceParam wikibase:language
"[AUTO_LANGUAGE],en". } }
```

VIR [38] is an ontology that provides an extension of CIDOC-crm ontology[49] . It creates relationships between works of art and the iconographical recognitions made on them. It also uses external taxonomies for subject classification provided by Iconclass[50] , Warburg[51] and Garnier [39].

Although there exist ontologies that deal with these aspects, [36] shows how in the current state of cultural heritage knowledge graphs symbolic information is not yet encoded like other canonical metadata. The challenge of spice would be not only to develop an ontology that is able to encode this kind of information according to SPICE own requirements, but also to produce structured symbolic data based on the description of the items and user's interpretations considering Cultural Semiotics (see Deliverable 2.2).

### 7.1.3 Description of the ontology

This ontology is still on a prototypical stage, no owl serialization has been developed and for this reason it is still not connected to the whole SPICE ontology network. In fact, all the prototype classes are currently self-declared. In its first release, the symbolism ontology will be aligned with the current spice ontologies along with other more domain specific ones yet to be decided. It is planned to import some existing widely used ontology design patterns such as DOLCE+DnS UltraLite.

The prototype conceptualizes the class *SymbolicRecognition* which is a N-ary relationship class that links the participating entities in a symbolic recognition:

- *WorkOfArt*, which represents the object of the recognition, is linked to *SymbolicRecognition* with the property *aboutWorkOfArt*
- *User* and *Institution* are two classes that represent the possible interpreters of the work of art, and are linked to *SymbolicRecognition* using the the property *recognzingAgent*
- *PreiconographicalElement, IconographicElement, IconologicalElement* and *IntrinsicElement* represent the possible elements that can be recognized in a work of art. For an example of each one of those elements refer to the example in the Symbolism Knowledge Area.

The diagram below represents a modelet of the current version of the prototype.

[49] http://www.cidoc-crm.org/
[50] https://rkd.nl/nl/collecties/services-tools/iconclass
[51] https://warburg.libguides.com/classification

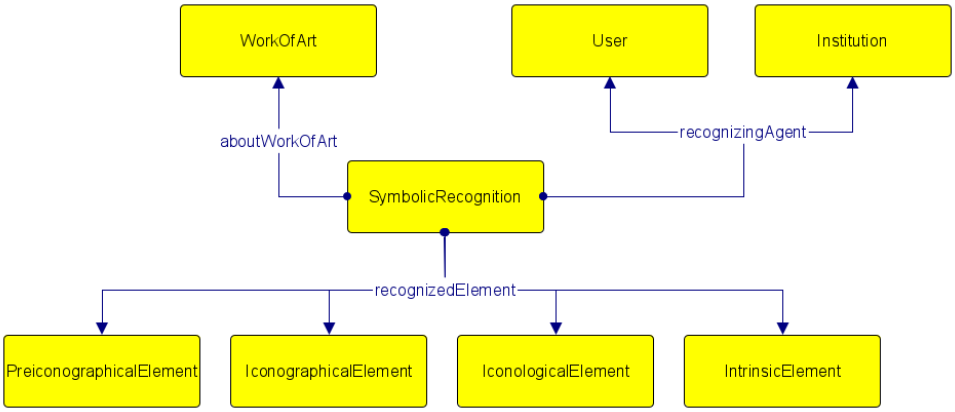



*Figure 13* Prototype Modelet of the Symbolism Ontology

The current competency questions from which this modelet was generated are the following:

**CQ1)** Retrieve all the pre-iconographical elements (or iconographical, or iconological, or intrinsic) elements recognized by a User (or Institution) of a specific Work of art.

**CQ2)** Retrieve all the Works of art which have at least one intrinsic element recognized.

**CQ3)** Retrieve all the Works of art that have a specific Iconological Element recognized.

**CQ4)** Retrieve the works of art that have an intrinsic element recognized only by Users (or only by institutions).

**CQ5)** Retrieve the works of art in which the iconographical element differs between a recognition made by a user and one made by an institution.

**CQ6)** Retrieve the work of art with most intrinsic element (or iconographical, pre-iconographical, iconological elements) recognized.

# 8 User and Community Knowledge Area

The User and Community Knowledge Area includes the ontological modules dedicated to deal with knowledge needed to represent, on the one side, the User interpretation of cultural heritage, -- in a broader view, part of the individual and collective sense-making process (cf. D2.2 Cultural Semiotics) --, and, on the other side, the appraising process, which depends on the distribution of values and meanings attributed by a User or a Community to a cultural entity (cf. D2.2 Heterarchical Value System and D2.2 Social Cohesion).

The User and Community Knowledge Area, furthermore, is specifically relevant for the Interpretation - Reflection loop (cf. D2.1-2.2) as well as for the recommender system (cf. D3.1) both for single Users and Communities, and for the scripting activities related to social cohesion (cf. D4.1 and D2.2 Social Cohesion). As a standalone, it is relevant as a first attempt to develop a general ontology of the notion of Values, and as being a formal representation of the main theories about Values in human cognition studies.

## 8.1 The Values Ontology

The Values Ontology is the ontological module of the User and Community Knowledge Area dealing with the representation of the complex concept of Value.

### 8.1.1 Introduction

The first version of the Value Ontology includes: two of the main theories about the conceptual structure of human values, namely the Theory of Human Values [40] and the Theory of Moral Foundation [41], as well as an ontological version of the bootstrapped data from the World Value Survey questionnaire, and a core module with a minimal vocabulary to talk about the general conceptual frames related to Value, which encompass the notion of value in different theories, and the occurrence of Value situations.

### 8.1.2 State of the art

The notion of moral values is relevant in the interpretation-Reflection Loop (cf. D2.2 Interpretation and Reflection Loop, in particular 3.0 and 4.3.7) which characterizes citizen curation in SPICE. Clearly distinct from moral norms (with which they can be in conflict), and from legal norms, values are variously represented in literature as either beliefs or goals, depending on the motivations behind value compliance implied by each theory. Differently from norms, values neither prescribe or inhibit specific behaviours, nor they imply a specific sanction, apart from the negative (for violation) or positive (for compliance) emotions postulated by emotion theories with respect to values.

The perspective of values differs from deontic reasoning: in van Fraassen's words, Deontology, or the theory of obligations) "deals with what ought to be because it is required by one's station and its duties, by the web of obligations and commitments the past has spun", while Axiology, or the theory of values, "deals with what ought to be because its being so would be good, or at least better than its alternative" [42].

Moral values are implied by the process of emotional appraisal, represented in the OCC ontology [43] (cf. Section 13): according to the OCC model, values, termed moral standards, take part in the appraisal of situations intended as actions, whose responsibility can be attributed to an agent (possibly the agent her/himself). According to [44], "there was a biological blueprinting for the intelligent construction of human values […] We also believe that a variety of natural modes of biological responses, which include those known as emotions, already embody such values." Any action compliant with the agent's moral standards will be appraised as praiseworthy, or blameworthy if non-compliant.

In social psychology, other accounts rely on moral values for the activation of emotions: in particular, the Contempt-Anger-Disgust (CAD) triad model of moral emotions proposed by [45] relates them to specific configurations of values, termed *ethics*, inspired by Schweder's work [46] on morality from an anthropological perspective. While OCC is neutral with respect to the notion of value, also defined as goals of ethical nature, and delegates their definition to an external theory, the CAD triad model relates each emotion type to the violation of a specific ethic, which motivates people to repair the moral order: Contempt to the Ethics of community, Anger to the Ethics of autonomy, Disgust to the Ethics of Divinity. These ethics can also be seen as a subset of the theory of Theory of Moral Foundations put forth by Haidt and colleagues.

In SPICE, since citizens express emotions in response to artworks, using the channels made available by the curation scripts (text, tags, labels, etc.), values are relevant to the extent the expressed emotions encompass moral aspects, affected by the visitors' own values. In some cases, values could be not only reflected in the emotions expressed by the citizens, but they could be directly expressed through language: as such, they might be automated detected, e.g. with the language technologies employed in SPICE (cf. D3.2), which process the textual content of citizens' contributions. Given their relevance for citizen modelling, in fact, values are represented in the User and Community models.

Relevant accounts of values for linguistic processing, which abstract for the emotional aspects of moral appraisal (but play a role in it) have been provided by two main lines of research. In particular, the Moral Foundation Theory [47] describes the innate, universal dyadic value oppositions that drive moral behaviour; the Theory of Basic Human values provides an account of values in terms of opposition and similarity relations.

Finally, it is worth mentioning the work by Hofstede, dating back to the 60s but refined in [48]. According to Hofstede, embedded cultures are characterized by values such as ingroup solidarity, social order, respect for tradition, security, while hierarchical ones value social power, authority, humility, and wealth.

## 8.2 Value Core Ontology

The Value Core module is the core module of the Value Ontology, consisting in the minimal vocabulary to talk about values. Its structure includes the conceptualization of Value according to different theories (namely Moral Foundation Theory by Haidt et al. [47], Theory of Basic Human Values by Schwartz [40] and the World Value Survey[52] data), conceptualized and implemented according to foundational design patterns (mainly the D&S [14] framework), and conceptual frame semantics as expressed in FrameNet [49] and implemented in Framester [50].

### 8.2.1 Introduction

The formalization follows the DUL Description and Situation pattern: the notion of Value is represented as a *ConceptualFrame*, subclass of *dul:Description*, as the conceptualization of the social notion of Value. The Value *dul:Description* can be satisfied by a Value *framester:FrameOccurrence*.

### 8.2.2 Description of the Ontology

Value is treated as a complex and blurry frame and for this reason the module includes the extraction of the Concept of Value from Framester [51], resulting in 7 Conceptual Frames and 6 Synsets Frames covering all linguistic senses of "value" (including the proper normative/goal, but also commercial sense and informational senses). The Framester frames evoked by the Conceptual Frame of Value, represented both as instances of the *ConceptualFrame* class and subclasses of the *FrameOccurrence* class are: Awareness, Differentiation, Expertise, Judgment, Quantity, Regard and Usefulness. Four more frames were added to those above mentioned in order to complete the *ValueScenario*.
The Value *ConceptualFrame* has been aligned to multiple resources that are aligned within the Framester factual-linguistic knowledge graph: the DBpedia entity "dbpedia:Value_(ethics)"; the synset-value-noun-6 from WordNet that defines value as "an ideal accepted by some individual or group"; the concept of Value as defined in different contexts by Schwartz.

The broad Value *ConceptualFrame* is a compositional frame scenario the *ValueScenario*, encompassing more specific Value frames: *ValueCommitment*, *ValueAppraisal* and *ValueRecognition.* Each Value frame corresponds to a Value situation class: a broader *ValueSituation*, and the component classes of *ValueCommitment*, *ValueAppraisal* and *ValueRecognition* situations.

**Value Situation** is defined as any situation satisfying a Value Description e.g. social fact, legal decision, opinion, story, etc. that is informed by, or depends on, values such as Tolerance, Concern, Power, Security etc.

[52] https://www.worldvaluessurvey.org/

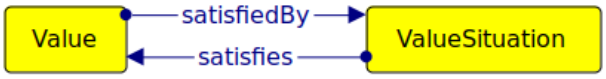



*Figure 14 Links between Value and ValueSituation*

Example: a Universalism Value Description is a frame including a Person that evaluates more the Community than him/herself (modelled in Schwartz Value module, section 8.4). The GAM cultural property "Pietro Micca" shows a soldier giving his life in order to save the city of Turin, and it is labelled as an instance of the Universalism value. This is an instance of a Value Situation that extensionally satisfies the intensional Value Description.

**Value Appraisal** is defined as a situation, in which an Agent provides an appraisal of something, attributing a value in context.

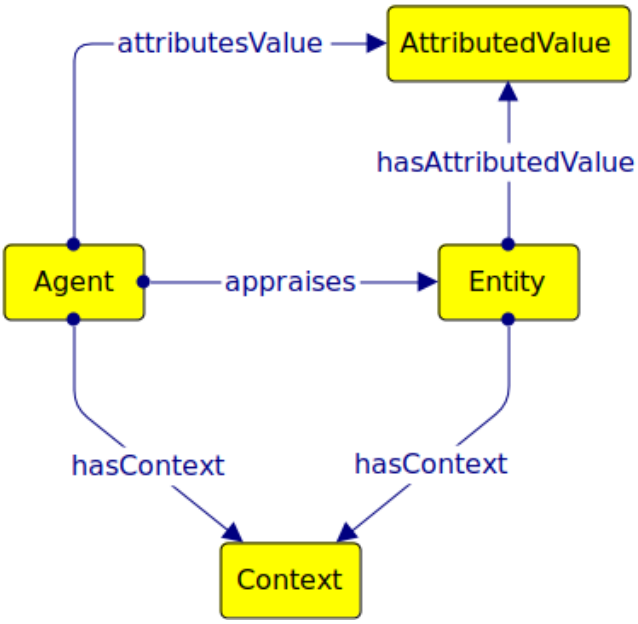



*Figure 15 Value Appraisal frame*

Example: User A appraises a Cultural Property C positively or negatively depending on sharing the same value(s) evoked by C.

**Value Commitment** is the commitment that an individual, group, society, culture, or even a piece of information, has to a certain value, given a circumstantial context (factoid, time, place, motivation, closed set of alternatives, trigger, medium, channel, etc.).

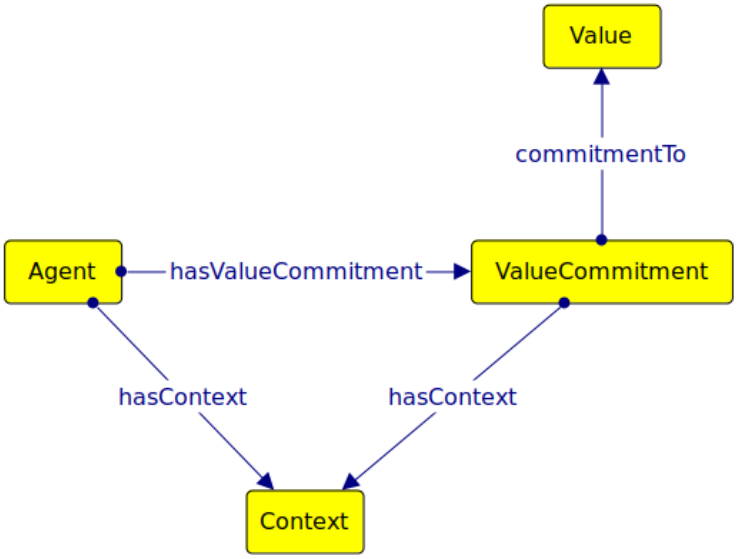



*Figure 16 Value Commitment frame*

Example: User A make an assertion about considering some Value as fundamental, e.g., Universalism. A possible consequence is that this value shapes the appraisal and evocation of emotions in User A, when exposed to a cultural entity evoking the Universalism value in him/her.

**Value Recognition** is the Recognition that an Agent makes about an individual, group, society, culture, or even a piece of information, committing to a certain value, given a circumstantial context, without expressing an explicit own Commitment or Appraisal.

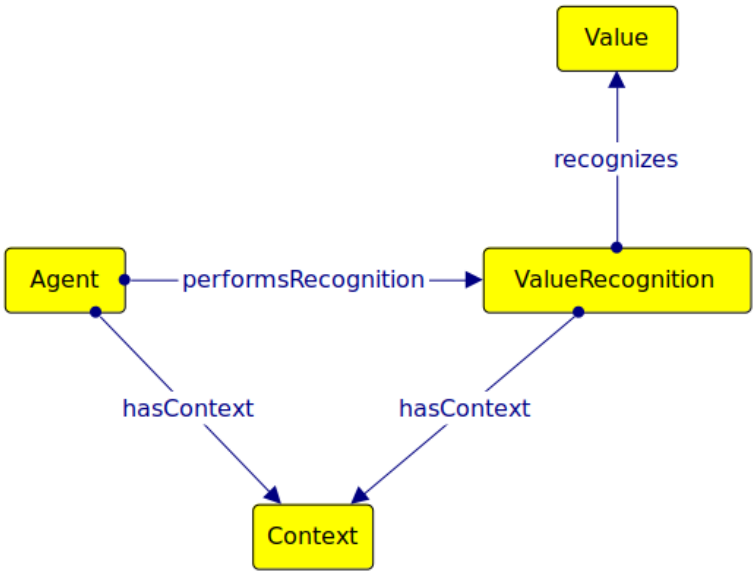



*Figure 17 Value Recognition Schema*

Example: User A recognizes the Universalism value in the Pietro Micca GAM's painting, even if he/she does not share the same value, or the commitment that drove Pietro Micca's action.

The ontology aims at answering to the following competency questions:

**CQ1:** Does the User express some Value Commitment?

**CQ1.1:** If so, is the Value Commitment related to a particular cultural area (e.g. politics, environment, religion science etc.)?

**CQ1.2:** If so, how is the User Value Commitment classifiable according to Schwartz - Haidt theories?

**CQ2:** Does the User express some Value Appraisal?

**CQ2.1:** If so, does the User Value Appraisal imply a Value Recognition?

**CQ3:** Does the User express some Value Recognition?

Being a work in progress, no example scenario is provided, and deeper extraction, research and testing on the different proposed frames needs to be done.

## 8.3 World Value Survey module

The World Value Survey is a research project, whose purpose is the investigation of Values - treated theoretically as beliefs - analysing their synchronic status quo, and diachronic changss. WVS has been active since 1981 as a globally extended network of researchers in the areas of social, economic and psychological sciences.

### 8.3.1 Description of the Ontology

This ontology provides data bootstrapped from the questionnaires, and formally represented by means of Value frame and of the *ValueSituation* class.

The data presents a great amount of different Value Situations, related to Politics, Political Participation, Religion, Ethics and Science.

This module is a work in progress and is planned to be the ontological basis for a tool of automated value detection, developed by CNR and UniBo in the context of WP3 tasks.

## 8.4 Schwartz Ontology

This module is the ontological version of the Theory of Human Values, updated to year 2012, and enriched in 2019 in [52].

### 8.4.1 Introduction

The Theory of Basic Human Values by Shalom Schwartz was proposed as a pan-cultural theory since the 1980s, and evolved in different versions, keeping its theoretical assumption that the human values form what has been called a “value wheel”, that is an ordering structure for values that organizes them in a circumplex model, dividing them in four quadrants with two conflict axes, and a congruity continuum between adjacent values.

### 8.4.2 State of the art

The model by Schwartz relies on the opposition and similarity of values, grouped into macro-categories which are mostly determined by individual personality traits (self-transcendence vs self-enhancement, conservation vs openness to change). This model has inspired the design of a questionnaire (Portrait Values Questionnaire, PTV) which has been employed by a number of studies to explore values across different countries [40]. In recent work [53] Schwartz provides evidence in favour of a pan-cultural arrangement of value priorities.

### 8.4.3 Description of the ontology

The ontology takes as source the 2012 Schwartz model version, reworked as in [52] so considering the 19 first order values organized as subclasses of one (or two) of the four main classes: *Conservation* vs *OpennessToChange*, *SelfEnhancement* vs *SelfTrascendence*. These above-mentioned classes are furthermore axiomatized considering the Focus: Social vs Personal, namely the main beneficiary which is the focus of the behaviour determined by some Value e.g. the class *SelfTrascendence* is the superclass grouping all the Values having a focus on society more than on the individual; its opposite quadrant *SelfEnhancement* is instead axiomatized as having the focus: *PersonalFocus*.

Furthermore, the above-mentioned classes are axiomatized also by their *Attitude*: *SelfProtectionAndAxietyAvoidance* vs *GrowthAndAnxietyFree*.

The Schwartz ontology is available at: https://w3id.org/spice/SON/SchwartzValues.
In the following picture the main classes and the properties of the ontology are presented.

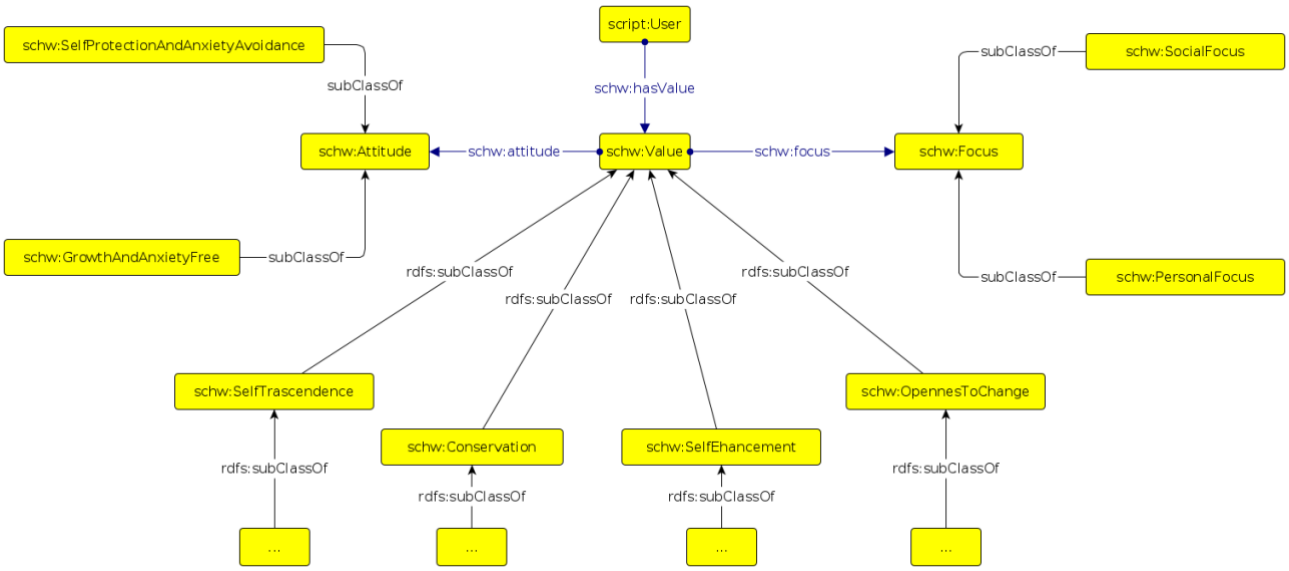



*Figure 18 Classes and Properties of the Schwartz Ontology*

This allows to make some inference about the praiseworthiness and blameworthiness of some Action or Event e.g. depicted in a cultural entity.

### 8.4.4 Example

The following example Scenario is provided in Turtle syntax in the Appendix section (13.4).

UserA and UserB are visiting GAM gallery and see a painting depicting Pietro Micca ("Pietro Micca nel punto di dare fuoco alla mina volge a Dio e alla Patria I suoi ultimi pensieri" - "Pietro Micca, the moment before setting fire to the bomb, directs his thoughts to God and his motherland") by Andrea Gastaldi. Pietro Micca is described as an Italian patriot who gave his life to save the to-be-born state of Italy, igniting some dynamite to detonate a tunnel that was being invaded by enemy soldiers, but sacrificing his own life with this act. The narrative character of Pietro Micca is described in the narrative ontology module as associated with the value of Patriotism.

UserA declares in the Scripting activity to be proud of the Action made by Pietro Micca, sharing with him the value Patriotism. UserB disagrees considering more important Self Preservation than sacrificing one's own life for the country. Thanks to Schwartz circumplex model and the lexical tokens linked to the first order values, Patriotism is inferred as being an instance of the Schwartz Value "Societal", situated in the "Conservation" quadrant, while "Self-Preservation" is an instance of "Action", situated in the "Openness to change" quadrants.

We can say that the Action of Pietro Micca is desirable for User A and undesirable for User B, being the first order Values Societal and Action in different and opposite quadrants.

## 8.5 Haidt Ontology

The Haidt Ontology module is the ontological version of the Theory of Moral Foundation, proposed in the model by Haidt et al. [54].

### 8.5.1 Introduction

The Moral Foundation Theory is a proposal for a pan-cultural theory of social, cultural and moral behaviours, and aims at being universal and not depending on culture - at least in its dyadic oppositional structure, namely in its intensionality, while what is context-specific is its extensionality - because of its cognitive embodied grounding.

Haidt et al. in fact explain each dyad in terms of behavioural cognitivism, namely: Care vs Harm is grounded in the attachment systems and some form of empathy, intended as the ability to not only understand, but also feel the same feelings as others, being able to imagine hypothetical scenarios, in which we are living some positive or negative mental or physical state, which we actually don't live.

Fairness vs Cheating is grounded in the evolutionary process of reciprocal altruism.

Loyalty vs Betrayal is grounded in the tribal dimension that for a long time characterized most of our societies. The ability to create links and alliances was a way to increase the surviving percentage possibilities for oneself and his/her close group.

Authority vs Subversion is grounded in the hierarchical social interactions directly inherited by primates' societies.

Sanctity vs Degradation is grounded in the triad CAD and the psychology of disgust, it is one of the most spread dyadic oppositions, being foundational for the opposition between soul and flesh.

Liberty vs Oppression is grounded in common feelings and experiences like solidarity, vs. episodes of unjustified violence or liberty restrictions.

### 8.5.2 State of the art

The model proposed by [54] focuses mainly on single value oppositions, where any pair of opposing values represent the poles of a prescribing/inhibiting dyad. MFT describes five innate moral foundations across cultures and societies: Care/harm, Fairness/cheating, Loyalty/betrayal, Authority/subversion, and Sanctity/degradation. Besides its relevance for the investigation of the emotional counterpart of value appraisal and for the cross-cultural investigation of values, MFT has inspired the design of the Moral Foundation Dictionary [55] and, more recently, of the Extended Moral Foundations Dictionary [56], which combines theory driven elements on moral intuitions with a data-oriented approach. These resources have paved the way to the creation of automatic tools for the detection of moral values in public discourse, from social media to political debates [57].

### 8.5.3 Description of the ontology

The ontology takes as source the Moral Foundation Theory [54], and conceptualizes Values in terms of dyadic oppositions between a Value and its Violation. Each Dyadic opposition has exactly two components, one Value and one Violation. Authority is opposed to Subversion, Care to Harm, Fairness to Cheating, Loyalty to Betrayal and Sanctity to Degradation.

The instances can adhere to some Value, and be opposed by some Violation, creating multi-shaped scenarios, in which the same Event or Action or Entity can be at the same time by different Values and their Violations.

The ontology, in the SPICE context, is an ongoing attempt to formalize different perspectivizations focusing on the possible cognitive framing that Users make in encountering some Cultural Entity.

The ontology is available at: https://w3id.org/spice/SON/HaidtValues

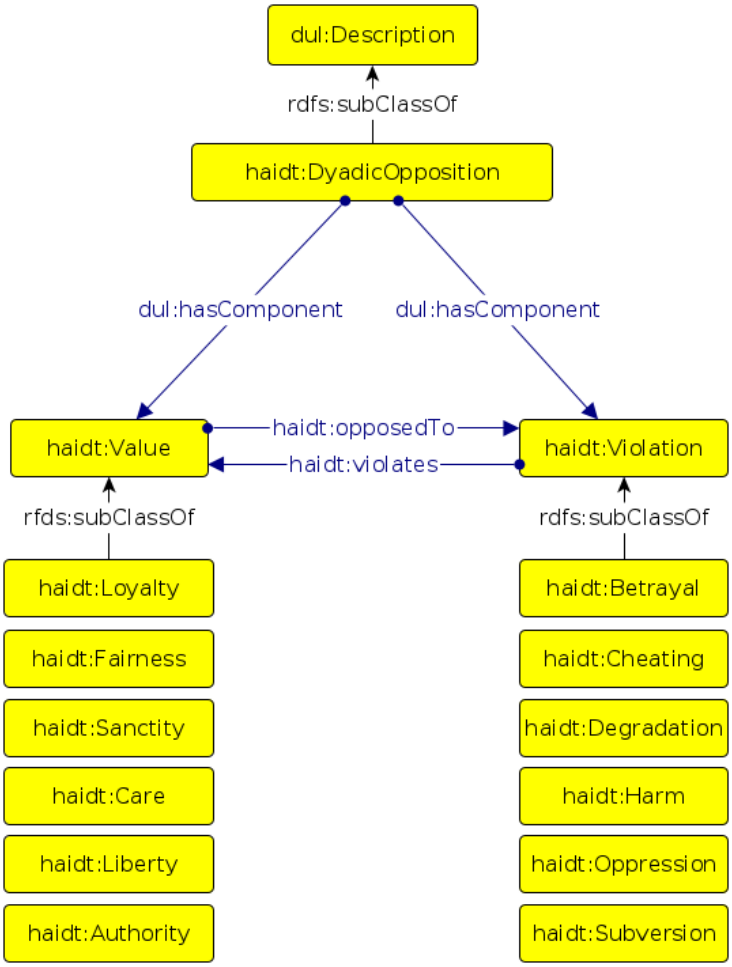



*Figure 19* Classes and Properties of the Haidt Ontology

The Haidt ontology allows to answer the following Competency Questions:

**CQ1:** is an Entity an instance of a Value?

**CQ2**: is an Entity an instance of a Violation of some Value?

**CQ3**: is an Event or Action desirable or undesirable based on some Value or Violation?

**CQ4**: is an Event or Action praiseworthy or blameworthy based on some Value or Violation?

**CQ5**: are there both Values and Violations considering different components of the same Event or Action?

### 8.5.4 Example

The following example Scenario is provided in Turtle syntax in the Appendix section (13.5).

UserA and UserB are visiting GAM gallery and see a painting depicting Pietro Micca ("Pietro Micca nel punto di dare fuoco alla mina volge a Dio e alla Patria I suoi ultimi pensieri" - "Pietro Micca, the moment before setting fire to the bomb, directs his thoughts to God and his motherland") by Andrea Gastaldi. Pietro Micca is described as an Italian patriot who gave his life to save the to-be-born state of Italy, igniting some dynamite to detonate a tunnel that was being invaded by enemy soldiers. The narrative character of Pietro Micca is described in the narrative ontology module as being a hero and a patriot. UserA declare in the Scripting activity to be proud of the Action made by Pietro Micca, focusing on the result of this Action, namely the Liberty of Italy.

UserB disagrees, considering more important Pietro Micca's life than any victory in war, in fact she/he considers it useless to sacrifice oneself for any country.

Thanks to the Haidt's dyadic model, LibertyOfItaly is inferred as being an instance of Haidt's Value "Liberty", while "CareOfPietroMicca" is an instance of "Care", and "PietroMiccaSacrifice" is an instance of Harm.

Being Harm a Violation of Care, we can say that the Action of Pietro Micca adheres to the Value of Liberty, but violates the Value of Care, and for this reason it is praiseworthy for UserA, but blameworthy for UserB. As a consequence, UserA and UserB would feel different emotions: Admiration for UserA, and Reproach for UserB.

# 9 Emotion Knowledge Area

The Emotion Knowledge Area is the area dedicated to the ontological representation of interactions triggering emotions, the nature of the triggering stimulus, and Emotions analysed in their linguistic, expressive and cognitive dimensions. In particular, emotions are relevant in the Reflection step of the Interpretation-Reflection Loop, since they provide a conceptual and practical tool for investigating the identity of individuals and groups as expressed through their narratives (see Section 4.1.5 of D2.2, *Recommendations for SPICE*).

## 9.1 Emotion Ontology

The Emotion Ontology is the closure module for the ontology network developed with the purpose to represent existing theories about Emotions, including the Emotion relation and its roles. The modules described include: the EmotionRelation, focusing on how an emotion is triggered by a stimulus, felt by a Person (represented with the role Experiencer of the Emotion Relation), and recognized by an Activity (e.g. a semantic analysis of the Person's utterance performed by an emotion annotator); the EmotionInCulturalContext, focusing in particular on the EmotionRelations in a CulturalContext; and four modules representing the nature of Emotions, analysed from a linguistic perspective (the Plutchik module), from a linguistic and expressive perspective (the Shaver and Ekman modules), and from a cognitive perspective (the Ortony-Clore-Collins module).

### 9.1.1 Introduction

In the context of SPICE, the Emotion Knowledge Area is related to the Prototyping and User and Community modelling activity (D3.1) and recommender (D3.6), for its multiple emotion theories transposed as Emotion Ontology modules, and for the presence of lexicons associated with emotions both relevant in ontology modelling and sentiment and opinion analysis (T3.1); to the developing of models of interpretations (D2.1) for its cognitive grounding of emotion theories; and with the case study semantic lifting (D7.1) through citizen curation activities with the purpose of enhancing current data about museum's cultural entities and collections. It is furthermore deeply connected to other knowledge areas such as the User and Community Knowledge Area (section 8) adding to the Emotion Relation the further layer of Value commitment, appraisal or recognition through an appraising process; the Interaction Knowledge Area (section 5) for making use of the modelling of the fruition context; with the Symbolism Knowledge Area (section 7) for adding a further layer of knowledge, namely the symbolical meaning; and with the Narrative Knowledge Area (section 6) for considering narrative elements as capable of emotion triggering or appraisal.

### 9.1.2 State of the art

Emotion theories broadly belong to three main categories, partly derived from different research traditions.

Categorical models focus on the definition of primary emotion types, which are assumed to be the result of phylogenesis. These emotion types are typically discrete and can be mapped straightforwardly onto face expressions. Sometimes referred to with the term 'basic emotions' to emphasize their innate nature, they appear at specific stages of the evolution of the child, progressively acquiring cognitive content. Depending on the reference theories, primary emotion types range from 5 to 7 [58] [59] [60], including joy, anger, fear, disgust, sadness and sometimes surprise. Thanks to the tight relation with the preverbal (and postulated cross cultural) expression of emotions, these theories have deeply influenced the research on face expression recognition, through models such as the Facial Action Coding System (FACS), on which face expression datasets are built [61]. The model of six basic emotion prototypes proposed by Shaver et al [62] has affinities with this group of models, but significantly differs from most of them from the methodological point of view: aimed at investigating the intuitions behind the human conceptualization of emotions, its design has been driven by the analysis of linguistic data.

Dimensional models represent emotions as the product of a set of predefined component dimensions, which axes such as polarity (often termed hedonic) and arousal. Historically derived from Wundt's three-dimensional definition of the emotional experience in terms of pleasure (pleasantness/unpleasantness), tension (tenseness /relaxedness), and excitement (excitement /depression) contemporary dimensional theories are usually represented through circumflex models, with significant variations: Plutchik's wheel of

emotions acknowledges 8 bipolar emotions, derived from theoretical assumptions and rooted in behaviour [63], while Russel's circumplex model arranges empirically collected emotion labels in the continuous space generated by the two basic dimensions of arousal and polarity [64] . Depending on the dimensions considered (e.g., Mehrabian added dominance to the standard bidimensional space) different emotion types emerge from the intersections of the dimensions in the 2D or 3D space; in some models (e.g., Plutchik) secondary emotion types are generated by combining the primitive emotion types. Mainly geared to the subjective description and consequent expression of feelings, these models have influenced the creation of lexical resources for the analysis of sentiment [65].

Appraisal theories describe the subjective process of assessment of a situation which leads to the activation of an emotional state in a subject. These theories focus on the cognitive dimension of emotions [43] [66] [67] [68] [69], describing analytically the parameters that affect the emotional appraisal process. According to appraisal models, subjective motivations, or goals, and cultural factors, such as moral norms, affect the assessment of a given situation by an agent: each emotional category, then, is the result of a specific configuration of appraisal parameters, usually represented in the form of an activation rule. Appraisal models allow the same situation to be appraised differently by different individuals, and postulate complex emotions as the result of the activation of multiple appraisal processes on the same situations: for example, in the OCC model [43], the activation of distress and reproach yields the emotion of anger. The emotional coping process [70], the natural complement of appraisal, describes how the agent responds to the activated emotions at the mental and behavioural levels, in continuity with the appraisal parameters. Due to their cognitive background, appraisal models lend themselves to the integration with agent models, and to mentalistic models such as the Belief-Desire-Intention model (BDI) [71].

Orthogonal to these broad distinctions, accounts of moral emotions, issued from social psychology, frame emotions as an evolutionarily determined means for enforcing group cohesion. Situated at the intersection between primary emotions and appraisal models, accounts of moral emotions [72] are deeply intertwined with research on moral values.

### 9.1.3 Description of the ontology

This ontology defines *EmotionRelation*, which is a n-ary relation class that represent the class of occurrences of an emotional frame. It is a subclass of *tis:TimeIndexedSituation*[53] because this relation happens at a certain time in a certain setting. *EmotionRelation* has multiple roles (or *participation* relations): the property *experiencer* links it to a person (class *dul:Person*), who is feeling an emotion. Moreover, the property *emotion* links it to the class *Emotion* that represent the felt emotion (and that can be furtherly specialized according to the Emotion Theories represented in the ontologies presented below). The property *emotion* is specialized in *emotion-e* (i.e. external emotion - the emotion of the experiencer as "hypothesized"/recognized by an external entity) and *emotion-i* (i.e. internal emotion – the actual emotion felt by the experiencer). The *stimulus* property links *EmotionRelation* to any entity that triggered the emotion. We defined co-participation relation, named *triggers*, which directly connect the entity that triggers an emotion with the triggered emotion. For example, this relation might be helpful for associating artworks with the collection of emotion they trigger. The co-participation relation has been formalised as property chain (i.e. *inverse(stimulus)* ∘ *emotion subPropertyOf triggers*[54]). In doing so, whenever an Emotion relation connecting the stimulus s with the emotion e is asserted the relation <s,triggers,e> can be automatically deduced. Furthermore, each *EmotionRelation* must indicate its provenance, namely the activity that recognized the occurrence of such relation. In order to represent the provenance, we adopted Prov-o [73], a W3C-recommened ontology for specifying provenance of objects. Specifically, we defined a constraint (i.e. an owl restriction) in order to impose that every instance of *EmotionRelation* must be connected to a *prov-o:Activity* by means of a the property *prov-o:wasGeneratedBy.* In doing *prov-o:Activity* can specify all the provenance information (e.g. the tool that recognized the emotion, how the emotion was recognized etc.). Optionally,

[53] http://ontologydesignpatterns.org/wiki/Submissions:TimeIndexedSituation
[54] ∘ indicate the composition of two object properties

an *EmotionRelation* may be associated with: (i) the Physical Place (dul:PhysicalPlace) where the emotion has been felt; and (ii) the experiencer activity (*dul:Action*) in which the emotion has been felt.

Finally, we defined some data properties related to *EmotionRelation*:

- *confidenceScore*: expresses the confidence of an Emotion Relation in case it was automatically detected with a computational system;
- *intensity*: specifies a degree of intensity of the emotion.

As for the class *Emotion*, two other data properties were defined:

- *label*: a literal that gives a name to the emotion;
- *description*: a potential description of that emotion.

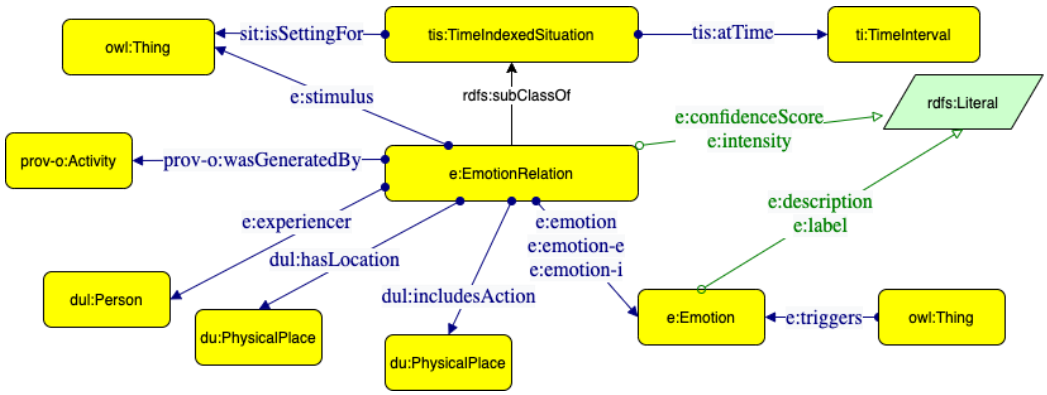



*Figure 20 Classes, Properties and Data Properties of the Emotion Ontology*

The ontology was created to answer the following competency questions:

**CQ1**: What are the emotions felt by someone in an Emotion Relation?

**CQ2**: What is the stimulus that triggered an Emotion Relation?

**CQ3**: When did the Emotion Relation happen?

**CQ4**: Who experienced the Emotion Relation?

**CQ5**: What is the activity that generated an Emotion Relation?

**CQ6**: What is the confidence score of an Algorithm that detected an emotion in an Emotion Relation?

In the context of the SPICE project, the Emotion Ontology needs to be used in combination with the EmotionInCulturalContext ontology provided in the following paragraphs and can be specialized by importing the specific components of the Ontologies of the Emotion Theories specified also in the following paragraphs.

## 9.2 Emotion in Cultural Context

This ontology aims at representing the Emotion Relation triggered in a User or Community by some Cultural Entity.

### 9.2.1 State of the art

Emotions have been acknowledged as an intrinsic component of aesthetic experience since ancient times, but only in recent years the emotional response to artworks has been measured, paving the way to the use of computational tools to model artistic experience.

The effect of art on emotional regulation has been measured by analysing the brain response through EEG [74], showing that artworks determine stronger electro-physiological responses than non-artistic depictions; Leder [75] argued in favour of the universality and spontaneity of this response, showing that facial muscle movements in response to artistic experience are stronger in non-expert. The response to the artistic expression conveyed by media, music and movies, has also been extensively studied. Music has proven to be an effective tool for emotion regulation [76], an effect which has been exploited to create affective music

recommender systems [77]. Finally, emotional engagement is of primary importance in narrative media, such as film and television, as extensively investigated by a line of research which draws from both media studies and emotion theories [78] [79]. In the last decade, annotated datasets with emotions have been made available for different media, from music (see [80] for a survey) to films [81].

As a consequence of the complex role played by emotions in the experience of art and media, the investigation of this phenomenon with computational tools has relied on a variety of models and methodologies, ranging from dimensional models, better suited to investigate physiological, continuous correlate of emotions [64] [82], to categorical models, which lend themselves to inspect the conscious level of emotional experience [63] [58]. In many cases, the emotional response to artworks is conveyed through language, not only in textual media, but also in relation to art and other media: this is the case, for example, of the tags and comments concerning artworks and exhibitions on social media. The crowdsourcing experiment conducted by Mohammad and Kiritchenko [83], where people were asked to associate discrete emotional labels, represents a milestone in the investigation of affective reactions to artworks through language, since it let correlations emerge between the subjects of the artworks, the likings of the users, and the attributed emotions.

### 9.2.2 Description of the ontology

EmotionInCulturalContext is an extension of the Emotion ontology. It deals with an emotion relation that happens in a cultural heritage context. In fact, the class *EmotionRelationInCulturalContext*, sub-class of the *EmotionRelation*, has two additional properties compared to its superclass: *fc:hasFruitionContext* (from the Fruition Context ontology) links it to a *FruitionContext* (from the same ontology), *cc:hasCuratorialContext* (from the Curatorial Context Ontology) links it to a *CuratorialContext* (from the same ontology). Moreover, the property *stimulus* from the Emotion Ontology has a more limited range if used with an *EmotionRelationInCulturalContext* as subject. In fact, the elements that can trigger an emotion in this kind of Emotion Relation are a Cultural Entity, a quality of a cultural entity, one of its visual representation, an entire collection of cultural entities, a cultural Event, and the FRBR conceptualizations of Expression and Manifestation[55].

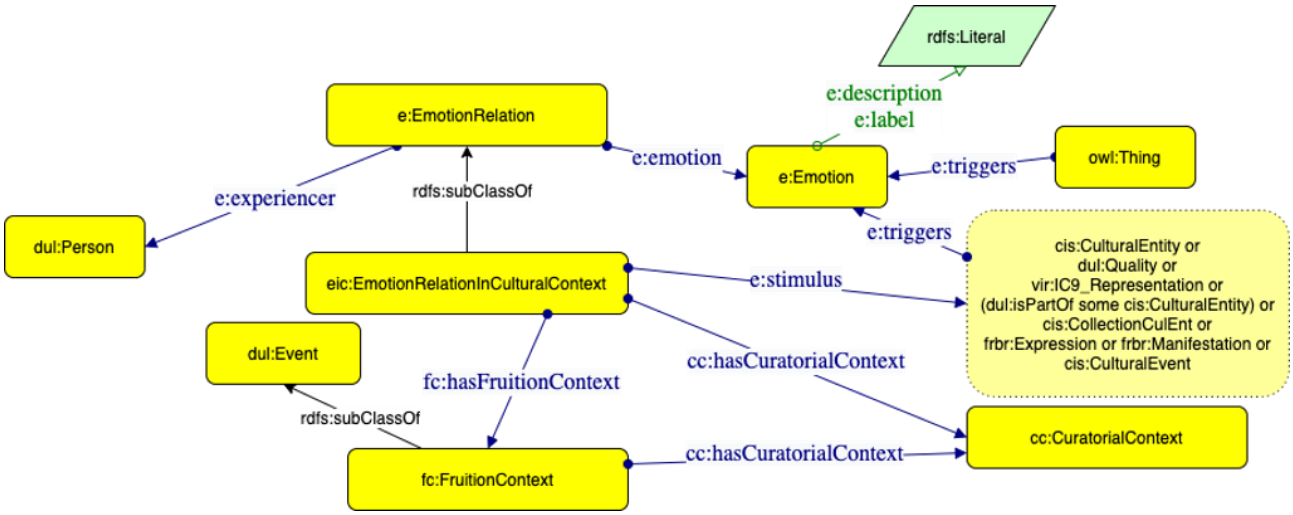



*Figure 21 Classes, Properties and Data Properties of the EmotionInCulturalHeritage Ontology*

This ontology inherits the same competency question as the Emotion Ontology, but it adds some more domain specific ones, such as:

- What are the emotions that have been triggered by a quality (or a representation, manifestation, expression…) of a cultural entity?
- What are the cultural entities that trigger a specific emotion?

[55] More information of FRBR here https://www.oclc.org/research/activities/frbr.html

- What are the Fruition Contexts that trigger Emotion Relations in Cultural Context? (CQ shared with the Fruition Context Ontology)

### 9.2.3 Example

Two users (A, C) are approaching two cultural entities in an Exhibition (in-presence Fruition Context) about the history of the Roman Empire. They are now in the part of the exhibition dedicated to the Fall of the Roman Empire. A goes straight to a painting in which Rome is burning at the hands of Vandals. User A states, in an activity related to the text answering Scripting task, that the Painting Size quality triggers, in her/him, the emotion of **Surprise**. The emotion detection algorithm that made this assertion has a confidence score of 0.94
C feels **Anger** towards the same *painting* because of the consequences of looting and expresses it in an activity related to the text answering Scripting task. The emotion detection algorithm that made this assertion has a confidence score of 0.67. C feels **Sadness** towards the manuscript and expresses it in an activity related to the emoji answering Scripting task. A sees the Manuscript and feels **confused and apathetic** and expresses it in the emoji answering Scripting task.
The turtle serialization of this example can be seen in the Appendix (13.7)

## 9.3 Ekman Emotions Ontology

The Ekman Emotions Ontology (showed in Figure 22) provides a vocabulary for specifying emotions according to the Ekman's theory on basic emotions [58]. According to his theory each emotion is a single affective state but is a family of related states. Each member of an emotion family shares similar characteristics, such as: distinctive universal signals (e.g., facial expressions), distinctive physiological signs, specific activity patterns in the central nervous system etc. Each emotion family can be considered as constituted by a theme and variations. The theme of a family are the characteristics unique to that family, the variations on that theme are the product of individual differences, and differences in the specific occasion in which an emotion occurs.

He proposed a list of 15 distinguishable emotion families: amusement, anger, contempt, contentment, disgust, embarrassment, excitement, fear, guilt, pride in achievement, relief, sadness/distress, satisfaction, sensory pleasure, and shame.

If one wants to look at Ekman's theory from an ontological point of view, the emotions he describes are actually classes where each class encloses all the occurrences of the emotions sharing the same theme. The Ekman Emotions ontology follows this interpretation of the theory and defines a class for emotion family.

Moreover, since the Ekman's theory defines an occurrence of a certain emotion as the co-occurrence of a set of recurrent characteristics, they can be interpreted as situations.

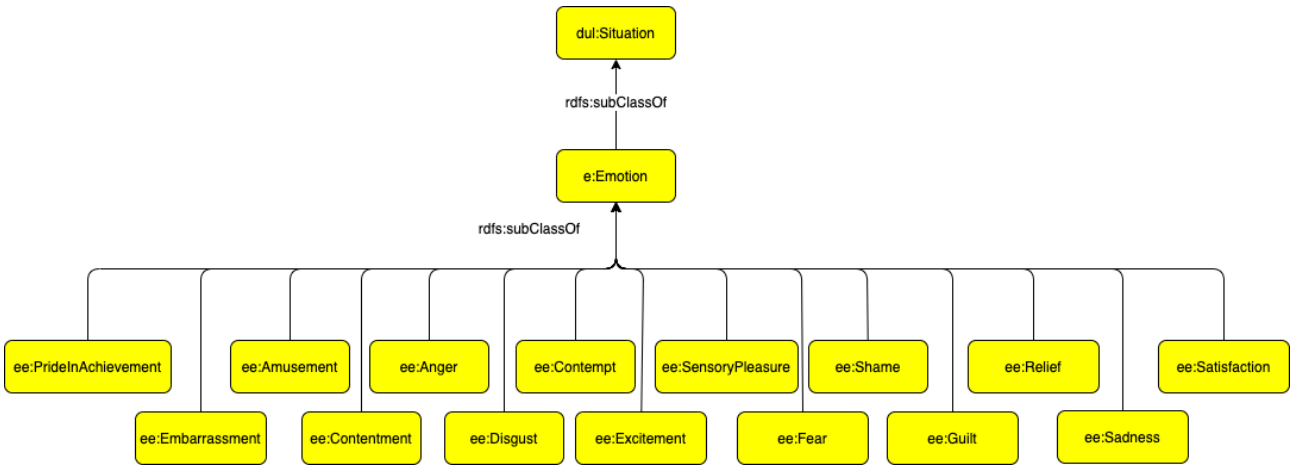



*Figure 22 The Ekman Emotion Ontology*

## 9.4 Plutchik Emotions Ontology

### 9.4.1 Introduction

Plutchik Emotion Ontology is the owl serialization of the cirmumplex theory of Emotion developed by Plutchik. As anticipated above, emotions, in this theory, are considered as a reaction to an event. The crucial feature of this model is that it provides a mechanism for generating complex emotions via combinatorial mechanisms. These mechanisms allow to generate a class of compound emotions based on dyads (combination of two basic emotion) and triads (combination of three basic emotions). Such model can encode the following elements:

- Basic or primary emotions: joy, trust, fear, surprise, sadness, disgust, anger, anticipation; in the color wheel this is represented by differently colored sectors.
- Opposites: basic emotions can be conceptualized in terms of polar opposites (e.g. joy versus sadness, anger versus fear, trust versus disgust, surprise versus anticipation) and this feture in modelled in the ontology.
- Intensity: each emotion can exist in varying degrees of intensity; in the wheel this is represented by the vertical dimension.
- Complex emotions: complex emotions are obtained by primary emotions with the compositional mechanisms devised by the Plutchik theory (assuming, for example, that the emotion of *Love* is obtained by the composition of the basic emotions *Joy* and *Trust*);

### 9.4.2 State of the art

The Plutchik Theory is a widely used reference theory for emotion modelling since it provides a procedural characterization to derive complex emotions from basic ones. Examples of use of such a theory are in the SenticNet model [65], using Plutchik as a starting point to generate their revised Hourglass model, and the ArsEmotica system [84] using such framework to automatically attribute, to different artworks, emotional labels.

### 9.4.3 Description of the ontology

The Emotion's hierarchy includes 32 emotional concepts. The overarching *Emotion* class has two disjoint subclasses: *BasicEmotion* and *ComplexEmotion*. Basic emotions of the Plutchik's model are direct sub-classes of *BasicEmotion*. Each of them is specialized again into two subclasses representing the same emotion with weaker or the stronger intensity (e.g. the basic emotion Joy has Ecstasy and Serenity as sub-classes). Therefore, we have 24 emotional concepts subsumed by the BasicEmotion concept. Instead, the class *ComplexEmotion* has 8 subclasses, corresponding to the primary dyads. Other relations in the Plutchik's model have been expressed in the ontology by means of object properties: the *hasOpposite* property encodes the notion of polar opposition; the *hasSibling* property encodes the notion of similarity and the *isComposedOf* property encodes the notion of composition of basic emotions. Moreover, a data type property *hasScore* was introduced to link each emotion with an intensity value I.

In the context of SPICE, this ontology offers a model to ground and infer a huge variety of emotions extracted from texts/visuals and provides a way to attribute complex emotions via inference by exploiting the compositional mechanisms to derive complex emotions by primary ones.

This ontology inherits the same competency question of the overarching Emotion Ontology and EmotionInCulturalContext ontology, but it adds some more domain specific ones, such as:

- Which complex emotions can we associate to the users and to their fruition experience given the basic emotions that they have reported during the visit?
- Which kind of cultural entities could be suggested to such users based on the inferred emotions associated via the Plutchik model?

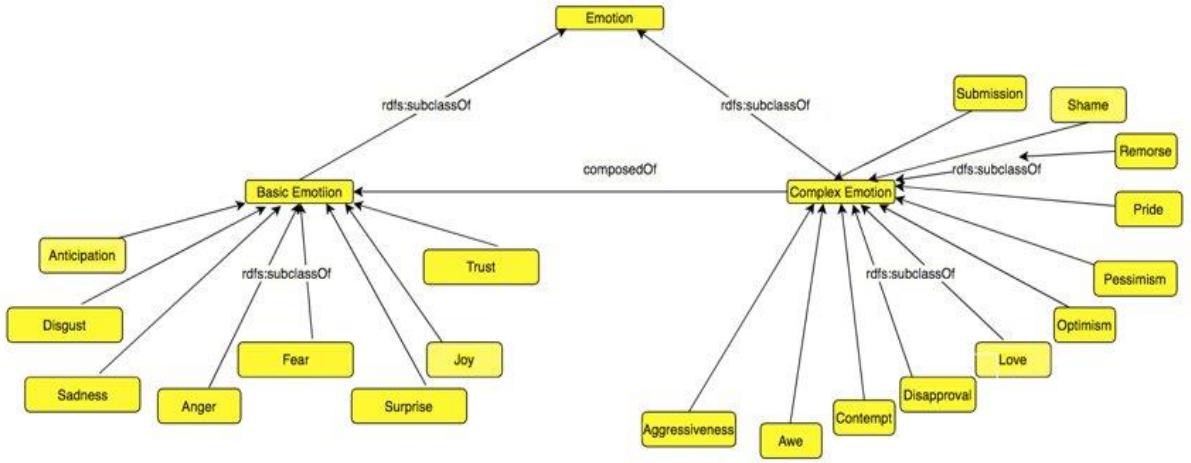



*Figure 23 Overview of the main Emotional Classes of the Plutchik ontology.*

### 9.4.4 Example

Giulio and Anna visit the GAM museum in Turin. During their visit, their interaction with the same museum item triggers different basic emotions in them (e.g. Joy for Giulio and Trust for Anna). The Plutchik's model automatically associates to the item triggering these emotions also the emotional concept Love (composed by those basic emotions in the Plutchik's model).

The turtle serialization of this example can be seen in the Appendix (13.3)

## 9.5 Ortony-Clore-Collins (OCC) Emotions Ontology

The OCC module is the ontological version of the Ortony-Clore-Collins cognitive model of emotions. In this model Emotions are considered as the "valenced response" (with positive or negative valence) in consequence to an appraisal process, both regarding a practical situation or an emotional and cognitive situation.

### 9.5.1 Introduction

The cognitive account of emotions provided by the OCC Theory provides a **comprehensive** model, which encompasses both utilitarian emotions, such as Joy and Distress, and social emotions, such as Pride or Shame, but also the self/other distinction, reflected in other oriented emotions such as Admiration and Reproach. Since the same situations can be appraised according to multiple appraisal dimensions

Also, the emotion activation rules (see below) represent analytically all the parameters that contribute to the activation of each emotion, namely the self/other distinction, the appraised dimension (event/action/object), the appraising agent's goal or value on which the appraisal is based. With respect to categorial and dictionary-based approaches, it enables a more fine-grained mapping between the (generation of) the emotional states and the representation of citizens provided by the user and group models (which contain the citizens' likes and values) and the results of the linguistic analysis of the citizens' interpretations.

Since the depiction of situations which display some type of agency is common in figurative artworks, and often mentioned by the artworks' metadata such as title, subject and description, we took OCC as the paradigmatic exemplar of appraisal theories, also due to its explicit connection with the notion of value. Since it can be easily operationalized in terms of the primitives of intelligent agents, the OCC model has been integrated in logical account of agents [85], and employed for the annotation of emotions in narrative characters [86].

### 9.5.2 State of the art

The OCC Theory is part of the Appraisal Theories: Emotions are elicited by a cognitive evaluation of an antecedent situation, which can be an entity, an action or an event: the different emotional responses are

determined by the outcome of this evaluation process, namely the Appraisal, and the same situation can receive multiple appraisals by the same subject. This approach aims at providing an account of the cognitive emotions, so it is not focused on a specific group of emotion words, alas some linguistic tokens are provided, but the pivoting principle is the compositionality of Emotions given some dimensions with which it is possible to axiomatize them.

The theory also introduces the Self/Other distinction, which provides a foundation to the notion of empathy (D2.2, Section 2.1). A situation, in fact, can be appraised from the perspective of the agent her/himself, or from the perspective of another agent, whom the appraising agent is in relation with. Depending on the type of this relation, negative or positive emotions can be triggered: for example, an event appraised as a negative outcome for the goals of another agent can generate an emotion of Pity for the other agent if the appraising agent likes her/him, or an emotion of Gloating if the appraising agent does not like her/him. The self/other distinction is consistent also with the organization of the Semiosphere into Sub-semiospheres, described in Section 4.3.3. of D2.2.

### 9.5.3 Description of the ontology

The OCC Ontology is the ontological version of the OCC Theory.

In the OCC Ontology Emotions are classified in a compositional way based on an opposition of polarity that develops on different dimensional axes. The structure of the Emotions, as in the figure below (Figure 24) resembles a "tree" structure, or a decision tree, with a first dichotomy constituted by the Emotion being the consequence of an Action versus an Event.

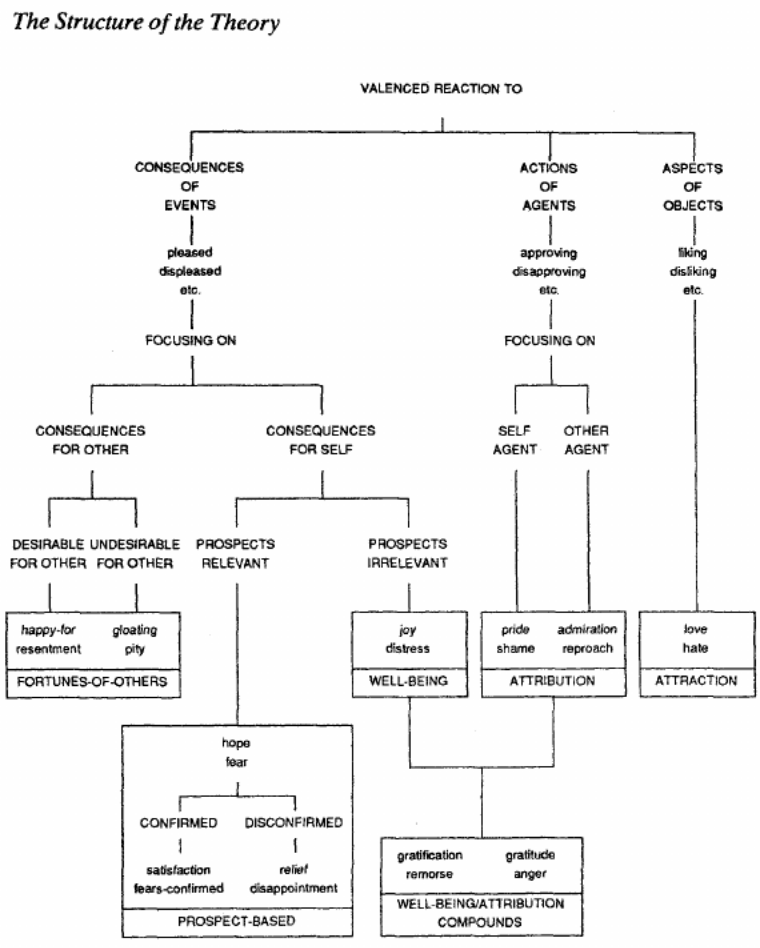



*Figure 24 Structure of the OCC Theory*

A further distinction, not represented in the ontology visualisation, but ontologically relevant, is the Positive or Negative Polarity Outcome: emotions subclasses of *NegativeOutcomeEmotion* are those often classified as "bad emotions" e.g., Anger, Distress, Fear, Pity etc. while those subclasses of the *PositiveOutcomeEmotion* are those often classified as "good emotions" e.g., Admiration, Gratitude, Joy, Hope etc.

The second dimension used to classify emotion is the Focus: Emotions are divided in those that focuses on Self, and those that focuses on Other. To give an example: Pride is an Emotion *feltBy* some *AppraisingAgent* in consequence of some Action *performedBy* Self, while Admiration is an Emotion *feltBy* some *AppraisingAgent* in consequence of some Action performed by Other than self.

The third dimension is the Prospect: *ProspectRelevant* Emotions are those that, for their semantics, describe a state "waiting to be confirmed or disconfirmed", namely Hope and Fear, axiomatized following a further dimension: the Desirability or Undesirability. The Prospect that has been confirmed is a deeper step in the ontology schema: depending on the desirability the compositionality allows to distinguish among e.g. Satisfaction (something desirable - hoped - and confirmed), Relief (something undesirable - feared - disconfirmed), and Disappointment (something desirable - hoped - disconfirmed).

Another class not included in the ontology visualisation is the class of *CompoundEmotion*: Emotions *equivalentTo* the overlap of two other Emotions e.g., Remorse, being the overlap of Distress and Shame, or Anger, as Distress and Reproach.

The OCC ontology allows in this way to automatically reason about data collected in some User Activity / Scripting Task, and to describe the emotions triggered in the Emotion Relation In Cultural Context module, having as stimulus a Cultural Entity, a part of it, a quality, some narrative Entity or Event represented by the Cultural Entity, and even, consistently with the Interpretation-Reflection Loop idea (cf. D2.1) and the User and Community modelling (cf. D3.1), another appraisal or statement collected in some Task defined in the Scripting ontology.

The Image below summarizes some of the main classes and properties of the OCC Ontology module.

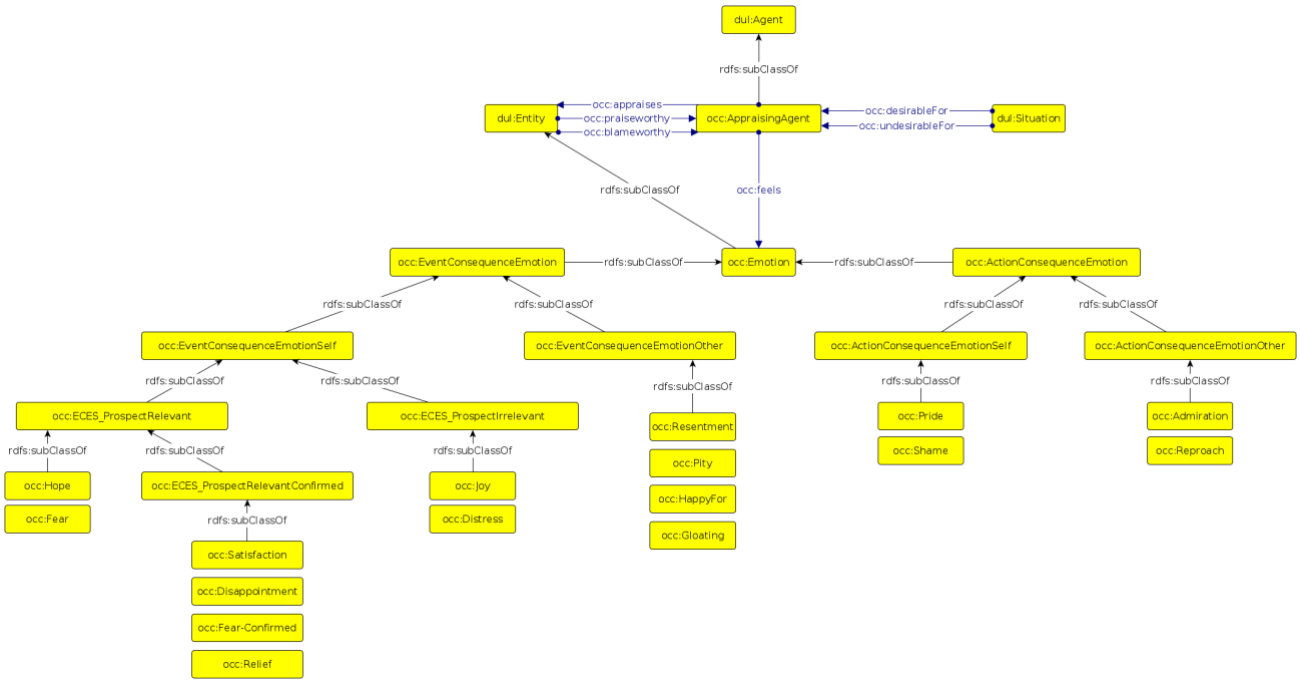



*Figure 25 Classes and Properties of the OCC Emotions Ontology*

These are some of the Competency Questions that can be answered by the OCC Ontology module:

**CQ1**: is the Emotion a consequence of an appraising process of an Action, Event, or some general Entity?
**CQ2**: Does the Emotion have a focus on Self or on some Agent other than self?
**CQ3**: is the polarity of an Emotion Positive or Negative?
**CQ4**: is the Emotion Prospect Relevant or Irrelevant?
**CQ5**: is the prospect Confirmed or waiting to be confirmed?
**CQ6**: based on an Emotion triggered by some Action or Event, is the Action or Event praiseworthy or blameworthy for the AppraisingAgent?
**CQ7**: based on an Emotion triggered by some Action or Event, is the Action or Event desirable or undesirable for the AppraisingAgent?

### 9.5.4 Example

UserA and UserB are visiting GAM gallery and see a painting depicting Pietro Micca ("Pietro Micca nel punto di dare fuoco alla mina volge a Dio e alla Patria I suoi ultimi pensieri" - "Pietro Micca, the moment before setting fire to the bomb, directs his thoughts to God and his motherland") by Andrea Gastaldi. Pietro Micca is described as an Italian patriot who gave his life to save the to-be-born state of Italy, igniting some dynamite to detonate a tunnel that was being invaded by enemy soldiers. The narrative character of Pietro Micca is described in the narrative ontology module as being a hero and a patriot. UserA declare in the Scripting activity to feel Pride and Admiration for the Action made by Pietro Micca, UserB instead declares that he/she feels only pity for the Death of Pietro Micca, considering more important Pietro Micca's life than any winning in war, in fact she/he considers it useless to sacrifice one's life for any country. Thanks to the compositionality of Emotions in OCC model, we know that Admiration and Pride are positive emotions, and in particular Admiration is axiomatized as the feeling that an Appraising Agent feels appraising some praiseworthiness Action.
We as well know that Pity is a negative emotion axiomatised as the feeling that an Appraising Agent feels when appraising some undesirable Event happened to someone other than self.
We can in this way infer the Action of Pietro Micca is praiseworthy for UserA and blameworthy for UserB.

The turtle serialization of this example can be found in the Appendix (13.6)

## 9.6 Shaver Emotions Ontology

### 9.6.1 Introduction

This ontology is based on a formalization of Shaver's Emotion Knowledge Theory [62]. Shaver formulated his theory from the knowledge and recognition of emotions from a set of participants in his experiments. The results of his experiments lead to six 2-level hierarchical clusters of emotion, each one starting from a so-called Prototype Emotion. The PE emotions are:

- Love
- Sadness
- Joy
- Fear
- Anger
- Surprise

More than 100 "Emotion Words" are distributed throughout the second level of the hierarchical clusters. Shaver defined emotions as a reaction to an Event and asked the participants of his experiments to describe events that triggered in them one of the Protype Emotions. Another result of his experiment is therefore a list of "Emotion Events" that can trigger or are the results of feeling a particular Prototype Emotion.

The key strength of the formalization of this theory is the large number of emotion words, that could cover very specific emotions felt by the users during the interaction with a cultural object and at the same time generalize them to an Emotion Prototype through simple logical inferences. This generalization could help us to generate clusters of the works that triggered that specific Emotion Prototype. Moreover, we could catch the emotion of the users if they express their emotions by describing them as events. For example: "That painting made me **grit my teeth**!" which is an emotion event that suggest **Anger**.

This information might be useful not only at a level of inference when the data has already been encoded with the ontology, but also on a prior level of emotion recognition, performed in the task of emotion classification of WP3.

### 9.6.2 State of the art

Shaver theory has been adopted in multiple Emotion Mining frameworks. EmoTxt [87] is a toolkit specialized in extraction of emotions, politeness, sentiment, and uncertainty from texts. The emotion classification uses Shaver's theory as the foundational framework and assigned the detection of the Prototype Emotions to six linear SVM binary classification models.

EmotionFinder [88] is a textual emotion classifier that relies on keywords detection and is supported by an ontology. The keywords are associated with either a prototypical emotion by shaver or one of the emotions in the hierarchy. They exploit the hierarchy structure of an ontology to generalize the prototype emotion from a more specific emotion. We did not directly import their ontology because they do not seem to use standard `rdfs:subClassOf` relationships, and they also do not mention the concept of Emotion Event. Moreover, they do not create a class Emotion that stands at the top of a hierarchy. Finally, we are sure that they are using the same Emotion Prototypes, but we are not sure about the specific emotions (Emotion Words in our ontology) because there is no full list of them available.

### 9.6.3 Description of the ontology

This ontology was built as an extension to the Emotion ontology in Spice. Therefore, both *EmotionWord* and *EmotionPrototype* are sub-classes of the class Emotion previously defined. They are linked by the property *refersToPrototypeEmotion* (and its inverse as seen in the picture [reference picture] below). Moreover, all the Prototype Emotions (Sadness, Love, Anger, Fear, Surprise and Joy) are subclasses of *EmotionPrototype.* The specific Emotion Words are of subclasses of *EmotionWord* and are subject to a restriction. As to say, every emotion word refers to one Emotion Prototype. Example: *Adoration*, subclass of *EmotionWord*, has this restriction: *refersToPrototypeEmotion Love*. *Love* is a subclass of EmotionPrototype. Moreover, *EmotionEvent* is a class that has been created a subclass to the *Event* class present in the DOLCE ontology design pattern. It is linked to the class *EmotionPrototype* through the property *triggers* that has been imported by the Spice Emotion Ontology. All the specific emotion events that Shaver collected in his theory are present as individuals of the class *EmotionEvent*.

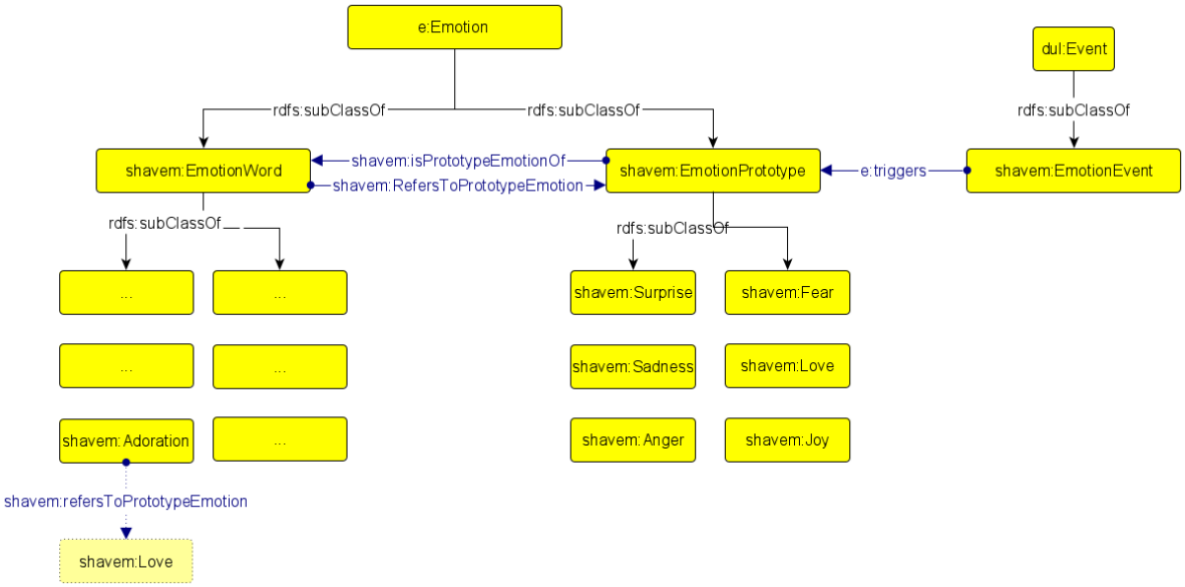



*Figure 26 Classes and Properties of the Shaver Emotions Ontology*

## Motivating Scenario

The emotions expressed by users can be classified using a Taxonomy extracted from Shaver's Emotion Knowledge Theory, the trigger of those emotion might be an emotion event present in the artwork that is being presented to the user. Different users might use different terms to express their emotion. These terms can then be generalized to one of the six prototype emotions.

Used as a standalone, the ontology only describes the emotion knowledge theory of Shaver. To be correctly applied to spice project it needs to be used in combination with the Emotion Ontology and Emotion in Cultural Context Ontology.

The ontology was developed to answer these Competency Questions:

**CQ1)** Retrieve the prototype emotion from an emotion word.

**CQ2)** Retrieve the emotion events that triggered a specific emotion word.

**CQ3)** Retrieve all emotion events that triggered a specific prototype emotion (in the query below, *Sadness* has been used as an example).

Shaver Emotions Ontology is available on GitHub: https://w3id.org/spice/ShaverEmotions

### 9.6.4 Example

Two users, **A** and **B** are dealing with the task of "text answering" (from Scripting Ontology) for the artwork **X**. **A** says that the EmotionEvent "crying" present in this artwork triggers in them the emotion "suffering". **B** instead describes this emotion as "unhappiness". Both suffering and "unhappiness" are then generalized to "Sadness".

The turtle serialization of this example can be seen in the appendix 13.8.

## 9.7 Final Overview

The variety of models proposed in the Emotion Knowledge Area allows to represent different aspects of the interactions triggering emotions, from the nature of the triggering stimulus, represented in the *EmotionInCulturalContext* module, to Emotion analysis according to their linguistic (Plutchik module), linguistic and expressive (Shaver and Ekman modules), or cognitive dimension (Ortony-Clore-Collins module).

While offering substantial coverage in data annotation, benefiting from the criteria and definition of emotions in all modules, the Emotion Knowledge Area also offers a flexible model to represent any aspect of the Emotion relation, being it an Event triggering some Emotion, a quality, a feeling, a part of a Cultural Entity etc. Furthermore, the interoperability within other knowledge areas allows to express the Emotion relation also with Symbols (cf. Section 7), Narrative Entities (cf. Section 6) and Values (cf. Section 8).

# 10 Interpretation Knowledge Area

The Interpretation knowledge area addresses (1) features and qualities of an artefact that are relevant in an encounter - e.g. colours, shapes, compositional aspects -, (2) the types of narratives that a person may use to describe the encounter - e.g. telling a story, sharing a memory, expressing a feeling -, (3) conclusions reached by an observer – e.g. judgement on the artefact, similarities with other artefacts, dis/agreement with the message proposed by the artist or museum professionals, and (4) a classification of the epistemological and interpretive mechanisms that are in place – e.g. empathy, analogies, metaphors, dialectics (see Deliverable D2.1 and D2.2 for further information). Altogether, those aspects allow us to characterise the type of encounter between persons and artefacts, and to describe how the artefacts are perceived by citizens, beyond the emotional responses that these may elicit.

The work in this knowledge area is still in a preliminary phase, since the design of the citizen curation activities (the pilots) has only recently been completed. We plan to reuse the general pattern-based framework applied in the design of ontologies for emotions, values, and narratives, jointly with a bottom-up approach, extracting requirements from representative situations (scenarios) that emerge from data collected during engagement activities.

Currently, we formally represent the encounter between a person and artefacts by using two ontology modules, namely, the Scripting ontology and the Fruition Context ontology. The former allows us to record the sequence of actions performed by a person when claiming his/her opinion with respect to the artefact. The latter allows us to annotate the context in which the claim was made.

In the future, we plan to extend these ontologies, to cover interpretive processes specifically. We have already identified some Semantic Web literature. Starting from seminal works on the role of argumentation and trust in the Semantic Web [89][90], we moved on selecting a few ontologies that can contribute to represent aspects that are relevant to epistemology and interpretation.

The Provenance Ontology (PROV-O) [73] is the W3C standard ontology for describing activities wherein agents create or modify entities and where entities have an influence on agents. We believe the ontology provides us with the core terminology for representing encounters in which citizens are influenced by features or qualities of the artefacts to develop their own interpretation of the artefact.

The HiCO ontology [91] is an extension of the PROV Ontology dedicated to representing hermeneutical aspects, that is, the usage of sources to support a claim on a subject of interest. The ontology allows to classify interpretive scenarios according to the type of situations (i.e., which type of hypothesis is in place), the motivation supporting the claim, the evidence, and the relation with other claims.

The ArCo ontology[16] includes patterns to represent interpretive situations that cataloguers may encounter in the cataloguing (e.g., artwork attributions), and to attribute a claim to an agent.

We also consider exploring CIDOC-CRM, in particular the comprehensive list of scenarios highlighted by the Linked.art community,[56] to review whether interpretive situations have been faced by museum professionals, and how they coped with those.

A very recent contribution [92] contains a frame-based ontology for perspectivisation, representing how a situation can be filtered through an interpretive lens, in order to shed a different light on that situation, possibly contrasting another perspective. It is supposed to be operationalised by means of knowledge extraction tools and the Framester knowledge graph (ongoing work).

[56] http://linked.art/

# 11 Conclusions

This document presented the SPICE Ontology Network (SON), which provides the ontological backbone for the representation of citizen curation activities. This is the first of two deliverables about the ontology network. Here we reported on the initial ontology specification. This report included: a brief overview of the principles and technologies the ontology network relies on, the design methods applied for developing the ontology network, the ontological requirements gathered so far, the first prototype of the ontology network built according to the collected requirements, and the protocol for testing and experimenting the ontology network in the context of the case studies.

The SPICE Ontology Network defines the ontological terms for building a Knowledge Level [93] on top of the data produced and exchanged by the systems implemented or integrated within SPICE. This KL has the advantage of providing a unique overview of the knowledge produced by the project, supporting long-term archiving and preservation of the data, and providing support for advanced inferencing.

Due to the initial stage of data gathering and design in the project, no strict ontological commitment is currently enforced on data, meaning that SPICE systems may exchange data according to any schema, but they would also have the ability of *projecting* their data into the Knowledge Level, thus accessing and validating them through the lenses of the ontology network. This solution ensures that data can be exchanged in a very flexible manner without losing its semantic characteristics that can be used when needed.

First year activities of the task T6.3 were mainly devoted to the collection of ontological requirements and the development of a first prototype of ontology network. In the second year, we are going to:

1. Experiment with the ontologies in the real use cases.
2. Refine modelling solutions by building on the results of the experimentations.
3. Collect additional requirements for the ontology network.
4. Introduce new ontologies (when needed).

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# 13 Appendix

## 13.1 Example of the Scripting ontology (JSON-LD)

```
{
  "@id": "spice:00003_script",
  "_label": "GAM game",
  "@type":"Script",
  "project": {
    "@id":"spice:00003_script_project",
    "@type":"StoryBasedNarrativeProject",
    "purpose": [
```

```
      {
        "@id": "spice:00003_user_stories_list",
        "@type":"StoryBasedNarrativeList"
      }
    ]
  },
  "purpose": [
    {
      "@id":"script:engagement",
      "@type":"Goal"
    },
    {
      "@id":"script:self-expression",
      "@type":"Goal"
    },
    {
      "@id":"script:storytelling",
      "@type":"Goal"
    }
  ],
  "stage": [
    {
      "@id": "spice:00003_preparation",
      "@type":"Preparation",
      "_label": "The selection of artefacts.",
      "task": [
        {
          "@id": "spice:00003_artefact_selection",
          "@type":["ArtefactsSelection","MultimediaSelection"],
          "_label": "The curators create a list of pictures of artefacts
to be shown to users.",
          "precedes":{"@id":"spice:00003_presentation"},
          "task_role":{"@id":"script:curator"},
          "input": {
            "@id": "spice:00003_gam_artefact",
            "belongs_to":"Artefact"
          },
          "output": {
            "@id": "spice:00003_gam_image",
            "belongs_to":"Photograph"
          }
        }
      ]
    },
    {
      "@id": "spice:00003_running",
      "@type":"Running",
```

```
      "_label": "The activity runs online. Users select pictures of
artefacts and contribute with stories",
      "task": [
        {
          "@id": "spice:00003_presentation",
          "@type":"PresentationCuratorialContents",
          "_label": "The web application shows the list of pictures in a
random order.",
          "precedes":{"@id":"spice:00003_user_picture_selection"},
          "follows":{"@id":"spice:00003_artefact_selection"},
          "task_role":{"@id":"script:software-agent"},
          "input": {
            "@id": "spice:00003_gam_image",
            "belongs_to":"Photograph"
          }
        },
        {
          "@id": "spice:00003_user_picture_selection",
          "@type":"MultimediaSelection",
          "_label": "The user may pick 1 picture.",
          "precedes":{"@id":"spice:00003_text_answering"},
          "follows":{"@id":"spice:00003_presentation"},
          "task_role":{"@id":"script:web-user"},
          "input": {
            "@id": "spice:00003_gam_image",
            "belongs_to":"Photograph"
          },
          "conditional_output": {
            "@id": "spice:00003_gam_selected_image",
            "belongs_to":"Photograph"
          }
        },
        {
          "@id": "spice:00003_text_answering",
          "@type":"FreeTextAnswering",
     "_label": "The web application prompts three suggestions (templates)
to encourage the user writing a story about the selected picture: 'Mi
ricorda:' (It reminds me), 'Mi fa sentire:' (It makes me feel), 'Mi fa
pensare a:' (It makes me think of). The user may or may not answer.",
          "precedes":{"@id":"spice:00003_emoji_answering"},
          "follows":{"@id":"spice:00003_user_picture_selection"},
          "task_role":{"@id":"script:web-user"},
          "input": {
            "@id": "spice:00003_gam_selected_image",
            "belongs_to":"Photograph"
          },
          "conditional_output": {
            "@id": "spice:00003_user_text",
            "belongs_to":"Text"
```

```
        }
      },
      {
        "@id": "spice:00003_emoji_answering",
        "@type":"AddEmoticon",
      "_label": "The web application allows the user to add an emoticon
related to the selected picture. The user may or may not answer.",
        "precedes":{"@id":"spice:00003_hashtag_answering"},
        "follows":{"@id":"spice:00003_text_answering"},
        "task_role":{"@id":"script:web-user"},
        "input": {
          "@id": "spice:00003_gam_selected_image",
          "belongs_to":"Photograph"
        },
        "conditional_output": {
          "@id": "spice:00003_user_emoji",
          "belongs_to":"Text"
        }
      },
      {
        "@id": "spice:00003_hashtag_answering",
        "@type":"Tagging",
        "_label": "The web application allows the user to add a list of
hashtags related to the selected picture. The user may or may not answer.",

         "conditional_precedes: [
              {"@id":"spice:00003_picture_recommendation"},
              {"@id":"spice:00003_user_picture_selection"}
         ],
        "follows":{"@id":"spice:00003_emoji_answering"},
        "task_role":{"@id":"script:web-user"},
        "input": {
          "@id": "spice:00003_gam_selected_image",
          "belongs_to":"Photograph"
        },
        "conditional_output": {
          "@id": "spice:00003_user_hashtag",
          "belongs_to":"Text"
        }
      },
      {
        "@id": "spice:00003_picture_recommendation",
        "@type":"Recommendation",
         "_label": "The web application recommends the user another
    picture to be included in the story. The user may or may not accept
    the suggestion.",
        "follows":{"@id":"spice:00003_hashtag_answering"},
        "task_role":[
           {"@id":"script:software-agent"},{"@id":"script:web-user"}],
```

```
          "input": {
            "@id": "spice:00003_gam_recommended_image",
            "belongs_to":"Photograph"
          },
          "conditional_output": {
            "@id": "spice:00003_user_acceptance",
            "belongs_to":"Text"
          }
        }
      ]
    }
  ],
 "@context": https://github.com/spice-h2020/manifest/blob/main/context.json
}
```


## 13.2 Example of the Narrative Ontology (Turtle Syntax)


```
@prefix : <https://w3id.org/spice/SON/NO/> .
@prefix dc: <http://purl.org/dc/elements/1.1/> .
@prefix SON: <https://w3id.org/spice/SON/> .
@prefix owl: <http://www.w3.org/2002/07/owl#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix xml: <http://www.w3.org/XML/1998/namespace> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
@prefix opla: <http://ontologydesignpatterns.org/opla/> .
@prefix prov: <http://www.w3.org/ns/prov#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix vann: <http://purl.org/vocab/vann/> .
@prefix terms: <http://purl.org/dc/terms/> .
@prefix catalogue: <https://w3id.org/arco/ontology/catalogue/> .
@prefix cidoc_crm_v5: <http://www.cidoc-crm.org/rdfs/cidoc_crm_v5.0.2_english_label.rdfs#> .
@prefix cpannotationschema: <http://www.ontologydesignpatterns.org/schemas/cpannotationschema.owl#> .
@base <https://w3id.org/spice/SON/NO/> .


spice:00002_script nar:has_project spice:story-based_narrative_project.
spice:story-based_narrative_project a nar:NarrativeProject ;
```

```
script:hasPurpose spice:engagement, spice:tagging, spice:storytelling , # inherited

spice:engagement a script:Goal

spice:tagging a script:Goal

spice:storytelling a script:Goal

spice:00002_script script:definesStage script:Preparation

script:definesTask spice:00002_select_artifact , spice:00002_ select curators_content ;

script:isTaskOf spice:curator , spice:mediator # inherited


spice:00002_script script:definesStage script:Preliminary_analysis

script:definesTask spice:00002_ annotation

script:isTaskOf spice:curator spice:mediator


spice:00002_script script:definesStage script:Running

script:isTaskOf spice:visitor spice:software_agent

script:definesTask spice:00002_ select_an_identifier

script:definesTask spice:00002_select_artifact

script:hasPurpose spice:tagging spice:sharing_opinion a script:Goal

script:definesTask spice:00002_expressing_opinion spice:00002_produce_multimedia_content spice_0002_share personal opinion spice:00002_suggest_action


spice:00002_script script:definesStage script:Analysis_of_results

script:isTaskOf spice:curator spice:mediator

script:hasPurpose spice:Reflection

script:definesTask spice:00002_select_user_generated_content spice:00002_navigation/browse

spice:00002_script script:definesStage script:Presentation_of_results

script:isTaskOf spice:curator spice:mediator

script:hasPurpose spice:Reflection

script:definesTask spice:00002_Show
```

## 13.3 Example of Plutchik ontology (Turtle Syntax)

```
@prefix owl: <http://www.w3.org/2002/07/owl#> .
```

```
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix plutchem: <https://w3id.org/spice/SON/PlutchikEmotions/> .
@prefix e: <https://w3id.org/spice/SON/emotion/> .
@prefix eicc: <https://w3id.org/spice/SON/emotionInCulturalContext/> .
@prefix ex: <https://example.org#> .
@prefix cis: <http://dati.beniculturali.it/cis/> .

ex:userA a ex:User .
ex:painting1 a cis:Painting .

ex:APaintingER a eicc:EmotionRelationInCulturalContext ;
    e:stimulus ex:painting1 ;
    e:emotion ex:Trust, ex:Joy
    e:experiencer e:A
#Inference: the user is feeling trust and joy so
    e:emotion ex:Love

ex:Joy a plutchem:BasicEmotion ;
    a plutchem: Joy .

ex:Trust a plutchem:BasicEmotion;
    a plutchem:Trust

### Inference from Plutching Model
ex:Love a plutchem:ComplexEmotion ;
    a plutchem:Love .
```

## 13.4 Example of the Schwartz Values ontology (Turtle Syntax)

```
@prefix dul: <http://www.ontologydesignpatterns.org/ont/dul/DUL.owl#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix occ: <https://w3id.org/spice/SON/OCCEmotion/> .
@prefix gam: <https://w3id.org/spice/GAM/> .
@prefix arco: <https://w3id.org/arco/ontology/core/> .
@prefix schw: <https://w3id.org/spice/SON/SchwartzValues/> .
@prefix nar: <https://w3id.org/spice/SON/Narrative-Labyrinth/> .


### CULTURAL ENTITY
```

```
gam:PietroMiccaDepiction a arco:CulturalEntity ;
    occ:hasAgent occ:PietroMicca .



### PEOPLE


occ:UserA a dul:Person ;
    schw:hasValue schw:Patriotism .

occ:UserB a dul:Person ;
    schw:hasValue schw:SelfPreservation .

nar:PietroMicca a dul:Person ;
    schw:hasValue schw:Patriotism .


### VALUES


occ:Patriotism a occ:Value .

schw:SelfPreservation a occ:Value .

schw:Patriotism a schw:Societal .           # "security and stability
                                           # in wider society."

schw:SelfPreservation a schw:Action .       # "the freedom to determine
                                           #  one's own actions."



### ACTIONS


schw:PietroMiccaAction dul:performedBy nar:PietroMicca ;
    occ:praiseworthy occ:AgentA ;
    occ:blameworthy occ:AgentB .
```

## 13.5 Example of the Haidt Values ontology (Turtle Syntax)

```
@prefix  dul:  <http://www.ontologydesignpatterns.org/ont/dul/DUL.owl#>  .
@prefix      rdf:      <http://www.w3.org/1999/02/22-rdf-syntax-ns#>      .
@prefix       rdfs:       <http://www.w3.org/2000/01/rdf-schema#>       .
@prefix       occ:       <https://w3id.org/spice/SON/OCCEmotion/>       .
@prefix           gam:           <https://w3id.org/spice/GAM/>           .
@prefix      sch:      <https://w3id.org/spice/SON/SchwartzValues/>      .
@prefix    nar:    <https://w3id.org/spice/SON/Narrative-Labyrinth/>    .
@prefix haidt: <https://w3id.org/spice/SON/HaidtValues/> .


### PEOPLE
```

```
occ:UserA a dul:Person ;
    a occ:AppraisingAgent ;
    haidt:hasValue haidt:LibertyOfItaly .

occ:UserB a dul:Person ;
    a occ:AppraisingAgent ;
    haidt:hasValue haidt:CareOfPietroMicca .

nar:PietroMicca a dul:Person ;
  a occ:AppraisingAgent ;
    haidt:hasValue haidt:LibertyOfItaly , haidt:CareOfPietroMicca .


#### ACTIONS


nar:PietroMiccaAction dul:hasComponent nar:LibertyOfItaly ,
nar:PiteroMiccaSacrifice ;
    dul:performedBy nar:PietroMicca .


### VALUES


haidt:LibertyOfItaly a haidt:Liberty .

haidt:PietroMiccaSacrifice a haidt:Harm .

haidt:CareOfPietroMicca a haidt:Care .

haidt:Care haidt:opposedTo haidt:Harm .


#### INFERENCES


haidt:PietroMiccaAction haidt:violates haidt:Care ;
    occ:adhereTo haidt:Liberty ;
    occ:praiseworthy occ:userA ;
    occ:blameworthy occ:UserB .
```

## 13.6 Example of the OCC Emotion ontology (Turtle Syntax)

```
@prefix dul: <http://www.ontologydesignpatterns.org/ont/dul/DUL.owl#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix occ: <https://w3id.org/spice/SON/OCCEmotion/> .
@prefix gam: <https://w3id.org/spice/GAM/> .
@prefix arco: <https://w3id.org/arco/ontology/core/> .
@prefix nar: <https://w3id.org/spice/SON/Narrative-Labyrinth/> .


### PEOPLE
```

```
occ:AgentA a dul:Person ;
    a occ:AppraisingAgent .

occ:AgentB a dul:Person ;
    a occ:AppraisingAgent .

nar:PietroMicca a dul:Person ;
    a occ:AppraisingAgent .


### CULTURAL ENTITY


gam:PietroMiccaDepiction a arco:CulturalEntity ;
    dul:hasAgent occ:PietroMicca .



### EMOTIONS


occ:PrideOfAgentA a occ:Pride ;
    occ:target occ:PietroMiccaAction .

occ:AdmirationOfA a occ:Admiration;
    occ:target occ:PietroMiccaAction .

occ:PityOfB a occ:Pity ;
    occ:target occ:PietroMiccaDeath .



#### EMOTION RELATION


occ:AgentA occ:feels occ:PrideOfA ;
    occ:feels occ:AdmirationOfA .

occ:AgentB occ:feels occ:PityOfB .

occ:PietroMicca occ:feels occ:PietroMiccaFear ;
    occ:feels occ:PietroMiccaPride ;
    occ:feels occ:PietroMiccaAnger .


### ACTION


occ:PietroMiccaAction occ:performedBy occ:PietroMicca ;
    occ:praiseworthy occ:AgentA ;
    occ:blameworthy occ:AgentB .
```

## 13.7 Example of the Emotion In Cultural Context Ontology (Turtle Syntax):

```
@prefix dul: <http://www.ontologydesignpatterns.org/ont/dul/DUL.owl#> .

@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
```

```
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix e: <https://w3id.org/spice/SON/emotion/> .
@prefix eic: <https://w3id.org/spice/SON/emotionInCulturalContext/> .
@prefix cis: <http://dati.beniculturali.it/cis/> .
@prefix ex: <http://example.org/> .
@prefix wd: <http://www.wikidata.org/entity/> .
@prefix prov: <http://www.w3.org/TR/prov-o/> .
@prefix script: <https://w3id.org/spice/SON/scripting/> .
@prefix fc: <https://w3id.org/spice/SON/fruitionContext> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .


# PEOPLE


ex:A a dul:Person .

ex:C a dul:Person .


# CULTURAL ENTITIES or QUALITIES or PARTS OF THEM


wd:Q19899820 a cis:CulturalEntity ;
    dul:hasQuality ex:PaintingSize ;
    e:triggers ex:AngerOfC .

ex:PaintingSize e:triggers ex:SurpriseOfA .

wd:Q1106059 a cis:CulturalEntity ;
    e:triggers ex:ApathyOfA , ex:ConfusionOfA , ex:SadnessOfC .


# EMOTIONS

ex:SurpriseOfA a e:Emotion .

ex:SadnessOfC a e:Emotion .
```

```
ex:AngerOfC a e:Emotion .

ex:ApathyOfA a e:Emotion .

ex:ConfusionOfA a e:Emotion .


# EMOTON RELATIONS


e:APaintingER a cis:EmotionRelationInCulturalContext ;
    fc:hasFruitionContext ex:fruition1 ;
    prov:wasGeneratedBy ex:text_answering_activity1 ;
    e:stimulus ex:PaintingSize ;
    e:emotion ex:SurpriseOfA ;
    e:confidenceScore "0.94"^^xsd:float ;
  e:experiencer ex:A .

e:AManuscriptER a cis:EmotionRelationInCulturalContext ;
    fc:hasFruitionContext ex:fruition1 ;
    prov:wasGeneratedBy ex:emoju_answering_activity1 ;
    e:experiencer ex:A ;
    e:emotion ex:ApathyOfA , ex:ConfusionOfA ;
    e:stimulus wd:Q1106059 .

e:CPaintingER a cis:EmotionRelationInCulturalContext ;
    fc:hasFruitionContext ex:fruition1 ;
    prov:wasGeneratedBy ex:text_answering_activity2 ;
    e:experiencer ex:C ;
    e:emotion ex:AngerOfC ;
    e:confidenceScore "0.67"^^xsd:float ;
    e:stimulus wd:Q19899820 .

e:CManuscriptER a cis:EmotionRelationInCulturalContext ;
    fc:hasFruitionContext ex:fruition1 ;
    prov:wasGeneratedBy ex:emoji_answering_activity2 ;
    e:experiencer ex:C ;
```

```
    e:emotion ex:SadnessOfC ;
    e:stimulus ex:Manuscript .


# Activities

ex:text_answering_activity1 a prov:Activity .

ex:text_answering_activity2 a prov:Activity .

ex:emoji_answering_activity2 a prov:Activity .

ex:emoju_answering_activity1 a prov:Activity .


#FruitionContext

ex:fruition1 a fc:FruitionContext;
    a fc:InPresenceFruitionContext .
```

Source of the example:
https://github.com/spice-h2020/SON/blob/main/emotionInCulturalContext/scenario1deliverable.ttl

## 13.8 Example of the Shaver Emotions Ontology (Turtle Syntax)

```
@prefix owl: <http://www.w3.org/2002/07/owl#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix shavem: <https://w3id.org/spice/SON/ShaverEmotions/> .
@prefix e: <https://w3id.org/spice/SON/emotion/> .
@prefix eicc: <https://w3id.org/spice/SON/emotionInCulturalContext/> .
@prefix ex: <https://example.org#> .
@prefix cis: <http://dati.beniculturali.it/cis/> .

ex:userA a ex:User .

ex:userB a ex:User .

ex:painting1 a cis:Painting .
```

```
ex:cryinginpainting1 a shavem:EmotionEvent ;
    a shavem:crying ;
    e:triggers ex:sufferingofA ;
    e:triggers ex:unhappinessofB ;


ex:APaintingER a eicc:EmotionRelationInCulturalContext ;
    e:stimulus ex:painting1, ex:cryinginpainting1 ;
    e:emotion ex:sufferingofA ;
    e:experiencer ex:userA .

ex:BPaintingER a eicc:EmotionRelationInCulturalContext ;
    e:stimulus ex:painting1, ex:cryinginpainting1 ;
    e:emotion ex:unhappinessofB ;
    e:experiencer ex:userB .


ex:sufferingofA a shavem:Suffering ;
    shavem:refersToPrototypeEmotion shavem:Sadness .

ex:unhappinessofB a shavem:Unhappiness ;
    shavem:refersToPrototypeEmotion shavem:Sadness .
```

Source of this example:

https://github.com/spice-h2020/SON/blob/main/ShaverEmotions/shaverscenario1.ttl