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AN EPIDOC ONTOLOGICAL PERSPECTIVE: THE EPIGRAPHS OF THE CASTELLO URSINO CIVIC MUSEUM OF CATANIA VIA CIDOC CRM

1. Introduction

The rich epigraphic heritage of the Castello Ursino Civic Museum of Catania has been studied and promoted in the last years by several monographs and, in particular, by the project EpiCUM (Epigraphs of Castello Ursino Museum: Agodi *et al.* 2018; Cristofaro, Spampinato 2019). The EpiCUM project aims at encoding in EpiDoc TEI XML[1] the entire epigraphic *corpus* of the Castello Ursino Civic Museum in Catania, in order to present and make it accessible via a single web interface – the digital museum[2]. The project stems from the collaboration between the CNR Institute of Cognitive Sciences and Technologies and the Municipality of Catania and gained the interest of the I.Sicily project[3] and the involvement of the Liceo Artistico M.M. Lazzaro of Catania[4]. EpiCUM falls among the various digital epigraphy experiences (see, e.g., De Santis, Rossi 2018).

The first phase of the project was mainly dedicated to the recognition of the epigraphs and the preparation of the *Voci di Pietra* exhibition, which proposes a selection of 35 epigraphs according to innovative presentation modalities through a smart use of technology and digital tools. The exhibition was created by developing a new communicative point of view of the epigraphic heritage, with the stylised reconstruction of a *columbarium*, the graphic restitution of an *edicoletta* tomb and the use of properly scenographic material such as the plexiglass reconstruction of a statuette of Venus Victrix. Innovative were the use of videos, real examples of storytelling for images, and the presence of a multimedia touch kiosk, which allows one to explore the exhibited material and to deepen the contents of the epigraphs.

The subsequent phase of the project focused on the analysis and on the EpiDoc encoding of all the inscriptions of the Civic Museum, and the creation of the digital museum. Through the EpiDoc encoding of the inscriptions and the online publication of the corresponding XML files, the epigraphic heritage of the Civic Museum becomes accessible to a wide range of possible users, ranging from the specialists to the more common home-users. All information

[1] https://sourceforge.net/p/epidoc/wiki/Home/.
[2] http://epicum.istc.cnr.it/.
[3] https://isicily.wordpress.com/.
[4] For details about the partners involved in the project see http://epicum.istc.cnr.it/?page_id=51.

on the epigraphs is contained in the XML files: currently, the EpiCUM project incorporates 580 different XML files, corresponding to the same number of different inscriptions collected in the Castello Ursino Civic Museum (conventionally referenced as EpiCUM1, EpiCUM2, EpiCUM3, etc.). In order to make the epigraphic information accessible and understandable even to a non-specialist audience, it has been chosen to codify in EpiDoc also the religious context, the provenance collections and the status of copy of the epigraphs.

In this contribution, we use semantic web technology – the Linked Open Data (LOD) paradigm, the Web Ontology Language (OWL)[5] and consolidated international standards for Digital Humanities – to develop a web ontology, called EpiONT, which models the knowledge enclosed in such epigraphs in a unique homogeneous container.

The task of semantically organizing knowledge has become urgent in many fields, especially in Human Sciences, where information, retrieved from different sources and contexts, is disseminated in many different, often isolated, places. This makes it difficult to gather, collect and integrate data. Moreover, application domains often present interesting implicit information that users cannot gather immediately with standard entity-relation databases, but can deduce from data if an appropriate tool for automated reasoning is applied.

The EpiONT ontology structure (taxonomy) and data are defined by exploiting the XML files containing the EpiDoc encoding of the epigraphs of Castello Ursino Civic Museum. Moreover, based on the CIDOC CRM model (Doerr 2003) and on the SKOS[6] vocabularies for inscriptions of the EAGLE project[7], the EpiONT ontology has been defined according to the paradigmatic semantic web model for museums and cultural heritage. This enables the EpiONT ontology to be connected in a global way with other knowledge sources available on the web and to support dedicated automated reasoning tools based on Description Logics (DLs).

The paper is organized as follows. Section 2 briefly reviews some related works. In Section 3.1, basic notions and concepts regarding the semantic web technology are introduced, whereas Sections 3.2 and 3.3 are devoted, respectively, to a brief overview of the model CIDOC CRM and of the EAGLE project, both used for the development of the EpiONT ontology, fully described in Section 4. Then Section 4.1 provides some significant examples of representation of epigraphs of the Castello Ursino Civic Museum in the EpiONT ontology. Finally, in Section 5 some conclusions are drawn, and hints for future work are discussed.

[5] https://www.w3.org/TR/owl2-syntax/.

[6] https://www.w3.org/2004/02/skos/.

[7] EAGLE. *The Europeana network of Ancient Greek and Latin Epigraphy*, https://www.eagle-network.eu/.

2. Related works

The use of ontology-based systems for knowledge management and organization is not new to the domain of digital epigraphy and, more generally, to the domain of Digital Cultural Heritage and Humanities. Several proposals have been made over the years to address different aspects and issues concerning the representation of and reasoning on historical and archaeological documents (see, for instance, Vavliakis *et al.* 2012, presenting the status of semantic data management in the cultural heritage field focusing on the challenges imposed by the multidimensionality of the information in this domain).

By relying on the Ontology-Based Data Access paradigm, D. Calvanese *et al.* (2016) introduce a framework that eases the access of scholars to historical and cultural data about food production and commercial trade system during the Roman Empire, distributed across different data sources. More closely to our approach, we mention the paper by A. Felicetti and F. Murano (2017) that proposes an extension of the standard CIDOC CRM ontology, namely the CRMtex, in order to make it more responsive to the specific requirements of the various disciplines involved in the study of ancient texts, including papyrology, paleography, codicology and, in fact, epigraphy. Similarly, V. Casarosa *et al.* (2014) define a unifying conceptual model, based on the CIDOC CRM ontology, to overcome the heterogeneity of the material collected by EAGLE from over 15 different Content Providers.

Other lines of research have been undertaken with the aim of integration, within a single homogeneous framework, of the different modelling paradigms related to the encoding of information and the reasoning about the coded data. We mention, in particular, F. Ciotti (2018) who proposes a preliminary architecture of a formal ontology of the Text Encoding Initiative (TEI) markup language, and A. Ciula and Ø. Eide (2014) who discuss and compare the CIDOC CRM and the TEI at an abstract level going beyond the pragmatic concerns (see also Álvarez *et al.* 2010 for a mapping from EpiDoc to an OWL ontology).

Some of the authors of this paper have already been involved in the definition of web ontologies for the Digital Humanities. Specifically, C. Cantale *et al.* (2017a) present an ontology suite to model the history of the renovation of the Benedictine Monastery of San Nicolò L'Arena in Catania by the architect Giancarlo De Carlo, whereas C. Cantale *et al.* (2017b) introduce an ontology representing the Saint Gall map, one of the most ancient descriptions of a Benedictine monastery, useful to design the shape of an ideal Benedictine monastery and the peculiarities that identify and distinguish it from other religious buildings.

3. Preliminaries

3.1 *Semantic web and web ontologies*

Semantic web is a vision of the web in which machine-readable data enable software agents to query and manipulate information on behalf of human agents. In such a vision web information carries an explicit meaning, so it can be automatically processed and integrated by machines and data can be accessed and modified at a global level, resulting in increased coherence and dissemination of knowledge. In addition, by means of automated reasoning procedures, it is possible to extract and process implicit information present in data, thus permitting to gain a deeper knowledge of the domain.

Informally, in the context of computer science, an ontology defines a set of representational primitives (classes and attributes) in order to model a domain of knowledge or discourse. Applications that need to automatically process the content of information, instead of just presenting information to humans, require an appropriate language with formally defined semantics. The goal of such language should be to simplify machine interoperability of information content by providing additional expressive power along with a formal syntax and semantics. This task turns out to be particularly critical in the case of web and distributed content. For this purpose, the Word Wide Web Consortium (W3C) identifies OWL as the standard for representing ontologies. An ontology (Oberle *et al.* 2009; Hofweber 2018) is a formal description of the domain of interest carried out by combining three basic syntactic categories: entities, expressions and axioms, which constitute the logical part of ontologies, namely what ontologies can express and the type of inferences that can be drawn. Ontologies can also be combined together in order to describe more complex domains.

OWL, currently in version 2.1, provides users with constructs useful for the design of ontologies in real-world domains that are not available in the basic semantic web model RDF[8] (Resource Description Framework) and in the basic semantic web language RDFS[9] (Schema). In fact, RDF allows structured and semi-structured data to be mixed, published and shared across different web applications but with no pretension of being a reasoning framework. A first attempt of extending RDF with such capabilities has been provided by RDFS, an extension of RDF with taxonomies, which extends it with a more expressive set of primitives permitting to define range and domain of relations and subsumption axioms.

[8] https://www.w3.org/TR/rdf11-concepts/.

[9] https://www.w3.org/TR/rdf-schema/.

As RDF, OWL 2 is based on the idea of triples, which represent its atomic unit. Triples are ways to connect two entities or an entity and a data-value. Entities represent the primitive terms of an ontology and are identified in a unique way. They are individuals (actors), object- and data-properties (actions) and classes (sets of actors with common features). In order to provide a formal description of the domain, OWL 2 triples can be organized in two main categories: expressions and axioms. Expressions are obtained by applying OWL 2 constructs to entities, thus forming complex descriptions, whereas axioms describe what is true in the domain. For example, referring to the EpiONT ontology (cfr. Section 4), one can combine an equivalent classes axiom, an expression of class intersection and an expression of existential quantification such as:

```
EquivalentClasses(:Epigraph ObjectIntersectionOf(:Physical Man-Made
Thing ObjectSomeValues(:has_epigraph_field :EpigraphField )))
```

in order to define the class of epigraphs as the collection of man-made objects carrying some epigraphic fields.

There are three main types of expressions, namely object-property expressions, data-property expressions and class expressions. Object-property expressions represent binary relationships among individuals, whereas data-property expressions represent binary relationships among individuals and data type values. Class expressions represent sets of individuals sharing common characteristics. Such individuals are said to be instances of the respective class expressions. Class expressions are constructed recursively by using classes, properties, and class expressions, and by applying restrictions on object-property expressions (for a detailed explanation of axioms and expressions introduced in OWL 2, see Allemang, Hendler 2011).

3.2 *The CIDOC CRM model*

The CIDOC Conceptual Reference Model[10] (CRM) is the international official standard ISO 21127:2006 for the controlled exchange of cultural heritage information since 2006. It provides a general specification which can be adopted in any cultural heritage context to construct a semantic web-based information system, to serve as a guide for good practices of conceptual modelling and to improve information sharing. There are several institutions that successfully implement CIDOC CRM such as galleries, libraries, museums, archives, as well as any other cultural environment based on cultural heritage data that publishes and shares its information in the semantic web formats.

The CIDOC core covers several general aspects of cultural information, such as material and immaterial entities, events, space and time. Such general

[10] http://www.cidoc-crm.org/.

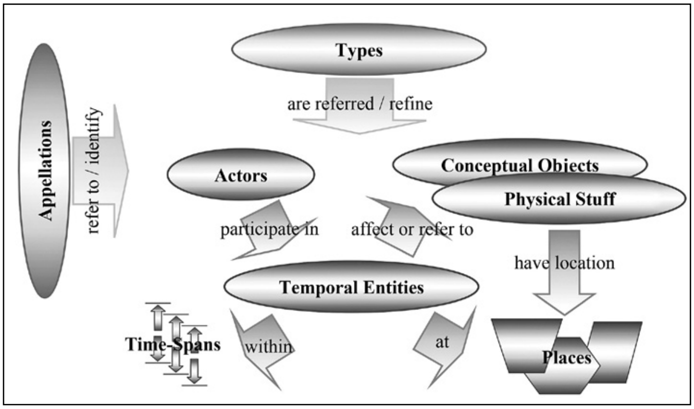

Fig. 1 – A qualitative meta-schema of the CIDOC CRM.

concepts can be specialized, contextualized and integrated in order to address practical aspects of cultural heritage issues. It models several notions, such as participation, appellation, parthood and structure, material and immaterial concepts, location, assessment and identification, purpose, motivation and so on.

All these notions act through temporal entities, as shown in Fig. 1 (see fig. 3 in Doerr 2003).

In this context, actors operate or deal with material and immaterial stuff within a certain temporal window. Such participation can occur in some real or figurative place. Everything can be classified in more details by introducing a "type" and can be identified by some appellation (name, labels, or title). The existence of objects that have a persistent life-span can be limited in specific temporal window (birth, death, creation, destruction and so on). Activities and events which introduce some change of state in cultural, social or physical systems can be modelled together with their results or products. Finally, objects and events that influenced or motivated activities can be also modelled by means of different forms of influence and their mutual relations. Entities and relations in CIDOC receive a deep specialization which maps several facets of their scope.

3.3 *The EAGLE vocabularies*

EAGLE, the Europeana network of Ancient Greek and Latin Epigraphy provides a web resource dedicated to the ancient world inscriptions based on SKOS, a set of RDFS concepts and relations intended to represent knowledge organization systems, *thesauri*, classification schemes and subject heading systems and taxonomies within the framework of the Semantic web. It provides

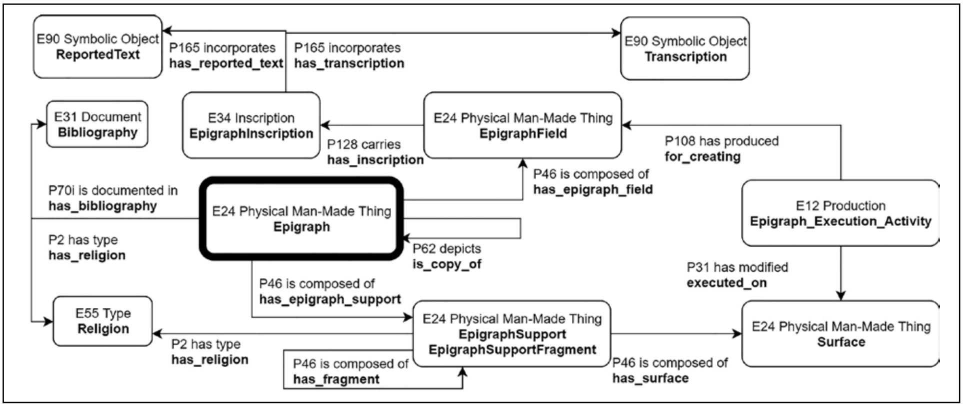

Fig. 2 – Diagram of the main concepts related to the class *Epigraph*.

a user-friendly interface together with a set of SKOS vocabularies containing, for each category, a set of terms with stable identifiers and relations among them, which can be used by any application related to the cultural aspects of inscriptions. It consists of seven vocabularies covering the most relevant aspects of an inscription, namely composition material, execution technique, type of inscription, type of support, decoration, dating criteria and state of preservation.

4. The EpiONT Ontology

In this section, we illustrate the EpiONT OWL 2 ontology, implemented by specializing a portion of the CIDOC CRM model, by integrating most of the EAGLE SKOS vocabularies and by modelling uncertainty of origin and discovery place of an epigraph. Since CIDOC CRM entities are too general to precisely characterize the domain of epigraphs, we endowed the EpiONT ontology with *ad-hoc* classes (resp., properties) defined as subclasses (resp., subproperties) of CIDOC CRM classes (resp., properties). Such entities are not to be considered as a formal extension of CIDOC CRM.

In EpiONT, epigraphs are represented by instances of the class *Epigraph*, defined as a subclass of the CIDOC class *E24 Physical Man-Made Thing*, whose main connections are depicted in Fig. 2. Each instance of the class *Epigraph* is related to its religion and bibliography, as illustrated in Fig. 2. The class *Bibliography*, a subclass of the CIDOC class *E31 Document*, contains objects representing bibliography items, whereas the class *Religion* is a subclass of the CIDOC class *E55 Type*. Each instance of the class *Epigraph* is associated to its references by means of the object-property *has_bibliography* and to its religion by means of the object-property *has_religion*. The property *has_bibliography* is a subproperty of the CIDOC relation *P70i is documented in*, whereas *has_religion* is subproperty of the CIDOC relation *P2 has type*. The relationship among instances of the class *Epigraph* and of the class *Religion* induces a classification of epigraphs based on their religion. For example, an epigraph related with the individual *christianreligion*, representing the Christian religion, is also an instance of the class *ChristianEpigraph*, which identifies all the epigraphs realized in a Christian context.

We also specify whether the epigraph is a copy (or it is original) by means of the data-property *is_original* having as range the data type *Boolean*. The classes *EpigraphField* and *EpigraphSupport*, subclasses of the CIDOC concept *E24 Physical Man-Made Thing*, are introduced to identify the epigraphic field and the epigraphic support, respectively. An epigraph support can be either intact or fragmented. In the latter case, each fragment is introduced by means of an instance of the subclass *EpigraphSupportFragment* of *EpigraphSupport* and by means of a subproperty of *P46 is composed of*, called *has_fragment*, connecting the epigraphic support to the fragments composing it. In addition, for an epigraphic support, one also specifies the engraved surface by means of a subproperty of *P46 is composed of* called *has_surface* with object an instance of the class *Surface*, subclass of *E24 Physical Man-Made Thing*.

Epigraphs are related with their epigraphic field by means of the property *has_epigraph_field*, and with their epigraph support by means of the property *has_epigraph_support*; both properties are subproperties of the CIDOC relation *P46 is composed of*. The activity that led to the realization of the epigraphic field from the physical epigraphic support is described by the subclass of *E12 Production* called *Epigraph_Execution_Activity*. Instances of the latter class are linked to instances of *EpigraphField* through the subproperty *for_creating* of *P108 has produced* and to instances of *Surface* by means of the subproperty *executed_on* of *P31 has modified*.

Epigraphic inscriptions are represented by means of the class *EpigraphInscription*, subclass of the CIDOC class *E34 Inscription*. Instances of *Transcription*, subclass of *E90 Symbolic Object*, are related with strings representing the text of the inscription by means of the data-property *has_transcribed_text*. In analogous way, instances of the class *Reported_Text*, subclass of *E90 Symbolic Object*, are related with the text of the inscription as it is physically reported on the epigraph by means of the data-property *has_inscription_text*. Instances of *EpigraphInscription* are related with instances of *Transcription* and of *Reported_Text* by means of the subproperties called *has_transcription* and *has_reported_text* of *P165 incorporates*, respectively. Instances of the class *EpigraphField* are connected to instances of the class *EpigraphInscription* by means of the property *has_inscription*, subproperty of the CIDOC relation *P128 carries*.

Motivations that have led to the realization of the epigraph and other information concerning the purpose of the epigraph is provided by means of a subclass of the CIDOC class *E5 Event* called *Motivation*. Instances of the class *Epigraph_Execution_Activity* are related with instances of the class *Motivation* by means of the object-property *has_motivation*, subproperty of the CIDOC relation *P20 had specific purpose*. Different types of motivations are defined by using the EAGLE vocabulary *TypeIns*, which provides a set of individuals, each describing a specific type of motivation. Such class is modelled as a subclass of the CIDOC class *E55 Type*. Instances of the class *Motivation* are linked to instances of *TypeIns* by means of the object-property *has_motivation_type*, subproperty of the CIDOC relation *P2 has type*.

Analogously to the class *Religion*, instances of the class *TypeIns* induce a classification of epigraphs based on the purpose of their realization. As an example, the instance *votive dedication*, representing the motivation of a dedication to a divinity, induces the class *VotiveEpigraph*, representing all epigraphs realized with the purpose of making an oath to some god. The execution techniques adopted for the realization of the epigraphic field can be provided by linking instances of the class *Epigraph_Execution_Activity* to instances of the class *ExecutionType*, subclass of the CIDOC class *E55 Type*. The object-property adopted for this purpose is called *has_execution_type* and is defined as a subproperty of the CIDOC relation *P32 used general technique*. The class *Execution Type* contains the EAGLE class *Writing*, which defines several writing techniques (for a recent discussion on epigraphic writing techniques see Evangelisti 2017).

We introduce the date of the execution of the epigraph by linking instances of the class *Epigraph_Execution_Activity* to instances of the class *Chronology*, subclass of the CIDOC class *E2 Temporal Entity,* by means of the property *has_chronology*, subproperty of the CIDOC property *P117 occurs during*. For each instance of the class *Chronology*, a start and an end date are provided by the classes *Start_Date* and *End_Date,* subclasses of the CIDOC class *E2 Temporal Entity*, respectively. Instances of the class *Chronology* are related with instances of the class *Start_Date* by means of the object-property *has_start_date* and are related with instances of *End_Date*, by means of the object-property *has_end_date*. The former property is subproperty of the CIDOC relation *P114 starts*, whereas the latter one of *P115 finishes*. The class *Dates* is a subclass of the class *Historical_Period*, which in its turn is a subclass of the CIDOC class *E52 Time-Span*. Instances of the class *Chronology* are related with instances of the class *Dates* by means of the object-property *has_historical_period*, which is defined as a subproperty of the CIDOC relation *P4 has time-span*.

An epigraphic execution activity is also related with the place where the execution of the epigraph has been accomplished. If the place has been

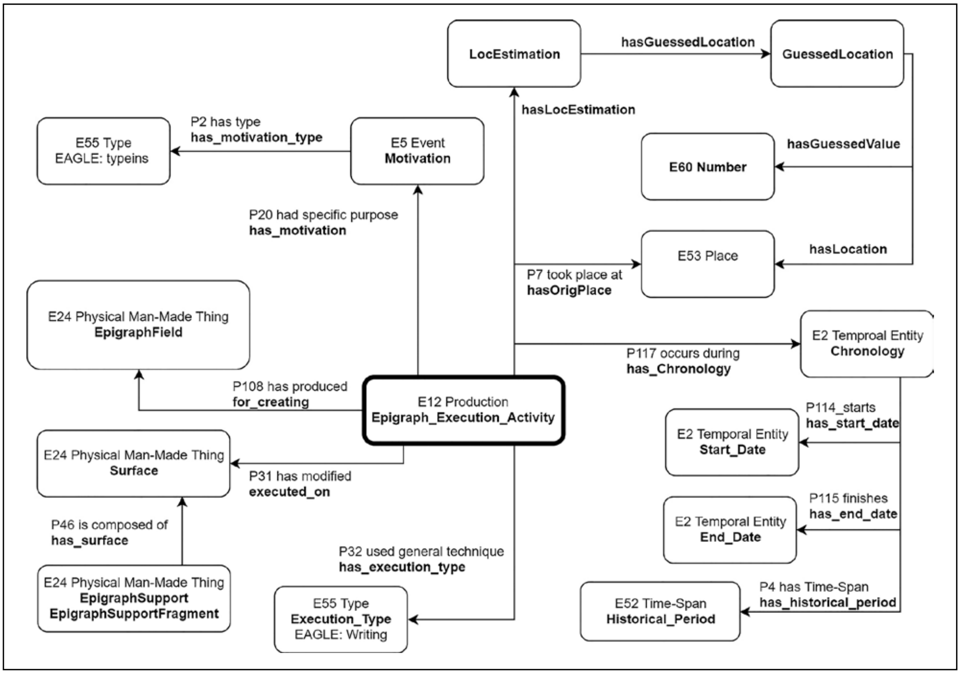

Fig. 3 – Schema of an epigraph execution activity.

established with certainty, we link instances of the class *Epigraph_Execution_Activity* with instances of the CIDOC class *E53 Place* by means of the object-property *has_origin_place*, subproperty of the CIDOC relation *P7 took place at*. Instead, if the compiler has only a fuzzy knowledge of the place, we use the schema introduced in (Cantone *et al.* 2016) in order to model such uncertainty. The schema contains two classes: the first class is called *LocEstimation* and represents the spotting act, whereas the second class, called *GuessedLocation,* models the spotted place. Instances of the class *Epigraph_Execution_Activity* are related with instances of the class *LocEstimation* by means of the object-property *hasLocEstimation*. Instances of the class *LocEstimation* are in their turn related with instances of the class *GuessedLocation* by means of the object-property *hasGuessedLocation*.

Finally, instances of the class *GuessedLocation* are related with the place of execution of the epigraph by means of the object-property *hasLocation*, which has as range the CIDOC class *E53 Place*. The data-property *hasGuessedValue* is used with instances of the class *GuessedLocation* to indicate the fuzziness of the spotted value that is specified by a double value. The classes *LocEstimation*, *GuessedLocation* and their related properties have not been mapped into the CIDOC CRM model because the latter does not admit the modelling of uncertain information. The schema of the attributes involving an execution activity is shown in Fig. 3.

Another important feature of epigraphs mapped in EpiONT is the epigraphic support, which is used in the epigraphic execution activity to produce the epigraphic field. The support of an epigraph is described by the subclass of the CIDOC class *E24 Physical Man-Made Thing*, called *EpigraphSupport*. The type of the epigraphic support is provided by the instances of the class *ObjType*, introduced in the EAGLE vocabulary. Such class is defined in EpiONT as a subclass of the CIDOC class *E55 Type*. Instances of *ObjType* are related with instances of the class *EpigraphSupport* by means of the object-property *has_support_type*, the latter a subproperty of the CIDOC relation *P2 has type*. Instances of the class *EpigraphSupport* also carry information concerning the material the support is made of. Such information is introduced by means of instances of the EAGLE class *Material*, defined as a subclass of the CIDOC class *E54 Material*. Instances of the class *EpigraphSupport* are related with instances of the class *Material* by means of a subproperty of the CIDOC relation *P45 consists of* called *has_material*. Dimensions of the epigraphic support are introduced by means of the class *Dimension*, subclass of the CIDOC class *E54 Dimension*, and its subclasses, *Dimension_1*, *Dimension_2*, and *Dimension_3*. Such subclasses represent the dimensions of the epigraphic support along the x-, y- and z-axes, respectively. The epigraphic support is related with instances of the class *Dimension* and of its subclasses by means of the subproperty of *P43 has dimension* called *has_dimension*. The compiler can introduce a range for a single dimension, instead of a precise measurement. In this case, we provide two classes, the class *Max_Dimension*

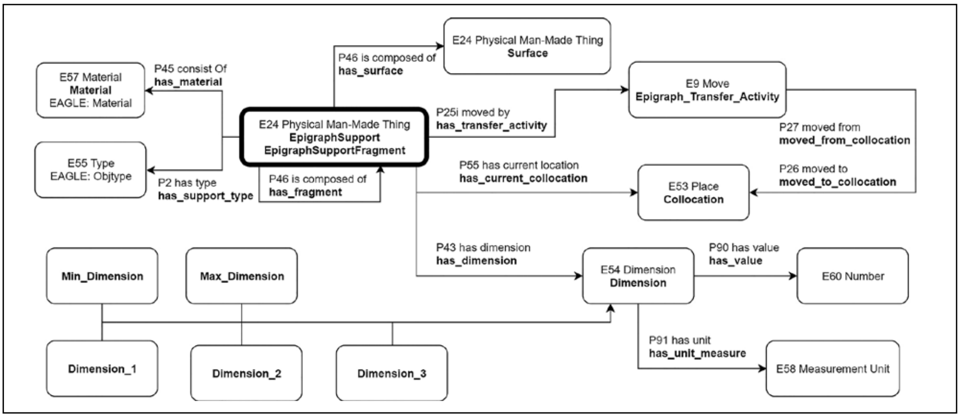

Fig. 4 – Schema of an epigraph support.

and *Min_Dimension*, standing for the maximum and minimum of the range, respectively. Such classes are defined as subclasses of the class *Dimension*. Each dimension is related with its value, represented by a double, by means of the object-property *has_value*, subproperty of the CIDOC relation *P90 has value*. Finally, instances of the class *Dimension* are related with instances of the CIDOC class *E58 Measurement Unit*, representing the measurement unit, by means of the object-property *has_unit_measure*, subproperty of the CIDOC relation *P91 has unit*.

Furthermore, by means of the class *Epigraph_Transfer_Activity*, a subclass of the CIDOC class *E9 Move*, we can describe the transfer activity that brought the epigraphic support to the Museum Collection of Castello Ursino in Catania from a previous collocation. Instances of the class *EpigraphSupport* are related with instances of the class *Epigraph_Transfer_Activity* by means of the object-property *has_transfer_activity*, subproperty of the CIDOC relation *P25i moved by*. The previous and the current collocation are modelled by means of the class *Collocation*, subclass of the CIDOC class *E53 Place*, and by means of the object-properties *moved_from_collocation* and *moved_to_collocation*, respectively. The former property is a subproperty of the CIDOC relation *P27 moved from*, whereas the latter is a subproperty of the CIDOC relation *P26 moved to*. The property *has_current_collocation*, which is a subproperty of *P55 has current collocation*, links the instances of the class *EpigraphSupport* to the current collocation. The complete schema concerning the epigraphic support is illustrated in Fig. 4.

The discovery place of an epigraph is mapped by means of a discovery event represented by the subclass of the CIDOC class *E5 Event*, called *Discovery_Event*, according to the schema illustrated in Fig. 5.

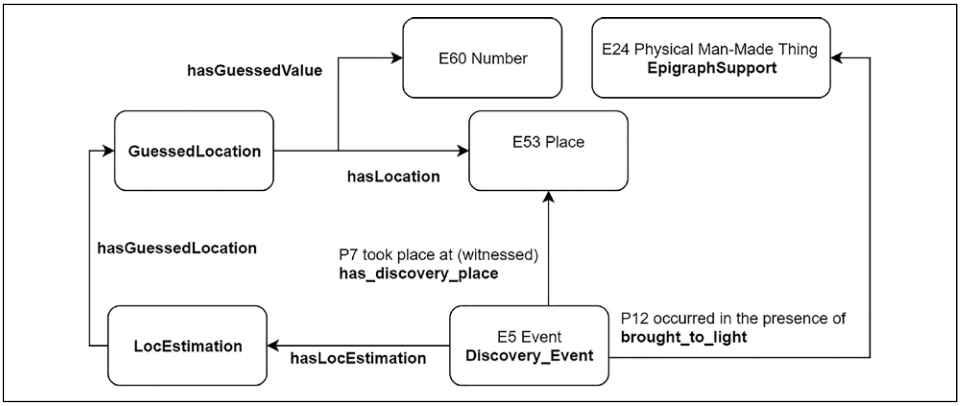

Fig. 5 – Schema of the discovery place of an epigraph.

Instances of the class *EpigraphSupport* are related with instances of the class *Discovery_Event* through the property *brought_to_light*, which is subproperty of the CIDOC relation *P12 occurred in the presence of*. In case the discovery place is known with certainty, the object-property *has_discovery_place*, subproperty of CIDOC relation *P7 took place at*, is used to link the discovery event to the physical place. The physical places are introduced as instances of the CIDOC class *E53 Place*. Otherwise, in case of uncertainty, the schema used for the origin place (Fig. 4) is adopted also for the discovery place.

EpiONT consists of 134 classes, 319 object-properties, 30 data-properties, more than 3,500 axioms, almost 11,000 individuals, more than 11,000 class assertions, more than 15,000 object-property assertions and more than 7,000 data-property assertions. It exploits the OWL 2 construct of existential restriction and it can be represented in the description logic ALCHOI(D). Further structural details are summarized in Tab. 1.

The EpiONT ontology has been populated using a JAVA application based on the OWL API[11] library faithfully mapping the EpiDoc XML files to EpiONT assertions as illustrated in Tab. 2.

METRIC TYPE	EpiONT metric value
DL expressivity	ALCHOI(D)
Axioms count	56696
Logical axioms count	35261
Declaration axioms count	11242
Classes count	134
Total classes count	134
Object-properties count	319
Data-properties count	30
Individuals count	10994
Sub-class axioms count	148
Equivalent classes axioms count	11
Hidden GCI count	11
Subobject-property axioms count	192
Inverse object-properties axioms count	2
Object-property domain axioms count	278
Object-property range axioms count	287
Data-property domain axioms count	13
Data-property range axioms count	14
Class assertion axioms count	11154
Different individuals axioms count	8
Annotation assertion axioms count	10161
Object-property assertions count	15446
Data-property assertions count	7698

Tab. 1 – EpiONT structural metrics.

[11] http://owlapi.sourceforge.net/.

EpiDoc entry for Epigraph EpiCUM234	EpiONT assertion
<objectType ref="http://www.eagle-network.eu/voc/objtyp/lod/257" n="tabula"> <seg xml:lang="en">tablet</seg> <seg xml:lang="it">lastra</seg> </objectType>	EpiCUM234EpigraphSupport has_support_type lastra.
<provenance type="found"> <seg xml:lang="it">Roma</seg> <seg xml:lang="en">Rome</seg> </provenance>	EpiCUM234ExecutionActivity has_origin_place Roma.
<material ref="http://www.eagle-network.eu/voc/material/lod/48.html" n="marble"> <seg xml:lang="en">marble</seg> <seg xml:lang="it">marmo</seg> </material>	EpiCUM234EpigraphSupport has_material marmo.

Tab. 2 – Example of mapping EpiDoc XML in EpiONT.

Fig. 6 – The epigraphs EpiCUM234, EpiCUM138 and EpiCUM139.

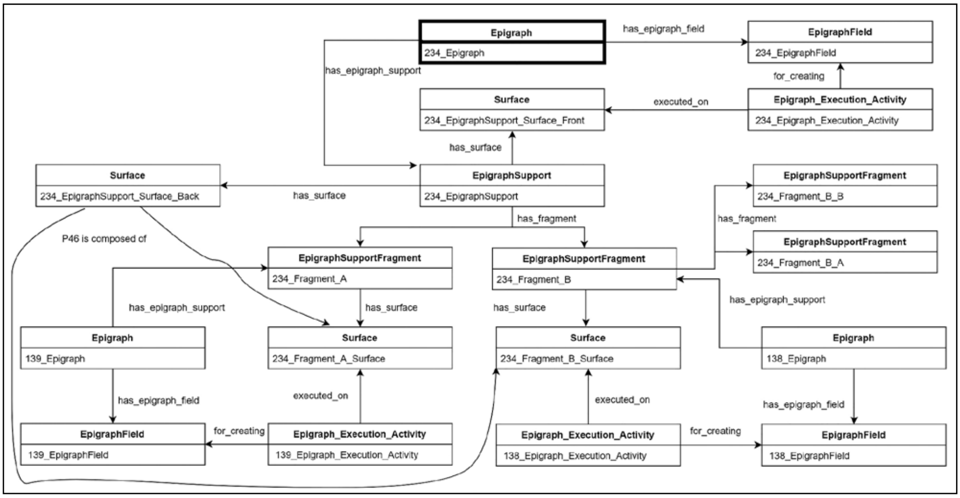

Fig. 7 – Schema of the epigraphs EpiCUM234, EpiCUM138 and EpiCUM139.

Fig. 8 – Relationships of the epigraph EpiCUM234 and its support.

Finally, the EpiONT ontology has been consistently classified by the reasoners Fact++[12] Hermit (Glimm *et al.* 2014) and Pellet (Sirin *et al.* 2007).

4.1 *Examples*

In this section, we illustrate some significant examples of epigraph representation in the ontology EpiONT, which serve as special case-examples for testing capabilities of our proposed framework. At first, we consider the epigraphs EpiCUM234, EpiCUM138 and EpiCUM139 contained in the Castello Ursino Museum and illustrated in Fig. 6. The epigraph EpiCUM234[13] consists of a marble tablet, broken into three fragments and engraved on both sides in different ages. On the front side of the tablet, there lies the inscription EpiCUM234, whereas the back contains the inscriptions EpiCUM138 and EpiCUM139. The inscription EpiCUM234, of which the right, left, and lower sides are partially missing, is dated to the first century AD and has an urban epitaph written in Latin, whose letters are partially covered by stucco; in the higher side there is a carved frame.

The two inscriptions EpiCUM138 and EpiCUM139 are Eighteenth century copies of two pagan funerary epigraphs both written in Latin. In fact, after the engraving of inscription EpiCUM234 in the front side, the tablet was later broken into two pieces, rotated by 90 degrees and reused on the back for the engraving of the inscriptions EpiCUM138 and EpiCUM139. The three inscriptions, originally coming from Roman area, subsequently became part of the Biscari Collection. Fig. 7 shows the attributes of the epigraph EpiCUM234 and its relationships with the individuals representing the epigraphic field and the epigraphic support described in Fig. 8.

[12] http://owl.man.ac.uk/factplusplus/.

[13] The epigraph is stored inside box 29, located at room XXII of the Castello Ursino Museum, with inventory numbers 892 and 911.

Fig. 9 – The epigraph EpiCUM549.

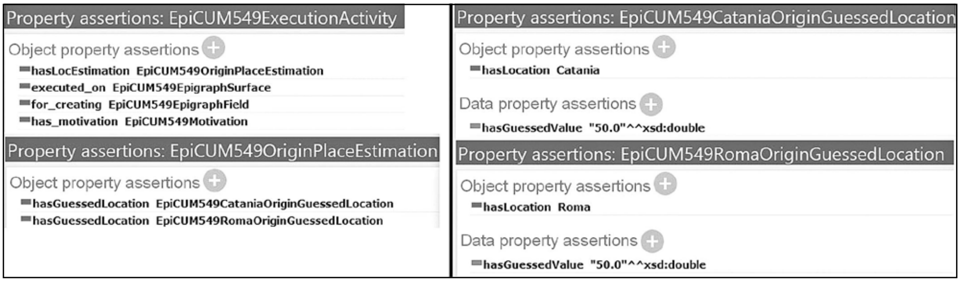

Fig. 10 – Estimation of the origin place of the epigraph EpiCUM549.

As a second example, we consider the epigraph EpiCUM549, reported in Fig. 9. EpiCUM549 consists of a funerary inscription written in ancient Greek, engraved on a marble tablet. The origin of this epigraph is uncertain. Inside the text of the inscription we can grasp the Ephesian origin of the dead person, but death and burial places are not present. The early news about EpiCUM549 are provided by K.O. Müller, who observed the epigraph inside the Benedettini Collection during his travel in Sicily in 1839/40. Georg Kaibel, the most important publisher of the *Inscriptiones Graecae*, included the epigraph in the Collection of the Catania's inscriptions, but considering it of an undefined origin (*incertae originis*); in addition, the absence of the inscription in the code A77 of the Florentine Marucelliana Library[14] makes the Catanese or Roman

[14] The code A77 of the Florentine Marucelliana Library is a fundamental source about the Benedettini Collection.

origin equally probable (Korhonen 2004). Fig. 10 shows how the estimation of the origin place of the epigraph EpiCUM549, which is attributed to Catania or Rome with the same probability, is modelled in the ontology EpiONT.

5. Conclusions

We introduced the semantic web ontology EpiONT for the rich epigraphic heritage of the Castello Ursino Civic Museum of Catania, designed according to the CIDOC CRM standard and using the SKOS vocabularies of the EAGLE project for material, execution technique, type of inscription, and type of support of an epigraph. The EpiONT ontology is currently populated by data of 580 epigraphs collected in the Castello Ursino Civic Museum and models the peculiar characteristics of these epigraphs. It additionally treats the uncertainty in the determination of the origin and discovery place of the epigraphs and it is consistently classified by the most widespread DL reasoners such as Fact++, Hermit, and Pellet.

We plan to semantically refine the modelling of the text of the inscriptions, taking into account its physical, semantic, and syntactical characteristics such as font features, line breaks, names of persons and places mentioned in the text. We intend also to model the rich photographic collections of epigraphs, their metadata information and related bibliographic entries. Moreover, we will integrate the ontology with other well-known foundational ontologies such as Descriptive Ontology for Linguistic and Cognitive Engineering (DOLCE) (Gangemi *et al.* 2002), the Bibliographic Reference Ontology (BiRO) (Di Iorio *et al.* 2014) and the Pleiades RDF Vocabularies[15]. Finally, we will also integrate the EpiONT ontology in the EpiCUM project by implementing a web service allowing users to query and visualize the huge amount of data provided by the ontology.

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[15] http://pleiades.stoa.org/.

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ABSTRACT

The rich epigraphic heritage of the Castello Ursino Civic Museum of Catania has been studied by the EpiCUM project that encoded it in EpiDoc TEI XML, an XML based standard digital representation for cultural heritage contents. The project made the epigraphic heritage available in a digital museum: under the guise of the 'Voci di Pietra' exhibition, a selection of epigraphs were presented, implementing innovative presentation modalities thanks to a smart use of technological and digital means. Information contained in the epigraphs was semantically reorganized in a unique homogeneous container, the EpiONT ontology, constructed according to the Linked Open Data paradigm and to consolidated international standards. The encoding of the ancient texts, by the TEI standard and its EpiDoc subset, is wedded to the paradigmatic semantic web model for museums and cultural heritage. The EpiONT ontology is currently populated by 580 epigraphs collected in the Castello Ursino Civic Museum. Designed according to the CIDOC CRM standard, it makes use of the SKOS vocabularies of the EAGLE project concerning material, execution technique, type of inscription, and type of support of an epigraph. The EpiONT ontology additionally can handle any uncertainty in the origin and place of discovery of the epigraphs.