Semantics-based models for the representation of claims about cultural artifacts and their sources

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Abstract. Uncertainty and ambiguity are two inherent properties of historical and archaeological data. It is very often that different researchers express conflicting opinions about an artifact's chronology, creation, origin, style or identification. Ontology-based models, such as CIDOC-CRM, are already widely used for the representation of cultural artifacts, offering significant benefits, such as formality, flexibility and extensibility. They were, though, specifically designed to represent factual cultural data, and not claims or conflicting opinions expressed about cultural artifacts. In this paper, we examine how such models may be extended to integrate information about the sources of cultural information (e.g. bibliographic data) enabling users to assess the validity of this information. We also propose an alternative approach based on a more expressive language, N3 Logic. Finally, we discuss argumentation theory as a tool for the natural representation of claims about cultural artifacts and the arguments they are associated with.

1. Introduction

The disciplines of both archaeology and history have long used scientific methods, such as *comparison*, *hypothesis* and *classification*, in order to explain historical phenomena. And indeed, the explanation of such phenomena, as well as of any others in the world of our experience, is, according to Hempel and Oppenheim, "one of the foremost objectives of all rational inquiry and especially scientific research" [16]. But outside the realm of research and in the field of knowledge representation, information is often presented as a sum of facts, conclusions or results that the user is forced to accept as true rather than to inquiry or even doubt about. In this sense for instance, instead of answering the question "why" an artifact is said to be of a particular type or style by providing certain evidence, systems present information that is restricted to answer the question "what" has been said about this artifact: in this case that it is of a particular type or style.

In view of the need for more expressive and explanatory forms of information presentation, capable of making available, apart from metadata related to a specific artifact in the form of mere statements, also the resources that assert or justify them, the current paper proposes the use of bibliographic data (such as books) as clues for supporting information regarding an artifact's date, location, style or identification. Following the Hempel-Oppenheim theory, in which explanation is divided into two sections: the *explanans*, namely the statements from which the conclusion (or *explanandum*) can be deduced; and the *explanandum*, which is the logical consequence of the *explanans*, we attempt to explain a "phenomenon", here a specific artifact perceived as a sum of cultural and historical features, by means of an *explanandum*, a conclusion in the form of a statement, and an *explanans*, a premise in the form of a resource (e.g. a book), which is based on a certain claim or argument (i.e a scientific opinion) made about this statement.

We use as an example the case of the sculpture "*Ephebe of Marathon*", a Greek bronze statue, which is conserved in the National Archaeological Museum of Athens, and a statement on the style of the sculpture: "*Ephebe of Marathon follows the Praxitelian style*" (the *explanandum*). This statement is derived from Kaltsas' book (the *explanans*) entitled "The National Archaeological Museum" where he claims: "The Praxitelian style is manifest in this artwork, that is why is regarded by many researchers as the work of the school of one of the most renown Greek artists of the 4th century BC, Praxiteles (around 340-330 BC)" [17]. We argue that this type of information management, which employs bibliographic resources as data sources referring to cultural metadata, allows the user to assert the provenance and validity of the information provided as well as it enables the development of a whole new network of associations between cultural artifacts; in this case between the *Ephebe of Marathon* and other "praxitelian" artworks, such as the *Hermes of Praxiteles*, a statue also verified as "praxitelian" by the Greek geographer and traveler Pausanias, in his work entitled "Description of Greece" (5:17:3)[1].

Considering the significance of making such information accessible and retrievable for a researcher, a student or even for a common user, the present paper intends to discuss and propose potential solutions for the challenges encountered in the process of representing claims about statements by linking these different types of data: cultural and bibliographic. First, we analyze the capabilities and limitations of CIDOC-CRM [12], an ontology written in RDF that has been established as standard for the representation of cultural information, and propose minimal extensions that enable linking statements about cultural objects with the relevant bibliographic information (e.g. the bibliographic resource, and its author(s)). Second, we present a logic-based approach that enables a more natural integration of different types of information and overcomes expressive limitations of RDF. And third, we discuss how AI tools, such as argumentation theory, may additionally enable the representation of claims made about cultural objects and the arguments that led to those claims.

The remainder of the paper is structured as follows: Section 2 presents background information on semantics-based representation models for cultural and bibliographic information. Section 3 describes potential semantics-based solutions for the problem of integrating these two types of information. Section 4 discusses the potential use of argumentation theory as a tool for the representation of claims about cultural artifacts and the reasoning behind the claims, and Section 5 concludes.

[1] http://www.perseus.tufts.edu/hopper/text?doc=Perseus:abo:tlg,0525,001:5:17:3

2. Background

The vast growth in the volume of digitized cultural data along with the current need of cultural heritage institutions, such as museums, libraries and archives, to interlink their datasets in large scale has raised the demand for more complex forms of data representation. In this process, pivotal is the role of semantic technologies, such as ontologies, as the examples of the Amsterdam Museum[2] and the *Europeana*[3] portal clearly manifest. Following these developments, the semantic models used for encoding cultural data, whether they are museum, bibliographic or archival, have been designed to correspond to this new need for mergence. Regarding museum information, CIDOC-CRM (Conceptual Reference Model) is one representative example of how such a model can map and integrate data coming from different sources in a global, extensive, and machine-readable way using the RDF semantics. Its event centric mechanism that employs a broad vocabulary (presently counting 86 classes and 137 unique properties) enables the inter-relation between people, things, places and time-spans through common events. On the other hand, the shift of attention in data integration has enforced the creation of more hybrid data models. One characteristic example of the new data representation strategies that are being currently yielded is FRBRoo[4], an entity relationship model comprised of four main entities: "work", "expression", "manifestation", and "item" according to the IFLA FRBR standards which aims to serve as an integrated ontology for both museum and bibliographic data by combining FRBR and CIDOC CRM classes and properties.

The idea of linking cultural and bibliographic data, as expressed in FRBRoo, has been the result of the huge discussion, initiated recently, on the potential of modeling not only the metadata about a cultural artifact in the form of concrete statements but also the resources (i.e bibliographic) that verify them, as it has also been envisioned by Le Boeuf [9]. In fact, the ability to assert and assess the provenance of cultural metadata is closely related to the interdisciplinary nature of humanistic research itself, at the core of which stands the process of comparing, referring and verifying the assembled information resources [3].

3. Problem Analysis

In the context of investigating and experimenting with more complex forms of data documentation able to commonly conceptualize both cultural and bibliographic information, the present analysis brings for discussion an issue that requires further research. This refers to the process of modeling claims concerning statements about artifacts, as they appear in bibliographic resources. In this sense, main objective of the current study is to semantically represent the integration of cultural and bibliographic information, such as Kaltsas' opinion about the *Ephebe of Marathon*, which is recorded in his book "The National Archaeological Museum" and allows the

[2] http://semanticweb.cs.vu.nl/lod/am/
[3] http://www.europeana.eu/portal/
[4] http://www.cidoc-crm.org/docs/frbr_oo/frbr_docs/FRBRoo_V1.0.2.pdf

connection with the *Hermes of Praxiteles* in terms of style according to Pausanias' claim in his "Description of Greece" (5:17:3).

3. 1 Modeling claims in CIDOC CRM: barriers and limitations

Semantic models for cultural heritage, such as CIDOC CRM, aim to conceptualize and map data as concrete statements in the form of "*Ephebe of Marathon* has praxitelian style" rather than as statements that result from certain claims, such as "The National Archaeological Museum states that *Ephebe of Marathon* has praxitelian style". In RDF terms, the last part of this sentence (i.e *Ephebe of Marathon* has praxitelian style) is not a mere class but a whole new triple. In order to represent the source of the above claim too, that is the bibliographic resource, the whole sentence in RDF would be formed as follows:

[*Ephebe of Marathon* has praxitelian style] (Subject)
[is referred to by] (Predicate) (1)
["The National Archaeological Museum"] (Object).

Using terms of the CIDOC CRM vocabulary, the *subject* of the above statement would be a RDF triple consisting of an instance of the *E24 Physical Man-Made Thing* class (*Ephebe of Marathon*) as the subject, an instance of the *E55 Type* class (*Praxitelian style*) as the object, and the *P2 has type* property. The P67 *is referred to by* property and an instance of the *E22 Man-Made Object* class ("The National Archaeological Museum") would then be the *predicate* and *object* of statement (1), respectively. Information about the author of the book could be provided through the path: "The National Archaeological Museum" (*E22*), *P108B was produced by*, an appropriate instance of the *E12 Production* class, *P14 was curried out by,* "Nikolaos Kaltsas" (instance of *E39* Actor). The *P14.1 in the role of* property and an instance of *E55 Type* class (*author*) are further used to specify Nikolaos Kaltsas' role as the author of this production (Figure 1).

Hence, in this case, the carrier of the particular claim (Nikolaos Kaltsas) is not represented directly as the *object* of statement (1), but indirectly as the creator of its bibliographic source due to a limitation of the underlying model: by linking the claim directly to its carrier, and the carrier to the source of the claim, we would miss the connection between the claim and its source, as more than one *productions* (e.g. books) may have been carried out by the same *actor* (e.g. author).

3.2 RDF reification: challenges and barriers

One way of solving this problem is to employ a mechanism which is enabled by the RDF language and is based on the use of rdf:statement, called "reification". rdf:statement is the class of RDF statements, and the domain of three properties: rdf:subject, rdf:predicate and rdf:object, which associate a statement to its parts. Here, we could define the subject of statement (1) as an instance of rdf:statement, and use these three properties to link this statement with its subject (*Ephebe of*

Marathon), its predicate (*P2 has type*), and its object (*Praxitelian style*). Reified statements are not currently supported by CIDOC CRM. They are, though, part of the standard RDF semantics. Subsequently, P67 *is referred to by* property may be used to connect the subject of statement (1) with the "The National Archaeological Museum".

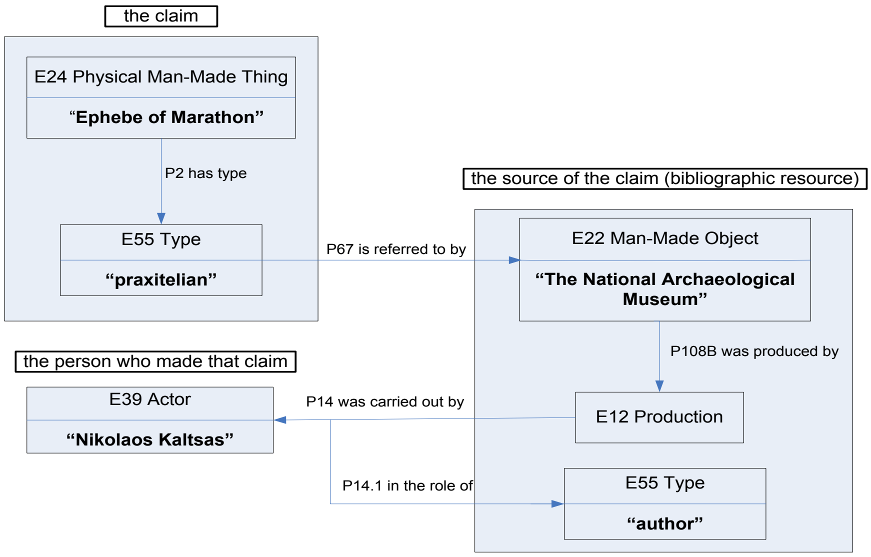

Figure 1: Representation of Kaltsas' claim and its bibliographic resource in CIDOC CRM.

On the other hand, setting an rdf:statement as the domain of a property, here *P67,* would actually mean diminishing the ability of CRM for self-containment, since such a class is not a component of the CIDOC semantics. From this aspect, only a CIDOC CRM statement (a crm:statement) could conform with CRM standards, which due to a current lack of specification in CIDOC CRM needs to be appropriately defined. Similarly to the properties attached to rdf:statement (rdf:subject, rdf:predicate, rdf:object), we define crm:statement as the class of all statements containing terms from CIDOC CRM. crm:statement is the domain of three properties: crm:subject, crm:predicate and crm:object. The range of crm:subject and crm:object is *E1 CRM Entity*, since *E1* is the top entity of the entire conceptual model, and therefore can be related to any class - given that all the classes are its subclasses. crm:predicate is then used to refer to any possible relation between instances of *E1* – in other words to any relation between the subject and the object of a crm:statement. This type of property serves as the superproperty of all properties of CIDOC-CRM and hence allows the linkage between any two of its classes. According to CRM rules and naming conventions, in which each property is represented by character "P" and a number (property id), as well as a name, we name this property as *P0 CRM Property*. The domain and range of *P0* is *E1 CRM Entity*. This enables *P0* to link any individuals of the CRM model. We also define *P0* as the range of crm:predicate in order to represent any relation that may connect any two individuals in a CIDOC CRM statement (crm:statement). Figure 2 shows how a crm:statement, as specified above, may be used to represent our example.

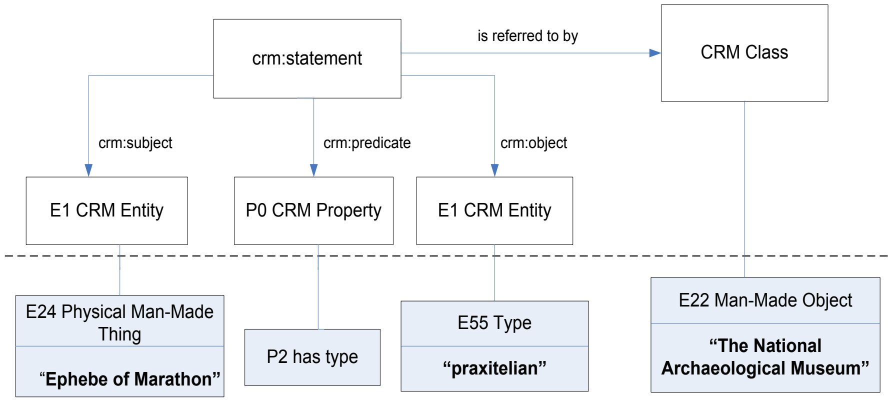

Figure 2: crm:statement, its properties and instances describing the running example.

The ability of *P0* to link any class of the CRM model and hence express a huge volume of relationships is actually enabled by the specification of *E1 CRM Entity* as its range and domain. Aside the property id, name, range and domain, other issues, such as quantification and scope note, need also to be considered. Quantification refers to the so called "property quantifiers", a term used for the "declaration of the allowed number of instances of a certain property that can refer to a particular instance of the range class or the domain class of that property" [12]. In this case, the quantification is unconstrained. This practically means that *E1 CRM Entity*, which is the range and domain class of *P0 CRM Property*, may have zero, one or more instances of *P0* (many to many (0,n:0,n)). Scope note, on the other hand, is the textual description of the meaning of the class or property. In this sense, *P0 CRM Property* can be described as the property that can take the meaning of any property in CIDOC CRM. Figure 3 depicts all these specifications along with an example, which is based on our running example. In this case, P0 CRM Property is superclass of the *P2 has type* property, which links *E24* to *E55*.

P0 CRM Property
Domain: E1 CRM Entity
Range: E1 CRM Entity
Quantification: many to one (0,n:0,n)
Scope note: This property can take the form of any property in CIDOC CRM
Example: *Ephebe of Marathon* (instance of *E24*) *has type (P2 sub property of CRM Property P0) Praxitelian style* (instance of *E55*)

Figure 3: P0 CRM Property specification

Notwithstanding its apparent advantages, reification is a mechanism that has been heavily criticized by the semantic community, among others also by Tim Berners-Lee [5], who claims that "the form of reification which is provided by the original RDF specification is not suitable". McDermott and Dou, in particular, argue that the creation of additional triples as a means of expressing statements results in a blow up of size due the increased number of the triples used [19]. The major issue, however, is that "reification triple is unrelated to the reified triple in the knowledge base" [23], since "if we choose to assert each triple as well as its reification, then it is asserted unconditionally" [21]. Consequently, "RDF reification does not assert the original triple", which means that the CIDOC-CRM triple comprised of an instance of class *E24*, the *P2 has type* property and an instance of class *E55* cannot actually relate to the above reified triple (crm:statement). As a result, such a statement is "rather cumbersome to query with SPARQL language" [15].

All these reasons explain why reification has been confronted with so much skepticism. Yet, it is also worth mentioning that it does provide a solution to the inability of RDF triples to express more complex datasets without requiring any further changes in the semantic structure of CIDOC-CRM, since reification is the only tool for modeling statements within RDF, the semantic language upon which CIDOC-CRM is based. However, the problematic nature of reification itself forces us to seek alternative ways of solving the present problem.

3.3 A rule-based approach: the use of N3 formulae

In view of the above need, the current study proposes the use of rules and rule-based reasoning. Rules are, according to [2], a key for the realization of more advanced reasoning capabilities for web applications. Furthermore, the implementation of logic and rules facilitates data integration, which is important when dealing with heterogeneous data, like in this case, since it allows us to make inferences which, in turn, enable data translations. Since RDF structure does not include rules a rule language could be used as its extension. One candidate "rule language" is N3 Logic, which aims to make a minimal extension to the RDF data model so that the same language could be used for logic and data" [6]. Given that CIDOC CRM is structured according to the RDF semantics, this solution could serve the purposes of the current study.

With respect to the current problem, N3Logic could provide the means of addressing statements by extending RDF triples with features, such as quoted formulae. According to the N3 syntax, a formula allows statements to be made about, and to query, other statements by grouping triples to sets, a process that is often referred to as "quoting" [7]. "Quoted formulae allow N3 formulae to be quoted within N3 formulae" using braces "{…}" [6]. It is due to "quoting" that it is possible to check the provenance of information, namely to distinguish who states (or believes) what. Another advantage of using quoted N3 formulae is that statements about other statements can be described within the same formula. This is, in fact, what differentiates a quoted formula from an RDF triple, since in the RDF language the ability to address a statement to another statement requires the addition of another triple (reified triple) along with the original one, as already discussed above.

In the context of the present analysis, we use N3 formulae to represent Kaltsas' and Pausanias' beliefs, as they are expressed in their books, and allow the stylistic connection between the two artifacts (*Hermes of Praxiteles* and *Ephebe of Marathon*). In this sense, "Description of Greece states" is a phrase that indicates the source of information, while the N3 formula "{mit: Hermes of Praxiteles has type style:praxitelian}." represents the information itself. The variable "style" is also added to form the statement. Ultimately, the whole formula can be read as: "Description of Greece states that *Hermes of Praxiteles* has praxitelian style". Similarly, information about the *Ephebe of Marathon* can be represented in an N3 formula where the phrase "The National Archaeological Museum states" indicates who has made the statement, whereas the formula {mit: *Ephebe of Marathon* has type style: praxitelian} expresses the content of the statement itself. Thus, one can read "The National Archaeological Museum states that the *Ephebe of Marathon* has praxitelian style". Hence, from these two N3 formulae one concludes, that both the *"Hermes of Praxiteles"* and the *"Ephebe of Marathon"* have praxitelian style, which should be considered to be true. In order to indicate the source of Kaltsas' claim which is a bibliographic resource (a book), we can use the following N3 formulae:

The National Archaeological Museum states {mit: *Ephebe of Marathon* has type style: praxitelian}. (2)
{The National Archaeological Museum is type: book}.
{Kaltsas is type: author of The National Archaeological Museum}.

The same applies regarding Pausanias' claim, as it is recorded in his book. In particular, the N3 formula "{"The National Archaeological Museum" is type: book}." represents the information that "*The National Archaeological Museum* is a book", whereas the N3 formula"{Kaltsas is type: author of "The National Archaeological Museum"}." represents the information about the role of Kaltsas as the author of the book "The National Archaeological Museum". In the first formula, the use of the keyword "is" and the variable "type" is appropriate, while in the second one the addition of the keyword "of" is used to link the author Kaltsas to the book "The National Archaeological Museum".

Hence, the ability to "quote" claims, provided here by N3Logic, can be a very expressive tool for addressing statements made about other statements which in the current study enables the interwieving of arguments (i.e "*Ephebe of Marathon* has praxitelian style" and "*Hermes of Praxiteles* has praxitelian style") whose origin can be known (Kaltsas – Pausanias) and assessable ("The National Archaeological Museum" -"Description of Greece" (5:17:3)). Furthermore, as Berners- Lee argues in [6], it "allows rules to integrate smoothly with RDF", making N3 an important candidate in the course of extending RDF. In addition, the combination of ontologies, such as RDF, with rules, such as N3 rule language, as it was attempted here, is a practice that conforms to current W3C standards [14]. Nevertheless, it is a nontrivial issue, since different structures make the overcoming of the impedance mismatch quite hard [8]. At this stage, the present research concentrates more on investigating N3 ability to address statements made about statements as alternative to RDF reification and less on the handling of these obstacles. Concluding, notwithstanding

N3 successful way of solving the current problem through "quoting", its rather simple "vocabulary" leaves the question of whether it is able to describe the complex structure of arguments and their sources open for further consideration.

4. Open Issues and Future Directions

Linking statements about cultural objects to the people who made them, or to the bibliographic resources that these statements are derived from, and making this information publicly available, is only the first step towards explaining why these statements were made, and helping people to assess their validity. For example, a claim made in a scientific journal by an expert is always considered more valid than one made by a journalist in a local newspaper. However, even experts may sometimes disagree and express conflicting claims about a cultural object.

Such is the case of our current example and the contradictory theories that have been built around the question whether *Hermes of Praxiteles* is actually an original artwork of the Greek artist Praxiteles or a roman copy. In the context of this discussion, Oscar Antonsson claims that it is Praxiteles' original artwork, yet it has endured some substantial alterations implemented by a roman sculptor later on. According to this theory, the original artwork initially represented Panas and not Hermes due to the existence of some marks at the back of the statue that signify the existence of some kind of cloth, probably of animal skin, pointing to Panas. On the other hand, the archaeologist Dora Katsonopoulou, in one of her articles about *Hermes of Praxiteles*, criticizes Antonsson's theory arguing that though attractive, his argument about Panas is rather weak, since the cloth could be used for Hermes. Her counter-argument is based on the tradition according to which it was Hermes and not Panas that carried his brother Dionysos to the Nymphs, as depicted in the complex.

For cases like this, the provenance of the claims may not be sufficient to assess their validity. One may also need to examine and analyze the reasoning that led to these claims, and apply certain criteria to resolve any potential conflicts. Below, we discuss these issues in more detail and propose potential solutions from the field of Artificial Intelligence.

4.1 Exposing the reasoning behind claims

As we already argued in the introduction, ontology-based models, such as CIDOC-CRM aim at answering questions about cultural objects of the form: "*What is known about a certain object?*" or "*What has been said and written about a certain object?*". On the other hand, the extensions that we propose in section 3 give answers for questions of the form: "*Who made a certain claim about a certain object?*". As we argue above, one may also want answers to the question: "*How was a certain claim made?*" or, in other words, "*what is the reasoning behind a certain claim?*" in order to be able to assess its validity. Let's take for example Antonsson's claim that *Hermes of Praxiteles* initially represented Panas and not Hermes. Assessing this claim may be based on assessing Antonsson's expertise as an art historian, but also on evaluating the argument that led to the particular claim: that there are marks that signify the existence of some cloth from animal skin, which point to Panas. We, therefore, need a way to represent this argument and link it to the claim that is supports.

Argumentation theory is a tool from Artificial Intelligence, which studies the formation of arguments for or against a certain claim, as well as the relations between these arguments. For example, Dung's abstract argumentation framework [13] is a tuple $<A,\rightarrow>$, where A is a finite set of *arguments* and $\rightarrow$ is a binary *attack* relation on $A\times A$. Other frameworks, such as the bipolar AFs [11] also define a *support* relation among arguments. Using such frameworks, we will be able to represent not just the final claim, but also the reasoning behind or against the claim, by defining the arguments that support or respectively oppose the claim. In our example, Antonsson's argument (A), and Katsonopoulou's counter-argument (K), according to which the cloth could be used for Hermes, since the tradition recognizes him as the person who carried Dionysos to the Nymphs, may be graphically represented as shown in Figure 4, where the arrow denotes an attack from B to A.

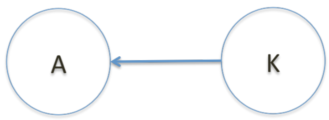

Figure 4: Antonsson's and Katsonopoulou's arguments in Dung's framework.

4.2 Resolving potential conflicts

When all the available arguments for or against claim are made available, one may be able to judge which if these arguments are valid, and reach a conclusion about the validity of the final claim. However, in more complex cases, where the number of arguments is big, and the arguments are interrelated in many different ways, it may not be straightforward to reach a conclusion just by looking at the available arguments. In such cases, users may want the system to be able to draw these conclusions on their behalf, possibly using their feedback.

Argumentation Frameworks may offer solutions to this problem too. AFs are not just representation models. They also define acceptability semantics, namely the set of arguments that are accepted as valid, given the overall set of arguments and their relations. For example, in Dung's AF, roughly an argument is accepted if all the arguments attacking it are rejected; and it is rejected if it has at least an argument attacking it which is accepted. The set of accepted arguments in this framework is a set of arguments that does not contain any argument attacking another argument in the set. In our example, according to Dung's acceptability semantics, argument K (Katsonopoulou's argument) will be labeled as accepted, since it is not attacked by any other argument, and argument A (Antonsson's argument) will be rejected, since it is attacked by an accepted argument (A). Preference-based argumentation frameworks, e.g. those described in [1,4,20] extend Dung's framework with preference criteria, e.g. related to the structure of arguments or to their provenance, or even user-defined criteria, to determine whether an attack is successful or not, i.e. whether it is sufficient to invalidate the argument under attack. In our example, preference criteria that can be used to determine whether K *successfully* attacks A, may include the expertise of the people who made the arguments (Antonsson, Katsonopoulou), their gender, nationality and education [22], since, for instance, nationality may affect the impartiality of an argument. Other parameters concern the chronology of the arguments (e.g. recent arguments may be considered *stronger* than older ones as they are based on new evidence) and the validity of the evidence that supports each argument. It is among our future plans to define a general set of preference criteria that may be applied for the comparison of arguments about cultural artifacts.

4.3 Linking statements, arguments and decisions

Applying argumentation theory enables formally representing arguments for or against certain claims, and evaluating the acceptable arguments by applying user-defined preference criteria. A further issue, which naturally arises, is how to represent these different types of information (statement, bibliographic references, arguments) in a common model, which is readable by human users, but may also be processed by machines. A common representation model will facilitate the management and processing of the available data. It will also enable creating views that cover all different aspects of cultural information.

The SIOC Argumentation Vocabulary [18] will enable us to create the link between all available information elements: the statements about the cultural objects, the bibliographic references that these statements are derived by, the arguments that are made for or against certain claims, and the set of acceptable arguments. The vocabulary includes concepts for the representation of statements, arguments about statements, support and attack relations between arguments (these are available in the extension proposed in [10]) and decisions on the acceptable arguments. By applying appropriate SPARQL queries, one may then retrieve more precise information about certain statements and arguments, or aggregate information e.g. about the set of statements that are evaluated as valid.

5. Conclusion

The semantic representation of claims regarding cultural metadata (i.e an artifact's style) along with their origin (i.e the person who made them) and their source (i.e their bibliographic expression), as it was attempted in this paper, is a step towards the realization of more sophisticated user queries in systems of higher intelligence able to process and further assess the provenance and validity of the arguments and the supporting evidences (i.e historical, philological or archaeological) upon which these claims are structured, prioritizing certain ones against others. Modeling arguments in the field of historical and archaeological research by employing Argumentation Frameworks, such as Dung's AF, and argumentation vocabularies, such as SIOC, is a challenging task that entails many difficulties due to the diverse nature of cultural data (e.g vagueness, uncertainty, ambiguity) that these arguments are referring to and the present study intends to investigate in the future.

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