Citations and Annotations in Classics: Old Problems and New Perspectives

Matteo Romanello
King's College London
Department of Digital Humanities
26-29 Drury Lane
London WC2B 5RL
matteo.romanello@kcl.ac.uk

Michele Pasin
Nature Publishing Group
The Macmillan Building
4 Crinan Street
London, N1 9XW, UK
michele.pasin@nature.com

ABSTRACT

Annotations played a major role in Classics since the very beginning of the discipline. Some of the first attested examples of philological work, the so-called *scholia*, were in fact marginalia, namely comments written at the margins of a text. Over the centuries this kind of scholarship evolved until it became a genre on its own, the classical commentary, thus moving away from the text with the result that philologists had to devise a solution to *linking* together the *commented* and the *commenting* text. The solution to this problem is the system of canonical citations, a special kind of bibliographic references that are at the same time very precise and highly interoperable.

In this paper we present HuCit, an ontology that models in depth the semantics of canonical citations. We discuss how it can be used to a) support the automatic extraction of canonical citations from texts and b) to publish them in machine-readable format on the Semantic Web. Finally, we describe how HuCit's machine-generated citation data can also be expressed as annotations by using the Open Annotation Collaboration (OAC) ontology, to the aim of increasing reuse and semantic interoperability.

Categories and Subject Descriptors

I.2.4 [**Artificial Intelligence**]: Knowledge Representation Formalisms and Methods—*ontologies*

General Terms

Standardization

Keywords

HuCit, Classics, primary sources, citations, ontological modeling

DH-case '13 September 10 2013, Florence, Italy
Copyright is held by the owner/author(s). Publication rights licensed to ACM. ACM 978-1-4503-2199-0/13/09 ...$15.00
http://dx.doi.org/10.1145/2517978.2517981.

1. INTRODUCTION

Classics as a discipline has always been heavily concerned with annotations since its very beginnings. Some of the first attested examples of philological work, the so-called *scholia*, were in fact marginalia, namely comments written at the margins of a text [8]. Over the centuries this kind of scholarship evolved until it became a genre on its own, the *classical commentary*, thus moving away from the text with the result that philologists had to devise a solution to linking together the [1, 4].

To solve this problem scholars in Classics have devised–well before the advent of digital technologies–a specific kind of references that are called *canonical citations*. Such a solution had to be at the same time precise and interoperable: *precise* because texts are the fundamental object of philological research, therefore a scholarly discourse about texts needs a very accurate and unambiguous way of referring to them; *interoperable* because although texts may exist in different editions and translations, scholars need to be able to refer to specific sections of them without having to worry about the many possible variations in pagination or layout each single edition may present. Some examples of canonical citations are "Aristot. *Poet.* 1451a.35", "Hom. *Il.* I 1-10" and "Thuc. I 33.1" that refer to specific sections respectively of Aristotle's *Poetics*, Homer's *Iliad* and Thucydides' *Histories*.

Although some ontologies that include the notion of citation already exist, none of them is really suitable to model the specificities of citations in Classics. To fill this gap we developed HuCit, an ontology that aims at representing in greater detail the semantics of canonical citations.

The starting point for our work was trying to answer questions such as "what is the denotation of a canonical citation?", "how is a canonical citation different from a normal citation?". These are important issues to solve when trying to construct a computational framework that permits to extract, store and interrogate the network of canonical citations that are commonly used in the classics literature. Accordingly, HuCit was developed with a two-fold goal in mind: on the one hand, to support the automatic extraction of canonical citations from texts and specifically by providing a source of domain knowledge that can be used to validate and disambiguate canonical citations; on the other hand, to publish the so extracted citations in a machine-readable format that is also compliant with the Semantic Web and Linked Open Data (LOD) philosophy [5].

This paper is structured as follows: in section 3 some examples of canonical citations are described in greater detail in order to highlight what are their specificities and to explain how they function. The ontology itself is introduced in section 4 where the main choices in terms of design are discussed in light of its intended use. In section 5 we provide a practical example of how a Knowledge Base built upon HuCit can be used to support the automatic extraction of canonical citations. Finally we illustrate how HuCit in combination with the Open Annotation Collaboration (OAC) ontology can be used to store and publish as LOD the citation network which starts to emerge once citations between primary and secondary sources are captured.

2. RELATED WORK

2.1 Citations and Annotations in Digital Classics

In carrying out this work we did not start from scratch but we built upon the results of research that was carried out over the last decade within the Digital Classics community with the goal of replicating the system of canonical citations in a digital, networked environment.

A first strand of research in this area, characterised by a stronger focus on how to transform canonical citations into a machine-actionable links on the Web, has produced two different solutions: CWKB OpenURL format [1] and the Canonical Text Services (CTS) protocol[2] [14]. The two solutions are very similar to each other as the problem they try to tackle is essentially the same, but at the same time they shed light on it from two different perspectives: a more librarian perspective in the case of the former and a perspective that is closer to the field of digitial scholarly editing in the case of the latter.

CTS is a network protocol designed to provide access to texts in a way that is conceptually identical to how scholars have been working with such texts for centuries. In the case of canonical texts this means replicating in a digital environment what canonical citations have allowed scholars to do already in a print-based endeavour, that is essentially to create references to texts that are fine-grained and at the same time independent from any specific version of a text (see section 3).

The current implementation of CTS provides a RESTful API to refer and to provide access to any repository of texts that are encoded following the Text Encoding Initiative guidelines, with the only pre-condition that such texts should be citable by using a logical, rather than physical, hierarchical division of the text. The Perseus Digital Library is to date the biggest repository of texts that can be accessed by using this protocol, although its CTS interface is still under development and has a few limitations[3].

There are two aspects of the design of CTS that HuCit tries to overcome. Firstly, CTS defines a syntax for persistent identifiers that can be used to refer to portions of canonical texts: they are called CTS URNs as they use the Uniform Resource Name (URN) notation. The semantics of such identifiers is clearly defined by the protocol but not in a machine-readable way, whereas in HuCit we define what is the ontological status of an object that can be identified by means of a CTS URN. Defining explicitly in a machine-readable fashion the meaning of such identifiers is very important, from an interoperability perspective, when publishing data on the web. Secondly, HuCit provides a means to capture and store information that is normally contained in any CTS repository but it makes it possible to use it independently from the repository from which it was originally acquired, that is useful for instance when the repository is no longer available or accessible. For example, by using the CTS protocol the only way to get topological information about a given text passage—such as its following and preceding passages—is to use the method `GetPrevNextUrn` of an existing repository by providing a CTS URN as one of the query parameters. This information can be stored by using HuCit and re-used later on for example to provide reasoning functionalities within an application.

Another related area of research is concerned with the problem of how to capture automatically such citations from unstructured texts. Gregory Crane argued that services which perform this task with a high degree of accuracy are an essential part of a cyberinfratructure for research in Classics. From a technical point of view, he suggested that the extraction of citations from texts can be seen as a discipline-specific task of Named Entity Recognition and, more generally, Information Extraction. Along the same line of thought, some recent studies have laid the foundations of such a service by showing how a machine learning based-system that can be trained to extract citations from multilingual corpora [11, 9].

The Pelagios project[4] is a compelling example of how OAC has been used in the field of Digital Classics. The goal of Pelagios was to create a network of linked resources related to ancient geographical places in order to enable new modes of discovery and visualisation of geodata [13]. Its approach to the problem is simple yet very powerful and can be summarised in the following basic tenets: 1) resources that make some assertion about the same place of the ancient world are linked to each other and such assertions are treated as OAC annotations; 2) the vocabulary to describe places is drawn from Pleiades, a community-built gazetteer of ancient places[5], and uses URIs to identify places.

2.2 Citations in Formal Ontology

In general, we can identify two main approaches to modeling bibliographic citations. The first one stresses the performative aspect of a citation, that is, it considers it as the *act* of linking two documents by means of a scholarly relationship. The second one instead focuses more on the *textual* dimension of a citation, namely, it considers it as a series of symbols that can be interpreted as a pointer to another bibliographical entity. It is important to underline that the two approaches are not antithetical, in fact both often coexist within a single data model or ontology. However this duality can generate some terminological ambiguity since people may refer to one or the other aspect using the same terms, which most often are *citation* and *reference*. We will look at both approaches in turns.

Citations as performative entities can be encoded simply as a relation between two bibliographical objects, or indirectly via a reified entity that represents the ‘reference

[1] http://cwkb.org/matrix/20100922/

[2] http://www.homermultitext.org/hmt-doc/

[3] http://sites.tufts.edu/perseusupdates/beta-features/perseus-cts-api/

[4] http://pelagios-project.blogspot.com/

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

event' - the act of referencing another object. We found no evidence of the latter strategy, on the contrary there are many instances of the former one. For example the BIBO ontology uses the `bibo:cites` object property that relates "a document to another document that is cited by the first document as reference, comment, review, quotation or for another purpose"[6]. In AKT the `akt:cites-publication-reference` is used very similarly[7]. More interestingly, ontologies like SWAN [2] and CiTO [12][8] go one step further in this direction by providing an explicit categorization of the types of rhetotical actions the citing relationship could mean. So for example by using CiTO one can specify whether a citation `cito:cites-as-evidence` or `cito:critiques` another object, thus allowing the creation of networks of scholarly bibliographical relationships that are semantically very rich. The main limitation of these approaches, however, is that since the ontological commitment of these citation relations rely almost entirely on their scope notes (no formal semantics is provided) it is very hard to achieve consensus with regards to the meaning of these relationships (as different people may mean different things by using the same relationship term).

Let us now consider the second approach to modeling citations. Here the focus is on the specific form a citation takes in the main body of a paper or within the references section (for this reason, it is often called `reference`). In other words, the accent here is posed on the symbolic level of a citation: what text it contains, how it is structured or how it is ordered. A citation object, thus intended, plays the same role of an address: it gives you useful information for finding an article. So for example in BiRO [9] a `biro:BibliographicReference` is seen as a textual component, which is normally part of a `biro:ReferenceList`. A similar approach is taken in DoCO[10] and DEO[11] where a `doco:BibliographicReferenceList` is said to contain one or more `deo:BibliographicReference`. Arguably the most comprehensive formalization of this idea is the one provided by Gruber in his Bibliographic-Data ontology [12], which predates the era of Linked Data (in fact it was not implemented using any of the RDF family of languages) but contains a number of useful insights. In particular, Gruber elucidates the terminological ambiguity between `citation` and `reference` by observing that a "reference is distinguished from a citation, which occurs in the body of a document and points to a reference" and that a "bibliographic reference is a description of some publication that uniquely identifies it, providing the information needed to retrieve the associated document". Based on these central ideas he provides a detailed characterization of subclasses of `Publication-Reference`, such as development of reference-formatting styles that are independent of database or tool, and to support remote services such as bibliography database search and reference-list generation". In our own work we share much of Gruber's approach, especially the conceptual and terminological distinction between a reference - the text appearing in the references section of a document - and a citation - the text appearing in the body of the document. Canonical citations, as we will see, are a special case of citations for they also normally appear within the main body of a document.

3. DOMAIN ANALYSIS

First off, we should say that the use of canonical citations in order to refer to primary sources is part of the training of any classicist. Therefore, a knowledge base built to support the automatic extraction of such citations from texts has to contain a number of notions that are normally acquired by classicists during their training phase.

A distinguishing feature of canonical citations is that they are valid no matter what specific edition one uses to look them up. For example, the citation "Hom. *Il.* I 1-10", which identifies the first ten lines of the first book of Homer's *Iliad*, can be looked up in the Italian translation by Monti as well as in the critical edition by M.L. West published in two volumes between 1998 and 2000. However, not all citations in classics are canonical. The way of citing fragmentary texts [10], for example, is not canonical since any citation refers to a specific (critical) edition of the text and there is no way to cite a fragmentary text without referring to a specific edition.

In general, canonical citations are possible because they refer to a standardized version of a classical text, which is then referenced to by any other subsequent edition. What is *canonical* about such kind of citations is the abstract text structure they refer to, which is often reducible to the physical characteristics of a specific edition (e.g. division into books, chapters, pages etc.). In this sense *canonical* means agreed upon by classicists over centuries and established through practice.

If we look at the historical evolution of this system, we can highlight two possible cases that led to the selection of a canonical text structure: 1) the text structure is the one originally given to a work by its author: this is the case of most of the poetic compositions with the exception of those originating from an oral tradition, as it might have happened with the Homeric poems; 2) the standard, canonical structure was imposed onto the text later on as an attempt to standardize and make more precise–that is fine-grained–the way of referring to the text. For example when referring to Aristotle's works we usually refer to a structure, the so-called Bekker numbers, that became canonical after Bekker's XIX century edition of the *Corpus Aristotelicum.*

It is worth pointing out though that the picture just delineated is not always so clearcut, and there are a number of hybrid situations. An interesting case, for example, is the way of citing the works by Aristotle. Here the canonical way of citing his works, based on the page numbers of the 1831 edition by Immanuel Bekker, often co-exists with a non-canonical one which refers to a division of the text into books, chapters and sentences (fig. 1).

Furthermore, it is common for modern editions of classical texts to refer to a number of overlapping structures of the text. The most simple example is a critical edition of Homer's *Iliad* where one will find at least two co-existing hierarchical structures of the text that can be used to cite

[6] `http://bibliontology.com/`

[7] `http://www.aktors.org/publications/ontology/`

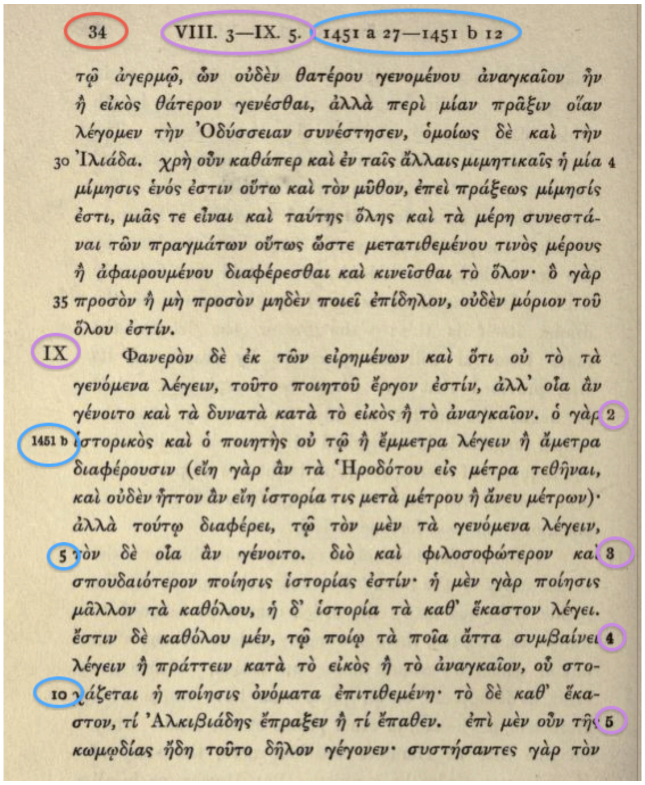
[8] `http://www.essepuntato.it/lode/http:/purl.org/spar/cito`

[9] `http://vocab.ox.ac.uk/biro#term_references`

[10] `http://www.essepuntato.it/lode/http://purl.org/spar/doco#d4e224`

[11] `http://www.essepuntato.it/lode/http://purl.org/spar/deo#d4e131`

[12] `http://www-ksl.stanford.edu/knowledge-sharing/ontologies/html/bibliographic-data/bibliographic-data.lisp.html`



34 VIII. 3—IX. 5. 1451 a 27—1451 b 12

τῷ ἀγερμῷ, ὧν οὐδὲν θατέρου γενομένου ἀναγκαῖον ἦν
ἢ εἰκὸς θάτερον γενέσθαι, ἀλλὰ περὶ μίαν πρᾶξιν οἵαν
λέγομεν τὴν Ὀδύσσειαν συνέστησεν, ὁμοίως δὲ καὶ τὴν
30 Ἰλιάδα. χρὴ οὖν καθάπερ καὶ ἐν ταῖς ἄλλαις μιμητικαῖς ἡ μία 4
μίμησις ἑνός ἐστιν οὕτω καὶ τὸν μῦθον, ἐπεὶ πράξεως μίμησίς
ἐστι, μιᾶς τε εἶναι καὶ ταύτης ὅλης καὶ τὰ μέρη συνεστά-
ναι τῶν πραγμάτων οὕτως ὥστε μετατιθεμένου τινὸς μέρους
ἢ ἀφαιρουμένου διαφέρεσθαι καὶ κινεῖσθαι τὸ ὅλον· ὃ γὰρ
35 προσὸν ἢ μὴ προσὸν μηδὲν ποιεῖ ἐπίδηλον, οὐδὲν μόριον τοῦ
ὅλου ἐστίν.

IX Φανερὸν δὲ ἐκ τῶν εἰρημένων καὶ ὅτι οὐ τὸ τὰ
γενόμενα λέγειν, τοῦτο ποιητοῦ ἔργον ἐστίν, ἀλλ' οἷα ἂν
γένοιτο καὶ τὰ δυνατὰ κατὰ τὸ εἰκὸς ἢ τὸ ἀναγκαῖον. ὁ γὰρ 2
1451 b ἱστορικὸς καὶ ὁ ποιητὴς οὐ τῷ ἢ ἔμμετρα λέγειν ἢ ἄμετρα
διαφέρουσιν (εἴη γὰρ ἂν τὰ Ἡροδότου εἰς μέτρα τεθῆναι,
καὶ οὐδὲν ἧττον ἂν εἴη ἱστορία τις μετὰ μέτρου ἢ ἄνευ μέτρων)·
ἀλλὰ τούτῳ διαφέρει, τῷ τὸν μὲν τὰ γενόμενα λέγειν,
5 τὸν δὲ οἷα ἂν γένοιτο. διὸ καὶ φιλοσοφώτερον καὶ 3
σπουδαιότερον ποίησις ἱστορίας ἐστίν· ἡ μὲν γὰρ ποίησις
μᾶλλον τὰ καθόλου, ἡ δ' ἱστορία τὰ καθ' ἕκαστον λέγει.
ἔστιν δὲ καθόλου μέν, τῷ ποίῳ τὰ ποῖα ἄττα συμβαίνει 4
λέγειν ἢ πράττειν κατὰ τὸ εἰκὸς ἢ τὸ ἀναγκαῖον, οὗ στο-
10 χάζεται ἡ ποίησις ὀνόματα ἐπιτιθεμένη· τὸ δὲ καθ' ἕκα-
στον, τί Ἀλκιβιάδης ἔπραξεν ἢ τί ἔπαθεν. ἐπὶ μὲν οὖν τῆς 5
κωμῳδίας ἤδη τοῦτο δῆλον γέγονεν· συστήσαντες γὰρ τὸν

Figure 1: The figure shows page 34 of Butcher's translation (1895) with critical text of Aristotle's *Poetics*. The rich paratext contains references to two different systems to divide the text: the canonical Bekker numbers (highlighted in blue) and the division of the text in chapters and sentences (in purple).

it: one is the structure of the edition itself as defined by its pagination and the other is the canonical structure of the text, namely its division into books and poetic lines. The way in which such overlapping text structures are expressed depends on the medium: in the case of printed editions the references to such structures are part of the paratext (see image above), whereas in the case of a TEI-encoded electronic edition they will be expressed by using markup elements such as `<milestone>` and `<div>`.

Finally, another important characteristic of canonical citations is that, despite the fact that their use has been standardized to a great degree, there exist multiple, equivalent ways of expressing the very same citation. The reason for choosing one or the other *citation style* may differ: in some cases it is merely matter of personal preference while in other cases may depend on the publication venue or even audience for which someone is writing. For example, in a journal or edited volume on epic poems it is common to find canonical citations to Homer's *Iliad* and *Odyssey* expressed in a particularly concise format which uses the uppercase letters of the Greek alphabet to identify the books of the Iliad and the lowercase ones for the Odyssey. The use of such a format in those cases where the number of citations tends to be in the order of hundreds improves dramatically the readability of the text.

4. ONTOLOGY WALKTHROUGH

HuCit is a light-weight ontology which consists in its current version (0.9.1) of 10 classes and 16 properties[13]. The ontology imports and extends–mostly by defining more specific sub-classes–concepts that are already defined in existing ontologies such as CIDOC-CRM[14] and FRBRoo[15]. In this section we shall introduce the main classes of HuCit and discuss the most important modeling decisions.

4.1 Citation and Canonical Citation

As noted above, we deliberately treated citations as textual objects rather than performative ones. As a result we have the classes `Citation`, and its sub-class `Canonical-Citation`, which are used to represent occurrences of a citation in the main body of a document. Both of these classes refer to abstract rather than physical objects. Specifically, we are dealing with textual entities that fall within the category of *representations* or *content-bearing objects*, that is, entities that are understood by humans as having a symbolic relationship to some other content.

The main difference between a `Citation`, and a `Canonical-Citation`, lies in the kind of object they represent. Using a language taken from FRBR, we could say that while a citation is a symbolic object that denotes another document (or part of it) conceived at the Expression or Manifestation level, a canonical citation makes reference to a more abstract document structure, which can be located in any Expression of a given Work. As a result, canonical citations can be used as 'universal' identifiers for (a subset of) classical texts.

4.2 Form and Content of a Canonical Citation

Following the approach delineated by Mizogouchi in his ontology of representations [6] and partially investigated by one of the two authors in previous work [7], we define a citation as an object that can be further characterized by using the categories of *form* and *content*. In other words, any citation can be described as having a specific *content* - what is being referenced - and a *form* - the style or structure used to express that reference.

This approach is particularly useful because it allows to specify formally how two citations are similar. For example, we can define as being *equivalent* two or more citations that express the same content but present different forms, such as 'Hom. *Od.* I 1', 'Hom. *Od.* 1.1' and 'α 1'. Although what all these citations mean is "book 1, line 1 of Homer's *Odyssey*", independently from the reference edition, they differ as to how such meaning is expressed or, in other words, they follow different citation styles.

The styles of canonical citations, however, are somehow less clearly standardized than those for citing modern publications, such as for example the Harvard or MLA style. What should also be noted is that it goes beyond the current scope of our work to define citation styles to a great degree of detail. This would allows us, however, to build on top of our ontology an application to apply automatically different styles to the same canonical citations, as reference manager applications such as Zotero or Mendeley can easily do for modern publications by using sets of rules expressed

[13] http://www.essepuntato.it/lode/owlapi/http://purl.org/net/hucit

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

[15] http://www.cidoc-crm.org/frbr_inro.html

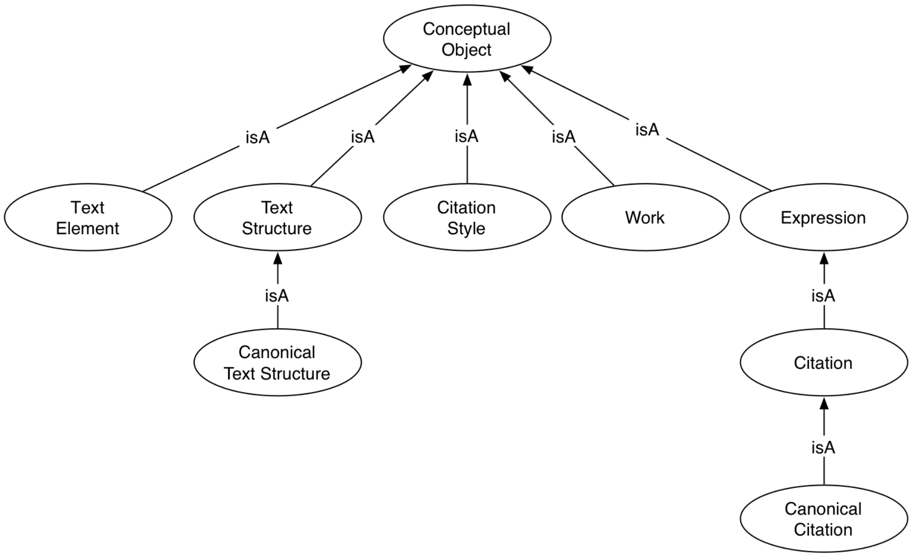


Figure 2: Overview of classes contained in HuCit.

in the Citation Style Language (CSL) format[16].

4.3 TextStructure and TextElement

More complex yet interesting is to define the *content* of a citation. As already observed above, two equivalent canonical citations present different citation styles but refer to the same section of a text. What is canonical–that is standard and agreed upon–in such citations is the document structure element which is being referenced. Such a structure exists at a more abstract level than the single existing editions of that text. Using FRBR, canonical citations imply a text structure that is common to all the existing `Expressions` of a given `Work`.

We thus introduced the class `TextStructure` to the purpose of representing an arbitrary set of hierarchically-ordered `TextElements`. The content of a canonical citation is ultimately a list of one or more `TextElement` within a given text structure. Furthermore, part-of relationships can be defined between a two or more `TextElements`. The properties `follows` and `precedes` are necessary to retain and make explicit information about the topology of texts, such as the fact that "book 1, line 611" of Homer's *Iliad* follows "book 1, line 610" and precedes "book 2, line 1". And in order to make quantifiable a citation expressed as a range (e.g. Hom. *Il.* 1.610-2.1) we need to know exactly which lines are comprised between "1.610" and "2.1".

Each text has its own canonical structure: however, the types of text elements that one encounters when dealing with such texts is limited. Poetic texts, for example, are often–but not always–divided into books and poetic lines: therefore, order to group together text elements of the same kind, we make use of the `Type` class as it is defined in CIDOC-CRM. In light of the intended use of the ontology (supporting the automatic extraction of canonical citations) such grouping made sense as it allows to define once and for all labels in several languages for the same text element type, such as livre (@fr), Buch (@de) and libro (@it) for book (@en) (see section 5.1 for how this information can be leveraged during the text processing).

We said above that our ontology can be mapped to and builds upon the data model defined in the CTS protocol. The connection between HuCit and the CTS lies in the CTS URNs, that is the identifiers used by this framework to identify persistently specific portions of canonical texts. However, whereas in the CTS protocol the semantics are not defined in a machine-readable format, in HuCit CTS URNs are defined explicitly as identifiers by using CIDOC-CRM (i.e. as specific kinds of appellations). Moreover, CTS URNs identify what in HuCit we call `TextElement`, that is the very content of a canonical citations: an abstract object that points to as many realisations of a text passage as they exist (fig. 4).

5. HUCIT IN ACTION

Learning how to properly decipher and forge citations to primary sources is part of the most basic training of any classicist. When building an expert system which extracts automatically such citations from unstructured texts, we need some sort of surrogate which provides us with such domain knowledge. In this section we shall examine how a knowledge base built upon HuCit can be queried in order to support this information extraction task.

5.1 Citation Identification

Let us consider now what are the types of queries that can be ran against our knowledge base. As an example let us take the one provided by Crane in [3] to exemplify the challenges of capturing canonical citations and their meaning. Crane defines *citation identification* as a particular case of *named entity identification* that focuses on "determining whether the string 'Th. 1.33' refers to book 1, chapter 33 of Thucydides, line 33 of the first Idyll of Theocritus".

Although "Th." is not a common way of abbreviating the name of Thucydides, what we have here is a typical example of ambiguous citation. In fact, the string "Th.", when considered without its surrounding context, can be a reference to the Greek historian Thucydides as well as to

[16] `http://citationstyles.org/`

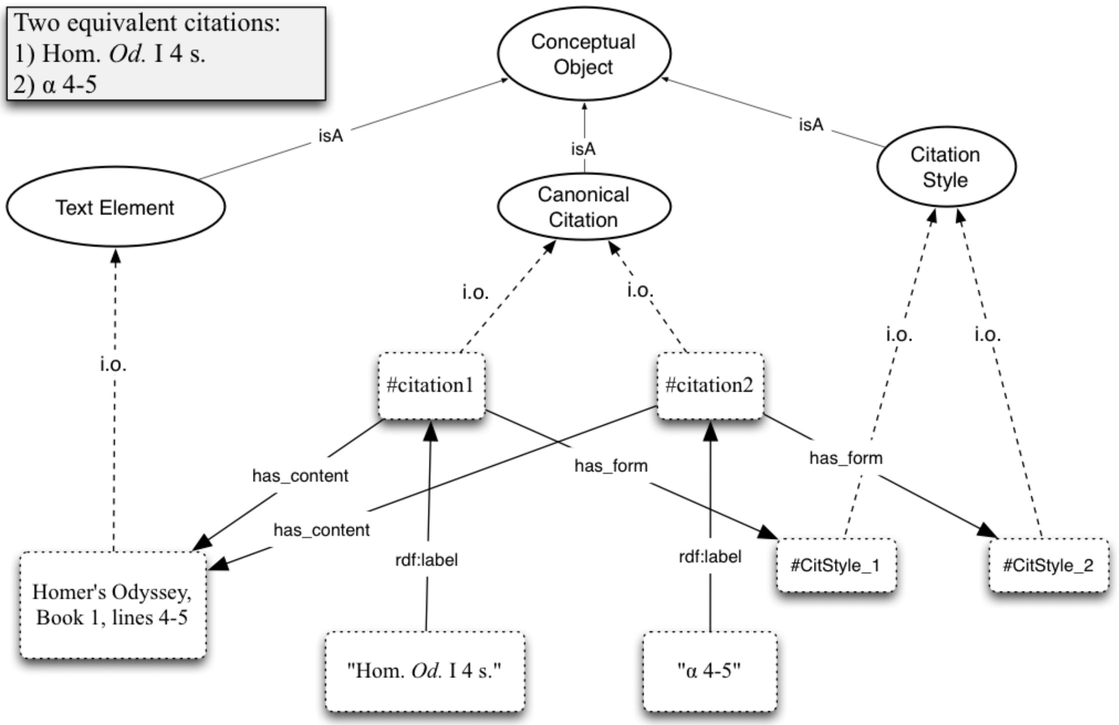


Figure 3: Example of how two equivalent canonical citations can be modeled in HuCit.

Theocritus. The idea underlying HuCit is that information about the structure of canonical texts can be exploited to improve the accuracy of an automatic system in determining the correct meaning of a citation in cases like the one above.

A first type of query can help us validating citations, i.e. checking whether the scope of the citation exists or not (in the example above, "1.33" is considered the *scope* of the citation). Following the example of "Th. 1.33", a query will look for works whose title can be abbreviated as "Th." and whose canonical text structure has a first-level element with value "1" and a second-level element with value "33". Such a query will return two matches however: book 1, chapter 33 of Thucydides' *Histories* and Idyll 1, line 33 of Theocritus', which is not enough for us to disambiguate the meaning of "Th". In order to refine these results, we may try to search for clue words within the context of the citation. These are words such as 'book', 'chapter', 'line' or 'idyll' and tell us something useful about the text that is being cited. One can try to match words from the context against such type labels and eventually narrow down further the list of candidates. If the context contains the word 'Idyll' or 'line/verse' the citation above is most probably referring to Theocritus' work, whereas if it contains words such as 'book', 'chapter' or 'section' it is very likely to be a citation of Thucydides' *Histories*.

5.2 Citations as Annotations: HuCit and OAC

The Open Annotation Collaboration (OAC) ontology is a simple yet very flexible semantic format which is suitable to publish not only user-generated annotations, but also annotations that are produced automatically, e.g. linguistic or named entities annotations. Annotations are represented as objects having a body and a target: the latter is the portion of an object, not necessarily text, that is annotated, whereas the former is the actual content of the annotation. Additionally, an annotation can have basic metadata such as creator, creation date, etc. Its flexibility lies in the fact that there are virtually no restrictions on the object type of the body or the target. As they can be referred to by means of URIs, the object type (i.e. its class) is determined when the URI is resolved and can be any, as long as its semantics are defined in a machine-readable format (e.g. OWL/RDF).

In the latest version of the OAC specifications (1.0) the new class `oa:Motivation` provides information about the reason why a a given annotation was created. For example, an annotation can be created to reply to another annotation. OAC defines already a number of instances of this class including `oa:identifying` that "represents the assignment of an identity to the target resource(s)" such as, for example, "annotating the name of a city in a string of text with the URI that identifies it"[17].

HuCit can be combined with OAC to store and publish the annotations produced by a service which extracts canonical citations from text: the motivation behind such annotations can be expressed by means of that was tagged as being a canonical citation, whereas `oa:Body` identifies its content, that is in HuCit terms one or more `TextElement` (fig. 5).

6. CONCLUSIONS AND FURTHER WORK

The work we presented in this paper is a first attempt to provide a formal modeling of citations to primary sources in Classics. The benefit of the presented approach–reifying the content of citations, rather than treating them as mere relationships between documents–is two-fold: 1) since the

[17] `http://www.openannotation.org/spec/core/`

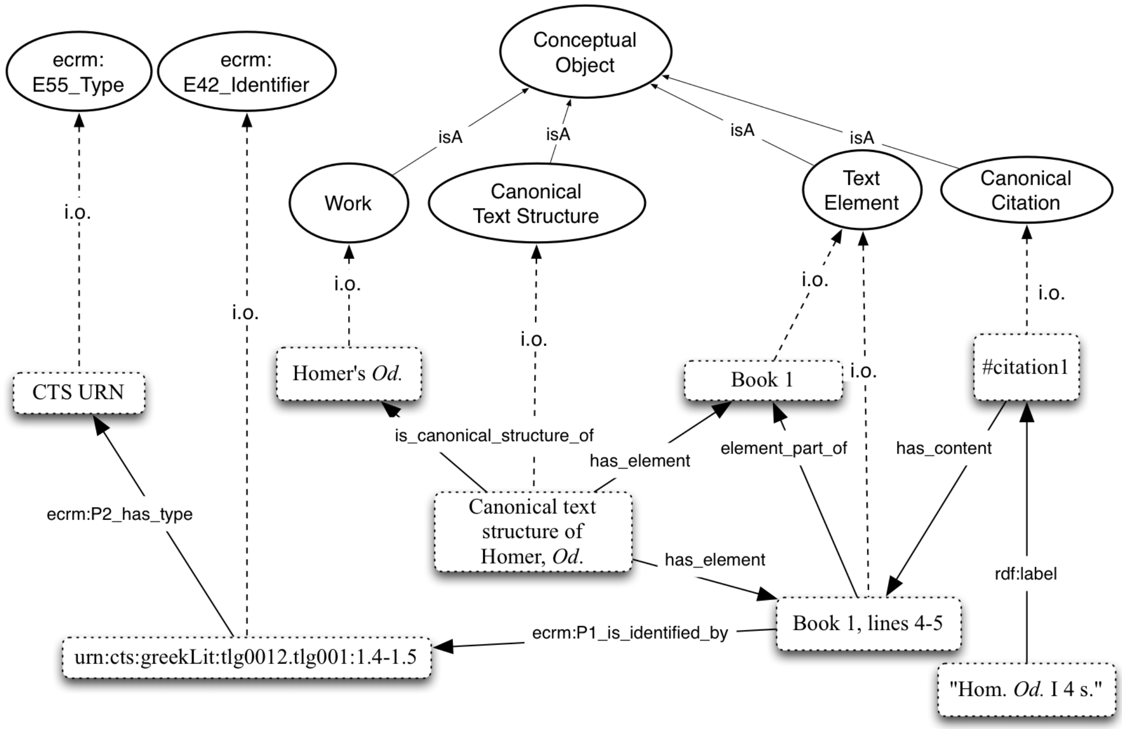


Figure 4: This figure shows how the hierarchical, canonical structure of a text is modelled in HuCit. Also worth noting is the use of classes drawn from CIDOC-CRM to express explicitly the semantics that are already implicitly contained in a CTS URN.

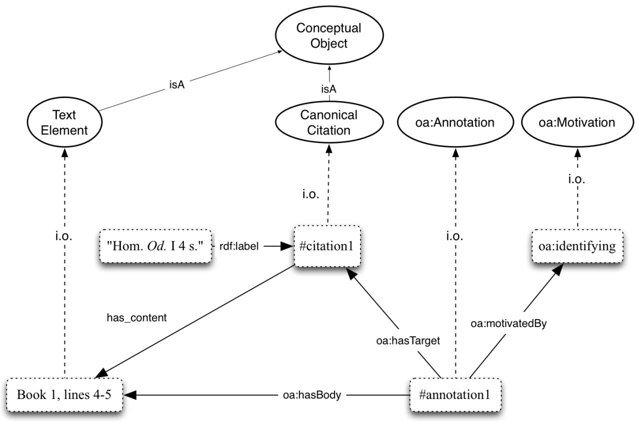


Figure 5: Example of how HuCit and OAC can be combined together in order to publish the extracted canonical citations as annotations.

content of a citation becomes an instance on its own, it can be given a URI and can be linked to related resources on the (Semantic) Web; 2) canonical citations contained in journal articles can be represented as OAC annotations, where the `Target` of the annotation is the portion of text containing the citation itself and its `Body` is the content of a citation. This solution allows us to model in depth our domain of interest while maintaining some degree of interoperability with other resources and services that make use of the OAC standard to describe annotations.

There is also an additional advantage in using a graph-based format such as RDF to store the data. Since HuCit allows one to store a very detailed representation of the citation network existing between primary and secondary sources, the fact that such network is already expressed in a graph-based format makes it easier to manipulate and transform the data in order to further analyse specific network aspects in dedicated software or environments.

Another research direction that might be considered in the future is exploring to what extent the intention behind citing primary sources in Classics can be determined and consequently modeled in our ontology, in a way that is similar to what CiTO already does with its taxonomy of citation types. The main problem with this is that the usual way of citing sources, for example as support to an argument or claim (e.g. "vd.","cfr.", "cf. e.g.", etc.), can be so vague or underspecified that is often hard, if not impossible, to establish the purpose of an author in citing a given text [4].

7. REFERENCES

[1] J. D. Bolter. Hypertext and the Classical Commentary. In *Accessing antiquity : the computerization of classical studies*, pages 157–171. University of Arizona Press, Tucson, 1993.

[2] P. Ciccarese, E. Wu, G. Wong, M. Ocana, J. Kinoshita, A. Ruttenberg, and T. Clark. The SWAN biomedical discourse ontology. *Journal of Biomedical Informatics*, 41(5):739–751, 2008.

[3] G. Crane, B. Seales, and M. Terras. Cyberinfrastructure for Classical Philology. *Digital Humanities Quarterly*, 3(1), 2009.

[4] D. Fowler. Criticism as commentary and commentary as criticism in the age of electronic media. In G. W. Most and D. Fowler, editors, *Commentaries = Kommentare*, number 4 in Aporemata: Kritische Studien zur Philologiegeschichte. Vandenhoeck & Ruprecht, Göttingen, 1999.

[5] T. Heath and C. Bizer. *Linked Data: Evolving the Web into a Global Data Space*. Synthesis Lectures on the Semantic Web. Morgan {&} Claypool Publishers, 2011.

[6] R. Mizoguchi. Tutorial on Ontological Engineering Part 3: Advanced Course of Ontological Engineering, 2004.

[7] M. Pasin and R. Mizoguchi. Moving EMLoT towards the web of data: an approach to the representation of humanities citations based on role theory and formal ontology (forthcoming), 2013.

[8] L. D. Reynolds and N. G. Wilson. *Scribes and Scholars: A Guide to the Transmission of Greek and Latin Literature*. Oxford University Press, USA, 3 edition, 1991.

[9] M. Romanello. Creating an Annotated Corpus for Extracting Canonical Citations from Classics-Related Texts by Using Active Annotation. In A. Gelbukh, editor, *Computational Linguistics and Intelligent Text Processing. 14th International Conference, CICLing 2013, Samos, Greece, March 24-30, 2013, Proceedings, Part I*, volume 1 of *Lecture Notes in Computer Science / Theoretical Computer Science and General Issues*, pages 60–76. Springer Berlin Heidelberg, 2013.

[10] M. Romanello, M. Berti, F. Boschetti, A. Babeu, and G. Crane. Rethinking Critical Editions of Fragmentary Texts By Ontologies. pages 155–174, Milano, Italy, 2009.

[11] M. Romanello, F. Boschetti, and G. Crane. Citations in the digital library of classics: extracting canonical references by using conditional random fields. In *Proceedings of the 2009 Workshop on Text and Citation Analysis for Scholarly Digital Libraries*, NLPIR4DL '09, pages 80–87, Morristown, NJ, USA, 2009. Association for Computational Linguistics.

[12] D. Shotton. CiTO, the Citation Typing Ontology. *Journal of biomedical semantics*, 1(Suppl 1):S6, 2010.

[13] R. Simon, E. Barker, and L. Isaksen. Exploring Pelagios: a visual browser for geo-tagged datasets. In *International Workshop on Supporting Users' Exploration of Digital Libraries*, 2012.

[14] N. Smith. Digital Infrastructure and the Homer Multitext Project. In G. Bodard and S. Mahony, editors, *Digital Research in the Study of Classical Antiquity*, pages 121–137. Ashgate Publishing, Burlington, VT, 2010.