Integrating Scholarly Argumentation, Texts and Community: Towards an Ontology and Services

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Abstract: This paper reports work in progress on an ontology-based approach to modelling the argumentative discourse, texts and community in an academic domain in order to support semantic browsing and search. We describe how diverse research into these aspects can be integrated in an ontology, and step through an example of the kind of service that can be provided given such an integrated model of a research field. We also begin to explore mechanisms for enriching the ontology with the outputs of other CMNA research, such as Reed and Walton's argumentation scheme models.

1. Introduction

This paper continues the research theme pursued in the ScholOnto project [1], namely, the challenge of facilitating scholarly analysis (or 'sensemaking') of academic domains. Whilst to date, we have emphasised the importance of the 'learnability' of a software tool for modelling the contributions and arguments in academic literature, and the tradeoffs in representational expressiveness which this may entail, we have also been exploring the potential of a system were we to focus more closely in a 'purer', less applied manner, on the ontological nature of scholarly discourse in academic fields.

This work builds on the progress made in the ScholOnto project which demonstrated that one can model naturally occurring scholarly discourse (in publications) at a relatively coarse granularity and provide novel, useful computational services based on these models. Our question now is what can be learned by modelling, in a structured way, more attributes of an academic domain than has been covered to date, and the nature of the computational sensemaking-support services which this enables.

Section 2 gives a brief overview of other research aimed at analysing academic domains. Section 3 then describes our ontology of the kinds of knowledge needed to support sensemaking of academic domains. Section 4 presents an extract from our model of the Turing debate (adapted from [2]) that is an instantiation of some of the key ontological concepts of the preceding section. Section 5 demonstrates the kinds of functionality that can be provided using our models. Section 6 briefly discusses how we might enrich our current model of argumentation with output from other CMNA research. Finally Section 7 concludes the paper and points to other future work.

2. Analysing Academic Domains

Current technologies (particularly web-based) play an important role in the research work of most academics, particularly by enabling greater *access* to academic literature and the work of other academic colleagues. However, until recently (see e.g. [1, 3]), there has not been as much support for researchers in their *analysis* of academic domains. Traditional methods for scholarly analysis are mainly rooted in citation analysis techniques (c.f. [4]). However, the limitations of such techniques have been highlighted both by the work in the aforementioned ScholOnto project, as well as the work in developing a system called ESKIMO that aimed to provide "a semantic network over scholarly resources to enable researchers to locate related material quickly and efficiently" [3]. Whereas ScholOnto facilitated the modelling of contested knowledge claims, ESKIMO concentrated exclusively on modelling resources in the research community such as projects and organisations. Both ScholOnto and ESKIMO seek to address questions that are difficult if not impossible to answer with the toolset presently available:

- Are there any arguments against the framework on which a particular paper builds?
- What is the structure of the community behind the literature?
- What is the nature of the most contentious issues of debate in the literature?

- What are the main philosophical camps in the field, and is there anyone that subscribes to more than one competing camp?

ScholOnto and ESKIMO can currently address the first two questions respectively. However, our initial modelling experiments indicated that these sensemaking questions (particularly the last two questions) can best be answered if one has an integrated view of the different types of knowledge of a research field as do experienced researchers to whom these kinds of questions are best directed. The experienced researcher has in his mind what Bazerman [5] calls a *schema* of the research field. This schema includes knowledge about the disciplines current practices, projections of its future development (including how the researcher's own work drives this future development), and judgements about the work of colleagues. In order to update their 'schema' of the field, academics rely on *textual* knowledge (i.e. published academic discourse) and *contextual* knowledge (i.e. knowledge surrounding the publication of this academic discourse) [6]. In the next section we present an ontology inspired by this notion of a researcher's schema, which formalises what we believe to be the key textual and contextual knowledge elements of an academic domain. To this end, our work now integrates the discourse modelling focus of ScholOnto (the textual element) with the community focus of ESKIMO (the contextual element) in order to explore the potential of reasoning over both community and discourse in an integrated ontology. In the next section we present this integrated ontology.

3. Different Elements of an Academic Field – the Ontology

This part of our work has been concerned with explicitly specifying the kinds of *objects*, *attributes* of objects, and *relations* between objects that can be said to make up an academic domain. Such an explicit specification is commonly referred to as an *ontology* [7]. As pointed out in the previous section, in order to support sense-making of academic domains, we need to be able to model *textual* as well as *contextual* knowledge. The ontology has therefore been structured along these lines, and this is described in the following subsections. The contextual knowledge is represented as the *Community of Practice* component, which is described in Section 3.1. The textual knowledge is represented in two parts as the *Lexical* component (Section 3.2) and the *Argumentative Discourse* component (Section 3.3). The following subsections present only a 'plain-English' description of the main ontological concepts we want to focus on in this paper. These – along with the other ontological concepts – are defined formally elsewhere[1] in a language now well established in the knowledge modelling and ontology engineering communities called OCML [8]. Though it is typical these days for most ontologies to be formalised in the new W3C standard Ontology Web Language (OWL), we have chosen OCML because of its greater expressivity and its built-in reasoning capabilities. However, if need be (e.g. to be more in line with current Semantic Web activity) we can convert concepts formalised in OCML to their equivalent in OWL.

3.1 *Community of Practice* component

Concept	Attributes	Typical relations
Publication	Author, Title, Year, Publisher	cites → [Publication]
Person	Name, Gender	researcher-at → [Institution] author-of → [Publication] collaborates with → [Person] believes → [Statement]

Table 1 – table of some of the Community of Practice concepts discussed in this paper

Although originally inspired by Kampa's work [3], most of the concepts for the Community of Practice component of the ontology have now been drafted from the AKT Reference ontology[2], which has subsequently surpassed the work on ESKIMO in terms of its coverage of various aspects of life in an academic community. The AKT Reference ontology describes such kinds of knowledge as *Persons*, *Projects*, *Publications*, *Research Events*, *Research Projects*, *Organisations*, *Institutions*, and it is this kind of knowledge that we seek to represent as Community of Practice concepts. The first entry in Table 1 shows the *Publication* concept, and its attributes *Author*, *Title*, *Year*, and *Publisher*. It also

[1] The interested reader can view the OCML version at http://kmi.open.ac.uk/people/benn/research/ontology.html

[2] http://www.aktors.org/publications/ontology/

shows that one of the relations that a publication is involved in is the citation ('*cites*') relation with other publications. In the full ontology, this generic Publication concept is specialised for *Journal Articles*, *Books*, *Theses*, *Conference Proceedings*, etc, with each of these specialised concepts having their own particular attributes (e.g. Journal Article has the *Journal* in which it is published as one of its attributes). The second concept shown in Table 1 is the *Person* concept. The main attributes that we are interested in for a Person are *Name* and *Gender*. A person may also (in addition to other relationships), '*research-at*' an Institution, be the '*author-of*' a publication, and '*collaborate*' with another Person.

3.2 *Lexical* component

Concept	Attributes	Typical relations
Lexical-Term	Gloss, Definition	{broader-term, narrower-term, equivalent-term, opposite-term, part-of, has-part} → [Lexical-Term]

Table 2 –Part of the Lexical ontology

The second component of the ontology is the Lexical component, which describes the kinds of concepts and relations typically used to structure Lexicons. Decomposition of *textual* knowledge into two separate components is inspired by Thagard [9]. He introduces the notion that an academic field can usefully be broken down into its *propositional* system and its *conceptual* system (his research is not concerned with Community of Practice concepts). The Argumentative Discourse component, discussed in the next section, corresponds to Thagard's propositional system while the Lexical component corresponds to his conceptual system. However, I note that in his conceptual system, Thagard is concerned with concepts as complex mental structures "akin to frames". The Lexical component here, however, deals with terms that researchers in the field use to *talk* about their field (and the definitional meaning of these terms) as opposed to mental representations.

The main element in the Lexical component component is the *Lexical-Term*. A Lexical-Term has a textual *Gloss*, and a textual *Definition*, which are typical attributes of entries in a lexicon. The relations between Lexical-Terms are representations of the various 'classic' lexical relationships described by Hirst [10]: classic lexical relationships pertaining to *identity of meaning* (synonymy), *inclusion of meaning* (hyponymy/hypernymy), *part-whole relationships* (meronymy/holonymy), and *opposite meanings* (antonymy). Hirst also points out that in addition to the classic lexical relationships, "there are many others, which may be broadly thought of as *associative* or *typicality* relations (as in the relationship between *dog* and *bark*). In line with common practice as Hirst points out, we have chosen to gloss our lexical relations as *has-equivalent-term*, *has-broader-term*, *has-narrower-term*, *part-of*, *has-part*, *has-opposite-term*, and *has-associated-term*.

3.3 *Argumentative Discourse* Component

Concept	Attributes	Typical relations
Statement	Text	{supports, disputes} → [Statement/Argument] {cohere, incohere} → [Statement/Argument] relates-to-term → [Lexical Term]
Question	Text	
Issue	Text	spawns → [Issue]
Perspective	Text	addresses → [Issue]
Argument	Premises, Conclusion	(*same as for Statement*)
School-of-Thought	Postulates, Members	competes-with → [School-of-Thought]

Table 3 – Part of the Argumentative Discourse ontology

Many of the concepts and relations of the Argumentative Discourse component take as a point of departure the propositional system of Thagard [9], as well as the discourse elements deployed in the debate maps of Horn [2] and discussed in [11]. The first Discourse concept shown in Table 3 is *Statement*. Statements here correspond to Horn's "simple declarative sentences" and to Thagard's propositions, which for him are mental structures representing what sentences represent. A Statement represents a declaration about any arbitrary thing, for example "Computers can think" and "Abortion should be made illegal". In a similar manner, *Questions* represent inquiries about any arbitrary thing. So for example, "Can computers think?" and "Should abortions be legal?" *Issues* and *Perspectives* are types of Questions and Statements respectively, and are the main organising elements we use in modelling academic discourse as discussed in the next section. This use of Issues to structure academic debate is again inspired by Horn, whose approach is sometimes referred to as Issue Mapping.[3] This approach to diagramming argument has indeed been recognised by others as a useful tool "for summarising a range of topics" [12]. Issues can '*spawn*' other Issues, and Perspectives are Statements that '*address*' Issues.

It should be noted that up to this point when we mention 'argumentation' we are pitching it at a 'macro-level' where individual argument structures (the focus of typical argumentation analysis) aggregate into debates. The *Argument* concept presented next in Table 3 is included to deal with the 'micro-level' of individual argument structures. This *Argument* concept corresponds to the classical argument structure of *premises* and *conclusion* (where premises and conclusions are themselves Statements). However, we have also specialised the 'classical' Argument structure to include Toulmin argument structures[4] (as shown formally in Figure 1), and we envisage possibly defining other argument structures at this level (e.g. analogical argument), with the goal being to enrich our conceptualisation of Argument with more state of the art models of natural argumentation that are being produced by ongoing CMNA research (see Section 6).

```
(def-class Argument ()
 ((has-premise :type Statement)
  (has-conclusion :type Statement
          :cardinality 1)))

(def-class Toulmin-Argument (Argument)
 ((has-grounds :type Statement)
  (has-warrant :type Statement)
  (warrant-backing :type Statement)
  (has-modal-qualifier :type Statement)
  (has-rebuttal :type Statement)))

(def-relation has-premise (?arg ?stmnt)
 :sufficient
  (and (Toulmin-Argument ?arg)
     (or (has-grounds ?arg ?stmnt)
       (has-warrant ?arg ?stmnt))))
```

Figure 1 - Toulmin-Argument structure inheriting from the 'classical' Argument and adding grounds, warrant, etc. The last definition says grounds (datum) and warrants are also considered as 'classical' premises.

The final concept shown in Table 1 is *School-of-Thought*. In our literature analysis we have identified two conceptions of School of Thought. Allen [13] describes a School of Thought as a group of statements that is coherent with a perspective on a given issue in a debate. The second notion (and probably what we should more aptly name Philosophical Camps) seems more 'fundamental' in the sense that it refers to an underlying belief system or philosophy, which in turn determines particular perspectives on a given issue, as in Allen's conception. It is this second notion of School of Thought that is represented in the table, with the belief system expressed as a set of postulates. This is again inspired by Horn's debate mapping approach. He suggests that one of the aspects of understanding debates is that "the protagonists come from quite different points of view" [11]. Horn discovered that a particular point of view is typically summed up by a listing of postulates representing the main claims underlying that point of view. For us, more work remains to be done on characterising additional attributes of Schools of Thought such as its origins and key influences, and competing schools.

Finally, Table 3 shows 4 main argumentative relations between Statements and Arguments – '*supports*', '*disputes*', '*cohere*', '*incohere*'. The '*supports*' and '*disputes*' relations have been taken directly from Horn's mapping approach and will be the main relations depicted in the example in the next section. The '*cohere*' and '*incohere*' relations are taken from Thagard [9] and map to the original ScholOnto notions of *positive* and *negative* links between argumentative nodes. So, defining Horn's debate relations in terms of Thagard's coherence relations, if one statement *supports* another, they are said to *cohere* or "hold together" to use Thagard's phraseology.[5] Other discourse relations have been adapted from the original ScholOnto ontology. However, what is listed in Table 3 is adequate to demonstrate important aspects of the modelling approach, which is presented in the next section.

[3] But the use of issues to structure arguments in complex domains first came to prominence with IBIS work on argumentation to solve 'wicked' problems.

[4] Actually this is an approximation to the Toulmin argument structure since it shows grounds, warrant, backing, etc. all being modelled as Statements, which is not necessarily Toulmin's original intention.

[5] Thagard expands on the notion of coherence as a relation between two propositions to broader notion of coherence being a property of *a whole set of* related propositions. He then implements mechanisms to be able to check whether one set of propositions taken together is more coherent than another. However, we are not concerned with this particular additional aspect of coherence.

4. Models of Academic Debate

The previous section presented the kinds of knowledge we are interested in when describing an academic domain, particularly its argumentation. As mentioned in the previous section, our view is that a field's argumentative discourse can be usefully framed in terms of the research *issues* being raised. In our analyses, it seems that the discourse of the field is largely built up around how these various issues are addressed. Horn refers to his approach [11] as Issue Mapping. However, whereas Horn is also concerned with a methodology for adequately *visualising* a field's argumentation, we are only concerned with the *essential* components of an argument, irrespective (at this stage) of how best to visualise them.

We now turn to one of our initial attempts at modelling academic argumentation. Figure 3 shows an extract from Map 1 of Horn's maps of the Turing debate, augmented with a partial depiction of the *Functionalism* School-of-Thought from Map 6. The diagram shown here has been handcrafted for presentation purposes. The actual model is implemented in an OCML knowledge base, but Figure 3 is a graphical equivalent to what is modelled in the knowledge base. We are currently working on automatic map generation from OCML knowledge models. The model in Figure 3 shows instantiations of the concepts and relations described in the ontology in Section 3. It depicts *Issues (Questions)*, *Perspectives (Statements)*, *Persons*, *Publications*, *Lexical Terms*, *Philosophical Camps*, and the various relations that occur between these concepts. One new item of knowledge, which isn't in the original Horn maps, is the *Cognitivism*[6] philosophical camp, which shows *Paul Thagard* as being one of its subscribers. This is based on our own reading of [9] and will be used to demonstrate some of the functionality we can obtain from the models in the next section. It also demonstrates that as new things become known, the models of the academic domain can be updated accordingly.

Note that we have only shown the main claim statement of each argument in the original Horn map. This is only for visual reasons: in the full OCML model each argument is modelled in full.

[6] The Cognitivism postulates shown are adapted from http://en.wikipedia.org/wiki/Cognitivism_(psychology)

5. Computational Services

Current technologies play an important part in providing timely access to academic literature. One example is CiteSeer[7], a free database that facilitates browsing of its articles via citation links and locates related documents using citation measures. Another example is Google Scholar, an off-shoot of the popular search engine Google. Still in beta form Google Scholar[8], like CiteSeer, ranks the relevance of academic articles based on the number of citations it has received from the literature. These technologies are welcome additions to the toolkit of the working academic. However we are interested in the question, "What *new* services can integrated models of text, argument and community enable?"

- It is straightforward to replicate the usual bibliographic database functions, e.g. find all the publications published after a given date for a given author (as shown in Figure 2 – OCML function to retrieve all of Douglas Hofstadter's papers published after 1980 below), or list citing documents.
- Equally simple, but still making an advance on current tools, we can list the key statements made by an author on a particular issue.
- Furthermore, as already shown in previous ScholOnto research, having the models rendered as interactive maps assists navigation around complex argumentation networks too large for a single poster or screen, and provides views that cannot be provided in current tools.

```
(setofall ?pub
 (and (Publication ?pub)
    (> (get-publication-year ?pub) 1980)
    (has-author ?pub Douglas_Hofstadter)))
```

Figure 2 – OCML function to retrieve all of Douglas Hofstadter's papers published after 1980

However, the most substantive advances on previous work are services able to infer new, potentially interesting and relevant kinds of connections. An example scenario that reasons over the model in Figure 3 is given below.

Consider a scenario where a user starts with a search for the term *ACME* and then goes on to discover an interesting feature that, whilst on the one hand *David*

[7] http://citeseer.ist.psu.edu/

[8] http://scholar.google.com/

Chalmers (and his co-authors *Robert French* and *Douglas Hofstadter*) *dispute* the statement marked **A** in Figure 3, on the other hand Chalmers appears to share the underlying philosophy of the very statement he is disputing. How can we discover this interesting pattern from the model? In Figure 3 let us conjecture that starting from the *ACME* term the user can easily work through queries such as *'show me what has been said about ACME'* and *'in what publications has it been said'* (the OCML implementation of which is shown in the first construct in Figure 4).

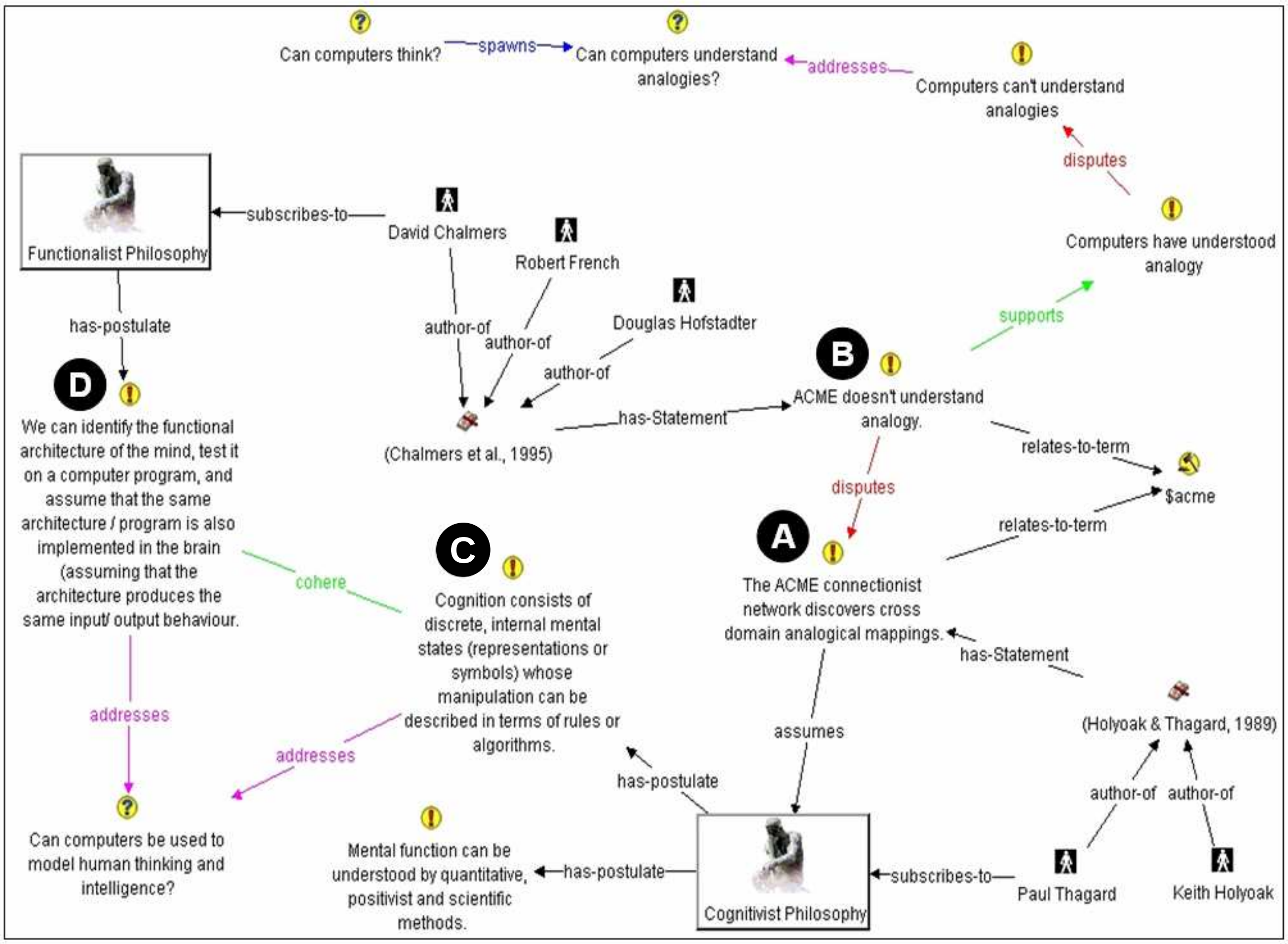

Figure 3 – Model of Turing Debate Extract

```
(setofall ?stmnt
  (and (Statement ?stmnt)
     (relates-to-term ?stmnt $acme))))

(def-function get-where-stated (?x) -> ?pub
  :constraint (Statement ?x)
  :body (setofall ?pub
      (has-Statement ?pub ?x)))

(def-relation believes (?p ?belief)
 :sufficient
  (or (and (has-author ?pub ?p)
      (has-statement ?pub ?belief))
    (and (subscribes-to ?p ?school)
      (has-postulate ?school ?belief))))
```

Figure 4 - OCML extracts that show how some of the services are implemented

Based on Figure 3, the answer to the first query would be the two statements marked **A** and **B** in Figure 3. The second query would reveal that the statements are from *(Chalmers et al, 1995)* and *(Holyoak & Thagard, 1985)* respectively, and, continuing along these lines, a third query would reveal David Chalmers as the first-author of the *Chalmers et al, 1995* publication. At this stage the user may decide to check for any other beliefs held by David Chalmers. As depicted in the OCML relation in Figure 4, a person believes either (1) the statements he has written in a publication or (2) the postulates of any school of thought that he subscribes to. Based on this rule, in addition to statement **B** in Figure 3, Chalmers *believes* the postulate (**D**) of the *Functionalism* school of thought to which he subscribes.

This is where the system can reveal an interesting pattern regarding Chalmers' two beliefs. A person's beliefs are expected to be coherent with each other, and are expected to be in similar relationships to other statements and beliefs. Running this check on Chalmers' two beliefs reveals an interesting pattern. It happens that his first belief (statement B) *disputes* (and therefore *incoheres* with) statement A. If his beliefs are consistent this should mean that his second belief (statement **D**) should also *incohere* with statement **A**. However, tracing a *path of coherence*[9] between Chalmers' second belief (the Functionalism postulate) and statement A reveals that this second belief actually *coheres* with statement A. This is due to the fact that Chalmers' second belief (**D**) is similar to the postulate (**C**) of the Cognitivism school of thought, which is the underlying philosophy of statement **A**. Tracing this path leads the system to flag an 'apparent contradiction' between the two beliefs of David Chalmers. Of course in the real world this situation is perfectly reasonable – two people do not have to agree on everything even if they share elements of the same underlying philosophy. However, our aim is to be able to highlight patterns that may be of interest to a researcher.

6. Enriching the ontology with lessons from CMNA research

Section 3 presented our definition of 'classical' Argument structure with premises and a statement of conclusion. This argument structure was then shown to be specialised to a Toulmin structure of argument with warrants and grounds, etc. The immediate question therefore is, is it possible to specialise to other types of argument reported in the CMNA literature, thereby enriching our model of natural argumentation? What computational benefit might be gained from defining these argument types within our ontology?

[9] This is performed using a normal graph algorithm to find a path between two nodes (beliefs), but also taking into account the *type* of relation (in this case either *cohere* or *incohere*) between nodes.

Figure 5 shows how two types of argument widely discussed in the CMNA literature – *Argument from Sign* and *Argument from Expert* Opinion [14] – might possibly be depicted in our ontological terms. In accordance with Walton [14] the 'sign' in the Argument from Sign structure is represented as a statement of empirical observation or findings. The conclusion of this argument structure is then said to '*explain*' the observed sign.

Argument from Expert Opinion is particularly interesting from the viewpoint of our ontology, since we have already formally characterised (and are continuing to refine) our notion of what it means to be an expert in a given context (we can already provide indicative measures of 'authority' not only in quantitative terms of 'presence' in a literature, but also qualitative impact). It therefore seems possible that we may be able to 'import' argumentation schemes of the sort modelled by Reed and others in AML notation, and implement the Critical Questions associated with these schemes as functions over our knowledge models.

```
(def-class Argument-from-Sign (Argument)
 ((has-sign :type Findings-Statement)
  (has-conclusion :type Statement))
  :slot-renaming ((has-sign has-premise)))

(def-relation explain (?x ?y)
  :sufficient
   (and (Argument-from-Sign ?arg)
     (has-conclusion ?arg ?x)
     (has-sign ?arg ?y)))

(def-class Argument-from-Expert (Argument)
 ((has-expert-source :type Person)
  (in-domain :type Set-of-Research-Issues)
  (has-conclusion :type Statement)))
```

Figure 5 – How Argument from Sign and Argument from Expert Opinion might be defined in our ontological terms

7. Summary and Future Work

This paper has described an ontology-based modelling approach for integrating the different kinds of knowledge in a research domain needed to support novel, and in our view, useful kinds of browsing and filtering. We have illustrated how the relevant concepts are instantiated using an extract from a model of the Turing Debate (adapted from [2]), and demonstrated an example service implemented over this model. Our next step is to evaluate our ontology by implementing complete scenarios that incorporate the questions identified in Section 2 and validating our responses to these questions with a domain expert. The ultimate evaluation, which is currently beyond the scope of this work, would be to build a fully-fledged, deployable digital library to evaluate the usefulness of this ontological approach in a real academic work setting.

One aspect of our hopeful future work is to explore the various methods of rhetorically analysing individual research articles in a field in order to be able to generate overview maps of that field similar to what we have outlined in Section 5. Two strands of research related to this long term challenge of automatically generating argument maps from a research literature corpus include the work of Teufel [15] in automatically analysing individual research articles to extract Rhetorical Document Profiles from which maps can then be generated, and Sereno et al [16] who have reported work on an active annotation tool to support analysts in tagging research documents with semantic triples based on the ScholOnto ontology. Future work aims to explore how these approaches can be integrated.

8. References

1. Buckingham Shum, S., et al., Modelling Naturalistic Argumentation in Research Literatures: Representation and Interaction Design Issues. *Int. Journal of Intelligent Systems*, Special Issue on Computational Models of Natural Argument (Editors: Chris Reed & Floriana Grasso), 2005: In Press.
2. Horn, R.E., *Mapping great debates: Can computers think? 7 maps and Handbook*. 1998, MacroVU: Bainbridge Island, WA.
3. Kampa, S., *Who are the experts? E-Scholars in the Semantic Web*. Doctoral Thesis, *Department of Electronics and Computer Science*. 2002, University of Southampton.
4. Garfield, E., Scientography: Mapping the Tracks of Science. *Current Contents: Social & Behavioural Sciences*, 1994. 7(45): p. 5-10.
5. Bazerman, C., *Shaping Written Knowledge: The genre and activity of the experimental article in science*. 1988, Madison, Wisconsin: The University of Wisconsin Press.
6. Geisler, C., *Academic Literacy and the Nature of Expertise: Reading, Writing, and Knowing in Academic Philosophy*. 1994: Lawrence Erlbaum Associates.
7. Gruber, T., *A Translation Approach to Portable Ontology Specifications*. Knowledge Acquisition, 1993. 5(2): p. 199-220.
8. Motta, E., *Reusable Components for Knowledge Modelling: Case Studies in Parametric Design Problem Solving*. Frontiers in Artificial Intelligence and Applications, ed. J.L.d.M. Breuker, R.; Ohsuga, S.; Swartout, W. Vol. 53. 1999, Amsterdam: IOS Press.
9. Thagard, P., *Conceptual Revolutions*. 1992: Princeton University Press.
10. Hirst, G., *Ontology and the Lexicon*, in *Handbook on Ontologies*, S. Staab and R. Studer, Editors. 2004, Springer: Karlsruhe. p. 209-230.
11. Horn, R.E., Infrastructure for Navigating Interdisciplinary Debates: Critical Decisions for Representing Argumentation, In *Visualizing Argumentation*, P. Kirschner, S. Buckingham Shum, and C. Carr, (Eds.). 2003, Springer: London. p. 165-184.
12. Reed, C.A. and T.J. Norman, A Roadmap of Research in Argument and Computation, In *Argumentation Machines: New Frontiers in Argument and Computation*, C.A. Reed and T.J. Norman (Eds.). 2003, Kluwer: Dordrecht. p. 1-12.
13. Allen, B., Referring to Schools of Thought: An Example of Symbolic Citations. *Social Studies of Science*, 1997. 27, (6): p. 937-949.
14. Walton, D., *Argumentation Schemes for Presumptive Reasoning*. 1996, Mahwah, New Jersey: Lawrence Erlbaum Associates.
15. Teufel, S., *Argumentative Zoning: Information Extraction from Scientific Text*. 1999, Doctoral Thesis, University of Edinburgh.
16. Sereno, B., S. Buckingham Shum, and E. Motta. ClaimSpotter: an environment to support sensemaking with knowledge triples. In *10th Int. Conf. Intelligent User Interfaces*. 2005. San Diego, CA, USA: ACM Press New York, NY, USA.