Modelling Scholarly Debate: Conceptual Foundations for Knowledge Domain Analysis Technology

Thesis

UNRESTRICTED

MODELLING SCHOLARLY DEBATE

CONCEPTUAL FOUNDATIONS FOR KNOWLEDGE DOMAIN ANALYSIS TECHNOLOGY

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ABSTRACT

Knowledge Domain Analysis (KDA) research investigates computational support for users who desire to understand and/or participate in the scholarly inquiry of a given academic knowledge domain. KDA technology supports this task by allowing users to identify important features of the knowledge domain such as the predominant research topics, the experts in the domain, and the most influential researchers. This thesis develops the conceptual foundations to integrate two identifiable strands of KDA research: *Library and Information Science (LIS)*, which commits to a citation-based *Bibliometrics* paradigm, and *Knowledge Engineering (KE)*, which adopts an ontology-based *Conceptual Modelling* paradigm. A key limitation of work to date is its inability to provide machine-readable models of the *debate* in academic knowledge domains. This thesis argues that KDA tools should support users in understanding the features of scholarly debate as a prerequisite for engaging with their chosen domain.

To this end, the thesis proposes a *Scholarly Debate Ontology* which specifies the formal vocabulary for constructing representations of debate in academic knowledge domains. The thesis also proposes an analytical approach that is used to automatically detect clusters of viewpoints as particularly important features of scholarly debate. This approach combines aspects of both the Conceptual Modelling and Bibliometrics paradigms. That is, the method combines an ontological focus on semantics and a graph-theoretical focus on structure in order to identify and reveal new insights about viewpoint-clusters in a given knowledge domain. This combined ontological and graph-theoretical approach is demonstrated and evaluated by modelling and analysing debates in two domains. The thesis reflects on the strengths and limitations of this approach, and considers the directions which this work opens up for future research into KDA technology.

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And finally, the biggest thank you goes to my parents. Mommy and Daddy you have been my enduring support throughout. It would have been impossible to complete this journey without you, and thus I wish to dedicate this thesis to you. I hope it does you proud.

No book can ever be finished. While working on it we learn just enough to find it immature the moment we turn away from it.

Karl R. Popper

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CHAPTER 1 INTRODUCTION

Established technologies such as electronic journals, digital libraries, and bibliographic databases enable scholars to have greater access to academic literature. However, in the wake of such technologies there has emerged a further research ambition which seeks to move beyond merely facilitating access to literature, to supporting more powerful analysis of the knowledge in the literature (Buckingham Shum *et al.*, 1999; Buckingham Shum *et al.*, 2007).

Traditionally, a large part of the support for analysing academic literature has been provided by the role of the subject-specialist academic librarian, whose job it is to organise the literature in order to help users understand and navigate "the evolving scholarly research landscape" (Kesselman and Watstein, 2005). However, even researchers in the library community (e.g. Downs and Friedman, 1999) have made the case for more powerful technology to better enable users to learn about their chosen knowledge domain.

1.1 The problem of analysing scholarly debate in knowledge domains

This challenge to develop more sophisticated technology for analysing and learning about knowledge domains has primarily been addressed by researchers in the field of *Library and Information Science (LIS)*, where a major part of the overall research is focussed on developing analytical techniques and tools that can be used to support the information needs of scholars. Information scientists are particularly concerned with identifying so-called *intellectual structures* in knowledge domains (Chen, 2002) – e.g. clusters of researchers and/or publications, and the dominant research topics in the domain. In this field, according to Andrews (2003), one set of analytical techniques for identifying intellectual structures has dominated. These techniques can be collectively characterised as *Bibliometrics* techniques.

The paradigmatic feature of these Bibliometrics techniques is that they typically follow a *citation-based* approach to representing knowledge domains. In this representational approach, citation relationships between publications are used as the basis for analysing knowledge domains in order to reveal features of the domain such as the most influential researchers and the main clusters of research topics. This citation-based approach to representing knowledge domains has a history going back to the pioneering work on citation indices by Eugene Garfield (Garfield, 1955), and includes landmark work by Henry Small (Small, 1980; Small and Garfield, 1985) and Derek de Solla Price (de Solla Price, 1965) on the use of citation analysis to map the history and geography of science and to identify the intellectual structure of knowledge domains.

Recent research subscribing to this Bibliometrics paradigm has exploited the advances made in computer processing power since that early pioneering work by using citation-based analysis as the basis for generating sophisticated visual representations of knowledge domains. This work has recently been labelled as *knowledge-domain visualisation (KDViz)* research, and is at the boundary of the *Information Science* and *Information Visualisation* fields. KDViz research aims to promote the exploration of knowledge domains through the use of visualisations to convey new insights about the intellectual structure of the domain (Chen, 2003). Börner *et al.* (2003) suggest that KDViz technology is useful for novices who need to become familiar with a knowledge domain through identification of important features of that domain such as the landmark publications and the predominant areas of research.

Outside of the LIS field, the challenge to develop more sophisticated technology for analysing knowledge domains has also been recently addressed by researchers working at the boundaries of the *Knowledge Representation (KR)*, *Knowledge Management (KM)*, and *Knowledge Engineering (KE)* fields, where the general aim is to build systems that assist users in performing some particular knowledge-intensive task. These researchers adopt a *Conceptual Modelling* paradigm, which is about constructing conceptual models of a particular *world of interest*. These conceptual models are commonly referred to as *ontologies*, and they consist of the formal specification of the *types* of entities and *types* of relations between entities in the world being represented. These ontologies are then used as templates for representing *particular facts* (i.e. both entity and relation *instances* of entities and *instances* of relations) in the world of interest. These facts are stored in what is called a *knowledge base*, which enables new facts to be inferred on the basis of existing facts and on the basis of *inference rules* that are specified in the ontology (these inference rules specify how new facts are to be derived from existing facts). Besides their use as templates for representation and the basis for reasoning, the use of ontologies is also advocated because of the role they can play when trying to establish agreement between people or between software systems about "shared assumptions and models of the world" (Gruber, 1995).

In the context of designing technology for analysing academic knowledge domains, the Conceptual Modelling paradigm is concerned with representing a wider range of features such as the types of agents in the domain, their intellectual affiliations, their social relations with other agents, and their research interests and activities within the domain. The aim of representing this wider range of knowledge domain features – as opposed to just the bibliometrical features of domains – is to enable tools to be developed that allow more precise queries to be asked and answered about the domain.

As the next chapter will explore in greater detail, both the Bibliometrics paradigm (with its citation-based representational approach) and the Conceptual Modelling paradigm (with its ontology-based representational approach) have their relative strengths and limitations with respect to the design of what this thesis collectively refers to as *knowledge* *domain analysis (KDA)*[1] technology. Most significantly, however, as that chapter will make clear, the existing KDA technology research is particularly limited in its treatment of what has been identified as one of the most important aspects of a knowledge domain to understand in order to engage with that domain – *scholarly debate*. This has the implication that the knowledge domain learner is unable to use existing technology to identify and navigate important features of knowledge domains such as the structure of the ongoing dialogue between academics, the controversial issues being debated, and the main bodies of opinion on these issues, all of which are a necessary part of the learner being able to understand and engage with the chosen domain (Davidson and Crateau, 1998).

1.2 Research question

It is against such a background that this thesis raises the following research question:

> *How can scholarly debate be formally conceptualised so as to enable the automatic identification of important debate phenomena in knowledge domains?*

This research question can be analysed in two parts. The first part of the research question is concerned with a conceptual model or *ontology* of scholarly debate – i.e., it is about determining the types of entities and types of relations between entities that constitute the world of scholarly debate. The second part of the research question is concerned with analysing scholarly debate in order to identify important, debate-oriented intellectual structures in a given knowledge domain. The concern here is with what can be called *aggregate* debate phenomena, such as the main bodies of opinion in the debate, which Davidson and Crateau (1998) have proposed as important for a learner's understanding and engagement with a knowledge domain. Bibliometrics research has been particularly successful in its use of graph-based analytical methods to enable what Small

[1] The term 'knowledge domain analysis' (KDA) used in the remainder of this thesis is derived from the earlier term of 'knowledge domain visualisation' (KDViz). However, the term KDA will be used to label any technology that aims to support the tasks of analysing and understanding knowledge domains, regardless of whether or not the technology produces sophisticated visualisations of knowledge domains.

(2003) refers to as “aggregate structural and thematic analysis” of knowledge domains. This implies a need to account for how graph-based analytical methods can combine with conceptual models of scholarly debate to enable the automated identification of macro-level features of debate in knowledge domains. Thus, whereas the first part of the research question situates this work within a Conceptual Modelling framework, the second part of the research question introduces some of the shared commitments of the Bibliometrics paradigm.

The original research question can therefore be decomposed into two sub- research questions:

(RQ-i) What is a suitable ontology for representing the essential elements of debate in academic knowledge domains?

(RQ-ii) How can the two representational approaches (citation-based and ontology-based) be bridged to allow graph-based analytical methods, typically used with great effect in Bibliometrics research, to be reused for detecting interesting and potentially significant ‘aggregate structures’ in scholarly debates?

Finally, these two sub- research questions suggest a final key question:

(RQ-iii) How robust is the resulting hybrid approach when applied to scholarly debates in specific knowledge domains?

The next section gives an overview of the steps taken in this thesis to tackle the above research questions.

1.3 A hybrid knowledge domain analysis approach

As the above research questions illustrate, in terms of meeting the challenge of designing effective KDA technology, the focus in this thesis is on the *what* and the *how* of representing and reasoning about scholarly debate rather than on issues to do directly with tool building (e.g. usability, scalability, and deployment). The thesis achieves this by taking a novel analytical approach which combines elements of the Bibliometrics and Conceptual Modelling paradigms together. Thus the steps taken by this thesis in addressing the above research questions are as follows:

1. **Design a Scholarly Debate Ontology that can be used to construct models of debate in knowledge domains.** The ongoing research into developing KDA technology within the Conceptual Modelling paradigm has led to the development of various ontologies that specify some of the types of entities and types of relations that make up a knowledge domain. Thus, the thesis reuses an *upper-level* ontology – i.e. one concerned with the structure of reality at a high-level of generality – as a way of contextualising the Scholarly Debate Ontology and the existing KDA ontologies in relation to each other. Using an upper-level reference ontology in such a manner is a way of adhering to ontology design best practice of *minimal ontology commitment* (Gruber, 1995)– i.e., the principle which advocates the selection of the essential elements of the portion of reality being represented.

2. **Design a hybrid ontology-based and graph-based method for detecting 'viewpoint-clusters'** as important debate phenomena and important intellectual structures in knowledge domains. In particular, the thesis explores how graph-based cluster analysis, typically used in Bibliometrics research to significant intellectual structures in knowledge domains, can be reused for the task of detecting clusters of viewpoints in scholarly debate. However, as will be discussed at length in the thesis, the cluster analysis cannot be directly applied to the semantic representations of the debate. Thus, a mechanism is needed that can translate the ontology-based semantic representation into a simplified form that is suitable for cluster analysis to be applied. This thesis proposes that such a mechanism can be implemented as ontological inference rules that are based on a theory of how people use a limited set of cognitively-based parameters to interpret more complex relations between units of information, thereby breaking new ground by spanning the research fields of knowledge representation and psycholinguistics in a new

way, via the use of a cognitively-based vocabulary of coherence parameters for implementing the inference rules.

3. **Demonstrate the adequacy of this hybrid ontology-based and graph-based approach by applying it to two case studies.** The Scholarly Debate Ontology is used to represent real debates in two knowledge domains and the inference rules and graph-based cluster analysis are applied to the ontology-based representations of scholarly debate to reveal important and meaningful results about the debate in these domains. In the two case studies an approach of manual ontology-based representation is used, where the information contained in plain-text source material describing a particular scholarly debate is coded by a knowledge modeller as instances in a knowledge base that correspond to actual elements of the debate as described in the source material. These ontology-based representations can then be analysed to detect important 'macro-level features' and such results can then be revealed to any subsequent user of the system – not necessarily the same person as the knowledge modeller – who aims to learn about and engage in the chosen knowledge domain. Note that this approach suggests two distinct roles – the knowledge modeller, with some level of domain expertise, contributing to the system, and the end-user, with perhaps less domain expertise, gaining insights from the system. However, as will be discussed at the end of the case studies, in practice this distinction may blur as knowledge modellers gain new insights through the work of interpreting source material to code in the knowledge base and end-users, through increased domain expertise over time, can extend the existing knowledge base through their own modelling of new source material.

1.4 Intended audience

The research described herein is intended for library and information scientists, both theorists and technologists, who are interested in investigating how the information needs of scholars can be met. Addressing the research questions stated in this thesis should also be of benefit to those researchers interested in modelling and *theorising* about argument structure (particularly macro-level argument), as well as for those technologists interested in *developing* practical tools to aid in the analysis and understanding of real-world argumentation.

1.5 Thesis structure

The rest of this thesis is organised as follows.

Chapter 2 surveys the current research contributions to addressing the challenge of designing KDA technology. It reviews current KDA technology research in both the Bibliometrics and Conceptual Modelling paradigms, critiquing both approaches to determine their relative strengths and limitations. Based on this critique, the motivation for the rest of the thesis is provided in the form of two concrete proposals.

Chapter 3 addresses the first sub- research question (RQ-i): What is a suitable ontology for representing the essential elements of debate in academic knowledge domains? To address this question, Chapter 3 introduces a characterisation of knowledge domains as settings for the collective construction of knowledge, thus motivating the reuse of an upper-level constructivist ontology as a framework for selecting the essential elements of scholarly debate and for relating those elements that are specific to scholarly debate to other elements within a knowledge domain more generally. Using this framework, Chapter 3 then describes a *Scholarly Debate Ontology*.

Chapter 4 addresses the second 'sub- research question' (RQ-ii): How can the two representational approaches (citation-based and ontology-based) be bridged to allow graph-based analytical methods, typically used with great effect in Bibliometrics research, to be reused for detecting interesting and potentially significant 'aggregate structures' in scholarly debates? To address this question, Chapter 4 explores the design of inference rules that can be used to translate semantic representations of scholarly debate into a simplified form that is amenable to graph-based analysis. In doing so, the chapter introduces a vocabulary of cognitively-primitive parameters for implementing the inference rules.

Chapter 5 addresses the third sub- research question (RQ-iii) by specifically asking: What are the results when the resulting hybrid approach is applied to the scholarly debate in the Artificial Intelligence domain about whether or not computers can or will be able to think – glossed here as the *Turing* debate? To address this question, Chapter 5 explores how information depicted on one of a series of seven *debate maps*' produced by Robert Horn (1998), about the Turing debate, is captured and coded as a collection of instances in a knowledge base, using the Scholarly Debate Ontology as a coding template. Then, the chapter shows how inference rules can be applied to the instances in the knowledge base to form the basis for identifying important and meaningful clusters of viewpoints in the Turing debate.

Chapter 6 also addresses the third sub- research question by specifically asking: What are the results when this representation and reasoning approach is applied to the scholarly debate in the Bioethics domain about whether or not abortions should be legal – glossed here as the *Abortion* debate? To address this question, Chapter 6 explores how unstructured information presented in the Wikipedia entry on the Abortion debate is captured and coded as a collection of instances in a knowledge base, again, as with the first case study, using the Scholarly Debate Ontology as a coding template. Then, the chapter shows how inference rules can be applied to the instances in the knowledge base to form the basis for identifying important and meaningful clusters of viewpoints in the Abortion debate.

Chapter 7 explores the strengths, limitations and open issues of the approach followed in this thesis research. It discusses the results of the two case studies from the perspective of a series of evaluative questions adapted from the GlobalArgument.net experiment into the effectiveness of computer-supported argumentation (CSA) tools and techniques when used for analysing and understanding debates. Finally, this chapter concludes the thesis by examining the main contributions of the research with respect to the overall challenge of designing technology for knowledge domain analysis.

Figure 1-1 graphically depicts this thesis structure.

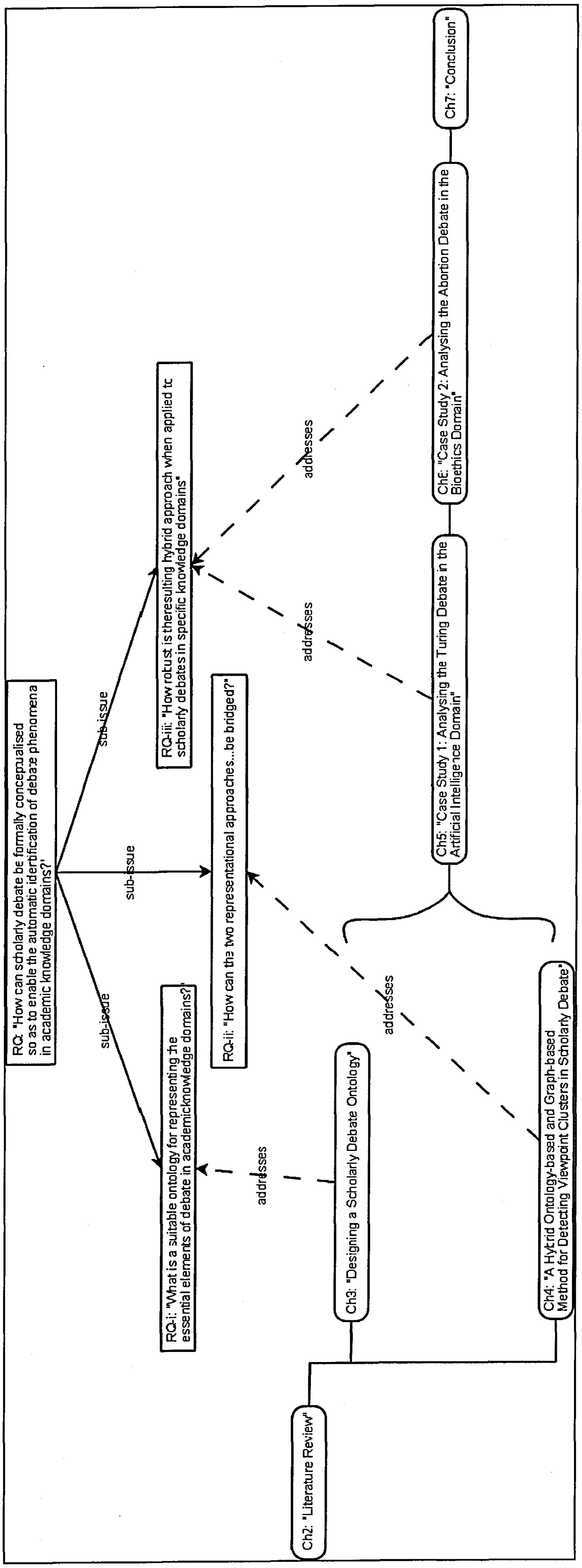

Figure 1-1 - A graphical illustration of the thesis structure.

CHAPTER 2 A REVIEW OF CURRENT RESEARCH ON KNOWLEDGE DOMAIN ANALYSIS TECHNOLOGY

This chapter investigates the state of the art in technology that supports knowledge domain analysis. It reviews the relevant literature, which is then used as the basis for motivating the main thesis proposals.

The chapter begins by reviewing current KDA technology that follows a predominantly *citation-based* approach to the task of analysing knowledge domains (§2.1). Next the chapter reviews KDA technology research that has investigated the use of ontology-based representation and reasoning to supporting the task of analysing knowledge domains (§2.2). The chapter then critiques both approaches to determine their relative strengths and limitations (§2.3). Finally, based on the preceding critique, the motivation for the rest of the thesis is provided in the form of two concrete proposals (§2.4).

2.1 Citation-based KDA technology

This section begins with a description of the main characteristics of citation-based analysis of knowledge domains (§2.1.1). It then describes specific examples of citation-based tools for analysing knowledge domains (§2.1.2).

2.1.1 Characteristics of citation-based analysis

The history of citation-based analysis of knowledge domains traces its roots back to Eugene Garfield's pioneering work on *citation indices* (Garfield, 1955). Citation indices are databases that catalogue and store the inter-publication citations in academic literature. They were originally developed as an answer to the growing size of academic literature, as well as the increasing need for more powerful multidisciplinary literature-retrieval capabilities (Weinstock, 1971).

According to Weinstock, before citation indices were introduced, human subject indexers would classify academic documents using keywords, headings, and/or subject terms. However, as the literature began to grow, this manual subject-based indexing began to suffer from long delays. This motivated the need for a system which could provide an up-to-date index of academic literature but which was not dependent on the manually entered knowledge of human indexers. It was envisaged that an up-to-date citation index would allow users to navigate the literature of a domain to (indirectly) answer questions such as the following (reproduced from Weinstock, 1971):

- *Has this basic concept been applied elsewhere?*
- *Has this theory been confirmed?*
- *Has this method been improved?*
- *Is there a new synthesis for this old compound?*
- *Have there been errata or correction notes published from this paper?*

Furthermore, once citation indices became available, it then became apparent that all the catalogued citation data could be used for more than just navigating and retrieving the ancestors and descendants of academic publications. Citation indices enabled the development of specific techniques for analysing the literature to reveal new insights about the knowledge domain, such as what were the emerging subject specialities within the domain.

Citation-based analysis can be divided into two categories – *Evaluative* and *Relational* (Borgman and Furner, 2002). Evaluative citation analysis is used to answer questions such as "Whose research has a greater impact than whose?" Answers to questions of this type may inform policies regarding the allocation and distribution of resources and funding. The main technique used for this type of analysis is *Citation Counting*, which is a method for determining the impact of individual publications (or journals) based on the number of times the publication (or journal) has been cited. This is often used as a measure of the landmark publications in a knowledge domain. As will be discussed later in this chapter (§2.3.1), this type of analysis – i.e. judging the merits of research based on the number of citations – is rather controversial.

Relational citation analysis is used to answer less controversial questions such as "Which research is related to which other research?". Three commonly used techniques for this kind of analysis are:

- *Bibliographic Coupling* – which is used as a measure of similarity between two publications based on the number of common references cited within the two publications. (This is graphically depicted, in its most basic form, in Figure 2-1(i));
- *Co-citation Analysis* – which is used as a measure of similarity between two publications (or authors) based on the number of times these two publications (or authors) are cited together. If the focus is on publications then this technique is referred to as *Document* Co-citation Analysis (DCA), whereas if the focus is on authors then it is referred to as *Author* Co-citation Analysis (ACA). (DCA is graphically depicted, in its most basic form, in Figure 2-1(ii));
- *Co-authorship Analysis* – which is used as a measure of collaboration between authors based on the number of times two or more authors produce publications together. (This is graphically depicted, in its most basic form, in Figure 2-1(iii)).

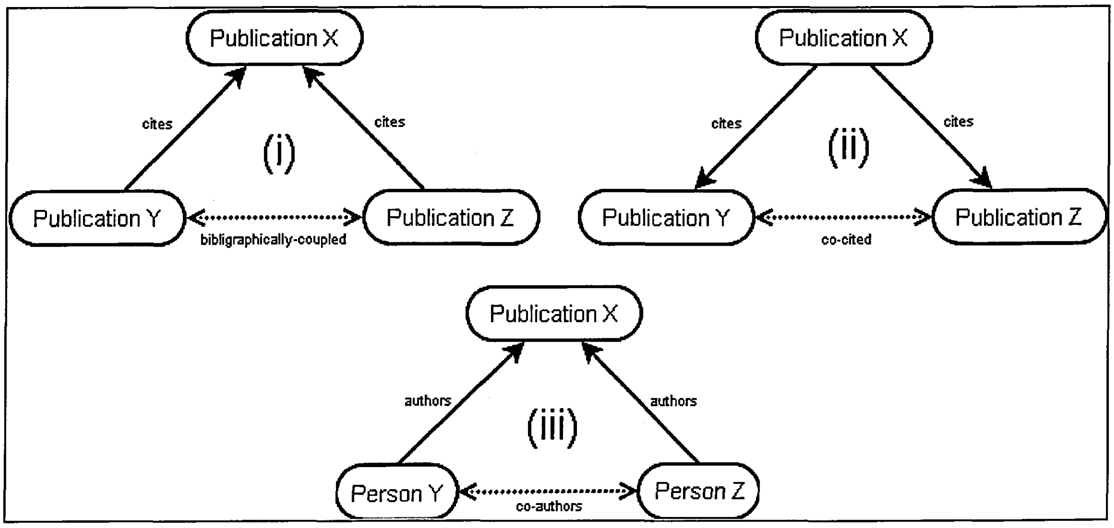

Figure 2-1 – Basic forms of the relational citation analysis techniques: Part (i) shows that Publications Y and Z are bibliographically coupled because they both cite Publication X. Part (ii) shows that Publications Y and Z are co-cited because they are both cited by Publication X. Part (iii) shows that Persons Y and Z are co-authors because they both author the same Publication X.

With the development of these citation-based methods and measures, researchers immediately began to utilise citation analysis results in order to generate visual representations or maps of the academic literature. Co-citation analysis, particularly author co-citation analysis (ACA), has become the most widely used of the citation analysis techniques for generating visualisations of the academic literature. According to White and McCain (1998), ACA can be used to reveal the disciplinary and institutional affiliations of authors, the speciality structure of the domain and authors' membership of one or more specialities, and the canonical authors and changes in authors' eminence and influence within the knowledge domain. More recently, Reid and Chen (2007) have demonstrated the use of ACA as the basis of their approach to investigating the *Terrorism* research field. Their analysis of that research field aims to answer questions such as the following:

- *Who are the core researchers?*
- *What institutions are they affiliated with?*
- *What are their influential publications?*

- *What are their collaboration patterns?*
- *What are the dominant topics in the 'Terrorism' research field?*
- *What are the new areas of research?*
- *What communities of authors have similar research specialities?*

Co-citation analysis also features in the work of Chen and Kuljis (2003). These authors have investigated the technique of tracking *paradigm shifts* in knowledge domains based on the growth of citations and the strength of co-citation links. In their method, firstly co-citation cluster analysis is used to find the leading or predominant clusters of researchers and publications in the domain. Secondly, they look for phenomena such as when a number of publications abruptly disappear from a leading cluster in one year to be replaced by a set of new publications in the next year. Finally, they examine the differences in citation patterns before and after the occurrence of such phenomena in an effort to detect a significant change in work being cited.

Finally, co-citation analysis also features in the work of Chen and Paul (2001), who have demonstrated how the simple co-citation inference pattern can be used as the basis for identifying what they call *intellectual structures* in a knowledge domain. Two such intellectual structures are *research fronts* and *invisible colleges*. Research fronts are defined as distinct clusters of publications which indicate the predominant research areas in a given domain (Chen and Carr, 1999). Invisible colleges, which can exist *within* research fronts, are groups of researchers in frequent communication with one another, where the groups are often considered to share an intellectual perspective concerning their specific subject area (Small, 1980).

2.1.2 Examples of citation-based KDA technology

This section describes specific examples of tools that implement some of the citation analysis techniques surveyed in the previous section. These tools vary in the complexity of the functionality they provide to the user, ranging from simple citation counting, to more complex analysis of macro-level structures such as research fronts and invisible colleges in a given knowledge domain. The tools reviewed here are *CiteSeer*, *Citebase*, *Google Scholar*, and *CiteSpace*.

CiteSeer

Early citation analysis tools were based on commercial citation indices that catalogued commercially available scholarly literature. Recently there has been research into developing citation-based tools that utilise literature freely available on the Web. One of the first tools to be made freely available is CiteSeer[2] (Lawrence *et al.*, 1999), which uses a technique the authors refer to as *autonomous citation indexing* to download and catalogue papers from the Web. Once a paper has been downloaded, the tool extracts the citations made in the body of the paper, and then stores the citation data in its database.

CiteSeer implements some of the citation analysis techniques introduced in the previous section to provide additional functionality for the end-user. For example, it allows the user to view the citation count of a given article and allows the user to sort articles based on citation counts. Figure 2-2 shows the result of searching the CiteSeer database for authors with part of their name matching the string "quinlan"[3]. The figure shows a list of "Quinlan"-authored publications sorted by descending citation count and followed by a graph of citation history for all "Quinlan"-authored publications in the database.

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

[3] This is the same search term used in Lawrence *et al.* (1999) to demonstrate the tool's functionality. However, the figure shown here is an updated version of that search.

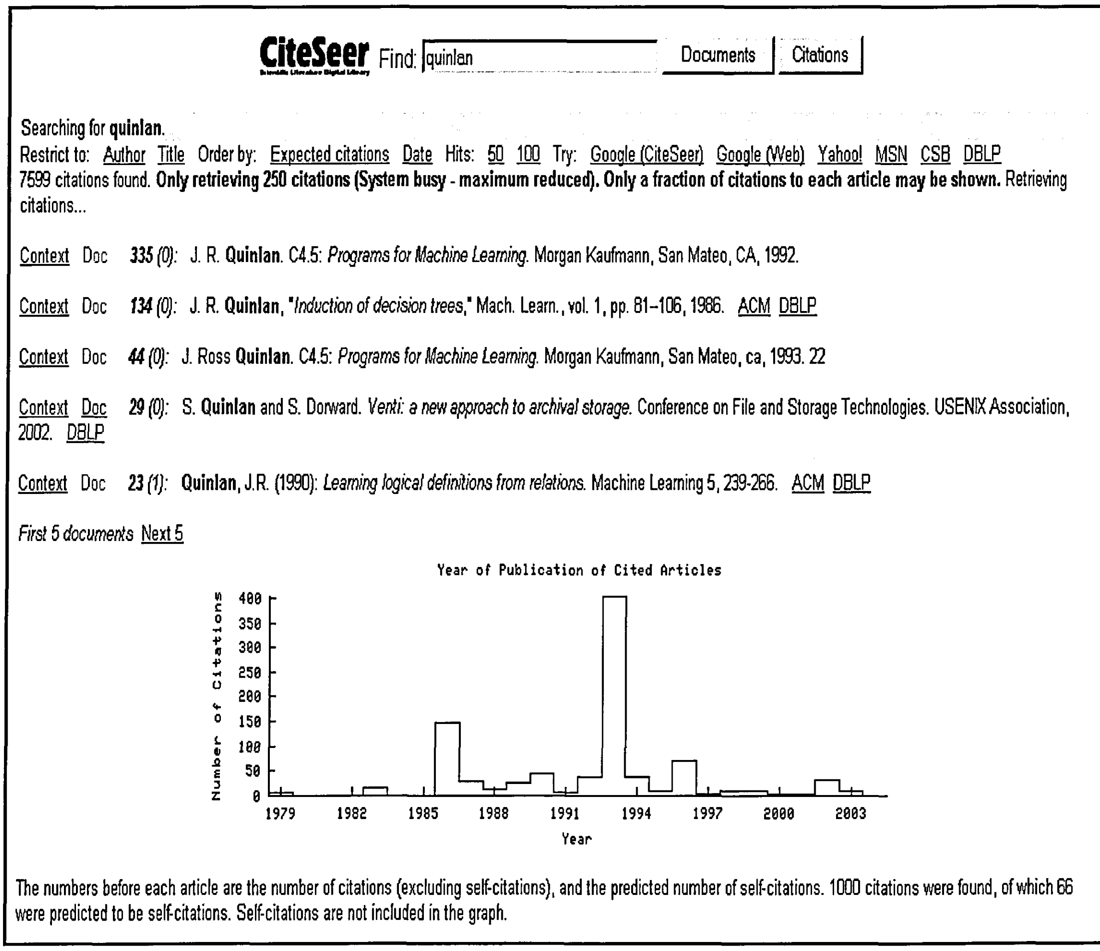
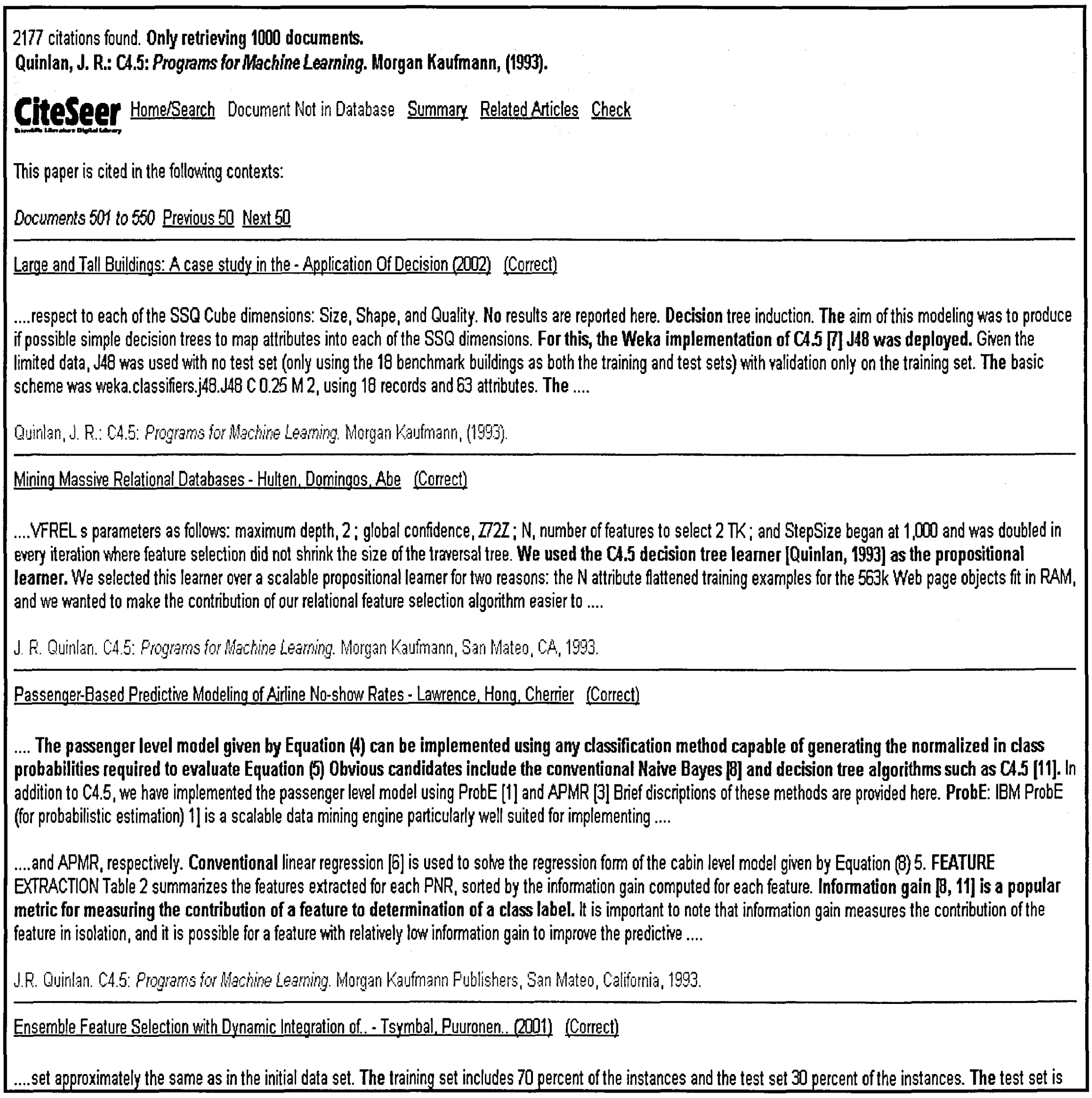


Figure 2-2 - The result of searching for "quinlan" in the CiteSeer database: CiteSeer returns a list of "Quinlan"-authored publications sorted by citation count and followed by a graph of citation history for all "Quinlan"-authored publications. (Search performed 12 February 2007).

However, Lawrence *et al.* (1999) recognise that using the citation count method as a ranking mechanism can lead to erroneous conclusions about the importance of a publication because the underlying assumption that a large number of citations implies scholarly impact is not always true. As one way of avoiding this potential pitfall, CiteSeer uses a technique known as *context citation analysis* to make the textual context of citations easily accessible. This textual context is a pre-specified number of sentences before and after the location of the citation in the text of a publication, which is intended to help users more accurately evaluate the importance of a particular citation. Figure 2-3 shows the result of another CiteSeer query that returns a list of publications that cite the first

"Quinlan"-authored publication from the previous query. Each publication in the list is accompanied by the relevant citation context.



2177 citations found. **Only retrieving 1000 documents.**
Quinlan, J. R.: C4.5: *Programs for Machine Learning.* Morgan Kaufmann, (1993).

CiteSeer Home/Search Document Not in Database Summary Related Articles Check

This paper is cited in the following contexts:

Documents 501 to 550 Previous 50 Next 50

Large and Tall Buildings: A case study in the - Application Of Decision (2002) (Correct)

....respect to each of the SSQ Cube dimensions: Size, Shape, and Quality. **No** results are reported here. **Decision** tree induction. **The** aim of this modeling was to produce if possible simple decision trees to map attributes into each of the SSQ dimensions. **For this, the Weka implementation of C4.5 [7] J48 was deployed.** Given the limited data, J48 was used with no test set (only using the 18 benchmark buildings as both the training and test sets) with validation only on the training set. **The** basic scheme was weka.classifiers.j48.J48 C 0.25 M 2, using 18 records and 63 attributes. **The** ....

Quinlan, J. R.: C4.5: *Programs for Machine Learning.* Morgan Kaufmann, (1993).

Mining Massive Relational Databases - Hulten, Domingos, Abe (Correct)

....VFREL s parameters as follows: maximum depth, 2 ; global confidence, 772Z ; N, number of features to select 2 TK ; and StepSize began at 1,000 and was doubled in every iteration where feature selection did not shrink the size of the traversal tree. **We used the C4.5 decision tree learner [Quinlan, 1993] as the propositional learner.** We selected this learner over a scalable propositional learner for two reasons: the N attribute flattened training examples for the 563k Web page objects fit in RAM, and we wanted to make the contribution of our relational feature selection algorithm easier to ....

J. R. Quinlan. C4.5: *Programs for Machine Learning.* Morgan Kaufmann, San Mateo, CA, 1993.

Passenger-Based Predictive Modeling of Airline No-show Rates - Lawrence, Hong, Cherrier (Correct)

.... **The passenger level model given by Equation (4) can be implemented using any classification method capable of generating the normalized in class probabilities required to evaluate Equation (5) Obvious candidates include the conventional Naive Bayes [8] and decision tree algorithms such as C4.5 [11].** In addition to C4.5, we have implemented the passenger level model using ProbE [1] and APMR [3] Brief discriptions of these methods are provided here. **ProbE:** IBM ProbE (for probabilistic estimation) 1] is a scalable data mining engine particularly well suited for implementing ....

....and APMR, respectively. **Conventional** linear regression [6] is used to solve the regression form of the cabin level model given by Equation (8) 5. **FEATURE** EXTRACTION Table 2 summarizes the features extracted for each PNR, sorted by the information gain computed for each feature. **Information gain [8, 11] is a popular metric for measuring the contribution of a feature to determination of a class label.** It is important to note that information gain measures the contribution of the feature in isolation, and it is possible for a feature with relatively low information gain to improve the predictive ....

J.R. Quinlan. C4.5: *Programs for Machine Learning.* Morgan Kaufmann Publishers, San Mateo, California, 1993.

Ensemble Feature Selection with Dynamic Integration of.. - Tsymbal, Puuronen.. (2001) (Correct)

....set approximately the same as in the initial data set. **The** training set includes 70 percent of the instances and the test set 30 percent of the instances. **The** test set is

Figure 2-3 - The result of a CiteSeer query that returns a list of citations to the first of the "Quinlan"-authored publications retrieved previously. The query also retrieves the relevant citation contexts. (Search performed 12 February 2007).

Besides citation counting, CiteSeer also utilises the bibliographic coupling and co-citation analysis inference patterns in order to determine the similarities between two publications. Figure 2-4 shows the profile of a publication indexed in the CiteSeer database. From the profile, the user is able to view certain attributes of the publication such as those other publications that cite it, that are related to it based on bibliographic coupling, that are similar to it based on textual content, and that are similar to it based on co-citation analysis.

Digital Libraries and Autonomous Citation Indexing (1999) (Make Corrections) (80 citations)
Steve Lawrence, C. Lee Giles, Kurt Bollacker
IEEE Computer

CiteSeer @NUS Home/Search Bookmark Context Related

View or download:
nec.com/homepages/...uter98letter.ps.Z
nec.com/homepages/...omputer98a4.ps.gz
com/homepages/gile...mputer.DLACI.ps.Z
Cached: PS.gz PS PDF Image Update Help

From: nec.com/homepages/lawren...pubdl (more)
From: nec.com/homepages/lawrenc...latex
(Enter author homepages)

Autonomous creation of citation indices and advantages for scientific communication and progress

Rate this article: 1 2 3 4 5 (best)
View Comments (0)

Abstract: The World Wide Web is revolutionizing the way that researchers access scientific information. Articles are increasingly being made available on the homepages of authors or institutions, at journal Web sites, or in online archives. However, scientific information on the Web is largely *disorganized. This article introduces the creation of digital libraries incorporating Autonomous Citation Indexing (ACI).* ACI autonomously creates citation indices similar to the Science Citation Index R . An ACI... (Update)

Cited by: **More**
A Multi-Agent System that Facilitates Scientific - Publications Search Aliaksandr (Correct)
Modeling the Author Bias Between Two On-line Computer - Science Citation Databases (Correct)
A Comparison of On-line Computer Science - Citation Databases Vaclav (Correct)

Active bibliography (related documents): **More** **All**
0.5: CiteSeer: An Automatic Citation Indexing System - Giles, Bollacker, Lawrence (1998) (Correct)
0.2: Indexing and Retrieval of Scientific Literature - Lawrence, Bollacker, Giles (1999) (Correct)
0.1: Determining the Publication Impact of a Digital Library - Kaplan, Nelson (2000) (Correct)

Similar documents based on text: **More** **All**
2.1: Autonomous Citation Matching - Lawrence, Giles, Bollacker (1999) (Correct)
1.0: Searching the Web: General and Scientific Information Access - Lawrence, Giles (1999) (Correct)
0.9: Distributed Error Correction - Lawrence, Bollacker, Giles (1999) (Correct)

Related documents from co-citation: **More** **All**
13: Authoritative sources in a hyperlinked environment - Kleinberg - 1997
11: The anatomy of a large-scale hypertextual Web search engine - Brin, Page
8: GroupLens: An Open Architecture for Collaborative Filtering of Netnews - Resnick - 1994

BibTeX entry: (Update)

Steve Lawrence, C. Lee Giles, and Kurt Bollacker. Digital libraries and autonomous citation indexing. IEEE Computer, 32(6):67--71, 1999.
http://citeseer.comp.nus.edu.sg/article/lawrence99digital.html More

```
@article{ lawrence99digital,
  author = "Steve Lawrence and C. Lee Giles and Kurt Bollacker",
  title = "Digital Libraries and {Autonomous Citation Indexing}",
  journal = "IEEE Computer",
```

Figure 2-4 - The CiteSeer page for the Lawrence et al. (1999) publication: For this publication, CiteSeer allows the user to view firstly publications that cite the current publication, secondly the active bibliography of related documents based on bibliographic coupling, thirdly related documents based on similarity of text, and finally related documents based on co-citation. (Search performed 01 March 2007).

Citebase

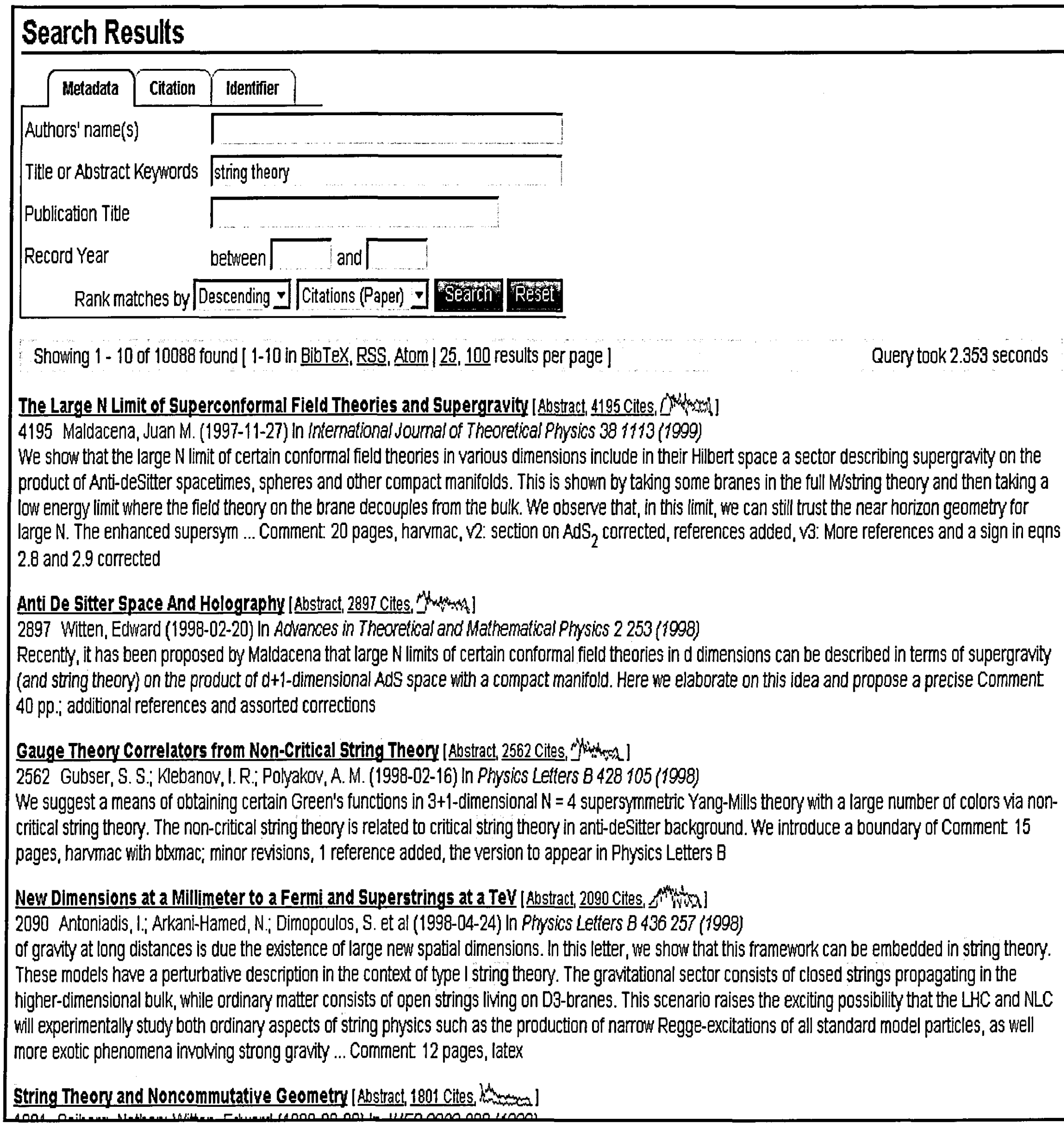
Citebase[4] is an experimental demonstrator tool developed as part of the *Open Citation (OpCit)* project (Hitchcock *et al.*, 2002). This project aimed to investigate the

[4] http://www.citebase.org/

benefits of automatically adding hyperlinks to citations in online scholarly publications. Like CiteSeer, Citebase is a freely available web-based tool. However, one difference between the two tools is that CiteSeer indexes papers available on the entire Web, whereas Citebase gathers reference information from discipline-specific e-print archives such as *arXiv*[5] (Physics), *CogPrints*[6](Cognitive Science), and *BioMed Central*[7](Bio-Medicine).

Like CiteSeer, Citebase offers end-user functionality that is based in large part on citation analysis techniques. Figure 2-5 shows part of the list of publications retrieved by Citebase after a search for "string theory". Similar to CiteSeer, Citebase makes use of the citation counting method as a ranking mechanism – in this case the list of publications retrieved for the "string theory" search is ranked by citation count.

[5] http://arxiv.org/
[6] http://cogprints.soton.ac.uk/
[7] http://ww.biomedcentral.com/



Search Results

Metadata | Citation | Identifier

Authors' name(s)

Title or Abstract Keywords string theory

Publication Title

Record Year between and

Rank matches by Descending Citations (Paper) Search Reset

Showing 1 - 10 of 10088 found [1-10 in BibTeX, RSS, Atom | 25, 100 results per page] Query took 2.353 seconds

The Large N Limit of Superconformal Field Theories and Supergravity [Abstract, 4195 Cites,]
4195 Maldacena, Juan M. (1997-11-27) In *International Journal of Theoretical Physics 38 1113 (1999)*
We show that the large N limit of certain conformal field theories in various dimensions include in their Hilbert space a sector describing supergravity on the product of Anti-deSitter spacetimes, spheres and other compact manifolds. This is shown by taking some branes in the full M/string theory and then taking a low energy limit where the field theory on the brane decouples from the bulk. We observe that, in this limit, we can still trust the near horizon geometry for large N. The enhanced supersym ... Comment: 20 pages, harvmac, v2: section on AdS_2 corrected, references added, v3: More references and a sign in eqns 2.8 and 2.9 corrected

Anti De Sitter Space And Holography [Abstract, 2897 Cites,]
2897 Witten, Edward (1998-02-20) In *Advances in Theoretical and Mathematical Physics 2 253 (1998)*
Recently, it has been proposed by Maldacena that large N limits of certain conformal field theories in d dimensions can be described in terms of supergravity (and string theory) on the product of d+1-dimensional AdS space with a compact manifold. Here we elaborate on this idea and propose a precise Comment: 40 pp.; additional references and assorted corrections

Gauge Theory Correlators from Non-Critical String Theory [Abstract, 2562 Cites,]
2562 Gubser, S. S.; Klebanov, I. R.; Polyakov, A. M. (1998-02-16) In *Physics Letters B 428 105 (1998)*
We suggest a means of obtaining certain Green's functions in 3+1-dimensional N = 4 supersymmetric Yang-Mills theory with a large number of colors via non-critical string theory. The non-critical string theory is related to critical string theory in anti-deSitter background. We introduce a boundary of Comment: 15 pages, harvmac with btxmac; minor revisions, 1 reference added, the version to appear in Physics Letters B

New Dimensions at a Millimeter to a Fermi and Superstrings at a TeV [Abstract, 2090 Cites,]
2090 Antoniadis, I.; Arkani-Hamed, N.; Dimopoulos, S. et al (1998-04-24) In *Physics Letters B 436 257 (1998)*
of gravity at long distances is due the existence of large new spatial dimensions. In this letter, we show that this framework can be embedded in string theory. These models have a perturbative description in the context of type I string theory. The gravitational sector consists of closed strings propagating in the higher-dimensional bulk, while ordinary matter consists of open strings living on D3-branes. This scenario raises the exciting possibility that the LHC and NLC will experimentally study both ordinary aspects of string physics such as the production of narrow Regge-excitations of all standard model particles, as well more exotic phenomena involving strong gravity ... Comment: 12 pages, latex

String Theory and Noncommutative Geometry [Abstract, 1801 Cites,]

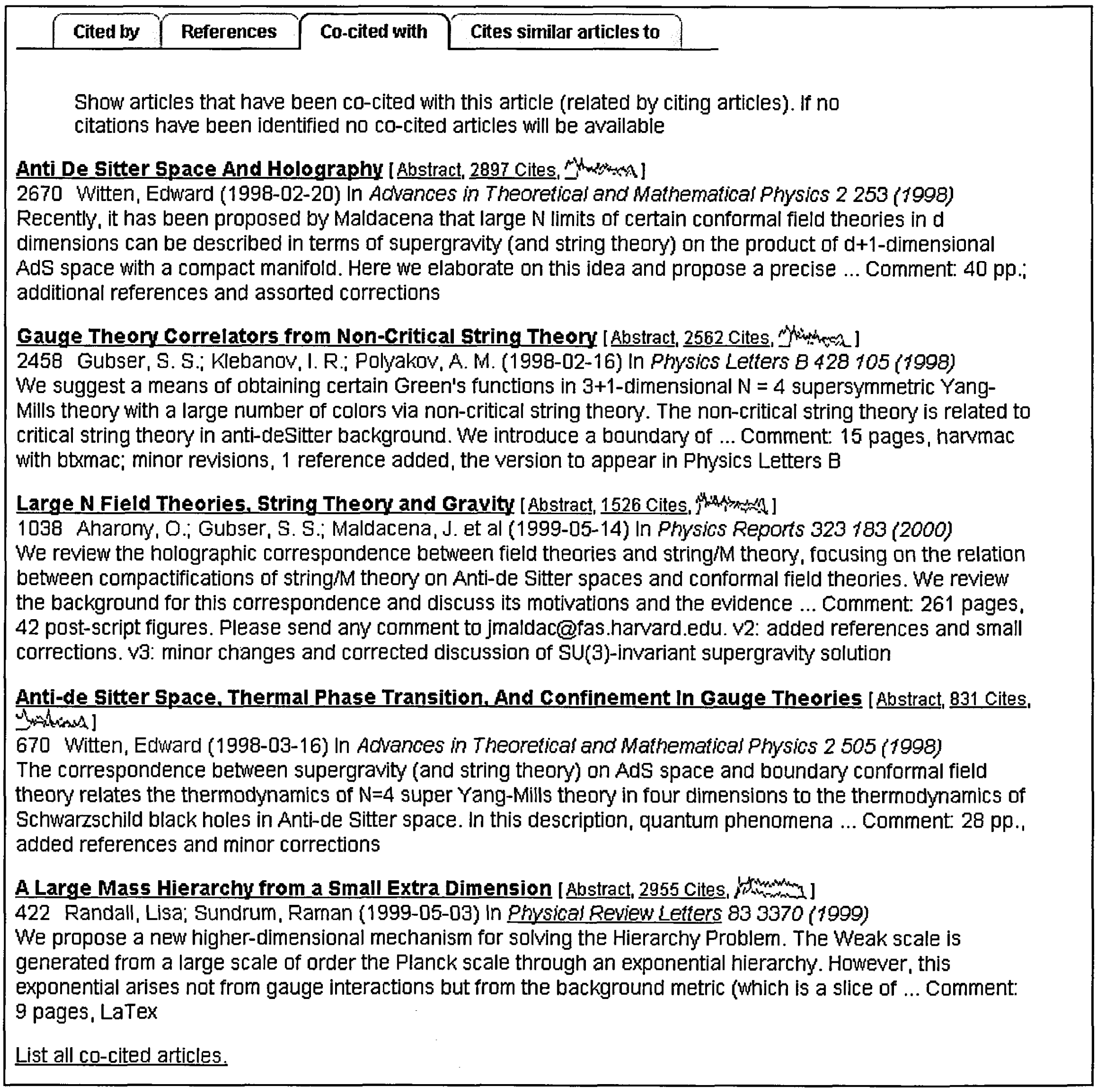
Figure 2-5 - The results, ranked by citation count, of searching in Citebase for publications about "string theory". For each publication returned in the results, the user is able to click to view the Abstract, the total number of citations to that publication, and a graph of the publication's citation history. This is an update of the figure provided by Hitchcock et al. (2002) and reflects the most recent tool interface. (Search performed 12 February 2007).

With regard to citation analysis inferences, Citebase also utilises co-citation analysis and bibliographic coupling as a way of determining similarity or general relatedness between publications. Citebase can retrieve, for a given publication *P*:

- All the publications citing *P*;
- All the publications cited by *P*;
- All the publications co-cited with *P*;

- All the publications bibliographically-coupled with *P*

Figure 2-6 shows a screenshot of publications that are co-cited with the first publication retrieved in the "string theory" search performed previously, while Figure 2-7 shows, for the same publication, a screenshot of other publications that are bibliographically coupled with it. Note that in both cases the list of publications displayed is ranked according to citation count.


Cited by | References | Co-cited with | Cites similar articles to

Show articles that have been co-cited with this article (related by citing articles). If no citations have been identified no co-cited articles will be available

Anti De Sitter Space And Holography [Abstract, 2897 Cites,]
2670 Witten, Edward (1998-02-20) In *Advances in Theoretical and Mathematical Physics 2 253 (1998)*
Recently, it has been proposed by Maldacena that large N limits of certain conformal field theories in d dimensions can be described in terms of supergravity (and string theory) on the product of d+1-dimensional AdS space with a compact manifold. Here we elaborate on this idea and propose a precise ... Comment: 40 pp.; additional references and assorted corrections

Gauge Theory Correlators from Non-Critical String Theory [Abstract, 2562 Cites,]
2458 Gubser, S. S.; Klebanov, I. R.; Polyakov, A. M. (1998-02-16) In *Physics Letters B 428 105 (1998)*
We suggest a means of obtaining certain Green's functions in 3+1-dimensional N = 4 supersymmetric Yang-Mills theory with a large number of colors via non-critical string theory. The non-critical string theory is related to critical string theory in anti-deSitter background. We introduce a boundary of ... Comment: 15 pages, harvmac with btxmac; minor revisions, 1 reference added, the version to appear in Physics Letters B

Large N Field Theories, String Theory and Gravity [Abstract, 1526 Cites,]
1038 Aharony, O.; Gubser, S. S.; Maldacena, J. et al (1999-05-14) In *Physics Reports 323 183 (2000)*
We review the holographic correspondence between field theories and string/M theory, focusing on the relation between compactifications of string/M theory on Anti-de Sitter spaces and conformal field theories. We review the background for this correspondence and discuss its motivations and the evidence ... Comment: 261 pages, 42 post-script figures. Please send any comment to jmaldac@fas.harvard.edu. v2: added references and small corrections. v3: minor changes and corrected discussion of SU(3)-invariant supergravity solution

Anti-de Sitter Space, Thermal Phase Transition, And Confinement In Gauge Theories [Abstract, 831 Cites,]
670 Witten, Edward (1998-03-16) In *Advances in Theoretical and Mathematical Physics 2 505 (1998)*
The correspondence between supergravity (and string theory) on AdS space and boundary conformal field theory relates the thermodynamics of N=4 super Yang-Mills theory in four dimensions to the thermodynamics of Schwarzschild black holes in Anti-de Sitter space. In this description, quantum phenomena ... Comment: 28 pp., added references and minor corrections

A Large Mass Hierarchy from a Small Extra Dimension [Abstract, 2955 Cites,]
422 Randall, Lisa; Sundrum, Raman (1999-05-03) In *Physical Review Letters 83 3370 (1999)*
We propose a new higher-dimensional mechanism for solving the Hierarchy Problem. The Weak scale is generated from a large scale of order the Planck scale through an exponential hierarchy. However, this exponential arises not from gauge interactions but from the background metric (which is a slice of ... Comment: 9 pages, LaTex

List all co-cited articles.

Figure 2-6 – A list of other publications that are co-cited with the first publication (Maldacena, 1998) about "string theory" retrieved by Citebase (Search performed 12 February 2007).

Cited by | References | Co-cited with | Cites similar articles to

Show articles that share one or more references with this article. If no references have been linked in this article no similar articles will be available

The Bekenstein Formula and String Theory (N-brane Theory) [Abstract, 109 Cites,]
48 Peet, Amanda W. (1997-12-30) In *Classical and Quantum Gravity 15 3291 (1998)*
A review of recent progress in string theory concerning the Bekenstein formula for black hole entropy is given. Topics discussed include p-branes, D-branes and supersymmetry; the correspondence principle; the D- and M-brane approach to black hole entropy; the D-brane analogue of Hawking radiation, and ... Comment: 53 pages, LaTeX. v3: Typos fixed, minor updates, references added, brief Note Added on AdS/CFT

Large N Field Theories, String Theory and Gravity [Abstract, 1526 Cites,]
43 Aharony, O.; Gubser, S. S.; Maldacena, J. et al (1999-05-14) In *Physics Reports 323 183 (2000)*
We review the holographic correspondence between field theories and string/M theory, focusing on the relation between compactifications of string/M theory on Anti-de Sitter spaces and conformal field theories. We review the background for this correspondence and discuss its motivations and the evidence ... Comment: 261 pages, 42 post-script figures. Please send any comment to jmaldac@fas.harvard.edu. v2: added references and small corrections. v3: minor changes and corrected discussion of SU(3)-invariant supergravity solution

Dynamics of D-brane Black Holes [Abstract, 3 Cites,]
39 Gubser, Steven S. (1999-07-31) oai:arXiv.org:hep-th/9908004
We explore the interplay between black holes in supergravity and quantum field theories on the world-volumes of D-branes. A brief summary of black hole entropy calculations for D-brane black holes is followed by a detailed study of particle absorption by black holes whose string theory description ... Comment: 117 pages, PhD thesis, completed June 1998. A few requests for copies suggested this hep-th version

Six-Dimensional Supergravity on S^3 X AdS_3 and 2d Conformal Field Theory [Abstract, 130 Cites,]
30 de Boer, Jan (1998-06-12) In *Nuclear Physics B 548 139 (1999)*
In this paper we study the relation between six-dimensional supergravity compactified on S^3 X AdS_3 and certain two-dimensional conformal field theories. We compute the Kaluza-Klein spectrum of supergravity using representation theory; these methods are quite general and can also be applied to other ... Comment: 32 pages, LaTeX; minor corrections, reference added

Black hole dynamics from instanton strings [Abstract, 4 Cites,]
25 Costa, Miguel S. (1998-07-24) In *JHEP 9811 007 (1998)*
A D-5-brane bound state with a self-dual field strength on a 4-torus is considered. In a particular case this model reproduces the D5-D1 brane bound state usually used in the string theory description of 5-dimensional black holes. In the limit where the brane dynamics decouples from the bulk the Higgs ... Comment: 37 pages, latex. Typos corrected, SUSY field configuration argued to be valid even when DBI corrections are important and two references added

List all articles co-citing with this one.

Figure 2-7 - A list of other publications that are bibliographically coupled with the first publication (Maldacena, 1998) about "string theory" retrieved by Citebase (Search performed 12 February 2007).

Google Scholar

Google Scholar[8] is regarded by some authors as representative of a new generation of citation indices (Noruzi, 2005). It is a derivative of the popular search engine Google but with a particular focus on indexing full-text journal articles, technical reports, preprints, theses, books, and other academic documents that are stored in various digital archives across the Internet (Vine, 2006). These digital archives tend to have limited proprietary search engines that can only reliably search on bibliographic records, abstracts, and subject terms. Google Scholar, however, is able to create indices from the full-text (or

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

at least a significant portion of the text) of scholarly publications. Thus the greatest beneficiaries of Google Scholar are those users who have subscriptions to a number of existing digital archives but have no means of performing a single, federated search for the full text across these different archives[9].

In terms of functionality based on citation analysis techniques, Google Scholar uses the citation counting method to rank the relevance of scholarly publications it receives as a result of a query. However, as with the main Google search engine, the details of the relevance-ranking algorithm are closely guarded, and it isn't clear whether ranking is based solely on formal citations or whether they are also influenced by Web-based links. Indeed, it is perhaps because of this obscurity that some authors have questioned the reliability of ranked results retrieved by Google Scholar (Kesselman and Watstein, 2005).

Figure 2-8 shows the results of a keyword search in Google Scholar for "string theory". As the figure reveals, Google Scholar allows the user to view *All articles* or the *Recent articles*. The figure also shows that for a given article, Google Scholar allows the user to retrieve the articles citing that article, as well as other related articles (though it isn't clear exactly how this relatedness is determined).

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[9] Jasco (2005), however, warns against assuming that because Google Scholar has access to many digital archives that it necessarily indexes a large number of articles within each archive.

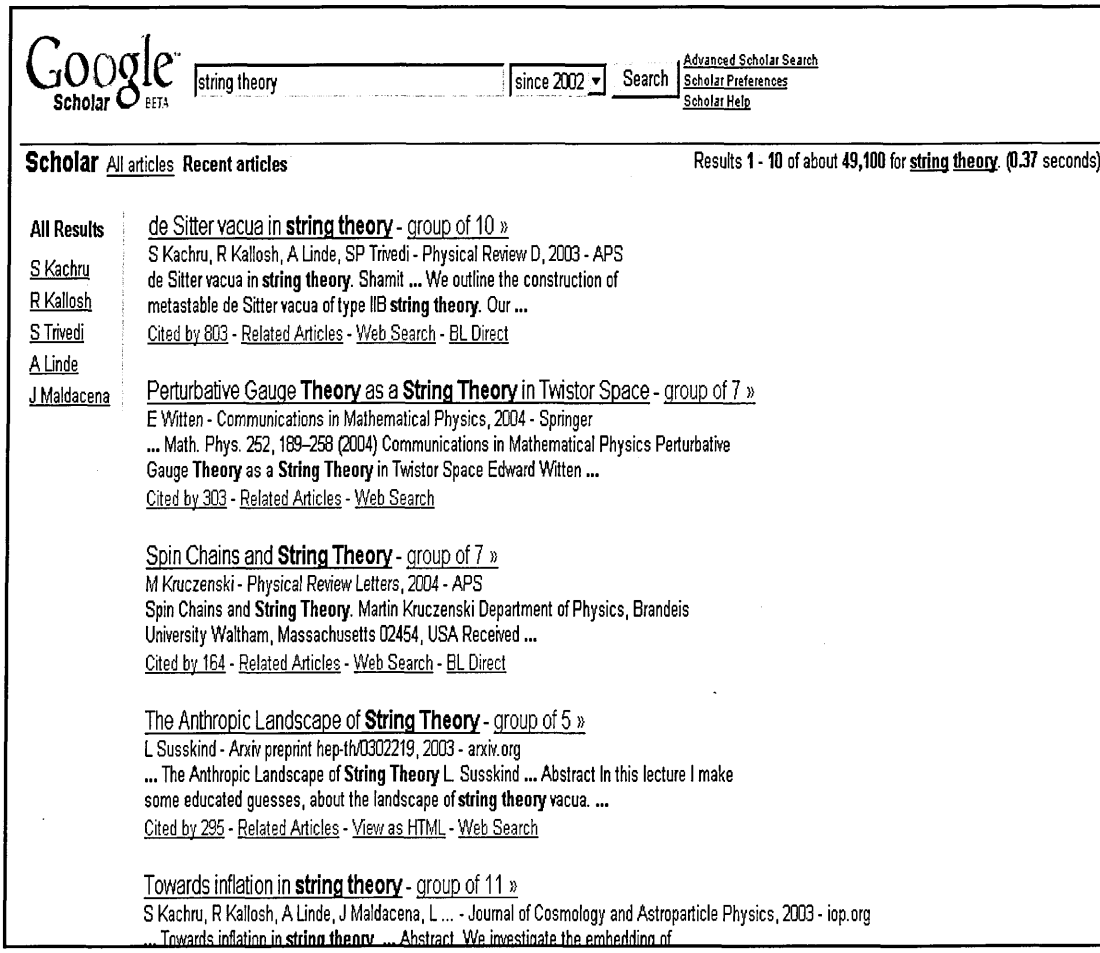

Figure 2-8 - Google Scholar's retrieval of recent articles on "string theory": The user is also able to retrieve other articles citing or related to any given article (Search performed 12 February 2007).

CiteSpace

CiteSpace (Chen, 2004; 2006) is a tool for visualising co-citation networks "with a primary goal of facilitating analysis of emerging trends in a knowledge domain" (Chen, 2006). Of the citation-based tools reviewed in this section, CiteSpace provides the most advanced KDA functionality. It is able to use the basic co-citation inference pattern as the basis for more advanced functionality such as identifying significant *intellectual structures* (e.g. prominent research fronts) in a given knowledge domain. Furthermore, recognising that scientific networks constantly change over time, the tool enables users to identify significant temporal patterns in a knowledge domain. These temporal patterns are a means of monitoring paradigm shifts in a knowledge domain over time. The author claims that the tool has potential benefit for a wide range of users including scientists, science policy advisors, and research students, since it provides a "roadmap" of a given knowledge domain and allows the user to detect and visualise changes in that domain over time.

In a typical usage scenario, the user first identifies a knowledge domain using the broadest possible search term. The tool then collects the relevant bibliographic data from sources such as the *Thomson ISI Web of Science*[10] or the *PubMed*[11] repository and extracts candidate research-front keywords from titles and abstracts. These keywords act as candidate descriptors for research fronts in the domain. Next, the tool performs a co-citation analysis that is used as the basis for generating a visualisation of the knowledge domain. The user is able to interact with the visualisation to gain new insights about the domain

Figure 2-9, reproduced from Chen (2006), shows how nodes, which correspond to publications in a knowledge domain (in this case the Palaeontology domain), are visualised in CiteSpace. The visualisation depicts a number of attributes of each publication, such as the years when the publication was cited (depicted using differently coloured rings around a given node), the number of citations in each of those years (depicted using the thickness of the ring around a given node), the total number of citations throughout its history, and the other publications with which it is co-cited.

[10] http://scientific.thomson.com/products/wos
[11] http://www.pubmedcentral.nih.gov

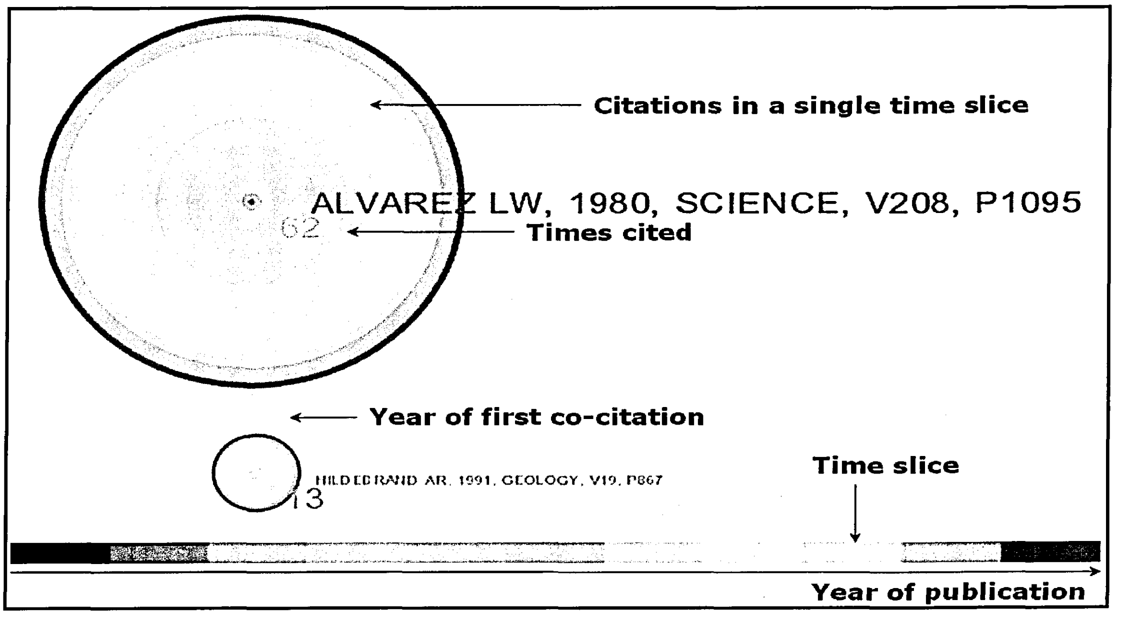

Figure 2-9 - The visualisation, in CiteSpace, of two co-cited publications, Alvarez (1980) and Hildebrand (1991), in the Palaeontology domain: The citation ring around each publication node represents the citation history of that publication. The colour of the citation ring denotes the time of corresponding citations. The thickness of a ring is proportional to the number of citations in a given time slice. The number next to the centre of a publication node is the citations throughout the entire time interval, 62 in the case of Alvarez (1980) and 13 in the case of Hildebrand (1991). (Reproduced from Chen, 2006).

Figure 2-10, also reproduced from Chen (2006), shows how more advanced cluster analysis of the co-citation data is used to identify the main research fronts in the *Terrorism* domain. The visualisation combines citation data with the candidate research-front keywords that would have been extracted earlier in the analytical process.

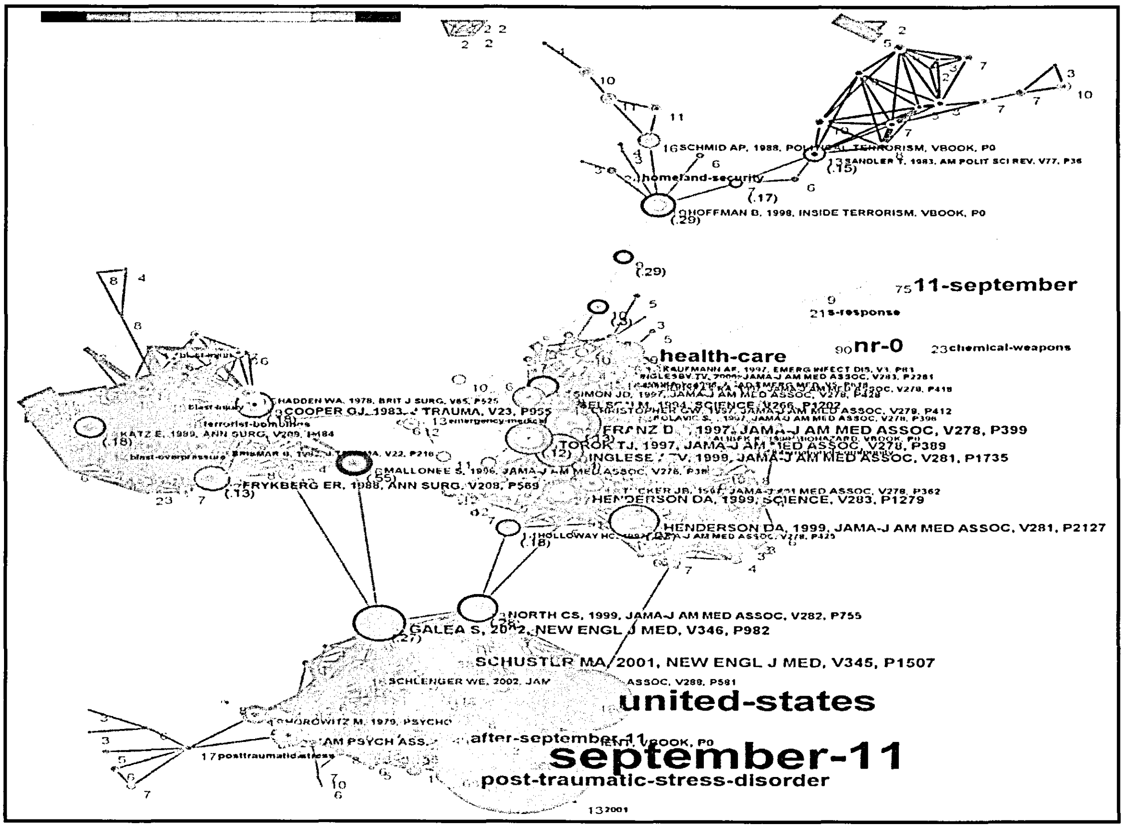

Figure 2-10 - The prominent clusters (research fronts) in the Terrorism domain, as depicted in CiteSpace: The visualisation is annotated with keywords from the domain (Reproduced from Chen, 2006).

2.2 *Ontology-based KDA technology*

This section begins by discussing the characteristics of ontology-based representation and reasoning (§2.2.1). This is followed by a description of specific examples of ontology-based tools for analysing knowledge domains (§2.2.2).

2.2.1 Characteristics of ontology-based representation and reasoning

The main characteristic of ontology-based KDA technology research is the formal representation of knowledge domains based on a pre-specified conceptual model of the types of entities and types of relations between entities that make up a knowledge domain. Such a conceptual model is typically referred to as an *ontology*. More precisely, an ontology is often defined as an *explicit* specification of a conceptual model, where the conceptual model (or conceptualisation) is an abstract view of some *world of interest* that needs to be represented for some purpose (Gruber, 1995).

Thus, ontologies are *design artefacts* that formalise the conceptualisation of the types of entities and types of relations in the world being represented. Once it has been specified, an ontology can then be used as a template for representing *particular facts* (i.e. instantiations of entity types and relation types) about a particular world of interest. These facts are represented in what is called a *knowledge base*. The ontology and the knowledge base then form the core components of what is characterised as an intelligent information system.

In addition to the types of entities and types of relations in some world, an ontology also specifies the reasoning or *inferencing* capability of the information systems of which it is a part. 'Inferencing' refers to the process of deriving new facts not recorded in the knowledge base, on the basis of two sources – (a) other facts which have already been represented in the knowledge base and (b) *inference rules* that are specified as part of the ontology (Grenon, 2008).

Although ontologies provide reasoning support for information systems, they are intended as application-neutral specifications of a world of interest. This application-neutrality is essential if ontologies are to be suitable for reuse across different information systems, which some authors (e.g. Motta, 1999) have suggested is a fundamental role of ontologies. Application-neutrality is also important if ontologies are to be suitable for large-scale integration and interoperability of software systems, which has also been recognised by some authors (Guarino, 1995) as a fundamental role of ontologies.

Furthermore, the application-neutrality of ontologies allows them to play a key role when trying to establish agreement between people or between software systems about "shared assumptions and models of the world" (Gruber, 1995). For this role, what are called *upper-level* ontologies are regarded as particularly useful. Upper-level ontologies are concerned with the structure of reality at a high-level of generality, and the ontology categories at this upper-level are intended to be applied and specialised in more restricted application domains. Thus, upper-level ontologies are not only regarded as application-neutral but also as application-*domain* neutral. Because of their generality and ability to specify ontology categories that can be mapped across more specialised ontologies, upper-level ontologies can be used as design tools for linking and comparing the ontologies of different information systems and even of different worlds of interest.

The most recent and prominent example of the ontology-based representation and reasoning approach is research into developing a *semantic Web,* where ontologies are used as vocabularies for annotating information resources that are found on the Web. This annotation process produces metadata that represents some computable aspect of the meaning conveyed by these information sources. This 'computable meaning' is often referred to as the *semantics* of these information sources.

2.2.2 Examples of ontology-based KDA technology

This section describes examples of ontology-based KDA tools and the various ontologies that underly these tools. Each ontology provides, firstly, a vocabulary for constructing semantic representations of knowledge domains, and secondly, inference rules that can be applied to the semantic representations to enable precise queries to be asked and answered about the knowledge domain. The tools reviewed are *Bibster*, *Flink*, *ESKIMO*, *CS AKTive Space*, and *ClaiMaker*.

Bibster

Bibster is a tool for asking queries about academic publications. Haase *et al.* (2004) envisage a use-case scenario of a researcher semantically searching through bibliographic data for publications that are of a specific type (e.g. article, book, technical report, etc.), that have specific attributes (e.g. author, year of publication, number of pages, etc.), and that are about a specific topic (e.g. biology, psychology, physics, etc.).

Figure 2-11, reproduced from Haase *et al.* (2004), shows the result of a query for *journal articles* written by authors with the surname *Codd* about the topic of *database* *management*[12]. The result is shown as a semantic network of nodes and links. The network depicts the results of the query as an article (represented by the *codd_70_relational* node) with title "A relational model for large shared data banks", published in the year 1970 in the journal "Communications of ACM". In the semantic network, the ellipses depict types of entities defined in the Bibster system's underlying ontology as well as instances of these types, while the boxes depict number and string-literal values. Relations between entities are depicted as labelled links in the network.

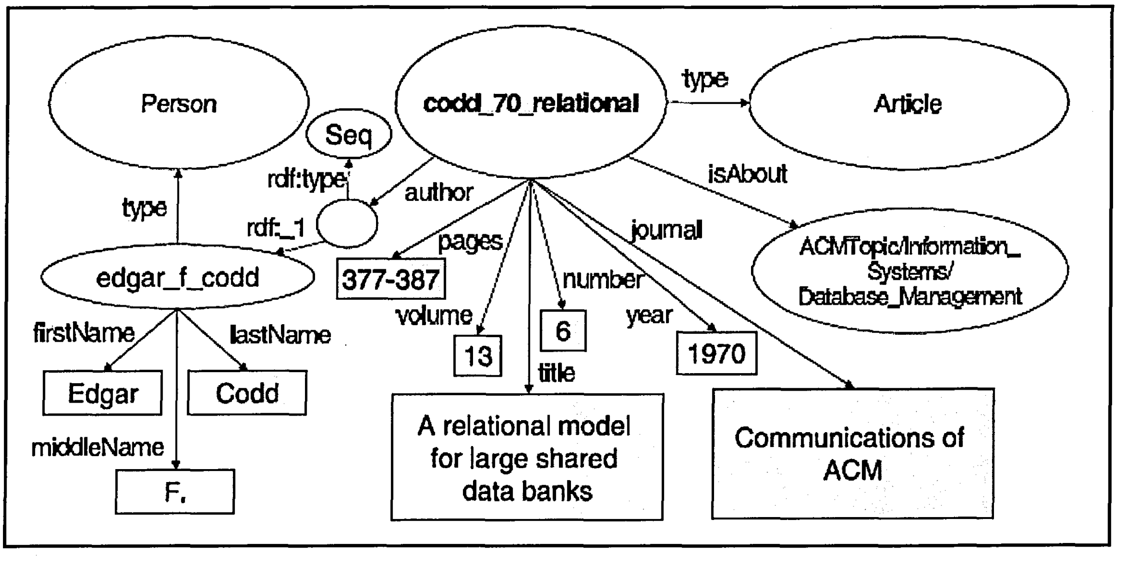

Figure 2-11 - The semantic network returned by the query for a journal article about 'Database Management' authored by 'Codd': The article is represented by the *codd_70_relational* node in the network, and this node has a number of labelled links to other nodes in the network that provide additional information about the article, such as its title and the journal it can be found in. (Reproduced from Haase *et al.*, 2004).

The entity types depicted in the previous query results such as *Article* and *Person* are specified in an underlying ontology called the *Semantic Web Research Community (SWRC)* ontology. This ontology specifies over 70 classes that cover common elements of bibliographic metadata as typically found in BibTeX files or in online bibliography servers such as *DBLP*[13] or CiteSeer (Sure *et al.*, 2005). In addition to bibliographic metadata

[12] From an implementation perspective, queries to the Bibster system are formalised in the Sesame RDF Query Language (SeRQL): http://www.openrdf.org/doc/SeRQLmanual.html
[13] http://dblp.uni-trier.de/db

elements, the SWRC ontology also specifies other knowledge domain entities such as research projects, universities, and conferences.

The previous query results also depict the concept *ACMTopic/Information_Systems/Database_Management* that the publication *isAbout*. An important feature of the Bibster tool is its ability to import specialist domain vocabulary so that the tool can be used to represent and reason about different knowledge domains. It is this feature which allows users to not only submit queries to Bibster about common bibliographic terms from the SWRC ontology, but also to submit queries concerning terms from the specialist domain vocabulary. As a proof-of-concept, the tool currently imports the ACM Computing Classification System[14], which describes over 1200 topics, organised in a topic-subtopic hierarchy, in the Computer Science domain. To import the ACM Computing Classification System, the individual topics in the classification are modelled as instances of the *Topic* class in the SWRC ontology.

Figure 2-12 shows a semantic-network-like visualisation of the main classes and relations in the SWRC ontology. In this and subsequent ontology figures, the graphical convention used is for 'hollow-triangle' arrowheads to depict 'subclass-of' relations between classes and for 'wedge' arrowheads to depict any other named relation between classes.

[14] http://www.acm.org/class/1998/TOP.html

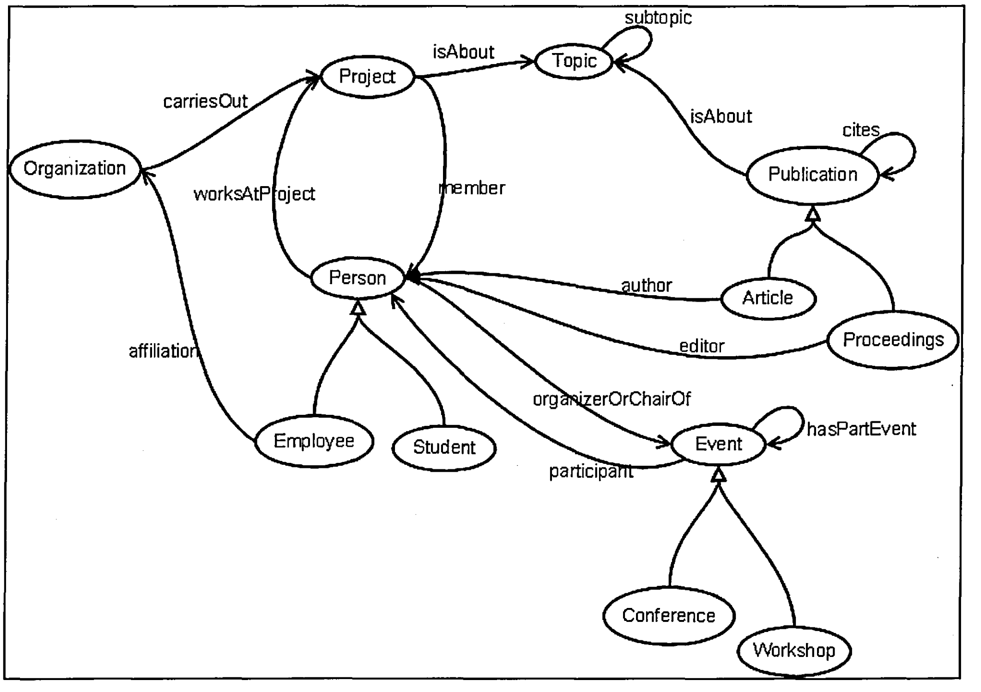

Figure 2-12 - The SWRC Ontology. The graphical convention is that 'hollow-triangle' arrowheads depict 'subclass-of' relations (e.g. *Employee* is a subclass-of *Person*) and 'wedge' arrowheads to depict any other named relation between classes.

Flink

Flink is a tool for analysing social networks in scholarly communities, the main goal of which is to support users in learning about the nature of power and innovativeness in scholarly communities. The tool combines existing social network analysis techniques with novel semantic technologies for storing, aggregating, and reasoning with social networks data (Mika *et al.*, 2006).

The functionality provided by Flink includes enabling users to determine the immediate neighbourhood in the social network for a given researcher – referred to as the *ego-network* of the researcher. Also, for a given researcher in the social network, the user is able to retrieve basic network statistics such as *indegree* (the number of connections, such as co-authorship, directed to the researcher), *closeness* (how short the paths between the researcher in question and all other researchers are), and *betweenness* (how often the researcher in question acts as a bridge between two other researchers). These are commonly used measures of importance or influence in social networks. Finally, the user is able to detect *cohesive subgroups* within the social network of the community.

Flink uses an ontology that includes elements of the *Friend-of-a-Friend (FOAF)* ontology and minimal extensions required to represent additional information (Mika, 2007). The Flink ontology is used as a template for constructing academic profiles and academic social networks on the Web. The social network ties in Flink are represented using the *knows* relation from the FOAF ontology. The FOAF ontology is also used to represent information about senders and receivers of emails, as well as the link between persons and research interests (using the *topic_interest* relation). Furthermore, Flink extends the FOAF ontology by incorporating the *SpatialThing* class from the W3C basic Geo ontology[15] to represent the geographical location (latitude and longitude coordinates) of a person. The FOAF ontology also imports elements of the WordNet ontology for the definition of classes in the FOAF ontology such as *Person* and *Organisation.* Finally, in Flink, publication metadata is expressed using the vocabulary specified in the SWRC ontology (i.e. the same ontology used by the Bibster tool described previously). Figure 2-13 shows a semantic-network-like visualisation of the main classes and relations in the Flink ontology. In the figure, those classes imported from the Geo ontology are prefixed with *geo:,* while those classes taken from the WordNet ontology are prefixed with *wordnet:*.

[15] http://www.w3c.org/2003/01/geo

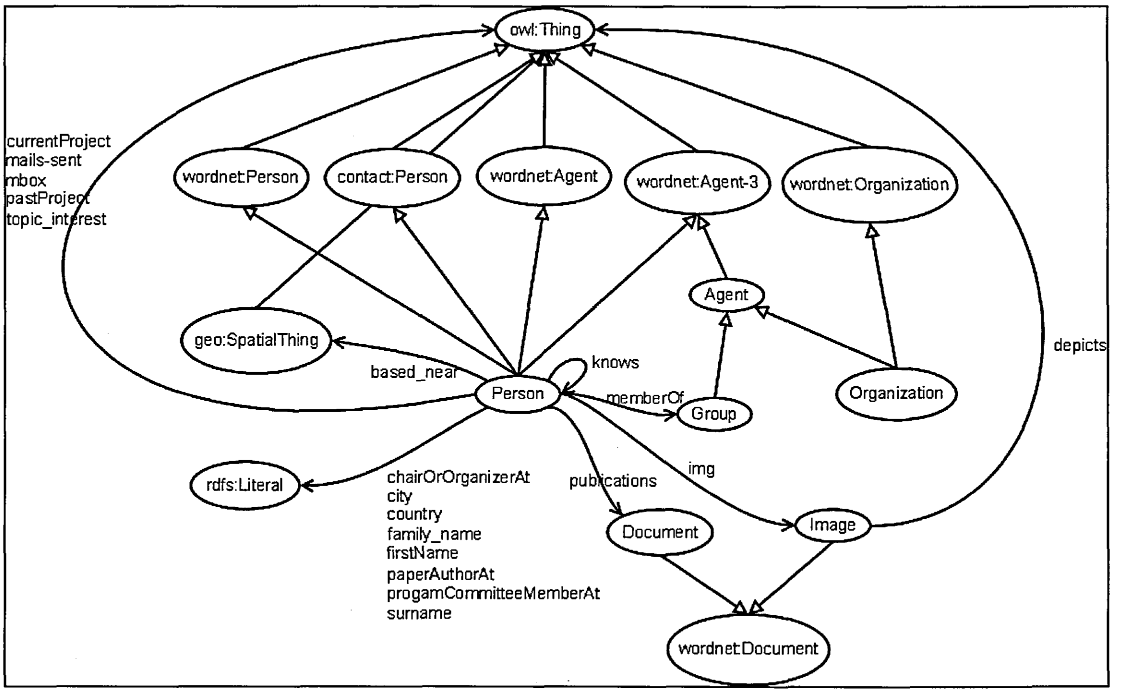

Figure 2-13 - The Flink ontology: those classes imported from the Geo ontology are prefixed with *geo:*, while those classes taken from the WordNet ontology are prefixed with *wordnet:*.

The Flink ontology also defines a number of inference rules for reasoning with social relationships. For example, there is a rule which states that the co-authors of publications are persons who have a *knows* relation between them. Such basic inferences are then used to underpin more advanced reasoning services.

As a test case, Mika (2007) uses Flink to capture the social network of the Semantic Web research community (a community at that time consisting of over 600 members). Figure 2-14 shows the social network and basic network statistics (indegree, closeness, betweeness, etc.) of Semantic Web community member *Pat Hayes*.

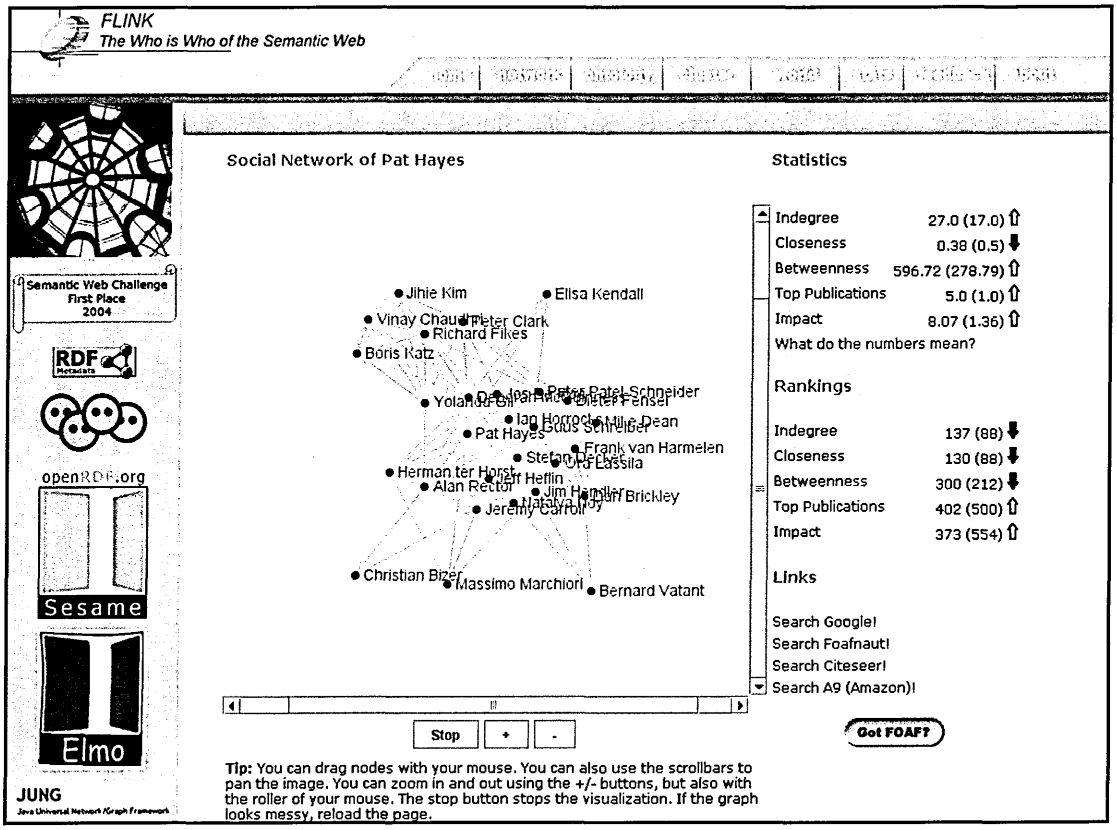

Figure 2-14 - The social network of Pat Hayes as retrieved by Flink: Network statistics such as 'indegree' and 'closeness' have also been calculated. (Retrieved on 28 February 2007).

In addition to a social network analysis of a scholarly community, Flink can also use information about the topical research interests of researchers to generate what Mika (2005) calls the *cognitive structure* of a specific research community. Figure 2-15, reproduced from Mika (2007), shows the cognitive structure generated for the Semantic Web research community. The nodes in the cognitive structure represent the specialist domain topics manually extracted from the proceedings of one of the premier conferences in the community. The links in the cognitive structure represent the associations between research topics. An association is inferred between two topics if a researcher has interest in both topics. The strength of association between two topics is then calculated based on the number of researchers who have interest in that topic pair.

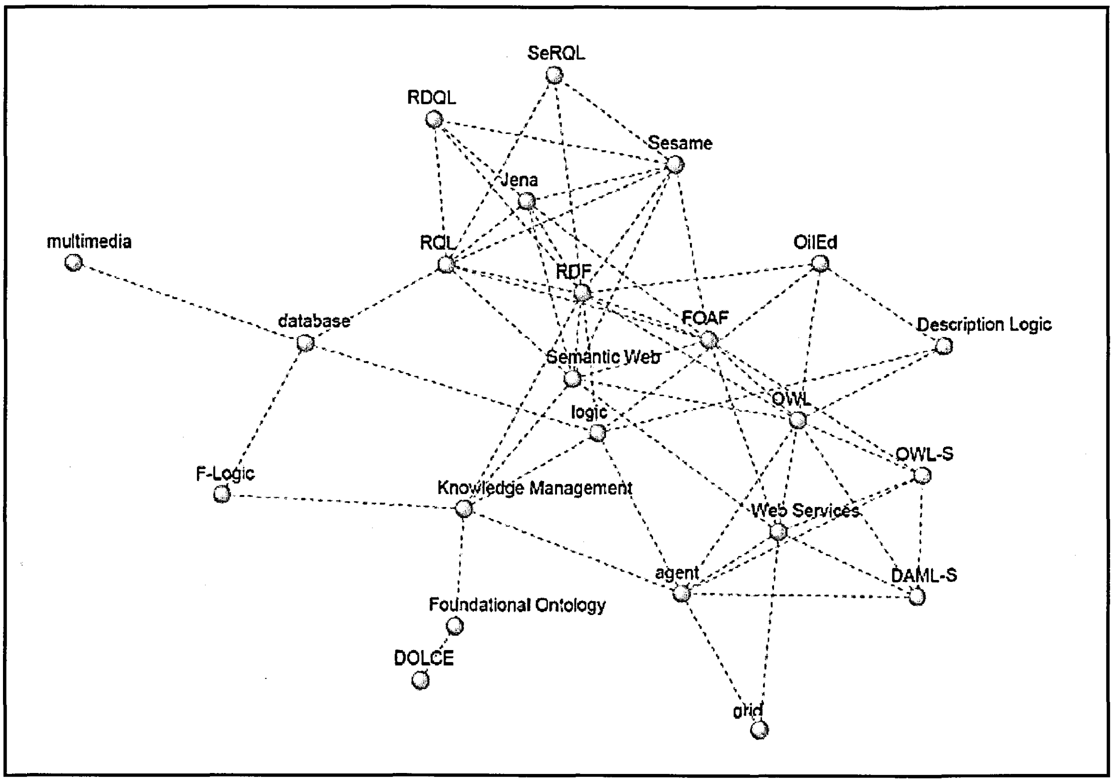

Figure 2-15 - The 'cognitive structure' of the Semantic Web research community as identified by Flink: Nodes represent research topics and links represent associations between research topics which are determined based on whether a researcher has interest in two given topics. (Reproduced from Mika, 2007).

ESKIMO

The E-Scholar Knowledge Inference Model (ESKIMO) tool was developed as part of the PhD research described in Kampa (2002). The purpose of the tool is to support users in quickly grasping and becoming proficient with the complexities of a given knowledge domain. The user-tasks that ESKIMO supports include reviewing a journal paper and completing a literature survey. The tool also enables the user to identify who the experts are in a research community as another means of giving an overview of a particular knowledge domain.

Table 2-1 shows a list of queries that ESKIMO supports. The first five queries in the table rely on some of the traditional citation analysis techniques that were introduced earlier in this chapter (*Cf.* §2.1.1). These queries support new scholars in understanding their domain from a purely bibliographic viewpoint via the discovery of research fronts and trends. Kampa argues that the remaining ten queries improve on the citation-based approach by considering additional features of scholarly communities. For example, rather than just use co-authorship as an indicator of collaboration, ESKIMO also determines collaborations in terms of the research teams and activities in which researchers participate. In addition, by extending the analysis beyond citations, ESKIMO can determine who the experts are, based on the activities in which researchers participate, the journals they edit, and the research teams of which they are members.

Table 2-1 - The types of queries that ESKIMO supports.

Type	Query
Citation-based queries	What are the most co-cited publications?
	What publications are often co-cited with this one?
	What are the most bibliographically coupled publications?
	What publications are highly coupled to this one?
	What impact has this journal had?
Ontology-based queries	What impact has this {team, organisation, conference, activity, person} had?
	Which {teams, organisations, activities, persons} collaborate with this one?
	With which {teams, persons} has this {team, person} frequently been co-cited?
	What {teams, organisations, activities, persons} have been regularly co-cited?
	Which {teams, organisations, activities, persons} collaborate the most?
	What are the seminal publications?
	What are the significant {teams, organisations, activities, conferences, journals}?
	Who are the experts?

The concepts and relations used to provide the additional ontology-based queries are specified in the underlying ESKIMO ontology, which specifies generic elements of academic knowledge domains. These ontological elements enable the tool to represent the persons, the organisations, the research activities, the research teams, and the conferences that make up the particular knowledge domain. In this regard, the ESKIMO ontology has a similar scope to that of the SWRC ontology. However, it defines fewer classes (15 in total) than the SWRC ontology. Figure 2-16 shows semantic-network-like visualisation of main classes and relations in the ESKIMO ontology.

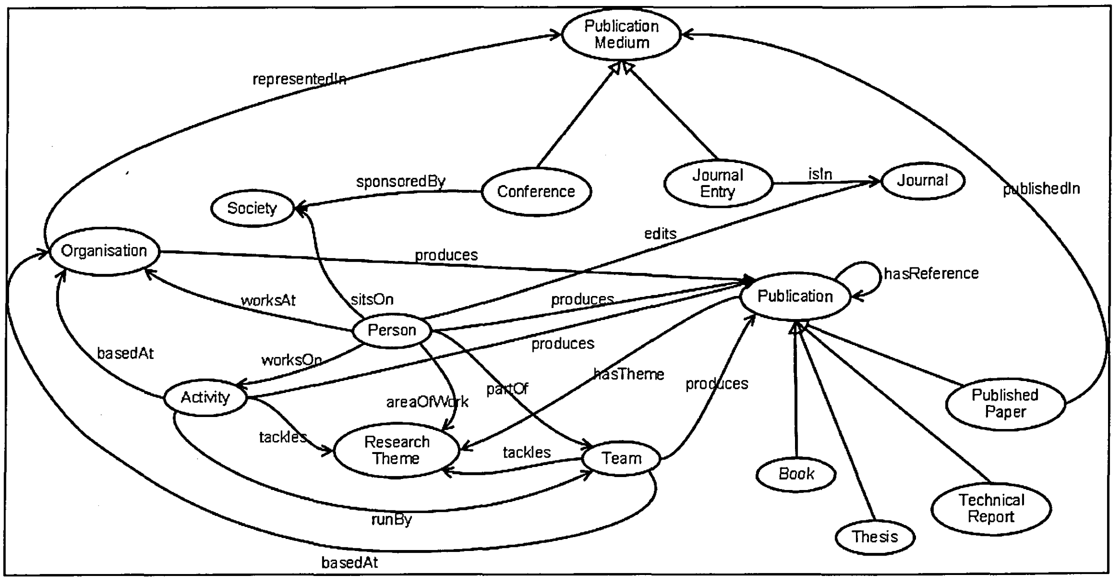

Figure 2-16 - The ESKIMO ontology.

In a case study, the ESKIMO ontology was used to represent data from the *ACM Conference on Hypertext and Hypermedia* series between 1988 and 2000. However, since the ontology specifies common scholarly community entities, a more general scenario was also envisaged where the user provides a corpus of literature for *any* given domain in order to determine, for example, the experts in that particular domain (Kampa, 2002).

CS AKTive Space

CS AKTive Space (CAS) has been developed as part of the *Advanced Knowledge Technologies (AKT)* project[16]. Research on the CAS tool has been largely concerned with the problem of "dynamic content acquisition and delivery" on the Web and with the kinds of visual interfaces that users need in order to engage productively with this dynamic content (Shadbolt *et al.*, 2004). The tool is designed to exploit "a wide range of semantically heterogeneous and distributed content related to Computer Science research in the UK" (schraefel *et al.*, 2004).

An example use case scenario for the CAS tool is an executive of a UK research funding organisation who wants to set up a workshop to discuss research issues for the

[16] http://www.aktors.org

Artificial Intelligence and *Human-Computer Interaction* knowledge domains in the UK. This executive seeks out the best people in the respective domains in the UK to consult about the workshop. In such a scenario, CAS provides functionality that allows the user to investigate the relevant communities of practice for the required information. This functionality includes answering queries such as: *"Who is working, researching or publishing with whom?", "Who are the top researchers in this particular topic?", "Who are the up-and-comers?",* and *"What articles has this particular researcher written about this particular topic?".*

In addition, the end-user is able to investigate particular regions of the country in order to see who, in a given region, is working on which research topics, as well as to explore a given researcher's community of practice to get a sense of where that person ranks in terms of funding-level in that particular knowledge domain (Glaser *et al.*, 2004).

In order to provide this functionality, CAS connects to a repository of RDF data that contains formal information about the UK Computer Science research domain. So, for example, when the user chooses to view a particular *Person* instance, a query is sent to the RDF repository to identify the community of practice of that *Person* instance. The result is returned as a list of persons that form the community of the selected individual. The list is returned to the tool as an RDF file, where it can be further processed for presentation to the end-user. Figure 2-17, reproduced from Schraefel *et al.* (2004), shows the results of a search for the top 5 researchers in the Artificial Intelligence domain. The user, having selected the *NR Shadbolt* result, is able to view information about this person, including his immediate community of practice (CoP).

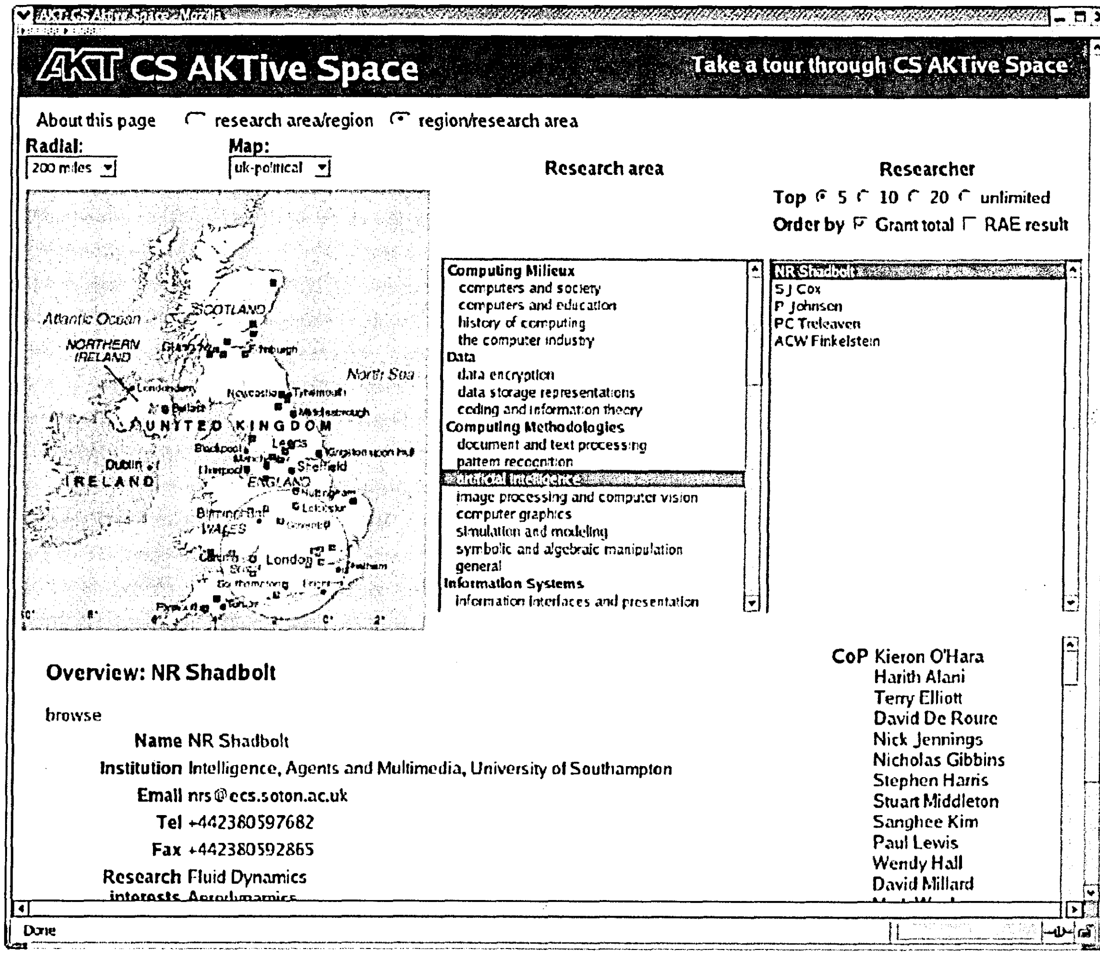

Figure 2-17 - The results of a search for the top 5 researchers in the Artificial Intelligence domain: The user selects the 'NR Shadbolt' result and is then able to view information about this person, including his immediate community of practice or 'CoP'. (Reproducd from Shraefel *et al.*, 2004).

The RDF data stored in the repository is structured according to the schema specified in the *AKT Portal Ontology*. Like the SWRC and the ESKIMO ontologies introduced previously, the AKT Portal Ontology formally specifies common elements of scholarly communities. However, the AKT Portal Ontology defines many more concepts (over 150 in total) and has a broader scope, which includes application-level classes as well as upper-level classes. For example, the ontology is organised under three main upper-level classes: *Temporal-Thing*, *Tangible-Thing*, and *Intangible-Thing*. These upper-level classes are defined in the *AKT Support ontology*. The AKT Portal Ontology imports the AKT Support Ontology and then specialises the AKT Support Ontology in order to define classes and relations for representing knowledge domains. Figure 2-18 shows a semantic-network-like visualisation of the main classes and relations in the AKT Portal ontology. The classes included from the AKT Support Ontology are depicted with the prefix '*support:*'.

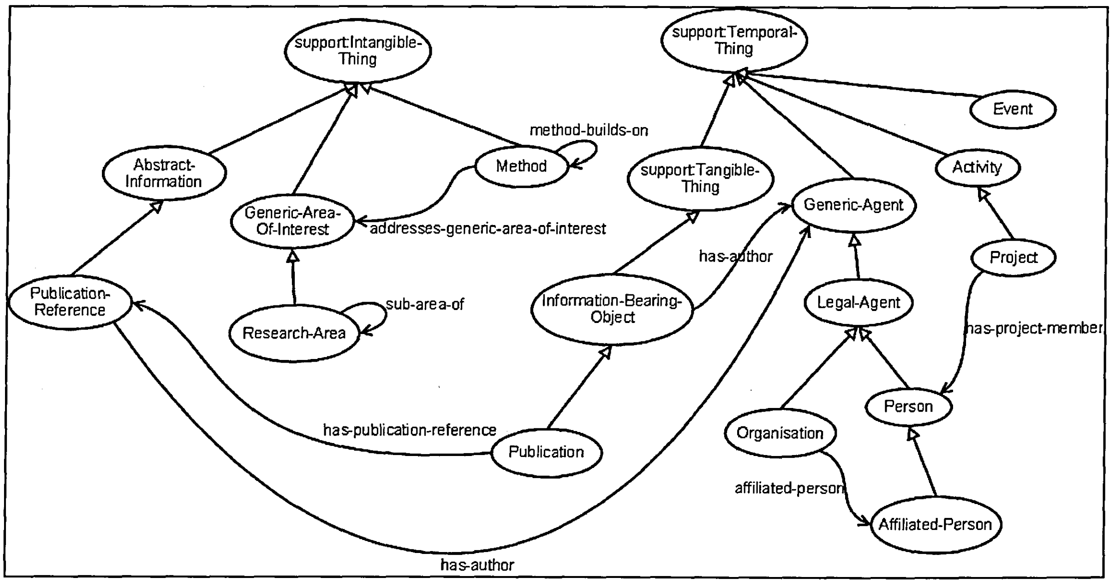

Figure 2-18 - The AKT Portal Ontology: The classes included from the AKT Support Ontology are depicted with the prefix 'support:'.

ClaiMaker

Buckingham Shum *et al.* (2007) pose the question:

> *In 2010, will scholarly knowledge still be published solely as prose, or can we imagine a complementary infrastructure that is 'native' to the emerging semantic, collaborative web, enabling more effective dissemination and analysis of ideas?*

To tackle this question, the *Scholarly Ontologies (ScholOnto)* project has developed ClaiMaker as part of an investigation into the practicality of publishing not only documents, but the conceptual structures that are implicit within the documents (Buckingham Shum *et al.*, 2003). ClaiMaker provides an interface for end-users to manually annotate a document with *claims* about the contributions of that particular document and its relationship to the literature (Li *et al.*, 2002). A search facility is then provided to help users navigate the resulting *network of claims*. This network of claims opens up possibilities for automated analysis of a community's published understanding of ideas. Buckingham Shum *et al.* (2003) refer to this 'analysis of ideas' as *sensemaking*. It is suggested that researchers, when seeking to analyse scholarly literature, are interested in a number of sensemaking queries, such as the following (taken from Buckingham Shum *et al.*, 2007):

- *What publications support and challenge this document?*
- *What is the intellectual lineage of this idea?*
- *What data is there to support this specific claim or prediction?*
- *Who else is working on this problem?*
- *Has this approach been used in other fields?*
- *What logical or analogical connections have been made between these ideas?*

In considering even the first of the above queries, Buckingham Shum *et al.* (2007) find that, despite its centrality to scholarly inquiry, "there is not even a language in which to articulate such a query to a library catalogue system, because there are no indexing schemes with a model of the world of scholarly discourse." It is here that ClaiMaker makes its significant contribution as the only ontology-based KDA tool that is explicitly concerned with the *discourse* dimension of knowledge domains. The representational approach taken by ClaiMaker consists of using an ontology of *scholarly discourse* as a scheme for annotating scholarly documents. Figure 2-19 shows a semantic-network-like visualisation of the main classes and relations in the ClaiMaker ontology.

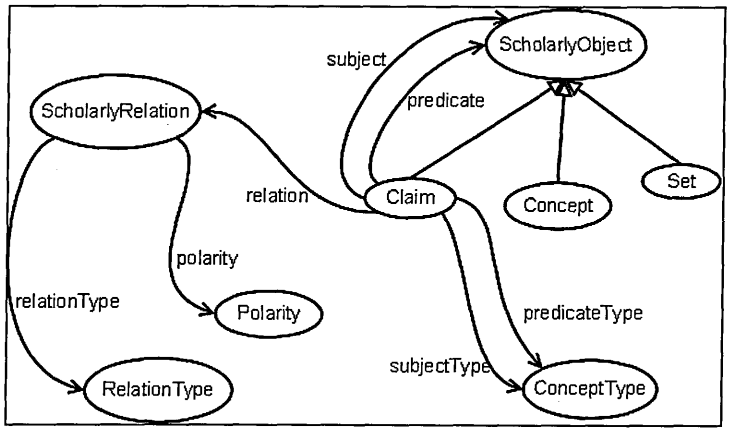

Figure 2-19 - The ClaiMaker ontology.

The top-level classes in the ClaiMaker ontology are *ScholarlyObject, ConceptType, ScholarlyRelation, RelationType*, and *Polarity*. The main unit of discourse analysis that is specified in the ontology is the *Claim*. A *Claim* is defined as a triple consisting of one *ScholarlyObject* (playing the role of 'subject') linked to another *ScholarlyObject* (playing the role of 'predicate') by a *ScholarlyRelation*. A *ScholarlyObject* can be a *Concept* (which is free-text of any length), a *Claim*, or a *Set* (which is a collection of *Concept* instances). This recursive definition of the *Claim* class allows claims to be made up of other claims.

Both the subject and predicate of a claim triple can have an optional *ConceptType*. Instances of *ConceptType* include: *Analysis*, *Approach*, *Assumption*, *Data*, *Definition*, *Evidence*, *Hypothesis*, *Language*, *Methodology*, *Model*, *Opinion*, *Phenomenon*, *Problem*, *Solution*, and *Theory*. Note, however, that the *ConceptType* instance is not permanently attached to the *ScholarlyObject* instance playing the role of subject or predicate; rather the *ConceptType* instance is stored as part of the claim-triple using the *subjectType* and *predicateType* relations. This allows a concept, for instance, to play the role of an *Assumption* in one claim-triple and *Evidence* in another claim-triple.

As mentioned, a claim triple also consists of a *ScholarlyRelation*. The ontology focuses on the kinds of discourse relations that can exist between claims made in scholarly literature, in particular, the most common relations that exist between (e.g.) academic theories, methodologies, and models in the knowledge domain (Motta *et al.*, 2000). The ClaiMaker ontology is unique in two respects: (1) it focuses on the discourse dimension of knowledge domains and (2) it focuses on representing relations as first-class elements in the ontology[17]. With respect to the latter point, the ClaiMaker ontology treats relations as first-class elements because discourse relations can have attributes such as *RelationType* and *Polarity*. In the ontology, each *ScholarlyRelation* instance is linked to an instance of *PolarityType* and an instance of *RelationType*. Instances of *PolarityType* include *Positive* and *Negative*. Instances of *RelationType* include: *General*, *Problem-related*, *Supports-Challenges*, *Taxonomic*, *Similarity*, and *Causal*. Table 2-2, reproduced from Mancini and Buckingham Shum (2006) shows the assignment of *PolarityType* and *RelationType* values to the instances of *ScholarlyRelation*.

Table 2-2 - The assignment of ScholOnto relations to relation classes and the polarity of each relation.

ScholarlyRelation Instance	RelationType	PolarityType
isAbout	GENERAL	+
uses-applies-isEnabledBy	GENERAL	+
improvesOn	GENERAL	+
impairs	GENERAL	-
addresses	PROBLEM RELATED	+
solves	PROBLEM RELATED	+
proves	SUPPORTS/CHALLENGES	+
refutes	SUPPORTS/CHALLENGES	-
isEvidenceFor	SUPPORTS/CHALLENGES	+
isEvidenceAgainst	SUPPORTS/CHALLENGES	-
agreesWith	SUPPORTS/CHALLENGES	+
disagreesWith	SUPPORTS/CHALLENGES	-
isConsistenceWith	SUPPORTS/CHALLENGES	+
isInconsistentWith	SUPPORTS/CHALLENGES	-
partOf	TAXONOMIC	+
exampleOf	TAXONOMIC	+
subclassOf	TAXONOMIC	+
isIdenticalTo	SIMILARITY	+
isSimilarTo	SIMILARITY	+
isDifferentTo	SIMILARITY	-
isTheOppositeOf	SIMILARITY	-
sharesIssuesWith	SIMILARITY	+

[17] Modelling relations as entities is often referred to as the reification of relations

ScholarlyRelation Instance	RelationType	PolarityType
hasNothingToDoWith	SIMILARITY	-
isAnalogousTo	SIMILARITY	+
isNotAnalogousTo	SIMILARITY	-
predicts	CAUSAL	+
envisages	CAUSAL	+
causes	CAUSAL	+
isCapableOfCausing	CAUSAL	+
isPrerequisiteFor	CAUSAL	+
isUnlikelyToAffect	CAUSAL	-
prevents	CAUSAL	-

The design rationale for having such a rich scheme of relations was the need to provide a range of naturalistic phrases that enable the ClaiMaker user to select the relation they regard as most appropriate for their particular modelling task at hand. In other words, the usability of the annotation scheme, in a practical tool was a major design criterion. However, in terms of machine processing, it is the use of the underlying relation-type and polarity, rather than the relation name, which provides the real semantics of the system and which thus forms the basis of ClaiMaker's automated analysis of the network of claims.

ClaiMaker implements two main types of analysis on the network of claims – *Perspective Analysis* and *Lineage Analysis*. Perspective Analysis allows the user to ask *"What arguments are there against this paper?"*. To answer this, the ClaiMaker system first finds all the scholarly objects (i.e. claims, concepts, and sets) that end-users have annotated on to the academic document in question. The system then extends this original set of scholarly objects by adding other scholarly objects, from other documents, that are positively linked to the original set. Now, with an extended set of positively associated scholarly objects, the ClaiMaker system returns all the scholarly objects that have been made *against* any member of the extended set. Figure 2-20, reproduced from Buckingham Shum *et al.* (2003), shows the results of the Perspective Analysis function, which has been used here to determine the arguments against a research paper by *Chen and Ho (2000).* Part (a) of the figure shows the scholarly objects "*Decision Forest classifier*" and

"*Decision Forest classifier improves on C4.5 and kNN*" which have been annotated on to the *Chen and Ho (2000)* paper. Part (b) of the figure then shows three additional concepts that are positively associated with the first two concepts – "*Instance based learning*", "*Decision tree learning*", and "*decision trees and naïve Bayes perform well for text categorisation*". Finally part (c) of the figure shows a scholarly object (retrieved from an unspecified document) that disagrees with one of the scholarly objects that is positively associated with the *Chen and Ho (2000)* paper.

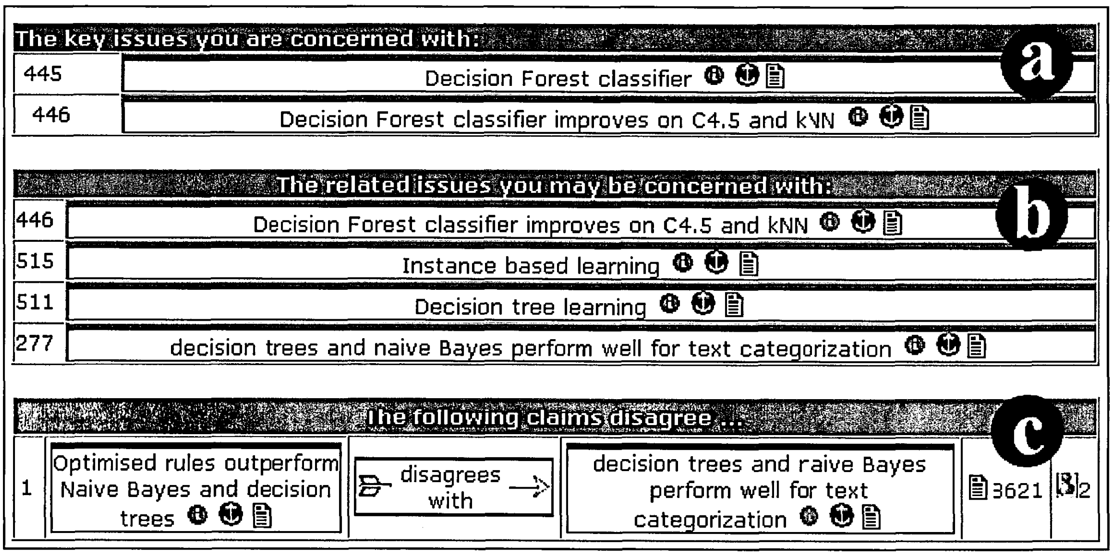

Figure 2-20 - Perspective analysis on an academic document by Chen and Ho (2000): Part (a) shows two concepts which have been annotated on to the Chen and Ho (2000) document. Part (b) of the figure then shows three additional concepts that are positively associated with the first two concepts that were annotated on to Chen and Ho (2000). Part (c) shows that there is one concept that 'disagrees-with' a concept that is positively associated with Chen and Ho (2000). (Reproduced from Buckingham Shum *et al.*, 2003).

The second type of automated analysis, Lineage Analysis, allows users to ask *"Where did this idea come from?"*. This analysis is able to trace backwards from a scholarly object to see how it evolved. Tracing backwards in this case does not refer to the chronology of the scholarly object; rather it refers to tracing connections between scholarly objects that are based on those *ScholarlyRelation* instances in the ontology that can be characterised as relations corresponding to notions of intellectual lineage – relations such as *uses-applies-isEnabledBy* and *improvesOn.* Figure 2-21, reproduced from Buckingham

Shum *et al.* (2003), shows the results of a Lineage Analysis to determine the intellectual history of the scholarly object "*2D spatial visualization of topics in database collections*". The figure shows that this scholarly object can be traced back to two other scholarly objects "*Singular value decomposition (SVD)*" and "*Labeled training data is expensive*", through a series of ScholarlyRelation instances (e.g. *uses-applies-isEnabledBy*, *improvesOn*, and *solves*) that are considered to reflect intellectual lineage.

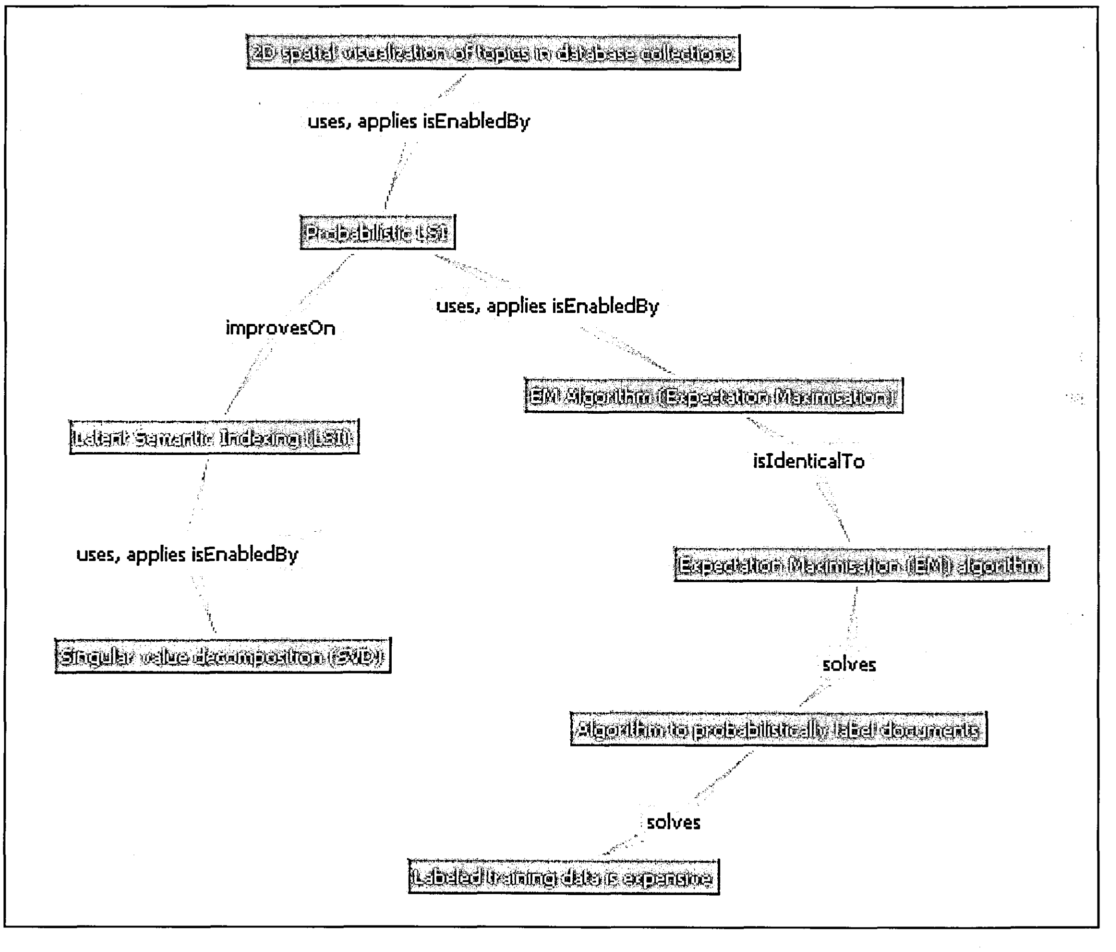

Figure 2-21 - Lineage analysis to determine the history of the concept "*2D spatial visualization of topics in database collections*": The analysis shows that the concept explicitly builds on two other concepts – "*Singular value decomposition (SVD)*" and "*Labeled training data is expensive*" (Reproduced from Buckingham Shum *et al.*, 2003).

2.3 Critique of the current research

This section critically examines the previously described citation-based (§2.3.1) and ontology-based KDA technology research (§2.3.2) in order to identify gaps in the existing research (§2.3.3).

2.3.1 Critique of citation-based KDA research

Critics of citation analysis have questioned the underlying assumption that citations uniformly represent the relevant influence that a *cited* article has on a *citing* article, arguing that an author's complex citation motives "cannot be satisfactorily described uni-dimensionally" (Liu, 1993). Even an advocate of the usefulness of citation indices (Weinstock, 1971) lists some 15 different reasons why one author cites another, which include: paying homage to pioneers, correcting one's own work, correcting the work of others, criticising previous work, substantiating claims, or disputing claims of others.

Some recent citation analysis research has sought to address this criticism by devising schemes of *citation types*, which aim to capture the various citation motives of authors. Promisingly, the work of Teufel *et al.* (2006) in particular, has explored the use of a scheme of citation types that can be used to automatically classify citations in documents. Adapting their classification scheme from the work of Spiegel-Rusing (1977), these authors have experimented with a supervised machine learning system – trained on a corpus of over 300 conference articles in Computational Linguistics[18] – and have demonstrated that the system can replicate citation classification performed by humans. Motivated by results described in Teufel (1999) and Teufel and Moens (2002), Teufel *et al.* (2006) hypothesise the creation of rhetorical citation maps that can give expert and novice alike an overview of a given academic domain, which resonates with the aims of this thesis. Along similar lines, Sandor *et al.* (2006) have also explored the use of a tool which annotates the *citation context* according to the type of relationship between citer and cited. Drawing on the citation typing work of Trigg (1983), their tool identifies four kinds of relationships: *background knowledge*, *based-on*, *comparison*, and *assessment*.

This recent research on citation types notwithstanding, criticism has also been targeted at other aspects of citation analysis research, particularly the 'evaluative' strand of

[18] The corpus is drawn from the Computation and Language E-Print Archive (http://xxx.lanl.gov/cmp-lg)

the research. For example, MacRoberts and MacRoberts (1989) argue that citation-based metrics can be potentially abused for evaluating research quality and setting research policy, particularly in situations where the quality of citations suffers from biased citing, self-citing and omission of informal influences.

In the context of designing KDA technology, the major benefit of the citation-based representation is that it enables the representation of knowledge domains as simplified, one-dimensional mathematical graphs - i.e. as a set of nodes and a set of links[19] of a single type. Graph-based analytical methods, which have been studied extensively in mathematics-oriented research fields and which are particularly successful at identifying macro-level patterns and features in the underlying data, can then be readily implemented in software and applied across large volumes of citation data[20] represented in this graph-based form.

This ability to perform macro-level analysis on large volumes of citation data was recognised early on by Henry Small, one of the pioneers of citation analysis research. Small (2003) recalls that his first attempt at devising an approach to representing and analysing knowledge domains was based on constructing information-rich *maps* of a given knowledge domain's intellectual landscape, down to the level of individual hypotheses and arguments[21].

> *For the nuclear physics project I first tried to map the intellectual landscape of leading researchers in the field such as Ernest Rutherford. By an intensive reading of their papers, I constructed diagrams of the evolving models of the atomic nucleus. Ideas or hypotheses were represented as nodes that were linked together if they were part of a supporting argument or assertion. I could then show how these networks evolved with each successive paper, and the introduction of new concepts such as the neutron.*

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[19] In mathematical terminology, 'vertices' and 'edges' are the terms used, rather than 'nodes' and 'links' when it comes to describing graphs. However, 'nodes' and 'links' are more typical of the terminology used in Bibliometrics research, so these terms are used throughout this thesis.

[20] CiteSeer, for example, indexes over 750,000 documents

[21] Small suggests that the more recent work of Paul Thagard (1992) is a more fully elaborated approach of what he was originally attempting.

However, Small explains that he was soon discouraged by the laborious nature of this representational approach and decided instead to turn to "a simpler kind of analysis focusing on bibliographic elements in papers". These bibliographic elements could include authors, keywords, and references, but Small eventually determined that *citations* provided a "unique mechanism" for establishing important co-occurrence connections, through, for example, the use of co-citation and bibliographic coupling inferences. Thus, he proposed that knowledge domains could be represented in a simple graph-based form with publications as nodes and citations as links. Such a graph could then be further analysed to reveal co-citation links between pairs of publications, and finally, graph-based clustering would then allow the analysis "to move beyond pair-wise linkages to an *aggregate structural and thematic analysis*" (Small, 2003, emphasis added). By assuming that bibliographic elements could function as *surrogates* for the ideas contained in the papers, Small hypothesised that this kind of aggregate- or macro-level analysis might reveal potentially significant *intellectual structures* – such as invisible colleges and research fronts – of the underlying knowledge domain.

However, the simplified representational approach also has limitations with respect to supporting knowledge domain analysis. A citation-based representation means that other relevant aspects of a knowledge domain (such as its detailed topic and subtopic-structure, discourse structure, and social structure) are removed from representations of the knowledge domain. Indeed, this additional information often needs to be superimposed on citation analysis results so that the revealed intellectual structures of the knowledge domain are meaningful and can be properly understood by the domain analyst.

This need to augment citation analysis results is seen, for example, when Chen and Carr (1999) perform an author co-citation analysis of the conference proceedings of the *Hypertext* conference series from 1987 to 1998, and use this to generate Web-based maps for users to identify the major research fronts and subject specialities in the Hypertext domain. While interpreting their results, the authors recognise a node on one of the maps with the name *van Rijsbergen*, and since the authors had prior knowledge that this name was associated with the *Information Retrieval* subject speciality, they labelled that particular area of the map as such. However, to achieve this, the authors admit that they use their "[implicitly held] knowledge about these nodes to suggest the nature of a speciality" (Chen and Carr, 1999).

2.3.2 Critique of the ontology-based KDA research

The ontology-based KDA approach can be regarded as one possible solution to the challenge of making *explicit*, in computable representations, information about the structure of the knowledge domain that would normally be implicit. Indeed, two of the ontology-based tools previously reviewed – ESKIMO and ClaiMaker – are motivated by the need to address the *semantic* limitation of citation-based analysis. For example, recognising that, with citation-based analysis, it is difficult to determine "if a paper is referenced because the authors support or are opposed to it" (Buckingham Shum *et al.*, 2003), the ClaiMaker tool represents connections in the literature at a finer granularity, thereby facilitating a more detailed analysis of the semantics that are implicit in a citation link.

Specifically, the aim of the ontology-based KDA approach has been to extend the scope of representation to include more dimensions of a knowledge domain than just citation data. This extended scope is specified in the underlying ontologies of each of the tools previously reviewed. For example, the SWRC, ESKIMO, and AKT Portal ontologies incorporate elements of bibliographic metadata into their specifications, which also includes representation of the community structure including researchers, research projects, academic organisations, and research events. The FOAF ontology used by Flink focuses on people and the social relations between people. The ClaiMaker ontology covers yet another important dimension of knowledge domains – the discourse moves made by the domain's authors. Table 2-3 summarises the representational scope of each of the ontology-based KDA tools. It indicates the choice that each underlying ontology has made with respect to which elements of knowledge domains they are focussed on representing.

Table 2-3 - The representational scope for each of the ontology-based KDA tools that has been reviewed: The table shows the design choice that each ontology has made with respect to which elements of a knowledge domain ought to be represented for the purpose of being able to analyse that domain.

Tool (Ontology)	Ontological scope
Bibster (SWRC)	- Bibliographic metadata, which includes some of the common types of academic publication (e.g. journal article and conference proceedings), as well as specifying 'author' and 'editor' attributes of publications - Academic community structure, which includes the affiliations of persons to organisations, participation of persons in conference and workshop events, and membership of persons on project teams - Topic structure, which includes topic-subtopic relationships, and relationships between topics and publications.
Flink (FOAF+)	- Bibliographic metadata (through use of SWRC ontology) - Academic community structure, which includes the membership of persons in groups, and importantly, the 'knows' relationship between persons - Topic structure, which includes the association between topics based on the common interest of researchers in the domain
ESKIMO (ESKIMO)	- Bibliographic metadata, which includes some of the common types of academic publications - Academic community structure, which includes the societies, research teams, and organisations to which persons are affiliated, and the research activities which persons work on - Topic structure, which includes the specification of so-called 'research-themes' in the domain.
CAS (AKT Portal)	- Bibliographic metadata, which includes some of the most common types of academic publication - Academic community structure, which includes persons membership on research projects and affiliations to organisations - Topic structure, which includes the specification of 'research areas' and sub research areas
ClaiMaker (ClaiMaker)	- Discourse moves, which includes the most common relationships (e.g. consistency and disagreement) between theories, models, and methodologies in academic domains - Conceptual Structure, which includes common similarity and taxonomic relationships between concepts in the domain

However, one limitation of the ontology-based approach is that by focussing on this level of detail within knowledge domains, the ontology-based KDA tools, perhaps with the exception of Flink, do not include an account of the macro-level features of knowledge domains, which citation-based research has revealed as important for gaining new insights about a given domain.

2.3.3 Identifying the gap in existing research

Based on this critique of both the citation-based and ontology-based approaches, it is apparent that existing KDA technology research is limited in its treatment of *scholarly debate*. The knowledge domain analyst is unable to use existing tools and techniques to answer important questions such as:

- *What is the structure of the ongoing dialogue in the domain?*
- *What are the controversial issues?*
- *What are the main bodies of opinion?*

Exploring these and similar macro-level debate features of knowledge domains is a necessary part of the analyst being able to understand and engage with their chosen domain (Davidson and Crateau, 1998). The last of the three questions is particularly important, since, as Stoan (1984) argues, learning about the main bodies of opinion or schools of thought is an important aspect of mastering a knowledge domain. Similarly, Davidson and Crateau (1998) argue that part of learning about a knowledge domain involves understanding how certain concepts are used differently by different camps in the domain. For example, the authors suggest that although the terminology "right to die" and "assisted suicide" point to similar states of affairs, they each have different "rhetorical ramifications" – with respect to the issue of whether it should be legal for a person to take his/her own life and to have someone assist them in doing so, the first term implies an affirmative position with respect to the issue, whereas the second term implies a negative position. It is clear that such elements of the debate in the domain can act as *subject access points (SAPs)* (Hjorland and Albrechsten, 1995) to help the user engage with the knowledge domain.

2.4 Research Proposals

This section describes two proposals that are motivated by the gaps in the current KDA technology research as critically reviewed in the preceding sections. The first proposal is to design a *Scholarly Debate Ontology* (§2.4.1). The second proposal is to design a method that can be applied to ontology-based representations of scholarly debate in order to detect clusters of viewpoints in the debate. Such *viewpoint-clusters* are proposed as important macro-level structures in knowledge domains (§2.4.2).

2.4.1 Proposal one: designing a *Scholarly Debate Ontology*

In order to support the types of queries highlighted above by Davidson and Crateau (1998), there needs to be KDA technology which is designed to represent and reason about scholarly debate. To enable this representation and reasoning, an ontology that specifies the essential elements of scholarly debate is needed. Specifically this Scholarly Debate Ontology needs to include the argumentation structures that make up dialectical exchange[22] in knowledge domains.

This need to focus on dialectical exchange in knowledge domains has similarities with the aim of Horn (1998) in his *debate mapping* work. According to Horn, one of the tasks involved in analysing and understanding a knowledge domain is understanding where and how all the arguments fit together. Therefore, in his Information Design research on creating educational resources, he focuses on using argumentation analysis to examine the history and status of major scholarly debates. In particular, he is interested in answering the question: "*Where can I get an overview of the history of the arguments so I can decide which I want to read?*". This question is similar in scope to the kinds of questions that

[22] The term 'dialectic' is used here in the sense of Rescher (1977) to mean rational controversy

Davidson and Crateau (1998) deem important for engaging with an unfamiliar knowledge domain. Thus, Horn's debate maps aim to capture the full communicative and instructional power of the dialectical exchange within a given knowledge domain. This approach is one where the maps reveal how articles that a reader may encounter fit into the bigger discourse landscape of the knowledge domain. The most widely known example of Horn's debate mapping approach is the series of seven paper-based wall mountable maps that depict the history and status of the debate in the *Artificial Intelligence* domain about whether computers can or will be able to think.

What emerges from Horn's work is a theory of the structure of scholarly debate. This theory has then been given a more extensive treatment by Yoshimi (2004) who proposes a "*logic of debate*". Whereas most argumentation research concentrates on the microstructure of arguments (e.g. modelling the common types of schemes for inferring conclusions from premises), the concern of a logic of debate is how arguments themselves are "constituents in *macro-level* dialectical structures" (Yoshimi, 2004, emphasis added). This thesis proposes to demonstrate how this logic of debate can be used as the basis for designing and implementing the Scholarly Debate Ontology.

2.4.2 Proposal two: designing a method for detecting viewpoint-clusters in scholarly debate

Of particular importance to engaging with and fully understanding a knowledge domain, is identifying the main bodies of opinion in the domain. Indeed, Horn (2003) has shown the importance of enabling map readers to identify these kinds of intellectual groupings that are formed as a result of debates in knowledge domains. However, he is concerned with manually identifying and naming these existing groups – what he calls *philosophical camps* and what the logic of debate labels as *positions* – and depicting them as important features of his debate maps. It is apparent, therefore, that a contribution can be made with technology that enables the automatic detection of the intellectual groupings that are formed as result of scholarly debate.

Yoshimi (2004), in his account of the logic of debate, has already suggested that graph-theoretic metrics can be used to reveal information about the structural features of a debate. This thesis proposes to extend this idea by investigating whether a combination of graph-based analysis and ontology-based analysis can reveal information about certain intellectual features of a scholarly debate.

Two ontology-based tools, ClaiMaker and Flink, have experimented with the combination of graph-based and ontology-based analysis. Flink provides a number of graph-theoretic metrics – such as indegree, closeness, and betweeness – to describe individual members of a research community, and uses graph-based analysis to detect cohesive subgroups in the research community. Meanwhile, Stix and Uren (2003) have experimented with using graph-based analysis to identify dense clusters of claims stored in the ClaiMaker knowledge base. This thesis proposes to extend this exploration of a hybrid approach that incorporates elements of the Bibliometrics paradigm and the Conceptual Modelling paradigm. This exploration will need to include a mechanism for bridging the two representational approaches.

The graph-based methods used in the Bibliometrics research offer a possible means of implementing the necessary functionality for automatically detecting intellectual groupings in scholarly debate, which this thesis argues should be a major aim of any technology that purports to enable representing and reasoning about debate in knowledge domains. Work in the Bibliometrics paradigm has successfully applied graph-based methods for detecting certain intellectual structures such as invisible colleges in knowledge domains. However, whereas an invisible college is typically characterised as a grouping or clustering of scholars, the intellectual groupings that are formed during scholarly debate are more appropriately characterised as 'clusters of viewpoints'. Nonetheless, this thesis raises the possibility that graph-based methods can potentially be applied just as well to detecting viewpoint-clusters as well as invisible colleges within a knowledge domain.

Chapter Summary

This chapter has reviewed current technological support for analysing knowledge domains. It began with an overview of citation-based KDA technology, which was then followed by an overview of ontology-based KDA technology. Based on a critique of these two research approaches, the chapter proposed the next steps for this research, namely the design of a suitable ontology for representing debate and the design of a method for automatically detecting viewpoint-clusters in scholarly debate.

The next chapter will explore the first proposal to design a *Scholarly Debate Ontology*.

CHAPTER 3 DESIGNING A SCHOLARLY DEBATE ONTOLOGY

This chapter describes the design of an ontology which specifies the essential elements of debate in knowledge domains. In accordance with best practices for ontology design, the chapter presents a design process that includes the use of an upper-level ontology, which provides a mechanism for selecting the essential elements of the world to be represented, thus ensuring that the design process adheres to the principle of *minimal ontological commitment.*

The chapter begins by characterising knowledge domains as settings for the collective construction of knowledge, thus motivating the reuse of an *upper-level constructivist* ontology, which is used as a 'frame of reference' for organising the relationships between the various dimensions of a knowledge domain as specified in the existing KDA ontologies previously introduced (§3.1). The chapter then defines the *Scholarly Debate Ontology (SDO),* which specifies the vocabulary for representing scholarly debates in knowledge domains. The upper-level ontology acts as a design aid for selecting the essential elements of scholarly debate to be specified in the SDO (§3.2).

3.1 The cDnS upper-level ontology

The *Constructivist Descriptions and Situations (cDnS)*[23] ontology "provides the expressivity to talk about the contexts (social, informational, circumstantial, and epistemic), in which collectives make and produce sense" (Gangemi, 2008). In other words, cDnS can be characterised as an *ontology of collective sensemaking.* 'Collective sensemaking' or 'collective knowledge construction' is a useful way of characterising the key activity of knowledge domains, thus the cDnS ontology provides a suitable vocabulary

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[23] Earlier iterations of this PhD work reused the earlier *DOLCE+DnS* foundation-ontology apparatus. However, in our present analysis we reflect the updating of DnS to *Constructive DnS (cDnS).* (*Cf.* Gangemi (2008) for a description of how cDnS relates to DOLCE)

for describing the current world of interest – in our case, the world of academic knowledge domains.

It should be noted here the existence of other upper-level ontology artefacts, the best known of which are the *Penman Upper Model* (Bateman, 1990), the *Generalised Upper Model (GUM)* (Bateman *et al.*, 1994), the *Suggested Upper Merged Ontology (SUMO)* (Niles and Pease, 2001), the *Cyc* ontology (Lenat and Guha, 1990), and the *Basic Formal Ontology (BFO)* (Grenon and Smith, 2004). The Penman Upper Model and the Generalised Upper Model are motivated by work in Natural Language Processing and are typically used for aligning components of NLP systems. The Penman Upper Model, developed within the Penman text generation project, is used for organising knowledge appropriately for linguistic realisation (Bateman, 1990). The GUM, which is a multilingual extension of the Penman Upper Model, supports Natural Language Processing for Italian, German, and English and is motivated directly on the basis of language evidence from these three languages rather than from any particular system requirements (Bateman *et al.*, 1994). The GUM provides the semantics for natural language expressions.

The SUMO and Cyc ontologies cover the particular portion of reality as it relates to discourse and knowledge construction. However, adopting the corresponding SUMO and Cyc characterisations would lead to a violation of the principle of minimal ontological commitment since the relevant modules of both SUMO and Cyc make certain ontological distinctions and refinements that would lead to ontological overcommitment on the part of the proposed Scholarly Debate Ontology. Also, both SUMO and Cyc have rather tangled ontology hierarchies, which again lead to overcommitment on any ontology that uses them as an upper-level ontology. For example, SUMO has a class that is of relevance called ContentBearingObject. However, this class on the one hand part of the hierarchy Entity -> Physical -> ContentBearingPhysical -> ContentBearingObject, while on the other hand it is also part of the hierarchy Entity -> Physical -> Object -> SelfConnectedObject -> CorpuscularObject -> ContentBearingObject.

Finally, the BFO is narrowly focussed on providing an upper-level ontology that supports the design of ontologies of scientific phenomenon, particular that in biomedical research. It therefore does not cover portions of reality that are relevant to this thesis, namely abstract entities such as discourse and argumentation.

Most importantly, the key knowledge domain activities of representing and communicating knowledge constitute *semiotic* processes. Semiotics is the study of signs and their use in the representation and communication of meaning. In Charles Sanders Peirce's prominent theory of semiotics (Atkin, 2007), the basic structure of signs in semiotic processes consists of three components: (1) the *sign-vehicle*, which is the entity perceived by the senses (2) the *object* referred to by the sign-vehicle, which may include imaginary objects and ideas, and (3) the *interpretant*, which is the mental representation that links the sign-vehicle to the object in the mind of some conceiving agent. As will be discussed later in the section, these semiotic components correspond to key elements of the cDnS ontology. Indeed, a core configuration of elements within the cDnS ontology[24] can be used to describe any generic semiotic process where an agent conceives some description or representation about entities in the world and communicates this description via some object for conveying information.

Although the design approach is to reuse this constructivist ontology, this thesis attempts to remain neutral with respect to the ongoing philosophical debate about whether we can only *construct* reality via our subjective and socially-mediated representations of it (a *constructivist* viewpoint) or whether we can *derive* true representations of a single objective reality that exists independently of our concepts of it (a *realist* viewpoint). That

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[24] In the cDnS ontology's original form as DOLCE+DnS this configuration of ontological categories was sometimes referred to as the *Semiotic Ontology Design Pattern*

philosophical debate is beyond the scope of this thesis, which, for the purposes of selecting a suitable upper-level reference ontology, is concerned with characterising knowledge domains as settings for conducting intellectual inquiry through its production of texts as the primary means of representing and communicating knowledge (Cf. Knorr-Cetina, 1981). This is irrespective of whether or not the "representations of knowledge" that are produced and communicated via published texts correspond to true facts in reality. As Driver et al. (1994) note, a view of knowledge as socially constructed and socially negotiated does not logically imply a relativist or *anti*-realist position.

The cDnS ontology is depicted in Figure 3-1. The figure shows the main classes and relations in the ontology, which will be described in more detail in the remainder of this section[25]. As each class is described, an analysis is made of how, as upper-level classes, they can be interpreted in the context of knowledge domains and thus used to frame the application-level classes in the existing KDA ontologies.

[25] The description of the cDnS ontology that follows is based on two main publications, Gangemi et al. (2007) and Gangemi (2008). There are some peripheral modifications made in the cDnS ontology between Gangemi et al. (2007) and Gangemi (2008), which demonstrates that the ontology is still a work in progress. Nonetheless, the core elements of the ontology have become stable enough to be suitable for the purposes of this thesis.

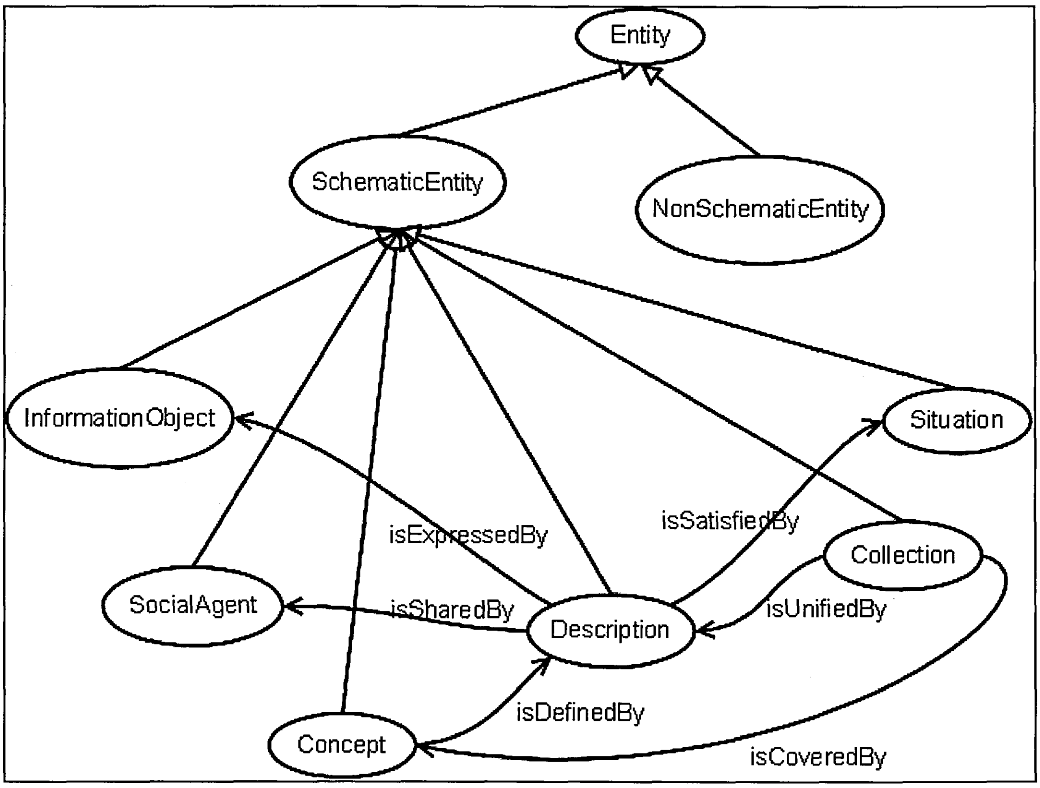


Figure 3-1- The Constructivist Descriptions and Situations (cDnS) ontology.

Entity

Entity is "the class of everything that is assumed to exist in some domain of interest for any possible world" (Gangemi *et al.*, 2007). In the cDnS ontology, the *cdns:Entity*[26] class is specified as the uppermost class in the hierarchy from which all other cDnS classes are sub-classed. There are two main categories of Entity: *SchematicEntity* (typically social entities like organisations and information), and *NonSchematicEntity* (for example, time intervals and spatial coordinates). However, the main development on the cDnS ontology focussed on 'axiomatising' the former type of Entity – i.e. *SchematicEntity.*

InformationObject

'Information objects' are the vehicles for communicating informational content between agents; they are the *expression* of informational content, or to use Peircean terminology, they are the *sign-vehicle* in any semiotic process, where *cdns:Entity* plays the

[26] In the remainder of the discussion in this section, classes from the cDnS ontology are prefixed with '*cdns:*'.

role of the 'object' in the semiotic process – i.e. an information object in the cDnS sense can be about any other entity. Any unit of information can be treated as an instance of *cdns:InformationObject*[27], and this is independently of how the information (as something which is abstract) is realised in a physical medium. However, according to Gangemi *et al.* (2007), information objects must have a physical realisation so that their informational content is perceivable by some agent. Based on this characterisation a single information object can have multiple physical realisations or modalities – e.g. a newspaper article can have a paper and an electronic realisation[28].

In the context of knowledge domains, this thesis's world of interest, the most typical examples of information objects are publications, which are the main vehicles of knowledge representation and communication in knowledge domains. A single publication, taken as a whole, can be considered to be an information object. Furthermore, a single publication is composed of clauses and sentences (which are *verbal* expressions of knowledge), as well as tables, graphs, and figures (which are hybrid – i.e. both verbal and *non-verbal* – expressions of knowledge). Each of these components of a publication can be considered to be an information object in its own right. This corresponds with the view of Lemke (1998) that academic publications, particularly scientific publications are semiotic hybrids.

As mentioned previously, the definition of *cdns:InformationObject* makes it clear that this class corresponds to any 'unit of abstract information', independently of how this information unit is physically realised. This is meant to account for how people often intuitively refer to a particular publication as a *conceptual* artefact rather than merely a

[27] The *InformationObject* class is sometimes referred to as the "reification [or 'thingification'] of abstract information". This means that the *InformationObject* class *treats* units of information as if they were concrete things when they are actually something abstract.

[28] There is an issue here with the ontological status of different modalities or modes of expression. For example, is an orally-delivered speech the same *expression* as the written speech but just a different modality or are they two entirely different expressions? The intuitive answer seems to be to treat the orally-delivered speech and the written speech as the same abstract conceptual work, in which case the cDnS characterisation is appropriate – i.e. a single information object can have multiple realisations.

physical one. However, this distinction between 'publication-as-conceptual-artefact' and 'publication-as-physical-artefact' isn't made explicit in all of the KDA tool ontologies reviewed in Chapter 2. For example, the definition of the *swrc:Publication*[29] class in the SWRC ontology is sufficiently ambiguous that it is possible to interpret this class as corresponding to both a conceptual artefact as well as a physical artefact. This means that it is possible to define *swrc:Publication* as a subclass-of *cdns:InformationObject*, but, in order to fully capture what the ontology designer's possible intended conceptualisation, *swrc:Publication* should ideally be regarded as a subclass-of a suitable upper-level class that corresponds to the conceptualisation of publications as physical artefacts. In an extended version of the cDnS ontology, a class called *InformationRealization* is included which accounts for the conceptualisation of publications as physical artefacts. If this extended version were used, then *swrc:Publication* could be defined as a subclass of *cdns:InformationRealization.*

The *esk:Publication*[30] class, in the ESKIMO ontology, provides a similar example. That is, as with the *swrc:Publication* class in the SWRC ontology, the definition of the *esk:Publication* class is sufficiently ambiguous that it is possible to interpret this class as corresponding to both notions of 'publication-as-conceptual-artefact' and 'publication-as-physical-artefact'. Thus, the *esk:Publication* class can be defined as a subclass of *cdns:InformationObject* and of *cdns:InformationRealization* in the extended version of the cDnS ontology.

The definition of the *aktp:Publication*[31] class in the AKT Portal Ontology is less ambiguous than the *swrc:Publication* class and the *esk:Publication* class just discussed. This is due to the fact that, as explained in Chapter 2, the AKT Portal Ontology includes

[29] In the remainder of the discussion in this section, classes from the SWRC ontology are prefixed with '*swrc:*'.
[30] In the remainder of the discussion in this section, classes from the ESKIMO ontology are prefixed with '*esk:*'.
[31] In the remainder of the discussion in this section, classes from the AKT Portal ontology and the AKT Support ontology are prefixed with '*aktp:*' and '*akts:*' respectively.

upper-level classes that help to clarify the ontological distinctions in the application-level classes. So, for example, the *aktp:Publication* class is a direct subclass of an upper-level class called *akts:Information-Bearing-Object*[32] which in turn is a subclass of *akts:Tangible-Thing*. This makes it clear that the *aktp:Publication* class is meant to represent the concept of 'publication-as-physical-artefact' rather than 'publication-as-conceptual-artefact'. To represent the latter, the AKT ontology defines the *aktp:Publication-Reference* class. The *aktp:Publication-Reference* class is a direct subclass of *aktp:Abstract-Information* which in turn is a direct subclass of *akts:Intangible-Thing*. The distinction between the two classes makes it possible for the AKT ontology to be used to represent multiple occurrences of the same publication in different physical media. Furthermore, based on this distinction, the *aktp:Publication-Reference* class can be defined as a subclass-of *cdns:InformationObject,* while the *aktp:Publication* can be defined as subclass of *cdns:InformationRealization* in the extended cDnS ontology.

Description

A Description is the abstract, communicable semantic content or meaning that an information object *expresses*. In Peircean terminology, they are the 'interpretant' that is formed in the mind of some conceiving agent. According to Masolo *et al.* (2004), different information objects, possibly even in different languages, can be associated with the same description or semantic content.

In the context of knowledge domains, just as there are different types of information objects, there are different types of descriptions. For example, a single scholarly publication can be regarded as an information object that expresses a *thesis*, in much the same manner as a novel can be regarded as an information object that expresses a

[32] As commented in the code for the AKT portal ontology, the concept of Information-Bearing-Object is borrowed from the CYC ontology. However, *akt:Information-Bearing-Object* is strictly a tangible thing (which is disjoint from intangible thing), whereas in CYC the *InformationBearingObject* class is treated as a *composite* tangible and intangible object – i.e. it has both a tangible and an intangible component. Specifically, the CYC *InformationBearingObject* class is said to consist of intangible information encoded in a tangible object).

plot. The thesis of a scholarly publication is therefore an example of a description in the cDnS sense. Furthermore, each clause or sentence that makes up a publication can be characterised as an information object that expresses either some *propositional content* (as is the case with declarative sentences that may represent some theory conceived by an agent) or some *non-propositional content* (as is the case with interrogative sentences – i.e. questions). Therefore, the propositional or non-propositional content of individual clauses and sentences are also examples of Descriptions.

Although the SWRC, ESKIMO, and AKT Portal ontologies are able to represent publications as information objects in academic knowledge domains, neither of these ontologies is concerned with representing the *content* of these information objects. Of the KDA tool ontologies introduced in Chapter 2, only the ClaiMaker ontology is interested in representing the content expressed within academic publications. This content is represented in the ClaiMaker ontology using instances of the *clm:ScholarlyObject*[33] class. Therefore *clm:ScholarlyObject* can be defined as a subclass of *cdns:Description.*

Situation

A situation is said to provide a setting for other entities, including other situations. A situation, in the cDnS sense, represents a state of affairs that is observable by some agent. A situation is said to *satisfy* a description. Inversely, a description is said to represent an agent's conceptualisation of a particular situation. The constructivist nature of the cDnS ontology suggests that situations do not exist independently of descriptions – i.e., a state of affairs requires an agent to conceive of it. However, the reverse is not necessarily true – that is descriptions are not dependent on situations, since there exist descriptions that do not describe a particular situation.

The constructivist nature of the cDnS ontology also suggests that the same situation can, to varying degrees, satisfy multiple descriptions. For example, consider that a

[33] In the remainder of the discussion in this section, classes from the ClaiMaker ontology are prefixed with '*clm:*'.

situation involving humans, cars, roads and signs can be described as a *driving situation*, but also re-described as a *racing situation* or a *speed-limit violation* situation depending on the intention of the agent who perceives the situation (Gangemi *et al.*, 2007). On the other hand, one description can be satisfied by multiple situations. Indeed, according to Gangemi *et al.* (2007), "each description generates a *situation class* which contains all the situations that satisfy that description". Thus, for example, a description of a law for how governments should be formed is satisfied by all states of affairs where a government is legally formed. This implies that descriptions can be both *universal statements* as well as *particular statements.*

In the context of knowledge domains, and considering the existing KDA ontologies, the application-level classes that are of relevance here are those that can be characterised as providing a context or a *setting* for other knowledge domain entities. Two classes in the SWRC ontology fit this characterisation – *swrc:Event* and *swrc:Project,* which both provide a setting for (at least) persons, organisations, and publications. Similarly, in the ESKIMO ontology, the relevant classes are *esk:Activity* (which refers to any "planned undertaking" such as a project) and *esk:Conference* (which refers to any meeting, seminar, workshop, or symposium of two or more persons for discussing common concerns). In the AKT Portal ontology the relevant classes are *aktp:Activity* and *aktp:Event*. Each of these application-specific classes can be mapped to the *cdns:Situation* class.

Concept

Concepts are *defined by* and *used by* Descriptions. Concepts can also classify and name other entities. So, for example, there is an article in the American constitution (i.e. a description in the cDnS sense) which defines the concept of 'US President'. This concept of 'US President' can then be said to classify the entity that is 'Barack Obama'. Note that a concept can classify different entities at different times – e.g. the concept 'US President' classified 'Bill Clinton' and also 'George Bush' – while a concept can also classify different entities at the same time – e.g. 'British MP' classifies a number of persons currently sitting in the British Parliament.

In the context of knowledge domains, concepts correspond to elements of the specialised vocabulary or conceptual system of a particular knowledge domain. These domain concepts are typically defined and used by the theories and statements (i.e. the descriptions in a cDnS sense) that are shared and communicated in the domain.

Considering first the SWRC ontology, the class that is relevant here is *swrc:Topic* which is meant to account for the names assigned to areas of interest in the knowledge domain. Thus *swrc:Topic* is defined as a direct subclass of *cdns:Concept*. Similarly, in the ESKIMO and AKT Portal ontology, the *esk:Research_Theme* class and *aktp:Research-Area* class respectively are meant to account for subject areas in the knowledge domain. Thus both the *esk:Research_Theme* class and the *aktp:Research-Area* class can be defined as subclasses of *cdns:Concept*. Finally, in the ClaiMaker ontology, the *clm:Concept* class is meant to account both for single terms (informally referred to as 'hard concepts') as well as extended phrases (informally referred to as 'soft concepts'). Hence, *clm:Concept* can also be defined as a subclass of *cdns:Concept*[34].

SocialAgent

An Agent is required to *interpret* a given Information Object. When an Agent interprets an Information Object, the agent is said to *conceive* the Description that is *expressed by* that particular Information Object.

In the context of knowledge domains, persons involved in the production of scholarly texts can be characterised as social agents. The organisations to which these persons are affiliated can also be characterised as agents in the cDnS sense. Also, in the

[34] Note that since *clm:Concept* is a subclass of *clm:ScholarlyObject*, and *clm:ScholarlyObject* is a subclass of *cdns:Description*, *clm:Concept* is also indirectly a subclass of *cdns:Description*

context of knowledge domains, one particularly important feature of agents and their relationship to information objects is that it is possible for two agents (e.g. an author and a reader) to *interpret* an Information Object differently, thereby conceiving of different descriptions (Behrendt *et al.*, 2005). These different descriptions can even sometimes be contradictory, even though ostensibly they have been derived from the same information object.

Considering the existing KDA ontologies, the SWRC ontology contains two classes that are of relevance here. These are *swrc:Person* and *swrc:Organization*, which can be defined as subclasses of *cdns:SocialAgent*. In the ESKIMO ontology, there are four classes that can be characterised as social agents and thus can be defined as subclasses of *cdns:SocialAgent*. These are *esk:Person*, *esk:Organisation*, *esk:Team*, and *esk:Society*. In the AKT Portal ontology the relevant classes here are *aktp:Person, aktp:Organization, aktp:Organization-Unit,* and *aktp:Awarding-Body,* which can each be defined as a subclass of *cdns:SocialAgent*.

Collection

The collection class captures the intuitive notion of such entities as groups, teams, and associations. A Collection has at least two entities as its members and is said to "emerge" out of its member entities such that, "while retaining their identity, unity, and physical separation, [member entities] are 'kept together' in order to form a new entity" (Bottazzi *et al.*, 2006). Note however, that the members of collection can change or be substituted during the life of a collection without affecting the identity of the collection. This is one feature of cDnS collections that helps to differentiate them from mathematical sets. Furthermore, mathematical sets can be empty or singletons, but no empty or singleton collections are allowed in the cDnS 'axiomatisation'.

In the context of knowledge domains, the community of researchers in a given knowledge domain can be thought of as a collection of agents that share one or more descriptions[35] - these descriptions are said to *unify* the collection (Gangemi, 2008). The 'collection of agents' characterisation also applies to such entities as organisations, research groups or teams, and conference committees.

In the SWRC ontology, the *swrc:Organization* class can be characterised as a collection of agents. Thus, in addition to being defined as a subclass of *cdns:SocialAgent*, *swrc:Organization* can also be defined as a subclass of *cdns:Collection*[36]. Similarly, in the ESKIMO and AKT Portal ontologies, there are classes that, in addition to being characterised as social agents, can also be characterised as collections of agents. These classes are *swrc:Organization, esk:Team, esk:Organisation, esk:Society, aktp:Organization,* and *aktp:Organization-Unit*) can be mapped to *cdns:Collection.*

In the case of the ClaiMaker ontology, one class that can be characterised as a collection is *clm:Set*. This seems to contradict the previous point that collections in cDnS are not the same thing as mathematical sets. However, despite the terminology used, the *clm:Set* ontology class does not correspond to a set in the mathematical sense. Specifically, the ClaiMaker ontology does not prevent the creation of an empty *clm:Set* instance. Also, the ontology has no constraint which requires that a new *clm:Set* instance be created if the members of the original *clm:Set* instance change. Since *clm:Set* instances in practice correspond to collections of scholarly objects, the *clm:Set* class can be defined as a subclass of *cdns:Collection.*

Figure 3-2 summarises the mappings from the cDnS upper-level classes to the corresponding application-level classes from the KDA tool ontologies described in Chapter 2. Through the mapping process, these application-level classes shown in the figure

---

[35] Gangemi (2008) uses the term 'knowledge community' to label such a collection of agents.

[36] In an extended version of cDnS where the ontological hierarchy of collections is extended, organisations, teams, societies, etc. would be more specifically characterised as *intentional collectives.* An intentional collective is defined as a collection of agents where the members are unified by a shared *plan* (Gangemi et al., 2007)

account for the essential types of knowledge domain entities, as defined in the existing KDA ontologies.

cdns:InformationObject swrc:Publication esk:Publication aktp:Publication-Reference ***cdns:Description*** clm:ScholarlyObject clm:ScholarlyRelation ***cdns:Situation*** swrc:Project swrc:Event esk:Activity esk:Conference aktp:Activity aktp:Event ***cdns:Concept*** swrc:Topic esk:Research_Theme aktp:Research-Area clm:Concept	***cdns:SocialAgent*** swrc:Person swrc:Organization esk:Person esk:Organisation esk:Team esk:Society aktp:Person aktp:Organization aktp:Organization-Unit aktp:Awarding-Body ***cdns:Collection*** swrc:Organization esk:Organisation esk:Team esk:Society aktp:Organization aktp:Organization-Unit clm:Set

Figure 3-2 - The mapping of existing KDA ontologies to the upper-level classes of the cDnS ontology (the cDnS classes are shown in bold text, and the corresponding application-level from the other ontologies are listed underneath in plain text). These application-level KDA classes account for the essential knowledge domain entities as defined in the existing KDA ontologies.

Having mapped the existing KDA ontology classes to the cDnS upper-level classes, attention now turns to mapping the relevant relations in the existing KDA ontologies to corresponding relations in the cDnS upper-level ontology. Table 3-1 provides a brief documentation of the main cDnS relations and shows the mapping between these upper-level relations and the application-level relations in the existing KDA ontologies.

Table 3-1 – The mapping of application-level relations in the existing KDA ontologies to the upper-level relations in the cDnS ontology: Firstly, the main cDnS relation is listed along with its inverse. Then a brief documentation of the cDnS relation is provided, followed by its mapping to the relevant application-level relations in the existing KDA ontologies.

cDnS Relation	Relation Inverse	Documentation	Mappings to relations in KDA ontologies
assumes (SocialAgent, Description)	isAssumedBy	This relation is intended as a more specific form of the 'shares' relation. 'Assumes' is a specific way of conceptualising a description. For example, the 'theory of phlogiston' (a description) was shared by both Stahl and Lavoisier. However, only Stahl assumed it.	(No corresponding relation in the existing KDA ontologies)
classifies (Concept, Entity)	isClassifiedBy	Concepts can classify entities. For example, classifies (PrimeMinister, TonyBlair). The 'classifies' relation captures the notion of 'redescribing' an entity so that it is possible to have different identities in different contexts. For example, classifies (QuartetEnvoy, TonyBlair).	esk:hasTheme (esk:Publication, esk:Research_Theme), swrc:isAbout (swrc:Project, swrc:Topic), swrc:isAbout (swrc:Publication, swrc:Topic)
covers (Concept, Collection)	isCoveredBy	The concept(s) that classify all the members of a collection are said to cover a collection.	(No corresponding relation in the existing KDA ontologies)
defines (Description, Concept)	isDefinedIn	The 'defines' relation formalises the intuition of a gestalt or context, that gives meaning to an aggregate of concepts.	(No corresponding relation in the existing KDA ontologies)
describes (Description, Entity)	isDescribedIn	The relation 'describes' is compositionally defined – i.e. a Description describes an Entity when the latter 'isClassifiedBy' a Concept that in turn 'isDefinedIn' the Description.	(No corresponding relation in the existing KDA ontologies)

cDnS Relation	Relation Inverse	Documentation	Mappings to relations in KDA ontologies
deputes (SocialAgent, Concept)	isDeputedBy	Social agents can depute concepts (e.g. roles) that are supposed to enact the actions of a social agent. For example, a telecom company can depute the role of 'engineer' (which as a concept can classify certain entities, typically, persons with the appropriate qualifications) to act for the company.	aktp:affiliated-person (aktp:Organisation, aktp:Affiliated-Person), swrc:affiliation (swrc:Person, swrc:Organization)
expresses (InformationObject, Description)	isExpressedBy	This relation formalises the intuition that every 'Description' is communicable in principle.	(No corresponding relation in the existing KDA ontologies)
hasMember (Collection, Entity)	isMemberOf	This relation formalises the notion of an entity being contained within a collection at a given time.	aktp:has-project-member (aktp:Project, aktp:Person), esk:partOf (esk:Person, esk:Team), swrc:member (swrc:Project, swrc:Person), foaf:memberOf (foaf:Person, foaf:Group)
hasSetting (Entity, Situation)	isSettingFor	This relation formalises the intuition of an entity being contextualised or 'situated'.	(No corresponding relation in the existing KDA ontologies)
interprets (SocialAgent, Entity)	isInterpretedBy	This relation captures the intuition that an entity's identity depends, in part, on an agent.	(No corresponding relation in the existing KDA ontologies)
isAbout (InformationObject, Entity)	isReferentOf	The 'Aboutness' principle states that, if the description expressed by an information object is satisfied by a situation, the information object can be about any entity that is within the setting of that situation.	(No corresponding relation in the existing KDA ontologies)

cDnS Relation	Relation Inverse	Documentation	Mappings to relations in KDA ontologies
satisfies (Situation, Description)	isSatisfiedBy	This relation captures the notion that an agent's perception and interpretation of a particular state of affairs depends on the agent 'carving up' reality according to some cognitive schema (i.e. a description).	(No corresponding relation in the existing KDA ontologies)
shares (SocialAgent, Description)	isSharedBy	This relation formalises the intuition of the social nature of a description. Note 'social nature' does not here imply that a description *ought* to be shared by a community (although this is typically what happens), but that a description must be in principle communicable among social agents.	(No corresponding relation in the existing KDA ontologies)
unifies (Description, Collection)	isUnifiedBy	The descriptions that define the concept(s) that cover a collection are said to unify it.	(No corresponding relation in the existing KDA ontologies)
usesConcept (Description, Concept)	isConceptUsedIn	The usesConcept relation reflects the fact that, besides defining concepts, descriptions can also use concepts defined by some other description.	aktp:addresses-generic-area-of-interest (aktp:Method, aktp:Generic-Area-Of-Interest),

With this semiotic and constructivist framework in place, the chapter proceeds to describe the design of the Scholarly Debate Ontology, which will define the vocabulary for representing debate in knowledge domains. As will be shown in the next section, the cDnS ontology just described will be used to illuminate some of the design choices in the Scholarly Debate Ontology.

3.2 The Scholarly Debate Ontology

The work in this section is directly motivated by the proposal, described previously (§2.4.2), to design an ontology suitable for representing debate in knowledge domains. This Scholarly Debate Ontology builds on the debate mapping approach of Robert Horn *et al.* (1998), which most prominently resulted in the creation of seven paper-based, wall-mountable debate maps for analysing the history and current status of scholarly debate between scholars about whether computers can think. Figure 3-3 shows Map 3 of the seven maps.

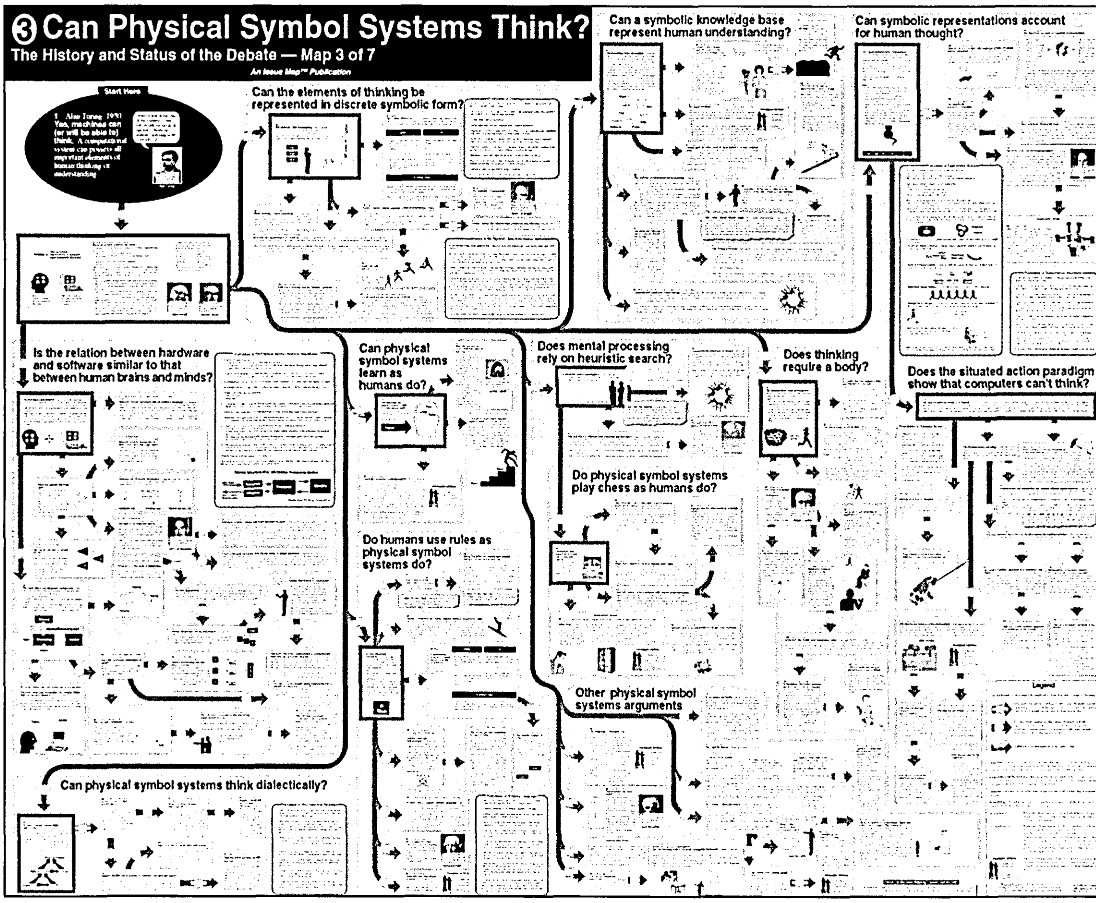


Figure 3-3 - Map 3 of the seven paper-based, wall-mountable debate maps created by Robert Horn in order to depict the history and current status of debate about whether computers can or will be able to think.

Horn's work is directly relevant here because he also recognises that when it comes to the task of analysing and understanding knowledge domains, it is important to understand how all the arguments fit together in that knowledge domain. He is particularly interested in representing dialectical exchange between scholars so as to be able to answer the question: *"Where can I get an overview of the history of the arguments so I can decide which I want to read?"*

What has emerged from Horn's work is a theory of the structure of scholarly debate, which has subsequently been articulated by his colleague in the creation of the maps, Jeffrey Yoshimi (2004), in what he calls a "logic of debate". Whereas most argumentation research concentrates on the microstructure of arguments (e.g. modelling the common types of schemes for inferring conclusions from premises), the concern of a logic of debate is how arguments themselves are "constituents in macro-level dialectical structures" (Yoshimi, 2004). Moreover, where argumentation research has focussed on macro-level argumentation, the purpose has not been on scholarly macro-argumentation. For example, the IBIS scheme is used in dialog mapping systems for capturing design rationale (i.e. the argument about design decisions) (Conklin, 2003). IBIS is a scheme that defines the basic elements of any analysis and design dialog – namely *Issues*, *Ideas*, and *Arguments*. Also, the work of van Gelder on the Reason!Able system is focussed on argumentation as it relates to deliberation – i.e. deciding on the attitude that one should have or on the action that one should take (van Gelder, 2003). Deliberation in this sense is distinct from debate which is aimed at persuading others of a particular point of view. However, as identified in the previous chapter (*Cf.* §2.3.3) tools that support uses in analysing knowledge domains must enable the user to identify and learn about the main bodies of opinion or schools of thought in the domain. Thus, for the purpose of characterising scholarly debate, any scheme that will be considered fit-for-purpose needs to cover important features such as schools of thought. Based on these criteria, the scheme used by Horn and described by Yoshimi as a logic of debate is the most suitable for the purposes of the thesis.

This section describes how the basic elements of this logic of debate are implemented as classes and relations in the Scholarly Debate Ontology. The ontology language used is the Operational Conceptual Modelling Language (OCML) (Motta, 1999). OCML supports both specification and 'operationalisation' of ontologies and knowledge bases, thus allowing rapid prototyping and evaluation. Listing 3-1 shows the new ontology being declared in OCML. As part of the declaration, the listing shows how the Scholarly Debate Ontology imports the cDnS ontology using the `:include` primitive in OCML. The SDO also imports the Simple-Time ontology (Rajpathak, 2004) to account for simple elements of time (such as 'year') that are not covered by the cDnS ontology but which are required for modelling some aspects of scholarly debate.

```
(def-ontology scholarly-debate-ontology
 :type :domain
 :includes (cDnS
            simple-time)
 :namespace-uri "http://kmi.open.ac.uk/ontologies/scholarly-debate-
ontology#"
 :namespaces (("sdo" scholarly-debate-ontology)
              ("cdns" cdns)
              ("time" simple-time)))
```

Listing 3-1 - The start of the specification of the Scholarly Debate Ontology.

sdo:Person, sdo:Publication, and sdo:DomainConcept

These classes do not correspond directly to elements of the logic of debate. However, based on the analysis in the preceding section, these classes can be characterised as core classes that belong to any ontology for supporting KDA technology. Furthermore, these classes correspond to what Yoshimi (2004) refers to as *argument classifiers* – i.e. additional information within the debate, such as who made a particular argument or in what year was the argument put forward, which is useful for the debate map reader. Yoshimi also recognises the special relevance that such additional information may have for computable representations of the debate, where a user may want to query a system to find (e.g.) all the arguments made by a particular author or in a particular journal. Listing 3-2 shows the specification of *sdo:Person* (which is defined as a subclass of *cdns:SocialAgent*), *sdo:Publication* (which is defined as a subclass of *cdns:InformationObject*), and *sdo:DomainConcept* (which is defined as a subclass of *cdns:Concept*).

```
(def-class #_sdo:Person (#_cdns:SocialAgent))

(def-class #_sdo:Publication (#_cdns:InformationObject)
  ((hasAuthor :type #_sdo:Person)
  (hasTitle :type String)
  (hasYear :type #_time:Year-In-Time)))

(def-class #_sdo:DomainConcept (#_cdns:Concept)
  ((#_cdns:isDefinedIn :type #_cdns:Description)))
```

Listing 3-2 - The specification of the sdo:Person, sdo:Publication, and sdo:DomainConcept classes in the Scholarly Debate Ontology.

sdo:Issue

In the Horn debate mapping approach, argumentative exchange between two or more scholars is depicted as occurring within the context of a particular *issue*[37]. Figure 3-4 shows a region on Map 1 with the issue "*Can computers draw analogies?*" as its title (hence the regions are often referred to as *issue regions*).

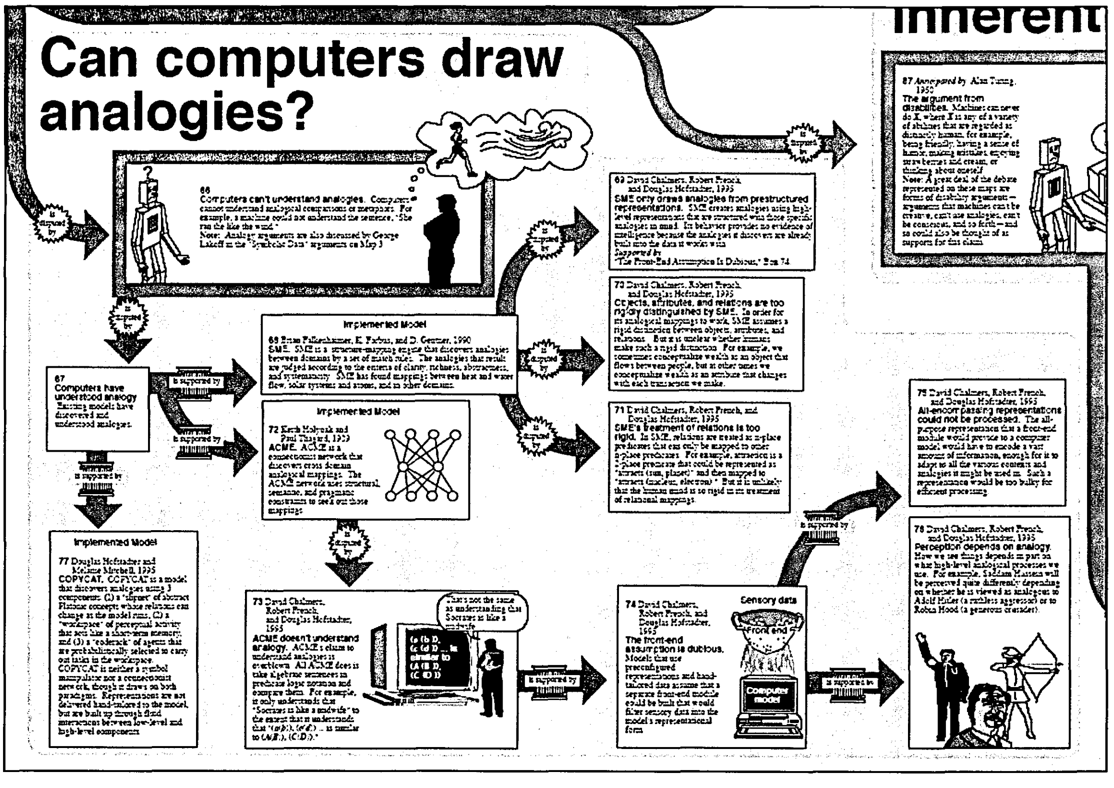


Figure 3-4 - An issue region (entitled "Can computers draw analogies?") on Map 1 of the Turing debate maps.

[37] Indeed, the approach taken by Horn is sometimes referred to as *issue mapping*.

This view of the important role that issues play in framing a debate is echoed across other argumentation research. For example, according to Walton (1996), one of the essential characteristics of argumentation is that there is an issue to be settled and that the argumentative reasoning is being used to contribute to a settling of the issue. Van Eemeren and Grootendorst (1989) also make the point that an important step in analysing any argumentative discourse is establishing which issues need to be resolved.

The use of issues as organising elements in representing argumentation has even earlier precedent in the work of Kunz and Rittel (1970) on developing a type of information system they call an *Issue-Based Information System* (IBIS). In the work on IBIS, the emphasis is on the use of argumentation to generate solutions to ill-structured design and planning problems. Using the IBIS representational approach, all design deliberations start with a root issue (in the form of a question), and ideas are offered as responses to this question. Arguments are then brought in that support or object to a particular idea. Thus, with the IBIS approach, issues are used as the *organisational atoms* when arguing over design decisions (Kunz and Rittel, 1970). In the Horn debate mapping scheme, issues can similarly be characterised as the organisational atoms in structuring scholarly debate.

Listing 3-3 shows the OCML definition of the *sdo:Issue* class. In the context of knowledge domains, issues typically correspond to the research questions expressed in individual academic publications. Thus, it is defined as an indirect subclass of the cDnS class *cdns:Description* via another new class for the Scholarly Debate Ontology, *sdo:NonPropositionalContent*[38]. Therefore, as a subclass of *cdns:Description*, an *Issue* inherits the *cdns:isExpressedBy* attribute, and specialises this attribute so that it holds values of type *sdo:Publication.* The Issue class is specified with another attribute –

[38] As explained in the previous section, descriptions found in scholarly publications represent either some propositional content (expressed in declarative sentences in the publication) or some non-propositional content (expressed in interrogative sentences – i.e. questions – in the publication).

verbalExpression – which allows an arbitrary text string[39] to be associated with a given *sdo:Issue* instance. The *verbalExpression* attribute is introduced here primarily because of pragmatic representation reasons, to make the manual representation process more tractable for a human modeller. The composition of the text string that appears as the value of the *verbalExpression* attribute has no impact on the reasoning of the system. Indeed, it is the case that an issue could be expressed in a non-textual manner, in which case the *verbalExpression* attribute might be replaced by a *nonVerbalExpression* attribute. Note, however, that this thesis does not suggest that all verbal and non-verbal forms of expression in scholarly text are directly interchangeable. As discussed previously (*Cf.* §3.1), scholarly texts consist of both verbal expressions (e.g. sentences and paragraphs) and non-verbal expressions (e.g. graphs and figures). According to Lemke (1998) “no verbal description can construct the same meaning as a picture”, which suggests that non-verbal expressions cannot be directly reduced to corresponding verbal expressions. However, Lemke also explains that we learn to count different abstractions as the same for some restricted purposes. Finally, the listing shows that the *sdo:Issue* class is also specified with one new relation – *relatedIssueOf* – which allows one issue to be asserted as related to another issue.

```
(def-class #_sdo:NonPropositionalContent (#_cdns:Description))

(def-class #_sdo:Issue (#_sdo:NonPropositionalContent)
  ((verbalExpression :type String)
   (#_cdns:isExpressedBy :type #_sdo:Publication)))

(def-relation relatedIssueOf (?iss1 ?iss2)
 :constraint (and (Issue ?iss1)
                  (Issue ?iss2)))
```

Listing 3-3 - Definition of the sdo:Issue class: sdo:Issue is defined as a subclass of sdo:NonPropositionalContent, which in turn is a subclass of cdns:Description. The sdo:Issue class inherits the cdns:isExpressedBy attribute from cdns:Description, and specialises it so that it holds values of sdo:Publication. The relatedIssueOf relation is defined as holding between two sdo:Issue instances.

[39] Even though the text string itself can have an arbitrary composition, as the case studies later in the thesis will demonstrate, it is useful to express the text-string in a grammatically well-formed manner even if it means that the text string no longer corresponds verbatim with the original source from which it has been taken.

Following the ontology-design principle of minimal ontological commitment, only the essentials of the *sdo:Issue* class for the purposes of representing scholarly debate, have been specified in the ontology. However, it is possible that in future iterations of the ontology design it may be desirable to extend the definition of the *sdo:Issue* class to incorporate various types of issues (as exemplified in the IBIS model of issues which specifies four types of issues – *Factual*, *Deontic*, *Explanatory*, and *Instrumental*). It may also be desirable to specify explicit constraints on an issue such as whether it allows a closed set of answers (e.g. 'Yes' or 'No' answers) or an open set of answers to be offered in response to a given issue.

sdo:Proposition and sdo:Argument

In addition to issues, the logic of debate consists of propositions[40] and arguments. As shown in Listing 3-4, both the *sdo:Proposition* class and the *sdo:Argument* class are defined as subclasses of the class *sdo:PropositionalContent*, which in turn is a specialisation of the cDnS class *cdns:Description*. Here the conceptualisation of *sdo:Argument* corresponds to a collection of propositions, one of which is a conclusion and the rest of which are premises. In Yoshimi's logic of debate, the distinction between propositions and arguments is one of a matter of scale – he suggests that it is possible to condense the representation of an entire argument down to a single declarative sentence and that furthermore, for argument visualisation, it is useful to do so. As with the *sdo:Issue* class described previously, the *verbalExpression* attribute is introduced here for the *sdo:Proposition* class primarily because of pragmatic representation reasons.

[40] Yoshimi actually uses the term 'claim'. Note that, this use of the term 'claim' is in a different sense to the use of 'claim' in the ClaiMaker ontology described in Chapter 2. In the ClaiMaker ontology, a claim refers to a structured entity where two scholarly objects are linked by a relation. However, in Horn's scheme, a claim is expressed as an unstructured declarative sentence. To avoid ambiguity, in specifying the Scholarly Debate Ontology, the term 'proposition' is used to replace 'claim' in the 'logic of debate'.

```
(def-class #_sdo:PropositionalContent (#_cdns:Description))

(def-class #_sdo:Proposition (#_sdo:PropositionalContent)
  (verbalExpression :type String)
  (#_cdns:isExpressedBy :type #_sdo:Publication))

(def-class #_sdo:Argument (#_sdo:PropositionalContent)
  ((hasPremise :type Proposition
               :min-cardinality 1)
   (hasConclusion :type Proposition :max-cardinality 1)))
```

Listing 3-4 - The definition of the sdo:Proposition and sdo:Argument classes: Both classes are subclasses of sdo:PropositionalContent, which in turn is a subclass of cdns:Description.

On Horn's debate maps, the arguments depicted as part of an issue region can be said to *address* the issue at the top of the issue region. The *addresses* relation is one that is implicit in Horn's representation scheme but which is now made explicit in the Scholarly Debate Ontology. Horn's representation scheme then defines two main relations – *is supported by* and *is disputed by* – that hold between arguments. Figure 3-5 shows an extract from Map 1 of the Turing maps which depicts the latter two relations.

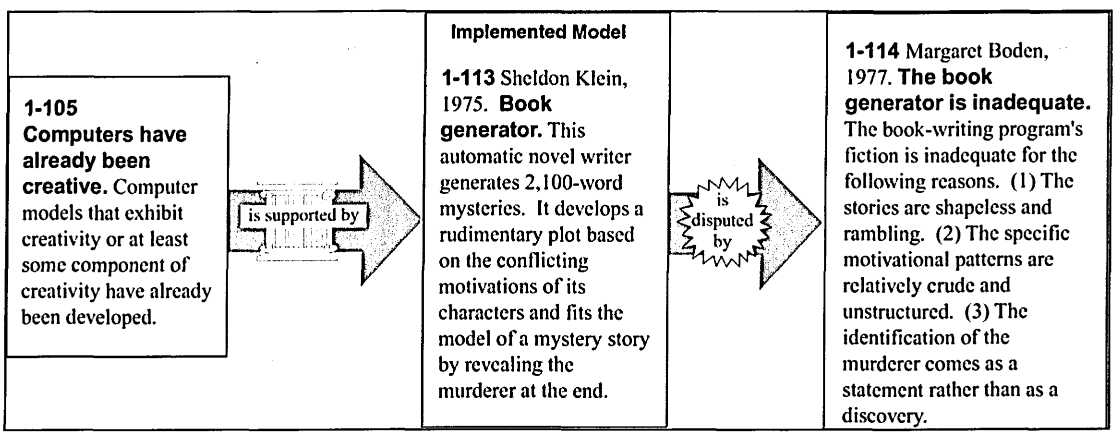


Figure 3-5 - Examples of the 'is supported by' and 'is disputed by' relations being used as part of the Horn debate mapping scheme.

Yoshimi (2004) offers three examples of types support between any arguments A1 and A2: (1) logical – i.e. A2 supports[41] A1 if A2 strengthens the conclusion of A1, (2)

[41] In detailing the terminology of his logic of debate, Yoshimi uses the active form of the verbs 'supports' and 'disputes'. In contrast the terminology of the Horn debate mapping scheme uses the passive form 'is supported by' and 'is disputed by', with the reason being that this allows the map reader to visualise the arguments from left to right. With respect to representing the relation in a formal knowledge base, the distinction between the active and passive form is not a fundamental one, and it is typical to have both forms

historical – i.e. A2 supports A1 if A2 is an earlier argument that A1 draws on, and (3) specialization – i.e. A2 supports A1 if A2 is a more specific version of A1. In terms of disputation, according to the logic of debate, argument A2 disputes argument A1 if the conclusion of A2 is the negation of some statement in A1. In the logic of debate, both *supports* and *disputes* are irreflexive, asymmetric, and non-transitive. Listing 3-5 shows the definition of the *addresses*, *supports*, and *disputes* relations in the Scholarly Debate Ontology. The *:sufficient* component of the *supports* relation definition specifies that the relation between premise and conclusion is also a special case of the *supports* relation.

```
(def-relation supports (?p1 ?p2)
   :constraint (and (PropositionalContent ?p1)
                    (PropositionalContent ?p2))
   :sufficient (and (Argument ?a)
                    (hasConclusion ?a ?p2)
                    (hasPremise ?a ?p1)))

(def-relation disputes (?p1 ?p2)
   :constraint (and (PropositionalContent ?p1)
                    (PropositionalContent ?p2)))

(def-relation addresses (?p ?iss)
   :constraint (and (PropositionalContent ?p)
                    (Issue ?iss)))
```

Listing 3-5 - The definition of 'supports', 'disputes', and 'addresses' relations in the Scholarly Debate Ontology.

The logic of debate also defines two other relations that are less frequently used on the debate maps. The first of these is the relation *is anticipated by*, which, as Yoshimi (2004) explains, is used to represent cases where an author formulates an argument for the express purpose of countering it. The second relation *as articulated by* is used to represent cases where an author reformulates an argument that was originally formulated by a different source. Since the reformulated argument may either have been distorted for the purpose of attacking it or might only emphasise certain aspects of the argument to suit the author's rhetorical purpose, this relation is introduced so that the reformulated argument doesn't have to be attributed to the original source. Finally, parts of the Turing map also

specified in the ontology (as inverses of each other). The choice is then left to the modeller as to which form to use when representing a particular relation instance.

utilise the relation *is interpreted as* to represent those cases where an author makes a "distinctive reconfiguration of an earlier claim" such that it is clear a distinctive shift in the definition of the issue being debated (Horn, 2003). Listing 3-6 shows the definition of the *isAnticipatedBy*, *asArticulatedBy*, and *isInterpretedAs* relations in the Scholarly Debate Ontology.

```
(def-relation isAnticipatedBy (?p1 ?p2)
   :constraint (and (#_sdo:PropositionalContent ?p1)
                    (#_sdo:Publication ?p2)))

(def-relation asArticulatedBy (?p1 ?p2)
   :constraint (and (#_sdo:PropositionalContent ?p1)
                    (#_sdo:Publication ?p2)))

(def-relation isInterpretedAs (?p1 ?p2)
   :constraint (and (#_sdo:PropositionalContent ?p1)
                    (#_sdo:PropositionalContent ?p2)))
```

Listing 3-6 - The definition of 'anticipates', 'articulates', and 'isInterpretedAs' relations in the Scholarly Debate Ontology.

sdo:Position and sdo:ViewpointCluster

The final element of the logic of debate is *position,* which Yoshimi informally defines as a "family of mutually complementary arguments" or, "a body of knowledge *relative to a debate*". More formally, a position is defined as a collection of arguments related by the *supports* relation, forming what the author refers to as an "aggregated support path". The author gives example positions such as *pro-choice* and *pro-life* in bioethics, *materialism* in the philosophy of mind, and *utilitarianism* in ethics. Opponents can either target such positions in their entirety or target individual elements of the positions for dispute.

According to Yoshimi, positions are important elements of the logic of debate because they provide additional information that is essential to understanding the structure of debate. This view about the informational value of positions or philosophical camps[42] is echoed by (Horn, 1998; 2003), who has identified that one of the difficult aspects of

[42] The term 'philosophical camp' is used by Horn (1998) to describe the same debate phenomenon.

understanding debates is that the protagonists come from quite different worldviews, bringing vastly different assumptions about the nature of reality. So in order to provide support for learners in gaining insight into why particular arguments take place, he includes in his Turing debate maps a description of all the major camps from which the participants enter the debate.

The specification of the *sdo:Position* class is shown in Listing 3-7. This specification shows that the *sdo:Position* class is defined as a subclass of the *cdns:Collection* class in the cDnS ontology. The specification also includes the attributes *hasViewpoint* (which links instances of the *sdo:PropositionalContent* class to a given position), *associatedPerson* (which links instances of *sdo:Person* to a given position) and *hasOpposingPosition* (which links one position to another when the two positions clash with each other in the context of a particular issue).

```
(def-class #_sdo:Position (#_cdns:Collection)

  ((hasViewpoint :type #_sdo:PropositionalContent)
   (associatedPerson :type #_sdo:Person)
   (hasOpposingPosition :type #_sdo:Position)))
```

Listing 3-7 - The definition of 'sdo:Position' as a subclass of the cDnS 'Collection' class.

Specifying the *sdo:Position* class in the ontology allows for top-down representation of existing intellectual groupings in a scholarly debate. However, it is argued here that supporting the bottom-up detection of similar intellectual groupings should be a major aim of any technology that purports to enable representing and reasoning about debates in knowledge domains. As will be explained in the next chapter, combining ontology-based analysis with graph-based cluster analysis is one viable approach to enabling bottom-up detection of coherent groups of argument. Listing 3-8 anticipates this work by introducing an ontological specification for these debate structures that will be automatically detected. This specification is introduced to be able to distinguish ontologically between what is explicitly represented in a top-down manner and what is detected in a bottom-up manner. The class *sdo:ViewpointCluster*[43] is introduced to account for the latter. The ontology specifies that two *ViewpointCluster* instances can be *opposed* to each other. The assumption here is that opposition between *ViewpointCluster* instances can be determined based on the occurrence of *disputes* relations between individual *Argument* instances that are part of each *ViewpointCluster* instance. Two intuitive criteria are being trialled here for detecting opposing *ViewpointCluster* instances. Using the first criterion, the system infers an opposition relation between two *ViewpointCluster* instances if at least *one* viewpoint in one cluster has a *disputes* relation with at least one viewpoint in the other cluster. This criterion is labelled as *weak opposition*. Using the second criterion, the system infers an opposition relation between two clusters if *more than half* (i.e. the *majority*) of the viewpoints in one cluster have a *disputes* relation with the viewpoints in the other cluster. This criterion is labelled as *strong opposition*. Weakly and strongly opposed clusters are related to the appropriate *ViewpointCluster* instance via the *hasOpposingClusterWeak* and *hasOpposingClusterStrong* attributes respectively

```
(def-class #_sdo:ViewpointCluster (#_cdns:Collection)

  ((hasViewpoint :type #_sdo:PropositionalContent)
   (associatedPerson :type #_sdo:Person)
   (hasOpposingClusterWeak :type #_sdo:ViewpointCluster)
   (hasOpposingClusterStrong :type #_sdo:ViewpointCluster)))
```

Listing 3-8 - The definition of the ViewpointCluster class as a subclass of the cdns:Collection class.

Figure 3-6 shows a semantic-network-like visualisation of the Scholarly Debate Ontology. The figure shows the relationship between some of the classes in the SDO ontology and some of the upper-level classes of the cDnS ontology.

[43] The rationale behind the name is that 'viewpoint' is used in Gangemi (2008) as a synonym for 'Description', and 'Cluster' indicates the central role played by cluster analysis to this task (as will be explained in Chapter 4).

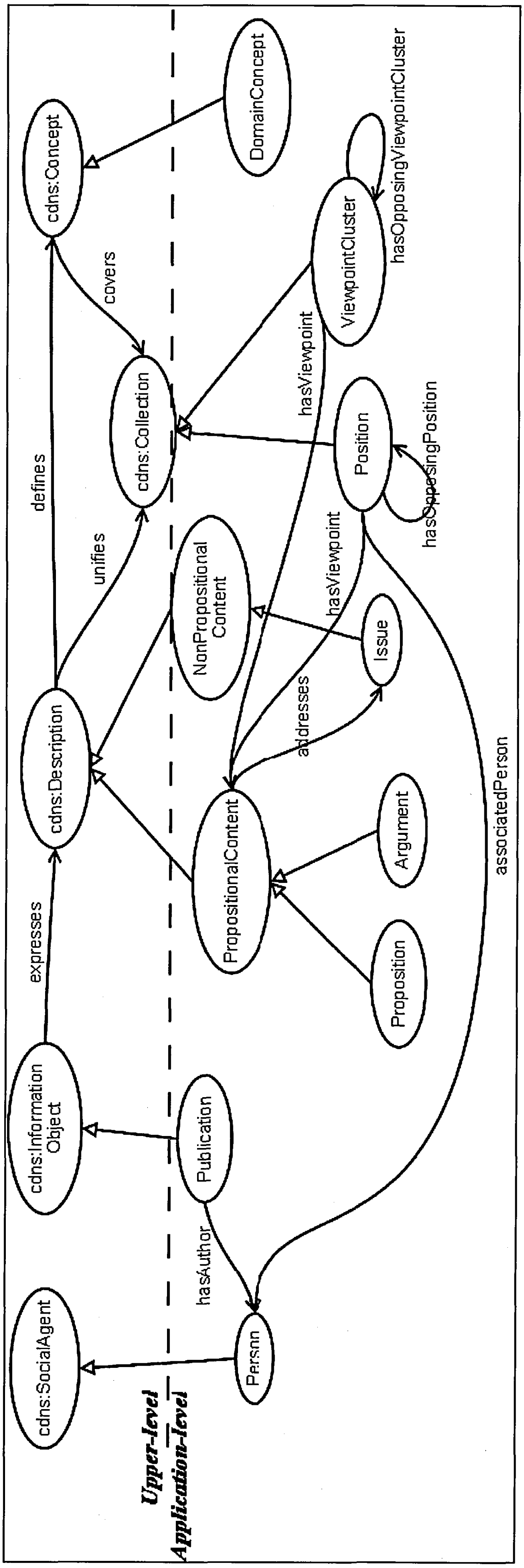


Figure 3-6 - The Scholarly Debate Ontology.

Chapter Summary

This chapter described the design of an ontology for representing and reasoning about scholarly debate in knowledge domains. It began by characterising knowledge domains as settings for the collective construction of knowledge, thus motivating the reuse of the upper-level Constructivist Descriptions and Situations (cDnS) ontology. This upper-level ontology acted as a framework for organising the relationship between the existing KDA ontologies and for ensuring the design process captured the essential elements of debate in knowledge domains. Finally, the chapter specified the classes and relations in the *Scholarly Debate Ontology.*

The next chapter describes the definition of a set of inference rules that are added to the ontology to enable semantic representations of debates to be translated to a form suitable for applying graph-based analysis. As the chapter will explain, this graph-based analysis can be used for automatically detecting clusters of viewpoints in scholarly debates.

CHAPTER 4 A HYBRID ONTOLOGY-BASED AND GRAPH-BASED METHOD FOR DETECTING VIEWPOINT-CLUSTERS IN SCHOLARLY DEBATE

This chapter describes the design of a method for detecting clusters of viewpoints as important intellectual structures in scholarly debate. As previously proposed, the kind of graph-based analysis used in Bibliometrics research, here combined with ontology-based analysis enabled by the Scholarly Debate Ontology, provides a means of implementing the necessary functionality for automatically detecting intellectual macrostructures in scholarly debate.

The chapter begins by exploring the design of ontological inference rules that can be triggered in order to translate ontology-based, semantic representations of scholarly debate into a suitable form to allow graph-based analysis. This will involve a consideration of *rhetorical-coherence* as the key connection between entities in scholarly debate, and then the use of a vocabulary of cognitively-primitive coherence parameters for implementing the rhetorical-coherence heuristics as ontological inference rules (§4.1). The chapter then explores how graph-based cluster analysis can be applied to the debate representations in order to detect viewpoint-clusters as important macro-level structures in scholarly debates (§4.2).

4.1 Using ontological inference rules to translate semantic representations into a suitable form for graph-based analysis

This section describes the design of the ontological inference rules which will be used later to translate semantic representations of scholarly debate into a form that is suitable for applying graph-based cluster analysis. First, the section demonstrates that essential to the functionality of most of the KDA tools previously reviewed is the ability to infer some form of 'similarity' relation, in some context, between pairs of entities in the domain, and this can be used to derive a set of rhetorical-coherence heuristics (§4.1.1). Next, the section describes a formal vocabulary of parameters based on research about *Cognitive Coherence Relations (CCR)*, which can be used as an efficient way of implementing the rhetorical-coherence heuristics as inference rules in the Scholarly Debate Ontology (§4.1.2).

4.1.1 Interpreting existing KDA reasoning patterns as rhetorical-coherence inference rules

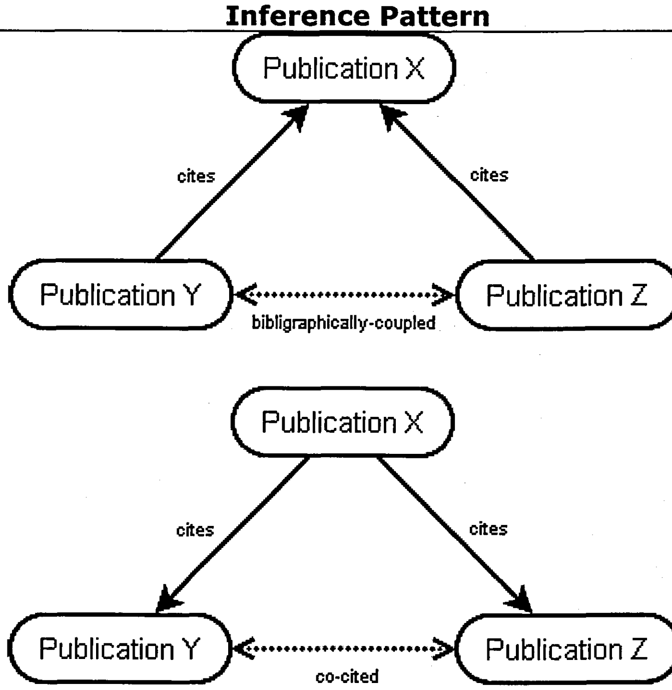
Chapter 2 proposed that graph-based analysis, typically applied to citation data in order to detect intellectual structures in the domain, can be reused for detecting important phenomena in scholarly debate. However, graph-based analytical methods are applied to single-link-type and single-node-type representations (so-called *one-mode* representations), rather than multiple-link-type and multiple-node-type (i.e. semantic) representations that would be the result of using the Scholarly Debate Ontology as a schema for representing debates in knowledge domains. As a solution to this problem, this section investigates the use of ontological inference rules to translate from a semantic representation into a one-mode representation to facilitate graph-based analysis of ontology-based, semantic representations of scholarly debate.

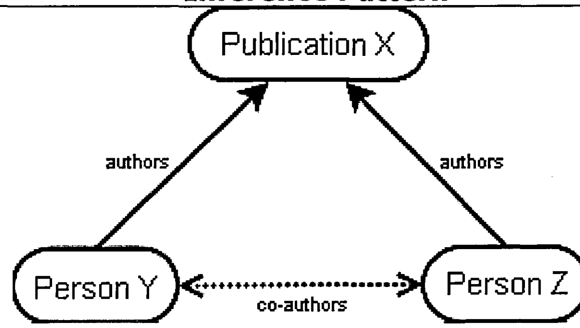
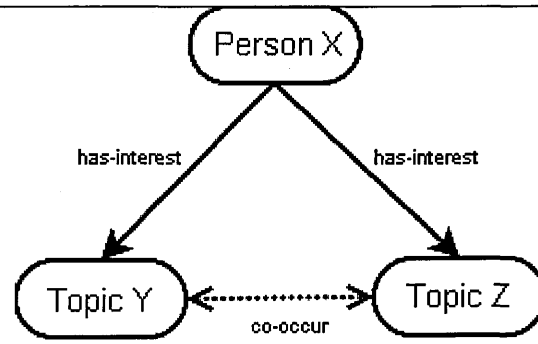
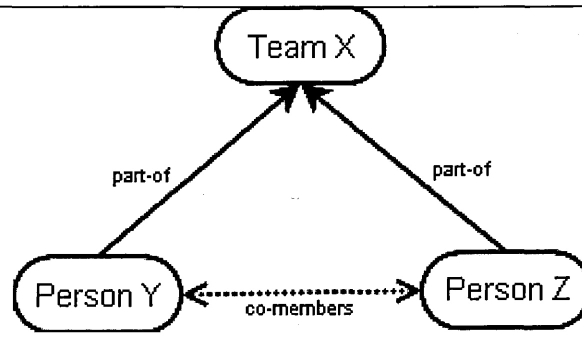
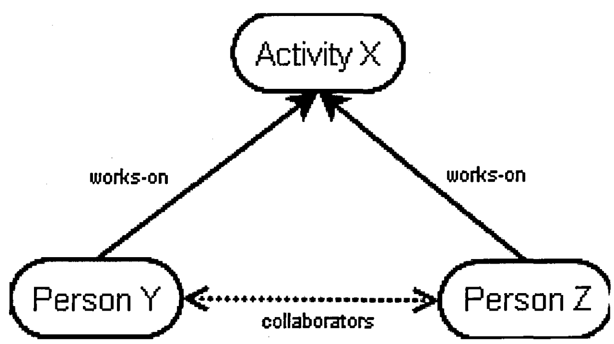
The inference patterns in the KDA tools reviewed in Chapter 2 offer clues as to how a suitable one-mode representation may be derived from semantic representations of scholarly debate. A notable feature of the citation analysis techniques reviewed in Chapter 2, is the basic task of inferring whether or not there is some form of similarity between two entities. For example, the basic inference patterns in citation analysis (*Cf.* Chapter 2, (§2.1.1) were concerned with determining whether two publications were co-cited by some third publication or whether two publications were bibliographically coupled because they cited similar publications, the presumption being that 'co-citation' and 'bibliographically-coupling' correspond to some form of 'similarity' relation. Indeed, one of the pioneers of citation analysis, Henry Small, explains the importance more generally of determining *co-*

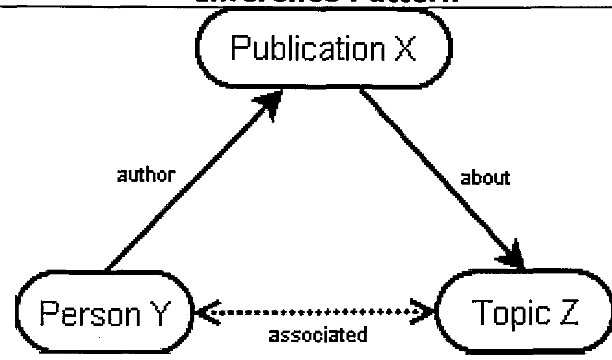
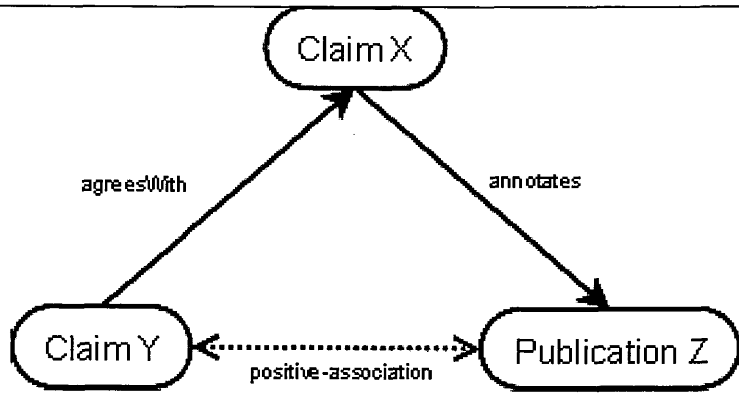
occurrence relations in a domain. Taking into account that word co-occurrence is a good indicator of topic similarity, Small reasons that "if words appeared together, or co-occurred, in multiple papers, then the community of authors probably saw some logical connection between them. The same held true for the co-assignment of classification headings, and *jointly cited papers and authors*" (Small, 2003, emphasis added).

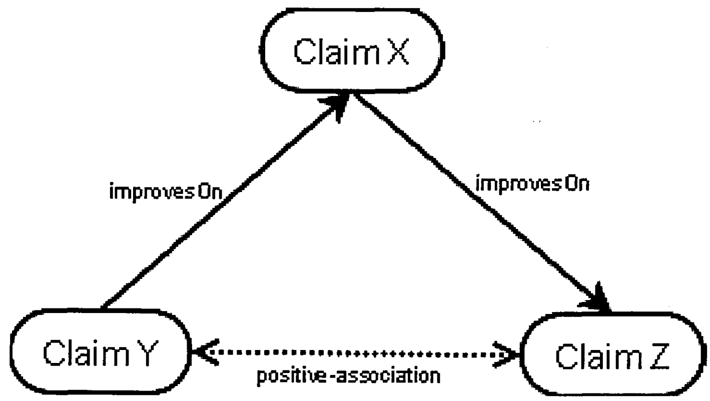
Examples of these kinds of inference patterns were also observed in the ontology-based KDA tools reviewed in Chapter 2. For example, Flink implements inference rules for determining the closeness of two topics in the domain based on the interests that researchers have in the topics. In the case of ESKIMO, there are inference rules for determining whether two scholars are members of the same team or are collaborators on the same activity. In the CAS tool there are inference rules for determining whether a scholar is associated with a particular topic. Finally, ClaiMaker implements inference rules for determining whether two claims agree or disagree as well as determining whether two concepts share a similar intellectual lineage. Table 4-1 summarises these KDA inference patterns encountered in Chapter 2.

Table 4-1 - Summary of the basic inference patterns underlying the KDA tools reviewed in Chapter 2.

Tool	Inference Pattern
CiteSeer, Citebase, CiteSpace	

Tool	Inference Pattern
	
Flink	
ESKIMO	 

<table>
<tr><th>Tool</th><th>Inference Pattern</th></tr>
<tr><td>CS AKTive Space</td><td>
</td></tr>
<tr><td>ClaiMaker</td><td>


</td></tr>
</table>

It is apparent that a common tripartite inference structure emerges for inferring some kind of similarity relation, which in the context of scholarly debate can be generally characterised as a rhetorical-coherence connection between entities. For example, co-citation can be interpreted as an indication of the rhetorical-coherence between the two publications in question. This rhetorical-coherence link has a valid interpretation in the different dimensions of a knowledge domain. The next section explores how the use of a formal vocabulary of cognitively-primitive parameters can be used to parameterise the various relations defined in the Scholarly Debate Ontology and provide a vocabulary for implementing the basic rhetorical-coherence heuristics as ontological inference rules.

4.1.2 A cognitively-primitive parameterisation of the relations in the Scholarly Debate Ontology

Previous work (Mancini, 2005; Mancini and Buckingham Shum, 2006), has begun to explore the application of a cognitive theory of coherence relations to the ClaiMaker tool introduced in Chapter 2 (*cf.* §2.2.2). The authors apply this work from both a theoretical and a practical knowledge modelling perspective. From a theoretical perspective, Mancini and Buckingham Shum (2006) apply this work with the aim of grounding their approach in established theories about discourse comprehension and about the role of language in the construction of coherent mental representations of the world. From a practical knowledge modelling perspective, the authors aim to explore how a small set of cognitively grounded, basic relational parameters, identified by psycholinguistic research on discourse coherence and referred to as *Cognitive Coherence Relations (CCR)* (Sanders *et al.*, 1992), can be framed as an upper-level discourse relations ontology and used to efficiently implement inference rules in the discourse ontology proposed in Mancini and Buckingham Shum (2006).

Cognitive coherence relation parameters

The relational vocabulary used in this thesis has emerged from the aforementioned research on discourse comprehension by Sanders *et al.* (1992). Discourse comprehension research is concerned with the process by which readers are able to construct a *coherent* mental representation of the information conveyed by a particular text. Such a coherent mental representation is constructed when the reader establishes meaningful connections between the different units of information in the discourse. For example, consider the following sentence: *"My clothes are soaked because I just walked through the rain"*. A reader is able to construct a coherent representation of this sentence by establishing a *cause-consequence* connection between the discourse units *"I just walked through the rain"* and *"My clothes are soaked"*.

In discourse comprehension research theories of discourse structure and of how readers establish meaningful connections between units of information in a discourse try to satisfy one of two requirements – *descriptive adequacy* or *psychological plausibility* (Sanders *et al.*, 1992). The 'descriptive adequacy' approach seeks to define a near-exhaustive list of discourse connections that can be used to describe the structure of any piece of discourse. The 'psychological plausibility' approach on the other hand seeks to define a few cognitively basic parameters from which it is claimed a reader is able to establish meaningful connections (composed from primitive parameters) between units of information in a discourse. Since the aim of this chapter is to parameterise the ontological relations in terms of their basic and essential characteristics, in this view, the work of (Sanders *et al.*, 1992), which falls under the 'psychological plausibility' approach is most appropriate. The objective of these authors is to derive "an economic theory that generates a limited set of classes of coherence relations" and to identify "the primitives in terms of which the set of coherence relations can be ordered." Sanders *et al.* thus propose a cognitively grounded coherence relation framework to account for how readers comprehend or make sense of discourse that is typically, but not necessarily, textual in nature. They contrast their theory of discourse structure to the Rhetorical Structure Theory developed by Mann and Thompson (1988) in that the discourse relations in RST are composite relations that can be analysed in terms of a limited set of more elementary parameters (e.g. causality), which Sanders et al. claim are the essential characteristics of discourse coherence relations. The work of Mann and Thompson can be considered as falling under the 'descriptive adequacy' approach.

Sanders and Noordman (2000) define coherence relations as "meaning relations that connect two text segments (e.g. paragraphs, sentences, or clauses)". That is, coherence relations encapsulate the meaning of how two discourse segments (or *information units* more generally) are connected. Although grammatical conjunctions (e.g. 'and', 'but', 'so', 'because') are often used to *signal* the presence of coherence relations in text, coherence relations are *conceptual* in nature (i.e. they are part of the mental representation of the text), and they may or may not be signalled by linguistic markers in the discourse. For example, consider the case where the grammatical conjunction 'because' is removed from the previous example: *"My clothes are soaked. I just walked through the rain"*. The reader is still likely to make the same meaningful cause-consequence connection even without the explicit linguistic marker.

Sanders *et al.* (1992) propose that coherence connections between discourse segments can be accounted for by a set of four bipolar, cognitive parameters: *Basic Operation* (with possible values of *Additive* or *Causal*), *Polarity* (with possible values of *Positive* or *Negative*), *Source of Coherence* (with possible values *Semantic* or *Pragmatic*), and *Order of Segments* (with possible values *Basic* or *Non-Basic*). A discourse relation is defined by the values of these parameters. These four parameters are depicted in Table 4-2.

Table 4-2 - The set of four cognitive coherence parameters and their possible bipolar values, as proposed by Sanders et al. (1992).

Parameter	Possible Values	
Basic Operation	Additive	Causal
Polarity	Positive	Negative
Source of Coherence	Semantic	Pragmatic
Order of Segments	Basic	Non-basic

The parameter *Basic Operation* has possible values *Additive* or *Causal*. According to Sanders *et al.* (1992), two discourse units can be described as having either a strong correlation or weak correlation. If two units are strongly correlated (corresponding to the logical operation of 'implication') they are said to be related by the basic operation of *causality*[44]. If two discourse units are weakly correlated (corresponding to the logical operation of 'conjunction'), they are said to be related by the basic operation of *additiveness*. For example, consider the following sentence reproduced from Sanders *et al.* (1992): *"Because he had vast political experience, he was elected president"*. This sentence has two discourse units – (1) "he had vast political experience" and (2) "he was elected president" – linked by the grammatical conjunction 'because'. The first discourse unit is strongly correlated to the second, thus the two units are said to be connected via a causal coherence relation, where "having vast political experience" is the cause and "being elected president" is the effect. For additiveness, consider the following example (Mancini, 2005): *"I went shopping this morning. I took a walk in the afternoon"*. Here, there is no strong implicative connection or correlation between the two discourse units; rather there is a weak association between the two units, thus they are connected via an additive relation. Of the two types of Basic Operation, additiveness is the most primitive, since as Louwerse (2001) explains, if two units are *causally* linked, then by implication they are *additively* linked.

The parameter *Polarity* has possible values *Positive* or *Negative*. A coherence relation is described as Positive or Negative depending, respectively, on whether or not the *expected* connection holds between the two discourse units. Reconsider the example above: *"Because he had vast political experience, he was elected president"*. Recall that the Basic Operation *Causal* holds between the unit "having vast political experience" and the unit "being elected president". Since this is the expected connection (i.e. having vast political experience usually makes a presidential candidate more attractive), the relation between the two discourse units is said to have Positive polarity. However, consider the sentence: *"Although he did not have any political experience, he was elected president"*.

[44] Here 'causality' is not restricted to cause-effect relations in physical reality. Instead it is given a broad reading to include the causality depicted in argumentation where a particular line of reasoning motivates (or causes) a particular conclusion to be drawn.

Here, the expected consequent of "*not* having any political experience" is "*not* being elected president". However, what is *actually* expressed here is the *negation* of what is expected (i.e. it turns out "he *was* elected president"). The fact that this is a violation of expectation is signalled by the conjunction *"Although"*. Thus, the coherence relation between the two discourse units "he did not have any political experience" and "he was elected president" has Negative polarity.

The parameter *Source of Coherence* has possible values *Semantic* or *Pragmatic*. According to Sanders *et al.* a relation between two discourse units is *semantic* if the connection between the two discourse units lies between their factual content. That is, the reason why the discourse can be considered to be meaningful is because the factual state of affairs described in the discourse is perceived as meaningful. On the other hand, the coherence relation between two discourse units is *pragmatic* if the connection between the two discourse units holds between the *rhetorical function* of the two units. That is, the reason the discourse can be considered meaningful is because the hearer is able to perceive the intended effect of the discourse in light of the speaker's rhetorical goals.

For example, consider the following sentence: *"The animal died because it was ill."* This statement consists of two discourse units – (1) "the animal died" and (2) "the animal was ill" – linked by the grammatical conjunction 'because'. These units are *semantically* connected because the reader is able to comprehend the discourse by establishing a meaningful connection between the two units on the basis of their factual content. That is, the state of affairs of 'dying' is perceived as related to (and actually caused by) the state of affairs of 'being ill'. On the other hand, in the sentence: *"John is not coming to school — he just called me."*, the two discourse units (1) "John is not coming to school" and (2) "John just called me" are *pragmatically* connected because the reader is able to establish a meaningful connection between the rhetorical functions of the two discourse units. That is, the connection is *not* between the physical state of affairs expressed by "John just called me" and the physical state of affairs expressed by "John is not coming to school"; rather the connection is at the rhetorical level, where the hearer perceives that the function of the discourse unit "John just called me" is to motivate the speaker's assertion of the second discourse unit "John is not coming to school".

The prototypical discourse relations resulting from the combination of these four parameters is shown in **Error! Reference source not found.**.

Table 4-3 - The prototypical discourse relations resulting from the combination of the four CCR parameters (table from Sanders et al., 1993).

Basic Operation	Polarity	Source of Coherence	Order of Segments	Discourse Relation
Causal	Positive	Semantic	Basic	*Cause-consequence*
Causal	Positive	Semantic	Non-Basic	*Consequence-cause*
Causal	Positive	Pragmatic	Basic	*Argument-claim*
Causal	Positive	Pragmatic	Non-Basic	*Claim-argument*
Causal	Negative	Semantic	Basic	*Contrastive cause-consequence*
Causal	Negative	Semantic	Non-Basic	*Contrastive consequence-cause*
Causal	Negative	Pragmatic	Basic	*Contrastive argument-claim*
Causal	Negative	Pragmatic	Non-Basic	*Contrastive claim-argument*
Additive	Positive	Semantic	-----------	*List*
Additive	Positive	Pragmatic	-----------	*Enumeration*
Additive	Negative	Semantic	-----------	*Opposition*
Additive	Negative	Pragmatic	-----------	*Concession*

As the basic unit of argumentation analysis is the "utterance in context" (Eemeren *et al.*, 1993), rather than the factual content of the utterance[45], the ontological relations in the context of debate representation will be parameterised as Pragmatic by default.

[45] The parameter *Source of Coherence* is the most controversial and is uncertain from the point of view of experimental evidence (Louwerse, 2001). Indeed, Sanders *et al.* (1992) accept that "the distinction between semantic and pragmatic relations is often somewhat difficult to make", while Pander Maat and Degand (2001) abandon the Semantic vs. Pragmatic dichotomy in favour of a scalar approach where the 'Semantic' and 'Pragmatic' parameters are reanalysed as two points of a "scale of increasing speaker involvement".

Finally, the parameter *Order of Segments* has possible values *Basic* or *Non-basic*. Consider again the example: *"Because he had vast political experience, he was elected president."* These two segments are in *Basic* order since the first segment expresses the cause and the second segment expresses the effect, mirroring the actual order of events in the represented world. On the other hand, consider the sentence: *"He was elected president because he had vast political experience"*. The order between the two segments is *Non-Basic* since the effect (first segment) precedes its cause (second segment). It should be noted that the parameter Order of Segments is specifically relevant to the analysis of textual discourse, where information is *presented* linearly and therefore the author has to make a presentational decision about whether to put the segments in basic or non-basic order. However, the choice about the order of segments does not affect the essential nature or meaning of the discourse connection. This means that the distinction between basic and non-basic order becomes irrelevant when relations are represented in a knowledge base (i.e. where they can be treated non-linearly and where the system doesn't need to use the Non-Basic parameterisation because it can always use relevant axioms to arrive at the Basic form from the Non-Basic form).

Mapping parameters to relations in the ontology

The above analysis has argued that the two coherence parameters *Source of Coherence*, and *Order of Segments* are less relevant when modelling literature. This leaves us with the *Basic Operation* parameter (with values of *causal* or *additive*) and the *Polarity* parameter (with values of *positive* or *negative*) as the most relevant for defining the rhetorical-coherence inference rules in the Scholarly Debate Ontology. This gives four possible combinations of parametrical values: *+CAUSAL*, *–CAUSAL*, *+ADDITIVE*, and *–ADDITIVE*.

Here, speaker involvement refers to the degree to which the speaker is perceived to be important in a hearer's successful comprehension of the coherence relation.

Table 4-4 below shows how the relations across each dimension in the ontology can be analysed in terms of the parametrical values just described. The coherence parameters defined by Sanders *et al.* (1992) are primarily concerned with the connections between discourse units, where the units occur at the clause, sentence, or paragraph level. Thus, for the Scholarly Debate Ontology described here, the coherence primitives can most readily be used to parameterise the *inter-proposition and inter-argument* relations implemented from the logic of debate. For example, Table 4-4 shows that the *supports* and *disputes* relations can be parameterised as +CAUSAL and –CAUSAL, respectively. Whether or not the coherence parameters apply equally well across different analytical dimensions is an empirical question. However, in agreement with Mancini and Buckingham Shum (2006), this thesis proposes that the other ontological relations can also be defined in terms of the coherence parameters, and this proposal will be tested, in terms of its usefulness to enabling a new KDA approach, in the following case study chapters (Chapter 5 and Chapter 6).

Table 4-4 - The cognitive-coherence parameterisation of the relations in the Scholarly Debate Ontology.

Parameterisation	Relations	Motivation
+CAUSAL	sdo:supports	If A2 supports A1, A2 can be characterised as motivating or 'causing' the assertion of A1.
	sdo:authorOf	If A is the author of P, then A can be characterised as 'bringing about' or 'causing' P.
	sdo:memberOf	In the cDnS sense, a collection is dependent on its members for its identity, or in other words, the members 'bring about' the collection.
	cdns:expresses	The information object can be characterised as 'bringing about' the description.
	cdns:classifies	In the cDnS sense, the identity of the entity being classified is dependent on the concept doing the classification.
-CAUSAL	sdo:disputes	An argument A2 disputes A1 if the conclusion of A2 is the negation of some statement in A1. This corresponds to Sanders et al. (1992) treatment of CAUSAL(PRAGMATIC) 'Contrastive Argument-Claim'[46].
+ADDITIVE	sdo:coAuthor	It is reasonable to assume that two authors would typically have a 'positive association' with each other, in the context of a particular conceptual work, when they co-author the same conceptual work.
	sdo:coMember	It is reasonable to assume that two researchers would typically have a 'positive association' with each other, in the context of some research group of which they both are members.
	sdo:collaborate	It is reasonable to assume that two researchers would typically have a 'positive association' with each other, in the context of some research activity in which they both participate.
	sdo:associatedConcept	Two concepts that are associated in a rhetorical context will be assumed to have a 'positive' association unless otherwise modelled.

[46] Note that, as explained by Mancini and Buckingham Shum (2006), even though intuitively the 'disputes' relation should be *directly* mapped to -CASUAL, in strict CCR terms, this is a shortcut and 'disputes' should be directly mapped to a parameterisation of +CAUSAL but "associated with opposition". This is because, in effect, when an argument A disputes another argument B, A supports the position that B cannot be claimed (either because of faulty premises or because of a faulty inference step).

Having described the coherence parameters and shown how these can be used to parameterise the relations across each dimension of the core ontology, the next section explores how these parameters can be used to define the ontological inference rules that will be used as the basis for reasoning about rhetorical structures in scholarly domains.

Describing the inference rules

This section describes how the coherence parameters are used as a vocabulary that provides a novel and efficient way of implementing the inference rules. As mentioned previously, the ontological inference rules will be implemented so as to mirror the inference patterns essential to the task of knowledge domain analysis (*cf.* Table 4-1). The rhetorical-coherence connection between knowledge domain entities is parameterised as *Positive-Additive* (henceforth *+ADDITIVE*). The ontological inference rules are based on the basic KDA inference patterns identified in Chapter 2. These patterns demonstrated that the key connection that needs to be inferred is whether or not there is some kind of similarity (or coherence) between two entities. Figure 4-1 shows a pattern for inferring a +ADDITIVE coherence connection, which is based on an abstraction of the 'co-cited', 'co-authors', 'co-members', and 'collaborators' inference patterns identified previously. The pattern shows that if two entities *Y* and *Z* both have a +CAUSAL connection to an entity *X*, then a +ADDITIVE connection can be inferred between *Y* and *Z*. .

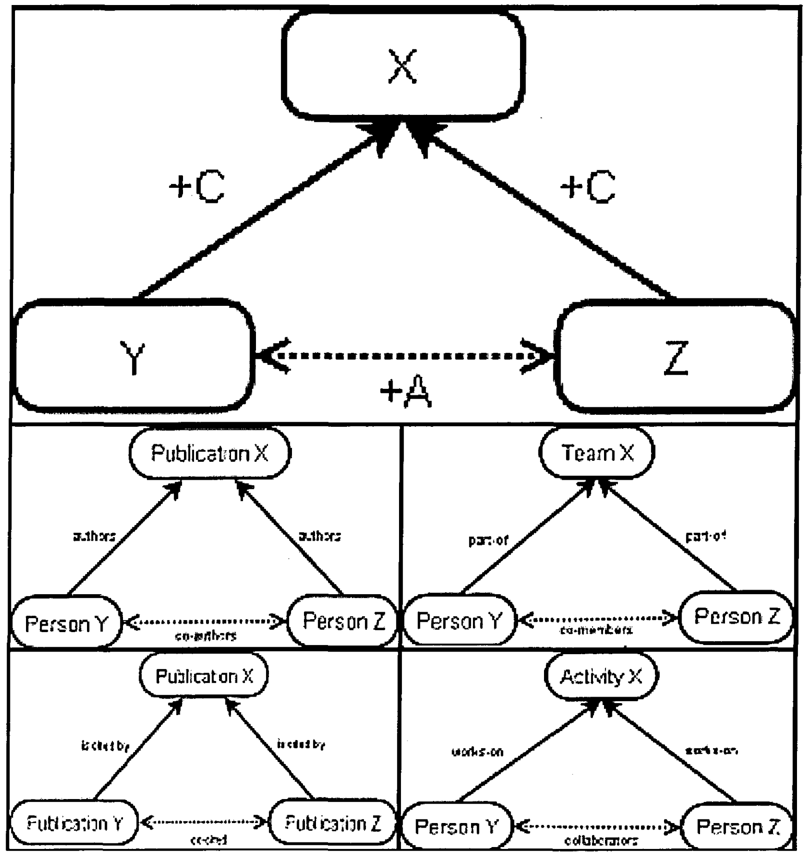


Figure 4-1 - +ADDITIVE Inference #1: If (+CAUSAL Y X) and (+CAUSAL Z X) then (+ADDITIVE Y Z) with respect to an issue.

In a scholarly debate context, this pattern is typically realised when two arguments are mutually supporting another argument. For example, assuming that the 'supports' relation is parameterised as +CAUSAL (*Cf.* Table 4-4), consider the instantiation of +ADDITIVE Inference Pattern #1 with the following argumentation taken from the Paleontology domain and the debate about how dinosaurs became extinct at the Cretaceous-Tertiary boundary approximately 65 million years ago. In this instantiation of the pattern, the two arguments Y and Z are mutually supporting the argument X: X = *"A large extraterrestrial object collided with the earth at the end of the Cretaceous Period."*; Y = *"At the Cretaceous-Tertiary boundary in several places around the globe, we have a thin layer of clay with an unusually high content of the asteroid mineral iridium."*; Z = *"There is an impact crater at Chicxulub on the Yucatan Peninsula of Mexico that dates to the end of the Cretaceous Period."*. In this example, the inference rule will correctly infer a +ADDITIVE connection between the arguments Y and Z, and intuitively it is clear that these two arguments are indeed rhetorically coherent with each other.

Extrapolated from this pattern are two other patterns where the presence of two +CAUSAL connections can be used to infer the presence of a +ADDITIVE connection. The first of these is shown in Figure 4-2 below. Here, the entity *X* has a +CAUSAL connection to both *Y* and *Z*. In this case, as an abstraction of the 'bibliographically-coupled' inference pattern introduced previously, a +ADDITIVE connection can also be inferred between *Y* and *Z*.

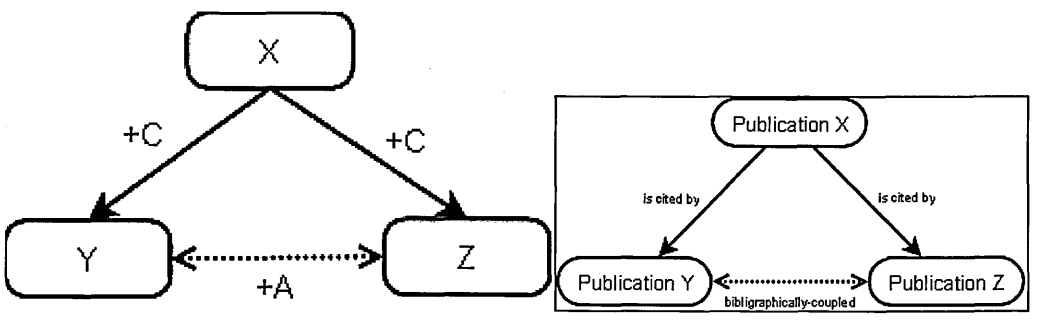


Figure 4-2 - +ADDITIVE Inference #2: If (+CAUSAL X Y) and (+CAUSAL X Z) then (+ADDITIVE Y Z).

The second extrapolation is shown in Figure 4-3 which depicts the situation where an entity Y has a +CAUSAL connection to X, and X in turn has a +CAUSAL connection to Z. In this case, as an abstraction of the 'positive-association' inference pattern implemented in ClaiMaker (*Cf.* Table 4-1), the figure shows how a +ADDITIVE connection can be inferred between Y and Z. In this case the ClaiMaker relations 'agreesWith' and 'annotates' can be parameterised as +CAUSAL – 'agreesWith' in the ClaiMaker sense is a strong argument relation similar to the common argumentation relation of 'supports', and as explained above (Cf. Table 4-4) if an argument Y supports an argument X, the Y can be characterised as motivating or 'causing' the assertion of X. Similarly, the 'annotates' relation in the ClaiMaker sense is similar to the notion of Concept in the cDnS sense classifying any other entity. And, since in classification (in the cDnS sense) the identity of the entity being classified is dependent on the concept doing the classification, we can parameterise the 'classifies' relation, and by extension the 'annotates' relation as +CAUSAL.

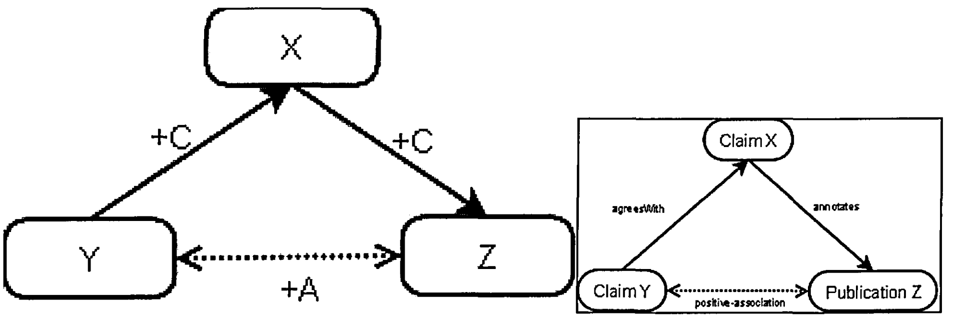


Figure 4-3 - +ADDITIVE Inference #3: If (+CAUSAL Y X) and (+CAUSAL X Z) then (+ADDITIVE Y Z).

In a scholarly debate context, this pattern is typically realised when two support relations are chained after each other. For example, assuming again that the 'supports' relation is parameterised as +CAUSAL (*Cf.* Table 4-4), consider the instantiation of +ADDITIVE Inference Pattern #3 with the following argumentation again taken from the Paleontology domain. In this instantiation of the pattern, the two arguments Y and Z are at the beginning and end of a supports chain that contains argument X: X = *"There was an asteroid collision 65 million years ago."*; Y = *"Many organisms, both marine and terrestrial, vertebrate and invertebrate, went extinct at the Cretaceous-Tertiary boundary due to climate change triggered by a massive terrestrial disturbance."*; Z = *"The dinosaur's were made extinct at a catasprohic event at the Cretaceous-Tertiary boundary."*. In this example, the inference rule will again correctly infer a +ADDITIVE connection between the arguments Y and Z, and again it is apparent that these two arguments are rhetorically coherent with each other. Note that the +CAUSAL parameterised 'supports' relation doesn't behave transitively in this case. This is because saying that Y outright 'supports' Z misses a step in the reasoning. In this case, Y can be considered to be indirectly supporting Z.

Continuing in this manner yields a number of permutations for this basic three-segment pattern. The first permutation yields a similar +ADDITIVE inference to the patterns described above. In this case, shown in Figure 4-4, the two entities *Y* and *Z* both have a –CAUSAL connection to the entity *X*. Again, a +ADDITIVE connection can be inferred between *Y* and *Z*. This pattern is not abstracted from previous KDA inference patterns; rather it is derived from argument analysis work, where two discourse units can be viewed as similar because of common disagreement with another discourse unit. This pattern can also be characterised as one form of the aphorism – "The enemy of my enemy is my friend". This inference pattern will be used later as the basis for detecting clusters of viewpoints which are formed out of common dispute with another viewpoint or set of viewpoints. Allen (1997) explains that schools of thought are typically associated with opposition to other schools since debates typically centre on "alternative explanatory theories or methodological preferences".

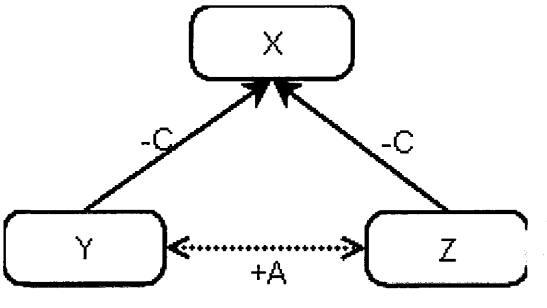


Figure 4-4 - +ADDITIVE Inference #4: If (-CAUSAL Y X) and (-CAUSAL Z X) then (+ADDITIVE Y Z).

In a scholarly debate context, this pattern is typically realised when two arguments are mutually disputing another argument. For example, assuming that the 'disputes' relation is parameterised as -CAUSAL (*Cf.* Table 4-4), consider the instantiation of +ADDITIVE Inference Pattern #4 with the following argumentation again taken from the Paleontology domain. In this instantiation of the pattern, the two arguments Y and Z are mutually disputing the argument X: X = *"The thin red layer, which is widely considered* *as the Cretaceous-Tertiary boundary impact ejecta, defines the Cretaceous-Tertiary boundary.*"; Y = "*Thin red layers are not unique and are usually present at the base of most clay layers.*"; Z = "*The International Commission on Stratigraphy really considers the thin red layer as an additional boundary marker and not as part of the Cretaceous-Tertiary boundary definition .*". In this example, the inference rule will again correctly infer a +ADDITIVE connection between the arguments Y and Z, and again it is apparent that these two arguments are rhetorically coherent with each other.

Figure 4-5 shows a final +ADDITIVE coherence pattern which is not abstracted from existing KDA patterns but rather is derived from consideration of argumentation analysis. The figure shows the case where an entity *Y* has a –CAUSAL connection to an entity *X*, which in turn has a –CAUSAL connection to an entity *Z*. In general, the status of a –CAUSAL connection followed by another –CAUSAL connection is unclear. However, in argumentation research *Y* can be characterised as protecting *Z* from the attack of *X* by undercutting *X*. Thus a +ADDITIVE connection can be inferred between *Y* and *Z*. This can be regarded as another form of the principle – "the enemy of my enemy is my friend".

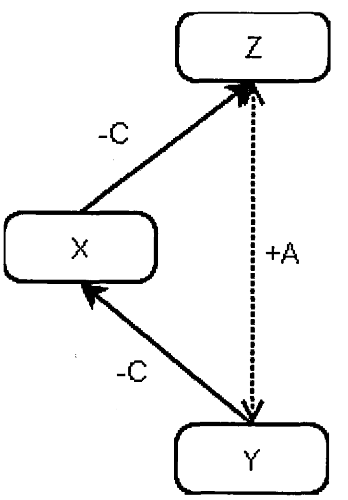


Figure 4-5 - +ADDITIVE Inference #5: If (-CAUSAL Y X) and (-CAUSAL X Z) then (+ADDITIVE Y Z).

As mentioned above, in a scholarly debate context, this pattern is typically realised when one argument is 'protecting' another argument from attack. For example, assuming that the 'disputes' relation is parameterised as -CAUSAL (*Cf.* Table 4-4), consider the instantiation of +ADDITIVE Inference Pattern #5 with the following argumentation again taken from the Paleontology domain. In this instantiation of the pattern, the two argument Y is undercutting X's attack on Z: X = *"There is an impact crater at Chicxulub on the Yucatan Peninsula that appears to match the profile of a Cretaceous-Tertiary impact crater."*; Y = *"The Chicxulub impact crater predates the Cretaceous-Tertiary boundary and hence could not be the cause of the dinosaur extinction."*; Z = *"No evidence has been found of an impact that could have led to the dinosaur extinction at the Cretaceous-Tertiary boundary."*. In this example, the inference rule will again infer a +ADDITIVE connection between the arguments Y and Z, and this seems intuitive due to the principle of 'the enemy of my enemy is my friend'. However, it is noted here that such an inference could be problematic in certain circumstances where it is not straightforward to assume that in when an argument Y protects another argument Z from attack that the two are necessarily rhetorically coherent with each other.

Implementing the inference rules in OCML

Listing 4-1 shows the ontological definitions for the coherence parameters and how existing relations are defined in terms of these parameters. As explained in the previous section, the two most relevant coherence parameters are the *Basic Operation* parameter (with a value of *Additive* or *Causal*) and the *Polarity* parameter (with a value of *Positive* or *Negative*). Thus the Listing shows how the class `CCR-PARAMETER` is specified in the ontology and how this is the parent class of both `CCR-BASIC-OPERATION-PARAMETER` and `CCR-POLARITY-PARAMETER`. It then shows that `ADDITIVE` is a subclass of `CCR-BASIC-OPERATION-PARAMETER` and that `CAUSAL` is a subclass of `ADDITIVE`, which implements the semantics that causality in the CCR sense also implies additiveness (Louwerse, 2001).

The Listing then shows how the classes POSITIVE-POLARITY and NEGATIVE-POLARITY are subclasses of CCR-POLARITY-PARAMETER.

```
(def-class CCR-PARAMETER ())
(def-class CCR-BASIC-OPERATION-PARAMETER (CCR-PARAMETER))
(def-class CCR-POLARITY-PARAMETER (CCR-PARAMETER))


(def-class ADDITIVE (CCR-BASIC-OPERATION-PARAMETER))
(def-class CAUSAL (ADDITIVE))

(def-class POSITIVE-POLARITY (CCR-POLARITY-PARAMETER))
(def-class NEGATIVE-POLARITY (CCR-POLARITY-PARAMETER))
```

Listing 4-1 - The OCML definitions of the four relevant coherence parameter values (ADDITIVE, CAUSAL, POSITIVE, & NEGATIVE).

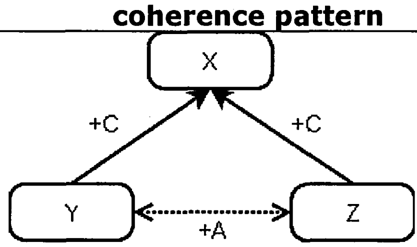
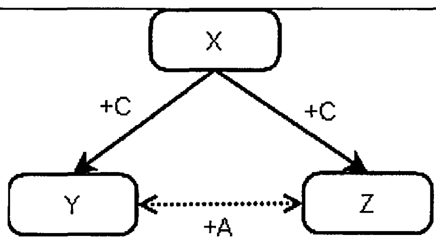
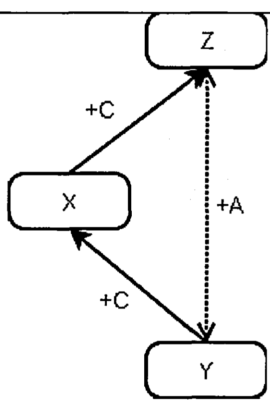
Finally, Listing 4-2 shows how the relations in the Scholarly Debate Ontology are specified in terms of the relevant relational parameters.

```
(def-relation-instances
  (CAUSAL supports)
  (CAUSAL disputes)
  (CAUSAL expresses)
  (CAUSAL author-of)
  (CAUSAL member-of)
  (CAUSAL classifies)
  (ADDITIVE co-author)
  (ADDITIVE co-member)
  (ADDITIVE affiliated-with)
  (ADDITIVE associated-with)
  (POSITIVE-POLARITY supports)
  (POSITIVE-POLARITY expresses)
  (POSITIVE-POLARITY author-of)
  (POSITIVE-POLARITY member-of)
  (POSITIVE-POLARITY co-author)
  (POSITIVE-POLARITY co-member)
  (POSITIVE-POLARITY affiliated-with)
  (POSITIVE-POLARITY classifies)
  (POSITIVE-POLARITY associated-concept)
  (NEGATIVE-POLARITY disputes))
```

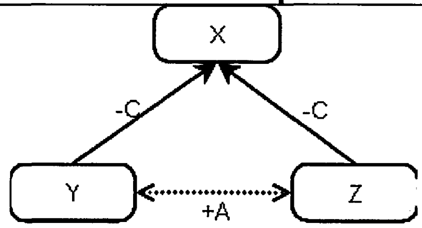
Listing 4-2 - Formal OCML definitions of the CCR parameterisation of the relations in the Scholarly Debate Ontology.

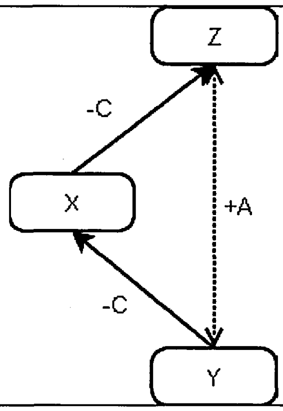
Table 4-5 shows five +ADDITIVE inference rules formalised in OCML as part of the Scholarly Debate Ontology. Taking the first inference rule as an example, these inferences can be read as: (1) If there is a relation ?r1 that is CAUSAL and has POSITIVE-POLARITY, (2) AND that relation holds between two entities ?y and ?x in a particular context ?con1, (3) AND there is another relation ?r2 that is CAUSAL and has POSITIVE-POLARITY, (4) AND that relation holds between two entities ?z and ?x in a particular context ?con2, (5) AND provided that ?y and ?z are not the same entity, (6) AND that the two contexts ?con1 and ?con2 are overlapping (i.e. related to each other), (7) then we can infer a +ADDITIVE relation between ?y and ?z.

Table 4-5 - The OCML specification of the five +ADDITIVE reasoning patterns as ontological inference rules.

Parameterised rhetorical-coherence pattern	Formal inference rule
	(def-rule positive-additive-1 ((+ADDITIVE ?y ?z ?con) if (CAUSAL ?r1) (POSITIVE-POLARITY ?r1) (holds ?r1 ?y ?x ?con1) (CAUSAL ?r2) (POSITIVE-POLARITY ?r2) (holds ?r2 ?z ?x ?con2) (<> ?y ?z) (= ?con (context-overlap? ?con1 ?con2)) (not (null ?con))))
	(def-rule positive-additive-2 ((+ADDITIVE ?y ?z ?con) if (CAUSAL ?r1) (POSITIVE-POLARITY ?r1) (holds ?r1 ?x ?y ?con1) (CAUSAL ?r2) (POSITIVE-POLARITY ?r2) (holds ?r2 ?x ?z ?con2) (<> ?y ?z) (= ?con (context-overlap? ?con1 ?con2)) (not (null ?con))))
	(def-rule positive-additive-3 ((+ADDITIVE ?y ?z ?con) if (CAUSAL ?r1) (POSITIVE-POLARITY ?r1) (holds ?r1 ?y ?x ?con1) (CAUSAL ?r2) (POSITIVE-POLARITY ?r2) (holds ?r2 ?x ?z ?con2) (<> ?y ?z) (= ?con (context-overlap? ?con1 ?con2)) (not (null ?con))))

Parameterised rhetorical-coherence pattern	**Formal inference rule**

	`(def-rule positive-additive-4`
	`((+ADDITIVE ?y ?z ?con)`
	`if`
	`(NEGATIVE-POLARITY ?r1)`
	`(CAUSAL ?r1)`
	`(holds ?r1 ?y ?x ?con1)`
	`(NEGATIVE-POLARITY ?r2)`
	`(holds ?r2 ?z ?x ?con2)`
	`(CAUSAL ?r2)`
	`(<> ?y ?z)`
	`(= ?con (context-overlap? ?con1`
	`?con2))`
	`(not (null ?con))))`

	`(def-rule positive-additive-5`
	`((+ADDITIVE ?y ?z ?con)`
	`if`
	`(NEGATIVE-POLARITY ?r1)`
	`(CAUSAL ?r1)`
	`(holds ?r1 ?y ?x ?con1)`
	`(NEGATIVE-POLARITY ?r2)`
	`(holds ?r2 ?x ?z ?con2)`
	`(CAUSAL ?r2)`
	`(<> ?y ?z)`
	`(= ?con (context-overlap? ?con1`
	`?con2))`
	`(not (null ?con))))`

Making inferences in context

Each of the inference rules listed previously utilises a variable called ?con. The `?con` variable in the ontological inference rules introduces the feature of reasoning in context. This acts as a constraint so that the inferred +ADDITIVE or –ADDITIVE connections can only be made if it has been determined that the discourse elements *X*, *Y*, and *Z* have been asserted in the same or related context (i.e. the discourse elements are relevant to each other). Therefore, before the inferred connection is made, the function `context-overlap?` determines whether the two different contexts are related. Furthermore, after the inference is made, the system then specifies that the newly inferred connection is only valid in that particular context-overlap. This kind of constraint is necessary to prevent the inference engine from inferring irrelevant and misleading links between discourse elements. For example, in one context, a discourse element Y may dispute a discourse element X, while in another context, discourse element X may dispute a discourse element Z. This has the shape of the 'undercutting' inference pattern

(+ADDITIVE Inference #5) described previously. However, an inference linking discourse element Y and discourse element Z might be misleading because they are occurring in different contexts and may not be relevant to each other.

This leads to the question: "What counts as *relevant* context?" According to Eemeren *et al.* (1993), relevance depends on determining what has an effect on accomplishing "the communicative and interactional goals" of a set of argumentative speech acts. In scholarly discourse, discourse units play roles with respect to the goal of addressing a particular issue, and thus only make sense in the context of that particular *issue*. It then follows that relational assertions between discourse units only make sense in the context of these issues being addressed. Thus, one useful way of demarcating relevance or context is through the use of issues. Indeed Horn (1998) used issue regions with good effect on his debate maps in order to place the argumentative exchanges between scholars in the context of some question that needs to be answered. Thus for any +ADDITIVE or –ADDITIVE inference to be made, the "issue context" needs to be established for the domain entities that are involved.

One option is to rely on the knowledge modeller to explicitly model the context of all assertions in the knowledge base. In this approach, the modeller makes all the decisions about what is relevant to include in a context representation. However, one drawback of this approach is that it severely adds to the already high modelling overhead. Thus it is desirable to have a system that automatically determines the context of assertions in those cases where the modeller has not provided an explicit context representation. Listing 4-3 shows the algorithm for how the issue context for a discourse element is established and how this affects what connections between discourse elements can be inferred.

```
1. First determine all of the issues which the discourse element X
   directly addresses
2. Then explore the network to find all discourse elements to which
   X has a path
3. For each of these discourse elements, determine the issues which
   they address
4. Append the names of these issues to the set of issues which
   discourse element X directly addresses
5. Return this set of issues as the context of X
```

Listing 4-3 - The algorithm to determine the context of a discourse element and to automatically add context information to relation assertions.

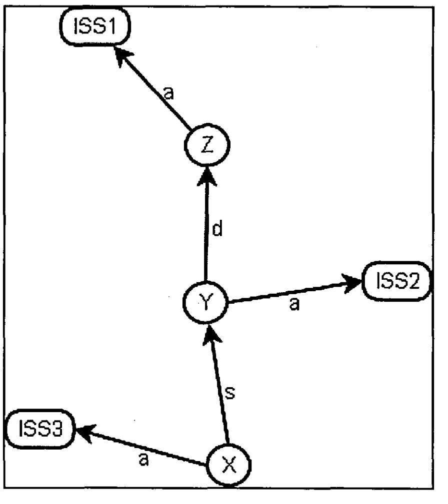


Figure 4-6 - An example of how 'issue context' is cascaded through a representation: X addresses ISS3, but since X has a path to Y (which addresses ISS2), and a path to Z (which addresses ISS1), then the issue context of X is (ISS1 ISS2 ISS3).

This thesis adopts the approach put forward by Theodorakis & Spyratos (2002) for context representation. According to these authors, the simplest approach to representing the fact that the value of some predicate is dependent on some state of affairs or context "is to add a context argument to the list of arguments for each predicate". For example, the relational assertion `(on block1 block2)` – which corresponds to the predication that "*blockl is on block2*" – would become `(on block1 block2 s1)`, where `s1` is a set of assertions representing a state of affairs.

Similarly, in the scholarly debate representation scenario depicted in Figure 4-6, the relational assertion that `(supports X Y)` – which corresponds to the predication "*Argument X supports Argument Y*" – would become `(supports X Y (ISS1 ISS2))`, where `(ISS1 ISS2)` represents the set of issues that make up the context of the assertion. This corresponds to the predication that "*Argument X supports Argument Y in the context of the two issues ISS1 and ISS2*".

The contextual state of affairs is determined by first finding the context of the discourse unit X (which is the set containing ISS1, ISS2, and ISS3), then finding the context of discourse unit Y (which is the set ISS1 and ISS2), and finally finding the intersection of these two sets (which is ISS1 and ISS2).

The case studies in Chapter 5 and Chapter 6 will demonstrate that this simple issue-based context representation is sufficient and has value for debate analysis. However, it is possible that in future application scenarios, the context representation could be extended to include other more complex approaches. One option may be to adopt the approach of the CYC ontology (Lenat and Guha, 1990), which treats contexts as first-class objects that can be structured into hierarchies. This makes it possible to have hierarchies of contexts or *microtheories* to use CYC terminology[47]. In CYC, all assertions are made within at least one microtheory, and microtheories can vary along dimensions of (e.g.) time, place, and topic.

Having formalised the basic reasoning patterns as ontological inference rules, the next section will explore how these inference rules can be used as the backbone for defining reasoning capabilities at the application level.

4.2 Detecting clusters of viewpoints using graph-based cluster analysis

This section proposes new functionality for clustering viewpoints across issues in a debate as an aid to providing overviews of complex scholarly debates. The previous

[47] for example, in the CYC ontology the context `#$MiddleEarthMt` is a specialisation of the context `#$FictionalContext`, which in turn is a specialisation of the context `#$FictionalOrMythologicalContext`. Thus, contexts that are lower in the hierarchy, inherit attributes from those higher up in the hierarchy, which in the case of contexts means that the assertions that are true in `#$FictionContext` are also true in the context `#$MiddleEarthMt`.

chapter discussed how *positions* within a scholarly domain could be explicitly modelled in a top-down fashion. This followed the work of Horn (1998) who focussed on identifying positions – or as he refers to them philosophical camps – as part of his scholarly debate mapping approach. Extending this work, the current section focuses on enabling *bottom-up* detection of positions within a particular domain. It is apparent that a contribution can be made by technology which can automatically detect these kinds of intellectual macro-structures in a knowledge domain.

As proposed in Chapter 2, techniques from the Bibliometrics tradition, such as cluster analysis, are useful for this task. However, such techniques are applicable to one-dimensional representations of the scholarly domain, where objects in the representation are connected by a single type of 'similarity' relation. As Jain *et al.* (1999) explain, similarity is fundamental to the definition of a cluster. Therefore, before applying clustering methods to discover viewpoint-clusters, there needs to be an intermediary step which converts the semantic representations of a scholarly domain into a graph-based representation suitable for cluster analysis.

Yoshimi (2004) suggests that argumentation has a graph-theoretic or network form if we treat individual arguments as vertices and the main relations of supports and disputes as edges. According to Pujol *et al.* (2002), communities of practice can be conceptualised as a series of social networks. These social networks can be represented as graph structures where community members appear as nodes, and the various social relationships connecting these members appear as edges. Typical social relationships can include relationships of "kinship, acquaintanceship, friendship, mutual support, cooperation, and similarity" (Pujol *et al.*, 2002). In general, knowledge domain analysis characterises knowledge domains as networks of interconnected entities – entities that include publications, people, organisations, agents, concepts, etc.

The inference rules defined in the previous section provide a mechanism for translating semantic representations into one-dimensional, rhetorical-coherence-relation-based representations. This is because the numerous semantic relations in each dimension of the ontology have been defined in terms of coherence parameters and the ontological inference rules implemented in this parametrical language are applied across the entire representation.

With a mechanism for translating multi-dimensional representations into graph-based representations, it is now possible to reuse graph analysis techniques from citation analysis work, specifically cluster analysis, for the purpose of detecting viewpoint-clusters within a knowledge domain.

As cluster analysis is a well-studied technique in network analysis research, there are a number of readily available tools for detecting clusters in networks. In this thesis, the *NetDraw*[48] network analysis and visualisation tool is used to detect clusters in the one-mode network representation of the debate.

NetDraw provides various algorithms for cluster detection. One such algorithm, *agglomerative hierarchical clustering*, is commonly used by Bibliometrics researchers for cluster analysis of co-citation networks. This algorithm works by first assigning each node in the network to a cluster with only itself as a member. Then after each pass of the algorithm those clusters which are closest[49] to each other are grouped together to form a new cluster. This is repeated until all nodes are grouped together in a single cluster. Figure 4-7 shows a simple network example where the agglomerative hierarchical clustering algorithm is applied. Note that at the start the seven nodes in the network are each placed in a cluster with only itself as a member. Then the algorithm determines that nodes ***A*** and ***B*** are closest together and these are grouped together in a single cluster to give a new

[48] The tool is available at http://www.analytictech.com/Netdraw/netdraw.htm
[49] A range of distance metrics exist but perhaps the most popular distance metric used in cluster analysis work is the Euclidean distance (Jain *et al.*, 1999).

overall cluster arrangement of 6 clusters. Next, the node ***C*** is determined to be closest to the cluster of ***A*** and ***B***, therefore these three nodes are grouped together into a single cluster {***A***, ***B***, ***C***} to yield a new overall cluster arrangement of 5 clusters. This process continues until all the nodes are grouped into 1 cluster.

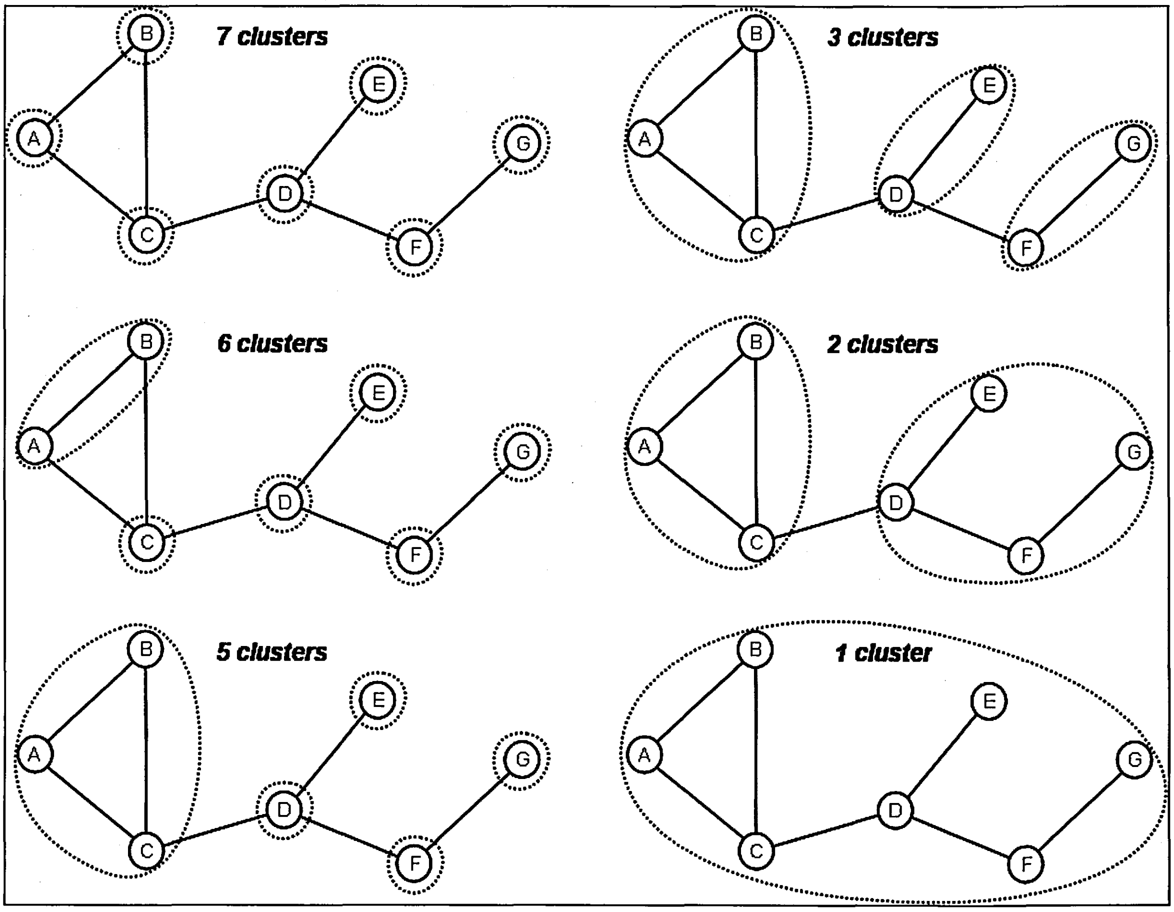


Figure 4-7 – Example of a simple network that is clustered using the agglomerative hierarchical clustering algorithm. Note that at the start of the clustering process all the nodes are placed in their own individual cluster. The process then continues until all nodes are grouped together in a single cluster.

However, one of the problems associated with using the agglomerative hierarchical clustering method is that it has "a tendency to separate single peripheral vertices from the communities to which they should rightly belong…[thus]…single nodes often remain isolated from the network when the communities are constructed" (Girvan and Newman, 2004). This can even be seen in the simple clustering example of Figure 4-7 where the algorithm has produced clustering arrangements with 6 and 5 clusters, where both arrangements contain a number of isolated nodes.

An alternative algorithm, which does not suffer from this particular problem, and which is thus the chosen algorithm for this thesis, is the *Newman-Girvan (NG)* algorithm (Newman and Girvan, 2004). Furthermore, the NG algorithm is chosen here because the authors have defined a measure of the strength of the various cluster-configurations it produces. This metric, which the authors call 'modularity' and which is perhaps more meaningfully referred to here as a *goodness-of-fit* measure, offers an objective metric for choosing the number of clusters into which a particular network should be divided. This being said, it should be noted that, as is typical in similar cluster analysis work of the Bibliometrics tradition (e.g. McCain, 1990; Andrews, 2003), the overall aim here is not to discover the perfect cluster-configuration, but rather to reveal interesting and potentially significant intellectual structures that will motivate further informed investigation on the part of the knowledge-domain analyst. Used in this manner, the goodness-of-fit measure can be an aid to the user of system in navigating different overviews of the domain depending on what clustering granularity they want to see.

The NG clustering algorithm groups works by first identifying those links that are most *between* groups of nodes. When it determines the links with the most *betweeness*, the algorithm then repeatedly removing these links, which leads to a gradual decomposing of the representation into clusters. Betweeness is a measure of the bridging role that a particular link provides. Betweeness of a link ***L***, say, is calculated by determining the shortest paths between all pairs of nodes in the network and summing up the number of those shortest paths that have ***L*** as part of the path. The main assumption underlying the focus on betweeness in the NG algorithm is that clusters in a network will have few inter-cluster connections. This means that traversing the shortest path from a node in one cluster to a node in another cluster will rely on the repeated use of a few links and these few links will be calculated as having high betweeness. Thus by removing these edges the clusters will be separated from each other and the community structure of the network will be revealed.

Figure 4-8 shows a simple network (the same as depicted in Figure 4-7) to which the NG clustering algorithm is applied. Note that the algorithm starts by treating the entire network as a single cluster. Then it calculates the betweeness of all the edges in the network and removes the link with the highest betweeness value (which in the first pass of the algorithm is the link between nodes ***C*** and ***D***). The algorithm continues to remove links with the highest betweeness values until no more links can be removed and all the nodes are in their own individual cluster. Note that this is one procedural distinction between the NG clustering algorithm and the hierarchical clustering algorithm – i.e. the NG algorithm works from a single group cluster to individual node clusters whereas the hierarchical clustering algorithm works from individual node clusters to a single group cluster. At each pass of the algorithm, a goodness-of-fit metric is calculated. For the simple network example given, the clustering arrangement with the maximum goodness-of-fit value is the arrangement with 2 clusters. A comparison with Figure 4-7 will reveal that, unlike with the agglomerative hierarchical clustering algorithm applied to the same simple network, the NG algorithm does not suffer from the problem of producing uninsightful cluster arrangements with isolated nodes (as seen with the cluster arrangements with 6 and 5 clusters in Figure 4-7).

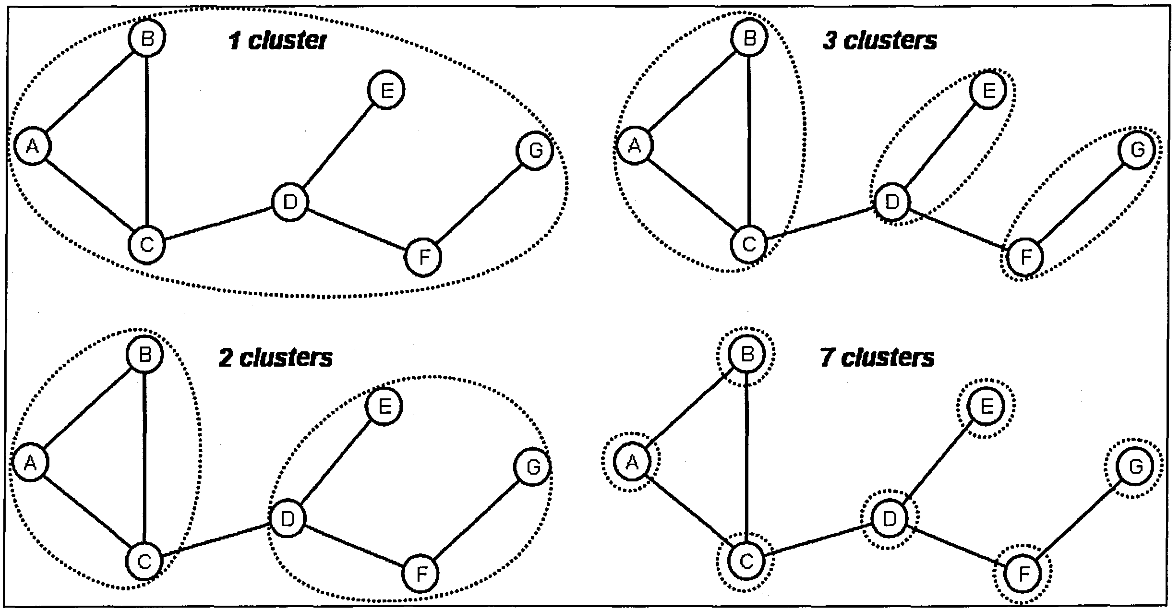


Figure 4-8 - Example of a simple network that is clustered using the NG algorithm. Note that the clustering process starts with the entire network treated as a single cluster and continues until all the nodes are in a cluster of their own. The arrangement with 2 clusters is the clustering arrangement with the maximum goodness of fit.

Chapter Summary

This chapter has explored how the *Scholarly Debate Ontology* defined in the previous chapter can be extended to include more inference rules for reasoning about scholarly debates. The chapter also explored how basic co-occurrence reasoning patterns that are at the heart of most knowledge domain analysis can be implemented as a limited set of parameterised inference rules in the ontology. Finally, the chapter explored how graph-theoretic methods typical of Bibliometrics research can be applied to suitable debate representations to detect aggregate structures, in particular viewpoint-clusters, in scholarly debate.

Until now, the ontology design process, including the design of the rhetorical-coherence inference rules, has been demonstrated to have some form of internal validation with respect to the reviewed literature. At this stage, what is needed is to have external validation of the ontology with respect to real-world debates. The next two chapters demonstrate how the ontology has been used to represent and reason about two case study scholarly debates as a means of providing a form of external validation for the ontology. The first case study involves using pre-structured source material as a means of verifying the consistency of the ontology and of the inference rules. The second case study enables the ontology to be tested using un-structured source material. Success in these case studies will demonstrate that a hybrid ontology-based and graph-based analytical method can be used to detect viewpoint-clusters as important phenomena in scholarly debates. The case studies will demonstrate that the Scholarly Debate Ontology *plus* rhetorical-coherence inference rules/heuristics *plus* graph-based cluster analysis can form important components of future KDA technology.

CHAPTER 5 CASE STUDY 1: ANALYSING THE TURING DEBATE IN THE ARTIFICIAL INTELLIGENCE DOMAIN

This chapter provides the first evaluation of the Scholarly Debate Ontology, from its application to modelling a real debate. The example is commonly referred to as the *Turing* debate, and is based on a question posed by Alan Turing (1950) about whether computers can or will be able to think. The source material for the case study is the description of the Turing debate as presented in a series of seven debate maps produced by Robert Horn (1998). These seven maps graphically represent the history and current status of the debate as derived from the prose of over 400 academic publications within the *Artificial Intelligence* research domain.

The chapter begins by describing how the information on Map 1 of the Turing debate maps is captured as a collection of ontological instances in a knowledge base. It demonstrates how the Scholarly Debate Ontology provides a vocabulary for formally coding the Turing debate (§5.1). Next, the chapter describes how hybrid ontology-based and graph-based analysis can be applied to the debate representation in order to detect viewpoint-clusters in the Turing debate (§5.2).

5.1 Coding representations of the debate in a knowledge base

Figure 5-1 shows Map 1 of the Turing debate maps produced by Horn (1998). The title of the map corresponds to the main issue being debated – *"Can computers think?"*. The map is then divided into a number of regions, each with a separate issue as a title. These issues are implicitly related to the main issue of the map.

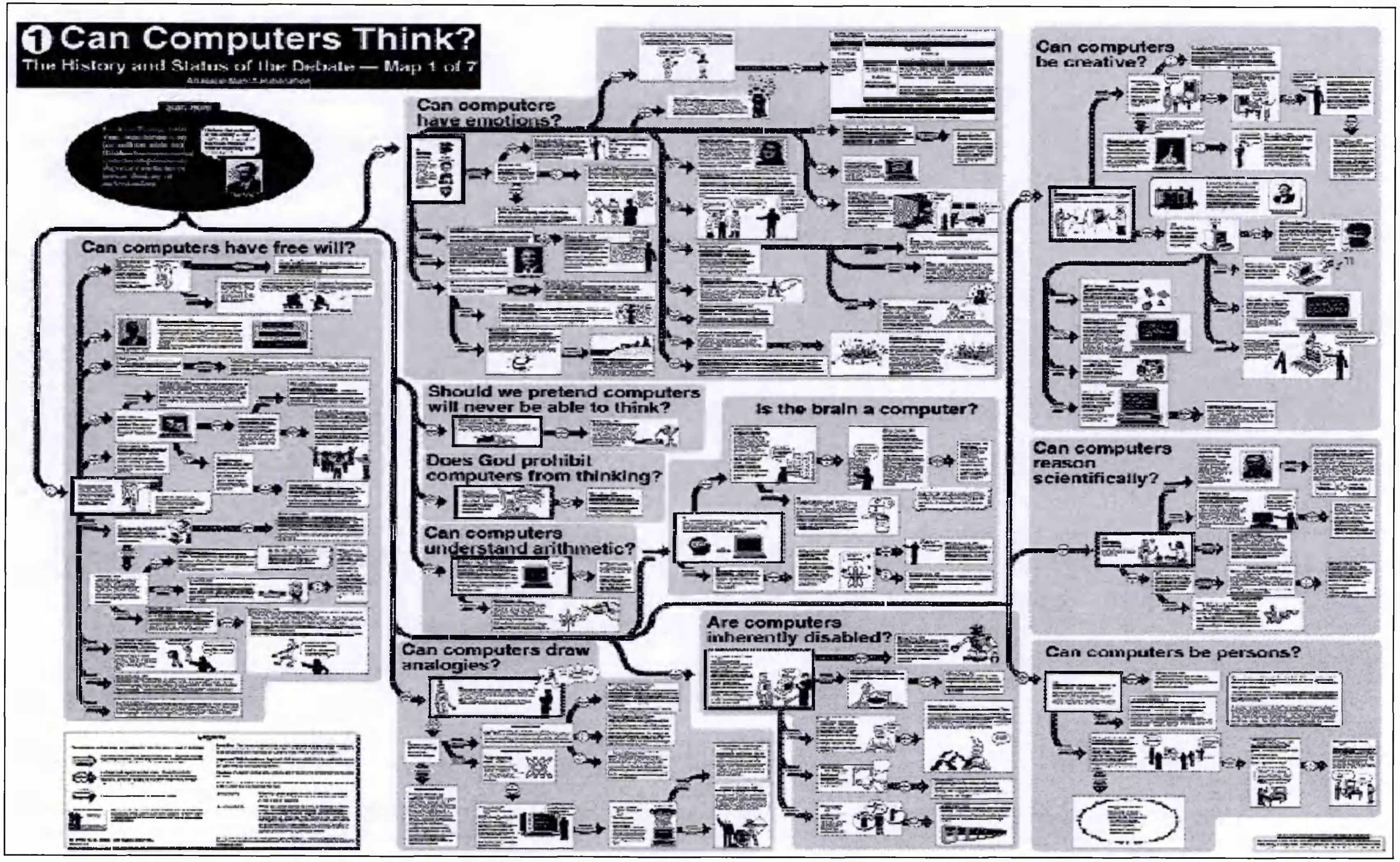


Figure 5-1 – Map 1 of the Turing Debate maps produced by Horn (1998): The map shows the main issue being debated – "Can computers think?" – as well as a number of regions, each with a separate but related issue as title.

This section describes how the debate information depicted on Map 1 is captured and coded as a collection of knowledge base instances. The coding is guided by the main concepts in the Scholarly Debate Ontology.

Issue instances

As specified in the ontology, one aspect of coding the debate focuses on capturing the issues that organise the argumentation in the debate. Capturing the issues from the Turing Debate maps is directly facilitated by Horn's use of *issue regions* to organise the map's contents. As mentioned previously, each issue region has a title, and each of these regions is meant as a related issue of the root issue – *"Can computers think?"* – which is being debated.

Listing 5-1 shows how the root issue is coded as an *Issue* instance (`TD_ISS1`) in the knowledge base. It also shows that *Issue* instances (`TD_ISS2 - TD_ISS12`) are coded in the knowledge base to correspond to each of the 11 issue regions on Map 1. Relation instances are then coded in the knowledge base that link each of these *Issue* instances to the root issue *"Can computers think?"* using the *relatedIssueOf* ontology relation.

```
(def-instance TD_ISS1 Issue
  ((verbalExpression "Can computers think?")))

(def-instance TD_ISS2 Issue
  ((verbalExpression "Can computers have free will?")))

(def-instance TD_ISS3 Issue
  ((verbalExpression "Can computers have emotions?")))

(def-instance TD_ISS4 Issue
  ((verbalExpression "Should we pretend that computers will never be
able to think?")))

(def-instance TD_ISS5 Issue
  ((verbalExpression "Does God prohibit computers from thinking?")))

(def-instance TD_ISS6 Issue
  ((verbalExpression "Can computers understand arithmetic?")))

(def-instance TD_ISS7 Issue
  ((verbalExpression "Can computers draw analogies?")))

(def-instance TD_ISS8 Issue
  ((verbalExpression "Is the brain a computer?")))

(def-instance TD_ISS9 Issue
  ((verbalExpression "Are computers inherently disabled?")))

(def-instance TD_ISS10 Issue
  ((verbalExpression "Can computers be creative?")))

(def-instance TD_ISS11 Issue
  ((verbalExpression "Can computers reason scientifically?")))

(def-instance TD_ISS12 Issue
  ((verbalExpression "Can computers be persons?")))


 (def-relation-instances
   (relatedIssueOf TD_ISS2 TD_ISS1)
   (relatedIssueOf TD_ISS3 TD_ISS1)
   (relatedIssueOf TD_ISS4 TD_ISS1)
   (relatedIssueOf TD_ISS5 TD_ISS1)
   (relatedIssueOf TD_ISS6 TD_ISS1)
   (relatedIssueOf TD_ISS7 TD_ISS1)
   (relatedIssueOf TD_ISS8 TD_ISS1)
   (relatedIssueOf TD_ISS9 TD_ISS1)
   (relatedIssueOf TD_ISS10 TD_ISS1)
   (relatedIssueOf TD_ISS11 TD_ISS1)
   (relatedIssueOf TD_ISS12 TD_ISS1))
```

Listing 5-1 - Coding of the root issue as an Issue instance (TD_ISS1) in the knowledge base, as well as the coding of the other related issues (TD_ISS2 – TD_ISS12) on Map 1 and their 'relatedIssueOf' to the root issue.

Proposition and Argument instances

In addition to issues, the Turing debate maps also depict the viewpoints of the various authors that participate in the debate. On the maps, the detailed argumentation for each viewpoint is presented in a *claim-box*. Each claim-box has a number, a short title to summarise the contents of the box, and then a more lengthy exposition of the viewpoint being argued. Figure 5-2 shows a close-up of claim-box #1 with the title *"Yes, machines can (or will be able to) think"* and expository text *"A computational system can possess all important elements of human thinking or understanding"*. Most of the arguments on the map also include the year of publication. In the case of claim-box #1, the text is taken from a *1950* publication by *Alan Turing*.

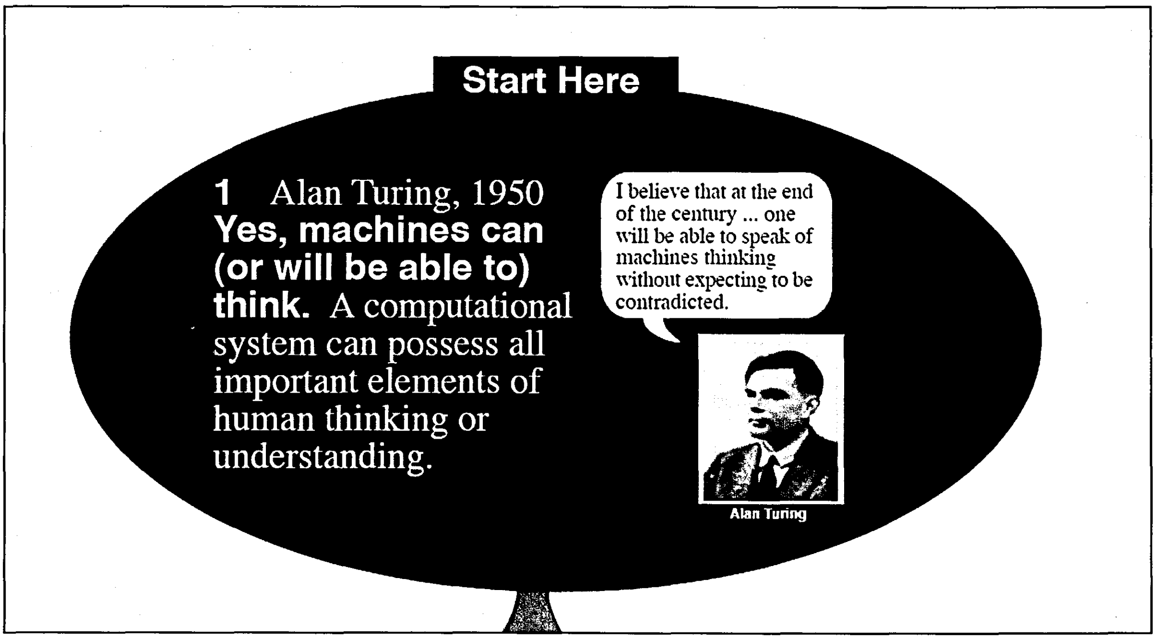


Figure 5-2 - Close-up of claim-box #1 on the debate map: As indicated, the text in the claim-box is taken from a 1950 Alan Turing publication.

The approach taken to capture claim-box contents in the knowledge base is to represent claim-boxes as *Argument* instances in the knowledge base. As defined in the ontology, the *Argument* class has one or more premises and at most one conclusion. In this case, the title of the claim-box is represented as the conclusion of the particular *Argument* instance, and the expository text inside the claim-box is represented as a premise of the same *Argument* instance.

Listing 5-2 first shows how both the title and the expository text in claim-box #1 are captured as two *Proposition* instances (`TD_P1` and `TD_P2` respectively) in the knowledge base. Next, the Listing shows the coding of an *Argument* instance (M1_ARG1) with its attributes *hasPremise* set to TD_P1, and *hasConclusion* set to TD_P2. Finally, the Listing shows two relation instances being coded in the knowledge base. The first relation instance links the *Publication* instance TURING1950COMPUTING to the *Argument* instance M1_ARG1 via the *cdns:expresses* relation. The second relation instance asserts an *addresses* relation between the *Argument* instance M1_ARG1 and the *Issue* instance TD_ISS1 previously coded in the knowledge base.

```
(def-instance TD_P1 Proposition
  ((verbalExpression "A computational system can possess all important
elements of understanding.")))

(def-instance TD_P2 Proposition
  ((verbalExpression "Yes, machines can (or will be able to) think.")))


(def-instance M1_ARG1 Argument
  ((hasPremise TD_P1)
   (hasConclusion TD_P2)))

(def-relation-instances
   (#_cdns:expresses TURING1950COMPUTING M1_ARG1)
   (addresses M1_ARG1 TD_ISS1))
```

Listing 5-2 - The representations in the knowledge base that correspond to claim-box #1 (coded as the M1_ARG1 Argument instance), its expository text (coded as argument premise TD_P1), and its summary title (coded as the argument conclusion TD_P2).

Argumentation moves such as one argument supporting or disputing another are played out in the issue regions on the map. For example Figure 5-3 shows a close-up of the issue region entitled *"Can computers draw analogies?"*. The issue region contains a number of claim-boxes that are depicted as supporting and disputing each other. For example, the argument in claim-box #66 is *disputed by* the argument in claim-box #67, which in turn is *supported by* the argument in claim-box #68.

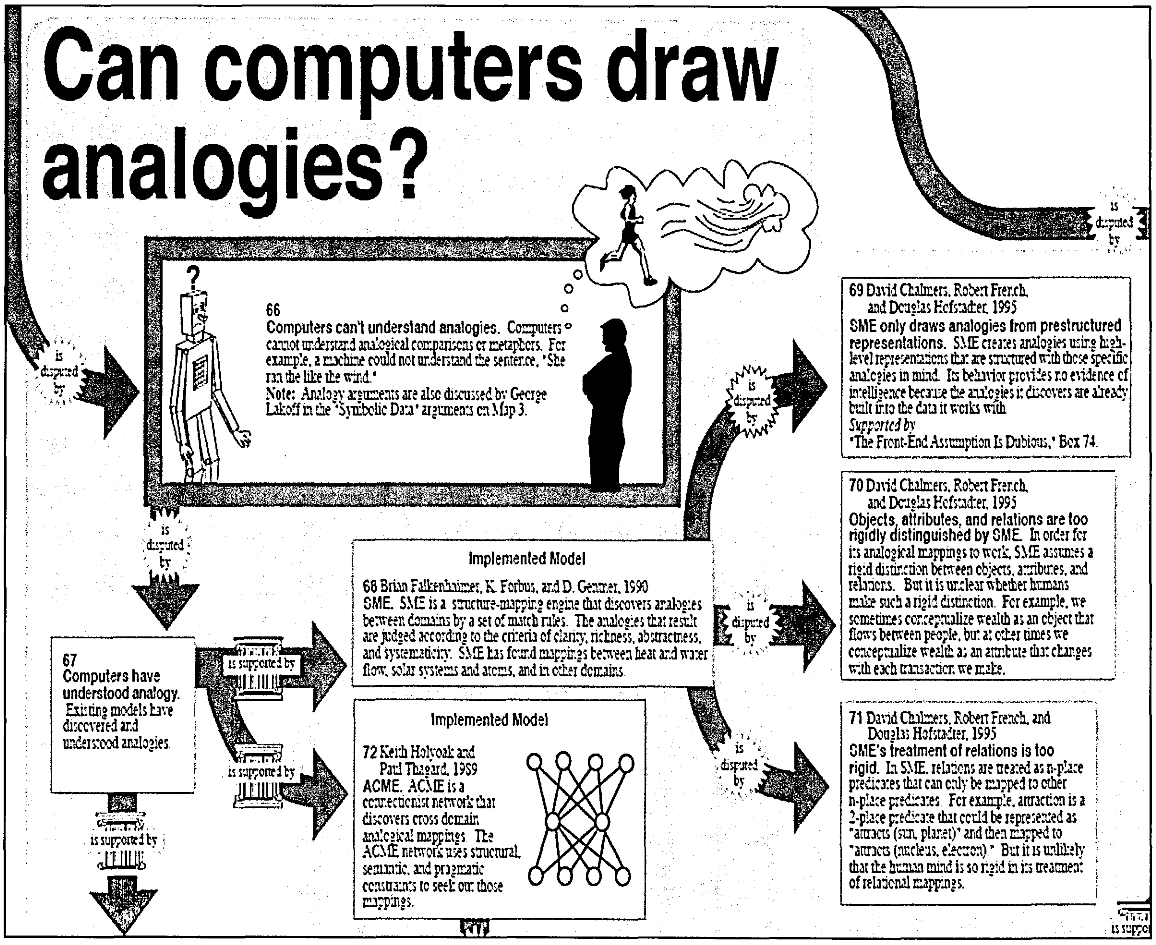


Figure 5-3 - Close-up of an issue region ("Can computers draw analogies?") and claim-boxes within that issue region that support and dispute each other.

Listing 5-3 shows part of the coding of *Argument* instances (`M1_ARG66`, `M1_ARG67`, and `M1_ARG68`) in the knowledge base that respectively correspond to the arguments in claim-boxes #66, #67, and #68. The listing first shows the relational assertion that *Argument* instance `M1_ARG66` *addresses* the issue represented by *Issue* instance `TD_ISS7` (*"Can computers draw analogies?"*). It also shows the relational assertion that *Argument* instance `M1_ARG66` *disputes Argument* instance `M1_ARG1`. The listing then shows the relational assertion that *Argument* instance `M1_ARG67` *disputes* `M1_ARG66`, and the relational assertion that *Argument* instance `M1_ARG68` *supports* `M1_ARG67`. Finally, the listing shows the relation instance that links the *Publication* instance `FALKENHAINER1990STRUCTURE` to the *Argument* instance `M1_ARG68` via the *cdns:expresses* relation.

```
...
(def-instance M1_ARG66 Argument
...

(def-relation-instances
   (addresses M1_ARG66 TD_ISS7)
   (disputes M1_ARG66 M1_ARG1))

...
(def-instance M1_ARG67 Argument
...

(def-relation-instances
   (disputes M1_ARG67 M1_ARG66))

...
(def-instance M1_ARG68 Argument
...

(def-relation-instances
   (supports M1_ARG68 M1_ARG67)
   (#_cdns:expresses FALKENHAINER1990STRUCTURE M1_ARG68))
```

Listing 5-3 - The representations in the knowledge base that correspond to claim-boxes #66, #67, and #68 (coded as Argument instances M1_ARG66, M1_ARG67, and M1_ARG68 respectively). The argument expressed in claim-box #67 (M1_ARG67) is disputing that in claim-box #66 (M1_ARG66) and the argument expressed in claim-box #68 (M1_ARG68) is supporting that in claim-box #67.

Position instances

According to Horn (2003), the authors in the Turing debate often "bring vastly different assumptions about the nature of reality". That is, as part of the discursive process of supporting their own arguments, authors often appeal to what Horn refers to as philosophical camps and what Yoshimi (2004) refers to as positions in his logic of debate. These camps are depicted as a set of claims and a set of authors who are known to subscribe to these claims. Listing 5-4 shows how the *Physical Symbol System* philosophical camp is represented as a *Position* instance (`PHYSICAL_SYMBOL_SYSTEM`) in the knowledge base, with attributes *hasViewpoint* set to a series of *Proposition* instances (`PSS_P1` - `PSS_P9`) and *associatedPerson* set to a series of *Person* instances (`ALLEN_NEWELL`, `HERBERT_SIMON`, etc.).

```
(def-instance PHYSICAL_SYMBOL_SYSTEM Position
   ((hasViewpoint
            PSS_P1
            PSS_P2
            PSS_P3
            PSS_P4
            PSS_P5
            PSS_P6
            PSS_P7
            PSS_P8
            PSS_P9)

    (associatedPerson
            ALLEN_NEWELL
            HERBERT_SIMON
            JERRY_FODOR
            JOHN_MCCARTHY
            ZENON_PYLYSHYN
            MARVIN_MINKSY
            DOUG_LENAT
            EDWARD_A_FEIGENBAUM
            PAT_HAYES)))

(def-instance PSS_P1 Proposition
  ((verbalExpression "There is a set of elements, called symbols.")))

(def-instance PSS_P2 Proposition
  ((verbalExpression "A symbol structure consists of a set of tokens of
symbols connected by a set of relations.")))

...
```

Listing 5-4 - Representation of the Physical Symbol System philosophical camp as a Position instance (PHYSICAL_SYMBOL_SYSTEM) in the knowledge base.

The philosophical camps in the Turing debate also exhibit a number of interesting features. One is that some persons appear as members of more than one camp. For example, as Listing 5-5 shows, the persons of *Jerry Fodor* and *Zenon Pylyshyn*, who were already represented as members of the *Physical Symbol System* camp, are also represented as members of the *Functionalism*[50] camp.

[50] In brief, Functionalism holds that since mental states are functional states, we can study the mind without studying the brain.

```
(def-instance FUNCTIONALISM Position
   ((hasViewpoint
            FUNCTIONALISM_P1
            FUNCTIONALISM_P2
            FUNCTIONALISM_P3
            FUNCTIONALISM_P4
            FUNCTIONALISM_P5)

    (associatedPerson
            HILARY_PUTMAN
            JERRY_FODOR
            ZENON_PYLYSHYN
            NED_BLOCK
            BRIAN_MCLAUGHLIN
            DAVID_CHALMERS)))
```

Listing 5-5 - Representation of the Functionalism camp which demonstrates that persons can be members of more than one position (Jerry Fodor and Zenon Pylyshyn are members of the Functionalism camp as well as the Physical Symbol System camp previously coded).

Person and Publication instances

On the debate maps, as well as the main arguments, most of the claim boxes identify the protagonist and the year. However, there are cases of unattributed arguments and cases where one argument is actually expressed in multiple publications. Listing 5-6 shows a *Person* instance (`ALAN_TURING`) being coded in the knowledge base to represent the actual person of *Alan Turing* depicted on the map. And as persons are typically depicted on the map as participating in the debate via the publications that they author, the Listing also shows the representation of a 1950 publication authored by Alan Turing entitled *"Computing Machinery and Intelligence"*. The publication is coded as a new *Publication* instance (`TURING1950COMPUTING`) with the attributes *hasAuthor* set to the *Person* instance `ALAN_TURING`, *hasTitle* set to the string `"Computing Machinery and Intelligence"`, and *hasYear* set to the *time:Year-In-Time* instance`1950`.

```
(def-instance ALAN_TURING Person)

(def-instance TURING1950COMPUTING Publication
  ((hasAuthor ALAN_TURING)
   (hasTitle "Computing Machinery and Intelligence")
   (hasYear 1950)
  )
)
```

Listing 5-6 - The coding of representations in the knowledge base that correspond to the person Alan Turing and one of his publications.

DomainConcept instances

A number of definitions of specialist domain vocabulary appear at various places on the debate maps. The items in this specialist domain vocabulary have been captured as *DomainConcept* instances in the knowledge base. For example, Listing 5-7 shows how the concept *Free Will*, which appears on Map 1, is captured as a *DomainConcept* instance (FREE_WILL). This instance has its attribute, *cdns:isDefinedIn*, set to the value of FREE_WILL_DEFINITION, which is a *Proposition* instance corresponding to the textual definition of *Free Will* as it appears on Map 1 of the debate maps. The Listing shows that in addition to abstract concepts like "free will", *DomainConcept* instances are also used to represent named artefacts of the domain. For example, the system referred to as *ACME*, which stands for *Analogical Constraint Mapping Engine*, is captured as a *DomainConcept* instance (ACME) with its attribute, *cdns:isDefinedIn*, set to the a *Proposition* instance ACME_DEFINITION.

```
(def-instance FREE_WILL DomainConcept
  ((#_cdns:isDefinedIn FREE_WILL_DEFINITION)))

(def-instance FREE_WILL_DEFINITION Proposition
  ((verbalExpression "Free Will is the ability to make voluntary,
unconstrained decisions. Freely made decisions are independent of the
influence of such deterministic factors as genetics (nature) and
conditioning (nurture).")))

(def-instance ACME DomainConcept
  ((#_cdns:isDefinedIn ACME_DEFINITION)))

(def-instance ACME_DEFINITION Proposition
  ((verbalExpression "ACME is an acronym for Analogical Constraint
Mapping Engine, which was developed by Holyoak and Thagard (1989).")))
```

Listing 5-7 - The representations in the knowledge base that correspond to "Free Will" and "ACME" concepts that make up part of the specialist domain vocabulary of the Turing debate.

5.2 Applying the hybrid approach to detecting clusters of viewpoints in the debate

As motivated in Chapter 2 (*Cf.* §2.4.2) and discussed in Chapter 4 (*Cf.* §4.2), this thesis advocates a hybrid ontology-based and graph-based analytical approach for the task of detecting clusters of viewpoints in a debate. It is argued throughout this thesis that these viewpoint-clusters provide the learner with additional means of navigating a complex debate.

The first step is to translate the ontology-based representation of the debate, described in the previous section, into a suitable representation for the graph-based cluster analysis method to be applied (§5.2.1). Once a suitable graph-theoretic representation is generated the cluster analysis is performed (§5.2.2). The results of the cluster analysis are then translated back into an ontology-based representation for further semantic analysis of the viewpoint-clusters, through the creation of new *ViewpointCluster* instances (§5.2.3). These results then form the basis of discussion about what insights the analysis was able to reveal about the Turing debate as set out in the source material (§5.2.4).

5.2.1 Translating the ontology-based representation to enable graph-based analysis

Applying graph-theoretic methods such as cluster analysis requires that the underlying data is represented as a graph consisting of a *single node type* and a *single link type* (a so-called *one-mode* representation). However, as demonstrated in the previous section, the ontology-based, semantic representations of the Turing Debate – i.e. they consist of *multiple* node types and *multiple* link types. Thus, before the graph-based cluster analysis can be used to detect viewpoint-clusters in the Turing debate, the semantic debate representations need to be translated into one-mode representations.

This translation from semantic representations to one-mode representations is achieved by executing the rhetorical-coherence inference rules defined in the previous chapter (*Cf.* §4.1.2). The rules act by interpreting the various ontological relations in a rhetorical context. This allows the generation of a one-mode representation of the Turing debate, where the single link type is the +ADDITIVE relation which in this context depicts a *rhetorical-coherence* relationship between two nodes. Note that in this rhetorical context each node in the one-mode representation is interpreted as a viewpoint in the debate.

Figure 5-4 shows how three of the rhetorical-coherence inference rules are applied to part of the ontology-based representation of the Turing debate. The section of the figure labelled (a) shows that the *Argument* instance `M1_ARG67` *disputes* `M1_ARG66`, which in turn *disputes* `M1_ARG1`. This pattern corresponds to one of the rhetorical-coherence inference rules and thus the system infers a +ADDITIVE relation between `M1_ARG67` and `M1_ARG1` (depicted as a dotted line, labelled '+A', in the figure). Sections (b) and (c) of the figure respectively show a +ADDITIVE relation being inferred because of common dispute and common support. Recall that, as discussed in the previous chapter, a +ADDITIVE inference rule is applied only if it has been determined that the various nodes are relevant to each other (i.e. they share some common context). In this case the common context for all the instances in the knowledge base is the root issue – *TD_ISS1: "Can computers think?"*. All arguments and relations between arguments on the map are assumed to be relevant to the addressing of this root issue.

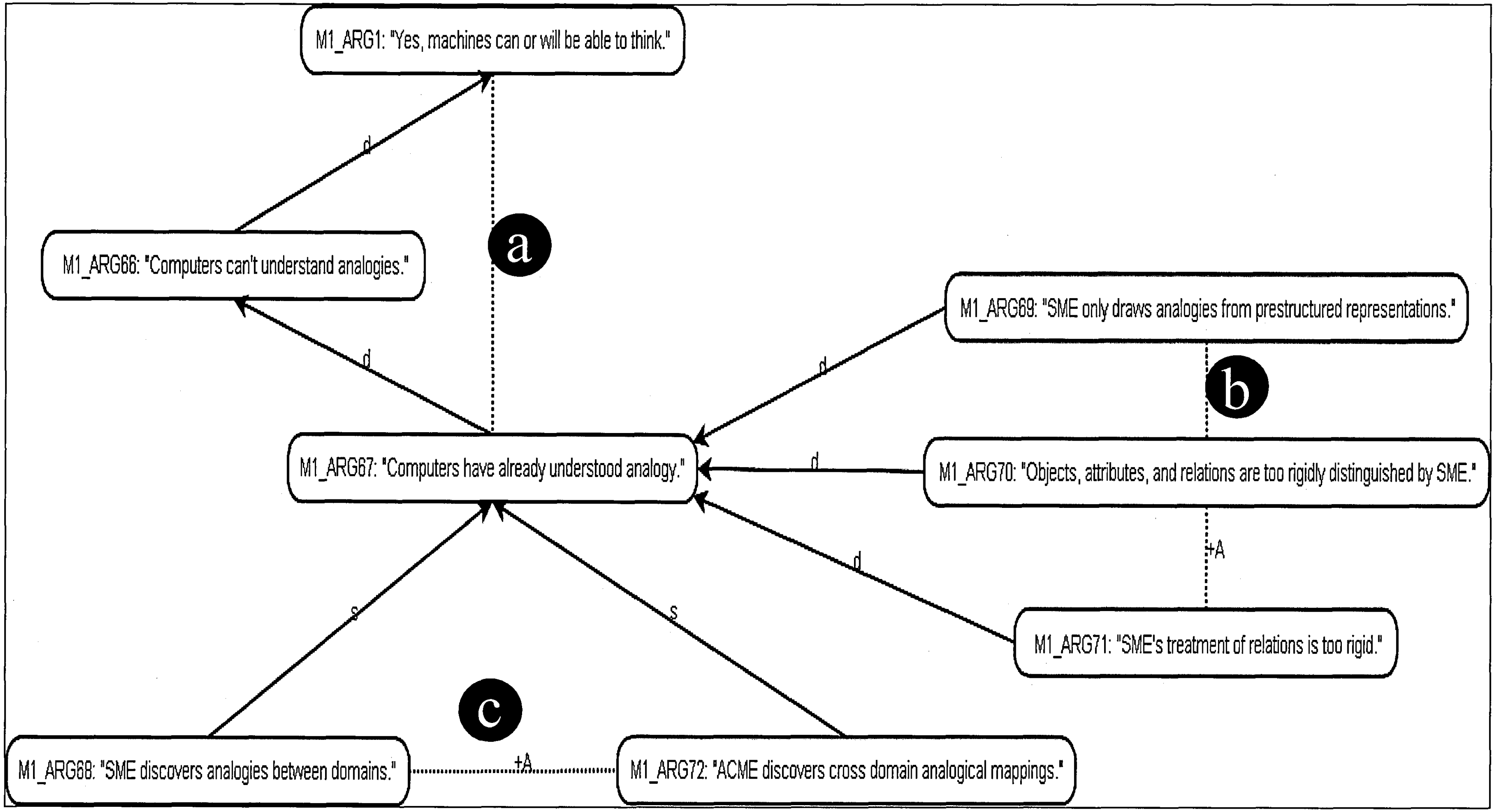


Figure 5-4 - Three of the rhetorical-coherence inference rules being applied to a part of the Turing Debate representation. (The link labels are abbreviated as 's' for 'supports', 'd' for 'disputes', and '+A' for '+ADDITIVE'.).

Once the +ADDITIVE inference rules are applied to the knowledge base instances and a one-mode representation of the debate is generated, the results are input into the cluster analysis tool.

5.2.2 Detecting clusters in the graph-based representation

As mentioned previously (*cf.* §4.2), the *NetDraw*[51] network analysis and visualisation tool is used here to detect clusters in the one-mode representation of the debate. Specifically *NetDraw*'s implementation of the *Newman-Girvan (NG)* algorithm for detecting clusters (Newman and Girvan, 2004) is used for the cluster analysis. The NG algorithm has been chosen because it provides a 'goodness-of-fit' metric (or what the authors call 'modularity') that can aid the analyst in choosing a suitable cluster configuration. That is, the tool produces various alternative ways that the same underlying data can be clustered, and for each alternative, it provides a measure of how good that particular arrangement of clusters fits with the underlying data. Figure 5-5 shows a plot of *Goodness-of-fit vs. Number of clusters* for the application of the Newman-Girvan algorithm to the one-mode representation of the Turing Debate[52]. The plot shows that the maximum goodness-of-fit value occurs when the network is decomposed into 13 clusters.

[51] The tool is available at http://www.analytictech.com/Netdraw/netdraw.htm

[52] NetDraw accepts graph representation in the '.net. text file format. A Lisp function is used to export the one-mode representation of the debate into a '.net' text file. (See Appendix D for a print out of this '.net' file)

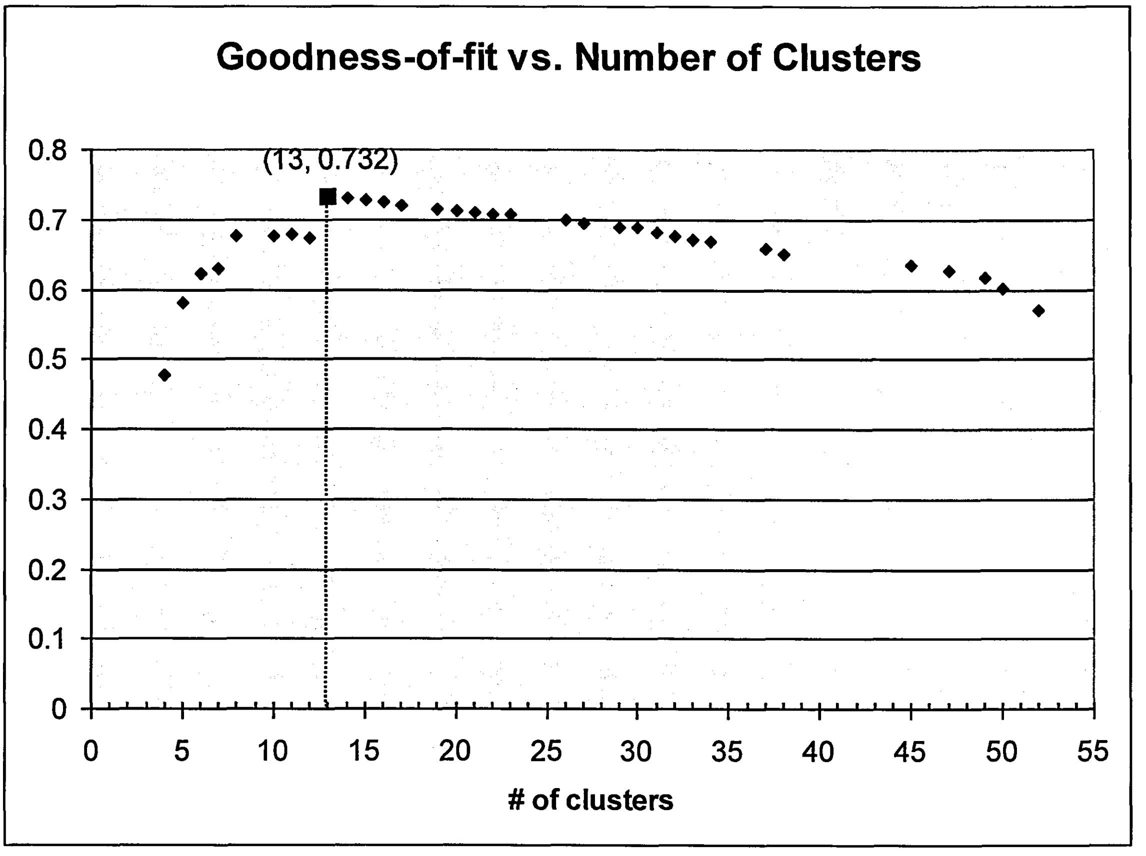


Figure 5-5 - The plot of goodness-of-fit vs. number of clusters for the application of the NG clustering algorithm to the graph-based representation of the Turing debate (Map 1): The goodness-of-fit value reaches a maximum value of 0.732 when the data is arranged into 13 clusters.

Figure 5-6 shows the NetDraw visualisation of the one-mode representation of the Turing Debate (Map1) divided into 13 clusters using the NG algorithm.

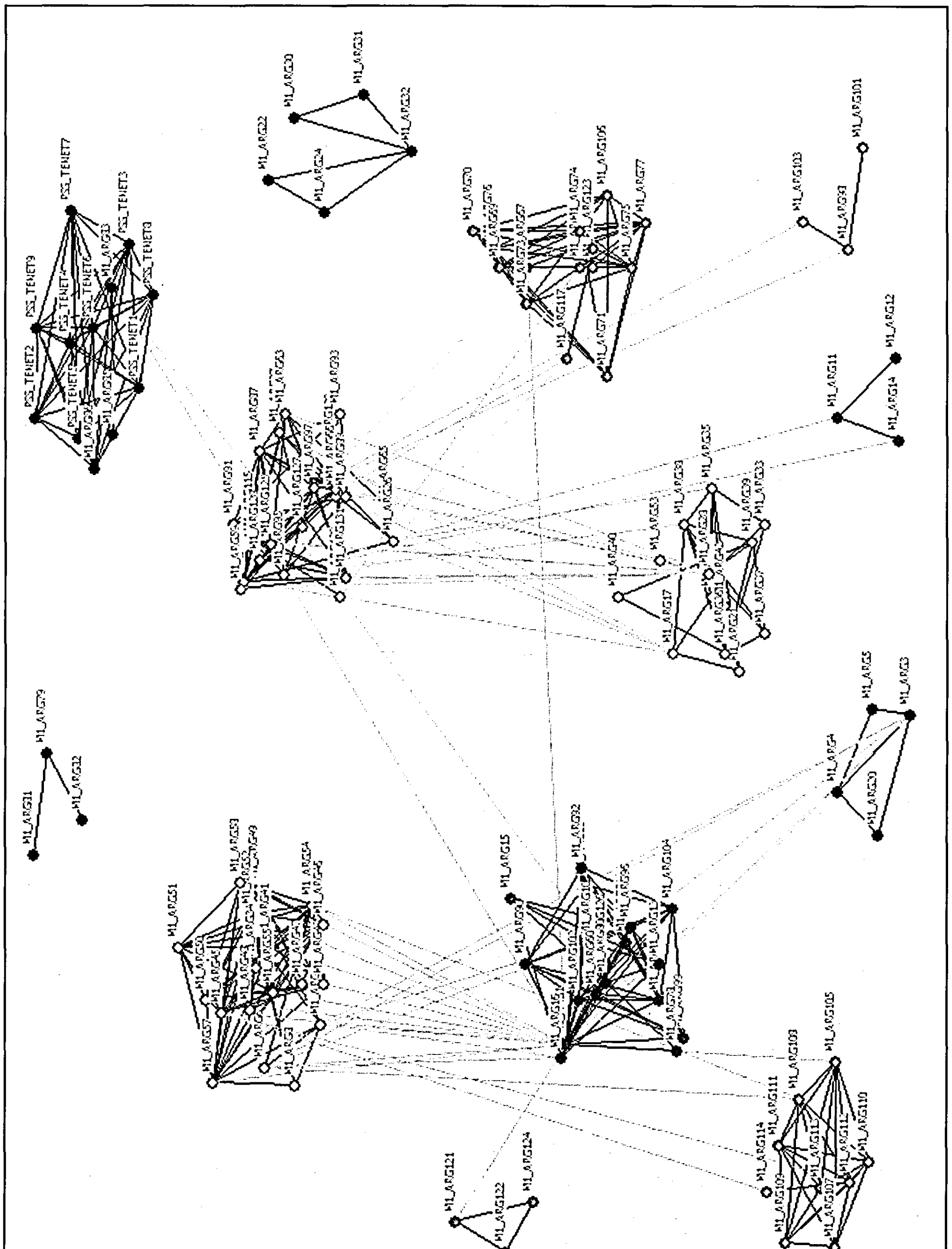


Figure 5-6 - The visualisation of 13 clusters in the graph-based representation of the Turing debate (Map 1): This arrangement of clusters has the maximum goodness-of-fit with respect to the underlying data. (The edges represent +ADDITIVE connections between viewpoints – grey links are +ADDITIVE connections between two clusters, whereas black links are +ADDITIVE connections within a cluster.).

5.2.3 Translating the graph-based cluster results into ontology-based ViewpointCluster instances in the knowledge base

At this stage, the clustering results are manually input back into the knowledge base for ontology-based analysis. Each of the clusters detected during the graph-based cluster analysis becomes a *ViewpointCluster* instance in the knowledge base. Critically, this allows the reintroduction of the original, more expressive semantics to the debate representation, which are not taken into account when conducting the cluster analysis. For example, for each *ViewpointCluster* instance the system determines the persons who are associated with that particular viewpoint-cluster. This is done by identifying the authors of the publications that express each individual viewpoint that make up a given cluster. Each *Person* instance that corresponds to a given author is then related to the appropriate *ViewpointCluster* instance via the *associatedPerson* attribute. Reintroducing the semantics to the graph-based cluster results is possible because the nodes which make up the graph-based representation are ultimately grounded in a formal conceptual model – i.e. the Scholarly Debate Ontology.

Furthermore, with respect to reintroducing semantics, for each *ViewpointCluster* instance, the system determines which other clusters are *opposed* to it. As indicated in Chapter 3, opposition between *ViewpointCluster* instances is determined based on the occurrence of *disputes* relations between individual *Argument* instances that are part of each *ViewpointCluster* instance. Recall that two intuitive criteria, weak opposition and strong opposition, have been trialled for detecting opposing *ViewpointCluster* instances. Using the first criterion, the system infers an opposition relation between two *ViewpointCluster* instances if at least *one* viewpoint in one cluster has a *disputes* relation with at least one viewpoint in the other cluster. Using the second criterion, the system infers an opposition relation between two clusters if *more than half* (i.e. the *majority*) of the viewpoints in one cluster have a *disputes* relation with the viewpoints in the other cluster. Weakly and strongly opposed clusters are related to the appropriate

ViewpointCluster instance via the *hasOpposingClusterWeak* and *hasOpposingClusterStrong* attributes respectively.

Figure 5-7 shows a manually sketched visualisation of the 13 *ViewpointCluster* instances in the knowledge base. The *ViewpointCluster* instances are labelled as *VC1 – VC13* on the figure. The figure shows lines of opposition going to and from the *ViewpointCluster* instance labelled *VC10*. The dashed lines show the weak opposition relations with *VC1*, *VC2*, *VC4*, *VC8*, and *VC13* (corresponding to *hasOpposingClusterWeak* relation instances in the knowledge base) whereas the thick solid line shows a strong opposition relation with *VC3* (corresponding to a *hasOpposingClusterStrong* relation instance in the knowledge base). On the opposition lines shown in the figure there appears two numbers that give an indication of the strength of the opposition relation. The numbers are in the form $x(y)$, where y is the total number of nodes in the two opposing clusters and x is the number of nodes in both clusters involved in 'disputes' relations with each other. When the ratio of x to y is greater than 0.5 then the opposition connection is depicted as strong opposition. Otherwise the opposition connection is depicted as weak opposition. In addition, for each of *VC3* and *VC10*, the figure shows two of the viewpoints that make up the viewpoint-cluster. These two viewpoints in either cluster address two issues in common – namely *"Can computers have free will?"* and *"Can computers be creative?"*. Finally, the figure shows two associated persons for each of *VC3* and *VC10*.

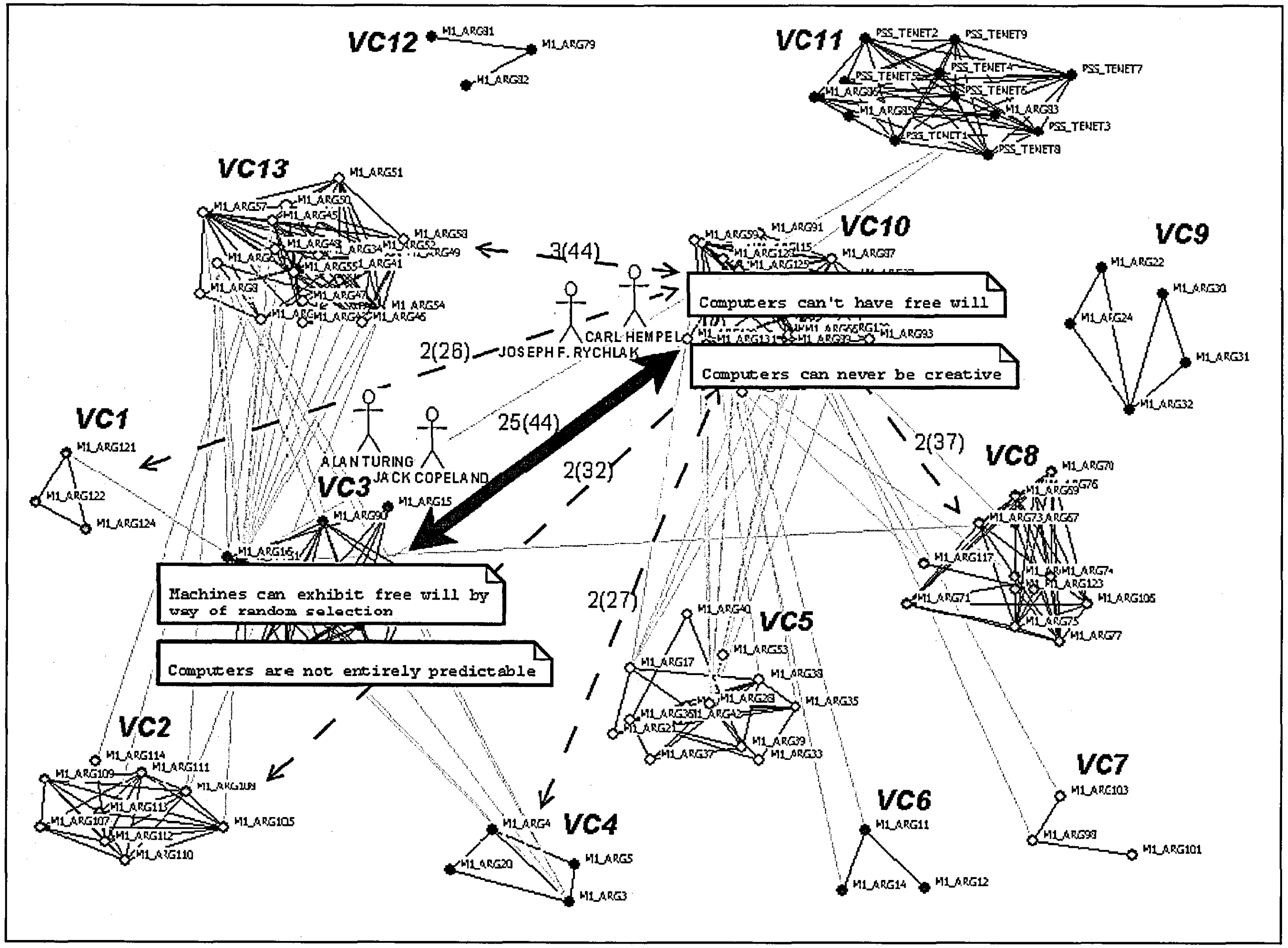


Figure 5-7- A sketch of the 13 Turing debate ViewpointCluster instances in the knowledge base. The thick solid arrow depicts strong opposition between VC3 and VC10, while the dashed arrows depict weak opposition between VC10 and a number of other viewpoint-clusters. For each of VC3 and VC10, the figure shows two associated viewpoints and two associated persons. An indication of the strength of the opposition is given by the numbers x(y), where y is the total number of nodes in the two clusters and x is the number of nodes in both clusters involved in 'disputes' relations with each other.

Table 5-1 shows the details of the 13 Turing debate *ViewpointCluster* instances in the knowledge base. This table is based on output from a query that retrieves the descriptions of each *ViewpointCluster* instance in the knowledge base.

Table 5-1 - The viewpoint-clusters detected on Map 1 of the Turing Debate (based on a query to retrieve the descriptions of the ViewpointCluster instances in the knowledge base). In the 'Opposing Cluster(s)' column, the opposition criterion is indicated by a 'Weak' or 'Strong' in parentheses.

VC	Associated Viewpoints (+ *Issue being addressed*)	Associated Persons	Opposing Cluster(s)
VC1	• *Can computers reason scientifically?* o M1_ARG121: *"Computers have already reasoned scientifically"* o M1_ARG122: *"BACON is a program for discovering laws from data by applying heuristics and it has discovered Kepler's law of planetary motion, Galileo's law of uniform acceleration, and Ohm's law of electrical resistance."* o M1_ARG124: *"DENDRAL is an expert system that analyzes and identifies chemical compounds by forming and testing hypotheses from experimental data."*	BRUCE_G_BUCHANAN C_DJERASSI D_H_SMITH EDWARD_A_FEIGENBAUM GARY_BRADSHAW HUBERT_SIMON J_LEDERGERG JAN_ZYTKOW PAT_LANGLEY R_GRITTER W_C_WHITE	VC8 (Weak) VC10 (Weak)
VC2	• *Can computers be creative?* o M1_ARG105: *"Computers have already been creative"* o M1_ARG107: *"The geometry program is a system that works backward from geometric theorems, searching for their proofs by means-end analysis."* o M1_ARG108: *"The jazz generator produces chord sequences and uses them to improvise chords, bass-line melodies, and rhythms."* o M1_ARG109: *"A program has been written that develops Haiku (a style of Japanese poetry) through interaction with humans."* o M1_ARG110: *"The TAIL-SPIN program writes stories with characters that have goals and subgoals dependent on their motivations."* o M1_ARG111: *"AARON produces visual art by selecting a random starting point on a canvas and then drawing lines from that point using a complex set of if-then rules."* o M1_ARG112: *"Connectionist systems exhibit creativity."* o M1_ARG113: *"The Book Generator is an automatic novel writer that generates 2,100-word mysteries."* o M1_ARG114: *"The Book Generator is inadequate"*	BECKY_COHEN H_GELERNTER HAROLD_COHEN JIM_MEEHAN MARGARET_BODEN MARGARET_MASTERMAN PENNY_NII PHILIP_JOHNSON-LAIRD SHELDON_KLEIN	VC8 (Weak) VC10 (Weak)

VC	Associated Viewpoints (+ *Issue being addressed*)	Associated Persons	Opposing Cluster(s)
VC3	▪ *Can computers think?* o M1_ARG1: *"Yes, machines can or will be able to think"* ▪ *Can computers have free will?* o M1_ARG9: *"Machines can exhibit free will by way of random selection"* o M1_ARG10: *"Free will arises from random selection of alternatives in nil preference situations."* o M1_ARG13: *"Random choice and responsibility are compatible."* o M1_ARG15: *"The Turing randomizer is only a tiebreaker"* o M1_ARG16: *"Being a deterministic machine is compatible with having free will."* ▪ *Should we pretend computers will never be able to think?* o M1_ARG60: *"The head-in-the-sand objection is too trivial to deserve a response"* ▪ *Does God prohibit computers from thinking?* o M1_ARG62: *"The theological objection is ungrounded"* ▪ *Can computers understand arithmetic?* o M1_ARG64: *"Computers can learn to add"* • *Is the brain a computer?* o M1_ARG78: *"The brain is a machine that can think"* o M1_ARG80: *"Programs are not universally realizable."* ▪ *Are computers inherently disabled?* o M1_ARG88: *"Disability objections derive from our limited experience with machines"* o M1_ARG90: *"Computers may be made to enjoy strawberries and cream."* o M1_ARG92: *"Computers can make certain kinds of mistakes."* o M1_ARG94: *"Computers can be the subject of their own thoughts."* o M1_ARG96: *"Diversity of behavior depends only on storage capacity."* ▪ *Can computers be creative?* o M1_ARG99: *"Computers are not entirely predictable"* o M1_ARG100: *"Machines frequently take us by surprise."* o M1_ARG102: *"The argument from human creativity applies to any case of surprise."* o M1_ARG104: *"The analytical engine may have been able to think for itself."* • *Can computers be persons?* o M1_ARG126: *"An artificial person can be built"*	ALAN_TURING JACK_COPELAND JOHN_POLLOCK WILLIAM_RAPAPORT	VC5 (Weak) VC6 (Weak) VC7 (Weak) VC10 (Strong) VC12 (Weak)

VC	Associated Viewpoints (+ *Issue being addressed*)	Associated Persons	Opposing Cluster(s)
VC4	▪ *Can computers have free will?* o M1_ARG3: *"Humans also lack free will, so whether or not computers have free will is irrelevant to the issue of whether machines can think"* o M1_ARG4: *"Humans are programmed."* o M1_ARG5: *"Free will is just an illusion of experience."* o M1_ARG20: *"Preprogrammed humans have psychological states."*	GEOFF_SIMONS MARVIN_MINSKY NINIAN_SMART	VC5 (Weak) VC10 (Weak)
VC5	▪ *Can computers have free will?* o M1_ARG17: *"Computers only exhibit the free will of their programmers"* o M1_ARG19: *"Preprogrammed robots can't have psychological states."* o M1_ARG21: *"A robot 'plays' its behavior in the same way that a phonograph plays a record."* o M1_ARG23: *"Humans can't be reprogrammed in the arbitrary way that robots can be."* ▪ *Can computers have emotions?* o M1_ARG28: *"Machines can't have emotions"* o M1_ARG29: *"The concept of feeling only applies to living organisms."* o M1_ARG33: *"Machines lack the physiological components of emotion."* o M1_ARG35: *"Machines can't think dialectically, and dialectical thinking is necessary for emotions."* o M1_ARG36: *"Emotions are necessary for thought."* o M1_ARG37: *"Emotional experience is necessary for thought."* o M1_ARG38: *"Computers must be capable of emotional association to think."* o M1_ARG39: *"Emotional machines need limbic systems."* o M1_ARG40: *"Artificial minds should mimic animal evolution."* o M1_ARG42: *"Once an advanced robot is built, the way we talk about robots, machines, and feelings will either change or will not, and this poses a dilemma."* o M1_ARG53: *"Emotions color perception and action."*	ARTHUR_DANTO DAVID_GELERNTER GEOFFREY_JEFFERSON GEORGES_REY HANS_MORAVEC HILARY_PUTNAM JOSEPH_F_RYCHLAK MICHAEL_ARBIB PAUL_ZIFF TOM_STONIER	VC3 (Weak) VC4 (Weak) VC9 (Weak) VC13 (Weak)
VC6	▪ *Can computers have free will?* o M1_ARG11: *"Machines that make decisions based on random choices have no responsibility for their actions, and thus lack free will"* o M1_ARG12: *"Free will is necessary for moral responsibility."* o M1_ARG14: *"When agents (human or machine) make choices at random, they lack free will, because their choices are then beyond their control."*	A_J_AYER J_A_SHAFFER	VC3 (Weak)
VC7	• *Can computers be creative?* o M1_ARG98: *"Machines can never take us by surprise"* o M1_ARG101: *"Surprise is a result of human creativity."* o M1_ARG103: *"The analytical engine can never do anything original."*		VC3 (Weak)

VC	Associated Viewpoints (+ *Issue being addressed*)	Associated Persons	Opposing Cluster(s)
VC8	• *Can computers draw analogies?* o M1_ARG67: *"Computers have already understood analogy"* o M1_ARG68: *"SME is a structure-mapping engine that discovers analogies between domains by a set of match rules."* o M1_ARG69: *"SME only draws analogies from prestructured representations."* o M1_ARG70: *"Objects, attributes, and relations are too rigidly distinguished by SME."* o M1_ARG71: *"SME's treatment of relations is too rigid."* o M1_ARG72: *"ACME is a connectionist network that discovers cross domain analogical mappings."* o M1_ARG73: *"ACME doesn't understand analogy."* o M1_ARG74: *"The front-end assumption is dubious."* o M1_ARG75: *"All-encompassing representations could not be processed."* o M1_ARG76: *"Perception depends on analogy."* o M1_ARG77: *"COPYCAT is a model that discovers analogies"* • *Can computers be creative?* o M1_ARG106: *"The ELIZA effect is a tendency to read more into computer performance than is warranted by their underlying code"* ▪ *Can computers reason scientifically?* o M1_ARG117: *"The importance of socialisation is demonstrated by the socialisation test, which is a variant of the Turing test"* o M1_ARG123: *"BACON only works when humans filter its data."*	BRIAN_FALKENHAINER DAVID_CHALMERS DEDRE_GENTNER DOUGLAS_HOFSTADTER HARRY_COLLINS KEITH_HOLYOAK KENNETH_FORBUS MELANIE_MITCHELL PAUL_THAGARD ROBERT_FRENCH	VC1 (Weak) VC2 (Weak) VC10 (Weak)
VC9	▪ *Can computers have free will?* o M1_ARG22: *"A robot could be programmed to produce new behaviours by learning in the same way humans do"* o M1_ARG24: *"Reprogramming is consistent with free will."* ▪ *Can computers have emotions?* o M1_ARG30: *"Having feelings does not logically imply being a living organism"* o M1_ARG31: *"We can imagine artifacts that have feelings."* o M1_ARG32: *"'Alive' is not definitionally based on structure."*	HILARY_PUTNAM J_J_C_SMART	VC5 (Weak)

VC	Associated Viewpoints (+ *Issue being addressed*)	Associated Persons	Opposing Cluster(s)
VC10	▪ *Can computers have free will?* o M1_ARG2: *"Computers can't have free will"* o M1_ARG25: *"Computers do not choose their own rules."* o M1_ARG26: *"Computers cannot do otherwise."* o M1_ARG27: *"Free will yields an infinitude that finite machines can't reproduce."* ▪ *Should we pretend computers will never be able to think?* o M1_ARG59: *"The consequences of machine thought are too dreadful to accept, so we should 'stick our heads in the sand' and hope that machines will never be able to think"* ▪ *Does God prohibit computers from thinking?* o M1_ARG61: *"God has given souls to humans, but not to machines, therefore, humans can think, and machines can't"* ▪ *Can computers understand arithmetic?* o M1_ARG63: *"Computers can't add, much less think"* o M1_ARG65: *"Computers can't have an adding thought (much less have a more complex thought) because the symbols being added don't have any meaning to the computer, and they don't have any meaning because they don't play a causal role based on that meaning."* ▪ *Can computers draw analogies?* o M1_ARG66: *"Computers can't understand analogies"* ▪ *Are computers inherently disabled?* o M1_ARG87: *"Machines can never do X, where X is any of a variety of abilities that are regarded as distinctly human, for example, being friendly, having a sense of humor, making mistakes, enjoying strawberries and cream, or thinking about oneself."* o M1_ARG89: *"Computers can't enjoy strawberries and cream."* o M1_ARG91: *"Computers can't make mistakes."* o M1_ARG93: *"Computers can't think about themselves."* o M1_ARG95: *"Computers can't exhibit much diversity of behavior."* ▪ *Can computers be creative?* o M1_ARG97: *"Computers can never be creative"* ▪ *Can computers reason scientifically?* o M1_ARG115: *"Computers can't reason scientifically"* o M1_ARG116: *"Scientific reasoning requires social agreement."* o M1_ARG118: *"Computers can't introduce new terms or explanatory principles."* o M1_ARG120: *"Computers can't adequately evaluate hypotheses."* ▪ *Can computers be persons?* o M1_ARG125: "Computers can't be persons" o M1_ARG127: "Robots can do intelligent things but will never be persons" o M1_ARG128: "A machine isn't a person unless society deems it one." o M1_ARG130: "Laboratory performance isn't enough for full reciprocity of social behavior."	CARL_HEMPEL DWIGHT_VAN_DE_VATE_JR FRED_DRETSKE HARRY_COLLINS JONATHAN_L_COHEN JOSEPH_F_RYCHLAK SELMER_BRINGSJORD STANLEY_L_JAKI	VC1 (Weak) VC2 (Weak) VC3 (Strong) VC4 (Weak) VC8 (Weak) VC13 (Weak)

VC	Associated Viewpoints (+ *Issue being addressed*)	Associated Persons	Opposing Cluster(s)
VC11	• *Is the brain a computer?* o M1_ARG83: *"The operation of the brain is computable"* o M1_ARG85: *"Penrose gives an explanation 'by miracle'."* o M1_ARG86: *"Quantum effects are irrelevant to symbolic processes."* o PSS_P1: *"There is a set of elements, called symbols."* o PSS_P2: *"A symbol structure consists of a set of tokens of symbols connected by a set of relations."* o PSS_P3: *"A memory is a component of an IPS capable of storing and retaining symbol structures."* o PSS_P4: *"An information process is a process that has symbol structures for (some of) its inputs or outputs."* o PSS_P5: *"A processor is a component of an IPS consisting of: (a) a (fixed) set of elementary information processes EIP's); (b) a short-term memory (STM) that holds the input and output symbol structures of the eip's; (c) an interpreter that determines the sequence of eip's to be executed by the IPS as a function of the symbol structures in STM."* o PSS_P6: *"A symbol structure designates an object if there exist information processes that admit the symbol structure as input and either: (a) affect the object; or (b) produce, as output, symbol structures that depend on the object."* o PSS_P7: *"A symbol structure is a program if (a) the object it designates is an information process and (b) the interpreter, if given the program, can execute the designated process."* o PSS_P8: *"A symbol is primitive if its designation is fixed by the elementary information processes or by the external environment of the IPS."* o PSS_P9: *"The indefinite term object encompasses at least three sorts of things: (1) symbol structures stored in one or another of the IPS's memories; (2) processes that the UPS is capable of executing; (3) an external environment of readable stimuli."*	ALLEN_NEWELL HERBERT_SIMON KEITH_STANOVICH	
VC12	• *Is the brain a computer?* o M1_ARG79: *"Nothing is intrinsically a digital computer. So the question, 'Is the brain a digital computer?' is ill-defined, because syntax can be ascribed to any sufficiently complex system"* o M1_ARG81: *"Universal realizability is not essential to the argument."* o M1_ARG82: *"Formal programs can be realized in multiple physical media."*	JOHN_SEARLE	VC3 (Weak)

VC	Associated Viewpoints (+ *Issue being addressed*)	Associated Persons	Opposing Cluster(s)
VC13	▪ *Can computers have free will?* o M1_ARG6: *"Free will results from a multi-level representational structure"* o M1_ARG7: *"Free will is a decision-making process."* o M1_ARG8: *"Conditional jumps constitute free will."* o M1_ARG18: *"Some computers can program themselves."* ▪ *Can computers have emotions?* o M1_ARG34: *"Physiology is not essential to emotion"* o M1_ARG41: *"If a robot can honestly talk about its feelings, it has feelings."* o M1_ARG43: *"Machines cannot love or be loved."* o M1_ARG44: *"Emotions are cognitive schemata."* o M1_ARG45: *"Our intuitions about pain are incoherent."* o M1_ARG46: *"Emotions can be modeled by describing their relations to other cognitive states."* o M1_ARG47: *"BORIS is a narrative reader designed to understand descriptions of the emotional states of narrative characters."* o M1_ARG48: *"OpEd is an editorial reader that deals with nonnarrative editorials-for example, critical book reviews."* o M1_ARG49: *"DAYDREAMER is a stream of thought generator that specifies how representations of emotional states affect other forms of cognitive processing."* o M1_ARG50: *"Emotions are the solution to a design problem."* o M1_ARG51: *"Emotions are manifestations of concern realization."* o M1_ARG52: *"Emotions are cognitive evaluations."* o M1_ARG54: *"Feelings are information signals in a cognitive system."* o M1_ARG55: *"Emotions are the product of motivational representations."* o M1_ARG56: *"There is Hierarchical theory of affects."* o M1_ARG57: *"Emotion is a type of information processing."* o M1_ARG58: *"The Turing test provides evidence for emotions as well as for intelligence."*	AARON_SLOMAN ALLAN_COLLINS ANDREW_ORTONY DANIEL_DENNETT GEOFF_SIMONS GERALD_CLORE JAAP_SWAGERMAN MARGARET_BODEN MICHAEL_DYER MICHAEL_SCRIVEN MONICA_CROUCHER NICO_FRIJDA PAUL_WEISS PHILIP_JOHNSON-LAIRD	VC5 (Weak) VC10 (Weak)

5.2.4 Interpreting the results

New insight about the debate

What new insights about the debate can the preceding results reveal to a learner? Firstly, the preceding analysis has meaningfully assigned viewpoints and persons in the debate to various *ViewpointCluster* instances – i.e. the combined ontological and graph-theoretical analysis has produced what appears on closer reading to be genuine, rhetorically coherent intellectual groupings.

For example, the first *ViewpointCluster* instance shown in Table 5-1, *VC1*, on closer inspection contains arguments that appear to be genuinely in agreement with each other in the context of the issue of whether computers can reason scientifically. The first *Argument* instance in the *VC1* cluster, `M1_ARG121`, states that *"Computers have already reasoned scientifically"*, while the other *Argument* instances in the same cluster – `M1_ARG122` and `M1_ARG124` –state that there are two systems, *"BACON"* and *"DENDRAL"*, which provide examples of computers reasoning scientifically, thereby corroborating the first argument.

However, *ViewpointCluster* instance *VC1* only represents a small grouping of rhetorically coherent viewpoints and such a grouping of viewpoints would have been straightforward to detect on the original Horn debate maps since they appear in the same region on the map. The analytical method is *most* beneficial when it reveals groupings of arguments and persons that would have been less straightforward to detect from the original source because, for example, they represented viewpoints that cut *across* different issues in the debate.

One example of such cross-issue grouping of arguments is the *ViewpointCluster* instance *VC3*, which contains viewpoints from across *nine* different issues in the debate. In *ViewpointCluster* instance VC3, the arguments given in response to each of the nine issues appear to be in genuine agreement with the other arguments given in response to that same issue. For example, in response to the issue of whether computers can have free will, *Argument* instances `M1_ARG9` (*"Machines can exhibit free will by way of random selection"*), `M1_ARG10` (*"Free will arises from random selection of alternatives in nil preference situations"*), `M1_ARG13` (*"Random choice and responsibility are compatible"*), `M1_ARG15` (*"The Turing randomiser is only a tiebreaker"*), and `M1_ARG16` (*"Being a deterministic machine is compatible with having free will"*), all appear to be genuinely in agreement with the viewpoint that computers can have free will. Furthermore, in the context of the main issue in the debate of whether computers can think, on closer reading, all the *Argument* instances in *VC3* (even those *Argument* instances that are directly addressing other issues) are in genuine agreement with the claim that *"Yes, machines can or will be able to think"* (`M1_ARG1`).

In addition to meaningfully identifying the viewpoints and persons associated with *ViewpointCluster* instances, the analytical method also reveals those *ViewpointCluster* instances that are in *opposition* to each other. For example, it appears that persons who support the idea of a thinking computer (e.g. *Alan Turing*) have been assigned to one *ViewpointCluster* instance (*VC3*), whereas the persons who dispute the notion of a thinking computer (e.g. *Joseph Rychlak*) have been assigned to another *ViewpointCluster* instance (*VC10*). These two *ViewpointCluster* instances are connected in the knowledge base by a *hasOpposingClusterStrong* relation.

Violated expectations

There are, however, a few results that appear to violate expectations. For example, the two *Argument* instances `M1_ARG113` and `M1_ARG114` appear as part of the same *ViewpointCluster* instance *VC2*. However, on the original Horn debate map, and hence in the knowledge base, there is a *disputes* relation between *Argument* instance `M1_ARG114` and `M1_ARG113`, and indeed, on closer reading, these two *Argument* instances state viewpoints that, in the context of the main issue being debated, are clearly opposing – i.e.

M1_ARG113 states that *"The book generator is an automatic novel writer that generates 2,100-word mysteries"*, while M1_ARG114 states that *"The book generator is inadequate"*. Figure 5-8 shows the location on the source map where the original argumentation is captured from. The figure is annotated to show the *ViewpointCluster* instance to which the different arguments have been assigned, as well as the part of the argumentation that appears to be inconsistent with the clustering results (depicted with a warning sign).

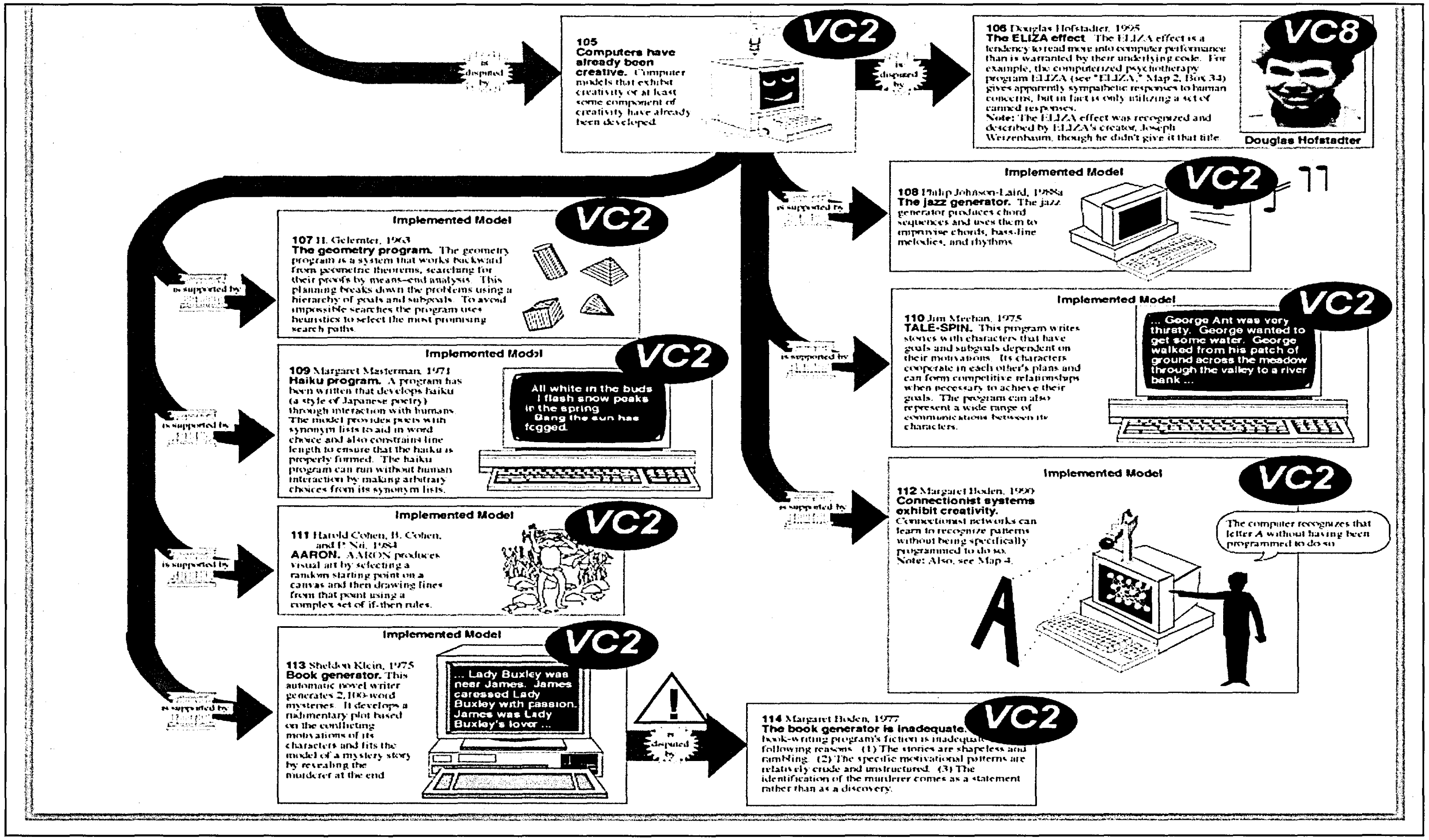


Figure 5-8 - The original location on Map 1 from where the two Argument instances M1_ARG113 and M1_ARG114 are derived: The figure is annotated to show that M1_ARG113 and M1_ARG114 have been associated with the same ViewpointCluster instance (i.e. VC2) but that these arguments have a 'disputes' connection between them (depicted on the figure with a warning sign).

In order to determine whether this violated expectation in the results is valid in reality, it is necessary to take a closer look at the representation of this part of the debate map in the knowledge base. Figure 5-9 shows the visual representation of the relevant instances in the knowledge base. As the figure depicts, it appears as if the clustering algorithm has placed two *Argument* instances `M1_ARG113` (*"The Book Generator is an automatic novel writer that generates 2,100-word mysteries."*) and `M1_ARG114` (*"The Book Generator is inadequate."*) in the same cluster because of the +ADDITIVE connection inferred first between `M1_ARG112` (*"Connectionist systems exhibit creativity"*) and `M1_ARG113` and then between `M1_ARG112` and `M1_ARG114` (indicated with thick arrows in the figure). The +ADDITIVE connection between `M1_ARG112` and `M1_ARG113` would appear to have been inferred because of the fact that they both have a *supports* relation to `M1_ARG105` (*"Computers have already been creative"*), whereas the +ADDITIVE connection between `M1_ARG112` and `M1_ARG114` would appear to have been inferred because of the fact that both of these have been authored by the same person, *Margaret Boden*. All of this then leads to the unexpected situation where `M1_ARG114` and `M1_ARG113` are presented as part of the same viewpoint-cluster even though they have a *disputes* relation between them.

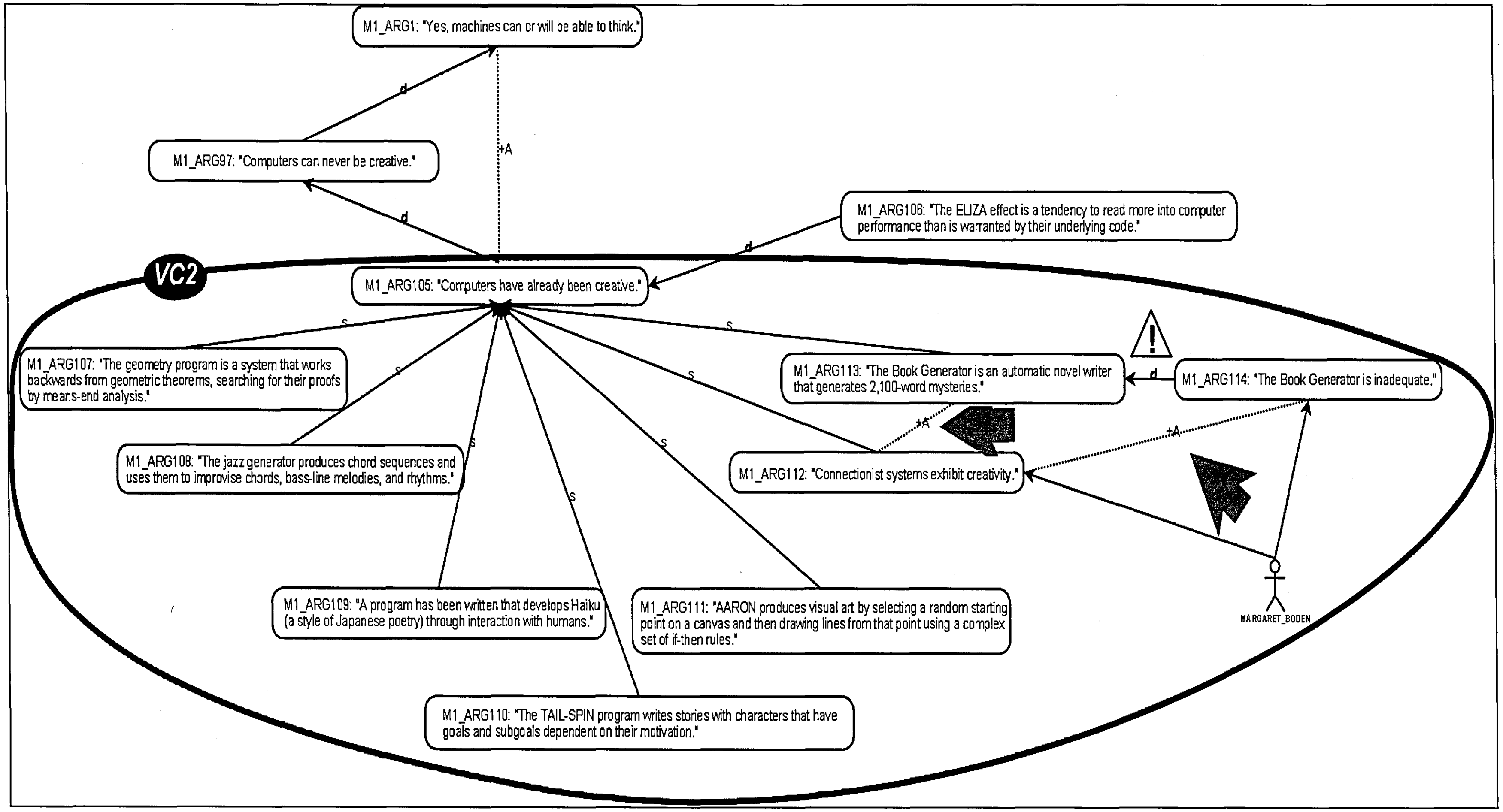


Figure 5-9 - Visual representation of the relevant class and relation instances representing violated expectation in VC2: The thick arrows indicate where +ADDITIVE connections have been inferred, which have led the clustering algorithm to group M1_ARG113 and M1_ARG114 in the same viewpoint-cluster. (The link label 'd' represents a 'disputes' relation, while the link label 's' represents a 'supports' relation. The dotted lines with link label '+A' indicate where a +ADDITIVE connection has been inferred by the system.).

This points to an apparent limitation of the graph-based, cluster analysis stage of the overall approach taken, since the clustering algorithm only considers the +ADDITIVE connections between nodes and does not take into account the *disputes* connection when it is arranging the data into clusters. Chapter 7 discusses how this limitation might be addressed and what implications this would have for the overall analytical approach.

A similar type of violated expectation can be seen in the *ViewpointCluster* instance *VC8*, where there is a *disputes* links between *Argument* instances `M1_ARG73` (*"ACME doesn't understand analogy."*) and `M1_ARG72` (*"ACME is a connectionist network that discovers cross domain analogical mappings."*), and a *disputes* link between *Argument* instances `M1_ARG68` (*"SME is a structure-mapping engine that discovers analogies between domains by a set of match rules."*) and each of `M1_ARG69` (*"SME only draws analogies from prestructured representations."*), `M1_ARG70` (*"Objects, attributes, and relations are too rigidly distinguished by SME."*), and `M1_ARG71` (*"SME's treatment of relations is too rigid."*), *yet* all of these have been placed within the same cluster. Figure 5-10 shows the location on the source map where this argumentation takes place. As before, the figure, is annotated to show the *ViewpointCluster* instance to which the different arguments have been assigned, as well as the parts of the argumentation that appears to be inconsistent with the clustering results (depicted with warning signs on the figure).

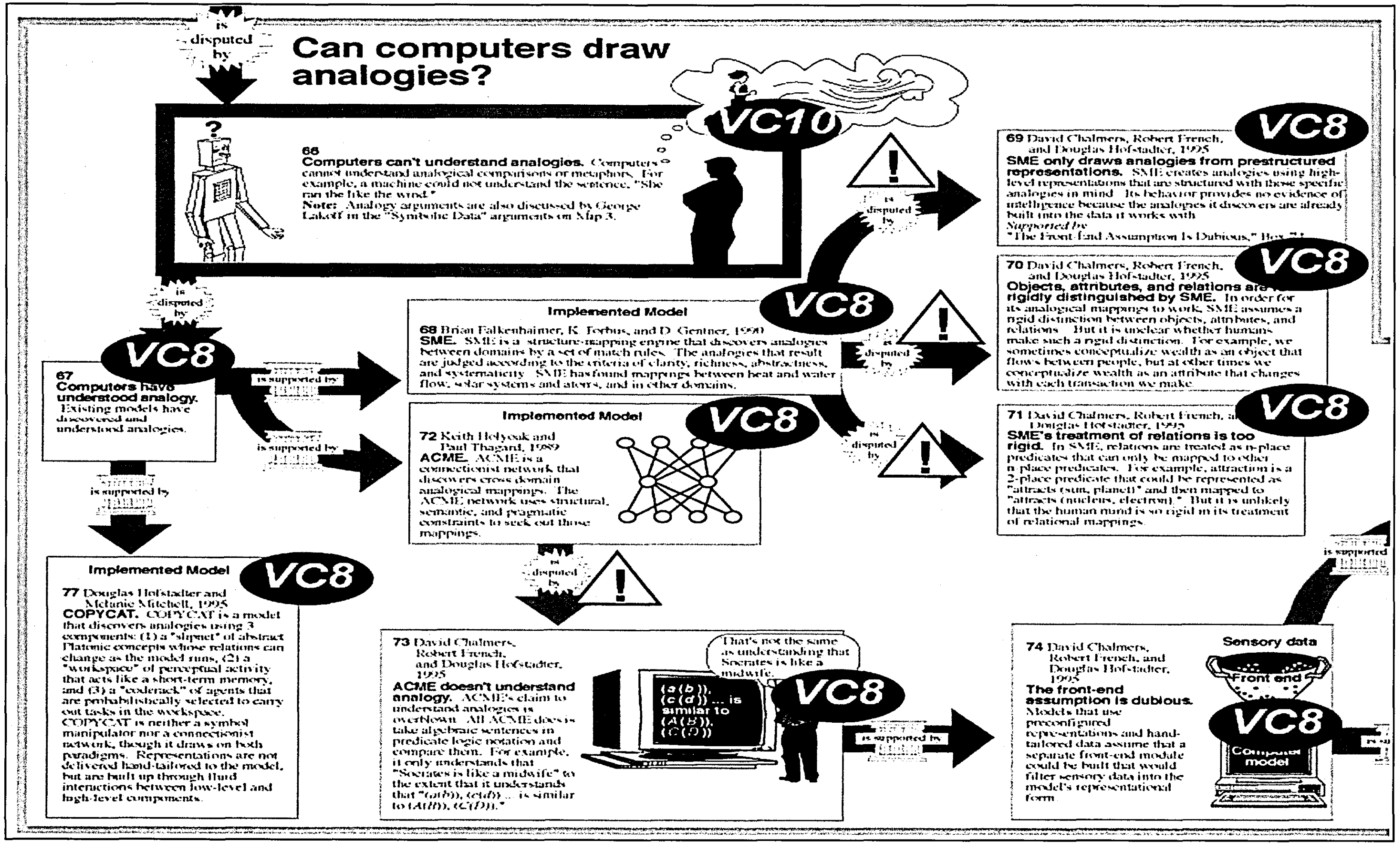


Figure 5-10 - The original location on Map 1 from where the Argument instances M1_ARG68 – M1_ARG73 are derived: The figure is annotated to show that M1_ARG68 – M1_ARG73 have been associated with the same ViewpointCluster instance (i.e. VC8) but that some of these arguments have a 'disputes' connection between them (depicted on the figure with warning signs).

As with the previous violated expectation, in order to determine whether this result is valid in reality, it is necessary to take a closer look at the representation of this part of the debate map in the knowledge base. Figure 5-11 shows the visual representation of the relevant instances in the knowledge base so that the rationale behind grouping arguments together in a viewpoint-cluster can be explored. As the figure depicts, it appears as if the *Argument* instances `M1_ARG67`, `M1_ARG68`, `M1_ARG72`, and `M1_ARG77` (enclosed in region '**a**' in the figure) have been grouped together because `M1_ARG67` states that *"Computers have already understood analogy"*, and all three of `M1_ARG68`, `M1_ARG72`, and `M1_ARG77` state specific examples to support this viewpoint. Thus, these four *Argument* instances appear to form a genuinely rhetorical coherent grouping. A second apparently rhetorically coherent grouping of *Argument* instances consists of `M1_ARG69`, `M1_ARG70`, `M1_ARG71`, `M1_ARG73`, `M1_ARG74`, `M1_ARG75`, and `M1_ARG76` (enclosed in region '**b**' in the figure). These arguments have been grouped together, firstly because each one *disputes* that the specific examples given are genuine examples of computers understanding analogy, and, secondly, because of their common authorship by *Chalmers, French and Hofstadter (1995)*. This is, however, where the system deviates from what might have been expected. Why, with the explicit *disputes* relations between some of the *Argument* instances depicted in region '**a**' and some of the *Argument* instances in region '**b**' has the system grouped all of these *Argument* instances together in the same viewpoint-cluster (i.e. VC8)? This is due to the limitation, previously highlighted, of the system not considering *disputes* relations during the actual cluster process but only considering +ADDITIVE connections. In this case, the system uses the common authorship of *Douglas Hofstadter* (indicated with thick arrows on the figure) to make a +ADDITIVE connection between `M1_ARG77` (shown in region '**a**') and each of the *Argument* instances `M1_ARG73`, `M1_ARG74`, and `M1_ARG75` (shown in region '**b**'), and this then leads the clustering algorithm to arrange all of these *Argument* instances into the same viewpoint-cluster.

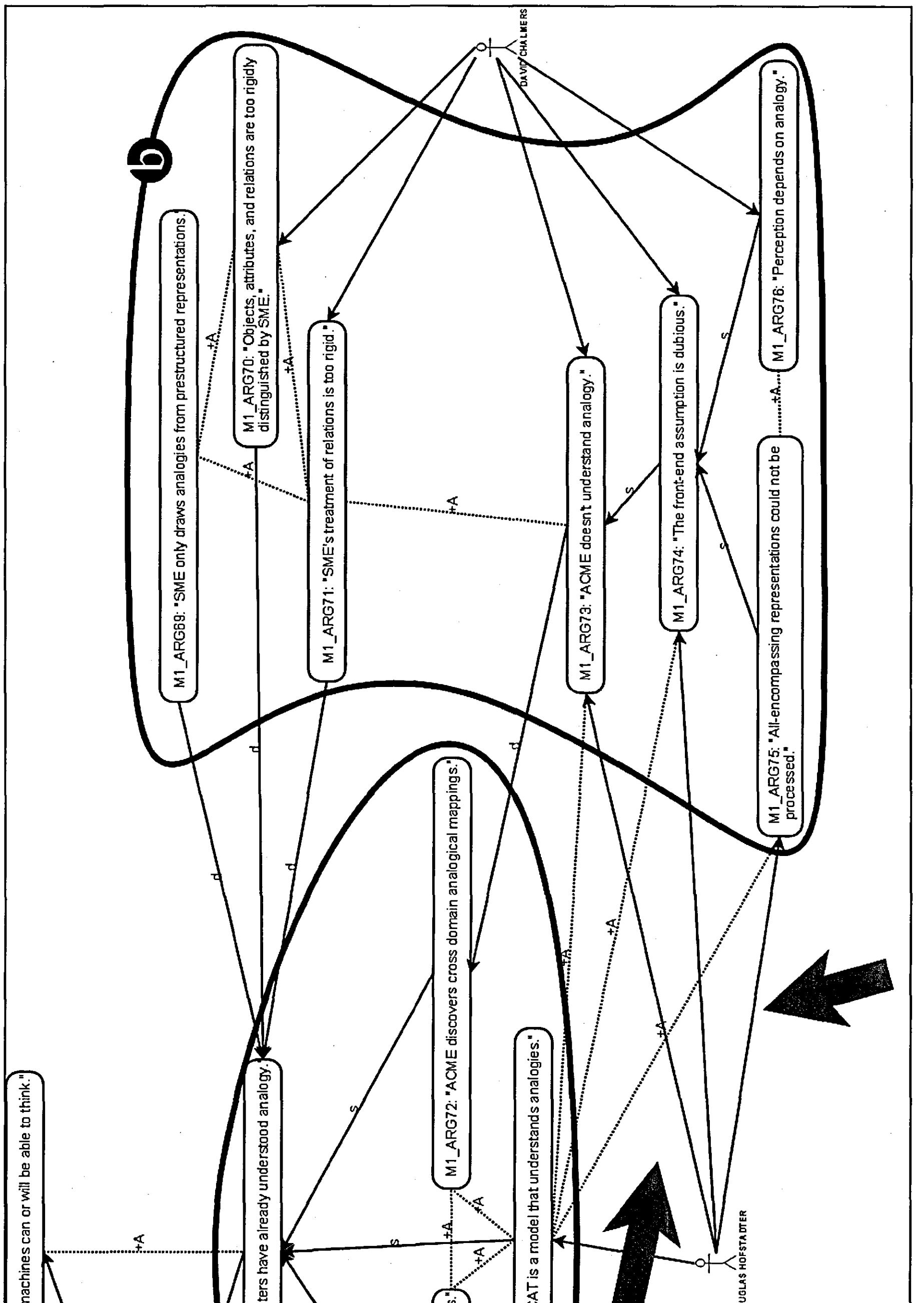


Figure 5-11 - Visual representation of the relevant class and relation instances representing violated expectation in VC8: The thick arrows indicate where +ADDITIVE connections have been inferred, which have led the clustering algorithm to group M1_ARG68 – M1_ARG73 in the same viewpoint-cluster (VC8). (The link label 'd' represents a 'disputes' relation, while the link label 's' represents a 'supports' relation. The dotted lines with link label '+A' indicate where a +ADDITIVE connection has been inferred by the system.).

Another violated expectation emerging from the results pertains to some persons being members of multiple, opposing clusters[53]. For example, *Harry Collins* is simultaneously a member of the two opposing *ViewpointCluster* instances *VC8* and *VC10*. In order to determine whether this is a reasonable state of affairs, it is necessary to determine the reasoning which has led the system to assign *Harry Collins* to these two viewpoint-clusters. It is also necessary to determine the reasoning which has led the system to assert that the two viewpoint-clusters are opposing each other.

Figure 5-12 shows a visual representation of the relevant class and relation instances. With regard to the first concern about the rationale for assigning *Harry Collins* to both *VC8* and *VC10*, in the case of *VC8*, *Argument* instance `M1_ARG123` (*"BACON only works when humans filter its data"*) has a *supports* connection to `M1_ARG74` (*"The front-end assumption is dubious"*), which in turn has +ADDITIVE connections to other *Argument* instances `M1_ARG69`, `M1_ARG70`, `M1_ARG71`, `M1_ARG73`, `M1_ARG75`, and `M1_ARG76`. Thus the clustering algorithm groups `M1_ARG123` along with `M1_ARG74` and the other *Argument* instances, and *Harry Collins*, as the author of `M1_ARG123` has been assigned to this same viewpoint-cluster. *Harry Collins* has been assigned to *VC10* because, he is the author of the *Argument* instance `M1_ARG116` (*"Scientific reasoning requires social agreement."*), and this instance has a +ADDITIVE connection with *Argument* instances `M1_ARG118` (*"Computers can't introduce new terms or explanatory principles."*) and `M1_ARG120` (*"Computers can't adequately evaluate hypotheses."*), which leads the clustering algorithm to place them all in the same cluster. Indeed, in the context of the main issue in the debate of whether computers can think, on closer reading, all the *Argument* instances in *VC10* are generally in disagreement with the claim that *"Yes, machines can or will be able to think"* (which is represented as the `M1_ARG1` *Argument*

[53] Note that, as demonstrated during the semantic representation process for this case study (*cf.* §5.1), there is no inherent inconsistency in having a person explicitly assigned to multiple positions. However, 'violated expectation' seems reasonable as a description of any case where a person is a member of more than one intellectual grouping and these groupings are also *opposing* each other.

instance). With regard to the reasoning which has led the system to assert that *VC8* and *VC10* are opposing each other, the opposition between *VC8* and *VC10* is a weak opposition connection that is inferred because of the single *disputes* relation between `M1_ARG67` (*"Computers have understood analogies"*) and `M1_ARG66` (*"Computers can't understand analogies"*). It is apparent that the violated expectation of *Harry Collins* being in opposing viewpoint-clusters is as a direct consequence of the previously highlighted violated expectation within *ViewpointCluster VC8* where one collection of *Argument* instances `M1_ARG67`, `M1_ARG68`, `M1_ARG72`, and `M1_ARG77` (*Cf.* region '**a**' in Figure 5-11) have been erroneously grouped together with another collection of *Argument* instances `M1_ARG69`, `M1_ARG70`, `M1_ARG71`, `M1_ARG73`, `M1_ARG74`, `M1_ARG75`, and `M1_ARG76` (*Cf.* region '**b**' in Figure 5-11). Thus *Harry Collins* should not have been assigned membership to the current configuration of *VC8*, a membership assignment that is leading to the unexpected situation of him being a member of two opposing viewpoint-clusters.

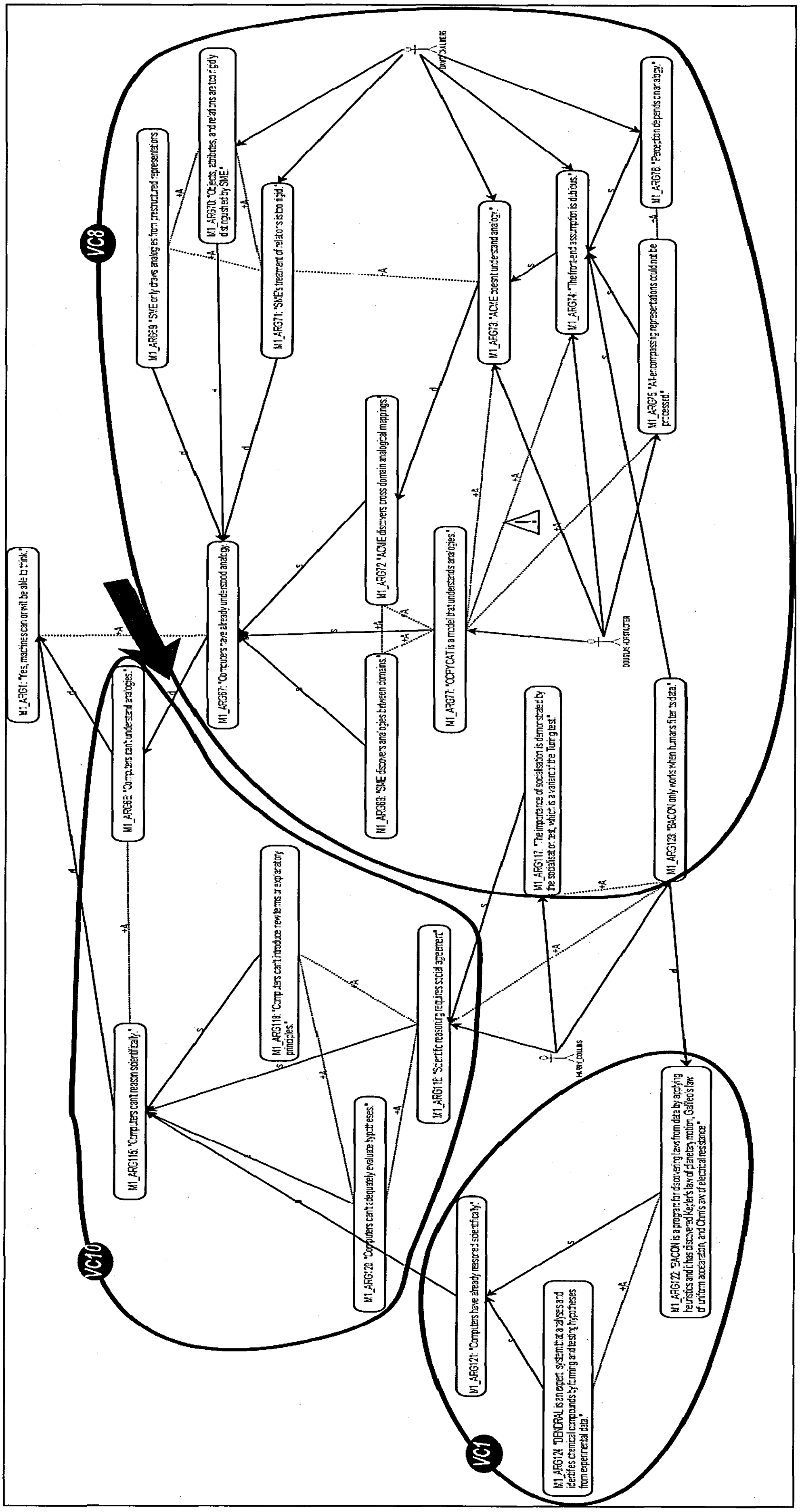


Figure 5-12 - Visual representation of the relevant class and relation instances representing violated expectation in VC8 and VC10: The thick arrow indicates the source of the (weak) opposition between VC8 and VC10.

The final violated expectation to be considered here is the case where *Hilary Putman* is simultaneously associated with two opposing *ViewpointCluster* instances instances *VC5* and *VC9*. As previously, in order to determine whether this is a reasonable state of affairs, it is necessary to determine the reasoning which has led the system to assign *Hilary Putnam* to these two viewpoint-clusters, as well as the reasoning which has led the system to assert the two viewpoint-clusters *VC5* and *VC9* as opposing to each other. The *ViewpointCluster* instance *VC5* contains a set of *Argument* instances that are broadly in agreement with the claim that *"Computers can't have free will"* (`M1_ARG2`), as well as a set of *Argument* instances that are in agreement with the claim that *"Machines can't have emotions"* (`M1_ARG28`). On the other hand, the *ViewpointCluster* instance *VC9* contains a collection of *Argument* instances that are broadly in *disagreement* with both the claims that *"Computers can't have free will"* (`M1_ARG2`) and *"Machines can't have emotions"* (`M1_ARG28`).

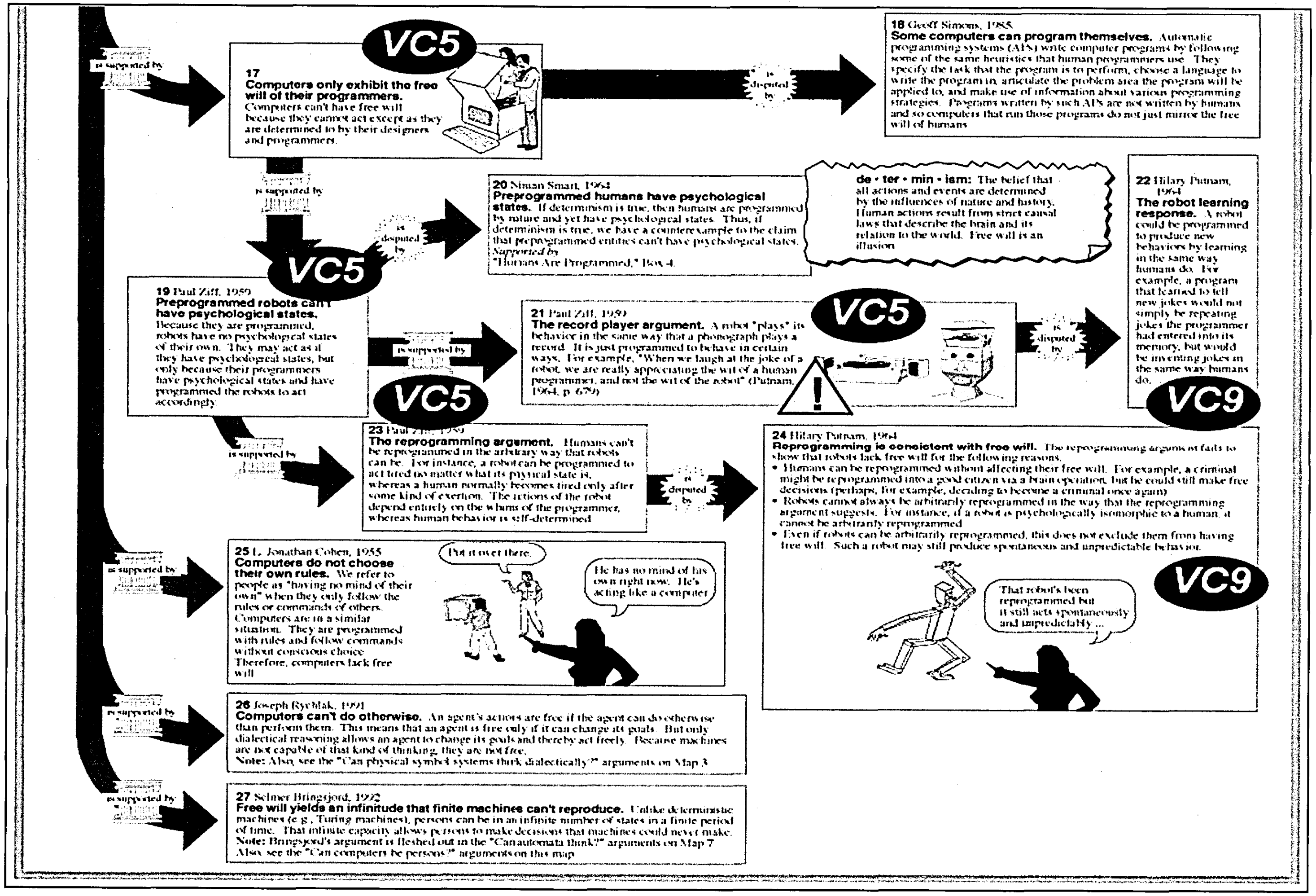


Figure 5-13 - The source of the unexpected result that one person, Hilary Putnam, has been placed in more than one ViewpointCluster which happen to be opposing each other.

It is possible to investigate this violated expectation even further by following up the exact source of the *Hilary Putnam* quote – given in the map as a direct page reference. Figure 5-14 shows the relevant section of the article – specifically the section entitled *"Anti-civil-libertarian Arguments"*. The article reference reveals a misrepresentation (or at least a misleading depiction) on the debate map. The quote from *Hilary Putman* is depicted on the map as if it were a direct claim of the author (and this is mirrored in the representation in the knowledge base). However, on closer reading of the article reference, the quote is an articulation of an opposing viewpoint, which the author expresses in order to dispute it. Thus, this is a case of one result from the analysis revealing something new about the original source material itself.

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and with a perhaps ultimately more serious interest in the relevant semantical aspects of our language.

Anti-civil-libertarian Arguments

Some of the arguments designed to show that Oscar *could not* be conscious may be easily exposed as bad arguments. Thus, the *phonograph-record argument:* a robot only "plays" behavior in the sense in which a phonograph record plays music. When we laugh at the joke of a robot, we are really appreciating the wit of the human programmer, and not the wit of the robot. The *reprogramming argument:* a robot has no real character of its own. It could at any time be reprogrammed to behave in the reverse of the way it has previously behaved. But a human being who was "reprogrammed" (say, by a brain operation performed by a race with a tremendously advanced science), so as to have a new and completely predetermined set of responses, would no longer be a human being (in the full sense), but a monster. The *question-begging argument:* the so-called "psychological" states of a robot are in reality just physical states. But *our* psychological states are *not* physical states. So it could only be in the most Pickwickian of senses that a robot was "conscious."

The first argument ignores the possibility of robots that *learn.* A robot whose "brain" was merely a library of predetermined behavior routines, each imagined in full detail by the programmer, would indeed be uninteresting. But such a robot would be incapable of learning anything that the programmer did not know, and would thus fail to be psychologically isomorphic to the programmer, or to any human. On the other hand, if the programmer constructs a robot so that it will be a model of certain psychological laws, he will *not,* in general, know how it will behave in real-life situations, just as a psychologist might know all of the *laws* of human psychology, but still be no better (or little better) than any one else at predicting how humans will behave in real-life situations. Imagine that the robot at "birth" is as helpless as a new-

Figure 5-14 - Location of quoted text from Putman (1964): Under the section "Anti-civil-libertarian Arguments", it is clear that, rather than being a direct claim of the author, the '*phonograph-record argument*' is actually being articulated here by the author so that it can be disputed.

Additional clustering arrangements

Finally, although the clustering arrangement with 13 clusters has been chosen for further analysis, it is useful to consider other clustering arrangements, in particular those arrangements with fewer clusters since they provide an additional filter on the complexity of the debate. As with McCain (1990) the aim is to inform a more general exploration by "referring 'down' to sub-clusters or 'up' to higher-level aggregations where useful."

Figure 5-15 and Figure 5-16 show the debate abstracted to 8 and 4 viewpoint-clusters respectively. For the decomposition into 8 viewpoint clusters, the system has combined ViewpointCluster instances VC3, VC4, and VC13 from the 13-cluster-arrangement (*Cf.* Figure 5-7) into a single cluster (now VC8 in Figure Figure 5-15). Similarly, the system has combined ViewpointCluster instances VC5, VC6, VC7, and VC10 from the 13-cluster-arrangement into a single cluster (now VC4 in Figure 5-16). For the decomposition into 4 viewpoint clusters, the system has combined ViewpointCluster instances VC1, VC2, VC6, and VC8 from the 8-cluster-arrangment into a single cluster (now VC1 in Figure 5-16). Similarly, the system has combined ViewpointCluster instances VC3 and VC4 into a single cluster (now VC in Figure 5-16). The decomposition into 4 clusters is particularly interesting because it shows the least number of clusters in an arrangement that is possible but is the closest approximation to viewing the Turing debate from two sides of the main issue of whether computers can or will be able to think.

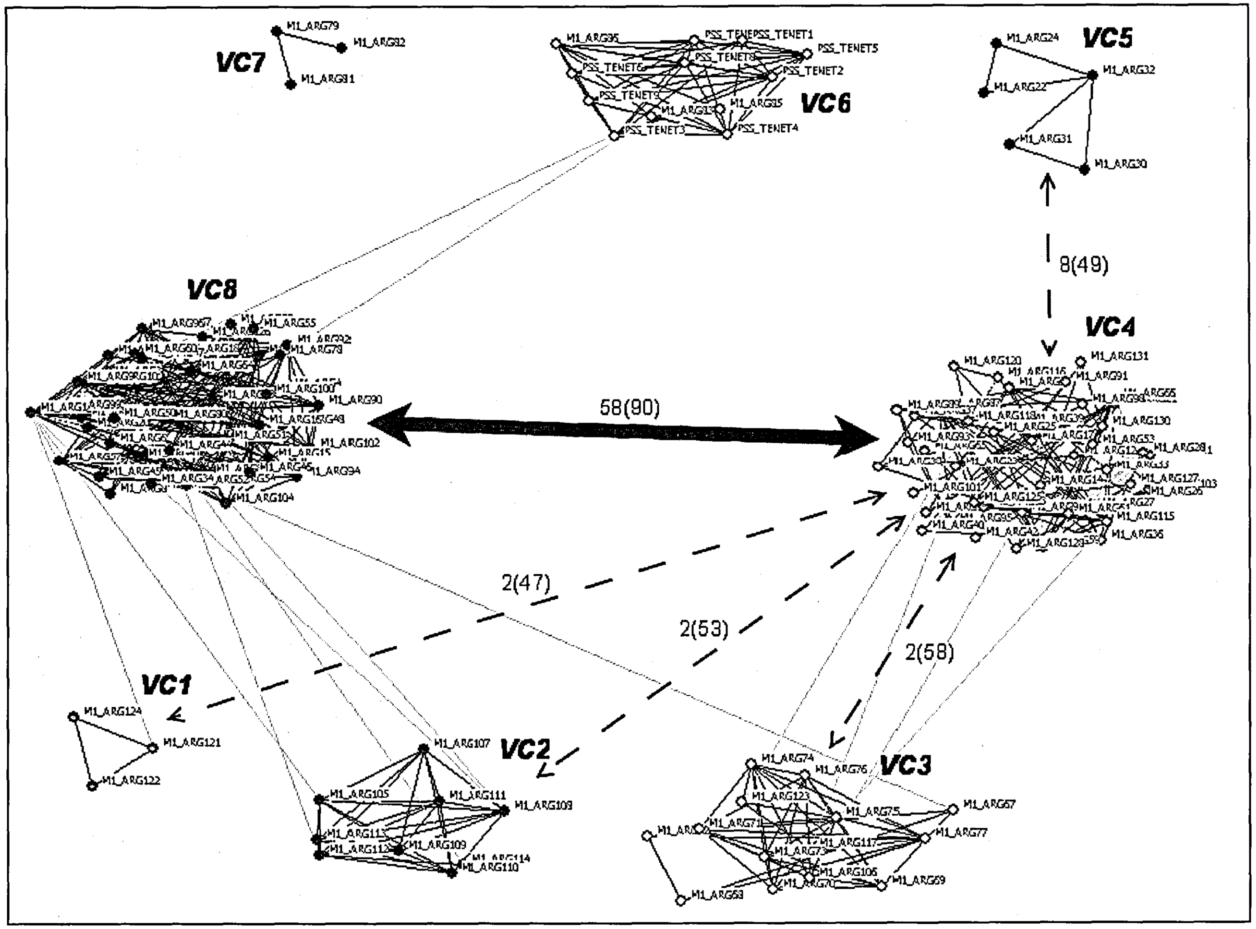

Figure 5-15 – A sketch of the Turing debate decomposed into 8 ViewpointCluster instances in the knowledge base. As before, the thick solid arrow depicts strong opposition between VC4 and VC8, while the dashed arrows depict weak opposition between VC4 and a number of other ViewpointCluster instances. Also as before, an indication of the strength of the opposition is given by the numbers x(y), where y is the total number of nodes in the two clusters and x is the number of nodes in both clusters involved in 'disputes' relations with each other.

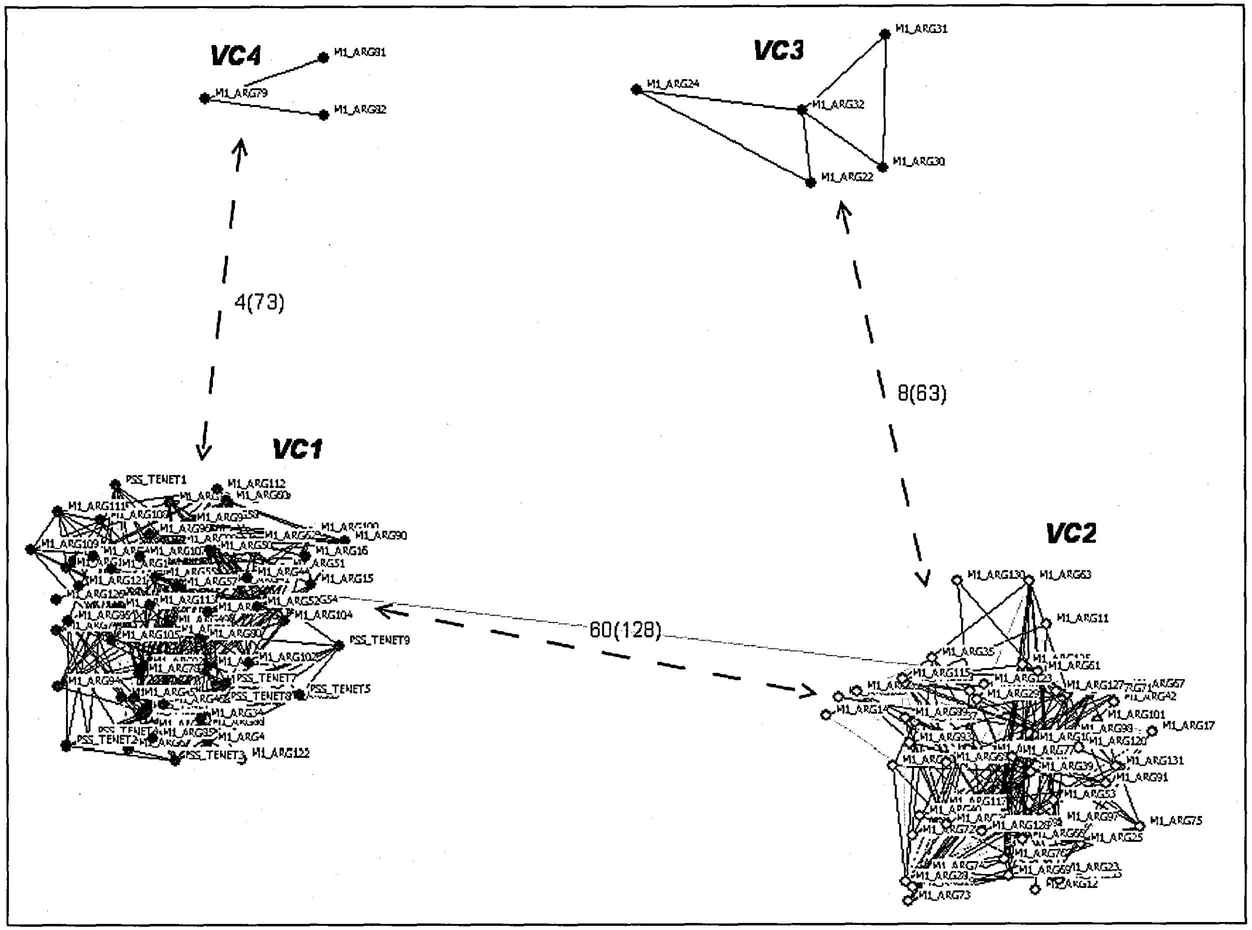

Figure 5-16 – A sketch of the Turing debate decomposed to 4 ViewpointCluster instances in the knowledge base. This decomposition shows the possibility of abstracting two main sides of the debate. As before, the dashed arrows depict weak opposition between the indicated ViewpointCluster instances. Also as before, an indication of the strength of the opposition is given by the numbers x(y), where y is the total number of nodes in the two clusters and x is the number of nodes in both clusters involved in 'disputes' relations with each other.

Chapter Summary

This chapter has shown how the Scholarly Debate Ontology has been applied to representing and reasoning about the Turing debate as described by Horn *et al.* (1998). The ontology enables the information conveyed on the maps to be represented in a computable form, which in turn facilitates the automatic detection of interesting and potentially significant features of the debate. In particular, a graph-theoretic cluster analysis method – as is typical in Bibliometrics research – has been applied to representations of the debate in order to reveal clusters of viewpoints in the debate.

The ontology applied in this case study was based in part on the explicit debate representation scheme used by Horn to create the Turing Debate maps in the first place. Thus, applying the ontology to the task of coding representations of the Turing Debate did not present many intractable modelling decisions. The next chapter demonstrates the use of the ontology in representing a debate where the information resources describing the debate have not already been given an explicit structure based on a debate representation scheme.

CHAPTER 6 CASE STUDY 2: ANALYSING THE ABORTION DEBATE IN THE BIOETHICS DOMAIN

This chapter explores the use of the Scholarly Debate Ontology for representing and reasoning about one of the central debates within the *Bioethics* domain – the *Abortion* debate – as described in an entry of the online *Wikipedia*. This debate is concerned with the issue of whether or not abortions should be legal. In contrast to the case study described in the previous chapter, the information resources describing the debate have not already been given an explicit structure according to some debate representation scheme. This case study is therefore an examination of whether the ontology can be applied to an unstructured information resource that describes a scholarly debate.

The chapter begins by describing how the information in the Wikipedia *Abortion debate* entry is captured as a collection of ontological instances in a knowledge base (§6.1). Then, the chapter shows how this new way of representing the information in the Wikipedia article in a knowledge base can be processed using the hybrid ontology-based and graph-based method in order to detect viewpoint-clusters in the Abortion debate (§6.2).

6.1 Coding representations of the debate in a knowledge base

Figure 6-1 shows the beginning of the Abortion debate entry in the online Wikipedia[54]. This Wikipedia entry provides the source material for capturing computable representations of the debate, thus demonstrating, as a proof-of-concept, the potential use of the ontology in semantically marking up scholarly information resources on the Web. This section describes how the debate described in the Wikipedia entry is coded as a

[54] This Wikipedia entry was originally accessed on 17 October 2006. The original entry has subsequently been split into two separate entries, one entitled *Abortion debate* and the other entitled *Philosophical aspects of the abortion debate*.

collection of ontological instances in a knowledge base using the Scholarly Debate Ontology as the basis for representation.

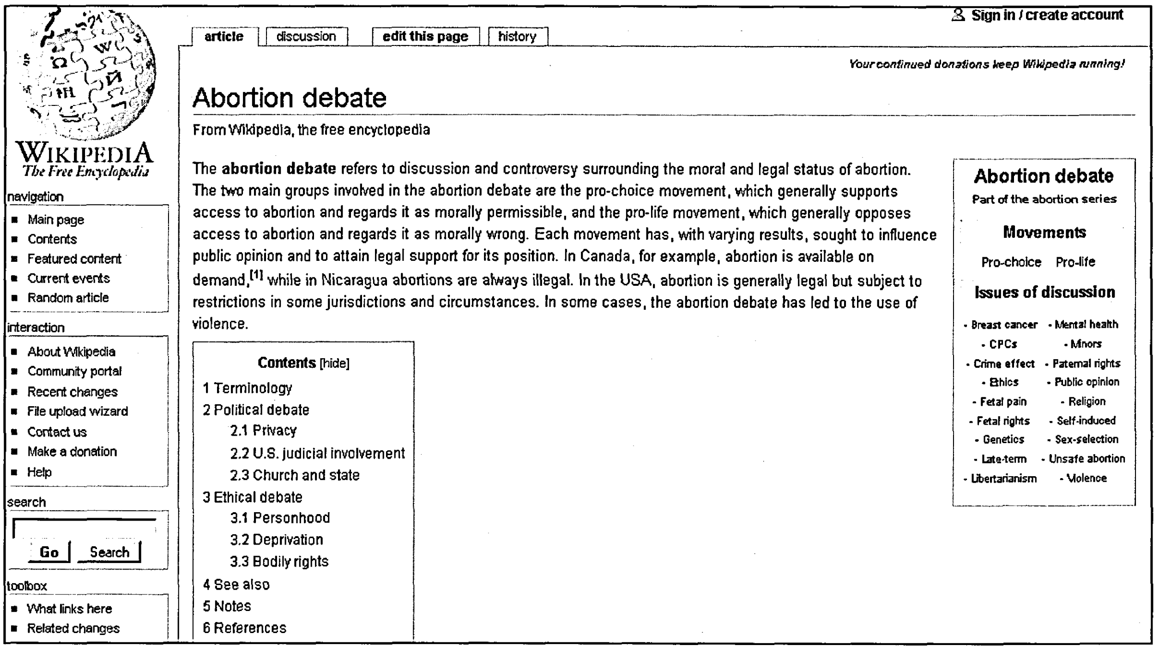

Figure 6-1 – Part of the 'Abortion debate' entry in the online Wikipedia.

Issue instances

As with Case Study 1, the first step in capturing debate-mapping-specific instances is to identify the issues that the debate seeks to resolve. Figure 6-2 shows the relevant parts of the Wikipedia source material which describes the issues in the debate.

Significant issues [edit]

Some of the most significant and common issues treated in the abortion debate are:

- The beginning of personhood (sometimes phrased ambiguously as "the beginning of life"): When is the embryo or fetus considered a person?
- Universal human rights: Is aborting a zygote, embryo, or fetus a violation of human rights? What about fetuses with genetic disabilities? On the other hand, is not allowing a woman to terminate her unwanted pregnancy a violation of the woman's human rights?
- Circumstances of conception: How important are the circumstances of conception to the ultimate fate of the embryo or fetus? Does pregnancy induced by rape or incest, or by poor or non-existent birth control use change the permissibility of abortion?
- Alternatives to abortion: Is adoption a viable and fair alternative to abortion? Are there resources available to aid mothers who are unprepared for parenthood, but who may wish to keep their child?
- Limit of government authority: Are laws controlling abortion violations of privacy and/or other personal liberty rights?

Figure 6-2 - The debate issues identified in the Wikipedia entry.

Listing 6-1 shows how the debate issues described in the Wikipedia entry have been captured in the knowledge base. As stated previously, the root issue being debated pertains to the legality of abortion. Therefore, an *Issue* instance (`AD_ISS1`) is coded in the knowledge base with the `verbalExpression` attribute assigned the value *"What should be the legal status of abortions?"*. The Listing then shows the coding of other *Issue* instances (`AD_ISS2` - `AD_ISS9`), which correspond to the other issues described in the Wikipedia text. This coding of *Issue* instances demonstrates how the modeller can use his/her judgement to paraphrase the text from the source material within the `verbalExpression` attribute value without affecting the semantics of the debate representation. For example, in representing *Issue* instance `AD_ISS4`, the value of the `verbalExpression` attribute is *"Is preventing a woman from terminating her unwanted pregnancy a violation of her human rights?"*. This is a paraphrase of the original text *"On the other hand, is not allowing a woman to terminate her unwanted pregnancy a violation of the woman's human rights?"*. Furthermore, the coding demonstrates how the modeller can use his/her judgement in extracting the questions as they appear in the source material into *Issue* instances. For example, within the bullet point *"Alternatives to abortion"*, the source material contains the text *"Are there resources available to aid mothers who are unprepared for parenthood, but who may wish to keep their child"*. The judgement is made here that this is a question of fact rather than an issue for debate, thus the relevant question extracted for use as an *Issue* instance is *"Is adoption a viable and fair alternative to abortion?"* (`AD_ISS6`). Finally, the Listing shows how the *relatedIssueOf* relation is used to link the *Issue* instances `AD_ISS2` to `AD_ISS9` to the root *Issue* instance `AD_ISS1`.

```
(def-instance AD_ISS1 Issue
  ((verbalExpression "What should be the legal status of abortions?")))

(def-instance AD_ISS2 Issue
  ((verbalExpression "When is the embryo or fetus considered a
person?")))

(def-instance AD_ISS3 Issue
  ((verbalExpression "Is aborting a zygote, embryo, or fetus a
violation of human rights?")))

(def-instance AD_ISS4 Issue
  ((verbalExpression "Is preventing a woman from terminating her
unwanted pregnancy a violation of her human rights?")))

(def-instance AD_ISS5 Issue
  ((verbalExpression "Does pregnancy induced by rape or incest or by
poor birth control use change the permissibility of abortion?")))

(def-instance AD_ISS6 Issue
  ((verbalExpression "Is adoption a viable and fair alternative to
abortion?")))

(def-instance AD_ISS7 Issue
  ((verbalExpression "Are laws controlling abortion violations of
privacy and/or other personal liberties?")))

(def-instance AD_ISS8 Issue
  ((verbalExpression "Should a pregnant minor need the consent of her
parents for abortion?")))

(def-instance AD_ISS9 Issue
  ((verbalExpression "Should a pregnant woman need the consent of the
biological father for abortion?")))

(def-relation-instances
   (relatedIssueOf AD_ISS2 AD_ISS1)
   (relatedIssueOf AD_ISS3 AD_ISS1)
   (relatedIssueOf AD_ISS4 AD_ISS1)
   (relatedIssueOf AD_ISS5 AD_ISS1)
   (relatedIssueOf AD_ISS6 AD_ISS1)
   (relatedIssueOf AD_ISS7 AD_ISS1)
   (relatedIssueOf AD_ISS8 AD_ISS1)
   (relatedIssueOf AD_ISS9 AD_ISS1))
```

Listing 6-1 - Representation of the debate issues: The Issue instance AD_ISS1 corresponds to the root issue of the debate, which pertains to the legality of abortion. The remaining Issue instances correspond to other issues expressed in the Wikipedia entry. In the knowledge base, these are all connected to the root issue by the 'relatedIssueOf' relation.

Proposition and Argument instances

This section now focuses on representing the viewpoints in the debate. According to the Wikipedia entry, the argumentation in the debate is generated by two broadly opposing viewpoints – the *pro-life* and the *pro-choice* arguments. The coding process starts with representing these two basic arguments and then branches off to represent the range of arguments that extend the basic arguments.

As mentioned previously, the first case study utilised source material where the argumentation had been structured according to a predefined argument modelling scheme. In particular, on the Horn Turing debate maps, there were clearly demarcated arguments with explicit relations (*supports* or *disputes*) between them. However, in the case of the Wikipedia entry, with unstructured text on display, more attention had to be paid to argumentation cues in the text. Figure 6-3 shows the extract from the Wikipedia entry that gives an overview of the two basic viewpoints. Both viewpoints are based on three premises (the numbered statements) depicted in the figure.

> - Mental health - Violence
>
> This box: view • talk • edit
>
> The **central arguments** in the abortion debate are deontological or rights-based. The view that all or almost all abortion should be illegal generally rests on the claims: (1) that the existence and moral right to life of human beings (human organisms) begins at or near conception-fertilisation; (2) that induced abortion is the deliberate and unjust killing of the embryo in violation of its right to life; and (3) that the law should prohibit unjust violations of the right to life. The view that abortion should in most or all circumstances be legal generally rests on the claims: (1) that women have a right to control what happens in and to their own bodies; (2) that abortion is a just exercise of this right; and (3) that the law should not criminalise just exercises of the right to control one's own body. Both sides of the debate would grant premise (3) of the central pro-life argument and premises (1) and (3) of the central pro-choice argument.

Figure 6-3 - Extract from the Wikipedia entry that describes the claims made by the two basic 'pro-life' and 'pro-choice' viewpoints.

Listing 6-2 shows how these two basic viewpoints in the abortion debate are captured in the knowledge base. The three premises for the basic pro-life argument have been captured as *Proposition* instances `PRO-LIFE-P1` (*"The existence and moral right to life of human organisms begins at or near conception-fertilisation"*), `PRO-LIFE-P2` (*"Induced abortion is the deliberate and unjust killing of the fetus in violation of its right to life"*), and `PRO-LIFE-P3` (*"The law should prohibit unjust violations of the right to life"*). The conclusion is also represented as a *Proposition* instance `PRO-LIFE-P4` (*"Abortion should be illegal"*) in the knowledge base. An *Argument* instance (`BASIC-PRO-LIFE-ARGUMENT`) is then coded, with *hasPremise* attribute set to `PRO-LIFE-P1`, `PRO-LIFE-P2`, and `PRO-LIFE-P3`, as well as *hasConclusion* attribute set to `PRO-LIFE-P4`. Similar steps are performed to represent the basic pro-choice argument in the debate – there are three *Proposition* instances `PRO-CHOICE-P1` (*"Women have a right to control* *what happens in and to their bodies"*), PRO-CHOICE-P2 (*"Abortion is a just exercise of a woman's right to control what happens in and to her body"*), PRO-CHOICE-P3 (*"The law should not criminalise just exercises of the right to control one's own body"*) that correspond to the premises of the argument, and a *Proposition* instance PRO-CHOICE-P4 (*"Abortion should be legal"*) that corresponds to the conclusion. Finally, the Listing shows the coding of relation instances in the knowledge base – firstly, an *addresses* link is established between both of the BASIC-PRO-LIFE-ARGUMENT and BASIC-PRO-CHOICE-ARGUMENT *Argument* instances and the AD_ISS1 *Issue* instance; and secondly, a *disputes* link is asserted between the two *Argument* instances BASIC-PRO-LIFE-ARGUMENT and BASIC-PRO-CHOICE-ARGUMENT.

```
(def-instance PRO-LIFE-P1 Proposition
  ((verbalExpression "The existence and moral right to life of human
organisms begins at or near conception-fertilisation")))

(def-instance PRO-LIFE-P2 Proposition
  ((verbalExpression "Induced abortion is the deliberate and unjust
killing of the fetus in violation of its right to life")))

(def-instance PRO-LIFE-P3 Proposition
  ((verbalExpression "The law should prohibit unjust violations of the
right to life")))

(def-instance PRO-LIFE-P4 Proposition
  ((verbalExpression "Abortion should be illegal.")))

(def-instance BASIC-PRO-LIFE-ARGUMENT Argument
  ((hasPremise PRO-LIFE-P1
               PRO-LIFE-P2
               PRO-LIFE-P3)
   (hasConclusion PRO-LIFE-P4)))



(def-instance PRO-CHOICE-P1 Proposition
  ((verbalExpression "Women have a right to control what happens in and
to their own bodies")))

(def-instance PRO-CHOICE-P2 Proposition
  ((verbalExpression "Abortion is a just exercise of a woman's right to
control what happens in and to her body")))

(def-instance PRO-CHOICE-P3 Proposition
  ((verbalExpression "The law should not criminalise just exercises of
the right to control one's own body")))

(def-instance PRO-CHOICE-P4 Proposition
  ((verbalExpression "Abortion should be legal")))

(def-instance BASIC-PRO-CHOICE-ARGUMENT Argument
  ((hasPremise PRO-CHOICE-P1
               PRO-CHOICE-P2
               PRO-CHOICE-P3)
   (hasConclusion PRO-CHOICE-P4)))


(def-relation-instances
  (addresses BASIC-PRO-CHOICE-ARGUMENT AD_ISS1)
  (addresses BASIC-PRO-LIFE-ARGUMENT AD_ISS1)
  (disputes BASIC-PRO-CHOICE-ARGUMENT BASIC-PRO-LIFE-ARGUMENT)
  (disputes BASIC-PRO-LIFE-ARGUMENT BASIC-PRO-CHOICE-ARGUMENT))
```

Listing 6-2 - Representation of the two basic pro-life and pro-choice viewpoints in the debate (as described in the Wikipedia entry): These are represented as two Argument instances BASIC-PRO-LIFE-ARGUMENT and BASIC-PRO-CHOICE-ARGUMENT respectively. Both of these Argument instances are connected via an 'addresses' relation to the Issue instance AD_ISS1 that corresponds to the root issue of the debate. The two Argument instances are also connected to each other via a 'disputes' relation.

However, the Wikipedia entry, does not simply describe the debate in terms of pro-choice vs. pro-life since these basic viewpoints do not encompass all the argumentation in the debate. Figure 6-4 shows an extract from the Wikipedia entry that describes further argumentation in the debate. It is an example of how other issues are raised that relate to the root issue being debated, and how argumentation on these newly raised issues is linked to the rest of the debate.

> Contemporary philosophical literature contains two kinds of arguments concerning the morality of abortion. One family of arguments (see the following three sections) relates to the moral status of the embryo—the question of whether the embryo has a right to life, is the sort of being it would be seriously wrong to kill, or in other words is a 'person' in the moral sense. An affirmative answer would support claim (1) in the central pro-life argument, while a negative answer would support claim (2) in the central pro-choice argument.
>
> Another family of arguments (see the section on Thomson, below) relates to bodily rights—the question of whether the woman's bodily rights justify abortion *even if* the embryo has a right to life. A negative answer would support claim (2) in the central pro-life argument, while an affirmative answer would support claim (2) in the central pro-choice argument.

Figure 6-4 – Representation of additional argumentation in the debate: Other issues are raised which relate to the root issue (What should be the legal status of abortions?) and the arguments that address these newly raised issues are linked to the arguments in the rest of the debate.

Listing 6-3 shows how the additional argumentation is captured in the knowledge base. Another *Issue* instance (`AD_ISS10`) is coded in the knowledge base, with *verbalExpression* attribute set to the text string *"Is the fetus a person in the moral sense?"*. This is linked to the root issue of the debate (`AD_ISS1`) via a *relatedIssueOf* relation. Two *Proposition* instances (`AD_ISS10_VIEW1` and `AD_ISS10_VIEW2`) are then coded in the knowledge base, which correspond respectively to the two claims *"The fetus is a person in the moral sense."* and *"The fetus is not a person in the moral sense."*. These two *Proposition* instances are then both linked to the *Issue* instance `AD_ISS10` via an *addresses* relation. Next, to capture the fact that the two claims on the issue are mutually opposed to each other, two *disputes* relation instances are coded in the knowledge base, the first one capturing the *disputes* relation in the direction `AD_ISS10_VIEW1` to `AD_ISS10_VIEW2` and the second one capturing the *disputes* relation in the direction `AD_ISS10_VIEW2` to `AD_ISS10_VIEW1`. Finally, as indicated by the text in the Wikipedia entry the two views are linked to the basic pro-choice and pro-life claims in the debate. The *Proposition* instance `AD_ISS10_VIEW1` (*"The fetus is a person in the moral sense"*) is captured as having a *supports* link to the *Proposition* instance `PRO-LIFE-P1` (*"Abortion should be* *illegal"*), whereas the *Proposition* instance AD_ISS10_VIEW2 (*"The fetus is not a person in the moral sense"*) is captured as having a *supports* link to the *Proposition* instance PRO-CHOICE-P2 (*"Abortion should be legal"*). The Listing goes on to show the code that corresponds to the second 'family of arguments' as presented in the Wikipedia entry.

```
(def-instance AD_ISS10 Issue
  ((verbalExpression "Is the fetus a person in the moral sense?")))

(def-relation-instances
  (relatedIssueOf AD_ISS10 AD_ISS1))

(def-instance AD_ISS10_VIEW1 Proposition
  ((verbalExpression "The fetus is a person in the moral sense")))

(def-instance AD_ISS10_VIEW2 Proposition
  ((verbalExpression "The fetus is not a person in the moral sense")))

(def-relation-instances
  (addresses AD_ISS10_VIEW1 AD_ISS10)
  (addresses AD_ISS10_VIEW2 AD_ISS10)
  (disputes AD_ISS10_VIEW1 AD_ISS10_VIEW2)
  (disputes AD_ISS10_VIEW2 AD_ISS10_VIEW1)
  (supports AD_ISS10_VIEW1 PRO-LIFE-P1)
  (supports AD_ISS10_VIEW2 PRO-CHOICE-P2))

(def-instance AD_ISS11 Issue
  ((verbalExpression "Do a woman's bodily rights justify abortion even
if the fetus has a right to life?")))

(def-instance AD_ISS11_VIEW1 Proposition
  ((verbalExpression "A woman's bodily rights do not justify abortion
even if the fetus has a right to life")))

(def-instance AD_ISS11_VIEW2 Proposition
  ((verbalExpression "A woman's bodily rights justify abortion even if
the fetus has a right to life")))

(def-relation-instances
  (relatedIssueOf AD_ISS11 AD_ISS1)
  (addresses AD_ISS11_VIEW1 AD_ISS11)
  (addresses AD_ISS11_VIEW2 AD_ISS11)
  (disputes AD_ISS11_VIEW1 AD_ISS11_VIEW2)
  (disputes AD_ISS11_VIEW2 AD_ISS11_VIEW1)
  (supports AD_ISS11_VIEW1 PRO-LIFE-P2)
  (supports AD_ISS11_VIEW2 PRO-CHOICE-P2)
```

Listing 6-3 - Representation of two additional kinds of arguments in the debate concerning the morality of abortions.

Position instances

The Wikipedia entry describes how some of the arguments in the debate appeal to existing philosophical positions. Figure 6-5 shows an extract from the Wikipedia entry that describes various appeals to a *Utilitarian* philosophical position.

> Although both sides are likely to see the rights-based considerations as paramount, some popular arguments appeal to consequentialist or utilitarian considerations. For example, pro-life advocacy groups (see the list below) sometimes draw attention to the abortion-breast cancer hypothesis, post-abortion syndrome, and other alleged medical and psychological risks of abortion. On the other side, some pro-choice groups (see the list below) claim that criminalizing abortion will lead to the deaths of many women through 'back-alley abortions'; that unwanted children have a negative social impact (or conversely that abortion lowers the crime rate); or that reproductive rights are necessary to achieve the full and equal participation of women in society and the workforce. Consequentialist arguments on both sides tend to be vigorously disputed, though are not widely discussed in the philosophical literature.

Figure 6-5 - Wikipedia extract describing an appeal to Utilitarianism in the debate.

Listing 6-4 shows how philosophical positions can be captured in the knowledge base using the *Position* class. The Listing then shows how two *Proposition* instances, `ABORTION-BREAST-CANCER-HYPOTHESIS` (*"There is a causal relationship between induced abortion and an increased risk of developing breast cancer"*) and `POST-ABORTION-SYNDROME-VIEWPOINT` (*"Women who have elective abortions can suffer from post-abortion syndrome"*) both have a *supports* link to `BASIC-PRO-LIFE-ARGUMENT` and also how both *Proposition* instances have been classified as *Utilitarian* viewpoints using the *cdns:classifies* relation.

```
(def-instance UTILITARIANISM Position)

(def-instance ABORTION-BREAST-CANCER-HYPOTHESIS Proposition
   ((verbalExpression "There is a causal relationship between induced
abortion and an increased risk of developing breast cancer.")))

(def-instance POST-ABORTION-SYNDROME-VIEWPOINT Proposition
   ((verbalExpression "Women who have elective abortions can suffer
from post-abortion syndrome.")))

(def-relation-instances
  (supports ABORTION-BREAST-CANCER-HYPOTHESIS BASIC-PRO-LIFE-ARGUMENT)
  (supports POST-ABORTION-SYNDROME-VIEWPOINT BASIC-PRO-LIFE-ARGUMENT)
  (#_cdns:classifies UTILITARIANISM ABORTION-BREAST-CANCER-HYPOTHESIS)
  (#_cdns:classifies UTILITARIANISM POST-ABORTION-SYNDROME-VIEWPOINT))
```

Listing 6-4 - Representation of the Utilitarianism philosophical position and two 'pro-life' viewpoints in the debate that can be classified as Utilitarian.

Listing 6-5 shows how three Proposition instances, BACK-ALLEY-VIEWPOINT (*"Criminalising abortion will lead to the deaths of many women through back-alley abortions"*), UNWANTED-CHILDREN-VIEWPOINT (*"Unwanted children have a negative social impact"*), and EQUAL-PARTICIPATION-VIEWPOINT (*"Reproductive rights are necessary to achieve the full and equal participation of women in society"*) each have a *supports* link to BASIC-PRO-CHOICE-ARGUMENT and also how all three *Proposition* instances have been classified as *Utilitarian* viewpoints using the *cdns:classifies* relation.

```
(def-instance BACK-ALLEY-VIEWPOINT Proposition
   ((verbalExpression "Criminalising abortion will lead to the deaths
of many women through back-alley abortions")))

(def-instance UNWANTED-CHILDREN-VIEWPOINT Proposition
   ((verbalExpression "Unwanted children have a negative social
impact")))

(def-instance EQUAL-PARTICIPATION-VIEWPOINT Proposition
   ((verbalExpression "Reproductive rights are necessary to achieve the
full and equal participation of women in society")))

(def-relation-instances
  (supports BACK-ALLEY-VIEWPOINT BASIC-PRO-CHOICE-ARGUMENT)
  (supports UNWANTED-CHILDREN-VIEWPOINT BASIC-PRO-CHOICE-ARGUMENT)
  (supports EQUAL-PARTICIPATION-VIEWPOINT BASIC-PRO-CHOICE-ARGUMENT)
  (#_cdns:classifies UTILITARIANISM BACK-ALLEY-VIEWPOINT)
  (#_cdns:classifies UTILITARIANISM UNWANTED-CHILDREN-VIEWPOINT)
  (#_cdns:classifies UTILITARIANISM EQUAL-PARTICIPATION-VIEWPOINT))
```

Listing 6-5 - Representation of three 'pro-choice' viewpoints in the debate that can be classified as Utilitarian.

Person and Publication instances

Capturing and coding person and publication instances was facilitated by the reference list at the end of the Wikipedia entry. The reference list includes all the publications from which the Wikipedia entry was composed as well as the publication authors who have participated in the debate. Figure 6-6 shows part of this reference list.

References

[edit]

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Figure 6-6 - Part of the reference list that appears at the end of the Wikipedia entry.

Listing 6-6 shows how the *Person* and *Publication* instances corresponding to the first two references have been captured in the knowledge base. For example, the first publication in the reference list gives the author as a person called *L. Baker*. Therefore, a *Person* instance (`LYNNE_BAKER`) is coded in the knowledge base. A *Publication* instance (`BAKER2000PERSONS`) is also coded to represent the relevant publication with attributes *hasAuthor* set to `LYNNE_BAKER`, *hasTitle* set to the *String* instance `"Persons and Bodies: A Constitution View"`, and *hasYear* set to *time:Year-In-Time* instance `2000`.

```
(def-instance LYNNE_BAKER  Person)

(def-instance BAKER2000PERSONS Publication
  ((hasAuthor LYNNE_BAKER)
   (hasTitle "Persons and Bodies: A Constitution View")
   (hasYear 2000)))

(def-instance FRANCIS_BECKWITH Person))

(def-instance BECKWITH1993POLITICALLY Publication
  ((hasAuthor FRANCIS_BECKWITH)
   (hasTitle "Politically Correct Death")
   (hasYear 1993)))
```

Listing 6-6 - Coding representations of two Publication and Person instances in the knowledge base that correspond to the first two items in the reference list of the Wikipedia entry.

DomainConcept instances

Specialist domain vocabulary appears throughout the Abortion debate entry in Wikipedia. Typically, where a specialist term appears in the text, a link is provided to another Wikipedia entry, which then gives the definition of the term. Listing 6-7 shows the representation of "Embryo" and "Fetus", captured as *DomainConcept* instances EMBRYO and FETUS with the *definedBy* attribute set respectively to the *Proposition* instances EMBRYO-DEFINITION and FETUS-DEFINITION. The text values assigned to the *verbalExpression* attributes of EMBRYO-DEFINITION and FETUS-DEFINITION have been taken from the respective Wikipedia entries.

```
(def-instance EMBRYO DomainConcept
  ((definedBy EMBRYO-DEFINITION)))

(def-instance EMBRYO-DEFINITION Proposition
  ((verbalExpression "An embryo is a multicellular diploid eukaryote in
its earliest stage of development, from the time of first cell division
until birth, hatching, or germination. In humans, it is called an
embryo from the moment of fertilisation until the end of the 8th week
of gestational age, whereafter it is instead called a fetus.")))

(def-instance FETUS DomainConcept
  ((definedBy FETUS-DEFINITION)))

(def-instance FETUS-DEFINITION Proposition
  ((verbalExpression "A fetus is a developing mammal or other
viviparous vertebrate, after the embryonic stage and before birth. In
humans, the fetal stage of prenatal development begins about eight
weeks after fertilization, when the major structures and organ systems
have formed, until birth.")))
```

Listing 6-7 - The representations in the knowledge base that correspond to "Embryo" and "Fetus" that make up part of the specialist domain vocabulary of the Abortion debate.

6.2 Applying the hybrid approach to detecting clusters of viewpoints in the debate

As in the previous chapter, the first step in detecting viewpoint clusters in the debate is to translate the ontology-based representation of the debate into a suitable graph-based representation so that the cluster analysis technique can be applied (§6.2.1). Once a suitable graph-based representation is generated, the cluster analysis is performed (§6.2.2).

The results of the cluster analysis are then translated back into an ontology-based representation for further semantic analysis of the viewpoint clusters, through the creation of new *ViewpointCluster* instances (§6.2.3). These results then form the basis of discussion about what insights the analysis was able to reveal about the Abortion Debate as set out in the source material (§6.2.4).

6.2.1 Translating the ontology-based representation to enable graph-based analysis

Figure 6-7 shows how three of the basic +ADDITIVE inference rules are applied to part of the ontology-based representation of the Abortion debate. The section of the figure labelled (a) shows that a +ADDITIVE relation is inferred between the *Argument* instances `DEPRIVATION-ARGUMENT` and `ABORTION-BREAST-CANCER-HYPOTHESIS` because of a common *supports* connection to the *Argument* instance `BASIC-PRO-LIFE-ARGUMENT`. The section labelled (b) shows that the *Argument* instance `BOONIN2003DEFENSE-ARGUMENT` *disputes* `TACIT-CONSENT-OBJECTION-ARGUMENT` which in turn is disputing `BODILY-RIGHTS-ARGUMENT`. This pattern corresponds to one of the rhetorical-coherence inference rules previously defined and thus the system infers a +ADDITIVE relation between `BOONIN2003DEFENSE-ARGUMENT` and `BODILY-RIGHTS-ARGUMENT` (depicted as a dotted line, labelled '+A', in the figure). The section labelled (c) shows that a +ADDITIVE relation is inferred between the *Argument* instances `CONTRACEPTION-OBJECTION-ARGUMENT`, `IDENTITY-OBJECTION-ARGUMENT` and `EQUALITY-OBJECTION-ARGUMENT` because of a common *disputes* connection to *Argument* instance `DEPRIVATION-ARGUMENT`.

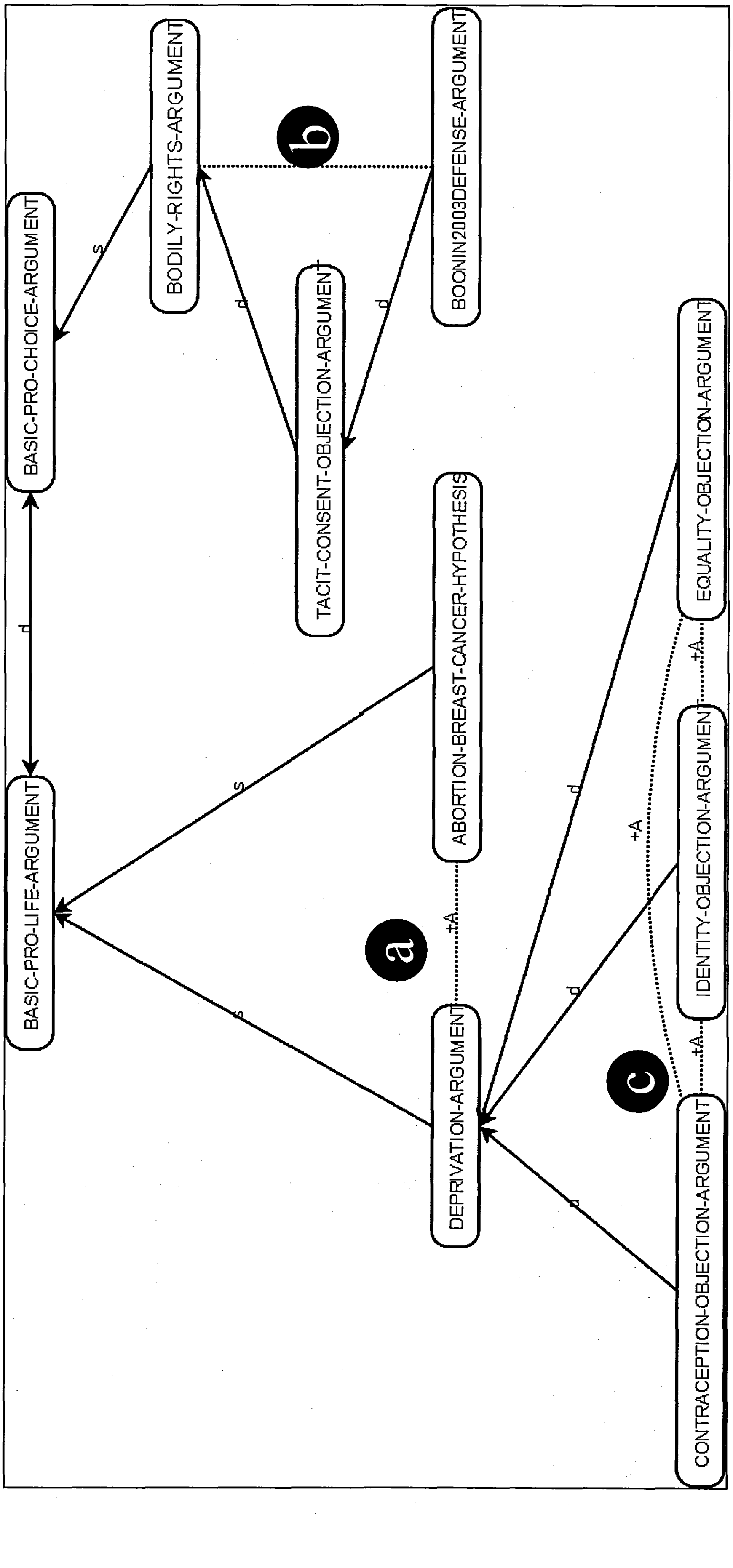

Figure 6-7 - Three of the core +ADDITIVE inference rules being applied to a part of the Abortion debate representation. The link labels are abbreviated as 's' for 'supports', 'd' for 'disputes', and '+A' for '+ADDITIVE'.

6.2.2 Detecting clusters in the graph-based representation

Figure 6-8 shows a plot of *Goodness-of-fit vs. Number of clusters* for the application of the Newman-Girvan algorithm to the one-mode representation of the Abortion Debate. The plot shows that the maximum goodness-of-fit value occurs when the network is decomposed into 5 viewpoint-clusters. However, as with the first case study, the aim is not to identify the perfect clustering arrangement; rather the aim is to identify potentially interesting features of the scholarly debate that will motivate further informed investigation from the knowledge domain analyst.

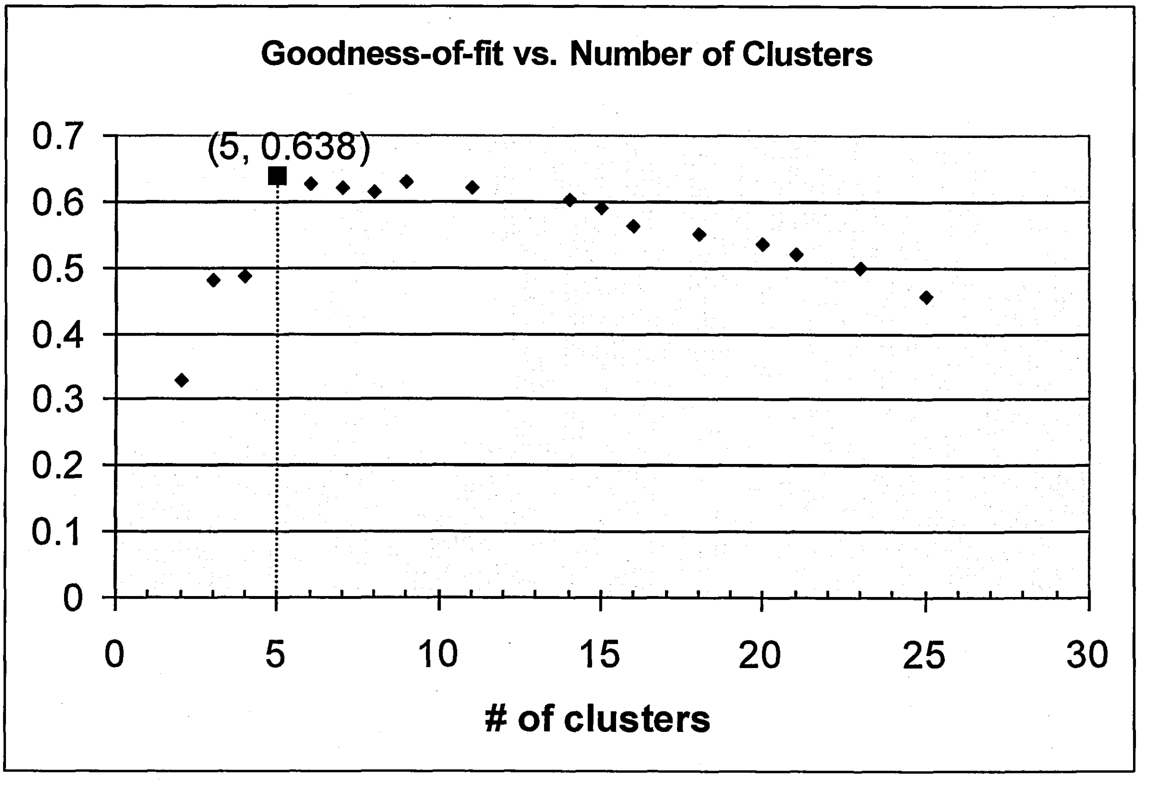

Figure 6-8 - The plot of goodness-of-fit vs. number of clusters for the abortion debate network: The goodness-of-fit measure reaches a maximum value of 0.638 when the data is arranged into 5 clusters.

Figure 6-9 shows the NetDraw visualisation of the one-mode representation of the Abortion Debate divided into 5 clusters using the NG algorithm.

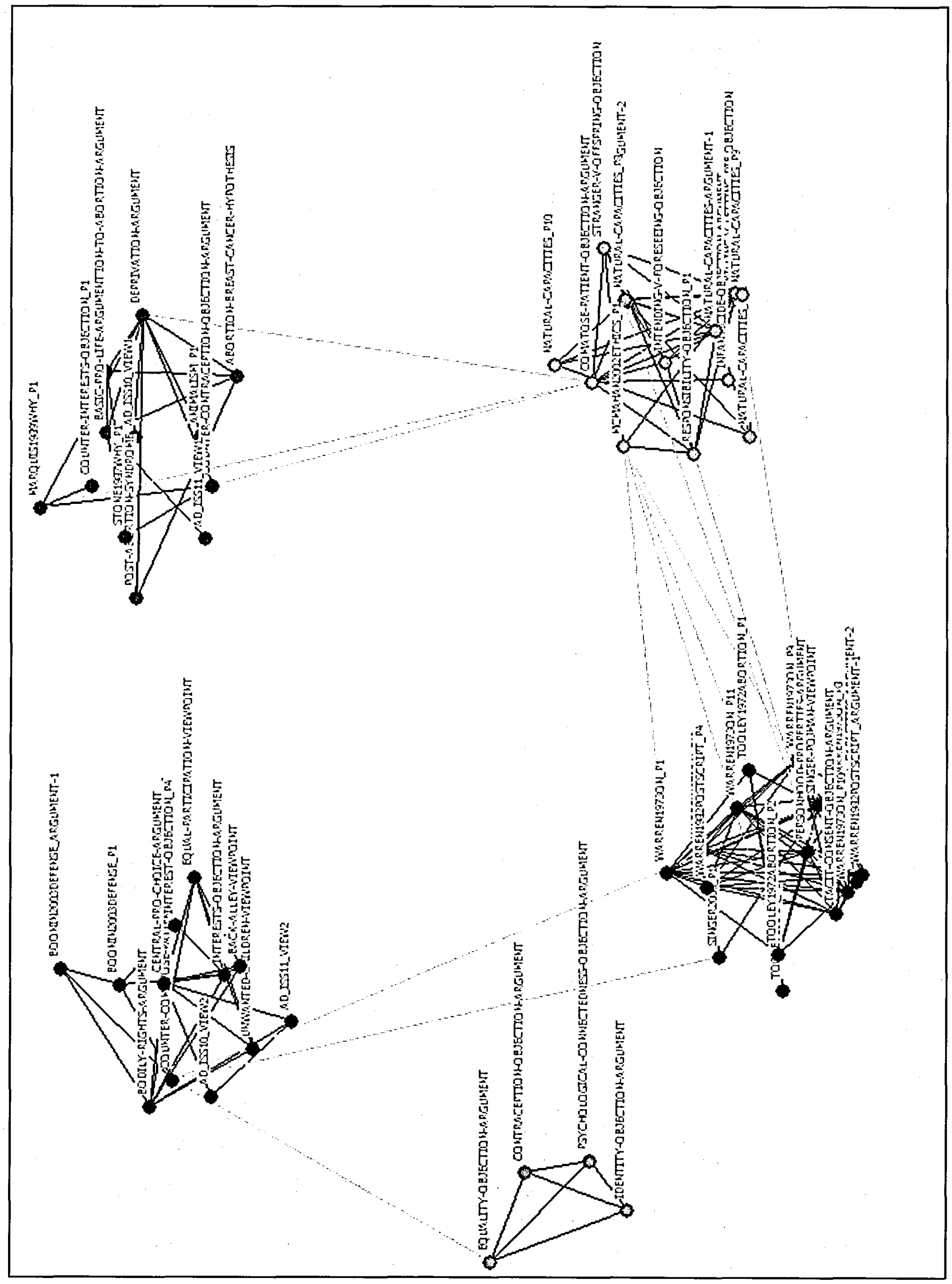

Figure 6-9 - The visualisation of 5 clusters in the one-mode representation of the Abortion Debate: The edges represent +ADDITIVE connections between viewpoints.

6.2.3 Translating the graph-based cluster results into ontology-based ViewpointCluster instances in the knowledge base

At this stage, the clustering results are manually input back into the knowledge base for ontology-based analysis. Each of the 5 clusters detected during the cluster analysis now becomes a *ViewpointCluster* instance in the knowledge base, thereby facilitating the reintroduction of semantics to the debate representation. More specifically, *Person* instances are linked to *ViewpointCluster* instances using the *associatedPerson* attribute. Also, as with the previous case study, the system determines which clusters are opposing each other, using both strong and weak opposition criteria[55] (*Cf.* Chapter 5, §5.2.3). Figure 6-10 shows a sketched visualisation of the five viewpoint-clusters, labelled as *VC1 – VC5*. The dashed lines show the weak opposition relations between the relevant clusters. As in the previous case study, on the opposition lines shown in the figure there appears two numbers that give an indication of the strength of the opposition relation. The numbers are in the form $x(y)$, where y is the total number of nodes in the two opposing clusters and x is the number of nodes in both clusters involved in 'disputes' relations with each other. When the ratio of x to y is greater than 0.5 then the opposition connection is depicted as strong opposition. Otherwise the opposition connection is depicted as weak opposition. In addition, for two of the ViewpointCluster instances *VC3* and *VC4*, the figure shows two of the viewpoints that make up the viewpoint-cluster. These two viewpoints in either cluster address two issues in common – namely *"What should be the legal status of abortions?"* and *"Do a woman's bodily rights justify abortion even if the fetus has a right to life?"*. Finally, the figure shows two associated persons for each of *VC3* and *VC4*.

[55] Recall that the system infers a 'weak' opposition between two *ViewpointCluster* instances if *at least one* viewpoint in one cluster has a 'disputes' relation with at least one viewpoint in the other cluster, while it infers a 'strong' opposition if a *majority* (i.e. more than half) of viewpoints in one cluster have a '*disputes*' relation with the viewpoints in the other cluster.

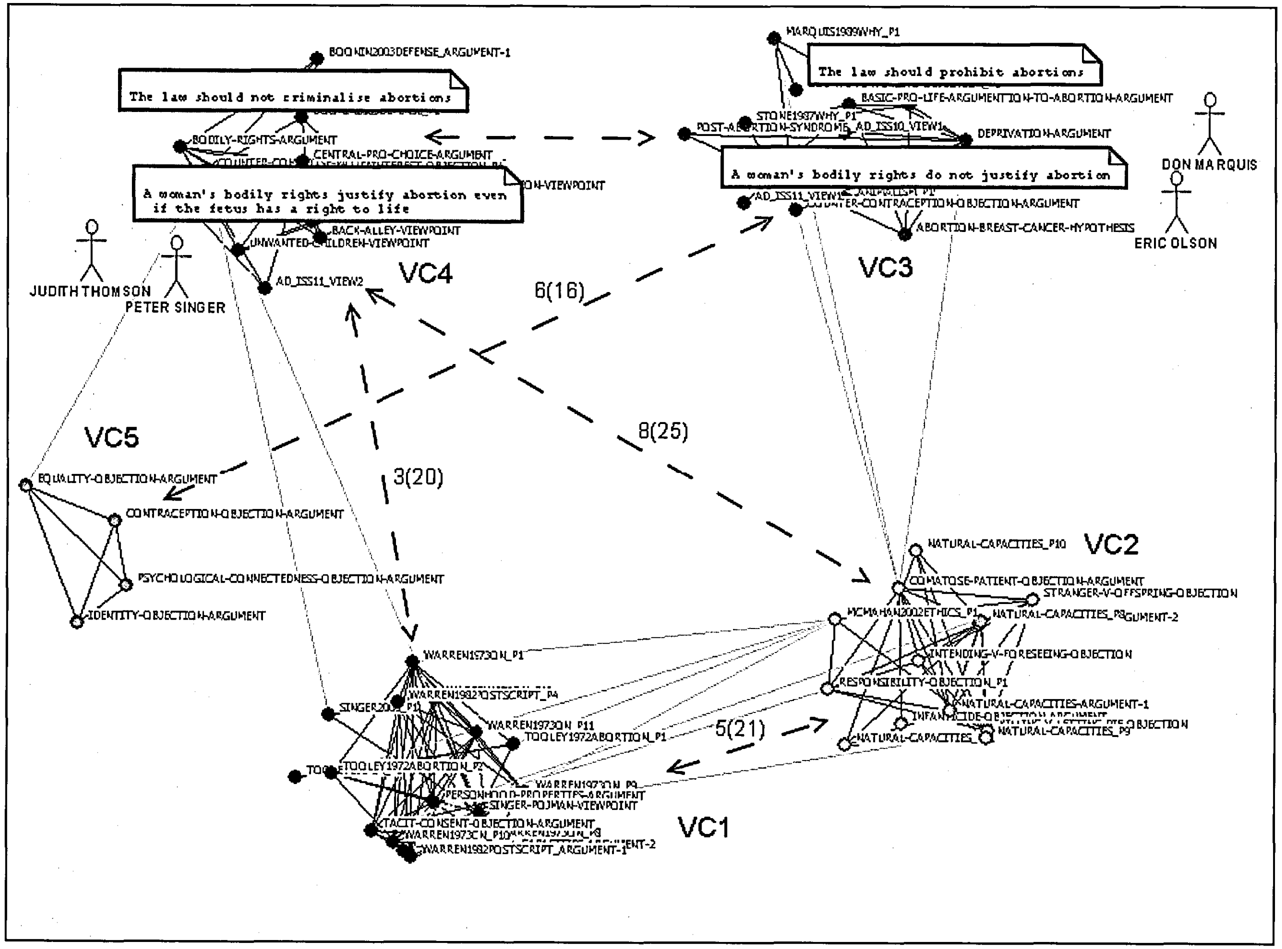

Figure 6-10 – A sketch of the Abortion debate decomposed into 5 ViewpointCluster instances in the knowledge base. The dashed arrows show opposing ViewpointCluster instances. For two ViewpointCluster instances VC3 and VC4, the figure shows two associated viewpoints and two associated persons. As in the previous case study, an indication of the strength of the opposition is given by the numbers x(y), where y is the total number of nodes in the two clusters and x is the number of nodes in both clusters involved in 'disputes' relations with each other.

Table 6-1 shows the details of the 5 *ViewpointCluster* instances in the knowledge. As with the first case study, this table is based on output from a simple query that retrieves the descriptions of each *ViewpointCluster* instance in the knowledge base (*Cf.* Appendix for the OCML expression of this query).

Table 6-1 – The five viewpoint-clusters detected in the Abortion Debate (based on a query to retrieve the descriptions of the ViewpointCluster instances in the knowledge base). In the 'Opposing Cluster(s)' column, the opposition criterion is indicated the word 'Weak' or 'Strong' in parentheses.

VC	Associated Viewpoints	Associated Persons	Opposing Cluster(s)
VC1	COUNTER-NATURAL-CAPACITIES-ARGUMENT-2: *"The argument that the fetus itself will develop complex mental qualities fails"* PERSONHOOD-PROPERTIES-ARGUMENT: *"The fetus is not a person because it has at most one of the properties – consciousness – that characterises a person"* SINGER2000_P1: *"Infanticide is justifiable under certain conditions such as when the infant is severely disabled"* SINGER-POJMAN-VIEWPOINT: *"The fetus lacks rationality and self-consciousness"* TACIT-CONSENT-OBJECTION-ARGUMENT: *"A pregnant woman who has had intercourse voluntarily has tacitly consented to allowing the fetus to use her body so the violinist argument doesn't hold"* TOOLEY1972ABORTION_P1: *"The bearer of a right to life must conceive of itself as a continuing subject of experience and other mental states"* TOOLEY1972ABORTION_P2: *"The fetus lacks a right to life"* TOOLEY1984IN_P1: *"The bearer of a right to life must at some time possess the concept of a continuing self or mental substance"*	BONNIE_STEINBOCK DAVID_BOONIN DEAN_STRETTON JEFF_MCMAHAN LOUIS_POJMAN MARY_ANNE_WARREN MICHAEL_TOOLEY PETER_SINGER	VC2 (Weak) VC4 (Weak)

VC	Associated Viewpoints	Associated Persons	Opposing Cluster(s)
VC2	COMATOSE-PATIENT-OBJECTION-ARGUMENT: *"Personhood criteria are not a justifiable way to determine right to life"* INFANTICIDE-OBJECTION-ARGUMENT: *"Using personhood criteria would permit not only abortion but infanticide"* INTENDING-V-FORESEEING-OBJECTION: *"Abortion intentionally causes the fetus's death whereas unplugging the violinist merely causes death as a foreseen but unintended side-effect"* KILLING-V-LETTING-DIE-OBJECTION: *"Abortion kills the fetus whereas unplugging the violinist merely lets him die"* MCMAHAN2002ETHICS_P1: *"The fetus lacks higher psychological capacities such as autonomy"* NATURAL-CAPACITIES-ARGUMENT-1: *"Human beings could not possibly fail to have a right to life"* NATURAL-CAPACITIES_P10: *"Those whose capacities are more developed would have more of a right to life on the 'developed capacities' view whereas the natural capacities view entails we all have an equal right to life"* NATURAL-CAPACITIES_P11: *"The continuum of developed capacities makes the exact point at which personhood ensues vague whereas there is no such indeterminacy on the 'natural capacities' view"* NATURAL-CAPACITIES-ARGUMENT-2: *"The right to life begins at conception"* NATURAL-CAPACITIES_P8: *"Grounding the right to life in essential natural capacities rather than accidental developed capacities has several advantages"* NATURAL-CAPACITIES_P9: *"The developed capacities view must arbitrarily select some particular degree of development as the cut-off point for the right to life whereas the natural capacities view is non-arbitrary"* RESPONSIBILITY-OBJECTION: *"A pregnant woman who has had intercourse voluntarily has caused the fetus to stand in need of her body"* STRANGER-V-OFFSPRING-OBJECTION: *"The fetus is the pregnant woman's child whereas the violinist is a stranger"*	DON_MARQUIS FRANCIS_BECKWITH GERMAINE_GRISEZ JEFF_MCMAHAN JOHN_FINNIS KATHERINE_ROGERS MASSIMO_REICHLIN PATRICK_LEE ROBERT_GEORGE ROBERT_LARMER STEPHEN_SCHWARZ	VC1 (Weak) VC4 (Weak)

VC	Associated Viewpoints	Associated Persons	Opposing Cluster(s)
VC3	ABORTION-BREAST-CANCER-HYPOTHESIS: *"There is a causal relationship between induced abortion and an increased risk of developing breast cancer"* AD_ISS10_VIEW1: *"The fetus is a person in the moral sense"* AD_ISS11_VIEW1: *"No, a woman's bodily rights do not justify abortion even if the fetus has a right to life"* ANIMALISM-VIEWPOINT: *"People can be said to persist through time insomuch as the living, physical human animal that they most usually call their body, persists."* BASIC-PRO-LIFE-ARGUMENT: *"The law should prohibit abortions"* COUNTER-CONTRACEPTION-OBJECTION-ARGUMENT: *"Neither the sperm, nor the egg, nor any particular sperm-egg combination will ever itself live out a valuable future"* COUNTER-INTERESTS-OBJECTION: *"Why wouldn't the fetus, under ideal conditions, desire to preserve its future?"* DEPRIVATION-ARGUMENT: *"Abortion is wrong because it deprives the fetus of a valuable future"* MARQUIS1989WHY_P1: *"A suicidal teenager takes no interest in his or her future yet killing a suicidal teenager is still wrong"* MORAL-OPPOSITION-TO-ABORTION-ARGUMENT: *"It is wrong to kill a fetus"* POST-ABORTION-SYNDROME-VIEWPOINT: *"Women who have elective abortions can suffer from post-abortion syndrome"* STONE1987WHY_P1: *"The fetus can also have an interest in it's own future without taking an interest in it"*	DON_MARQUIS ERIC_OLSON JIM_STONE	VC4 (Weak) VC5 (Weak)
VC4	AD_ISS10_VIEW2: *"The fetus is not a person in the moral sense"* AD_ISS11_VIEW2: *"A woman's bodily rights justify abortion even if the fetus has a right to life"* BACK-ALLEY-VIEWPOINT: *"Criminalising abortion will lead to the deaths of many women through back-alley abortions"* BODILY-RIGHTS-ARGUMENT: *"Abortion is in some circumstances permissible even if the fetus has a right to life"* BOONIN2003DEFENSE_ARGUMENT-1: *"Alleged disanalogies between the violinist scenario and typical cases of abortion do not hold"* BOONIN2003DEFENSE_P1: *"What is crucial is having a valuable future which one would, under ideal conditions, desire to preserve whether or not one does in fact desire to preserve it"* BASIC-PRO-CHOICE-ARGUMENT: *"The law should not criminalise abortions"* COUNTER-COMATOSE-PATIENT-OBJECTION-ARGUMENT: *"Comatose patients are able to satisfy some of Warren's personhood criteria"* EQUAL-PARTICIPATION-VIEWPOINT: *"Reproductive rights are necessary to achieve the full and equal participation of women in society"* INTERESTS-OBJECTION-ARGUMENT: *"To kill a fetus is not wrong because the fetus has no conscious interest in its future"* INTEREST-OBJECTION_P4: *"One can have an interest in one's future without taking a conscious interest in it"* UNWANTED-CHILDREN-VIEWPOINT: *"Unwanted children have a negative social impact"*	DAVID_BOONIN DEAN_STRETTON JONATHAN_GLOVER JUDITH_THOMSON PETER_SINGER	VC1 (Weak) VC2 (Weak) VC3 (Weak)

VC	Associated Viewpoints	Associated Persons	Opposing Cluster(s)
VC5	CONTRACEPTION-OBJECTION-ARGUMENT: *"The argument that contraception is as wrong as abortion is unsound"* EQUALITY-OBJECTION-ARGUMENT: *"The argument that some killings are more wrong than others leads to unacceptable inequalities"* IDENTITY-OBJECTION-ARGUMENT: *"The fetus does not itself have a future value but has merely the potential to give rise to a different entity, an embodied mind or a person, that would have a future of value"* PSYCHOLOGICAL-CONNECTEDNESS-OBJECTION-ARGUMENT: *"Depriving the fetus of its future does not seriously harm it and hence is not seriously wrong"*	DEAN_STRETTON FREDERICK_DOEPKE GERALD_PASKE JEFF_MCMAHAN LYNNE_BAKER MARY_ANNE_WARREN MICHAEL_TOOLEY PETER_MCINERNEY WILLIAM_HASKER	VC3 (Weak)

6.2.4 Interpreting the results

New insight about the debate

This first point of discussion concerns the new insights about the Abortion debate that the results reveal to a hypothetical user and domain analyst. As with the previous case study, the results appears to have meaningfully assigned arguments and persons to the various *ViewpointCluster* instances, in addition to meaningfully identifying those clusters that are opposing each other. For example, the *Argument* instance `BASIC-PRO-CHOICE-ARGUMENT` has been assigned to one *ViewpointCluster* instance (*VC4*) along with other *Argument* instances that appear genuinely to be in agreement with the basic pro-choice viewpoint in this debate (i.e. *"The law should note criminalise abortions"*). These *Argument* instances include `BODILY-RIGHTS-ARGUMENT` (*"Abortion is in some circumstances permissible even if the fetus has a right to life"*), `EQUAL-PARTICIPATION VIEWPOINT` (*"Reproductive rights are necessary to achieve the full and equal participation of women in society"*), and `INTERESTS-OBJECTION-ARGUMENT` (*"To kill a fetus is not wrong because the fetus has no conscious interest in its future"*). At the same time, the *Argument* instance `BASIC-PRO-LIFE-ARGUMENT` has been assigned to the *ViewpointCluster* instance (*VC3*) along with other *Argument* instances that appear genuinely to be in agreement with the basic pro-life viewpoint in the debate (i.e. *"The law should prohibit abortion"*). These *Argument* instances include `ABORTION-BREAST-CANCER-HYPOTHESIS` (*"There is a causal relationship between induced abortion and an increased risk of developing breast cancer"*), `COUNTER-INTERESTS-OBJECTION` (*"Why wouldn't the fetus, under ideal conditions, desire to preserve its future"*), and `DEPRIVATION-ARGUMENT` (*"Abortion is wrong because it deprives the fetus of a valuable future"*). Furthermore, in line with expectations, the system has also assigned *VC3* and *VC4* as opposing viewpoint-clusters.

Violated expectations

However, as with the previous case study, there are a number of violated expectations in this case study. In particular, there are cases where persons are members of opposing *ViewpointCluster* instances. For example, *Jeff McMahan* is a member of both *ViewpointCluster* instances *VC1* and *VC2* but these two *ViewpointCluster* instances are coded as opposing each other. In order to determine whether this is a reasonable state of affairs, it is necessary to determine the reasoning which has led the system to assign Jeff McMahan to these two viewpoint-clusters. It is also necessary to determine the reasoning which has led the system to assert that the two viewpoint-clusters are opposing each other.

Figure 6-11 shows a visual representation of the relevant class and relation instances. With regard to the first concern about the rationale for assigning *Jeff McMahan* to both *VC1* and *VC2*, *Jeff McMahan* is the author of the *Proposition* instance `COUNTER-NATURAL-CAPACITIES_P4` which is the premise of the *Argument* instance `COUNTER-NATURAL-CAPACITIES-ARGUMENT-2` which in turn has been assigned to *VC1*. *Jeff McMahan* has been assigned to *VC2* because in the system he is represented as the author of *Argument* instances `RESPONSIBILITY-OBJECTION` (*"A pregnant woman who has had intercourse voluntarily has caused the fetus to stand in need of her body"*), `STRANGER-V-OFFSPRING-OBJECTION` (*"The fetus is the pregnant woman's child whereas the violinist is a stranger"*), `KILLING-V-LETTING-DIE-OBJECTION` (*"Abortion kills the fetus whereas unplugging the violinist merely lets him die"*), and `INTENDING-V-FORESEEING-OBJECTION` (*"Abortion intentionally causes the fetus's death, whereas unplugging the violinist merely causes death as a foreseen but unintended side effect."*), which have all been grouped together because of their common dispute of the *Argument* instance `BODILY-RIGHTS-ARGUMENT` (*"Abortion is in some circumstances permissible even if the fetus has a right to life."*). With regard to the reasoning which has led the system to assert that *VC1* and *VC2* are opposing each other, the opposition between *VC1* and *VC2* is a weak opposition connection that is inferred firstly because of the *disputes* relation between COUNTER-NATURAL-CAPACITIES-ARGUMENT-2 (*"The argument that the fetus itself will develop mental qualities fails."*) and NATURAL-CAPACITIES-ARGUMENT-1 (*"Human beings could not possibly fail to have a right to life."*), and then secondly because of the *disputes* relation between NATURAL-CAPACITIES-ARGUMENT-2 (*"The right to life begins at conception."*) and TOOLEY1972ABORTION_P2 (*"The fetus lacks a right to life."*). As indicated on the figure, it appears that the source of the violated expectation is the authorship connection between *Jeff McMahan* and the four *Argument* instances RESPONSIBILITY-OBJECTION, STRANGER-V-OFFSPRING-OBJECTION, KILLING-V-LETTING-DIE-OBJECTION, and INTENDING-V-FORESEEING-OBJECTION. This needs to be explored in more detail.

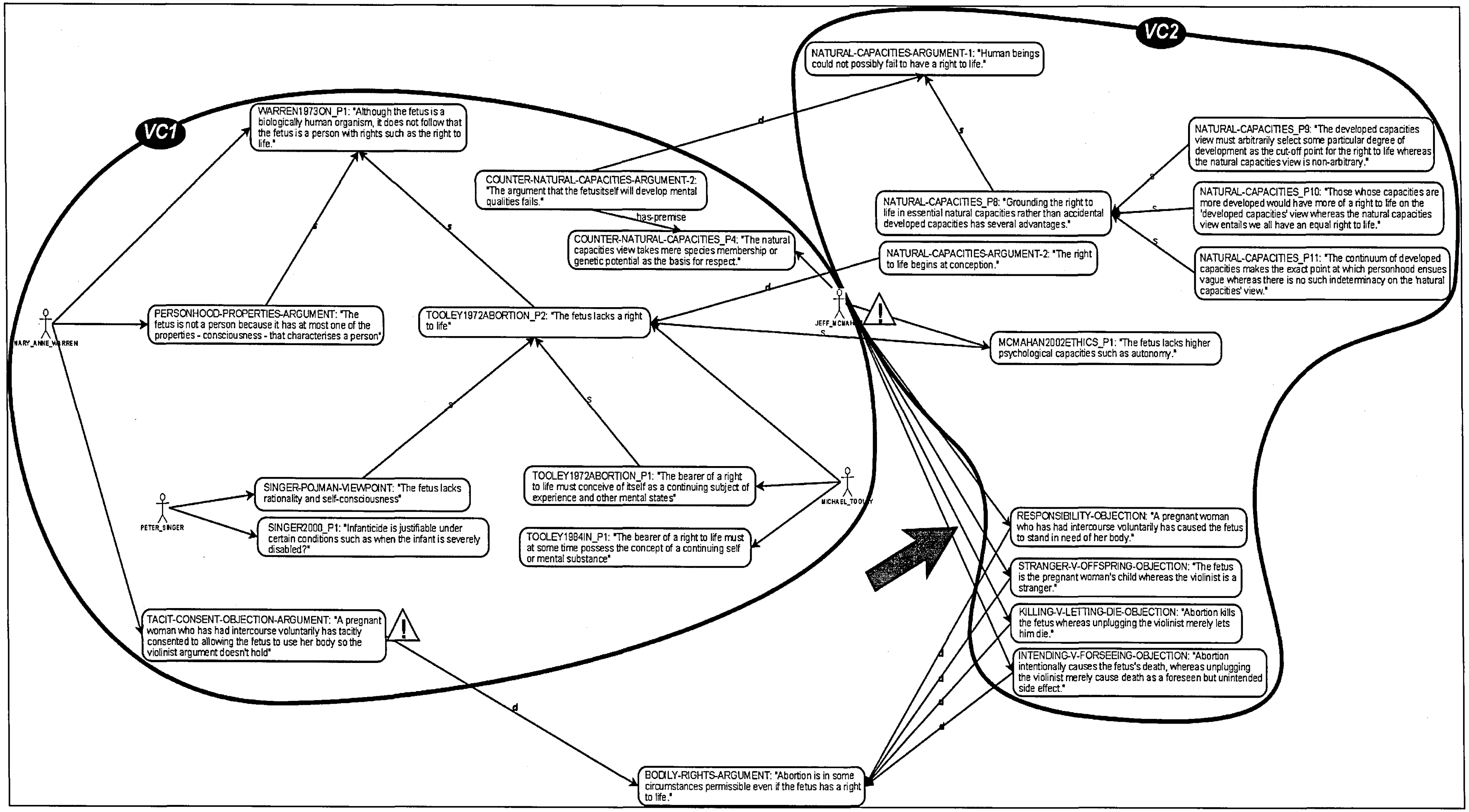

Figure 6-11 - The source of the violated expectation of Jeff McMahan being a member of two ViewpointCluster instances that are opposing each other.

Continuing with the examination of the violated expectation of Jeff McMahan being a member of two opposing *ViewpointCluster* instances, Figure 6-12 shows the relevant section of the article *McMahan (2002)* – specifically the section of the article entitled *"Responsibility for the Fetus's Need for Aid"*. The article reference reveals a misleading presentation in the Wikipedia entry. The *McMahan (2002)* publication is referenced in the Wikipedia entry as if it were a direct source claim of the *Responsibility Objection* (shown in Figure 6-13), and this is subsequently mirrored in the representation in the knowledge base. However, on closer reading of the article reference, the author is merely reporting this viewpoint rather than claiming it outright. Thus, the Responsibility Objection should not have been presented as direct claim of *McMahan (2002)*, and as with the previous case study, this demonstrates a case where the results from the analysis have revealed some new insight about the source material itself.

There is a well-developed literature on the Thomson argument in which at least four seemingly significant failures of analogy have been noted.

1. Whereas the involuntary benefactor is in no way responsible for the fact that she is hooked up to the violinist, a pregnant woman bears some measure of responsibility for the fact that she is connected to the fetus—unless, of course, the pregnancy is a result of rape.
2. Whereas the involuntary benefactor is in no way responsible for the fact that the violinist needs her aid in order to survive, a woman whose pregnancy is the result of her having voluntarily engaged in sexual intercourse does bear some responsibility for the fact that the fetus requires her aid in order to survive.
3. Whereas the involuntary benefactor is not specially related to the violinist in any way, a pregnant woman is the biological parent of the fetus she carries (unless, of course, she is merely the surrogate mother).
4. Whereas the involuntary benefactor would merely be allowing the violinist to die if she were to unhook herself from him, a woman who has an abortion kills the fetus.

Many of Thomson's critics have thought that the first of these four failures of analogy undermines her case for abortion. They have suggested that, when a woman becomes pregnant by voluntarily engaging in sexual intercourse, she thereby gives the fetus a right to the use of her body by tacitly consenting to its being there. I will not pursue this objection. It seems to me manifestly false that a woman consents to support a fetus simply by having sex. Those who do not find this obvious can consult the extensive discussions of the objection in the literature.[76]

9.2. *Responsibility for the Fetus's Need for Aid*

The second failure of analogy is more significant. In cases in which a pregnancy arises as a result of a woman's voluntary behavior—as a direct result of what she *chose* to do—it may seem that she is to some degree *responsible* for the fetus's dependency on her, or for its need for her aid, and that this fact gives her a special moral reason to provide that aid. This objection to the Thomson argument is generally referred to, in the literature, as the *Responsibility Objection*.[77] Thomson in fact considers this objection, arguing in effect that the extent of the pregnant woman's responsibility may be insufficient to give the fetus a right to the use of her body.[78] Even in

Figure 6-12 - An excerpt from McMahan (2002) "The Ethics of Killing": It is apparent that the author is reporting the Responsibility Objection rather than claiming it outright.

The bodily rights argument [edit]

In her well-known article *A Defense of Abortion*, Judith Jarvis Thomson argues that abortion is in some circumstances permissible *even if* the embryo has a right to life. Her central argument involves a thought experiment. Imagine, Thomson says, that you wake up in bed next to a famous violinist. He is unconscious with a fatal kidney ailment; and because only you happen to have the right blood type to help, the Society of Music Lovers has kidnapped you and plugged your circulatory system into his so that your kidneys can filter poisons from his blood as well as your own. If he is disconnected from you now, he will die; but in nine months he will recover and can be safely disconnected. Thomson takes it that you may permissibly unplug yourself from the violinist even though this will kill him. The right to life, Thomson says, does not entail the right to use another person's body, and so in disconnecting the violinist you do not violate his right to life but merely deprive him of something—the use of your body—to which he has no right. Similarly, even if the embryo has a right to life, it does not have a right to use the pregnant woman's body; and so aborting the embryo is permissible in at least some circumstances. However, Thomson notes that the woman's right to abortion does not include the right to directly insist upon the death of the child, should the fetus happen to be viable, that is, capable of surviving outside the womb.[37]

Critics of this argument generally agree that unplugging the violinist is permissible, but claim there are morally relevant disanalogies between the violinist scenario and typical cases of abortion. The most common objection is that the violinist scenario, involving a kidnapping, is analogous only to abortion after rape. In most cases of abortion, it is said, the pregnant woman was *not* raped but had intercourse voluntarily, and thus has either tacitly consented to allowing the embryo to use her body (the **tacit consent** objection[38]), or else has a duty to sustain the embryo because the woman herself caused it to stand in need of her body (the **responsibility** objection[39]). Other common objections turn on the claim that the embryo is the pregnant woman's child whereas the violinist is a stranger (the **stranger versus offspring** objection[40]); that abortion kills the embryo whereas unplugging the violinist merely lets him die (the **killing versus letting die** objection[41]); or, similarly, that abortion intentionally causes the embryo's death whereas unplugging the violinist merely causes death as a foreseen but unintended side-effect (the **intending versus foreseeing** objection;[42] cf the doctrine of double effect).

Defenders of Thomson's argument—most notably David Boonin[43]—reply that the alleged disanalogies between the violinist scenario and typical cases of abortion do not hold, either because the factors that critics appeal to are not genuinely morally relevant, or because those factors are morally relevant but do not apply to abortion in the way that critics have claimed. Critics have in turn responded to Boonin's arguments.[44] Thomson's argument thus remains highly controversial; but arguably it does at least show that the moral impermissibility of abortion does not obviously and necessarily follow from the claim that the embryo has a right to life.

38. ^ eg Warren 1973; Steinbock 1992
39. ^ eg Beckwith 1993; McMahan 2002
40. ^ eg Schwarz 1990; Beckwith 1993; McMahan 2002
41. ^ eg Schwarz 1990; Beckwith 1993; McMahan 2002
42. ^ eg Finnis 1973; Schwarz 1990; Lee 1996; Lee and George 2005
43. ^ Boonin 2003: ch 4
44. ^ eg, Beckwith 2006

Figure 6-13 - The Wikipedia entry's misleading presentation of the 'Responsibility Objection' as a claim attributable to McMahan (2002).

Additional clustering arrangements

As with the previous case study, it is possible to consider other clustering arrangements, in particular those arrangements with few clusters since they provide a means to further abstract from the complexity of the debate. Figure 6-14 shows the debate clustered into just two sides. It should be noted, however, that this arrangement receives the lowest goodness-of-fit score, - as shown in Figure 6-15 - suggesting that clustering the debate into two sides may not be the most appropriate approach to analysing the debate as it may abstract away too much of the complexity of the debate. This corroborates the comment in the Wikipedia entry that the debate is not neatly divided into *pro-life* vs. *pro-choice* sides. In such cases it would be beneficial to provide the analyst with this goodness-of-fit score to alert them that they are viewing a possible oversimplification of the debate.

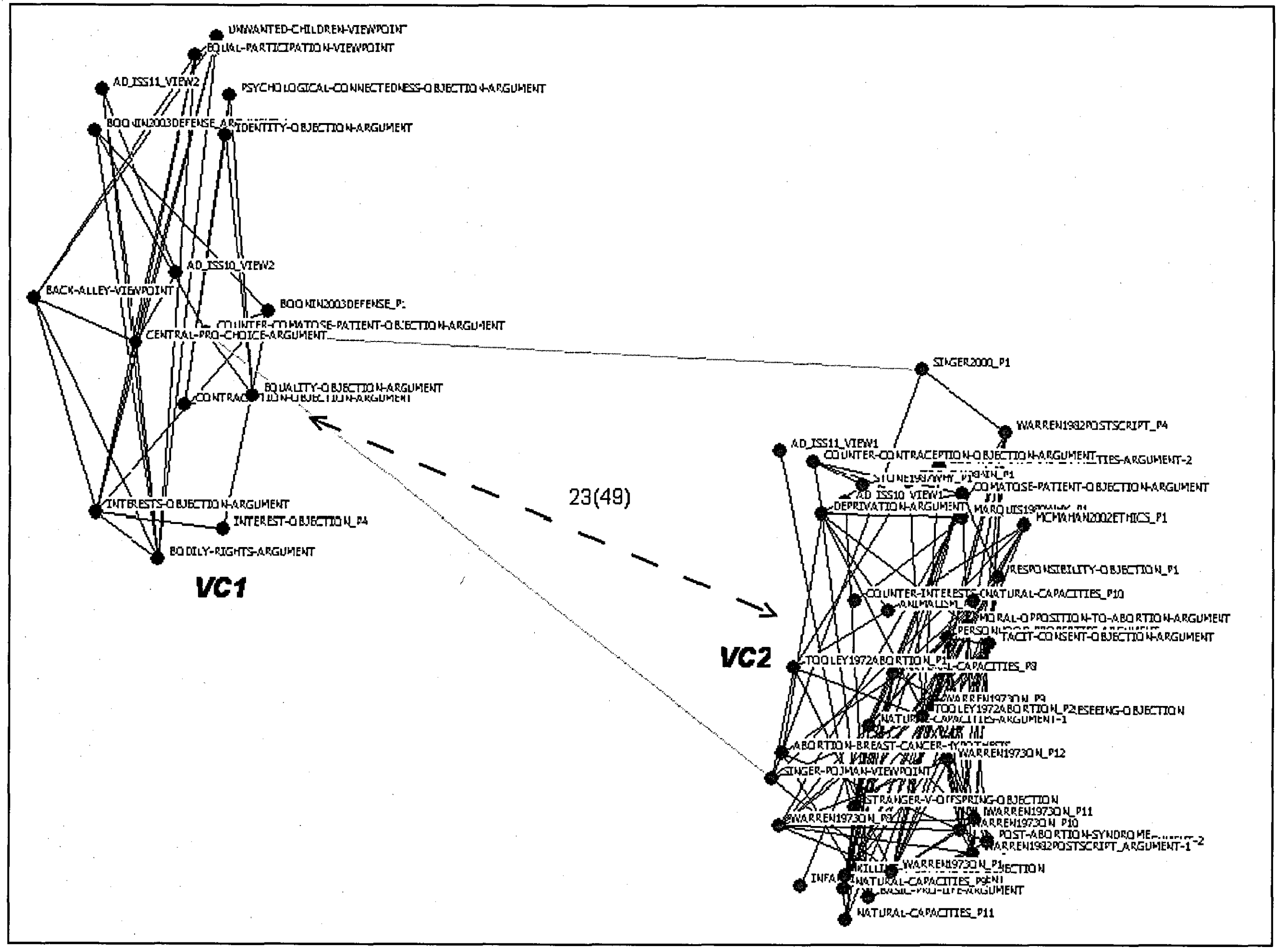

Figure 6-14 – A sketch of the Abortion debate decomposed into 2 ViewpointCluster instances in the knowledge base. It shows the possibility of abstracting two main sides of the debate. As before, the dashed arrow shows the opposition relation between the two ViewpointCluster instances. Also as before, an indication of the strength of the opposition is given by the numbers 23(49), where 49 is the total number of nodes in the two clusters and 23 is the number of nodes in both clusters involved in 'disputes' relations with each other.

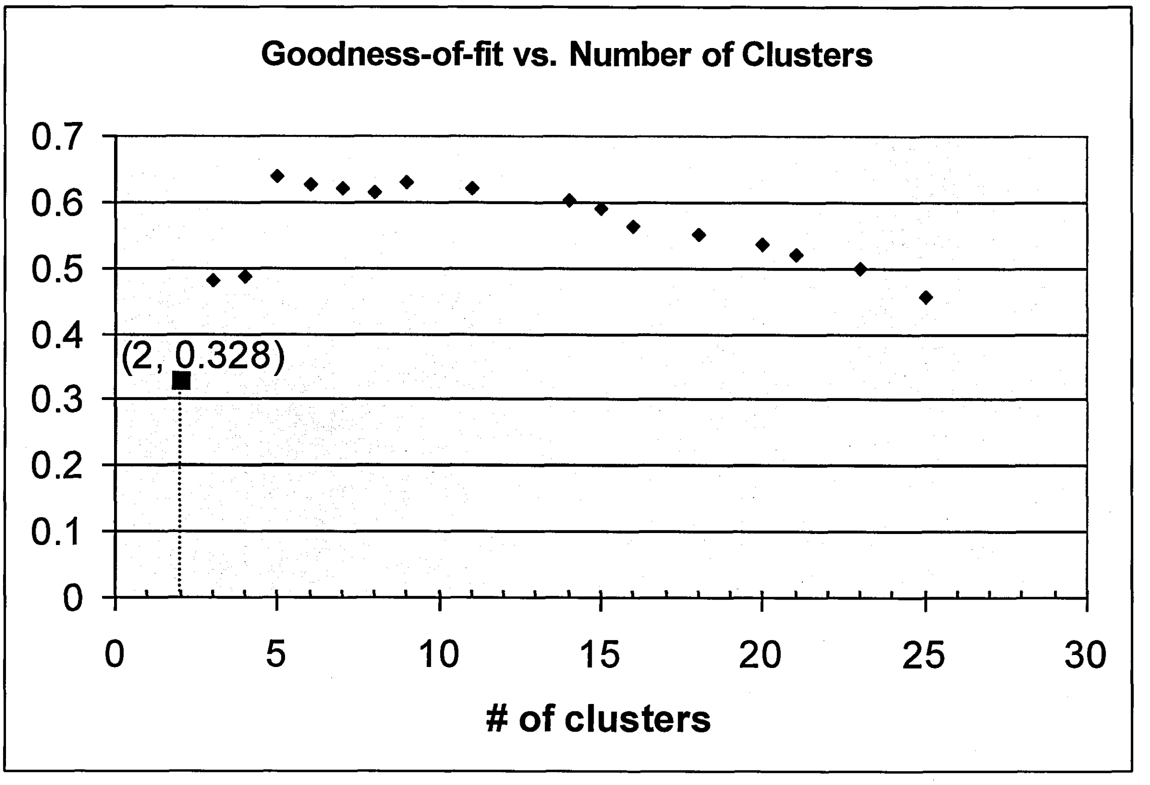

Figure 6-15 - The plot of goodness-of-fit vs. number of clusters for the application of the NG clustering algorithm to the Abortion debate network: The goodness-of-fit value is at a low-point of 0.328 when the data is arranged into 2 clusters.

Chapter Summary

This chapter has shown how the Scholarly Debate Ontology has been applied to representing and reasoning about the Abortion debate as described in the online Wikipedia. As with the first case study a graph-theoretic cluster analysis method – as is typical in Bibliometrics research – has been applied to representations of the debate in order to reveal clusters of viewpoints in the debate.

In light of the case studies, we can now reflect on the strengths and limitations of the hybrid approach to modelling scholarly debate taken in this thesis. The next chapter identifies a number of open issues and challenges for developing this work.

CHAPTER 7 CONCLUSION

The aim of this chapter is to discuss and summarise the key insights that have emerged from the results described in the previous chapters. The focus is on the value added by the hybrid Bibliometrics/Conceptual Modelling approach developed in the thesis, as well as the limitations of, and future challenges for the research.

The chapter begins by discussing the first two case studies from the perspective of a series of evaluative questions. These questions will be used to organise discussion about the added value and the limitations of the approach adopted and demonstrated in the case studies (§7.1). Based on the responses to these evaluative questions, the chapter then focuses on the remaining issues and challenges of the work. These open issues and challenges are presented as the basis of future research (§7.2). The chapter concludes with a point-by-point summary of the research contributions (§7.3)

7.1 Discussion: evaluating the approach and results

The evaluation of the approach is organised using a series of questions adapted from the GlobalArgument.net experiment[56]. These questions were used in that experiment to evaluate various *Computer-Supported Argumentation (CSA)* approaches to modelling the debate about the legitimacy of the second Gulf War – often referred to as the Iraq War. The questions are used in this section to elicit discussion about two main points – firstly, the added value of the hybrid KDA approach (§7.1.1), and secondly, the limitations of this approach (§7.1.2).

7.1.1 In what ways does this combined ontological and graph-theoretical KDA approach add value for the end-user?

The question of 'added value' for a hypothetical end-user is decomposed into two more specific questions: *"How does this approach guide a user through a complex*

[56] http://kmi.open.ac.uk/projects/GlobalArgument.net

knowledge domain?" and *"To what extent is human expertise critical to achieving this added value?"*

How does this approach guide a user through a complex knowledge domain?

The approach described and demonstrated in the previous chapters combines both ontology-based and graph-based analysis as a response to the challenge of designing KDA tools and techniques. Specifically, the aim has been to provide analytical functionality that enables an end-user to gain new insights about a scholarly debate.

This hybrid approach enables a range of analysis, from the typical database-style query (e.g. what are the publications authored by a particular person after a particular year?) to the automatic detection of an important feature of scholarly debates – meaningful clusters of viewpoints. Thus it is argued here that the approach guides a user through a complex knowledge domain by analysing the debate in order to reveal how entities in the domain are grouped together intellectually. Furthermore, it can be argued that the user is able to gain insights that may not have been readily obtained from the raw source material alone.

For example, in the case of the Turing debate maps, a user would not be able to determine that two arguments which address different (but related) issues may form part of the same intellectual grouping in the debate (*Cf.* §5.2.4, where viewpoints across as many as nine different issues are grouped together in the context of the main issue of debate). This added value is also demonstrated in the second case study, where the reader of the *Abortion debate* Wikipedia entry would not be able to determine at a glance what position a particular author takes in relation to the main issue being debated (*Cf.* §6.2.4). And although the visualisations shown in the case studies have not been automatically generated by the system, it is hypothesised that future versions of the system would be able to add further value to the end-user by providing interactive visualisations of the analytical results. This point is discussed in more detail in the 'Future work' section (§7.2) of this chapter, but already promising indications of such interactive tools can be seen with *DebateGraph*[57] and *Cohere*[58].

Furthermore, the approach produced a number of results that not only reveal insights that are hard to obtain from the source material alone, but that also, on further exploration, reveal a number of possible misrepresentations in the source material. For example, in the Turing Debate case study, exploring the apparently anomalous result of *Hilary Putnam* being placed in two opposing viewpoint-clusters reveals that, on Map 1 of the Turing Debate maps, the contents of claim-box *#21* gives the misleading presentation that the so-called 'Record Player argument'[59] is directly attributable to *Hilary Putnam*, the author *of Putnam (1964)*[60]. In reality, the author reports this argument from elsewhere in the literature in order to refute it. Similarly, in the Abortion Debate case study, exploring the violated expectation of *Jeff McMahan* being placed in two opposing viewpoint-clusters revealed that the original Wikipedia entry gives the misleading presentation that the so-called 'Responsibility Objection to the Violinist Analogy'[61] is directly attributable to the author *Jeff McMahan* in his *McMahan (2002)*[62] publication, when, in reality, the author is merely reporting a viewpoint expressed elsewhere in the literature.

To what extent is human expertise critical to achieving this added-value?

This question pertains particularly to the expertise of the *knowledge modeller* – i.e. the person who applies the Scholarly Debate Ontology to representing the instances, in a knowledge base, that correspond to actual elements of the debate in question. As the case studies demonstrate, capturing and coding the various elements of scholarly debate in a knowledge base relies firstly on the ability of the knowledge modeller to interpret the

[57] http://debategraph.org/
[58] http://cohere.open.ac.uk
[59] Recall that the 'record player argument' claims: "A robot 'plays' its behavior in the same way that a phonograph plays a record."
[60] Putnam, H (1964), "Robots: Machines or Artificially Created Life?", Journal of Philosophy 61(21), p. 668-691
[61] Recall that the 'responsibility objection' claims: "A pregnant woman who has had intercourse voluntarily has caused the fetus to stand in need of her body"
[62] McMahan, J. (2002), The Ethics of Killiing. New York: Oxford University Press.

elements of debate described in the source material with respect to the formal vocabulary of the Scholarly Debate Ontology.

Furthermore, s/he should be able to understand elements of the knowledge domain that are relevant (though s/he need not necessarily be a domain expert). This is because the accuracy of the knowledge base relies on the correct instantiation of the classes and relations in the ontology, as well as the correct reconstruction of the details of the argumentation. This latter point is especially important in those instances where either parts of the argument or the inter-argument relations are not directly expressed in the original information source. The knowledge modeller's skill at reconstructing the argument is crucial to the overall process because the factual assertions that are captured in the knowledge base have a direct impact on the new connections that can be made during the inferencing stage, which then has an impact on the features of the debate that can be automatically detected.

Note however, that the roles of knowledge modeller and system user can begin to blur in some circumstances as the knowledge modeller himself can derive similar benefits to that of an ordinary user of the system - i.e. the knowledge modeller can also gain new insights about the structure of the ongoing dialogue in the domain as s/he interprets and instantiates the debate in a knowledge base. For example, in representing *Issue* instances in the Abortion Debate case study the knowledge modeller has to interpret which questions in the source material are rhetorical questions that themselves make a point (*What liberal media?*), which are simple questions of fact (*Are there resources available to aid mothers who are unprepared for parenthood?*), and which are central issues that help to structure the debate (*Is adoption a viable and fair alternative to abortion?*, thus represented in the knowledge base as an *Issue* instance). Also, the knowledge modeller might be able to detect some of the main bodies of opinion or schools of thought in the debate even before the viewpoint cluster analysis is performed. Again, in the Abortion Debate, the knowledge modeller is able to detect that one family of arguments is being offered from within a *Utilitarianism* perspective – i.e. where arguments supporting (or not) the claim for legalised abortion are made on the grounds of measurable risks and benefits.

7.1.2 What are the limitations of the KDA approach?

The question of 'limitations of the KDA approach' is decomposed into two more specific questions: *"What aspects of the knowledge domain proved difficult to model?"* and *"What missing capabilities and open issues have been identified?"*

What aspects of the knowledge domain proved difficult to model?

In both case studies, it proved difficult to elicit, from the source material, a comprehensive representation of the social structure of the domains. Specifically, the source material did not cover such aspects as the organisational affiliations of participants in the debate or their collaborations with each other.

It was also difficult to elicit a comprehensive vocabulary of domain concepts from the source material. Only a few domain concepts were introduced in the material, and when they were, it was difficult without the requisite domain expertise to determine and hence formalise their interrelationships. Furthermore, it was difficult to capture complex details of the domain concepts. In relation to this latter point, the next section on 'Future work' will speculate on how the ontology might be extended to allow the representation of complex domain concepts.

What missing capabilities and open issues have been identified?

While conducting the case studies, a number of issues were encountered, which indicated that perhaps a few capabilities were missing from the approach. These missing capabilities mainly revolve around the Scholarly Debate Ontology. For example, because of the focus on macro-level argumentation, when representing debate in the case studies, there is no ontological capability to account for the different types of rationale for moving from premises to conclusion in individual arguments. For example, some individual arguments used analogical reasoning to move from premises to conclusion. A specific example of analogical reasoning is the *Bodily Rights Argument* in the Abortion Debate, which uses an extended analogy to conclude that "Abortion is in some circumstances permissible even if the fetus has a right to life".

The bodily rights argument [edit]

In her well-known article *A Defense of Abortion*, Judith Jarvis Thomson argues that abortion is in some circumstances permissible *even if* the embryo has a right to life. Her central argument involves a thought experiment. Imagine, Thomson says, that you wake up in bed next to a famous violinist. He is unconscious with a fatal kidney ailment; and because only you happen to have the right blood type to help, the Society of Music Lovers has kidnapped you and plugged your circulatory system into his so that your kidneys can filter poisons from his blood as well as your own. If he is disconnected from you now, he will die; but in nine months he will recover and can be safely disconnected. Thomson takes it that you may permissibly unplug yourself from the violinist even though this will kill him. The right to life, Thomson says, does not entail the right to use another person's body, and so in disconnecting the violinist you do not violate his right to life but merely deprive him of something—the use of your body—to which he has no right. Similarly, even if the embryo has a right to life, it does not have a right to use the pregnant woman's body; and so aborting the embryo is permissible in at least some circumstances. However, Thomson notes that the woman's right to abortion does not include the right to directly insist upon the death of the child, should the fetus happen to be viable, that is, capable of surviving outside the womb.[37]

Figure 7-1 - The extract from the Abortion Debate Wikipedia entry showing the analogical reasoning behind the 'Bodily Rights Argument'.

This is currently represented in the knowledge base as an *Argument* instance, `BODILY-RIGHTS-ARGUMENT`, with *hasPremise* attribute set to four *Proposition* instances `THOMSON1971DEFENSE_P1`, `THOMSON1971DEFENSE_P2`, `THOMSON1971DEFENSE_P3`, and `THOMSON1971DEFENSE_P4`, and the *hasConclusion* attribute set to the *Proposition* instance `THOMSON1971DEFENSE_P5`. This is shown in Listing 7-1. As can be seen, the ontology does not facilitate the representation of analogical reasoning as a type of inference move between premises and conclusion.

```
(def-instance THOMSON1971DEFENSE_P1 Proposition
   ((verbalExpression "If you wake up in bed next to a famous violinist
you may permissibly unplug yourself from the violinist even though this
will kill him")))

(def-instance THOMSON1971DEFENSE_P2 Proposition
   ((verbalExpression "In disconnecting the violinist you do not
violate his right to life but merely deprive him of the use of your
body to which he has no right")))

(def-instance THOMSON1971DEFENSE_P3 Proposition
   ((verbalExpression "The right to life does not entail the right to
use another person's body")))

(def-instance THOMSON1971DEFENSE_P4 Proposition
   ((verbalExpression "Similarly, even if the fetus has a right to
life, it does not have a right to use the pregnant woman's body")))

(def-instance THOMSON1971DEFENSE_P5 Proposition
   ((verbalExpression "Abortion is in some circumstances permissible
even if the fetus has a right to life")))

(def-instance BODILY-RIGHTS-ARGUMENT Argument
   ((hasPremise THOMSON1971DEFENSE_P1
                THOMSON1971DEFENSE_P2
                THOMSON1971DEFENSE_P3
                THOMSON1971DEFENSE_P4)
    (hasConclusion THOMSON1971DEFENSE_P5)))

(def-relation-instances
   (expresses THOMSON1971DEFENSE BODILY-RIGHTS-ARGUMENT))
```

Listing 7-1 - The representation of the analogically reasoned 'Bodily Rights Argument'. The ontology does not facilitate the representation of this special type of inference move between premises and conclusion.

Another missing capability of the ontology in light of the case studies is being able to model complex features of the intellectual groupings in the domains of both case studies. Specifically, the *Position* class in the ontology does not cover some important features of the intellectual groupings encountered during the modelling process in both case studies. These features included being able to model the fact that one intellectual grouping is a 'descendant' of another intellectual grouping. For example, in the Turing debate case study, the source material described a position called *Dreideggereanism* as being *Hubert Dreyfus's* application of *Heiddeggerean* phenomenology to issues in Artificial Intelligence. The next section explores how this representational gap may be filled.

In addition to this, the case studies revealed a further requirement to be able to model complex features of domain concepts. For example, in the Abortion debate case study, the concepts *Foetus* and *Embryo* were encountered have been described as stages in the process of pre-natal mammalian development. Currently it is possible to represent each of these as an instance of *DomainConcept* and connect them via an *associatedConcept* relationship as shown in Listing 7-2. However, it is not possible currently to formalise the temporal relationship between an Embryo and a Foetus. The next section discusses how this missing capability may be addressed.

```
(def-instance EMBRYO DomainConcept
  ((definedBy EMBRYO-DEFINITION)))

(def-instance EMBRYO-DEFINITION Proposition
  ((verbalExpression "An embryo is a multicellular diploid eukaryote in
its earliest stage of development, from the time of first cell division
until birth, hatching, or germination. In humans, it is called an embryo
from the moment of fertilisation until the end of the 8th week of
gestational age, whereafter it is instead called a fetus.")))

(def-instance FETUS DomainConcept
  ((definedBy FETUS-DEFINITION)))

(def-instance FETUS-DEFINITION Proposition
  ((verbalExpression "A fetus is a developing mammal or other viviparous
vertebrate, after the embryonic stage and before birth. In humans, the
fetal stage of prenatal development begins about eight weeks after
fertilization, when the major structures and organ systems have formed,
until birth.")))
```

Listing 7-2 - Current representation of the concepts Embryo and Fetus as instances of the DomainConcept class.

The final missing capability relates to the approach more generally, and highlights the issue of the scalability of the approach. It is clear that to achieve large-scale deployment of KDA technology, the analytical approach on which the technology is based needs to be adaptable to a distributed environment. The next section on 'Future work' will explore in greater detail this issue of how to move from a setting of centralised, single-person knowledge modelling to a distributed, mass modelling environment.

Addressing these missing capabilities and open issues forms the basis of future research in this area, as will be explored in the next section.

7.2 *Future work: open issues and challenges*

This section considers the open issues and challenges that have been raised by the work of this thesis. Firstly, the discussion focuses on how the Scholarly Debate Ontology might be extended with a specification of *argument schemes* in order to address the challenge of representing micro-level argumentation within a macro-level debate representation framework (§7.2.1). Next, the discussion considers the need for a more comprehensive typology of intellectual groupings in knowledge domains in order to address the challenging representational issues encountered during the case studies (§7.2.2). Thirdly, the section discusses the need for the capability to represent *domain ontologies* in order to address the challenge of representing complex features of knowledge-domain concepts (§7.2.3). Finally, the discussion turns to the need for distributed, mass modelling of scholarly source material in order to address the issue of the scalability of the approach demonstrated in the thesis (§7.2.4).

7.2.1 Accounting for argument schemes within the Scholarly Debate Ontology

As previously mentioned, the representational approach does not cover the different types of reasoning that an author can use to infer a conclusion from a set of premises in an argument. One possible solution to this representational challenge is to consider the widely referenced model of the micro-structure of individual arguments offered by Toulmin (1958). Toulmin's model consists of the following components:

- a *Ground* (sometimes referred to as the 'minor premise')
- a *Warrant* (sometimes referred to as the major premise)
- a *Backing* (for the Warrant)
- a *Claim* (which accounts for the main conclusion or assertion)
- a *Modal-Qualifier* (which represents the degree of certainty in the conclusion)

- a *Rebuttal* (directed at the Claim).

Note that Toulmin uses the term *Warrant* to refer to the link between premises and conclusion, and this is what facilitates the inference from *Ground* (premise) to *Claim* (conclusion). Listing 7-3 shows how the ontology might be extended to include the model of argumentation proposed by Toulmin (1958), via the introduction of a *ToulminArgument* class that is defined as a subclass of the *Argument* class. This new class is specified with attributes *hasGround, hasWarrant, warrantBacking, hasClaim, hasModalQualifier,* and *hasRebuttal*, which correspond to the elements of the Toulmin argument model. Also, the specification of the *ToulminArgument* class shows how, using the appropriate language primitives of OCML, the *hasGround and hasClaim* attributes of the *ToulminArgument* class map respectively to the *hasPremise* and *hasConclusion* attributes of the *Argument* class. Finally, the Listing shows how the *Bodily Rights Argument*, previously identified as a representational challenge, can be represented as an instance of the *ToulminArgument* class. The part of the argument which accounts for the analogical step is represented as the value of the *hasWarrant* slot of the BODILY-RIGHTS-ARGUMENT instance.

```
(def-class ToulminArgument (Argument)
"This represents Toulmin's Argument structure which extends the basic
argument structure of premises and conclusion to include warrant,
backing, modal qualifier and rebuttal."
 ((hasGround :type Proposition)
  (hasWarrant :type Proposition)
  (warrantBacking :type Proposition)
  (hasClaim :type Proposition)
  (hasModalQualifier :type Proposition)
  (hasRebuttal :type Proposition))
 :slot-renaming ((hasGround hasPremise)
                 (hasClaim hasConclusion)))

(def-instance BODILY-RIGHTS-ARGUMENT ToulminArgument
   ((hasGround  THOMSON1971DEFENSE_P1
                THOMSON1971DEFENSE_P2)
    (hasWarrant THOMSON1971DEFENSE_P4)
    (warrantBacking THOMSON1971DEFENSE_P3)
    (hasClaim THOMSON1971DEFENSE_P5)))
```

Listing 7-3 - The definition of ToulminArgument class as an example of further argumentation extensions to the ontology.

A more comprehensive solution to the representational challenge may be offered by research into *argument schemes*. In the modern field of argumentation theory, the stereotypical patterns of reasoning from premises to conclusion (i.e. the different types of warrants) are collectively referred to as *argumentation schemes* (Walton, 1996; Walton *et al.*, 2008). Thus, another possible solution to the present limitation is to extend the Scholarly Debate Ontology with an account of argumentation schemes that deals, at the micro-level, with the link between premises and conclusions in individual arguments. In principle, any argumentation scheme could be added to the ontology to improve its ability to deal with micro-level argumentation. For example, Listing 7-4 shows how one well-studied scheme, *Argument from Expert Opinion*, can be formalised in the Scholarly Debate Ontology. Rahwan *et al.* (2007) describe the components of this argumentation scheme as follows:

- *Premise*: Source *E* is an expert in subject domain *S*
- *Premise*: *E* asserts that the proposition *A* in domain *S* is true
- *Conclusion*: *A* may plausibly be taken to be true

Thus, a new class, *ArgumentFromExpertOpinion,* can be introduced in the Scholarly Debate Ontology as a subclass of the *Argument* class. This new class can be specified with attributes *hasExpertSource*, *inSubjectDomain,* and *hasConclusion* corresponding to the components of this argument scheme given in the literature.

```
(def-class ArgumentFromExpertOpinion (Argument)
   ((hasExpertSource :type #_cdns:SocialAgent)
    (inSubjectDomain :type List)
    (hasConclusion :type Proposition)))
```

Listing 7-4 - The definition of micro-level argumentation scheme "Argument from Expert Opinion" as a new class *ArgumentFromExpertOpinion* in the Scholarly Debate Ontology.

Alternatively, in the interest of ontological reuse, the Scholarly Debate Ontology could be mapped to an existing ontology that accounts for micro-level argumentation. One such ontology is the *Argument Interchange Format (AIF)* (Rahwan *et al.*, 2007). These authors propose the AIF ontology as part of the foundation for what they call a *World Wide Argument Web*, where the concern is with a broad range of argumentation genres, rather than just the particular genre of scholarly debate. They use the AIF ontology to demonstrate an open, web-based platform called *ArgDF*[63].

Figure 7-2 shows the main classes and relations in the AIF ontology. There are two disjoint classes in AIF ontology, which correspond to two different node types in an AIF argument network: *Information Nodes (I-Nodes)*, which hold fragments of information or data, and *Scheme Nodes (S-Nodes)*, which represent the "inferential passage" associated with an argumentative statement (Rahwan *et al.*, 2007). An S-Node is said to instantiate or apply a particular scheme. There are three disjoint scheme-types: *rule of inference schemes, conflict schemes,* and *preference schemes*. Consequently, there are three types of S-Nodes: *Rule-of-inference Application nodes (RA-Nodes), Conflict Application nodes (CA-Nodes),* and *Preference Application nodes.* A simple argument in AIF is represented as a set of premises linked to a conclusion via a Rule-of-inference-Application (RA) node, which corresponds to the Warrant in Toulmin's model of argument.

[63] http://www.argdf.org

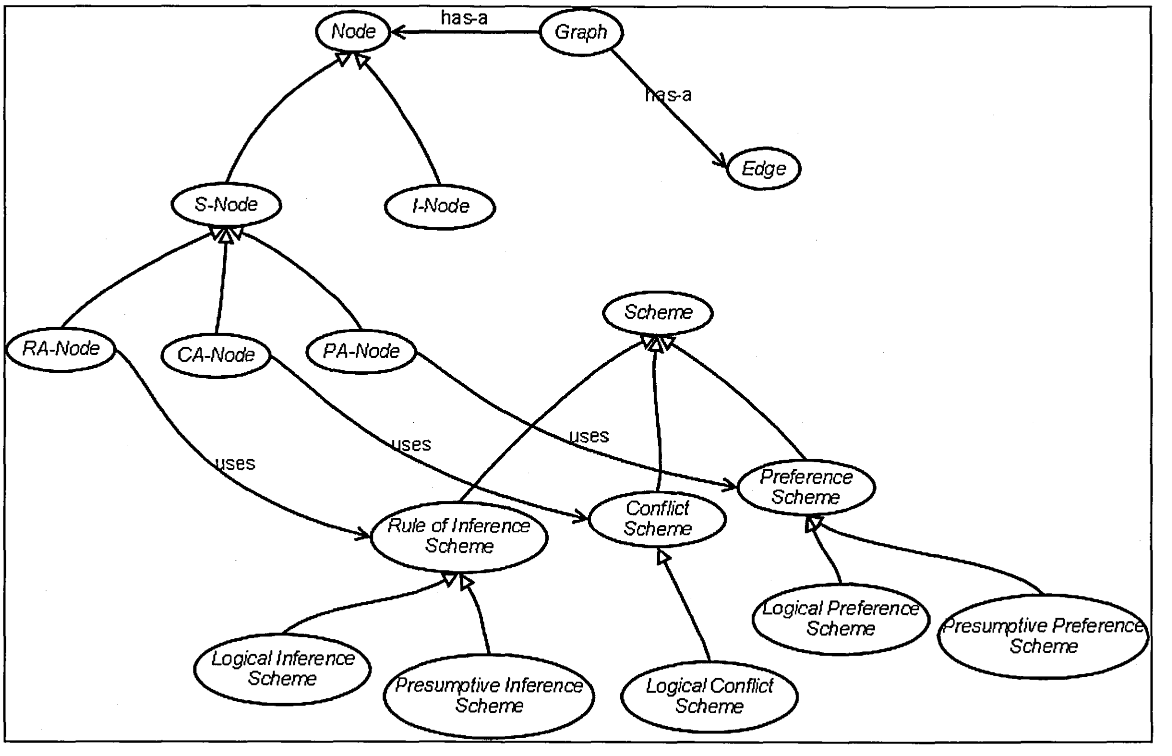

Figure 7-2 - The Argument Interchange Format (AIF) ontology.

Figure 7-3 shows a simple argument network based on the AIF ontology. In Argument A1 (the top box in the figure), the nodes labelled '*p*' and '$p \rightarrow q$' are propositions which play the role of the premises in the argument, while the node labelled '*q*' is a proposition which plays the role of the conclusion in the argument. All three of these nodes are instances of *I-Node* in the AIF ontology. The move from premises to conclusion is made through the application of the *modus ponens*[64] rule of inference, depicted by the node with label '*MP1*', which is an instance of *RA-Node* in the AIF ontology. In Argument A2 (the bottom box in the figure), the nodes labelled '*r*' and '$r \rightarrow \neg p$' are propositions which play the role of the premises in the argument, while the node labelled '$\neg p$' is a proposition which plays the role of the conclusion in the argument. The move from premises to conclusion in Argument A1 is also made through the application of the *modus ponens* rule of inference represented by the node labelled '*MP2*', which is an

[64] 'Modus ponens' is a commonly applied rule of inference in deductive logic. Given a premise which says "If *p* is true, then *q* is true", and given another premise which says "*p* is true", the application of modus ponens allows us to logically conclude that "*q* is true".

instance of *RA-Node* in the AIF ontology. Argument A2 is said to undermine Argument A1 by supporting the negation of the premise in A1. This is depicted as a "symmetrical propositional conflict" with two Conflict-Application Nodes (CA-Nodes) labelled '*neg1*' and '*neg2*'

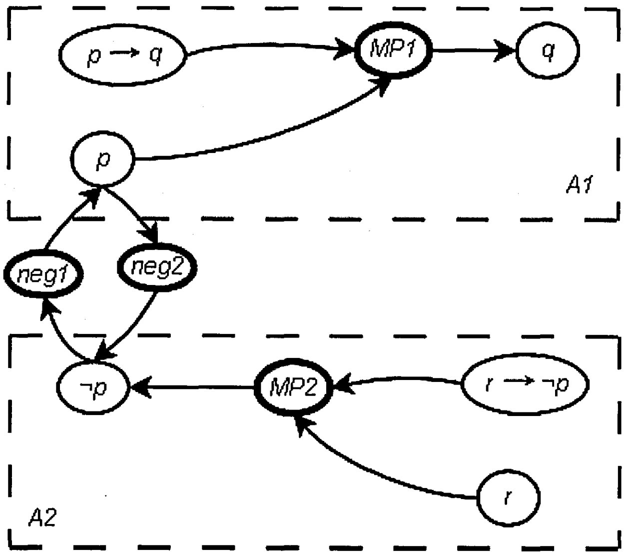

Figure 7-3 - Simple argument network representation using the AIF ontology: This network shows attack between simple arguments (redrawn from Rahwan et al., 2007).

How does the Scholarly Debate Ontology map to the AIF ontology? Propositions in the Scholarly Debate Ontology correspond to I-nodes in the AIF ontology. At present, there is no class in the Scholarly Debate Ontology that maps to the S-Node class in the AIF ontology. However, in order to extend the Scholarly Debate Ontology by reusing the AIF ontology (after translating to an OCML format), the *Argument* class in the Scholarly Debate Ontology may be specified with a new attribute, *hasInferenceMove*, and the value of this attribute can be of type *RA-Node* from the AIF ontology. This is depicted in Listing 7-5.

```
(def-class Argument (PropositionalContent)
  ((hasPremise :type Proposition
               :min-cardinality 1)
   (hasConclusion :type Proposition :max-cardinality 1)
   (hasInferenceMove :type # aif:RA-Node)))
```

Listing 7-5 - The redefinition of the Argument class to allow the representation of the move from premises to conclusion in individual arguments.

7.2.2 Extending the ontological account of intellectual groupings in knowledge domains

Chapter 3 introduced the classes *Position* and *ViewpointCluster* in the Scholarly Debate Ontology. The *Position* class corresponds to what Yoshimi (2004) refers to as families of mutually complementary arguments, and is used to represent such coherent intellectual groupings as have already been identified and named in a given knowledge domain. The *ViewpointCluster* class provides the vocabulary for labelling coherent clusters of arguments that have been automatically detected in a scholarly debate, with the assumption that these *ViewpointCluster* instances correspond to previously unidentified and unnamed coherent intellectual groupings in a knowledge domain. This section describes a preliminary solution to the challenge of being able to model complex features of intellectual groupings. It explores how future work could extend the Scholarly Debate Ontology with a more thorough treatment of intellectual groupings in knowledge domains. In particular, this treatment needs to include a clarification of the relationships among positions, viewpoint-clusters, which are defined in the ontology, and invisible colleges and schools of thought, which are common terms used in the literature related to the topic of coherent groups/collectives in knowledge domains.

'Invisible colleges' have been introduced in Chapter 2 (2.1). They can be regarded as examples of intellectual groupings in knowledge domains. One definition given for invisible colleges is that they are "groups of researchers in frequent communication with one another, where the groups are often considered to share an intellectual perspective concerning their subject area" (Small, 1980). Zuccala (2006) remarks that, although the role of invisible colleges with respect to knowledge growth has fascinated Information Science researchers, there is little agreement about the precise definition of an invisible college. In an effort to provide a definition that accounts for the multifaceted nature of invisible colleges, the author proposes that an invisible college is "a set of interacting scholars or scientists who share similar research interests concerning a subject speciality, who often produce publications relevant to this subject and who communicate both formally and informally with one another to work towards important goals in the subject, even though they may belong to geographically distant research affiliates."

Thus, ontologically speaking it can be said that disciplines contain specialities, which in turn contain invisible colleges. As Zuccala (2006) concludes, "an invisible college can exist within a *subject speciality*, but a subject speciality is not necessarily an invisible college".

As previously discussed, positions in Yoshimi's (2004) logic of debate are defined as a "family of mutually complementary arguments". Positions are intuitively similar to what are commonly referred to as *schools of thought* or simply *schools*. Thus to extend the account of positions in the Scholarly Debate Ontology, it is useful to consider the literature related to the phenomena of schools of thought. Much of the literature is found in the *Sociology of Science* field.

However, because of the typical conflation of meanings of the term 'school of thought' it cannot be regarded as a straight synonym of 'position'. Allen (1997) offers a good example of how the term 'school of thought' is conflated so that it seems intuitively to cover more than the concept 'position'. The author variously refers to a school of thought as:

- A "[cluster] of like-minded researchers and scholars in science", which he then suggests is the same phenomena that sociologists of science are interested in when they say that they are studying invisible colleges.
- A 'body of opinion', which suggests that the cluster phenomenon is no longer just about like-minded researchers but also about the opinions and views that they hold.

- An 'approach to a topic'
- A '[cluster] of related ideas', which can develop "in response to a theoretical perspective which purports to explain certain phenomena."
- A 'general perspective' that can be applied to different, more specific issues, which has similarities with Yoshimi's (2004) 'position', highlighted in Chapter 4, that one possible feature of positions is that they may be the cause of the debate – i.e. when two already articulated belief systems encounter each other in the context of a particular issue then this triggers debate.

Furthermore, Allen (1997), describes a number of features of schools of thought. For example, he suggests that schools of thought are typically associated with opposition to other schools. Also, he suggests that a school of thought can be symbolised by a paper or a particular author.

McLaughlin's (1998) sociological analysis of the collapse of neo-Freudianism as a separate school of psychoanalysis offers a new vocabulary that can be used to extend the conceptualisation of schools of thought in the Scholarly Debate Ontology. Table 7-1 shows extracts of the key terminology McLaughlin uses to describe the neo-Freudian school. These extracts indicate that key features of schools of thought include the fact that they have major and minor members, that they have major and minor tenets, and that they can have factions.

Table 7-1 - Extracts from McLaughlin (1990) that show key terminology used to describe schools of thought in sociology of knowledge literature.

Quote	School of Thought feature
"…I argue that there was a sociological instability inherent in neo-Freudianism deriving from the intellectual orientations…of the major members of the emergent school"	*Major members (and consequently, minor members)*
"The fact that many neo-Freudian ideas were very much in the mainstream of psychoanalytic thought in	*Major tenets (and consequently,*

Quote	School of Thought feature
the 1990s and that major tenets of neo-Freudianism have diffused widely throughout modern culture and contemporary academic social science suggests the need for a sociological analysis"	*minor tenets)*
"There are several reasons why Fromm went to Mexico and stayed for a couple of decades, but one important aspect of his decision was surely a desire to isolate himself from Freudian faction fighting"	*Factions*

Note that, whereas, ontologically speaking, an invisible college requires its members to have some kind of social relationship (e.g. informally-communicates-with), a school of thought does not ontologically require a social dimension – i.e. the interactions can be purely on an epistemic level and what members of a single school of thought share above all else is a set of *issue↔argument* pairings. Nonetheless, it is typical to characterise schools of thought as intellectual groups within a knowledge domain, where members of a group commit to a point of view (Crane, 1972). In terms of containment, a number of invisible colleges can be part of the same school of thought.

All of the above has led to a specification of the *SchoolOfThought* class as a possible enhancement of the *Position* class, and this is shown in Listing 7-6. This specification shows that the *SchoolOfThought* class extends the *Collection* class in the cDnS ontology as described by Gangemi *et al.* (2007). Schools of thought can also play the role of concepts (cf. Allen, 1997) which means that they can 'classify' other entities (particularly descriptions) in the knowledge domain.

```
(def-class SchoolOfThought (#_cdns:Collection)

  ((hasCoreViewpoint :type Proposition)
   (associatedViewpoint :type Proposition)
   (hasCoreMember :type Person)
   (associatedMember :type Person)
   (hasOpposingSchool :type SchoolOfThought)
   (hasParentSchool :type SchoolOfThought)
   (hasFaction :type SchoolOfThought)
   (classifies :type Entity)
   (isSymbolisedBy :type Publication)))
```

Listing 7-6 - The definition of 'SchoolOfThought' as a specialisation of the cdns:Collection class.

7.2.3 Representing 'domain ontologies'

This section considers a third aspect of the representational challenge. The case studies in the previous chapters have focused on modelling argumentative moves in scholarly debate– the "relatively stable dimension[s] of what are otherwise constantly evolving research fields" (Buckingham Shum *et al.*, 1999). This section now explores how to represent, the constantly evolving domain-ontology of the knowledge domain being analysed. In the process, this case study brings with it new modelling problems that were not encountered in the other case studies. The modelling approach used in the previous case studies therefore has to be modified to accommodate modelling of both the stable dimensions and the evolving phenomenon-level[65]. This challenge is seen most clearly in domains with highly specialised concepts (typically scientific domains). This section explores the formal representation of phenomenon-level knowledge.

The representation of *DomainConcept* instances in the case studies amounts to a representation of the *lexicon* of the domain. Hirst (2004) argues that the obvious parallel between the hyponymy/hypernymy relations typical of lexicons and the subsumption relation typical of ontologies suggests that lexicons are very similar to ontologies. Also, since the "meaning" or "sense" of a word pertains in some manner to *categories* in the world itself, it is then an easy step to identify word senses with ontological categories, and lexical relations with ontological relations. However, Hirst cautions that a lexicon gives at best what he refers to as an "ersatz" (or artificial) ontology, since an ontology is not, strictly speaking, a linguistic object, as are lexicons. Hirst does suggest, however, that it is possible for a lexicon to "serve as the basis for a useful ontology, and an ontology may

[65] In the terminology of Haggith (1994) these two dimensions are referred to as the meta-level and the object-level respectively. However, the term *object* has many connotations in the computing field, and so this thesis opts to use the term phenomenon-level instead.

serve as a grounding for a lexicon", especially in particular in technical domains, where vocabulary and ontology are more closely tied than in more general domains.

Smith (2004) makes a similar distinction between lexicons and ontologies – i.e. that lexicons are, strictly speaking, linguistic artefacts, whereas ontologies are not. In his view, the assertions between terms in the Lexicon are assertions about meanings. For example, the assertion "mass-extinction has-narrower-term KT-extinction" is not an assertion about extinctions; rather it is an assertion about language use. It tells us that the meaning associated with KT-extinction is narrower or more specific than the meaning associated with mass-extinction. As Smith explains:

> *"[With terminologies] we are interested not in is_a relations in the strict sense (and not in scientific laws), but rather only in various kinds of relations of 'association' between concepts and in the networks which these form."*

However, for this author, 'real' ontology is concerned with the question of "what entities exist" and he argues that an entity is distinct from a term used *to refer to* that entity. Furthermore, the interplay between an ontological entity and its corresponding lexical entity is not always straightforward. For example, two people can speak and disagree about the claimed existence of Aliens, while agreeing on what the term means, as a lexical entity. Similarly, the term *phlogiston* is still part of the lexicon of science, yet the supposed existence of phlogiston as a chemical element has long ago been disputed.

This section is concerned with whether it is possible to implement additional functionality with more formal representations of the phenomenon-level in the knowledge domain. One possibility is that more formal representations of the phenomenon-level in the domain might enable functionality to be implemented which allows users to test experimental hypotheses and to demonstrate the ramifications of new experimental data with respect to what data has already been published. One tool that is already concerned with such functionality, based on formal, domain-specific, phenomenon-level representation is *NeuroScholar* (Burns *et al.*, 2003). It provides an online environment to help scholars design neurological experiments and keep track of their own experimental results. The following are examples of queries specific to the neuroscience domain that the system aims to support. These queries contain concepts (e.g. 'brain stressors', and 'cell population') that are likely to be irrelevant outside the neuroscientific domain):

- How does the brain discriminate between stressors?
- Can stressors act similarly on the brain?
- How does a single cell population such as the PVH integrate the various signals encoding information about different stressors?

Up until this point, like the approach of Haggith (1994), the modelling strategy in this thesis focussed on producing "abstract representations of the arguments" within the domain. Haggith adopts a meta-level approach because of the difficulties of using a formal object-level knowledge representation "without knowing in advance which inferences will need to be possible" (Haggith, 1994). To show this difficulty, Haggith gives as an example a restricted, horn clause form of first-order predicate calculus used to represent the object-level. The example sentence to be represented is: "When [the ice] becomes water then the level of the sea will rise."

Haggith's account is that: "This could be done as follows, using predicate names to represent relations or processes, with arguments representing objects, reserving the first argument for a crude representation of the temporal nature of the predicate". So the example proposition above might become: *melt(T, ice) -> increase(T, attribute(sea, level))*, where T is a variable representing some instance of time.

Recognition of this difficulty was, in the case studies of Chapter 5 and Chapter 6, part of the motivation for using the more tractable option of what amounts to a lexicon to account for the phenomenon-level knowledge of the research domain. Future work would need to investigate what additional benefits can be obtained by performing the difficult task of producing a formal phenomenon-level knowledge representation. In the case studies, the identification of viewpoint-clusters was solely based on traversing argumentation-level relations. Future research would need to investigate whether, with the use of formal representations at the phenomenon-level, one might be able to automatically identify inconsistencies at the debate-level. This will be of benefit because scholarly work is precisely about competing conceptualisations of how the world is, was, or ought to be.

One example debate in a knowledge domain where the usefulness of such an approach may ideally be tested is the debate in the Palaeontology domain over the cause of the extinction of the dinosaurs at the so-called Cretaceous-Tertiary (KT) boundary, approximately 65 million years ago. There is an interesting database developed by Kiessling and Claeys (2001) called KTbase, that can answer queries about experimental data but it does not allow inconsistent data (such as two distinct paleontological ages for the same object) to be modelled, as would be the case in a domain where this kind of data is regularly the source of debate.

The approach in this future work can draw on the insights from Haggith, where "no attempt is made to create a single knowledge base in which inconsistency is handled, and reasoned *with* in the object-level logic, but rather, the inconsistencies between knowledge bases are reasoned *about* at the meta-level", which provides a level of representation appropriate for an overview of disagreement (Haggith, 1994). In her examples, Haggith (1994) uses plain English text as the object-level knowledge representation, but the claim is that this meta-level approach can then be applied to any system that focuses on representing the object-level (Haggith, 1994).

As an early demonstration of this idea, Listing 7-7 shows a possible specification of part of a Palaeontology-domain-ontology. The concern of a Palaeontology-domain-ontology would not so much be about a theory of the kinds of things that exist but rather about the kinds of things that existed at some point in the past. So, for example, time units would now need to be conceptualised in the millions of years. Such an ontology would allow the representation of phenomenon-level facts in a database of facts such as the aforementioned KTbase.

```
(def-class Geologic-Time-Element ()
  ((has-start-time )
   (has-end-time )
   (part-of :type Geologic-Time-Element))

(def-class Eon (Geologic-Time-Element))

(def-class Era (Geologic-Time-Element)
  ((part-of :type Eon)))

(def-class Period (Geologic-Time-Element)
  ((part-of :type Era)))

(def-class Epoch (Geologic-Time-Element)
  ((part-of :type Period)))
```

Listing 7-7 - Preliminary conceptualisation of the types of time periods in a Palaeontology domain-ontology.

To represent what is referred to in that domain as the "impact hypothesis"[66] would involve representing the Cretaceous and Tertiary periods as elements of time, the impact itself as an event in time, which then is the cause of the mass extinction represented as another event in time. This is shown in Listing 7-8.

```
(def-instance Cretaceous-Period Period
  ((has-start-time 145)
   (has-end-time 65)
   (part-of Mesozoic-Era)))

(def-instance Tertiary-Period Period
  ((has-start-time 65)
   (has-end-time 1.8)
   (part-of Cenozoic-Era)))
```

Listing 7-8 - Preliminary conceptualisation of two time period instances in a possible Palaeontology domain-ontology.

[66] Put most simply, the 'impact hypothesis' claims that an asteroid collision with the Earth at the boundary of the Cretaceous and Tertiary time periods was the cause of the mass extinction of the dinosaurs.

7.2.4 Using distributed, mass modelling of scholarly source material for scalability

As indicated in Chapter 1 (§1.3), this thesis has been concerned with the ontological issues of representing and reasoning about debate in knowledge domains, rather than on issues to do directly with technology deployment – in particular the issue of scalability. Thus for the short-term, pragmatic concerns of both case studies, the modelling was conducted in a centralised, single-person setting, as this enabled rapid prototyping of the proposed approach to knowledge domain analysis. However, in the longer term, decentralised, mass modelling/annotation of scholarly material would be necessary to allow the technology to be widely deployed.

The scenario of distributed, mass annotation is likely to involve individual authors submitting representations of their papers. Indeed, it is not overly ambitious to envisage a future scenario where authors submit a formal representation of their paper along with the actual paper itself, in much the same manner that they currently submit abstracts as meta-descriptions of the paper. However, it is likely that other users of such a system would contribute models of literature where they are not the original authors. Thus distributed annotation itself presents a conceptual challenge – i.e. the challenge of determining how to deal with multiple, possibly contradictory representations of the same source material.

To address this challenge, the Scholarly Debate Ontology needs to account for the scenario where there will be different people performing the modelling, so the system will need to record a timestamp for the modelling, as well as the identity of the modeller and the sources being modelled. This is already accounted for to some extent in the ClaiMaker (Buckingham Shum *et al.*, 2007) and Cohere (Buckingham Shum, 2008) ontologies and tools. The ClaiMaker ontology specifies the attributes *contributedBy*, and *atTime* of the *clm:ScholarlyObject* class, which actually correspond to attributes of the *representation of* a scholarly object rather than attributes of the scholarly object itself. This is fundamental to enabling ClaiMaker to support users in making claims about what they regard as a document's key contributions and relationships to the literature. These claims about a document form a given reader's *interpretation* of the document. ClaiMaker then enables readers to contest their individual interpretations of the same document.

It is clear that in a scholarly discourse there can be competing conceptualisations (descriptions) of the 'real world' AND we can have competing interpretations (descriptions) of a publication that expresses conceptualisations of the 'real world'. ClaiMaker is primarily concerned with the competition between the latter kinds of description, whereas concern of the case studies was to represent the competing conceptualisations of the world, where the competition is carried out within and between published scholarly texts. The strength of the ClaiMaker approach is that it allows multiple interpretations of the same text, whereas, for pragmatic purposes, the approach that was demonstrated in the case study chapters only considered that a text has a single sanctioned representation[67]. The ideal solution is to explicitly represent both but make a clear ontological distinction between them.

The cDnS ontology, with its formal treatment of *situations,* provides a possibly more comprehensive framework for solving this problem. As mentioned previously, one instance of *cdns:Situation* can provide the setting or context for another *cdns:Situation* instance. This means that situations can be layered, with one situation having the other within its scope.

Multiple contradictory representations that would likely result from distributed annotation also has implications for the method used in the case studies to detect viewpoint-clusters. Since the rhetorical motives of individual authors and knowledge modellers are likely to be present in the representations, it is not straightforward to provide an objective, high-level view of how clusters of viewpoints in the entire debate are

[67] Of course there still needs to be awareness that there can never be a completely neutral, interpretation-free representation of a scholarly text. Note: thinking in terms of 'interpretations', the claims made within a publication can be characterised as interpretations that the publication's author makes about the world.

structured. As an alternative, however, the opportunity would then be available to present users with different rhetorical views of the domain based on different annotators' perspectives.

Anderson (2002) presents three categories of literature – *primary, secondary,* and *tertiary.* In his categorisation, primary literature contains new knowledge claims, secondary literature catalogues knowledge for easy retrieval of the primary literature, and tertiary literature synthesises and consolidates the primary literature. Examples of primary literature include the traditional experimental article and the monograph, since these are the typical vehicles for new knowledge claims in a domain. Examples of secondary literature include online bibliographies and library catalogues, since these provide users with ready access to primary literature. Examples of tertiary literature include encyclopaedias, handbooks, and review articles, since these are typical means of synthesising primary research. Based on this categorisation, the source material used in the two case studies – i.e. the Horn debate maps and the *Abortion debate* Wikipedia entry – are examples of tertiary literature, since they, in an encyclopaedic manner, synthesise and consolidate primary literature in the Artificial Intelligence and Bioethics subject domains respectively. The rationale for using tertiary literature in the case studies was to enable the manual coding of the debate, which would have been too vast to code using all the primary literature that was synthesised (e.g. the Turing debate maps synthesise over 400 academic publications). Also, manually coding the tertiary literature is a reasonable approach for this thesis since the immediate concern is with the kinds of analysis that are possible, *given* suitable representations of a scholarly debate. However, this has meant that the debate representations rely on the accuracy of the tertiary-level synthesis of the primary literature. Indeed, what elements of the debate form part of the tertiary-level synthesis may *itself* be a matter of debate (*Cf.* for example, the critical review by Saygin (2004) of Horn's Turing maps).

Though Anderson (2002) correctly indicates that tertiary literature itself is not a neutral synthesis of the primary literature, it is nonetheless a reasonable observation that tertiary literature typically conceals the author's involvement in the debate. Thus the modelling in the previous case studies did not account for the fact that the source material (from which the formal representation is derived) is the interpretation of a particular author (or authors), and in both case studies, the fact that the material has been authored by someone else has been omitted from the formal representation.

This situation would need to be altered if the source material used as a basis for the formal representation were taken directly from the primary literature of the field. This is because a piece of primary literature does not conceal its author's involvement in the debate. Even if sections of an instance of primary literature (e.g. the 'Literature Review' section of the typical journal article) performs the same 'synthesise and consolidate' function as tertiary literature, the primary literature author has a much clearer rhetorical motive in setting out the research landscape as s/he views it. Therefore, one author's rhetorical motive behind the interpretation of *other* authors' work must be taken into consideration when formally representing the argumentation moves in the scholarly debate.

Finally, the technological challenge of distributed annotation consists of developing tools especially for annotation, and which take into account the varied skills-set of different annotators. This means that research and development is needed to make available highly interactive tools to support annotation, where the end-users may not necessarily be expert annotators. Promising research in this direction includes the development of the Cohere tool, which seeks to provide an interactive interface in a Web2.0 context to allow distributed annotation of discourse over the Web (Buckingham Shum, 2008). Promising research on tools for mass annotation is also being conducted in the context of the ESSENCE (eScience/Sensemaking/Climate Change) project[68].

The tools to support distributed, mass annotation are likely to be semi-automated at best. However, there is ongoing research into developing automated tools for summarising academic articles (e.g. Teufel *et al.*, 2006), with the possibility of having these summaries formally represented and aggregated to generate overviews of entire academic domains. In her work, Teufel regards the academic article as "one rhetorical act", with argumentation being an important part of how academic articles are presented, even in fields where overt argumentation is not part of the presentational tradition (Teufel, 1999). Teufel is interested in the role that an author's rhetorical stance to existing literature plays in the argumentation of the article. The tradition of scholarly writing dictates that when an author is expressing a particular stance to another article this is accompanied by a citation to the target article. The assumption underlying Teufel's work is that the author's stance itself is typically expressed in the context surrounding the citation to the target article, and, furthermore, that this stance can be automatically extracted from the citation context. Teufel is particularly focussed on two types of citation context: contrastive and positive. These correspond to disputes and supports in the Scholarly Debate Ontology.

As mentioned above, Teufel's work is about generating single-article summaries, which she envisages can be use for generating an overview of an entire academic field. The author hypothesises that such an overview can take the form of a rhetorical citation map which displays contrastive and supportive links between articles that cite each other. Teufel and Moens (2002) even hypothesise that such rhetorical citation maps can be used by researchers for finding schools of thought in an academic domain. In this regard, the work of Teufel is complementary to the work in this thesis. The distinction between the approach in the thesis and Teufel's approach is that the 'supports' and 'disputes'

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[68] http://events.kmi.open.ac.uk/essence

connections in the debate representations coded in the thesis approach are derived from argumentation analysis of the entire information resource rather than just the immediate context surrounding a citation.

Promising research in this area also includes the recent work by Pang and Lee (2008), referred to as *sentiment analysis*. Sentiment analysis aims to analyse a document in order to automatically determine the attitude of a writer with respect to some topic.

Besides elements of the discourse, annotation tools in a future distributed annotation scenario would also need to facilitate the capture of other important elements of the representation, including the domain-concepts and the community of practice of the knowledge domain. Currently domain-specific concepts are manually entered into the knowledge base. However, a future scenario may be that lexical resources for the field are available in machine-processable form and terms can be automatically extracted from them to populate the knowledge base. With regard to community of practice elements, these can be taken from Web pages about researchers, projects, organisations, etc. With the advancement of the Semantic Web, there is also ongoing research and development into providing semantic RDF representations of communities of practice[69]. Again, a future scenario might involve automatically extracting this kind of knowledge through the mining of unstructured text on researchers' homepages.

7.3 Thesis contributions

The thesis has offered debate analysis as one potentially valuable solution to the challenge of providing technology to support users in understanding the intellectual landscape of any given knowledge domain. More specifically, the thesis has proposed a model of scholarly debate which can be used (e.g.) to identify bodies of opinion (operationalised as 'ViewpointClusters) in the intellectual space of a knowledge domain. It is within this context that this section describes the main contributions of the thesis,

[69] The FOAF initiative is a good example of this

namely a Scholarly Debate Ontology (§7.3.1), a novel approach to knowledge domain analysis that combines ontological and graph-theoretical methods to identify clusters of viewpoints in a debate (§7.3.2), a corpus of scholarly debate representations that account for the application of the ontology and the analytical approach in two case study debates (§7.3.3), and of the foundations for future research (§7.3.4).

7.3.1 A Scholarly Debate Ontology

This thesis has put forward a *Scholarly Debate Ontology* which specifies a formal vocabulary for representing the key elements of dialectical exchange in knowledge domains. This contribution addresses research question *RQ-i: What is a suitable ontology for representing the essential elements of debate in academic knowledge domains?* (*Cf.* §1.2). A suitable Scholarly Debate Ontology is one that characterises the essential elements of debate in knowledge domains such as Issues, Propositions and Arguments, Positions (or Bodies of Opinion), Persons, Publications, and Domain Concepts.

The ontology is inspired by the contribution to the research area of debate mapping by Horn *et al.* (1998), as well as the theory of the structure of debate and macro-argumentation as presented by Yoshimi (2004) in his 'logic of debate'. The ontology has extended the logic of debate by formally specifying additional relations (e.g. *addresses*, *relatedIssueOf*, and *expresses*) that make explicit the nature of the relationship between components of scholarly debate. Also, a new ontological category, *ViewpointCluster*, has also been added, which is used to classify intellectual groupings that have been automatically detected.

Furthermore, by characterising knowledge domains as domains of collective sensemaking, the Scholarly Debate Ontology is implemented in alignment with the upper-level *Constructivist Descriptions and Situations (cDnS) ontology* (Gangemi, 2008). The cDnS ontology provides a generic vocabulary for describing and relating the different dimensions of knowledge domains and has been used here to clarify the design decisions relating to the Scholarly Debate Ontology and to ensure that the essential elements for representing debate in knowledge domains have been specified in the ontology.

The case studies have provided initial evidence that the Scholarly Debate Ontology is expressive enough to represent real debate in knowledge domains and to be used as the basis for analysing these debates for new insights and connections.

7.3.2 A combined ontological and graph-theoretical approach to knowledge domain analysis

The ontological paradigm is about gaining new insights based on the semantics of links, whereas the graph-theoretical paradigm is about gaining new insights based solely on the topology or arrangement of links. The thesis demonstrated how these two paradigms can be bridged to enable the application of graph-based cluster analysis to ontology-based representations of scholarly debate in order to automatically detect viewpoint-clusters in the given knowledge domain. This contribution addresses research question *RQ-ii: How can the two representational approaches (citation-based and ontology-based) be bridged to allow graph-based analytical methods, typically used with great effect in Bibliometrics research, to be reused for detecting interesting and potentially significant 'aggregate structures' in scholarly debates?* (*Cf.* §1.2) Specifically, a number of ontological inference rules were defined that are used to translate the ontology-based representations into a suitable form that allows graph-based methods as applied, for example, in Bibliometrics to be applied.

As previously explained, graph-based cluster analysis relies on a suitable measure of similarity between nodes in the network being analysed. In this work, the similarity relation is defined in terms of rhetorical-coherence, which is adopted from research on the theory of discourse connectedness. Therefore, an important contribution of this work is formalising the *inference rules* needed for reasoning over debate representations in order to generate a representation suitable for graph-theoretic methods to be applied. This requires interpreting the ontological relations – which cover the different dimensions of knowledge domains (e.g. community structure) – from a rhetorical-coherence perspective so as to generate graph-theoretic representation, nodes are interpreted as viewpoints and the links between nodes are interpreted as rhetorical-coherence.

The case studies constitute preliminary evidence of the applicability of this combined ontological and graph-theoretical approach to detecting viewpoint-clusters in knowledge domains. This is a particularly significant contribution in light of the gap analysis in Chapter 2 (§2.3.3) highlighted three important questions that KDA tools need to help users to answer. These questions (about 'macro-level features' of debate in academic knowledge domains) are:

- What is the structure of the ongoing dialogue in the domain?
- What are the controversial issues?
- What are the main bodies of opinion?

The approach described in the thesis tackles the the above questions by demonstrating how the knowledge domain can be structured into clusters of viewpoints about certain issues of debate. These clusters of viewpoints can act as important entry points into a given knowledge domain to help the user engage with the domain.

7.3.3 A corpus of scholarly debate representations

As a result of applying the ontology, the third contribution of this thesis is a knowledge base which contains formal representations of two scholarly debates – the Turing Debate in the Artificial Intelligence domain and the Abortion Debate in the Bioethics domain. These formal representations are based respectively on Horn's *Turing Debate* maps and the online Wikipedia *Abortion Debate* entry, and particularly for the latter, the representations demonstrate the feasibility of producing semantic representations of scholarly material that may be distributed on the Web. This contribution addresses the research question *RQ-iii: How robust is the resulting hybrid approach when applied to scholarly debates in specific knowledge domains?* (*Cf.* §1.2) Specifically, robustness here can be taken as an indication of how well the approach can be applied in different circumstances and how meaningful the obtained results are in these different cases. The two case studies constitute a corpus of scholarly debate representations and a demonstration of the meaningful results that are obtained when the hybrid analytical approach is applied to these representations.

Furthermore, it is here argued that such machine-processable knowledge bases containing formal representations of scholarly debate will contribute to ongoing scholarship in this field, in much the same way as machine-processable text corpora and genome datasets forms a central plank in ongoing computational linguistics and bioinformatics research, respectively.

7.3.4 Foundations for a future research programme

The final contribution is a future research programme to explore the new avenues opened up by the thesis, as summarised in this chapter. The work described in this thesis has already begun to explore the use of semantic representations to support more advanced interaction with the published knowledge of a knowledge domain. Ultimately, future research will need to investigate the impact that KDA technologies, when fully deployed in a working environment, have on scholarly practices. Ultimately, the research question that needs to be investigated is: *Does KDA technology change the way that scholars and analysts work?*

Concluding remarks

This chapter discussed the key implications that have emerged from the case studies previously described. The focus was on the value added by the approach taken in the thesis as well as the limitations of and open issues around the research.

The thesis has presented work which contributes to addressing the long term vision of Knowledge Domain Analysis (KDA) research that aims to provide computational support for understanding the intellectual landscape of any given knowledge domain. The thesis has demonstrated the value of a KDA approach that supports learners, scholars, and analysts in the key task of understanding debate as an important means of engaging with knowledge domains.

APPENDIX A FULL OCML SPECIFICATION OF THE SCHOLARLY DEBATE ONTOLOGY

This Appendix presents the OCML code used to formalise the Scholarly Debate Ontology. The OCML system is implemented as a Lisp system so the ontology code is valid Lisp code.

A.1 'load.lisp'

When specifying an OCML ontology, it is necessary to create a 'load.lisp' that formally defines the ontology, and specifies any other ontologies that are imported.

```
;;; Mode: Lisp; Package: ocml

(in-package "OCML")

(eval-when (eval load)
  (ensure-ontology simple-time-modified domain
"ocml:library;domains;simple-time-modified;load.lisp" ))

(eval-when (eval load)
  (ensure-ontology cDnS domain "ocml:library;domains;cDnS;load.lisp" ))

(def-ontology scholarly-debate-ontology
 :type :domain
 :includes (cDnS
           simple-time-modified)
 :namespace-uri "http://kmi.open.ac.uk/ontologies/scholarly-debate-
ontology#"
 :namespaces (("sdo" scholarly-debate-ontology)
              ("cdns" cdns)
              ("time" simple-time-modified))
 :author "neil"
 :files ("scholarly-debate-ontology"
         "scholarly-debate-ccr-parameterisation"))
```

A.2 'scholarly-debate-ontology.lisp'

The file 'scholarly-debate-ontology.lisp' contains the OCML code that defines the classes and relations in the Scholarly Debate Ontology.

```
;;; -*- Mode : LISP; Syntax: Common-Lisp; Base: 10; Package: OCML -*-

(in-package "OCML")

(in-ontology scholarly-debate-ontology)

(def-class Person ()
"Presently not concerned with any other attribute of a person other
than the person's name"
```

```
   ((display-name :type String)))

;for backwards compatibility just in case all the models haven't been
updated
(def-relation display-name (?p ?n)
   :sufficient (and (or (Person ?p)
                        (Organisation ?p))
                    (display-name ?n)))

(def-relation works-at (?p ?work-place)
"This relation links a person to their place of work."
  :constraint (and (Person ?p)
                   (or (Organisation ?work-place)
                       (Department ?work-place))))


(def-class Organisation ()
"Some administrative or functional structure irrespective of whether or
not this also includes the personnel of the organisation. Currently the
'has-location' attribute of Organisation is just represented as a
string but it would be possible to replace this with a Location concept
that is decomposed into street, city, post code, etc."
   ((display-name :type String)
    (has-location :type String)))

(def-class Publication ()
"This is a piece of published work (with Title), that has been written
by a particular Author (or authors), in a particular Year (note that
type 'Year-in-Time' is taken from the Simple Time ontology authored by
Dynanesh Rajpathak."
   ((has-author :type (or (Organisation)
                          (Person)))
    (has-title :type String)
    (has-year :type Year-in-Time)
    (has-publisher :type Organisation)
    (has-reference-string :type String :documentation "This String is
for display purposes")))

(def-relation co-author (?a1 ?a2)
"This is a relation that links two authors who have written on the same
publication"
   :sufficient (and (has-Author ?pub ?a1)
                    (has-Author ?pub ?a2)
                    (not (= ?a1 ?a2))))

(def-relation cites (?pub1 ?pub2 &optional ?context)
"This is a relation that links ?pub1 to ?pub2 each time that ?pub2 is
mentioned in the text of ?pub1. Optionally the ?context of the citation
- i.e. where it appears in the document - can be included when the
relation is specified."
   :constraint (and (Publication ?pub1)
                    (Publication ?pub2)))

(def-class Proposition () ?x
"A proposition describes some fact in or opinion about the 'real
world'.  This description can be represented by a string of text, using
the 'display-text' attribute.  This string of text is typically written
as a declarative sentence.  'Proposition' here is similar to the
concept of knowledge statement of Burns et al. (2003).  A knowledge
statement according to Burns et al. (2003) is the 'unit of information
from which science operates'."
   ((display-text :type String))
)
  ;:sufficient (Proposition-Collection ?x))
```

```
(def-class Issue ()
"An issue describes some inquiry about something in the 'real world'.
The inquiry can be represented by a string of text using the 'display-
text' attribute. This string of text is typically written in the
interrogative form."
   ((display-text :type String)))



(def-class Argument (Proposition)
"This concept represents classical argument structure of premises and a
statement of conclusion"
  ((has-premise :type Proposition :min-cardinality 1)
   (has-conclusion :type Proposition :max-cardinality 1)))

(def-class Proposition-Collection () ?collection
"This is for the representation of lists of propositions where no
single proposition is the conclusion (cf ScholOnto set). In the case of
publications, those that are Composite Publications (i.e. edited
collections) are not treated in this way."
  ((contains-Proposition :type Proposition))

  :sufficient (or (Argument ?collection)
                  (and (Publication ?collection)
                       (not (Composite-Publication ?collection)))
                  (Position ?collection)))

(def-relation contains-Proposition (?collection ?Proposition)
"This relation links a Proposition Collection to the Propositions it
contains."
  :sufficient (or (and (Argument ?collection)
                       (or (has-premise ?collection ?Proposition)
                           (has-conclusion ?collection ?Proposition)))
                  (and (Publication ?collection)
                       (or (has-claim ?collection ?Proposition)
                           (has-findings ?collection ?Proposition)
                           (has-proposition ?collection ?Proposition)))
                  (and (Position ?collection)
                       (associated-claim ?collection ?Proposition))))

(def-relation addresses (?p ?i)
"This relation links a proposition to the issue that it addresses."
   :constraint (and (Proposition ?p)
                    (Issue ?i))
   :sufficient (or (and (Publication ?p)
                        (contains-proposition ?p ?q)
                        (addresses ?q ?i))
                   (and (has-conclusion ?arg ?p)
                        (addresses ?arg ?i))
                   (and (has-conclusion ?p ?c)
                        (addresses ?c ?i)))
   :avoid-infinite-loop t)

(def-relation supports (?x ?y)
"This is taken from Horn's argumentation mapping approach (he uses 'is-
supported-by'). According to Yoshimi there are three separate concepts
of support: (1) logical (A2 strengthens the conclusion of A1), (2)
historical (A2 is an earlier argument that A1 drawns on), and (3)
specialization (A2 is a more specific version of A1). According to
Yoshimi, support is irreflexive, asymmetric, and non-transitive.
Yoshimi also brings in the notion of intention - i.e. we can only say
that A disputes B if we know that the author of A intends for A to
```

```
dispute B. This is a modelling decision."
   :constraint (and (Proposition ?x)
                    (Proposition ?y))
   :sufficient   (or
                    (and (Argument ?a)
                         (has-conclusion ?a ?y)
                         (has-premise ?a ?x))
                    (and (Argument ?y)
                         (has-premise ?y ?x))))

(def-relation disputes (?x ?y)
"This is taken from Horn's argumentation mapping approach (he uses 'is-
disputed-by'). According to Yoshimi argument A2 disputes argument A1
if: (1) the conclusion of A2 is the negation of some statement in A1
(2) A2 is relevant to A1 (3) the author of A2 intends for A2 to dispute
A1. According to Yoshimi, dispute (like 'support') is irreflexive,
asymmetric, and non-transitive. This relation also covers Thagard's
'contradicts' relation from Principle 5 in the theory of explanatory
coherence. Thagard talks about logically contradiction which includes
'negative evidence' contradicting other observed evidence."
   :constraint (and (Proposition ?x)
                    (Proposition ?y)))


(def-relation claims (?p ?c)
  :constraint (and (Person ?p)
                   (Proposition ?c))
 ; :sufficient (and (has-author ?pub ?p)
 ;                  (has-Proposition ?pub ?c))
)

(def-class DomainConcept ()
"The display-name is how the term is written, and the definition is a
textual description of what the term means."
   ((display-name :type String)
    (text-definition :type String)))

(def-relation anticipates-proposition (?pub ?prop)
"Proposition that author of ?pub anticipates that some other person
might say (usually as counter-argument) [adapted from Horn and
Yoshimi]."
  :constraint (and (Publication ?pub)
                   (Proposition ?prop)))

(def-class Position ()
  ((associated-claim :type Proposition)
   (associated-person :type Person)
   (has-opposing-position :type Position)))
```

A.3 'scholarly-debate-ccr-parameterisation.lisp'

The file 'scholarly-debate-ccr-parameterisation.lisp' contains the OCML definitions of the Cognitive Coherence Relations introduced in Chapter 4. The file also formalizes how the relations in the Scholarly Debate Ontology are parameterised.

```
(in-package "OCML")

(in-ontology scholarly-debate-ontology)
```

```
(def-class CCR-PARAMETER ())
(def-class CCR-BASIC-OPERATION-PARAMETER (CCR-PARAMETER))
(def-class CCR-POLARITY-PARAMETER (CCR-PARAMETER))


(def-class ADDITIVE (CCR-BASIC-OPERATION-PARAMETER))

(def-class CAUSAL (ADDITIVE))

(def-class POSITIVE-POLARITY (CCR-POLARITY-PARAMETER))
(def-class NEGATIVE-POLARITY (CCR-POLARITY-PARAMETER))

(def-relation-instances
      (CAUSAL supports)
      (POSITIVE-POLARITY supports)

      (CAUSAL disputes)
      (NEGATIVE-POLARITY disputes)

      (CAUSAL claims)
      (POSITIVE-POLARITY claims)

      (CAUSAL classifies)
      (POSITIVE-POLARITY claims)

      (ADDITIVE accepts)
      (POSITIVE-POLARITY accepts)

      (ADDITIVE rejects)
      (NEGATIVE-POLARITY rejects)
)

(def-procedure infer-positive-additive-step1 ()
""
 :body (in-environment
         ((?list . (setofall (?b ?c ?con)

                             (or
                                 (and (CAUSAL ?r1)
                                      (POSITIVE-POLARITY ?r1)
                                      (holds ?r1 ?b ?a ?con1)
                                      (CAUSAL ?r2)
                                      (POSITIVE-POLARITY ?r2)
                                      (holds ?r2 ?c ?a ?con2)
                                      (<> ?b ?c)
                                      (= ?con (context-overlap? ?con1
?con2))
                                      (not (null ?con)))
                                 (and (CAUSAL ?r1)
                                      (POSITIVE-POLARITY ?r1)
                                      (holds ?r1 ?b ?a ?con1)
                                      (CAUSAL ?r2)
                                      (POSITIVE-POLARITY ?r2)
                                      (holds ?r2 ?a ?c ?con2)
                                      (<> ?b ?c)
                                      (= ?con (context-overlap? ?con1
?con2))
                                      (not (null ?con))
                                 ))))
         (if (null ?list)
            (output "No inference made.~%")
           (loop for ?pair in ?list do
            (output "Inferring (+ADDITIVE ~a ~a ~a)~%" (first ?pair)
```

```
(second ?pair) (third ?pair))
            (tell (+ADDITIVE (first ?pair) (second ?pair) (third
?pair)))
            (tell (POSITIVE-POLARITY +ADDITIVE))
            (tell (ADDITIVE +ADDITIVE))
            (record-inference '+ADDITIVE ?pair)))))

(def-procedure infer-positive-additive-step2 ()
""
 :body (in-environment
         ((?list . (setofall (?b ?c ?con)


                                  (and (CAUSAL ?r1)
                                       (POSITIVE-POLARITY ?r1)
                                       (holds ?r1 ?a ?b ?con1)
                                       (CAUSAL ?r2)
                                       (POSITIVE-POLARITY ?r2)
                                       (holds ?r2 ?a ?c ?con2)
                                       (<> ?b ?c)
                                       (= ?con (context-overlap? ?con1
?con2))
                                       (not (null ?con)))
                                  )))
         (if (null ?list)
            (output "No inference made.~%")
           (loop for ?pair in ?list do
            (output "Inferring (+ADDITIVE ~a ~a ~a)~%" (first ?pair)
(second ?pair) (third ?pair))
            (tell (+ADDITIVE (first ?pair) (second ?pair) (third
?pair)))
            (tell (POSITIVE-POLARITY +ADDITIVE))
            (tell (ADDITIVE +ADDITIVE))
            (record-inference '+ADDITIVE ?pair)))))


(def-procedure infer-positive-additive-step3 ()
""
 :body (in-environment
         ((?list . (setofall (?b ?c ?con)

                              (or

                                  (and (NEGATIVE-POLARITY ?r1)
                                       (CAUSAL ?r1)
                                       (holds ?r1 ?b ?a ?con1)
                                       (NEGATIVE-POLARITY ?r2)
                                       (holds ?r2 ?c ?a ?con2)
                                       (CAUSAL ?r2)
                                       (<> ?b ?c)
                                       (= ?con (context-overlap? ?con1
?con2))
                                       (not (null ?con)))
                                  (and (NEGATIVE-POLARITY ?r1)
                                       (CAUSAL ?r1)
                                       (holds ?r1 ?b ?a ?con1)
                                       (NEGATIVE-POLARITY ?r2)
                                       (holds ?r2 ?a ?c ?con2)
                                       (CAUSAL ?r2)
                                       (<> ?b ?c)
                                       (= ?con (context-overlap? ?con1
?con2))
                                       (not (null ?con)))))))
         (if (null ?list)
```

```
            (output "No inference made.~%")
           (loop for ?pair in ?list do
            (output "Inferring (+ADDITIVE ~a ~a ~a)~%" (first ?pair)
(second ?pair) (third ?pair))
            (tell (+ADDITIVE (first ?pair) (second ?pair) (third
?pair)))
            (tell (POSITIVE-POLARITY +ADDITIVE))
            (tell (ADDITIVE +ADDITIVE))
            (record-inference '+ADDITIVE ?pair)))))




(def-function list-positive-additive-connections (?p)
   :body
   (setofall ?q (and (POSITIVE-POLARITY ?r)
                     (ADDITIVE ?r)
                     (or (holds ?r ?p ?q ?c)
                         (holds ?r ?q ?p ?c)))))


(def-function list-positive-additive-connections-only-arguments (?p)
   :body
   (setofall ?q (and (POSITIVE-POLARITY ?r)
                     (ADDITIVE ?r)
                     (or (holds ?r ?p ?q ?c)
                         (holds ?r ?q ?p ?c))
                     (Argument ?q))))

(def-function list-positive-additive-connections-only-persons (?p)
   :body
   (setofall ?q (and (POSITIVE-POLARITY ?r)
                     (ADDITIVE ?r)
                     (or (holds ?r ?p ?q ?c)
                         (holds ?r ?q ?p ?c))
                     (Person ?q))))

(def-function list-positive-additive-connections-only-arguments-and-
persons (?p)
   :body
   (setofall ?q (and (POSITIVE-POLARITY ?r)
                     (ADDITIVE ?r)
                     (or (holds ?r ?p ?q ?c)
                         (holds ?r ?q ?p ?c))
                     (or (Argument ?q)
                         (Person ?q)))))

(def-function list-positive-additive-connections-only-arguments-and-
lonely-propositions (?p)
   :body
   (setofall ?q (and (POSITIVE-POLARITY ?r)
                     (ADDITIVE ?r)
                     (or (holds ?r ?p ?q ?c)
                         (holds ?r ?q ?p ?c))
                     (or (Argument ?q)
                         (= t (lonely-proposition-p ?q))))))




(defun name-positions (positions)
  ;for each p in positions
```

```
  (dolist (p positions)
     (setf pos-name (read-from-string (string (gensym "EMPOS"))))
     (add-assertion 'Position (list pos-name)) ;assert new instance
EMPOSn

    ;for each proposition c in p
     (dolist (c p)
       (if (ocml-apply 'proposition-p (list c))
          (add-assertion 'associated-claim (list pos-name c)))
       (setf authors (ocml-apply 'get-claim-authors (list c)))
       (dolist (a authors)
         (add-assertion 'associated-person (list pos-name a))
       )
     )
  )
)

(defun identify-opposing-positions-weak-criteria ()
   (let ((positions (ocml-apply 'list-all-positions nil)))

       (dolist (p positions)
          (setf temp (remove p positions :test #'equal))
          (setf p-claims (ocml-apply 'list-associated-claims (list p)))

          (dolist (q temp)
             (setf q-claims (ocml-apply 'list-associated-claims (list
q)))

             (dolist (c1 p-claims)
                (dolist (c2 q-claims)
                   (if (ocml-apply 'disputing? (list c1 c2))
                      (add-assertion 'has-opposing-position (list p
q)))
                )
             )
          )
       )
   )
)




(defun identify-opposing-positions-strong-criteria ()
   (let ((positions (ocml-apply 'list-all-positions nil))
         (p-in-opposition nil)
         (q-in-opposition nil))

       ;(dolist (p positions)
       (loop until (null positions) do
          (setf p (first positions))
          (setf positions (rest positions))
          ;(setf temp (remove p positions :test #'equal))
          (setf p-claims (ocml-apply 'list-associated-claims (list p)))

          (dolist (q positions)
             (if (not (ocml-apply 'opposing? (list p q)))
               (progn
                 (setf q-claims (ocml-apply 'list-associated-claims
(list q)))

                 (setf p-in-opposition nil)
                 (setf q-in-opposition nil)
```

```
                  (dolist (c1 p-claims)
                    (dolist (c2 q-claims)
                       (if (ocml-apply 'disputing? (list c1 c2))
                          (progn
                             (if (not (member c1 p-in-opposition))
                                (setf p-in-opposition (cons c1 p-in-
opposition)))
                             (if (not (member c2 q-in-opposition))
                                (setf q-in-opposition (cons c2 q-in-
opposition)))
                          )
                       )
                    )
                 )

                 (if (and (not (null p-claims))
                          (not (null q-claims))
                          (> (/ (length p-in-opposition) (length p-
claims)) 0.5)
                          (> (/ (length q-in-opposition) (length q-
claims)) 0.5))
                     (progn (print "making an assertion")
                        (add-assertion 'has-opposing-position (list p
q))
                        (add-assertion 'has-opposing-position (list q
p))
                     )
                  )
                 )
               )
            )
         )
     )
)
```

APPENDIX B FULL OCML SPECIFICATION OF THE TURING DEBATE KNOWLEDGE BASE

This Appendix presents the OCML code used to create the class and relation instances that correspond to representations of the Turing debate.

```
;;; -*- Mode : LISP; Syntax: Common-Lisp; Base: 10; Package: OCML -*-

(in-package "OCML")

(in-ontology scholarly-debate-ontology)



(def-instance TD_ISS1 Issue
  ((verbalExpression "Can Computers Think?")))

(def-instance TD_ISS2 Issue
  ((verbalExpression "Can Computers Have Free Will?")))

(def-instance TD_ISS3 Issue
  ((verbalExpression "Can computers have emotions?")))

(def-instance TD_ISS4 Issue
  ((verbalExpression "Should we pretend that computers will never be
able to think?")))

(def-instance TD_ISS5 Issue
  ((verbalExpression "Does God prohibit computers from thinking?")))

(def-instance TD_ISS6 Issue
  ((verbalExpression "Can computers understand arithmetic?")))

(def-instance TD_ISS7 Issue
  ((verbalExpression "Can computers draw analogies?")))

(def-instance TD_ISS8 Issue
  ((verbalExpression "Is the brain a computer?")))

(def-instance TD_ISS9 Issue
  ((verbalExpression "Are computers inherently disabled?")))

(def-instance TD_ISS10 Issue
  ((verbalExpression "Can computers be creative?")))

(def-instance TD_ISS11 Issue
  ((verbalExpression "Can computers reason scientifically?")))

(def-instance TD_ISS12 Issue
  ((verbalExpression "Can computers be persons?")))


 (def-relation-instances
   (relatedIssueOf TD_ISS2 TD_ISS1)
   (relatedIssueOf TD_ISS3 TD_ISS1)
   (relatedIssueOf TD_ISS4 TD_ISS1)
   (relatedIssueOf TD_ISS5 TD_ISS1)
   (relatedIssueOf TD_ISS6 TD_ISS1)
```

```
    (relatedIssueOf TD_ISS7 TD_ISS1)
    (relatedIssueOf TD_ISS8 TD_ISS1)
    (relatedIssueOf TD_ISS9 TD_ISS1)
    (relatedIssueOf TD_ISS10 TD_ISS1)
    (relatedIssueOf TD_ISS11 TD_ISS1)
    (relatedIssueOf TD_ISS12 TD_ISS1))

;;===============================================================
;;TD_ISS1 "Can Computers Think?"
;;===============================================================

(def-instance TD_P1 Proposition
  ((verbalExpression "Yes, machines can or will be able to think.")))

(def-instance TD_P2 Proposition
  ((verbalExpression "A computational system can possess all
important elements of human thinking or understanding.")))

(def-relation-instances

    (addresses M1_ARG1 TD_ISS1)
    (expresses TURING1950COMPUTING TD_P1)
    (expresses TURING1950COMPUTING TD_P2)
    (expresses TURING1950COMPUTING M1_ARG1))

(def-instance M1_ARG1 Argument
  ((hasPremise TD_P1)
   (hasConclusion TD_P2)))



;;===============================================================
;;TD_ISS2 "Can computers have free will?"
;;===============================================================
(def-instance TD_PERSP2 Proposition
  ((verbalExpression "Computers can't have free will.")))

(def-relation-instances
    (relates-to-concept TD_ISS2 $FREE_WILL)
    (relates-to-concept TD_PERSP2 $FREE_WILL)
    (addresses M1_ARG2 TD_ISS2)
    (disputes M1_ARG2 M1_ARG1))


;;;These two Propositions are not tied to a publication, which is a
deviation from my approach
(def-instance TD_P3 Proposition
  ((verbalExpression "Machines only do what they have been designed
or programmed to do.")))

(def-instance TD_P4 Proposition
  ((verbalExpression "Since free will is necessary for thought, and
machines lack free will, then this implies that computers can't
think")))

(def-instance M1_ARG2 Argument
  ((hasConclusion TD_PERSP2)
   (hasPremise TD_P3 TD_P4))) ;TD_P4 really seems like the conclusion

;;;Again the four Propositions following are not tied to a
publication, which is a deviation from my approach.
(def-instance TD_P5 Proposition
  ((verbalExpression "Humans also lack free will.")))
```

```
(def-instance TD_P6 Proposition
  ((verbalExpression "Whether or not computers have free will is
irrelevant to the issue of whether machines can think.")))

(def-instance TD_P7 Proposition
  ((verbalExpression "People can think and they don't have free
will.")))

(def-instance TD_P8 Proposition
  ((verbalExpression "Since people are just as deterministic as
machines are, and people can think, machines may yet be able to
think.")))

(def-relation-instances
   (disputes M1_ARG3 M1_ARG2))

(def-instance M1_ARG3 Argument
  ((hasConclusion TD_P5)
   (hasPremise TD_P6 TD_P7 TD_P8)))


(def-instance TD_P9 Proposition
  ((verbalExpression "Humans are programmed.")))
(def-instance TD_P10 Proposition
  ((verbalExpression "If you accept determinism, then you accept that
nature has programmed you to behave in certain ways in certain
contexts, even thought that programming is subtler than the
programming a computer receives.")))

(def-relation-instances
   (expresses SMART1964PHILOSOPHERS TD_P9)
   (expresses SMART1964PHILOSOPHERS TD_P10)
   (expresses SMART1964PHILOSOPHERS M1_ARG4)
   (supports M1_ARG4 M1_ARG3))

(def-instance M1_ARG4 Argument
  ((hasConclusion TD_P9)
   (hasPremise TD_P10)))


;;;Two more Propositions that are not tied to a particular
publication
(def-instance TD_P11 Proposition
  ((verbalExpression "Free will is just an illusion of
experience.")))

(def-instance TD_P12 Proposition
  ((verbalExpression "We are determined to do what we do by our
underlying neural machinery.")))

(def-instance TD_P13 Proposition
  ((verbalExpression "According to the modern scientific view, there
is simply no room at all for freedom of the human will.")))

(def-instance TD_P14 Proposition
  ((verbalExpression "Human beings are slaves of brute matter,
compelled to act in particular ways by virtue of biochemical and
neuronal factors, and so what we see is the illusory nature of free
will.")))

(def-relation-instances
   (expresses MINSKY1986SOCIETY TD_P13)
   (expresses SIMONS1985BIOLOGY TD_P14)
   (supports M1_ARG5 M1_ARG3))
```

```
(def-instance M1_ARG5 Argument
  ((hasConclusion TD_P11)
   (hasPremise TD_P12 TD_P13 TD_P14)))


(def-instance TD_P15 Proposition
  ((verbalExpression "Free will results from a multilevel
representation structure.")))
(def-instance TD_P16 Proposition
  ((verbalExpression "The system must have levels for representing
options for action, representing the grounds for deciding which
option to take, and representing a method for deciding which
decision-making process to follow.")))
(def-instance TD_P17 Proposition
  ((verbalExpression "Computers that have been programmed with such
multilevel structures can exhibit free will.")))

(def-relation-instances
   (expresses JOHNSON-LAIRD1988COMPUTER TD_P15)
   (expresses JOHNSON-LAIRD1988COMPUTER TD_P16)
   (expresses JOHNSON-LAIRD1988COMPUTER TD_P17)
   (expresses JOHNSON-LAIRD1988COMPUTER M1_ARG6)
   (disputes M1_ARG6 M1_ARG2))

(def-instance M1_ARG6 Argument
  ((hasConclusion TD_P15)
   (hasPremise TD_P16 TD_P17)))

(def-instance TD_P18 Proposition
  ((verbalExpression "Free will is a decision-making process.")))
(def-instance TD_P19 Proposition
  ((verbalExpression "Free will is a decision-making process
characterized by selection of options, discrimination between
clusters of data, and choice between alternatives.")))
(def-instance TD_P19a Proposition
  ((verbalExpression "Because computers already make such choices,
they posess free will.")))

(def-relation-instances
   (expresses SIMONS1985BIOLOGY TD_P18)
   (expresses SIMONS1985BIOLOGY TD_P19)
   (expresses SIMONS1985BIOLOGY TD_P19a)
   (expresses SIMONS1985BIOLOGY M1_ARG7)
   (disputes M1_ARG7 M1_ARG2))

(def-instance M1_ARG7 Argument
  ((hasConclusion TD_P18)
   (hasPremise TD_P19 TD_P19a)))

(def-instance TD_P20 Proposition
  ((verbalExpression "Conditional jumps constitute free will.")))
(def-instance TD_P21 Proposition
  ((verbalExpression "The ability of a system to perform conditional
jumps when confronted with changing information gives it the
potential to make free decisions.")))
(def-instance TD_P21a Proposition
  ((verbalExpression "For example, a computer may or may not 'jump'
when it interprets the instruction 'proceed to address 9739 if the
contents of register A are less than 10'.")))
(def-instance TD_P21b Proposition
  ((verbalExpression "The decision making that results from this
ability frees the machine from being a more puppet of the
```

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programmer.")))

(def-relation-instances
   (expresses SIMONS1985BIOLOGY TD_P20)
   (expresses SIMONS1985BIOLOGY TD_P21)
   (expresses SIMONS1985BIOLOGY TD_P21a)
   (expresses SIMONS1985BIOLOGY TD_P21b)
   (expresses SIMONS1985BIOLOGY M1_ARG8)
   (supports M1_ARG8 M1_ARG7))

(def-instance M1_ARG8 Argument
  ((hasConclusion TD_P20)
   (hasPremise TD_P21 TD_P21a TD_P21b)))


(def-instance TD_P22 Proposition
  ((verbalExpression "Machines can exhibit free will by way of random
selection.")))
(def-instance TD_P23 Proposition
  ((verbalExpression "Free will can be produced in a machine that
generates random values, for example, by sampling random noise.")))

(def-relation-instances
   (expresses TURING1951CAN TD_P22)
   (expresses TURING1951CAN TD_P23)
   (expresses TURING1951CAN M1_ARG9)
   (disputes M1_ARG9 M1_ARG2))

(def-instance M1_ARG9 Argument
  ((hasConclusion TD_P22)
   (hasPremise TD_P23)))


(def-instance TD_P24 Proposition
  ((verbalExpression "Free will arises from random selection of
alternatives in nil preference situations.")))
(def-instance TD_P25 Proposition
  ((verbalExpression "When an otherwise deterministic system makes a
random choice in a nil preference situation, that system exhibits
free will.
")))

(def-relation-instances
   (expresses COPELAND1993ARTIFICIAL TD_P24)
   (expresses COPELAND1993ARTIFICIAL TD_P25)
   (expresses COPELAND1993ARTIFICIAL M1_ARG10)
   (relates-to-concept TD_P24 $NIL_PREFERENCE_SITUATION)
   (supports M1_ARG10 M1_ARG9))

(def-instance M1_ARG10 Argument
  ((hasConclusion TD_P24)
   (hasPremise TD_P25)))


(def-instance TD_P26 Proposition
  ((verbalExpression "Randomization sacrifies responsibility.")))
(def-instance TD_P27 Proposition
  ((verbalExpression "Machines that make decisions based on random
choices have no responsibility for their actions, because it is then
a matter of chance that they act one way rather than another.")))
(def-instance TD_P28 Proposition
  ((verbalExpression "Because responsibility is necessary for free
will, machines that make decisions based on random choices lack free
will.")))
```

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(def-relation-instances
   (disputes M1_ARG11 M1_ARG9))

(def-instance M1_ARG11 Argument
  ((hasConclusion TD_P26)
   (hasPremise TD_P27 TD_P28)))

(def-instance TD_P29 Proposition
  ((verbalExpression "Free will is necessary for moral
responsibility.")))
(def-instance TD_P30 Proposition
  ((verbalExpression "Randomness and moral responsibility are
incompatible.")))
(def-instance TD_P31 Proposition
  ((verbalExpression "We cannot be responsible for what happens
randomly any more than we can be responsible for what is
predetermined.")))
(def-instance TD_P32 Proposition
  ((verbalExpression "Because any adequate account of moral
responsibility should be grounded in the notion of free will,
randomness cannot adequately characterize free will.")))

(def-relation-instances
   (expresses some-publication-by-ayer-1954 TD_P29)
   (expresses some-publication-by-ayer-1954 TD_P30)
   (expresses some-publication-by-ayer-1954 TD_P31)
   (expresses some-publication-by-ayer-1954 TD_P32)
   (expresses some-publication-by-ayer-1954 M1_ARG12)
   (supports M1_ARG12 M1_ARG11))

(def-instance M1_ARG12 Argument
  ((hasConclusion TD_P29)
   (hasPremise TD_P30 TD_P31 TD_P32)))


(def-instance TD_P33 Proposition
  ((verbalExpression "Random choice and responsibility are
compatible.")))
(def-instance TD_P34 Proposition
  ((verbalExpression "An agent that chooses randomly in a nil
preference situation is still responsible for its actions.")))
(def-instance TD_P35 Proposition
  ((verbalExpression "A gunman can randomly choose to kill 1 of 5
hostages, but he is still responsible for killing the person whom he
picks, because he was responsible for taking the people hostage in
the first place.")))
(def-instance TD_P36 Proposition
  ((verbalExpression "Random choice only revokes responsibility if
the choice is between alternatives of differing ethical value.")))

(def-relation-instances
   (expresses COPELAND1993ARTIFICIAL TD_P33)
   (expresses COPELAND1993ARTIFICIAL TD_P34)
   (expresses COPELAND1993ARTIFICIAL TD_P35)
   (expresses COPELAND1993ARTIFICIAL TD_P36)
   (expresses COPELAND1993ARTIFICIAL M1_ARG13)
   (disputes M1_ARG13 M1_ARG11))

(def-instance M1_ARG13 Argument
  ((hasConclusion TD_P33)
   (hasPremise TD_P34 TD_P35 TD_P36)))

(def-instance TD_P37 Proposition
```

```
  ((verbalExpression "There is the helplessness argument.")))
(def-instance TD_P37a Proposition
  ((verbalExpression "When agents (human or machine) make choices at
random, they lack free will, because their choices are then beyond
their control.")))
(def-instance TD_P38 Proposition
  ((verbalExpression "The agent is at the helpless mercy of these
random eruptions within him which control his behavior.")))

(def-relation-instances
   (expresses some-publication-by-shaffer-1968 TD_P38)
   (disputes M1_ARG14 M1_ARG9))

(def-instance M1_ARG14 Argument
  ((hasConclusion TD_P37)
   (hasPremise TD_P37a TD_P38)))


(def-instance TD_P39 Proposition
  ((verbalExpression "The Turing randomizer is only a tiebreaker.")))
(def-instance TD_P40 Proposition
  ((verbalExpression "The helplessness argument is misleading,
because it implies that random processes control all decision making
- for example, the decision of whether to wait at the curb or jump
out in front of an oncoming truck.")))
(def-instance TD_P41 Proposition
  ((verbalExpression "All the Turing randomizer does is determine
what a machine will do in those situations in which options are
equally preferred.")))

(def-relation-instances
   (expresses COPELAND1993ARTIFICIAL TD_P39)
   (expresses COPELAND1993ARTIFICIAL TD_P40)
   (expresses COPELAND1993ARTIFICIAL TD_P41)
   (expresses COPELAND1993ARTIFICIAL M1_ARG15)
   (disputes M1_ARG15 M1_ARG14))

(def-instance M1_ARG15 Argument
  ((hasConclusion TD_P39)
   (hasPremise TD_P40 TD_P41)))

(def-instance TD_P68 Proposition
  ((verbalExpression "Being a deterministic machine is compatible
with having free will.")))
(def-instance TD_P69 Proposition
  ((verbalExpression "Humans and machines are both deterministic
systems, but this is compatible with their being free.")))
(def-instance TD_P70 Proposition
  ((verbalExpression "Actions caused by an agents beliefs, desires,
inclinations, and so forth are free, because if those factors had
been different, the agent might have acted differently.")))

(def-relation-instances
   (expresses COPELAND1993ARTIFICIAL TD_P68)
   (expresses COPELAND1993ARTIFICIAL TD_P69)
   (expresses COPELAND1993ARTIFICIAL TD_P70)
   (expresses COPELAND1993ARTIFICIAL M1_ARG16)
   (disputes M1_ARG16 M1_ARG2))


(def-instance M1_ARG16 Argument
  ((hasConclusion TD_P68)
   (hasPremise TD_P69 TD_P70)))
```

```
(def-instance TD_P42 Proposition
  ((verbalExpression "Computers only exhibit the free will of their
programmers")))
(def-instance TD_P43 Proposition
  ((verbalExpression "Computers can't have free will because they
cannot act except as they are determined to by their designers and
programmers.")))

(def-relation-instances
   (supports M1_ARG17 M1_ARG2))

(def-instance M1_ARG17 Argument
  ((hasConclusion TD_P42)
   (hasPremise TD_P43)))


(def-instance TD_P44 Proposition
  ((verbalExpression "Some computers can program themselves.")))
(def-instance TD_P45 Proposition
  ((verbalExpression "Programs written by Automatic Programming
systems (APs) are not written by humans, and so computers that run
those programs do not just mirror the free will of humans.")))

(def-relation-instances
   (expresses SIMONS1985BIOLOGY TD_P44)
   (expresses SIMONS1985BIOLOGY TD_P45)
   (expresses SIMONS1985BIOLOGY M1_ARG18)
   (disputes M1_ARG18 M1_ARG17))

(def-instance M1_ARG18 Argument
  ((hasConclusion TD_P44)
   (hasPremise TD_P45)))


(def-instance TD_P46 Proposition
  ((verbalExpression "Preprogrammed robots can't have psychological
states.")))
(def-instance TD_P47 Proposition
  ((verbalExpression "Robots may act as if they have psychological
states, but only because their programmers have psychological states
and have programmed the robots to act accordingly.")))

(def-relation-instances
  (expresses ZIFF1959FEELINGS TD_P46)
  (expresses ZIFF1959FEELINGS TD_P47)
  (expresses ZIFF1959FEELINGS M1_ARG19)
  (supports M1_ARG19 M1_ARG17))

(def-instance M1_ARG19 Argument
  ((hasConclusion TD_P46)
   (hasPremise TD_P47)))


(def-instance TD_P71 Proposition
  ((verbalExpression "Preprogrammed humans have psychological
states.")))
(def-instance TD_P72 Proposition
  ((verbalExpression "If determinism is true, then humans are
programmed by nature and yet have psychological states.")))
(def-instance TD_P73 Proposition
  ((verbalExpression "Thus, if determinism is true, we have a
counterexample to the claim that preprogrammed entities can't have
psychological states.")))
```

```
(def-relation-instances
   (expresses SMART1964PHILOSOPHERS TD_P71)
   (expresses SMART1964PHILOSOPHERS TD_P72)
   (expresses SMART1964PHILOSOPHERS TD_P73)
   (expresses SMART1964PHILOSOPHERS M1_ARG20)
   (disputes M1_ARG20 M1_ARG19)
   (supports M1_ARG20 M1_ARG4))

(def-instance M1_ARG20 Argument
  ((hasConclusion TD_P71)
   (hasPremise TD_P72 TD_P73)))


(def-instance TD_P48 Proposition
  ((verbalExpression "There is the record player argument.")))
(def-instance TD_P48a Proposition
  ((verbalExpression "A robot 'plays' its behavior in the same way
that a phonograph plays a record.")))
(def-instance TD_P48b Proposition
  ((verbalExpression "It is just programmed to behave in certain
ways.")))

(def-relation-instances
   (expresses ZIFF1959FEELINGS TD_P48)
   (expresses ZIFF1959FEELINGS TD_P48a)
   (expresses ZIFF1959FEELINGS TD_P48b)
   (expresses ZIFF1959FEELINGS M1_ARG21))

(def-instance TD_P49 Proposition
  ((verbalExpression "When we laugh at the joke of a robot, we are
really appreciating the wit of a human programmer, and not the wit of
the robot.")))

(def-relation-instances
   (expresses PUTNAM1964ROBOTS TD_P49)
   (supports M1_ARG21 M1_ARG19))

(def-instance M1_ARG21 Argument
  ((hasConclusion TD_P48)
   (hasPremise TD_P48a TD_P48b TD_P49)))

(def-instance TD_P50 Proposition
  ((verbalExpression "There is the 'robot learning' response.")))
(def-instance TD_P50a Proposition
  ((verbalExpression "A robot could be programmed to produce new
behaviors by learning in the same way humans do.")))
(def-instance TD_P51 Proposition
  ((verbalExpression "A program that learned to tell new jokes would
not simply be repeating jokes the programmer had entered into his
memory, but would be inventing jokes in the same way humans do.")))

(def-relation-instances
   (expresses PUTNAM1964ROBOTS TD_P50)
   (expresses PUTNAM1964ROBOTS TD_P50a)
   (expresses PUTNAM1964ROBOTS TD_P51)
   (expresses PUTNAM1964ROBOTS M1_ARG22)
   (disputes M1_ARG22 M1_ARG21))

(def-instance M1_ARG22 Argument
  ((hasConclusion TD_P50)
   (hasPremise TD_P50a TD_P51)))

(def-instance TD_P52 Proposition
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  ((verbalExpression "There is the 'reprogramming' argument.")))
(def-instance TD_P52a Proposition
  ((verbalExpression "Humans can't be reprogrammed in the arbitrary
way that robots can be.")))
(def-instance TD_P53 Proposition
  ((verbalExpression "A robot can be programmed to act tired no
matter what its physical state is, whereas a human normally becomes
tired only after some king of exertion.
")))
(def-instance TD_P54 Proposition
  ((verbalExpression "The actions of the robot depend entirely on the
whims of the programmer, whereas human behavior is self-
determined.")))

(def-relation-instances
   (expresses ZIFF1959FEELINGS TD_P52)
   (expresses ZIFF1959FEELINGS TD_P52a)
   (expresses ZIFF1959FEELINGS TD_P53)
   (expresses ZIFF1959FEELINGS TD_P54)
   (expresses ZIFF1959FEELINGS M1_ARG23)
   (supports M1_ARG23 M1_ARG19))

(def-instance M1_ARG23 Argument
  ((hasConclusion TD_P52)
   (hasPremise TD_P52a TD_P53 TD_P54)))


(def-instance TD_P55 Proposition
  ((verbalExpression "Reprogramming is consistent with free will.")))
(def-instance TD_P56 Proposition
  ((verbalExpression "Humans can be reprogrammed without affecting
their free will.")))
(def-instance TD_P57 Proposition
  ((verbalExpression "A criminal might be reprogrammed into a good
citizen via a brain operation, but he could still make free decisions
(perhaps, for example, deciding to become a criminal once again).")))
(def-instance TD_P58 Proposition
  ((verbalExpression "Robots cannot always be arbitrarily
reprogrammed in the way that the reprogramming Argument suggests.")))
(def-instance TD_P59 Proposition
  ((verbalExpression "If a robot is psychologically isomorphic to a
human, it cannot be arbitrarily reprogrammed.")))
(def-instance TD_P60 Proposition
  ((verbalExpression "Even if robots can be arbitrarily reprogrammed,
this does not exclude them from having free will.")))
(def-instance TD_P61 Proposition
  ((verbalExpression "A robot that has been arbitrarily reprogrammed
may still produce spontaneous and unpredictable behavior.")))

(def-relation-instances
   (expresses PUTNAM1964ROBOTS TD_P55)
   (expresses PUTNAM1964ROBOTS TD_P56)
   (expresses PUTNAM1964ROBOTS TD_P57)
   (expresses PUTNAM1964ROBOTS TD_P58)
   (expresses PUTNAM1964ROBOTS TD_P59)
   (expresses PUTNAM1964ROBOTS TD_P60)
   (expresses PUTNAM1964ROBOTS TD_P61)
   (expresses PUTNAM1964ROBOTS M1_ARG24)
   (disputes M1_ARG24 M1_ARG23))

(def-instance M1_ARG24 Argument
  ((hasConclusion TD_P55)
   (hasPremise TD_P56 TD_P57 TD_P58 TD_P59 TD_P60 TD_P61)))
```

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(def-instance TD_P62 Proposition
  ((verbalExpression "Computers do not choose their own rules.")))
(def-instance TD_P63 Proposition
  ((verbalExpression "Computers lack free will because they are
programmed with rules and follow commands without conscious
choice.")))

(def-relation-instances
   (expresses SOME-PUBLICATION-BY-COHEN-1955 TD_P62)
   (expresses SOME-PUBLICATION-BY-COHEN-1955 TD_P63)
   (expresses SOME-PUBLICATION-BY-COHEN-1955 M1_ARG25)
   (supports M1_ARG25 M1_ARG2))

(def-instance M1_ARG25 Argument
  ((hasConclusion TD_P62)
   (hasPremise TD_P63)))

(def-instance TD_P64 Proposition
  ((verbalExpression "Computers cannot do otherwise.")))
(def-instance TD_P64a Proposition
  ((verbalExpression "An agent's actions are free if the agent can do
otherwise than perform them.")))
(def-instance TD_P64b Proposition
  ((verbalExpression "This means that an agent is free only if it can
change its goals.")))
(def-instance TD_P65 Proposition
  ((verbalExpression "Only dialectical reasoning allows an agent to
change its goals and thereby act freely, and since machines are not
capable of that kind of thinking they are not free.")))


(def-relation-instances
   (expresses SOME-PUBLICATION-BY-RYCHLAK-1991 TD_P64)
   (expresses SOME-PUBLICATION-BY-RYCHLAK-1991 TD_P64a)
   (expresses SOME-PUBLICATION-BY-RYCHLAK-1991 TD_P64b)
   (expresses SOME-PUBLICATION-BY-RYCHLAK-1991 TD_P65)
   (expresses SOME-PUBLICATION-BY-RYCHLAK-1991 M1_ARG26)
   (supports M1_ARG26 M1_ARG2)
   (relates-to-issue TD_P65 TD_ISS13))

(def-instance M1_ARG26 Argument
  ((hasConclusion TD_P64)
   (hasPremise TD_P64a TD_P64b TD_P65)))

(def-instance TD_P66 Proposition
  ((verbalExpression "Free will yields an infinitude that finite
machines can't reproduce.")))
(def-instance TD_P67 Proposition
  ((verbalExpression "Unlike deterministic machines (e.g. Turing
machines), persons can be in an infinite number of states in a finite
period of time, and this capacity allows persons to make decisions
that machines can never make.")))

(def-relation-instances
   (expresses SOME-PUBLICATION-BY-BRINGSJORD-1992 TD_P66)
   (expresses SOME-PUBLICATION-BY-BRINGSJORD-1992 TD_P67)
   (expresses SOME-PUBLICATION-BY-BRINGSJORD-1992 M1_ARG27)
   (supports M1_ARG27 M1_ARG2)
   (relates-to-issue TD_P66 TD_ISS14)
   (relates-to-issue TD_P66 TD_ISS15))

(def-instance M1_ARG27 Argument
  ((hasConclusion TD_P66)
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    (hasPremise TD_P67)))


;;===========================================================
;;TD_ISS3 "Can computers have emotions?"
;;===========================================================

(def-instance TD_PERSP3 Proposition
  ((verbalExpression "Machines can't have emotions.")))
(def-instance TD_P74 Proposition
  ((verbalExpression "Machines can never be in emotional states (they
can never be angry, joyous, fearful, etc.).")))
(def-instance TD_P75 Proposition
  ((verbalExpression "Emotions are necessary for thought, therefore,
computers can't think.")))

(def-relation-instances
   (addresses TD_PERSP3 TD_ISS3)
   (disputes M1_ARG28 M1_ARG1))


(def-instance M1_ARG28 Argument
  ((hasConclusion TD_PERSP3)
   (hasPremise TD_P74 TD_P75)))


(def-instance TD_P76 Proposition
  ((verbalExpression "The concept of feeling only applies to living
organisms.")))
(def-instance TD_P77 Proposition
  ((verbalExpression "Because robots are mechanistic artifacts, not
organisms, they cannot have feelings.")))

(def-relation-instances
   (expresses ZIFF1959FEELINGS TD_P76)
   (expresses ZIFF1959FEELINGS TD_P77)
   (expresses ZIFF1959FEELINGS M1_ARG29)
   (supports M1_ARG29 M1_ARG28))

(def-instance M1_ARG29 Argument
  ((hasConclusion TD_P76)
   (hasPremise TD_P77)))


(def-instance TD_P78 Proposition
  ((verbalExpression "Having feelings does not logically imply being
a living organism.")))
(def-instance TD_P79 Proposition
  ((verbalExpression "Although we haven't yet come across any
nonliving entities with feelings, perhaps in the future we will.")))
(def-instance TD_P80 Proposition
  ((verbalExpression "There is no logical contradiction in the idea
of a nonliving being that has feelings.")))

(def-relation-instances
   (expresses SOME-PUBLICATION-BY-J-J-C-SMART-1964 TD_P78)
   (expresses SOME-PUBLICATION-BY-J-J-C-SMART-1964 TD_P79)
   (expresses SOME-PUBLICATION-BY-J-J-C-SMART-1964 TD_P80)
   (expresses SOME-PUBLICATION-BY-J-J-C-SMART-1964 M1_ARG30)
   (disputes M1_ARG30 M1_ARG29))

(def-instance M1_ARG30 Argument
  ((hasConclusion TD_P78)
   (hasPremise TD_P79 TD_P80)))
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(def-instance TD_P81 Proposition
  ((verbalExpression "We can imagine artifacts that have
feelings.")))
(def-instance TD_P82 Proposition
  ((verbalExpression "Several cases show that artifacts could have
feelings.")))
(def-instance TD_P83 Proposition
  ((verbalExpression "(1) If the biblical account of creation in
Genesis were true, then humans would be both living creatures and
artifacts created by God.")))
(def-instance TD_P84 Proposition
  ((verbalExpression "(2) We could imagine self-replicating
mechanisms whose offspring would manifest small random alterations,
allowing them to evolve.")))
(def-instance TD_P85 Proposition
  ((verbalExpression "Such mechanisms might be considered living and
at the same time artifacts.")))

(def-relation-instances
   (expresses SOME-PUBLICATION-BY-J-J-C-SMART-1964 TD_P81)
   (expresses SOME-PUBLICATION-BY-J-J-C-SMART-1964 TD_P82)
   (expresses SOME-PUBLICATION-BY-J-J-C-SMART-1964 TD_P83)
   (expresses SOME-PUBLICATION-BY-J-J-C-SMART-1964 TD_P84)
   (expresses SOME-PUBLICATION-BY-J-J-C-SMART-1964 TD_P85)
   (expresses SOME-PUBLICATION-BY-J-J-C-SMART-1964 M1_ARG31)
   (disputes M1_ARG31 M1_ARG29))

(def-instance M1_ARG31 Argument
  ((hasConclusion TD_P81)
   (hasPremise TD_P82 TD_P83 TD_P84 TD_P85)))


(def-instance TD_P86 Proposition
  ((verbalExpression "'Alive' is not definitionally based on
structure.")))
(def-instance TD_P87 Proposition
  ((verbalExpression "Because the definition of 'alive' is not based
on structure, it allows for nonhuman robot physiologies.")))
(def-instance TD_P88 Proposition
  ((verbalExpression "Robots made up of cogs and transistors instead
of neurons and blood vessels might have feelings because they might
actually be alive.")))

(def-relation-instances
   (expresses PUTNAM1964ROBOTS TD_P86)
   (expresses PUTNAM1964ROBOTS TD_P87)
   (expresses PUTNAM1964ROBOTS TD_P88)
   (expresses PUTNAM1964ROBOTS M1_ARG32)
   (disputes M1_ARG32 M1_ARG29))

(def-instance M1_ARG32 Argument
  ((hasConclusion TD_P86)
   (hasPremise TD_P87 TD_P88)))


(def-instance TD_P89 Proposition
  ((verbalExpression "Machines lack the physiological components of
emotion.")))
(def-instance TD_P90 Proposition
  ((verbalExpression "Machines lack the human physiology that is
essential to emotions, for example, the ability to secrete hormones
and neuroregulators.")))
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(def-instance TD_P91 Proposition
  ((verbalExpression "Because machines can't reproduce such a
physiology through abstract computational processes, they can't
possess emotions.")))

(def-relation-instances
   (expresses some-publication-by-rey-1980 TD_P89)
   (expresses some-publication-by-rey-1980 TD_P90)
   (expresses some-publication-by-rey-1980 TD_P91)
   (expresses some-publication-by-rey-1980 M1_ARG33)
   (supports M1_ARG33 M1_ARG28))

(def-instance M1_ARG33 Argument
  ((hasConclusion TD_P89)
   (hasPremise TD_P90 TD_P91)))



(def-instance TD_P92 Proposition
  ((verbalExpression "Physiology is not essential to emotion.")))
(def-instance TD_P93 Proposition
  ((verbalExpression "Human emotion can be implemented on a computer
because the relevant features can be modeled (the emotion's
interaction with cognitive states, motivations, etc.).")))
(def-instance TD_P94 Proposition
  ((verbalExpression "The physiological aspects of emotion (which
include biochemistry, behavior, and proprioception) are evolutionary
remnants; they are not essential.")))

(def-relation-instances
   (expresses SOME-PUBLICATION-BY-SLOMAN-1987 TD_P92)
   (expresses SOME-PUBLICATION-BY-SLOMAN-1987 TD_P93)
   (expresses SOME-PUBLICATION-BY-SLOMAN-1987 TD_P94)
   (expresses SOME-PUBLICATION-BY-SLOMAN-1987 M1_ARG34)
   (disputes M1_ARG34 M1_ARG33))

(def-instance M1_ARG34 Argument
  ((hasConclusion TD_P92)
   (hasPremise TD_P93 TD_P94)))


(def-instance TD_P95 Proposition
  ((verbalExpression "Machines can't think dialectically, and
dialectical thinking is necessary for emotions.")))
(def-instance TD_P96 Proposition
  ((verbalExpression "Emotions are experienced in complicated
dialectical circumstances, which require the ability to make
judgments about others and gauge oppositions.")))
(def-instance TD_P97 Proposition
  ((verbalExpression "Machines can't reason in that way, so machines
can't experience emotions.")))

(def-relation-instances
   (expresses SOME-PUBLICATION-BY-RYCHLAK-1991 TD_P95)
   (expresses SOME-PUBLICATION-BY-RYCHLAK-1991 TD_P96)
   (expresses SOME-PUBLICATION-BY-RYCHLAK-1991 TD_P97)
   (expresses SOME-PUBLICATION-BY-RYCHLAK-1991 M1_ARG35)
   (supports M1_ARG35 M1_ARG28))

(def-instance M1_ARG35 Argument
  ((hasConclusion TD_P95)
   (hasPremise TD_P96 TD_P97)))
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(def-instance TD_P98 Proposition
  ((verbalExpression "Emotions are necessary for thought.")))
(def-instance TD_P99 Proposition
  ((verbalExpression "Only systems that can be in emotional states
can be said to think.")))

(def-relation-instances
   (supports M1_ARG36 M1_ARG28))

(def-instance M1_ARG36 Argument
  ((hasConclusion TD_P98)
   (hasPremise TD_P99)))


(def-instance TD_P100 Proposition
  ((verbalExpression "Emotional experience is necessary for
thought.")))
(def-instance TD_P101 Proposition
  ((verbalExpression "The only entities that can possess human
abilities are entities that can act on the basis of felt
emotions.")))
(def-instance TD_P102 Proposition
  ((verbalExpression "No mechanism can feel anything, therefore,
machines can't possess human abilities, in particular, the ability to
think.")))

(def-relation-instances
   (expresses SOME-PUBLICATION-BY-JEFFERSON-1949 TD_P100)
   (expresses SOME-PUBLICATION-BY-JEFFERSON-1949 TD_P101)
   (expresses SOME-PUBLICATION-BY-JEFFERSON-1949 TD_P102)
   (expresses SOME-PUBLICATION-BY-JEFFERSON-1949 M1_ARG37)
   (supports M1_ARG37 M1_ARG36))

(def-instance M1_ARG37 Argument
  ((hasConclusion TD_P100)
   (hasPremise TD_P101 TD_P102)))


(def-instance TD_P103 Proposition
  ((verbalExpression "Computers must be capable of emotional
association to think.")))
(def-instance TD_P104 Proposition
  ((verbalExpression "In order to think, a computer must be capable
of a full spectrum of thought.")))
(def-instance TD_P105 Proposition
  ((verbalExpression "Computers may be capable of high-end thinking,
which is focused, analytic, and goal-oriented but in order
to think as humans do they must also be capable of low-end thinking,
which is diffuse, analogical, and associative.")))
(def-instance TD_P106 Proposition
  ((verbalExpression "For example, a flower and a flowered dress
might be associated in low-end thought by a diffuse set of
emotionally charged linkages.")))

(def-relation-instances
   (expresses SOME-PUBLICATION-BY-GELERNTER-1994 TD_P103)
   (expresses SOME-PUBLICATION-BY-GELERNTER-1994 TD_P104)
   (expresses SOME-PUBLICATION-BY-GELERNTER-1994 TD_P105)
   (expresses SOME-PUBLICATION-BY-GELERNTER-1994 TD_P106)
   (expresses SOME-PUBLICATION-BY-GELERNTER-1994 M1_ARG38)
   (supports M1_ARG38 M1_ARG36))

(def-instance M1_ARG38 Argument
  ((hasConclusion TD_P103)
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   (hasPremise TD_P104 TD_P105 TD_P106)))


(def-instance TD_P107 Proposition
  ((verbalExpression "Emotional machines need limbic systems.")))
(def-instance TD_P108 Proposition
  ((verbalExpression "Emotional machines need the machine equivalent
of the human limbic system.")))
(def-instance TD_P109 Proposition
  ((verbalExpression "The limbic system subserves emotional states,
fosters drives, and motivates behavior.")))
(def-instance TD_P110 Proposition
  ((verbalExpression "It is also responsible for the pleasure-pain
principle, which guides the activities of all higher animals.")))
(def-instance TD_P111 Proposition
  ((verbalExpression "Through the development of artificial limbic
systems, emotional machines will be attainable in 20-50 years.")))

(def-relation-instances
   (expresses SOME-PUBLICATION-BY-STONIER-1992 TD_P107)
   (expresses SOME-PUBLICATION-BY-STONIER-1992 TD_P108)
   (expresses SOME-PUBLICATION-BY-STONIER-1992 TD_P109)
   (expresses SOME-PUBLICATION-BY-STONIER-1992 TD_P110)
   (expresses SOME-PUBLICATION-BY-STONIER-1992 TD_P111)
   (expresses SOME-PUBLICATION-BY-STONIER-1992 M1_ARG39)
   (supports M1_ARG39 M1_ARG36))

(def-instance M1_ARG39 Argument
  ((hasConclusion TD_P107)
   (hasPremise TD_P108 TD_P109 TD_P110 TD_P111)))


(def-instance TD_P112 Proposition
  ((verbalExpression "Artificial minds should mimic animal
evolution.")))
(def-instance TD_P113 Proposition
  ((verbalExpression "The fastest progress in AI research can be made
by imitating the capabilities of animals, starting near the bottom of
the phylogenetic scale and working upward toward animals with more
complex nervous systems.")))

(def-relation-instances
   (expresses SOME-PUBLICATION-BY-MORAVEC-1988 TD_P112)
   (expresses SOME-PUBLICATION-BY-MORAVEC-1988 TD_P113)
   (expresses SOME-PUBLICATION-BY-MORAVEC-1988 M1_ARG40)
   (supports M1_ARG40 M1_ARG39))

(def-instance M1_ARG40 Argument
  ((hasConclusion TD_P112)
   (hasPremise TD_P113)))


(def-instance TD_P114 Proposition
  ((verbalExpression "If a robot can honestly talk about its
feelings, it has feelings.")))
(def-instance TD_P115 Proposition
  ((verbalExpression "We can determine whether a robot has feelings
once we configure it to (1) use English the way humans do, (2)
distinguish truth from falsehood, (3) answer questions honestly.")))
(def-instance TD_P116 Proposition
  ((verbalExpression "We then simply ask, 'Are you conscious of your
feelings?' If it says, 'yes', then it has feelings.")))

(def-relation-instances
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  (has-attributed-proposition SOME-PUBLICATION-BY-SCRIVEN-1960
TD_P114 SOME-PUBLICATION-BY-DANTO-1960)
  (has-attributed-proposition SOME-PUBLICATION-BY-SCRIVEN-1960
TD_P115 SOME-PUBLICATION-BY-DANTO-1960)
  (has-attributed-proposition SOME-PUBLICATION-BY-SCRIVEN-1960
TD_P116 SOME-PUBLICATION-BY-DANTO-1960)
  (has-attributed-proposition SOME-PUBLICATION-BY-SCRIVEN-1960
M1_ARG41 SOME-PUBLICATION-BY-DANTO-1960)
  (disputes M1_ARG41 M1_ARG28))

(def-instance M1_ARG41 Argument
  ((hasConclusion TD_P114)
   (hasPremise TD_P115 TD_P116)))

(def-instance TD_P117 Proposition
  ((verbalExpression "There is the robot's dilemma.")))
(def-instance TD_P118 Proposition
  ((verbalExpression "Once an advanced robot is built, the way we
talk about robots, machines, and feelings will either change or will
not, and this poses a dilemma.")))
(def-instance TD_P119 Proposition
  ((verbalExpression "Either English will not change, in which case
we will be forced to say the robot is not conscious, because English
speakers do not use 'conscious' as a predicate for machines.")))
(def-instance TD_P120 Proposition
  ((verbalExpression "Or English will change, in which case English
can evolve in 1 of 2 ways.")))
(def-instance TD_P121 Proposition
  ((verbalExpression "Either We simply decide to call robots
'conscious', in which case we have an arbitrary and hence unwarranted
change in the language.")))
(def-instance TD_P122 Proposition
  ((verbalExpression "Or We construct a special language that applies
exclusively to machines, for example, a language that uses the suffix
'-m' to represent the fact that mentalistic terms like 'knows' and
'conscious' apply to physical events ('knows-m', 'conscious-m') in
machines, in which case words like 'conscious-m' would be used for
the robot in the same situations in which 'conscious' would be used
for humans.")))
(def-instance TD_P123 Proposition
  ((verbalExpression "But a lack of knowledge about how human
consciousness might correspond to robot consciousness is precisely
the issue at hand.")))
(def-instance TD_P124 Proposition
  ((verbalExpression "In either case, no means is provided to tell
whether a robot is conscious and at best the question is pushed
back.")))
(def-instance TD_P125 Proposition
  ((verbalExpression "In either case, Simply asking the machine if it
has conscious feeling will not help us determine if it does.")))

(def-relation-instances
   (expresses SOME-PUBLICATION-BY-DANTO-1960 TD_P117)
   (expresses SOME-PUBLICATION-BY-DANTO-1960 TD_P118)
   (expresses SOME-PUBLICATION-BY-DANTO-1960 TD_P119)
   (expresses SOME-PUBLICATION-BY-DANTO-1960 TD_P120)
   (expresses SOME-PUBLICATION-BY-DANTO-1960 TD_P121)
   (expresses SOME-PUBLICATION-BY-DANTO-1960 TD_P122)
   (expresses SOME-PUBLICATION-BY-DANTO-1960 TD_P123)
   (expresses SOME-PUBLICATION-BY-DANTO-1960 TD_P124)
   (expresses SOME-PUBLICATION-BY-DANTO-1960 TD_P125)
   (expresses SOME-PUBLICATION-BY-DANTO-1960 M1_ARG42)
   (disputes M1_ARG42 M1_ARG41))
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(def-instance M1_ARG42 Argument
  ((hasConclusion TD_P117)
   (hasPremise TD_P118 TD_P119 TD_P120 TD_P121 TD_P122 TD_P123
TD_P124 TD_P125)))


(def-instance TD_P126 Proposition
  ((verbalExpression "Machines cannot love or be loved.")))
(def-instance TD_P127 Proposition
  ((verbalExpression "Machines, which are mere collections of parts,
cannot love or be loved.")))
(def-instance TD_P128 Proposition
  ((verbalExpression "Only unified wholes that govern their parts,
such as humans, have the capacity to love what is lovable or be loved
by those who love.")))
(def-instance TD_P129 Proposition
  ((verbalExpression "Machines fail on both counts, so they are
subhuman and lack minds.")))

(def-relation-instances
   (expresses SOME-PUBLICATION-BY-WEISS-1960 TD_P126)
   (expresses SOME-PUBLICATION-BY-WEISS-1960 TD_P127)
   (expresses SOME-PUBLICATION-BY-WEISS-1960 TD_P128)
   (expresses SOME-PUBLICATION-BY-WEISS-1960 TD_P129)
   (expresses SOME-PUBLICATION-BY-WEISS-1960 M1_ARG43)
   (disputes M1_ARG43 M1_ARG28));;;this is how it is modelled on the
map, but it seems to me to be an error

(def-instance M1_ARG43 Argument
  ((hasConclusion TD_P126)
   (hasPremise TD_P127 TD_P128 TD_P129)))


(def-instance TD_P130 Proposition
  ((verbalExpression "Emotions are cognitive schemata.")))
(def-instance TD_P131 Proposition
  ((verbalExpression "What is essential to emotions is the schema of
cognitive evaluation that determines the relationship between the
emotion and the rest of the cognitive states of the subject.")))
(def-instance TD_P132 Proposition
  ((verbalExpression "In order for machines to have emotions, they
must model the complex interactions involved in the use of such
concepts as pride, shame, and so forth.")))
(def-instance TD_P133 Proposition
  ((verbalExpression "Furthermore, these concepts must be (partially)
responsible for the behavior of the system.")))

(def-relation-instances
   (expresses SOME-PUBLICATION-BY-BODEN-1977 TD_P130)
   (expresses SOME-PUBLICATION-BY-BODEN-1977 TD_P131)
   (expresses SOME-PUBLICATION-BY-BODEN-1977 TD_P132)
   (expresses SOME-PUBLICATION-BY-BODEN-1977 TD_P133)
   (expresses SOME-PUBLICATION-BY-BODEN-1977 M1_ARG44)
   (disputes M1_ARG44 M1_ARG28))

(def-instance M1_ARG44 Argument
  ((hasConclusion TD_P130)
   (hasPremise TD_P131 TD_P132 TD_P133)))


(def-instance TD_P134 Proposition
  ((verbalExpression "Our intuitions about pain are incoherent.")))
(def-instance TD_P135 Proposition
  ((verbalExpression "At present, it's easy to criticize the
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possibility of robot pain, but only because our everyday
understanding of pain is incoherent and self-contradictory.")))
(def-instance TD_P136 Proposition
  ((verbalExpression "For example, morphine is sometimes described as
preventing the generation of pain, and sometimes as just blocking
pain that already exists; but those are inconsistent
descriptions.")))
(def-instance TD_P137 Proposition
  ((verbalExpression "Once we have a coherent theory of pain, a robot
could in principle be constructed to instantiate that theory and
thereby feel pain.")))

(def-relation-instances
   (expresses SOME-PUBLICATION-BY-DENNETT-1978 TD_P134)
   (expresses SOME-PUBLICATION-BY-DENNETT-1978 TD_P135)
   (expresses SOME-PUBLICATION-BY-DENNETT-1978 TD_P136)
   (expresses SOME-PUBLICATION-BY-DENNETT-1978 TD_P137)
   (expresses SOME-PUBLICATION-BY-DENNETT-1978 M1_ARG45)
   (disputes M1_ARG45 M1_ARG28))

(def-instance M1_ARG45 Argument
  ((hasConclusion TD_P134)
   (hasPremise TD_P135 TD_P136 TD_P137)))


(def-instance TD_P138 Proposition
  ((verbalExpression "Emotions can be modeled by describing their
relations to other cognitive states.")))
(def-instance TD_P139 Proposition
  ((verbalExpression "Modeling emotions involves two tasks: (1) the
semantic task of programming a system to understand emotions, and (2)
the functional/behavioral task of programming a system to behave
emotionally through the interaction of emotional states and other
cognitive states, such as planning, learning, and recall.")))

(def-relation-instances
   (expresses SOME-PUBLICATION-BY-DYER-1987 TD_P138)
   (expresses SOME-PUBLICATION-BY-DYER-1987 TD_P139)
   (expresses SOME-PUBLICATION-BY-DYER-1987 M1_ARG46)
   (disputes M1_ARG46 M1_ARG28))

(def-instance M1_ARG46 Argument
  ((hasConclusion TD_P138)
   (hasPremise TD_P139)))



(def-instance TD_P140 Proposition
  ((verbalExpression "There is the implemented model BORIS.")))
(def-instance TD_P141 Proposition
  ((verbalExpression "BORIS is a narrative reader designed to
understand descriptions of the emotional states of narrative
characters.")))
(def-instance TD_P142 Proposition
  ((verbalExpression "BORIS can predict the emotional responses of
characters and interpret those responses by tracing them back to
their probable causes.")))

(def-relation-instances
   (supports M1_ARG47 M1_ARG46))

(def-instance M1_ARG47 Argument
  ((hasConclusion TD_P140)
   (hasPremise TD_P141 TD_P142)))
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(def-instance TD_P143 Proposition
  ((verbalExpression "There is the implemented model OpEd.")))
(def-instance TD_P144 Proposition
  ((verbalExpression "OpEd is an editorial reader that deals with
nonnarrative editorials-for example, critical book reviews.")))
(def-instance TD_P145 Proposition
  ((verbalExpression "The program tracks the beliefs of the writer as
well as the beliefs the writer ascribes to his or her critics.")))
(def-instance TD_P146 Proposition
  ((verbalExpression "Unlike BORIS, OpEd is able to deal with
nonnarrative texts, in which 'the writer explicitly supports one set
of beliefs while attacking another'.")))

(def-relation-instances
   (supports M1_ARG48 M1_ARG46))

(def-instance M1_ARG48 Argument
  ((hasConclusion TD_P143)
   (hasPremise TD_P144 TD_P145 TD_P146)))



(def-instance TD_P147 Proposition
  ((verbalExpression "There is the implemented model DAYDREAMER.")))
(def-instance TD_P148 Proposition
  ((verbalExpression "DAYDREAMER is a stream of thought generator
that specifies how representations of emotional states affect other
forms of cognitive processing.")))
(def-instance TD_P149 Proposition
  ((verbalExpression "It does this by concocting 'daydreams' of
possible outcomes and reactions and then using those daydreams to
represent the stream of consciousness of the system.")))

(def-relation-instances
   (supports M1_ARG49 M1_ARG46))

(def-instance M1_ARG49 Argument
  ((hasConclusion TD_P147)
   (hasPremise TD_P148 TD_P149)))

(def-instance TD_P150 Proposition
  ((verbalExpression "Emotions are the solution to a design
problem.")))
(def-instance TD_P151 Proposition
  ((verbalExpression "Emotions (both in organic creatures and in
artificial creations) are the solution to a design problem-how to
cope intelligently with a rapidly changing environment, given
established goals and limited processing resources.")))
(def-instance TD_P152 Proposition
  ((verbalExpression "In both humans and machines the problem is
solved with intelligent computational strategies.")))

(def-relation-instances
   (expresses SOME-PUBLICATION-BY-SLOMAN-1987 TD_P150)
   (expresses SOME-PUBLICATION-BY-SLOMAN-1987 TD_P151)
   (expresses SOME-PUBLICATION-BY-SLOMAN-1987 TD_P152)
   (expresses SOME-PUBLICATION-BY-SLOMAN-1987 M1_ARG50)
   (disputes M1_ARG50 M1_ARG28))

(def-instance M1_ARG50 Argument
  ((hasConclusion TD_P150)
   (hasPremise TD_P151 TD_P152)))
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(def-instance TD_P153 Proposition
  ((verbalExpression "Emotions are manifestations of concern
realization.")))
(def-instance TD_P154 Proposition
  ((verbalExpression "Emotional states result from a 'concern
realization system' that matches internal representations against
actual circumstances in order to cope with an uncertain
environment.")))
(def-instance TD_P155 Proposition
  ((verbalExpression "Computers that implement the concern
realization system go through emotional states.")))

(def-relation-instances
   (expresses SOME-PUBLICATION-BY-FRIJDA-1987 TD_P153)
   (expresses SOME-PUBLICATION-BY-FRIJDA-1987 TD_P154)
   (expresses SOME-PUBLICATION-BY-FRIJDA-1987 TD_P155)
   (expresses SOME-PUBLICATION-BY-FRIJDA-1987 M1_ARG51)
   (disputes M1_ARG51 M1_ARG28))

(def-instance M1_ARG51 Argument
  ((hasConclusion TD_P153)
   (hasPremise TD_P154 TD_P155)))


(def-instance TD_P156 Proposition
  ((verbalExpression "Emotions are cognitive evaluations.")))
(def-instance TD_P157 Proposition
  ((verbalExpression "Emotions are determined by the structure,
content, and organization of knowledge representations and the
processes that operate on them.")))
(def-instance TD_P158 Proposition
  ((verbalExpression "A machine equipped with the correct knowledge-
handling mechanisms, which result in appropriate behavior,will have
emotions.")))

(def-relation-instances
   (expresses SOME-PUBLICATION-BY-ORTONY-1988 TD_P156)
   (expresses SOME-PUBLICATION-BY-ORTONY-1988 TD_P157)
   (expresses SOME-PUBLICATION-BY-ORTONY-1988 TD_P158)
   (expresses SOME-PUBLICATION-BY-ORTONY-1988 M1_ARG52)
   (disputes M1_ARG52 M1_ARG28))

(def-instance M1_ARG52 Argument
  ((hasConclusion TD_P156)
   (hasPremise TD_P157 TD_P158)))


(def-instance TD_P159 Proposition
  ((verbalExpression "Emotions color perception and action.")))
(def-instance TD_P160 Proposition
  ((verbalExpression "Cognitive appraisal, in the form of knowledge
representation plus appropriate behavior, is not enough to convert
bare information processing into emotion.")))
(def-instance TD_P161 Proposition
  ((verbalExpression "Such a theory does not account for the fact
that emotions can color one's perceptions and actions.")))
(def-instance TD_P162 Proposition
  ((verbalExpression "For example, the perception of a winning
touchdown in a football game could be computationally modeled as
knowledge representation plus appropriate behavior.")))
(def-instance TD_P163 Proposition
  ((verbalExpression "But this doesn't account for the differently
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colored perceptions of fans of opposing teams.")))

(def-relation-instances
   (expresses some-publication-by-arbib-1992 TD_P159)
   (expresses some-publication-by-arbib-1992 TD_P160)
   (expresses some-publication-by-arbib-1992 TD_P161)
   (expresses some-publication-by-arbib-1992 TD_P162)
   (expresses some-publication-by-arbib-1992 TD_P163)
   (expresses some-publication-by-arbib-1992 M1_ARG53)
   (disputes M1_ARG53 M1_ARG52))

(def-instance M1_ARG53 Argument
  ((hasConclusion TD_P159)
   (hasPremise TD_P160 TD_P161 TD_P162 TD_P163)))


(def-instance TD_P164 Proposition
  ((verbalExpression "Feelings are information signals in a cognitive
system.")))
(def-instance TD_P165 Proposition
  ((verbalExpression "Feelings are needs and emotions, which
correspond to information signals of two kinds: (1) needs, which
arise from lower-level distributed processors that monitor certain
internal aspects of the body; (2) emotions, which also arise from
lower-level distributed processors but originate as cognitive
interpretations of external events, especially social events.")))
(def-instance TD_P166 Proposition
  ((verbalExpression "A robot could have feelings if its
computational structure implemented those 2 kinds of signals.")))

(def-relation-instances
   (expresses JOHNSON-LAIRD1988COMPUTER TD_P164)
   (expresses JOHNSON-LAIRD1988COMPUTER TD_P165)
   (expresses JOHNSON-LAIRD1988COMPUTER TD_P166)
   (expresses JOHNSON-LAIRD1988COMPUTER M1_ARG54)
   (disputes M1_ARG54 M1_ARG28))

(def-instance M1_ARG54 Argument
  ((hasConclusion TD_P164)
   (hasPremise TD_P165 TD_P166)))


(def-instance TD_P167 Proposition
  ((verbalExpression "Emotions are the product of motivational
representations.")))
(def-instance TD_P168 Proposition
  ((verbalExpression "Emotions result from interactions between
motives and other cognitive states.")))
(def-instance TD_P169 Proposition
  ((verbalExpression "Motives are representations of states of the
world to be achieved, prevented, and so forth.")))
(def-instance TD_P170 Proposition
  ((verbalExpression "A robot with the proper motivational processes
will have emotions.")))

(def-relation-instances
   (expresses some-publication-by-sloman-1981 TD_P167)
   (expresses some-publication-by-sloman-1981 TD_P168)
   (expresses some-publication-by-sloman-1981 TD_P169)
   (expresses some-publication-by-sloman-1981 TD_P170)
   (expresses some-publication-by-sloman-1981 M1_ARG55)
   (disputes M1_ARG55 M1_ARG28))

(def-instance M1_ARG55 Argument
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  ((hasConclusion TD_P167)
   (hasPremise TD_P168 TD_P169 TD_P170)))


(def-instance TD_P171 Proposition
  ((verbalExpression "There is Hierarchical theory of affects.")))
(def-instance TD_P172 Proposition
  ((verbalExpression "Emotional states arise from hierarchically
structured dispositional states, that is, tendencies to behave in
certain ways given certain circumstances.")))
(def-instance TD_P173 Proposition
  ((verbalExpression "Higher-level dispositions influence lower-level
dispositions, which in turn influence external behavior.")))

(def-relation-instances
   (expresses SOME-PUBLICATION-BY-SLOMAN-1987 TD_P171)
   (expresses SOME-PUBLICATION-BY-SLOMAN-1987 TD_P172)
   (expresses SOME-PUBLICATION-BY-SLOMAN-1987 TD_P173)
   (expresses SOME-PUBLICATION-BY-SLOMAN-1987 M1_ARG56)
   (supports M1_ARG56 M1_ARG55))

(def-instance M1_ARG56 Argument
  ((hasConclusion TD_P171)
   (hasPremise TD_P172 TD_P173)))


(def-instance TD_P174 Proposition
  ((verbalExpression "Emotion is a type of information
processing.")))
(def-instance TD_P175 Proposition
  ((verbalExpression "Once we understand the biochemical and
cybernetic aspects of human emotion, we will be able to build
computers with emotions.")))

(def-relation-instances
   (expresses SIMONS1985BIOLOGY TD_P174)
   (expresses SIMONS1985BIOLOGY TD_P175)
   (expresses SIMONS1985BIOLOGY M1_ARG57)
   (disputes M1_ARG57 M1_ARG28))

(def-instance M1_ARG57 Argument
  ((hasConclusion TD_P174)
   (hasPremise TD_P175)))


(def-instance TD_P176 Proposition
  ((verbalExpression "The Turing test provides evidence for emotions
as well as for intelligence.")))
(def-instance TD_P177 Proposition
  ((verbalExpression "Because behavior is an important part of
determining whether a system has emotions, the Turing test is useful
as a test for emotional capacities as well as for general
intelligence.")))
(def-instance TD_P178 Proposition
  ((verbalExpression "If a robot can pass the Turing test and if it
has a cognitively plausible internal structure, then it can have
emotions.")))

(def-relation-instances
   (expresses SIMONS1985BIOLOGY TD_P176)
   (expresses SIMONS1985BIOLOGY TD_P177)
   (expresses SIMONS1985BIOLOGY TD_P178)
   (expresses SIMONS1985BIOLOGY M1_ARG58)
   (disputes M1_ARG58 M1_ARG28))
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(def-instance M1_ARG58 Argument
  ((hasConclusion TD_P176)
   (hasPremise TD_P177 TD_P178)))



;;============================================================
;;TD_ISS4 "Should we ever pretend that computers will be able to
think?"
;;============================================================

(def-instance TD_PERSP4 Proposition
  ((verbalExpression "There is the head-in-the-sand objection.")))
(def-instance TD_P179 Proposition
  ((verbalExpression "The consequences of machine thought are too
dreadful to accept.")))
(def-instance TD_P180 Proposition
  ((verbalExpression "We should 'stick our heads in the sand' and
hope that machines will never be able to think or have souls.")))

(def-relation-instances
   (anticipates-Proposition TURING1950COMPUTING TD_PERSP4)
   (anticipates-Proposition TURING1950COMPUTING TD_P171)
   (anticipates-Proposition TURING1950COMPUTING TD_P180)
   (anticipates-Proposition TURING1950COMPUTING M1_ARG59)
   (addresses TD_PERSP4 TD_ISS4)
   (disputes M1_ARG59 M1_ARG1))

(def-instance M1_ARG59 Argument
  ((hasConclusion TD_PERSP4)
   (hasPremise TD_P179 TD_P180)))


(def-instance TD_P181 Proposition
  ((verbalExpression "There is the transmigration consolation.")))
(def-instance TD_P182 Proposition
  ((verbalExpression "The heads-in-the-sand objection is too trivial
to deserve a response; consolation is more appropriate.")))
(def-instance TD_P183 Proposition
  ((verbalExpression "It may be comforting to believe that souls are
passed from humans to machines when humans die by the theological
doctrine of the transmigration of souls.")))

(def-relation-instances
   (expresses TURING1950COMPUTING TD_P181)
   (expresses TURING1950COMPUTING TD_P182)
   (expresses TURING1950COMPUTING TD_P183)
   (expresses TURING1950COMPUTING M1_ARG60)
   (disputes M1_ARG60 M1_ARG59))

(def-instance M1_ARG60 Argument
  ((hasConclusion TD_P181)
   (hasPremise TD_P182 TD_P183)))



;;============================================================
;;TD_ISS5 "Does God prohibit computers from thinking?"
;;============================================================

(def-instance TD_PERSP5 Proposition
  ((verbalExpression "There is the theological objection.")))
(def-instance TD_P184 Proposition
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  ((verbalExpression "Only entities with immortal souls can
think.")))
(def-instance TD_P185 Proposition
  ((verbalExpression "God has given souls to humans, but not to
machines, therefore, humans can think, and computers can't.")))

(def-relation-instances
   (anticipates-Proposition TURING1950COMPUTING TD_PERSP5)
   (anticipates-Proposition TURING1950COMPUTING TD_P184)
   (anticipates-Proposition TURING1950COMPUTING TD_P185)
   (anticipates-Proposition TURING1950COMPUTING M1_ARG61)
   (addresses TD_PERSP5 TD_ISS5)
   (disputes M1_ARG61 M1_ARG1))

(def-instance M1_ARG61 Argument
  ((hasConclusion TD_PERSP5)
   (hasPremise TD_P184 TD_P185)))


(def-instance TD_P186 Proposition
  ((verbalExpression "The theological objection is ungrounded.")))
(def-instance TD_P187 Proposition
  ((verbalExpression "The view that only humans have souls is as
ungrounded and arbitrary as the view that men have souls but women
don't.")))
(def-instance TD_P188 Proposition
  ((verbalExpression "For all we know, in creating thinking machines
we may be serving God's ends by providing dwellings for souls he
creates.")))

(def-relation-instances
   (expresses TURING1950COMPUTING TD_P186)
   (expresses TURING1950COMPUTING TD_P187)
   (expresses TURING1950COMPUTING TD_P188)
   (expresses TURING1950COMPUTING M1_ARG62)
   (disputes M1_ARG62 M1_ARG61))

(def-instance M1_ARG62 Argument
  ((hasConclusion TD_P186)
   (hasPremise TD_P187 TD_P188)))


;;==============================================================
;;TD_ISS6 "Can computers understand arithmetic?"
;;==============================================================

(def-instance TD_PERSP6 Proposition
  ((verbalExpression "Computers can't add, much less think.")))
(def-instance TD_P189 Proposition
  ((verbalExpression "Machines only operate on uninterpreted
symbols.")))
(def-instance TD_P190 Proposition
  ((verbalExpression "Even when they perform the operations
corresponding to addition, they are merely shuffling symbols that are
meaningless to them.")))
(def-instance TD_P191 Proposition
  ((verbalExpression "These manipulations become mathematics only
when humans interpret them.")))


(def-relation-instances
   (expresses some-publication-by-jaki-1969 TD_PERSP6)
   (expresses some-publication-by-jaki-1969 TD_P189)
   (expresses some-publication-by-jaki-1969 TD_P190)
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   (expresses some-publication-by-jaki-1969 TD_P191)
   (expresses some-publication-by-jaki-1969 M1_ARG63)
   (expresses some-publication-by-dretske-1990 TD_PERSP6)
   (expresses some-publication-by-dretske-1990 TD_P189)
   (expresses some-publication-by-dretske-1990 TD_P190)
   (expresses some-publication-by-dretske-1990 TD_P191)
   (expresses some-publication-by-dretske-1990 M1_ARG63)
   (addresses TD_PERSP6 TD_ISS6)
   (disputes M1_ARG63 M1_ARG1))


(def-instance M1_ARG63 Argument
  ((hasConclusion TD_PERSP6)
   (hasPremise TD_P189 TD_P190 TD_P191)))


(def-instance TD_P192 Proposition
  ((verbalExpression "Computers can learn to add.")))
(def-instance TD_P193 Proposition
  ((verbalExpression "Computers that possess internal semantic
networks can learn dialectically in the same way that humans do.")))
(def-instance TD_P194 Proposition
  ((verbalExpression "Thus, while they do not intrinsically know how
to add, they can learn.")))

(def-relation-instances
   (expresses some-publication-by-rapaport-1988 TD_P192)
   (expresses some-publication-by-rapaport-1988 TD_P193)
   (expresses some-publication-by-rapaport-1988 TD_P194)
   (expresses some-publication-by-rapaport-1988 M1_ARG64)
   (disputes M1_ARG64 M1_ARG63))

(def-instance M1_ARG64 Argument
  ((hasConclusion TD_P192)
   (hasPremise TD_P193 TD_P194)))


(def-instance TD_P195 Proposition
  ((verbalExpression "There is the marijuana-sniffing dog.")))
(def-instance TD_P196 Proposition
  ((verbalExpression "Computers can't have an adding thought (much
less have a more complex thought) because the symbols being added
don't have any meaning to the computer, and they don't have any
meaning because they don't play a causal role based on that
meaning.")))
(def-instance TD_P197 Proposition
  ((verbalExpression "A trained dog, for example, will wag its tail
when it smells marijuana, but (like a robot) it's only responding
because it's been trained to do so, not because the meaning of the
smell causes it to wag its tail.")))

(def-relation-instances
   (expresses some-publication-by-dretske-1990 TD_P195)
   (expresses some-publication-by-dretske-1990 TD_P196)
   (expresses some-publication-by-dretske-1990 TD_P197)
   (expresses some-publication-by-dretske-1990 M1_ARG65)
   (supports M1_ARG65 M1_ARG63))

(def-instance M1_ARG65 Argument
  ((hasConclusion TD_P195)
   (hasPremise TD_P196 TD_P197)))


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;;TD_ISS7 "Can computers draw analogies?"
;;==============================================================

(def-instance TD_PERSP7 Proposition
  ((verbalExpression "Computers can't understand analogies.")))
(def-instance TD_P198 Proposition
  ((verbalExpression "Computers cannot understand analogical
comparisons or metaphors.")))
(def-instance TD_P199 Proposition
  ((verbalExpression "For example, a machine could not understand the
sentence, 'She
ran the like the wind'.")))

(def-relation-instances
   (addresses TD_PERSP7 TD_ISS7)
   (disputes M1_ARG66 M1_ARG1))


(def-instance M1_ARG66 Argument
  ((hasConclusion TD_PERSP7)
   (hasPremise TD_P198 TD_P199)))


(def-instance TD_P200 Proposition
  ((verbalExpression "Computers have understood analogy.")))
(def-instance TD_P201 Proposition
  ((verbalExpression "Existing models have discovered and understood
analogies.")))

(def-relation-instances
   (disputes M1_ARG67 M1_ARG66))

(def-instance M1_ARG67 Argument
  ((hasConclusion TD_P200)
   (hasPremise TD_P201)))


(def-instance TD_P202 Proposition
  ((verbalExpression "There is the implemented model SME.")))
(def-instance TD_P203 Proposition
  ((verbalExpression "SME is a structure-mapping engine that
discovers analogies between domains by a set of match rules.")))
(def-instance TD_P204 Proposition
  ((verbalExpression "The analogies that result are judged according
to the criteria of clarity, richness, abstractness, and
systematicity.")))
(def-instance TD_P205 Proposition
  ((verbalExpression "SME has found mappings between heat and water
flow, solar systems and atoms, and in other domains.")))

(def-relation-instances
   (expresses FALKENHAINER1989STRUCTURE TD_P202)
   (expresses FALKENHAINER1989STRUCTURE TD_P203)
   (expresses FALKENHAINER1989STRUCTURE TD_P204)
   (expresses FALKENHAINER1989STRUCTURE TD_P205)
   (expresses FALKENHAINER1989STRUCTURE M1_ARG68)
   (supports M1_ARG68 M1_ARG67))

(def-instance M1_ARG68 Argument
  ((hasConclusion TD_P202)
   (hasPremise TD_P203 TD_P204 TD_P205)))


(def-instance TD_P206 Proposition
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  ((verbalExpression "SME only draws analogies from prestructured
representations.")))
(def-instance TD_P207 Proposition
  ((verbalExpression "SME creates analogies using highlevel
representations that are structured with those specific analogies in
mind.")))
(def-instance TD_P208 Proposition
  ((verbalExpression "Its behavior provides no evidence of
intelligence because the analogies it discovers are already built
into the data it works with.")))

(def-relation-instances
   (expresses CHALMERS1995HIGH TD_P206)
   (expresses CHALMERS1995HIGH TD_P207)
   (expresses CHALMERS1995HIGH TD_P208)
   (expresses CHALMERS1995HIGH M1_ARG69)
   (disputes M1_ARG69 M1_ARG68))

(def-instance M1_ARG69 Argument
  ((hasConclusion TD_P206)
   (hasPremise TD_P207 TD_P208)))


(def-instance TD_P209 Proposition
  ((verbalExpression "Objects, attributes, and relations are too
rigidly distinguished by SME.")))
(def-instance TD_P210 Proposition
  ((verbalExpression "In order for its analogical mappings to work,
SME assumes a rigid distinction between objects, attributes, and
relations.")))
(def-instance TD_P211 Proposition
  ((verbalExpression "But it is unclear whether humans make such a
rigid distinction.")))
(def-instance TD_P212 Proposition
  ((verbalExpression "For example, we sometimes conceptualize wealth
as an object that flows between people, but at other times we
conceptualize wealth as an attribute that changes with each
transaction we make.")))

(def-relation-instances
   (expresses CHALMERS1995HIGH TD_P209)
   (expresses CHALMERS1995HIGH TD_P210)
   (expresses CHALMERS1995HIGH TD_P211)
   (expresses CHALMERS1995HIGH TD_P212)
   (expresses CHALMERS1995HIGH M1_ARG70)
   (disputes M1_ARG70 M1_ARG68))

(def-instance M1_ARG70 Argument
  ((hasConclusion TD_P209)
   (hasPremise TD_P210 TD_P211 TD_P212)))


(def-instance TD_P213 Proposition
  ((verbalExpression "SME's treatment of relations is too rigid.")))
(def-instance TD_P214 Proposition
  ((verbalExpression "In SME, relations are treated as n-place
predicates that can only be mapped to other n-place predicates.")))
(def-instance TD_P215 Proposition
  ((verbalExpression "For example, attraction is a 2-place predicate
that could be represented as 'attracts (sun, planet)' and then mapped
to
'attracts (nucleus, electron)'.")))
(def-instance TD_P216 Proposition
  ((verbalExpression "But it is unlikely that the human mind is so
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rigid in its treatment of relational mappings.")))

(def-relation-instances
   (expresses CHALMERS1995HIGH TD_P213)
   (expresses CHALMERS1995HIGH TD_P214)
   (expresses CHALMERS1995HIGH TD_P215)
   (expresses CHALMERS1995HIGH TD_P216)
   (expresses CHALMERS1995HIGH M1_ARG71)
   (disputes M1_ARG71 M1_ARG68))

(def-instance M1_ARG71 Argument
  ((hasConclusion TD_P213)
   (hasPremise TD_P214 TD_P215 TD_P216)))


(def-instance TD_P217 Proposition
  ((verbalExpression "There is the implemented model ACME.")))
(def-instance TD_P218 Proposition
  ((verbalExpression "ACME is a connectionist network that discovers
cross domain analogical mappings.")))
(def-instance TD_P219 Proposition
  ((verbalExpression "The ACME network uses structural, semantic, and
pragmatic constraints to seek out those mappings.")))

(def-relation-instances
   (expresses HOLYOAK1989ANALOGICAL TD_P217)
   (expresses HOLYOAK1989ANALOGICAL TD_P218)
   (expresses HOLYOAK1989ANALOGICAL TD_P219)
   (expresses HOLYOAK1989ANALOGICAL M1_ARG72)
   (supports M1_ARG72 M1_ARG67)
   (relates-to-concept TD_P217 $acme))

(def-instance M1_ARG72 Argument
  ((hasConclusion TD_P217)
   (hasPremise TD_P218 TD_P219)))


(def-instance TD_P220 Proposition
  ((verbalExpression "ACME doesn't understand analogy.")))
(def-instance TD_P221 Proposition
  ((verbalExpression "ACME's claim to understand analogies is
overblown.")))
(def-instance TD_P222 Proposition
  ((verbalExpression "All ACME does is take algebraic sentences in
predicate logic notation and compare them.")))
(def-instance TD_P223 Proposition
  ((verbalExpression "For example, it only understands that 'Socrates
is like a midwife' to the extent that it understands that '(a(b)),
(c(d)) ... is similar to (A(B)), (C(D))'.")))

(def-relation-instances
   (expresses CHALMERS1995HIGH TD_P220)
   (expresses CHALMERS1995HIGH TD_P221)
   (expresses CHALMERS1995HIGH TD_P222)
   (expresses CHALMERS1995HIGH TD_P223)
   (expresses CHALMERS1995HIGH M1_ARG73)
   (disputes M1_ARG73 M1_ARG72)
   (relates-to-concept TD_P220 $acme))

(def-instance M1_ARG73 Argument
  ((hasConclusion TD_P220)
   (hasPremise TD_P221 TD_P222 TD_P223)))
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(def-instance TD_P224 Proposition
  ((verbalExpression "The front-end assumption is dubious.")))
(def-instance TD_P225 Proposition
  ((verbalExpression "Models that use preconfigured representations
and hand-tailored data assume that a separate front-end module could
be built that would filter sensory data into the model's
representational form.")))

(def-relation-instances
   (expresses CHALMERS1995HIGH TD_P224)
   (expresses CHALMERS1995HIGH TD_P225)
   (expresses CHALMERS1995HIGH M1_ARG74)
   (supports M1_ARG74 M1_ARG73)
   (supports M1_ARG74 M1_ARG69))

(def-instance M1_ARG74 Argument
  ((hasConclusion TD_P224)
   (hasPremise TD_P225)))


(def-instance TD_P226 Proposition
  ((verbalExpression "All-encompassing representations could not be
processed.")))
(def-instance TD_P227 Proposition
  ((verbalExpression "The all-purpose representation that a front-end
module would provide to a computer model would have to encode a vast
amount of information, enough for it to adapt to all the various
contexts and analogies it might be used in.")))
(def-instance TD_P228 Proposition
  ((verbalExpression "Such a representation would be too bulky for
efficient processing.")))

(def-relation-instances
   (expresses CHALMERS1995HIGH TD_P226)
   (expresses CHALMERS1995HIGH TD_P227)
   (expresses CHALMERS1995HIGH TD_P228)
   (expresses CHALMERS1995HIGH M1_ARG75)
   (supports M1_ARG75 M1_ARG74))

(def-instance M1_ARG75 Argument
  ((hasConclusion TD_P226)
   (hasPremise TD_P227 TD_P228)))


(def-instance TD_P229 Proposition
  ((verbalExpression "Perception depends on analogy.")))
(def-instance TD_P230 Proposition
  ((verbalExpression "How we see things depends in part on what high-
level analogical processes we use.")))
(def-instance TD_P231 Proposition
  ((verbalExpression "For example, Saddam Hussein will be perceived
quite differently depending on whether he is viewed as analogous to
Adolf Hitler (a ruthless aggressor) or to Robin Hood (a generous
crusader).")))

(def-relation-instances
   (expresses CHALMERS1995HIGH TD_P229)
   (expresses CHALMERS1995HIGH TD_P230)
   (expresses CHALMERS1995HIGH TD_P231)
   (expresses CHALMERS1995HIGH M1_ARG76)
   (supports M1_ARG76 M1_ARG74))

(def-instance M1_ARG76 Argument
  ((hasConclusion TD_P229)
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   (hasPremise TD_P230 TD_P231)))


(def-instance TD_P232 Proposition
  ((verbalExpression "There is the implemented model COPYCAT.")))
(def-instance TD_P233 Proposition
  ((verbalExpression "COPYCAT is a model that discovers analogies
using 3 components: (1) a 'slipnet' of abstract Platonic concepts
whose relations can change as the model runs, (2) a 'workspace' of
perceptual activity that acts like a short-term memory, and (3) a
'coderack' of agents that are probabilistically selected to carry out
tasks in the workspace.")))
(def-instance TD_P234 Proposition
  ((verbalExpression "COPYCAT is neither a symbol manipulator nor a
connectionist network, though it draws on both paradigms.")))
(def-instance TD_P235 Proposition
  ((verbalExpression "Representations are not delivered hand-tailored
to the model, but are built up through fluid interactions between
low-level and high-level components.")))

(def-relation-instances
   (expresses HOFSTADTER1995COPYCAT TD_P232)
   (expresses HOFSTADTER1995COPYCAT TD_P233)
   (expresses HOFSTADTER1995COPYCAT TD_P234)
   (expresses HOFSTADTER1995COPYCAT TD_P235)
   (expresses HOFSTADTER1995COPYCAT M1_ARG77)
   (supports M1_ARG77 M1_ARG67))

(def-instance M1_ARG77 Argument
  ((hasConclusion TD_P232)
   (hasPremise TD_P233 TD_P234 TD_P235)))



;;============================================================
;;TD_ISS8 "Is the brain a computer?"
;;============================================================

(def-instance TD_PERSP8 Proposition
  ((verbalExpression "There is the biological assumption.")))
(def-instance TD_P236 Proposition
  ((verbalExpression "The brain is a machine that can think.")))
(def-instance TD_P237 Proposition
  ((verbalExpression "Its neurobiological processes are similar to or
identical with the information processes of a computer.")))

(def-relation-instances
   (addresses TD_PERSP8 TD_ISS8)
   (supports M1_ARG78 M1_ARG1))

(def-instance M1_ARG78 Argument
  ((hasConclusion TD_PERSP8)
   (hasPremise TD_P236 TD_P237)))



(def-instance TD_P238 Proposition
  ((verbalExpression "Nothing is intrinsically a digital
computer.")))
(def-instance TD_P239 Proposition
  ((verbalExpression "The syntactic structures that define computers
are not intrinsic to physics; they are ascribed to physical systems
by humans.")))
(def-instance TD_P240 Proposition
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  ((verbalExpression "So the question, 'Is the brain a digital
computer?' is ill-defined, because syntax can be ascribed to any
sufficiently complex system.")))
(def-instance TD_P241 Proposition
  ((verbalExpression "Syntactic structures are not just multiply
realizable in numerous physical systems, they are universally
realizable in any physical system.")))

(def-relation-instances
   (expresses SEARLE1992REDISCOVERY TD_P238)
   (expresses SEARLE1992REDISCOVERY TD_P239)
   (expresses SEARLE1992REDISCOVERY TD_P240)
   (expresses SEARLE1992REDISCOVERY TD_P241)
   (expresses SEARLE1992REDISCOVERY M1_ARG79)
   (disputes M1_ARG79 M1_ARG78))

(def-instance M1_ARG79 Argument
  ((hasConclusion TD_P238)
   (hasPremise TD_P239 TD_P240 TD_P241)))


(def-instance TD_P242 Proposition
  ((verbalExpression "Programs are not universally realizable.")))
(def-instance TD_P243 Proposition
  ((verbalExpression "Even if it is true that during some interval of
time a pattern of molecule movements on the wall is isomorphic with,
for example, the formal pattern of the WordStar computer program, the
wall will not support the same counterfactuals as the program.")))
(def-instance TD_P244 Proposition
  ((verbalExpression "If the WordStar program had been given
different input, it would have behaved differently.")))
(def-instance TD_P245 Proposition
  ((verbalExpression "But the wall, which was not engineered to
implement WordStar, would not respond to different 'input' (that is,
a different pattern of molecular organization) in the same way.")))
(def-instance TD_P246 Proposition
  ((verbalExpression "So WordStar is not universally realizable.")))

(def-relation-instances
   (expresses COPELAND1993ARTIFICIAL TD_P242)
   (expresses COPELAND1993ARTIFICIAL TD_P243)
   (expresses COPELAND1993ARTIFICIAL TD_P244)
   (expresses COPELAND1993ARTIFICIAL TD_P245)
   (expresses COPELAND1993ARTIFICIAL TD_P246)
   (expresses COPELAND1993ARTIFICIAL M1_ARG80)
   (disputes M1_ARG80 M1_ARG79)
   (relates-to-concept TD_P243 $counterfactual))


(def-instance M1_ARG80 Argument
  ((hasConclusion TD_P242)
   (hasPremise TD_P243 TD_P244 TD_P245 TD_P246)))


(def-instance TD_P247 Proposition
  ((verbalExpression "Universal realizability is not essential to the
argument.")))
(def-instance TD_P248 Proposition
  ((verbalExpression "Even without universal realizability, it is
still true that syntax is observer relative.")))
(def-instance TD_P249 Proposition
  ((verbalExpression "And this is enough to show that nothing,
including the brain, is intrinsically a digital computer.")))
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(def-relation-instances
   (expresses SEARLE1992REDISCOVERY TD_P247)
   (expresses SEARLE1992REDISCOVERY TD_P248)
   (expresses SEARLE1992REDISCOVERY TD_P249)
   (expresses SEARLE1992REDISCOVERY M1_ARG81)
   (disputes M1_ARG81 M1_ARG80))

(def-instance M1_ARG81 Argument
  ((hasConclusion TD_P247)
   (hasPremise TD_P248 TD_P249)))


(def-instance TD_P250 Proposition
  ((verbalExpression "Formal programs can be realized in multiple
physical media.")))
(def-instance TD_P251 Proposition
  ((verbalExpression "The same formal program could be realized in a
digital computer, in a human brain, in beer cans and toilet paper, or
in any number of physical implementations.")))
(def-instance TD_P252 Proposition
  ((verbalExpression "The program is defined solely in terms of its
formal syntactic structure; its mode of physical implementation is
irrelevant.")))

(def-relation-instances
   (supports M1_ARG82 M1_ARG79))

(def-instance M1_ARG82 Argument
  ((hasConclusion TD_P250)
   (hasPremise TD_P251 TD_P252)))


(def-instance TD_P253 Proposition
  ((verbalExpression "The operation of the brain is computable.")))
(def-instance TD_P254 Proposition
  ((verbalExpression "Once we have a sufficient understanding of the
laws of physics and the structure of the brain, we will be able to
precisely simulate the operation of the brain with a computer.")))

(def-relation-instances
   (supports M1_ARG83 M1_ARG78))

(def-instance M1_ARG83 Argument
  ((hasConclusion TD_P253)
   (hasPremise TD_P254)))


(def-instance TD_P255 Proposition
  ((verbalExpression "Low-level quantum effects are uncomputable.")))
(def-instance TD_P256 Proposition
  ((verbalExpression "The biological phenomena that underlie
consciousness operate at a level at which quantum effects could exert
an influence.")))
(def-instance TD_P257 Proposition
  ((verbalExpression "Because quantum effects are not computable, the
brain and consciousness may be noncomputational and
nonalgorithmic.")))

(def-relation-instances
   (expresses PENROSE1990PRECIS TD_P255)
   (expresses PENROSE1990PRECIS TD_P256)
   (expresses PENROSE1990PRECIS TD_P257)
   (expresses PENROSE1990PRECIS M1_ARG84)
   (disputes M1_ARG84 M1_ARG83))
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(def-instance M1_ARG84 Argument
  ((hasConclusion TD_P255)
   (hasPremise TD_P256 TD_P257)))

(def-instance TD_P258 Proposition
  ((verbalExpression "Penrose gives an explanation 'by miracle'.")))
(def-instance TD_P259 Proposition
  ((verbalExpression "Penrose does not explain how quantum effects in
the brain might affect consciousness.")))
(def-instance TD_P260 Proposition
  ((verbalExpression "He simply assumes that quantum effects and the
brain are miraculously related.")))

(def-relation-instances
   (expresses some-publication-by-stanovich-1990 TD_P258)
   (expresses some-publication-by-stanovich-1990 TD_P259)
   (expresses some-publication-by-stanovich-1990 TD_P260)
   (expresses some-publication-by-stanovich-1990 M1_ARG85)
   (disputes M1_ARG85 M1_ARG84))

(def-instance M1_ARG85 Argument
  ((hasConclusion TD_P258)
   (hasPremise TD_P259 TD_P260)))


(def-instance TD_P261 Proposition
  ((verbalExpression "Quantum effects are irrelevant to symbolic
processes.")))
(def-instance TD_P262 Proposition
  ((verbalExpression "Quantum uncertainties are unimportant to the
study of symbolic thought processes, because they occur at a low
level of organization and are averaged out before they can affect
higher-level processes.")))

(def-relation-instances
   (expresses some-publication-by-simon-1995 TD_P261)
   (expresses some-publication-by-simon-1995 TD_P262)
   (expresses some-publication-by-simon-1995 M1_ARG86)
   (disputes M1_ARG86 M1_ARG84))

(def-instance M1_ARG86 Argument
  ((hasConclusion TD_P261)
   (hasPremise TD_P262)))



;;===============================================================
;;TD_ISS9 "Are computers inherently disabled?"
;;===============================================================

(def-instance TD_PERSP9 Proposition
  ((verbalExpression "There is the argument from disabilities.")))
(def-instance TD_P263 Proposition
  ((verbalExpression "Machines can never do X, where X is any of a
variety of abilities that are regarded as distinctly human, for
example, being friendly, having a sense of humor, making mistakes,
enjoying strawberries and cream, or thinking about oneself.")))

(def-relation-instances
   (anticipates-Proposition TURING1950COMPUTING TD_PERSP9)
   (anticipates-Proposition TURING1950COMPUTING TD_P263)
   (anticipates-Proposition TURING1950COMPUTING M1_ARG87)
   (addresses TD_PERSP9 TD_ISS9)
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   (disputes M1_ARG87 M1_ARG1))

(def-instance M1_ARG87 Argument
  ((hasConclusion TD_PERSP9)
   (hasPremise TD_P263)))


(def-instance TD_P264 Proposition
  ((verbalExpression "Disability Arguments derive from our limited
experience with machines.")))
(def-instance TD_P265 Proposition
  ((verbalExpression "Because the machines we've seen are clunky,
ugly, mechanical, and so forth, we assume that a machine could never
fall in love or enjoy strawberries and cream.")))
(def-instance TD_P266 Proposition
  ((verbalExpression "But these are just bad inductions from a
limited base of experience.")))

(def-relation-instances
   (expresses TURING1950COMPUTING TD_P264)
   (expresses TURING1950COMPUTING TD_P265)
   (expresses TURING1950COMPUTING TD_P266)
   (expresses TURING1950COMPUTING M1_ARG88)
   (disputes M1_ARG88 M1_ARG87))

(def-instance M1_ARG88 Argument
  ((hasConclusion TD_P264)
   (hasPremise TD_P265 TD_P266)))


(def-instance TD_P267 Proposition
  ((verbalExpression "Computers can't enjoy strawberries and
cream.")))
(def-instance TD_P268 Proposition
  ((verbalExpression "Computers will never possess the human ability
to enjoy strawberries and cream.")))


(def-relation-instances
   (anticipates-Proposition TURING1950COMPUTING TD_P267)
   (anticipates-Proposition TURING1950COMPUTING TD_P268)
   (anticipates-Proposition TURING1950COMPUTING M1_ARG89)
   (supports M1_ARG89 M1_ARG87))

(def-instance M1_ARG89 Argument
  ((hasConclusion TD_P267)
   (hasPremise TD_P268)))


(def-instance TD_P269 Proposition
  ((verbalExpression "Computers may be made to enjoy strawberries and
cream.")))
(def-instance TD_P270 Proposition
  ((verbalExpression "Computers might be made that will enjoy
strawberries and cream, but the only importance of this would be to
illuminate other issues, such as the possibility of friendship
between man and machine.")))

(def-relation-instances
   (expresses TURING1950COMPUTING TD_P269)
   (expresses TURING1950COMPUTING TD_P270)
   (expresses TURING1950COMPUTING M1_ARG90)
   (disputes M1_ARG90 M1_ARG89))
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(def-instance M1_ARG90 Argument
  ((hasConclusion TD_P269)
   (hasPremise TD_P270)))


(def-instance TD_P271 Proposition
  ((verbalExpression "Computers can't make mistakes.")))
(def-instance TD_P272 Proposition
  ((verbalExpression "Computers differ from humans in that humans can
make mistakes, whereas computers can't.")))
(def-instance TD_P273 Proposition
  ((verbalExpression "They are easily unmasked in the Turing test,
because humans would frequently make mistakes in complex arithmetic
whereas computers never do.")))

(def-relation-instances
   (anticipates-Proposition TURING1950COMPUTING TD_P271)
   (anticipates-Proposition TURING1950COMPUTING TD_P272)
   (anticipates-Proposition TURING1950COMPUTING TD_P273)
   (anticipates-Proposition TURING1950COMPUTING M1_ARG91)
   (supports M1_ARG91 M1_ARG87))

(def-instance M1_ARG91 Argument
  ((hasConclusion TD_P271)
   (hasPremise TD_P272 TD_P273)))


(def-instance TD_P274 Proposition
  ((verbalExpression "Computers can make certain kinds of
mistakes.")))
(def-instance TD_P275 Proposition
  ((verbalExpression "Those who think computers can't make mistakes
confuse errors of functioning (errors that result from the physical
construction of the machine) with errors of conclusion (errors that
result from the machine's reasoning process).")))
(def-instance TD_P276 Proposition
  ((verbalExpression "It is true that machines can't commit errors of
functioning if they are properly constructed.")))
(def-instance TD_P277 Proposition
  ((verbalExpression "But machines can commit errors of conclusion,
for example, by making faulty inferences based on a lack of adequate
information.")))

(def-relation-instances
   (expresses TURING1950COMPUTING TD_P274)
   (expresses TURING1950COMPUTING TD_P275)
   (expresses TURING1950COMPUTING TD_P276)
   (expresses TURING1950COMPUTING TD_P277)
   (expresses TURING1950COMPUTING M1_ARG92)
   (disputes M1_ARG92 M1_ARG91))

(def-instance M1_ARG92 Argument
  ((hasConclusion TD_P274)
   (hasPremise TD_P275 TD_P276 TD_P277)))


(def-instance TD_P278 Proposition
  ((verbalExpression "Computers can't think about themselves.")))
(def-instance TD_P279 Proposition
  ((verbalExpression "Computers cannot be the object of their own
thoughts.")))

(def-relation-instances
   (anticipates-Proposition TURING1950COMPUTING TD_P278)
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   (anticipates-Proposition TURING1950COMPUTING TD_P279)
   (anticipates-Proposition TURING1950COMPUTING M1_ARG93)
   (supports M1_ARG93 M1_ARG87))

(def-instance M1_ARG93 Argument
  ((hasConclusion TD_P278)
   (hasPremise TD_P279)))



(def-instance TD_P280 Proposition
  ((verbalExpression "Computers can be the subject of their own
thoughts.")))
(def-instance TD_P281 Proposition
  ((verbalExpression "When a computer solves equations, the equations
can be said to be the object of its thought.")))
(def-instance TD_P282 Proposition
  ((verbalExpression "Similarly, when a computer is used to predict
its own behavior or to modify its own program, we can say that it is
the object of its own thoughts.")))

(def-relation-instances
   (expresses TURING1950COMPUTING TD_P280)
   (expresses TURING1950COMPUTING TD_P281)
   (expresses TURING1950COMPUTING TD_P282)
   (expresses TURING1950COMPUTING M1_ARG94)
   (disputes M1_ARG94 M1_ARG93))

(def-instance M1_ARG94 Argument
  ((hasConclusion TD_P280)
   (hasPremise TD_P281 TD_P282)))


(def-instance TD_P283 Proposition
  ((verbalExpression "Computers can't exhibit much diversity of
behavior.")))
(def-instance TD_P284 Proposition
  ((verbalExpression "Humans can display much more diversity of
behavior than machines ever will.")))


(def-relation-instances
   (anticipates-Proposition TURING1950COMPUTING TD_P283)
   (anticipates-Proposition TURING1950COMPUTING TD_P284)
   (anticipates-Proposition TURING1950COMPUTING M1_ARG95)
   (supports M1_ARG95 M1_ARG87))

(def-instance M1_ARG95 Argument
  ((hasConclusion TD_P283)
   (hasPremise TD_P284)))


(def-instance TD_P285 Proposition
  ((verbalExpression "Diversity of behavior depends only on storage
capacity.")))
(def-instance TD_P286 Proposition
  ((verbalExpression "Great diversity of behavior is possible for
machines if they have large enough storage capacities.")))
(def-instance TD_P287 Proposition
  ((verbalExpression "The objection is based on the misconception
that it is not possible for a machine to have much storage
capacity.")))

(def-relation-instances
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   (expresses TURING1950COMPUTING TD_P285)
   (expresses TURING1950COMPUTING TD_P286)
   (expresses TURING1950COMPUTING TD_P287)
   (expresses TURING1950COMPUTING M1_ARG96)
   (disputes M1_ARG96 M1_ARG95))

(def-instance M1_ARG96 Argument
  ((hasConclusion TD_P285)
   (hasPremise TD_P286 TD_P287)))



;;============================================================
;;TD_ISS10 "Can computers be creative?"
;;============================================================

(def-instance TD_PERSP10 Proposition
  ((verbalExpression "Computers can never be creative.")))
(def-instance TD_P288 Proposition
  ((verbalExpression "Computers only do what they are programmed to
do; they have no originality or creative powers.")))

(def-relation-instances
   (addresses TD_PERSP10 TD_ISS10)
   (disputes M1_ARG97 M1_ARG1))

(def-instance M1_ARG97 Argument
  ((hasConclusion TD_PERSP10)
   (hasPremise TD_P288)))


(def-instance TD_P289 Proposition
  ((verbalExpression "Machines can never take us by surprise.")))
(def-instance TD_P290 Proposition
  ((verbalExpression "Machines are entirely predictable in their
behavior.")))
(def-instance TD_P291 Proposition
  ((verbalExpression "Because they never do anything new, they can
never surprise us.")))


(def-relation-instances
   (anticipates-Proposition TURING1950COMPUTING TD_P289)
   (anticipates-Proposition TURING1950COMPUTING TD_P290)
   (anticipates-Proposition TURING1950COMPUTING TD_P291)
   (anticipates-Proposition TURING1950COMPUTING M1_ARG98)
   (supports M1_ARG98 M1_ARG97))

(def-instance M1_ARG98 Argument
  ((hasConclusion TD_P289)
   (hasPremise TD_P290 TD_P291)))



(def-instance TD_P292 Proposition
  ((verbalExpression "Computers are not entirely predictable.")))
(def-instance TD_P293 Proposition
  ((verbalExpression "The belief that computers are entirely
predictable arises from the false assumption (widespread in
philosophy and in mathematics) that humans can know everything that
follows deductively from a set of premises.")))
(def-instance TD_P294 Proposition
  ((verbalExpression "But humans learn new things in part through the
working out of deductive consequences.")))
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(def-instance TD_P295 Proposition
  ((verbalExpression "Similarly, humans don't know everything a
computer will do given some initial state of the computer; we learn
new things in part by watching them perform their calculations.")))

(def-relation-instances
   (expresses TURING1950COMPUTING TD_P292)
   (expresses TURING1950COMPUTING TD_P293)
   (expresses TURING1950COMPUTING TD_P294)
   (expresses TURING1950COMPUTING TD_P295)
   (expresses TURING1950COMPUTING M1_ARG99)
   (disputes M1_ARG99 M1_ARG98))

(def-instance M1_ARG99 Argument
  ((hasConclusion TD_P292)
   (hasPremise TD_P293 TD_P294 TD_P295)))


(def-instance TD_P296 Proposition
  ((verbalExpression "Machines frequently take us by surprise.")))
(def-instance TD_P297 Proposition
  ((verbalExpression "Computer users and even experts are often
surprised by the things that computers do.")))

(def-relation-instances
   (expresses TURING1950COMPUTING TD_P296)
   (expresses TURING1950COMPUTING TD_P297)
   (expresses TURING1950COMPUTING M1_ARG100)
   (disputes M1_ARG100 M1_ARG98))

(def-instance M1_ARG100 Argument
  ((hasConclusion TD_P296)
   (hasPremise TD_P297)))

(def-instance TD_P298 Proposition
  ((verbalExpression "Surprise is a result of human creativity.")))
(def-instance TD_P299 Proposition
  ((verbalExpression "Even if we are surprised by what a machine
does, that reaction does not mean that the machine has done anything
original or creative.")))
(def-instance TD_P300 Proposition
  ((verbalExpression "It just means that the human made a creative
prediction about what the computer would do, and was then surprised
when the computer acted differently.")))

(def-relation-instances
   (anticipates-Proposition TURING1950COMPUTING TD_P298)
   (anticipates-Proposition TURING1950COMPUTING TD_P299)
   (anticipates-Proposition TURING1950COMPUTING TD_P300)
   (anticipates-Proposition TURING1950COMPUTING M1_ARG101)
   (disputes M1_ARG101 M1_ARG100))

(def-instance M1_ARG101 Argument
  ((hasConclusion TD_P298)
   (hasPremise TD_P299 TD_P300)))


(def-instance TD_P301 Proposition
  ((verbalExpression "The argument from human creativity applies to
any case of surprise.")))
(def-instance TD_P302 Proposition
  ((verbalExpression "You could always say that being surprised came
from you, the interpreter, rather than from anything original on the
other person's or machine's part.")))
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(def-instance TD_P303 Proposition
  ((verbalExpression "For example, if a human surprises you with a
joke, then you could argue that the surprise was a result of your
interpretation of the joke rather than anything creative on the joke
teller's part.")))

(def-relation-instances
   (expresses TURING1950COMPUTING TD_P301)
   (expresses TURING1950COMPUTING TD_P302)
   (expresses TURING1950COMPUTING TD_P303)
   (expresses TURING1950COMPUTING M1_ARG102)
   (disputes M1_ARG102 M1_ARG101))

(def-instance M1_ARG102 Argument
  ((hasConclusion TD_P301)
   (hasPremise TD_P302 TD_P303)))


(def-instance TD_P304 Proposition
  ((verbalExpression "The analytical engine can never do anything
original.")))
(def-instance TD_P305 Proposition
  ((verbalExpression "The analytical engine could never discover any
new facts.")))
(def-instance TD_P306 Proposition
  ((verbalExpression "It is limited to drawing out consequences of
facts that it has been provided with.")))
(def-instance TD_P307 Proposition
  ((verbalExpression "The analytical engine has no pretensions to
originate anything.")))
(def-instance TD_P308 Proposition
  ((verbalExpression "It can follow analysis; but it has no power of
anticipating any analytical relations or truths.")))

(def-relation-instances
   (expresses some-publication-by-lovelace-1842 TD_P304)
   (expresses some-publication-by-lovelace-1842 TD_P305)
   (expresses some-publication-by-lovelace-1842 TD_P306)
   (expresses some-publication-by-lovelace-1842 TD_P307)
   (expresses some-publication-by-lovelace-1842 TD_P308)
   (expresses some-publication-by-lovelace-1842 M1_ARG103)
   (relates-to-concept TD_P304 $Analytical_Engine)
   (supports M1_ARG103 M1_ARG98))

(def-instance M1_ARG103 Argument
  ((hasConclusion TD_P304)
   (hasPremise TD_P305 TD_P306 TD_P307 TD_P308)))


(def-instance TD_P309 Proposition
  ((verbalExpression "The analytical engine may have been able to
think for itself.")))
(def-instance TD_P310 Proposition
  ((verbalExpression "Ada Lovelace was justified in denying that the
analytical engine could be creative, because she had no evidence that
it was creative.")))
(def-instance TD_P311 Proposition
  ((verbalExpression "But because the analytical engine was in fact a
universal digital computer, it may have had far greater capabilities
than she realized.")))
(def-instance TD_P312 Proposition
  ((verbalExpression ". With added speed and storage capacity the
analytical engine may have been able to think for itself.")))
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(def-relation-instances
   (expresses TURING1950COMPUTING TD_P309)
   (expresses TURING1950COMPUTING TD_P310)
   (expresses TURING1950COMPUTING TD_P311)
   (expresses TURING1950COMPUTING TD_P312)
   (expresses TURING1950COMPUTING M1_ARG104)
   (disputes M1_ARG104 M1_ARG103))

(def-instance M1_ARG104 Argument
  ((hasConclusion TD_P309)
   (hasPremise TD_P310 TD_P311 TD_P312)))


(def-instance TD_P313 Proposition
  ((verbalExpression "Computers have already been creative.")))
(def-instance TD_P314 Proposition
  ((verbalExpression "Computer models that exhibit creativity or at
least some component of creativity have already been developed.")))

(def-relation-instances
   (disputes M1_ARG105 M1_ARG97))

(def-instance M1_ARG105 Argument
  ((hasConclusion TD_P313)
   (hasPremise TD_P314)))



(def-instance TD_P315 Proposition
  ((verbalExpression "There is the ELIZA effect.")))
(def-instance TD_P316 Proposition
  ((verbalExpression "The ELIZA effect is a tendency to read more
into computer performance than is warranted by their underlying
code.")))
(def-instance TD_P317 Proposition
  ((verbalExpression "For example, the computerized psychotherapy
program ELIZA gives apparently sympathetic responses to human
concerns, but in fact is only utilizing a set of canned
responses.")))

(def-relation-instances
   (is-label-for $eliza_effect TD_P315)
   (expresses HOFSTADTER1995FLUID TD_P315)
   (expresses HOFSTADTER1995FLUID TD_P316)
   (expresses HOFSTADTER1995FLUID TD_P317)
   (expresses HOFSTADTER1995FLUID M1_ARG106)
   (disputes M1_ARG106 M1_ARG105))


(def-instance M1_ARG106 Argument
  ((hasConclusion TD_P315)
   (hasPremise TD_P316 TD_P317)))


(def-instance TD_P318 Proposition
  ((verbalExpression "There is the implemented model geometry
program.")))
(def-instance TD_P319 Proposition
  ((verbalExpression "The geometry program is a system that works
backward from geometric theorems, searching for their proofs by
means-end analysis.")))
(def-instance TD_P320 Proposition
  ((verbalExpression "This planning breaks down the problems using a
hierarchy of goals and subgoals.")))
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(def-instance TD_P321 Proposition
  ((verbalExpression "To avoid impossible searches the program uses
heuristics to select the most promising search paths.")))

(def-relation-instances
   (expresses some-publication-by-gelernter-1963 TD_P318)
   (expresses some-publication-by-gelernter-1963 TD_P319)
   (expresses some-publication-by-gelernter-1963 TD_P320)
   (expresses some-publication-by-gelernter-1963 TD_P321)
   (expresses some-publication-by-gelernter-1963 M1_ARG107)
   (supports M1_ARG107 M1_ARG105))

(def-instance M1_ARG107 Argument
  ((hasConclusion TD_P318)
   (hasPremise TD_P319 TD_P320 TD_P321)))


(def-instance TD_P322 Proposition
  ((verbalExpression "There is the implemented model jazz
generator.")))
(def-instance TD_P323 Proposition
  ((verbalExpression "The jazz generator produces chord sequences and
uses them to improvise chords, bass-line melodies, and rhythms.")))

(def-relation-instances
   (expresses JOHNSON-LAIRD1988COMPUTER TD_P322)
   (expresses JOHNSON-LAIRD1988COMPUTER TD_P323)
   (expresses JOHNSON-LAIRD1988COMPUTER M1_ARG108)
   (supports M1_ARG108 M1_ARG105))

(def-instance M1_ARG108 Argument
  ((hasConclusion TD_P322)
   (hasPremise TD_P323)))


(def-instance TD_P324 Proposition
  ((verbalExpression "There is the implemented model Haiku
program.")))
(def-instance TD_P325 Proposition
  ((verbalExpression "A program has been written that develops haiku
(a style of Japanese poetry) through interaction with humans.")))
(def-instance TD_P326 Proposition
  ((verbalExpression "The model provides poets with synonym lists to
aid in word choice and also constrains line length to ensure that the
haiku is properly formed.")))
(def-instance TD_P327 Proposition
  ((verbalExpression "The haiku program can run without human
interaction by making arbitrary choices from its synonym lists.")))

(def-relation-instances
   (expresses some-publication-by-masterman-1971 TD_P324)
   (expresses some-publication-by-masterman-1971 TD_P325)
   (expresses some-publication-by-masterman-1971 TD_P326)
   (expresses some-publication-by-masterman-1971 TD_P327)
   (expresses some-publication-by-masterman-1971 M1_ARG109)
   (supports M1_ARG109 M1_ARG105))

(def-instance M1_ARG109 Argument
  ((hasConclusion TD_P324)
   (hasPremise TD_P325 TD_P326 TD_P327)))


(def-instance TD_P328 Proposition
  ((verbalExpression "There is the implemented model TAIL-SPIN.")))
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(def-instance TD_P329 Proposition
  ((verbalExpression "This program writes stories with characters
that have goals and subgoals dependent on their motivations.")))
(def-instance TD_P330 Proposition
  ((verbalExpression "Its characters cooperate in each other's plans
and can form competitive relationships when necessary to achieve
their goals.")))
(def-instance TD_P331 Proposition
  ((verbalExpression "The program can also represent a wide range of
communications between its characters.")))

(def-relation-instances
   (expresses some-publication-by-meehan-1975 TD_P328)
   (expresses some-publication-by-meehan-1975 TD_P329)
   (expresses some-publication-by-meehan-1975 TD_P330)
   (expresses some-publication-by-meehan-1975 TD_P331)
   (expresses some-publication-by-meehan-1975 M1_ARG110)
   (supports M1_ARG110 M1_ARG105))

(def-instance M1_ARG110 Argument
  ((hasConclusion TD_P328)
   (hasPremise TD_P329 TD_P330 TD_P331)))


(def-instance TD_P332 Proposition
  ((verbalExpression "There is the implemented model AARON.")))
(def-instance TD_P333 Proposition
  ((verbalExpression "AARON produces visual art by selecting a random
starting point on a canvas and then drawing lines from that point
using a complex set of if-then rules.")))

(def-relation-instances
   (expresses some-publication-by-cohen-1984 TD_P332)
   (expresses some-publication-by-cohen-1984 TD_P333)
   (expresses some-publication-by-cohen-1984 M1_ARG111)
   (supports M1_ARG111 M1_ARG105))

(def-instance M1_ARG111 Argument
  ((hasConclusion TD_P332)
   (hasPremise TD_P333)))


(def-instance TD_P334 Proposition
  ((verbalExpression "Connectionist systems exhibit creativity.")))
(def-instance TD_P335 Proposition
  ((verbalExpression "Connectionist networks can learn to recognize
patterns without being specifically programmed to do so.")))

(def-relation-instances
   (expresses some-publication-by-boden-1990 TD_P334)
   (expresses some-publication-by-boden-1990 TD_P335)
   (expresses some-publication-by-boden-1990 M1_ARG112)
   (supports M1_ARG112 M1_ARG105))

(def-instance M1_ARG112 Argument
  ((hasConclusion TD_P334)
   (hasPremise TD_P335)))


(def-instance TD_P336 Proposition
  ((verbalExpression "There is the implemented model book
generator.")))
(def-instance TD_P337 Proposition
  ((verbalExpression "This automatic novel writer generates 2,100-
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word mysteries.")))
(def-instance TD_P338 Proposition
  ((verbalExpression "It develops a rudimentary plot based on the
conflicting motivations of its characters and fits the model of a
mystery story by revealing the murderer at the end.")))

(def-relation-instances
   (expresses some-publication-by-klein-1975 TD_P336)
   (expresses some-publication-by-klein-1975 TD_P337)
   (expresses some-publication-by-klein-1975 TD_P338)
   (expresses some-publication-by-klein-1975 M1_ARG113)
   (supports M1_ARG113 M1_ARG105))

(def-instance M1_ARG113 Argument
  ((hasConclusion TD_P336)
   (hasPremise TD_P337 TD_P338)))


(def-instance TD_P339 Proposition
  ((verbalExpression "The book generator is inadequate.")))
(def-instance TD_P340 Proposition
  ((verbalExpression "The book-writing program's fiction is
inadequate for the following reasons: (1) The stories are shapeless
and rambling, (2) The specific motivational patterns are relatively
crude and unstructured, and (3) The identification of the murderer
comes as a Proposition rather than as a discovery.")))

(def-relation-instances
   (expresses SOME-PUBLICATION-BY-BODEN-1977 TD_P339)
   (expresses SOME-PUBLICATION-BY-BODEN-1977 TD_P340)
   (expresses SOME-PUBLICATION-BY-BODEN-1977 M1_ARG114)
   (disputes M1_ARG114 M1_ARG113))

(def-instance M1_ARG114 Argument
  ((hasConclusion TD_P339)
   (hasPremise TD_P340)))


;;==============================================================
;;TD_ISS11 "Can computers reason scientifically?"
;;==============================================================

(def-instance TD_PERSP11 Proposition
  ((verbalExpression "Computers can't reason scientifically.")))
(def-instance TD_P341 Proposition
  ((verbalExpression "Computers are unable to think and reason as
human scientists do.")))

(def-relation-instances
   (addresses TD_PERSP11 TD_ISS11)
   (disputes M1_ARG115 M1_ARG1))

(def-instance M1_ARG115 Argument
  ((hasConclusion TD_PERSP11)
   (hasPremise TD_P341)))


(def-instance TD_P342 Proposition
  ((verbalExpression "Scientific reasoning requires social
agreement.")))
(def-instance TD_P343 Proposition
  ((verbalExpression "Computers cannot reason scientifically because
they are not members of society.")))
(def-instance TD_P344 Proposition
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  ((verbalExpression "Scientific laws and data do not follow from the
application of an algorithm, but are developed through a
quasipolitical process of negotiation.")))

(def-relation-instances
   (expresses some-publication-by-collins-1994 TD_P342)
   (expresses some-publication-by-collins-1994 TD_P343)
   (expresses some-publication-by-collins-1994 TD_P344)
   (expresses some-publication-by-collins-1994 M1_ARG116)
   (supports M1_ARG116 M1_ARG115))

(def-instance M1_ARG116 Argument
  ((hasConclusion TD_P342)
   (hasPremise TD_P343 TD_P344)))


(def-instance TD_P345 Proposition
  ((verbalExpression "There is the socialization test.")))
(def-instance TD_P346 Proposition
  ((verbalExpression "The importance of socialization is demonstrated
by the 'socialization
test', a variant of the Turing test.")))
(def-instance TD_P347 Proposition
  ((verbalExpression "In the socialization test, a human control and
a machine are both given a passage of 'mucked-up' English.")))
(def-instance TD_P348 Proposition
  ((verbalExpression "Both the machine and the human control must
correct all the errors and transliterate the passage into normal
English.")))
(def-instance TD_P349 Proposition
  ((verbalExpression "If a judge cannot tell which text was error-
corrected by machine and which by the human control subject, then the
machine passes this test for socialization.")))

(def-relation-instances
   (expresses some-publication-by-collins-1994 TD_P345)
   (expresses some-publication-by-collins-1994 TD_P346)
   (expresses some-publication-by-collins-1994 TD_P347)
   (expresses some-publication-by-collins-1994 TD_P348)
   (expresses some-publication-by-collins-1994 TD_P349)
   (expresses some-publication-by-collins-1994 M1_ARG117)
   (supports M1_ARG117 M1_ARG116))

(def-instance M1_ARG117 Argument
  ((hasConclusion TD_P345)
   (hasPremise TD_P346 TD_P347 TD_P348 TD_P349)))


(def-instance TD_P350 Proposition
  ((verbalExpression "Computers can't introduce new terms or
explanatory principles.")))
(def-instance TD_P351 Proposition
  ((verbalExpression "A computer cannot be original because it cannot
introduce new theoretical terms or principles.")))
(def-instance TD_P352 Proposition
  ((verbalExpression "Computers' 'discoveries' are limited to those
that can be expressed using the program's fixed vocabulary and
conceptual apparatus.")))
(def-instance TD_P353 Proposition
  ((verbalExpression "Human discovery, by contrast, involves the
introduction of new terms and principles that cannot be defined in
terms of those previously available.")))

(def-relation-instances
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   (expresses some-publication-by-hempel-1985 TD_P350)
   (expresses some-publication-by-hempel-1985 TD_P351)
   (expresses some-publication-by-hempel-1985 TD_P352)
   (expresses some-publication-by-hempel-1985 TD_P353)
   (expresses some-publication-by-hempel-1985 M1_ARG118)
   (supports M1_ARG118 M1_ARG115))

(def-instance M1_ARG118 Argument
  ((hasConclusion TD_P350)
   (hasPremise TD_P351 TD_P352 TD_P353)))


(def-instance TD_P354 Proposition
  ((verbalExpression "Computers can introduce new terms.")))
(def-instance TD_P355 Proposition
  ((verbalExpression "Computers can introduce new terms using
automated principles of explanatory adequacy.")))
(def-instance TD_P356 Proposition
  ((verbalExpression "This has been shown using a program that uses
explanatory adequacy principles to introduce new terms in the domain
of 'causal models'-a class of mathematical theories popular in social
science.")))

(def-relation-instances
   (expresses some-publication-by-scheines-1988 TD_P354)
   (expresses some-publication-by-scheines-1988 TD_P355)
   (expresses some-publication-by-scheines-1988 TD_P356)
   (expresses some-publication-by-scheines-1988 M1_ARG119)
   (disputes M1_ARG119 M1_ARG118))


(def-instance M1_ARG119 Argument
  ((hasConclusion TD_P354)
   (hasPremise TD_P355 TD_P356)))


(def-instance TD_P357 Proposition
  ((verbalExpression "Computers can't adequately evaluate
hypotheses.")))
(def-instance TD_P358 Proposition
  ((verbalExpression "A computer model of scientific discovery would
have to use a criterion of preference to choose between hypotheses
that account for available data equally well.")))
(def-instance TD_P359 Proposition
  ((verbalExpression "But criteria of preference tend to be imprecise
and idiosyncratic, so it is unlikely that such a criterion could be
implemented on a computer.")))

(def-relation-instances
   (expresses some-publication-by-hempel-1985 TD_P357)
   (expresses some-publication-by-hempel-1985 TD_P358)
   (expresses some-publication-by-hempel-1985 TD_P359)
   (expresses some-publication-by-hempel-1985 M1_ARG120)
   (supports M1_ARG120 M1_ARG115))

(def-instance M1_ARG120 Argument
  ((hasConclusion TD_P357)
   (hasPremise TD_P358 TD_P359)))



(def-instance TD_P360 Proposition
  ((verbalExpression "Computers have already reasoned
scientifically.")))
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(def-instance TD_P361 Proposition
  ((verbalExpression "Computer systems exist that have reasoned as
scientists do, proposing explanatory hypotheses and choosing among
them.")))

(def-relation-instances
   (disputes M1_ARG121 M1_ARG115))

(def-instance M1_ARG121 Argument
  ((hasConclusion TD_P360)
   (hasPremise TD_P361)))


(def-instance TD_P362 Proposition
  ((verbalExpression "There is the implemented model BACON.")))
(def-instance TD_P363 Proposition
  ((verbalExpression "A program for discovering laws from data by
applying heuristics, BACON has discovered Kepler's law of planetary
motion, Galileo's law of uniform acceleration, and Ohm's law of
electrical resistance.")))

(def-relation-instances
   (expresses some-publication-by-langley-1987 TD_P362)
   (expresses some-publication-by-langley-1987 TD_P363)
   (expresses some-publication-by-langley-1987 M1_ARG122)
   (supports M1_ARG122 M1_ARG121))

(def-instance M1_ARG122 Argument
  ((hasConclusion TD_P362)
   (hasPremise TD_P363)))


(def-instance TD_P364 Proposition
  ((verbalExpression "BACON only works when humans filter its
data.")))
(def-instance TD_P365 Proposition
  ((verbalExpression "Bacon only works through its interaction with
scientists who filter its data and thereby predetermine its
results.")))
(def-instance TD_P366 Proposition
  ((verbalExpression "If humans did not constrain its data, it is
doubtful that BACON would produce any original science.")))

(def-relation-instances
   (expresses some-publication-by-collins-1994 TD_P364)
   (expresses some-publication-by-collins-1994 TD_P365)
   (expresses some-publication-by-collins-1994 TD_P366)
   (expresses some-publication-by-collins-1994 M1_ARG123)
   (disputes M1_ARG123 M1_ARG122)
   (supports M1_ARG75 M1_ARG123))

(def-instance M1_ARG123 Argument
  ((hasConclusion TD_P364)
   (hasPremise TD_P365 TD_P366)))


(def-instance TD_P367 Proposition
  ((verbalExpression "There is the implemented model DENDRAL.")))
(def-instance TD_P368 Proposition
  ((verbalExpression "DENDRAL is an expert system that analyzes and
identifies chemical compounds by forming and testing hypotheses from
experimental data.")))
(def-instance TD_P369 Proposition
  ((verbalExpression "Meta-DENDRAL, a component of DENDRAL, has
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discovered how to synthesize previously unknown chemical compounds as
well as entirely new rules of chemical analysis, and it even has a
publication to its credit.")))

(def-relation-instances
   (expresses some-publication-by-buchanan-1976 TD_P367)
   (expresses some-publication-by-buchanan-1976 TD_P368)
   (expresses some-publication-by-buchanan-1976 TD_P369)
   (expresses some-publication-by-buchanan-1976 M1_ARG124)
   (supports M1_ARG124 M1_ARG121))

(def-instance M1_ARG124 Argument
  ((hasConclusion TD_P367)
   (hasPremise TD_P368 TD_P369)))


;;==============================================================
;;TD_ISS12 "Can computers be persons?"
;;==============================================================

(def-instance TD_PERSP12 Proposition
  ((verbalExpression "Computers can't be persons.")))
(def-instance TD_P370 Proposition
  ((verbalExpression "Machines can never be persons.")))
(def-instance TD_P371 Proposition
  ((verbalExpression "They lack ethical status and cannot bear
responsibility for their actions.")))
(def-instance TD_P372 Proposition
  ((verbalExpression "At best they can display personlike
behavior.")))

(def-relation-instances
   (addresses TD_PERSP12 TD_ISS12)
   (disputes M1_ARG125 M1_ARG1))

(def-instance M1_ARG125 Argument
  ((hasConclusion TD_PERSP12)
   (hasPremise TD_P370 TD_P371 TD_P372)))


(def-instance TD_P373 Proposition
  ((verbalExpression "An artificial person can be built.")))
(def-instance TD_P374 Proposition
  ((verbalExpression "An artificial person can be built from physical
ingredients provided it adequately models human rationality, which is
the suitable structure necessary for personhood.")))

(def-relation-instances
   (expresses some-publication-by-pollock-1989 TD_P373)
   (expresses some-publication-by-pollock-1989 TD_P374)
   (expresses some-publication-by-pollock-1989 M1_ARG126)
   (disputes M1_ARG126 M1_ARG125))

(def-instance M1_ARG126 Argument
  ((hasConclusion TD_P373)
   (hasPremise TD_P374)))



(def-instance TD_P375 Proposition
  ((verbalExpression "Robots can do intelligent things but will never
be persons.")))
(def-instance TD_P376 Proposition
  ((verbalExpression "AI will eventually succeed in building robots
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that can behave intelligently but will never make robots that are
actually persons.")))
(def-instance TD_P377 Proposition
  ((verbalExpression "Persons are genuine things (rather than logical
constructions) that bear psychological properties and that can bring
about states of affairs in the world.")))

(def-relation-instances
   (expresses SOME-PUBLICATION-BY-BRINGSJORD-1992 TD_P375)
   (expresses SOME-PUBLICATION-BY-BRINGSJORD-1992 TD_P376)
   (expresses SOME-PUBLICATION-BY-BRINGSJORD-1992 TD_P377)
   (expresses SOME-PUBLICATION-BY-BRINGSJORD-1992 M1_ARG127)
   (supports M1_ARG127 M1_ARG125))

(def-instance M1_ARG127 Argument
  ((hasConclusion TD_P375)
   (hasPremise TD_P376 TD_P377)))


(def-instance TD_P378 Proposition
  ((verbalExpression "A machine isn't a person unless society deems
it one.")))
(def-instance TD_P379 Proposition
  ((verbalExpression "A machine or an individual is not a person
until society collectively declares it one.")))
(def-instance TD_P380 Proposition
  ((verbalExpression "This requires having a gender, a flesh-and-
blood body, the ability to feel pain, and so forth.")))
(def-instance TD_P381 Proposition
  ((verbalExpression "If a machine lacks any of these - if, for
example, it is disembodied and can't feel pain - it won't be
recognized as or treated as a person.")))

(def-relation-instances
   (expresses some-publication-by-van-de-vate-jr-1971 TD_P378)
   (expresses some-publication-by-van-de-vate-jr-1971 TD_P379)
   (expresses some-publication-by-van-de-vate-jr-1971 TD_P380)
   (expresses some-publication-by-van-de-vate-jr-1971 TD_P381)
   (expresses some-publication-by-van-de-vate-jr-1971 M1_ARG128)
   (supports M1_ARG128 M1_ARG125))

(def-instance M1_ARG128 Argument
  ((hasConclusion TD_P378)
   (hasPremise TD_P379 TD_P380 TD_P381)))


(def-instance TD_P382 Proposition
  ((verbalExpression "Machines can behave like persons in the
imitation game.")))
(def-instance TD_P383 Proposition
  ((verbalExpression "A machine could treat others like a person and
be treated like a person in an imitation game.")))


   (anticipates-Proposition some-publication-by-van-de-vate-jr-1971
TD_P382)
   (anticipates-Proposition some-publication-by-van-de-vate-jr-1971
TD_P383)
   (anticipates-Proposition some-publication-by-van-de-vate-jr-1971
M1_ARG129)
   (disputes M1_ARG129 M1_ARG128))

(def-instance M1_ARG129 Argument
  ((hasConclusion TD_P382)
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   (hasPremise TD_P383)))

(def-instance TD_P384 Proposition
  ((verbalExpression "Laboratory performance isn't enough for full
reciprocity of social behavior.")))
(def-instance TD_P385 Proposition
  ((verbalExpression "A machine in a lab playing the imitation game
is not yet a person because it is not really being treated like
one.")))
(def-instance TD_P386 Proposition
  ((verbalExpression "It's treated like an artifact in an experiment,
which we can unplug and ignore as we see fit.")))

(def-relation-instances
   (expresses some-publication-by-van-de-vate-jr-1971 TD_P384)
   (expresses some-publication-by-van-de-vate-jr-1971 TD_P385)
   (expresses some-publication-by-van-de-vate-jr-1971 TD_P386)
   (expresses some-publication-by-van-de-vate-jr-1971 M1_ARG130)
   (disputes M1_ARG130 M1_ARG129))

(def-instance M1_ARG130 Argument
  ((hasConclusion TD_P384)
   (hasPremise TD_P385 TD_P386)))

(def-instance TD_P387 Proposition
  ((verbalExpression "Reciprocity of social behavior is required for
personhood.")))
(def-instance TD_P388 Proposition
  ((verbalExpression "Persons must be capable of treating others like
persons in a variety of contexts.")))
(def-instance TD_P389 Proposition
  ((verbalExpression "Persons must be treated like a person by
members of society in a variety of contexts.")))

(def-relation-instances
   (expresses some-publication-by-van-de-vate-jr-1971 TD_P387)
   (expresses some-publication-by-van-de-vate-jr-1971 TD_P388)
   (expresses some-publication-by-van-de-vate-jr-1971 TD_P389)
   (expresses some-publication-by-van-de-vate-jr-1971 M1_ARG131)
   (supports M1_ARG131 M1_ARG128))

(def-instance M1_ARG131 Argument
  ((hasConclusion TD_P387)
   (hasPremise TD_P388 TD_P389)))
```

APPENDIX C FULL OCML SPECIFICATION OF THE ABORTION DEBATE KNOWLEDGE BASE

This Appendix presents the OCML code which defines the class and relation instances that correspond to the representation of the Abortion debate.

```
(in-package "OCML")

(in-ontology scholarly-domain)


;;The source material for the debate overview is largely taken from
the website http://en.wikipedia.org/wiki/Abortion_debate

;---------------------------------------------------------------------
-----------------------------------------------------
(def-instance ad_iss1 Issue
  ((verbalExpression "What should be the legal status of
abortions?")))

(def-instance ad_iss2 Issue
  ((verbalExpression "When is the embryo or fetus considered a
person?")))

(def-instance ad_iss3 Issue
  ((verbalExpression "Is aborting a zygote, embryo, or fetus a
violation of human rights?")))

(def-instance ad_iss4 Issue
  ((verbalExpression "Is preventing a woman from terminating her
unwanted pregnancy a violation of her human rights?")))

(def-instance ad_iss5 Issue
  ((verbalExpression "Does pregnancy induced by rape or incest or by
poor birth control use change the permissibility of abortion?")))

(def-instance ad_iss6 Issue
  ((verbalExpression "Is adoption a viable and fair alternative to
abortion?")))

(def-instance ad_iss7 Issue
  ((verbalExpression "Are laws controlling abortion violations of
privacy and/or other personal liberties?")))

(def-instance ad_iss8 Issue
  ((verbalExpression "Should a pregnant minor need the consent of her
parents for abortion?")))

(def-instance ad_iss9 Issue
  ((verbalExpression "Should a pregnant woman need the consent of the
biological father for abortion?")))

(def-relation-instances
   (relatedIssueOf ad_iss1 ad_iss2)
   (relatedIssueOf ad_iss1 ad_iss3)
   (relatedIssueOf ad_iss1 ad_iss4)
   (relatedIssueOf ad_iss1 ad_iss5)
   (relatedIssueOf ad_iss1 ad_iss6)
   (relatedIssueOf ad_iss1 ad_iss7)
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   (relatedIssueOf ad_iss1 ad_iss8)
   (relatedIssueOf ad_iss1 ad_iss9)
   (relates-to-concept ad_iss2 $human_personhood))

;----------------------------------------------------------------------
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(def-instance ad_p1 Proposition
  ((verbalExpression "Abortion should always be legal")))

(def-instance ad_p2 Proposition
  ((verbalExpression "Only abortion up to the start of the third
trimester should be legal")))

;IMPLIES "Abortion in the third trimester should be illegal"

(def-instance ad_p3 Proposition
  ((verbalExpression "Only abortion in the first trimester (or before
the embryo or fetus is viable outside the womb) should be legal")))
;IMPLIES "Abortion after the first trimester should be illegal"

(def-instance ad_p4 Proposition
  ((verbalExpression "Abortion should always be illegal, except in
some special circumstances - for example, when the woman's long-term
health or life is at stake, or when the pregnancy is the result of
rape or incest, or when the infant has no long-term viability, or
when the infant is likely to be born severely disabled")))
;FOR EXAMPLE "Abortion should be illegal except when the woman's
long-term health or life is at stake" "Abortion should be illegal
except when the pregnancy is the result of rape or incest" "Abortion
should be illegal except when the infant has no long-term viability"
;"Abortion should be illegal except when the infant is likely to be
born severely disabled"

(def-instance ad_p5 Proposition
  ((verbalExpression "Abortion should always be illegal")))
(tell (disputes ad_p5 ad_p1))

(def-instance ad_p6 Proposition
  ((verbalExpression "Abortion should be illegal and so should forms
of birth control that can act by preventing implantation of a
fertilised egg")))

(def-relation-instances
  (addresses ad_p1 ad_iss1)
  (addresses ad_p2 ad_iss1)
  (addresses ad_p3 ad_iss1)
  (addresses ad_p4 ad_iss1)
  (addresses ad_p5 ad_iss1)
  (addresses ad_p6 ad_iss1))

;----------------------------------------------------------------------
-------------------------------------------------


(def-instance pro-life-p1 Proposition
  ((verbalExpression "The existence and moral right to life of human
organisms begins at or near conception-fertilisation")))

(def-instance pro-life-p2 Proposition
  ((verbalExpression "Induced abortion is the deliberate and unjust
killing of the fetus in violation of its right to life")))

(def-instance pro-life-p3 Proposition
  ((verbalExpression "The law should prohibit unjust violations of
the right to life")))
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```
(def-instance pro-life-p4 Proposition
  ((verbalExpression "The law should prohibit abortions")))

(def-instance basic-pro-life-argument Argument
  ((hasPremise pro-life-p1
               pro-life-p2
               pro-life-p3)
   (hasConclusion pro-life-p4)))


(def-relation-instances
  (addresses basic-pro-life-argument ad_iss1)
  (addresses pro-life-p1 ad_iss2)
  (addresses pro-life-p2 ad_iss3))

(def-instance pro-choice-p1 Proposition
  ((verbalExpression "Women have a right to control what happens in
and to their own bodies")))

(def-instance pro-choice-p2 Proposition
  ((verbalExpression "Abortion is a just exercise of a woman's right
to control what happens in and to her body")))

(def-instance pro-choice-p3 Proposition
  ((verbalExpression "The law should not criminalise just exercises
of the right to control one's own body")))

(def-instance pro-choice-p4 Proposition
  ((verbalExpression "The law should not criminalise abortions")))

(def-instance basic-pro-choice-argument Argument
  ((hasPremise pro-choice-p1
               pro-choice-p2
               pro-choice-p3)
   (hasConclusion pro-choice-p4)))


(def-relation-instances
  (addresses basic-pro-choice-argument ad_iss1)
  (addresses pro-choice-p1 ad_iss4)
  (disputes basic-pro-choice-argument basic-pro-life-argument))



;---------------------------------------------------------------------
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;UTILITARIAN PRO-LIFE
;[http://en.wikipedia.org/wiki/Abortion-breast_cancer_hypothesis]
(def-instance ABC_p1 Proposition
  ((verbalExpression "In early pregnancy the level of estrogens
increases, leading to breast growth in preparation for lactation.")))

(def-instance ABC_p2 Proposition
  ((verbalExpression "If this process is interrupted with an abortion
- before full differentiation in the third trimester - then more
relatively vulnerable undifferentiated cells could be left than there
were prior to the pregnancy.")))

(def-instance ABC_p3 Proposition
  ((verbalExpression "There is a causal relationship between induced
abortion and an increased risk of developing breast cancer.")))

(def-instance abortion-breast-cancer-hypothesis Argument
```

```
  ((hasPremise ABC_p1 ABC_p2)
   (hasConclusion ABC_p3)))

(def-relation-instances
  (supports abortion-breast-cancer-hypothesis basic-pro-life-
argument)
  (classifies utilitarianism abortion-breast-cancer-hypothesis))


;[http://en.wikipedia.org/wiki/Post-abortion_syndrome]

(def-instance post-abortion-syndrome_p1 Proposition
   ((verbalExpression "Women who have elective abortions can suffer
from post-abortion syndrome")))

(def-relation-instances
   (supports post-abortion-syndrome_p1 basic-pro-life-argument)
   (classifies utilitarianism post-abortion-syndrome_p1))

;-------------------------------------------------------------------
--------------------------------------------------
;UTILITARIAN PRO-CHOICE

(def-instance back-alley_p1 Proposition
   ((verbalExpression "Criminalising abortion will lead to the deaths
of many women through back-alley abortions")))

(def-instance unwanted-children_p1 Proposition
   ((verbalExpression "Unwanted children have a negative social
impact")))

(def-instance equal-participation_p1 Proposition
   ((verbalExpression "Reproductive rights are necessary to achieve
the full and equal participation of women in society")))

(def-relation-instances
  (supports back-alley_p1 basic-pro-choice-argument)
  (supports unwanted-children_p1 basic-pro-choice-argument)
  (supports equal-participation_p1 basic-pro-choice-argument)
  (classifies utilitarianism back-alley_p1)
  (classifies utilitarianism unwanted-children_p1)
  (classifies utilitarianism equal-participation_p1))


;-------------------------------------------------------------------
----------------------------------------------


(def-instance ad_iss10 Issue
  ((verbalExpression "Is the fetus a person in the moral sense?")))

(def-instance ad_iss10_view1 Proposition
  ((verbalExpression "Yes the fetus is a person in the moral
sense")))

(def-instance ad_iss10_view2 Proposition
  ((verbalExpression "No the fetus is not a person in the moral
sense")))

(def-relation-instances
  (relatedIssueOf ad_iss1 ad_iss10)
  (addresses ad_iss10_view1 ad_iss10)
  (addresses ad_iss10_view2 ad_iss10)
  (supports ad_iss10_view1 pro-life-p1)
  (supports ad_iss10_view2 pro-choice-p2))
```

```
(def-instance ad_iss11 Issue
  ((verbalExpression "Do a woman's bodily rights justify abortion
even if the fetus has a right to life?")))

(def-instance ad_iss11_view1 Proposition
  ((verbalExpression "No, a woman's bodily rights do not justify
abortion even if the fetus has a right to life")))

(def-instance ad_iss11_view2 Proposition
  ((verbalExpression "Yes, a woman's bodily rights justify abortion
even if the fetus has a right to life")))

(def-relation-instances
  (relatedIssueOf ad_iss1 ad_iss11)
  (addresses ad_iss11_view1 ad_iss11)
  (addresses ad_iss11_view2 ad_iss11)
  (supports ad_iss11_view1 pro-life-p2)
  (supports ad_iss11_view2 pro-choice-p2))


;--------------------------------------------------------------------
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(def-instance warren1973on_p1 Proposition
   ((verbalExpression "Although the fetus is a biologically human
organism, it does not follow that the fetus is a person with rights
such as the right to life.")))


(def-instance moral-opposition-to-abortion_p1 Proposition
  ((verbalExpression "It is wrong to kill innocent human beings")))

(def-instance moral-opposition-to-abortion_p2 Proposition
  ((verbalExpression "The fetus is an innocent human being")))

(def-instance moral-opposition-to-abortion_p3 Proposition
  ((verbalExpression "It is wrong to kill a fetus")))


(def-instance moral-opposition-to-abortion-argument Argument
  ((hasPremise moral-opposition-to-abortion_p1
               moral-opposition-to-abortion_p2)
   (hasConclusion moral-opposition-to-abortion_p3)))

(def-relation-instances
   (expresses warren1973on warren1973on_p1)
   (anticipates warren1973on moral-opposition-to-abortion-argument)
   (accepts warren1973on moral-opposition-to-abortion_p1)
   (supports moral-opposition-to-abortion-argument basic-pro-life-
argument)
   (disputes warren1973on_p1 moral-opposition-to-abortion_p2))

(def-instance warren1973on_p8 Proposition
  ((verbalExpression "The first property that characterises a person
is consciousness of objects and event external and/or internal to the
being, in particular the capacity to feel pain")))

(def-instance warren1973on_p9 Proposition
  ((verbalExpression "The second property that characterises a person
is reasoning, which is the developed capacity to solve new and
relatively complex problems")))

(def-instance warren1973on_p10 Proposition
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  ((verbalExpression "The third property that characterises a person
is self-motivated activity that is relatively independent of either
genetic or direct external control")))

(def-instance warren1973on_p11 Proposition
  ((verbalExpression "The fourth property that characterises a person
is the capacity to communicate, by whatever means, messages of an
indefinite variety of types, that is, not just with an indefinite
number of possible contents, but on indefinitely many possible
topics")))

(def-instance warren1973on_p12 Proposition
  ((verbalExpression "The fifth property that characterises a person
is the presence of self-concepts, and self-awareness, either
individual or racial, or both")))

(def-instance warren_personhood_properties Proposition-Collection
  ((contains-proposition warren1973on_p8
                                warren1973on_p9
                                warren1973on_p10
                                warren1973on_p11
                                warren1973on_p12)))

(def-instance warren1973on_p13 Proposition
  ((verbalExpression "There is a cluster of properties that
characterise persons")))

(def-instance warren1973on_p14 Proposition
  ((verbalExpression "If a being has none or only one of the
properties that characterise persons then it is not a person, whether
it is biologically human or not")))

(def-instance warren1973on_p15 Proposition
  ((verbalExpression "The fetus has at most one of the properties -
consciousness - that characterises a person")))

(def-instance warren1973on_p16 Proposition
  ((verbalExpression "The fetus is not a person")))

(def-instance personhood-properties-argument Argument
  ((hasPremise warren1973on_p13
               warren1973on_p14
               warren1973on_p15)
   (hasConclusion warren1973on_p16)))

(def-relation-instances
  (expresses warren1973on warren1973on_p8)
  (expresses warren1973on warren1973on_p9)
  (expresses warren1973on warren1973on_p10)
  (expresses warren1973on warren1973on_p11)
  (expresses warren1973on warren1973on_p12)
  (expresses warren1973on warren1973on_p13)
  (expresses warren1973on warren1973on_p14)
  (expresses warren1973on warren1973on_p15)
  (expresses warren1973on warren1973on_p16)
  (expresses warren1973on personhood-properties-argument)
  (supports personhood-properties-argument warren1973on_p1))

(def-instance tooley1972abortion_p1 Proposition
  ((verbalExpression "The bearer of a right to life must conceive of
itself as a continuing subject of experience and other mental
states")))

(def-instance tooley1972abortion_p2 Proposition
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  ((verbalExpression "The fetus lacks a right to life")))

(def-instance tooley1984in_p1 Proposition
  ((verbalExpression "The bearer of a right to life must at some time
possess the concept of a continuing self or mental substance")))

(def-instance singer-pojman_p1 Proposition
  ((verbalExpression "The fetus lacks rationality and self-
consciousness")))


(def-instance mcmahan2002ethics_p1 Proposition
  ((verbalExpression "The fetus lacks higher psychological capacities
such as autonomy")))

(def-relation-instances
   (expresses tooley1972abortion tooley1972abortion_p1)
   (expresses tooley1972abortion tooley1972abortion_p2)
   (expresses tooley1984in tooley1984in_p1)
   (expresses singer2000 singer-pojman_p1)
   (expresses pojman1994abortion singer-pojman_p1)
   (expresses mcmahan2002ethics mcmahan2002ethics_p1)
   (supports tooley1972abortion_p2 warren1973on_p1)
   (supports tooley1972abortion_p1 tooley1972abortion_p2)
   (supports singer-pojman_p1 tooley1972abortion_p2)
   (supports mcmahan2002ethics_p1 tooley1972abortion_p2))

;---------------------------------------------------------------------
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;COMATOSE-PATIENT-OBJECTION

(def-instance comatose_p1 Proposition
  ((verbalExpression "Patients in reversible comas do not exhibit the
criteria for personhood")))

(def-instance comatose_p2 Proposition
  ((verbalExpression "Patients in reversible comas still have a right
to life")))

(def-instance comatose_p3 Proposition
  ((verbalExpression "Personhood criteria are not a justifiable way
to determine right to life")))

(def-instance comatose-patient-objection-argument Argument
   ((hasPremise comatose_p1
                       comatose_p2)
    (hasConclusion comatose_p3)))

(def-relation-instances
  (disputes comatose-patient-objection-argument warren1973on_p14)
  (expresses marquis1989why comatose-patient-objection-argument)
  (expresses schwarz1990moral comatose-patient-objection-argument)
  (expresses rogers1992personhood comatose-patient-objection-
argument)
  (expresses beckwith1993politically comatose-patient-objection-
argument)
  (expresses larmer1995abortion comatose-patient-objection-argument)
  (expresses lee2005wrong comatose-patient-objection-argument))

(def-instance counter-comatose_p1 Proposition
  ((verbalExpression "Although the reversibly comatose lack any
conscious mental states, they do retain all their unconscious mental
states since the appropriate neurological configurations are
preserved in the brain")))
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(def-instance counter-comatose_p2 Proposition
  ((verbalExpression "Comatose patients are able to satisfy some of
Warren's personhood criteria")))

(def-instance counter-comatose-patient-objection-argument Argument
  ((hasPremise counter-comatose_p1)
   (hasConclusion counter-comatose_p2)))

(def-relation-instances
  (disputes counter-comatose-patient-objection-argument comatose_p1)
  (expresses stretton2004essential counter-comatose-patient-
objection-argument)
  (expresses glover1977causing counter-comatose-patient-objection-
argument)
  (expresses singer2000 counter-comatose-patient-objection-argument)
  (expresses boonin2003defense counter-comatose-patient-objection-
argument))

;---------------------------------------------------------------------
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;INFANTICIDE-OBJECTION

(def-instance infanticide-objection_p1 Proposition
  ((verbalExpression "Infants have only one of Warren's
characteristics - consciousness")))

(def-instance infanticide-objection_p2 Proposition
  ((verbalExpression "Using Warren's characteristics means that
infants would have to be counted as non-persons")))

(def-instance infanticide-objection_p3 Proposition
  ((verbalExpression "Warren's characteristics would permit not only
abortion but infanticide")))

(def-instance infanticide-objection-argument Argument
  ((hasPremise infanticide-objection_p1
               infanticide-objection_p2)
   (hasConclusion infanticide-objection_p3)))

(def-relation-instances
   (disputes infanticide-objection-argument warren1973on_p14))

;---------------------------------------------------------------------
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;[Warren Response]

(def-instance warren1982postscript_p1 Proposition
  ((verbalExpression "The personhood characteristics do no make
infanticide generally permissible")))

(def-instance warren1982postscript_p2 Proposition
  ((verbalExpression "Once a human being is born, there is no longer
a conflict between it and the woman's rights, since the human being
can be given up for adoption")))

(def-instance warren1982postscript_p3 Proposition
  ((verbalExpression "Killing an infant would be wrong, not because
it is a person, but because it would go against the desires of people
willing to adopt the infant and to pay to keep the infant alive")))

(def-instance warren1982postscript_arg1 Argument
  ((hasPremise warren1982postscript_p2 warren1982postscript_p3)
   (hasConclusion warren1982postscript_p1)))
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(def-instance warren1982postscript_p4 Proposition
  ((verbalExpression "The personhood characteristics entail that
infanticide would be morally acceptable under some circumstances such
as those of a desert island")))

(def-relation-instances
   (expresses warren1982postscript warren1982postscript_arg1)
   (expresses warren1982postscript warren1982postscript_p4)
   (accepts warren1982postscript infanticide-objection_p2)
   (disputes warren1982postscript_arg1 infanticide-objection-
argument)
   (accepts warren1982postscript infanticide-objection_p3
(warren1982postscript_p4)))
;the last 'accepts' relation instance is a conditional (i.e.
qualified / context-constrained) acceptance
;---------------------------------------------------------------------
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;[Peter Singer] singer2000
;Similarly concludes/claims: "Infanticide is justifiable under
certain conditions"
;For example: "Infanticide is justifiable if the infants are severely
disabled"

(def-instance singer2000_p1 Proposition
  ((verbalExpression "Infanticide is justifiable under certain
conditions such as when the infant is severely disabled")))

(def-relation-instances
  (expresses singer2000 singer2000_p1)
  (supports singer2000_p1 warren1982postscript_p4))

;[Jeff McMahan] mcmahan2002ethics
;"Under very limited circumstances it may be permissible to kill one
infant to save the lives of several others"

(def-instance mcmahan2002ethics_p1 Proposition
  ((verbalExpression "Under very limited circumstances it may be
permissible to kill one infant to save the lives of several
others")))

(def-relation-instances
   (expresses mcmahan2002ethics mcmahan2002ethics_p1))

;---------------------------------------------------------------------
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;NATURAL-CAPACITIES-VIEW


(def-instance natural-capacities_p1 Proposition
  ((verbalExpression "What matters morally is not that one be
actually exhibiting complex mental qualities")))

(def-instance natural-capacities_p2 Proposition
  ((verbalExpression "What matters morally is that one have in
oneself a self-directed genetic propensity or natural capacity to
develop such qualities")))

(def-instance natural-capacities_p3 Proposition
  ((verbalExpression "What matters matters morally is that one be the
kind of entity or substance that, under the right conditions,
actively develops itself to the point of exhibiting Warren's
qualities at some point in its life, even if it does not actually
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exhibit them because of not having developed them yet (fetus, infant)
or having lost them (severe Alzheimer's)")))

(def-instance natural-capacities_p4 Proposition
  ((verbalExpression "Human beings essentially have the natural
capacity to develop the complex mental qualities of personhood")))

(def-instance natural-capacities_p5 Proposition
  ((verbalExpression "Human beings could not possibly fail to have a
right to life")))

(def-instance natural-capacities-argument-1 Argument
   ((hasPremise natural-capacities_p1 natural-capacities_p2 natural-
capacities_p3 natural-capacities_p4)
     (hasConclusion natural-capacities_p5)))

(def-relation-instances
   (disputes natural-capacities-argument-1 tooley1972abortion_p2)
   (expresses grisez1970abortion natural-capacities-argument-1)
   (expresses lee1996abortion natural-capacities-argument-1)
   (expresses lee2004pro natural-capacities-argument-1)
   (expresses lee2005wrong natural-capacities-argument-1)
   (expresses schwarz1990moral natural-capacities-argument-1)
   (expresses beckwith1993politically natural-capacities-argument-1)
   (expresses reichlin1997argument natural-capacities-argument-1))

;FURTHERMORE:

(def-instance natural-capacities_p6 Proposition
  ((verbalExpression "Modern embryology shows that at conception the
fetus has a natural capacity for complex mental qualities")))

(def-instance natural-capacities_p7 Proposition
   ((verbalExpression "The right to life begins at conception")))

(def-instance natural-capacities-argument-2 Argument
   ((hasPremise natural-capacities_p6)
     (hasConclusion natural-capacities_p7)))

(def-relation-instances
   (disputes natural-capacities-argument-2 tooley1972abortion_p2))


(def-instance natural-capacities_p8 Proposition
   ((verbalExpression "Grounding the right to life in essential
natural capacities rather than accidental developed capacities has
several advantages")))

(def-instance natural-capacities_p9 Proposition
   ((verbalExpression "The developed capacities view must arbitrarily
select some particular degree of development as the cut-off point for
the right to life whereas the natural capacities view is non-
arbitrary")))

(def-instance natural-capacities_p10 Proposition
   ((verbalExpression "Those whose capacities are more developed
would have more of a right to life on the 'developed capacities' view
whereas the natural capacities view entails we all have an equal
right to life")))

(def-instance natural-capacities_p11 Proposition
   ((verbalExpression "The continuum of developed capacities makes
the exact point at which personhood ensues vague whereas there is no
such indeterminacy on the 'natural capacities' view"))) ;discussed in
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mcmahan2002ethics

(def-relation-instances
   (supports natural-capacities_p8 natural-capacities-argument-1)
   (supports natural-capacities_p9 natural-capacities_p8)
   (supports natural-capacities_p10 natural-capacities_p8)
   (supports natural-capacities_p11 natural-capacities_p8)
   (expresses lee2004pro natural-capacities_p8)
   (expresses lee2005wrong natural-capacities_p8)
   (expresses schwarz1990moral natural-capacities_p8))


(def-instance counter-natural-capacities_p1 Proposition
  ((verbalExpression "The problem of arbitrariness and inequality
will apply equally to the 'natural capacities view")))

(def-instance counter-natural-capacities_p2 Proposition
  ((verbalExpression "Human beings vary significantly in their
natural cognitive capacities")))

(def-instance counter-natural-capacities_p3 Proposition
  ((verbalExpression "One can imagine a series or spectrum of species
with gradually diminishing natural capacities such as from human down
to amoebae")))

(def-instance counter-natural-capacities-argument-1 Argument
  ((hasPremise counter-natural-capacities_p1 counter-natural-
capacities_p2)
   (hasConclusion counter-natural-capacities_p3)))

(def-relation-instances
   (expresses stretton2004essential counter-natural-capacities_p1)
   (expresses mcmahan2002ethics counter-natural-capacities_p1)
   (expresses stretton2004essential counter-natural-capacities_p2)
   (expresses stretton2004essential counter-natural-capacities_p3)
   (expresses mcmahan2002ethics counter-natural-capacities_p3)
   (disputes counter-natural-capacities-argument-1 natural-
capacities_p9)
   (disputes counter-natural-capacities-argument-1 natural-
capacities_p10))


(def-instance counter-natural-capacities_p4 Proposition
   ((verbalExpression "The natural capacities view takes mere species
membership or genetic potential as a basis for respect")))

(def-instance counter-natural-capacities_p5 Proposition
   ((verbalExpression "The natural capacities view entails that
anencephalic infants and the irreversibly comatose have a full right
to life")))

(def-instance personal-identity-theory_p1 Proposition
  ((verbalExpression "The fetus will never itself develop complex
mental qualities")))

(def-instance personal-identity-theory_p2 Proposition
  ((verbalExpression "The fetus will simply give rise to a distinct
substance or entity that will have complex mental qualities")))

(def-instance counter-natural-capacities_p6 Proposition
   ((verbalExpression "The natural capacities argument fails")))

(def-instance counter-natural-capacities-argument-2 Argument
   ((hasPremise counter-natural-capacities_p4 counter-natural-
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capacities_p5 personal-identity-theory_p1 personal-identity-
theory_p2)
    (hasConclusion counter-natural-capacities_p6)))

(def-relation-instances
  (expresses mcmahan2002ethics counter-natural-capacities_p4)
  (expresses stretton2004essential counter-natural-capacities_p4)
  (expresses stretton2004essential counter-natural-capacities_p5)
  (expresses boonin2003defense counter-natural-capacities_p5)
  (disputes counter-natural-capacities-argument-2 natural-capacities-
argument-1))
;-----------------------------------------------------------------------
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;DEPRIVATION-ARGUMENT

(def-instance deprivation_p1 Proposition
   ((verbalExpression "What makes it wrong to kill a normal adult
human being is the fact that the killing inflicts a terrible harm on
the victim")))

(def-instance deprivation_p2 Proposition
   ((verbalExpression "When I die I am deprived of all the valuable
experiences, activities, projects, and enjoyments that I would
otherwise have had")))

(def-instance deprivation_p3 Proposition
   ((verbalExpression "If a being has a highly valuable future ahead
of it then killing that being would be seriously harmful")))

(def-instance deprivation_p4 Proposition
   ((verbalExpression "A standard fetus does have a valuable
future")))

(def-instance deprivation_p5 Proposition
   ((verbalExpression "Abortion is wrong because it deprives the
fetus of a valuable future")))

(def-instance deprivation_p6 Proposition
   ((verbalExpression "The overwhelming majority of deliberate
abortions are seriously immoral and in the same moral category as
killing an innocent adult human being")))

(def-instance deprivation-argument Argument
   ((hasPremise deprivation_p1 deprivation_p2 deprivation_p3
deprivation_p4)
    (hasConclusion deprivation_p5)))

(def-relation-instances
   (supports deprivation-argument basic-pro-life-argument)
   (expresses marquis1989why deprivation-argument)
   (expresses stone1987why deprivation-argument)
   (expresses stone1994why deprivation-argument))

;-----------------------------------------------------------------------
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;CONTRACEPTION-OBJECTION

(def-instance contraception-objection_p1 Proposition
  ((verbalExpression "If Marquis's argument is correct, then since
sperm and ova have a future like ours, contraception would be as
wrong as murder")))

(def-instance contraception-objection_p2 Proposition
  ((verbalExpression "Those who believe contraception is wrong do not
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believe it is as wrong as murder")))

(def-instance contraception-objection_p3 Proposition
  ((verbalExpression "Marquis's argument is unsound")))

(def-instance contraception-objection-argument Argument
  ((hasPremise contraception-objection_p1 contraception-objection_p2)
   (hasConclusion contraception-objection_p3)))


(def-instance counter-contraception_p1 Proposition
   ((verbalExpression "Neither the sperm, nor the egg, nor any
particular sperm-egg combination will ever itself live out a valuable
future")))

(def-instance counter-contraception_p2 Proposition
   ((verbalExpression "What will later have valuable experiences,
acitivities, projects, and enjoyments is a new entity that will come
into existence at conception and it is this entity that has a future
like ours")))

(def-instance counter-contraception-objection-argument Argument
  ((hasPremise counter-contraception_p2)
   (hasConclusion counter-contraception_p1)))

(def-relation-instances
   (disputes contraception-objection-argument deprivation-argument)
   (disputes counter-contraception-objection-argument contraception-
objection_p1)
   (expresses stone1987why counter-contraception-objection-argument)
   (expresses marquis1989why counter-contraception-objection-
argument))

;---------------------------------------------------------------------
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;IDENTITY-OBJECTION

;http://en.wikipedia.org/wiki/Animalism_%28personal_identity%29
;------
;Olson argues that mental states are irrelevant. If your cerebrum was
destroyed but the rest of your body continued to live (as with humans
in vegetative states), although you would not have any mental life at
all, you still exist. Controversially, personhood is not an essential
feature of something under animalism, but may be gained or lost.
;------
(def-instance animalism_p1 Proposition
   ((verbalExpression "People can be said to persist through time
insomuch as the living, physical human animal that they most usually
call their body, persists.")))

(def-instance animalism_p2 Proposition
   ((verbalExpression "The entity that will later have valuable
experiences and activities is the same entity as the fetus")))


(def-relation-instances
   (expresses olson1997human animalism_p1)
   (supports animalism_p1 deprivation_p1)
   (disputes animalism_p1 locke1689essay_p1))


(def-instance identity-objection_p1 Proposition
   ((verbalExpression "Each of us is not a biological organism but
rather an embodied mind or a person")))
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(def-relation-instances
   (expresses warren1978do identity-objection_p1)
   (expresses mcinerney1998does identity-objection_p1)
   (expresses doepke1996kinds identity-objection_p1)
   (expresses baker2000persons identity-objection_p1))

(def-instance identity-objection_p2 Proposition
   ((verbalExpression "The embodied mind or person comes into
existence when the brain gives rise to certain developed
psychological capacities")))

(def-relation-instances
   (expresses tooley1984in identity-objection_p2)
   (expresses mcmahan2002ethics identity-objection_p2)
   (expresses hasker1999emergent identity-objection_p2))


(def-instance identity-objection_p3 Proposition
   ((verbalExpression "The fetus does not itself have a future value
but has merely the potential to give rise to a different entity, an
embodied mind or a person, that would have a future of value")))

(def-instance locke1689essay Publication
   ((has-author John_Locke)))

(def-instance locke1689essay_p1 Proposition
   ((verbalExpression "A person is a thinking intelligent Being, that
has reason and reflection, and can consider it self as it self, the
same thinking thing in different times and places; which it does only
by that consciousness, which is inseparable from thinking, and as it
seems to me essential to it")))

(def-instance identity-objection-argument Argument
   ((hasPremise locke1689essay_p1
                identity-objection_p1
                identity-objection_p2)
    (hasConclusion identity-objection_p3)))

(def-relation-instances
   (disputes identity-objection-argument deprivation-argument))

;-------------------------------------------------------------------
-----------------------------------------------------
;INTERESTS-OBJECTION

(def-instance interests-objection_p1 Proposition
   ((verbalExpression "What makes murder wrong is not just the
deprivation of a valuable future, but the deprivation of a future
that one has an interest in")))

(def-instance interests-objection_p2 Proposition
   ((verbalExpression "The fetus has no conscious interest in its
future")))

(def-instance interests-objection_p3 Proposition
   ((verbalExpression "To kill a fetus is not wrong")))

(def-instance interests-objection-argument Argument
   ((hasPremise interests-objection_p1 interests-objection_p2)
    (hasConclusion interests-objection_p3)))

(def-relation-instances
   (supports interests-objection-argument basic-pro-choice-argument))
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;--------------------------------
;[Counter Interest-Objection]

(def-instance marquis1989why_p1 Proposition
   ((verbalExpression "A suicidal teenager takes no interest in his
or her future yet killing a suicidal teenager is still wrong")))

(def-relation-instances
   (expresses marquis1989why marquis1989why_p1)
   (disputes marquis1989why_p1 interests-objection-argument))

;--------------------------------
;[Counter Counter Interest-Objection]

(def-instance interest-objection_p4 Proposition
   ((verbalExpression "One can have an interest in one's future
without taking an interest in it")))

(tell (disputes interest-objection_p4 marquis1989why_p1))

;--------------------------------
;[Counter Counter Counter Interest-Objection]

(def-instance stone1987why_p1 Proposition
   ((verbalExpression "The fetus can also have an interest in it's
own future without taking an interest in it")))

(def-relation-instances
   (expresses stone1987why stone1987why_p1) ;added this relation
instance on 23/01/2007
   (disputes stone1987why_p1 interests-objection_p4))

;--------------------------------
;[Counter Counter Interest-Objection (2)]

(def-instance boonin2003defense_p1 Proposition
   ((verbalExpression "What is crucial is having a valuable future
which one would, under ideal conditions, desire to preserve whether
or not one does in fact desire to preserve it")))

(def-relation-instances
   (expresses boonin2003defense boonin2003defense_p1);added this
relation instance on 23/01/2007
   (disputes boonin2003defense_p1 marquis1989why_p1))

;--------------------------------
;[Counter Counter Counter Interest-Objection (2)]

(def-instance counter-interests-objection_p1 Proposition
   ((verbalExpression "Why wouldn't the fetus, under ideal
conditions, desire to preserve its future?")))

(tell (disputes counter-interests-objection_p1 boonin2003defense_p1))
;----------------------------------------------------------------------
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;EQUALITY-OBJECTION

(def-instance equality-objection_p1 Proposition
   ((verbalExpression "A 9 year old has a much longer future than a
90 year old")))

(def-instance equality-objection_p2 Proposition
   ((verbalExpression "A middle class person's future has much less
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gratuitous pain and suffering than someone in extreme poverty")))

(def-instance equality-objection_p3 Proposition
   ((verbalExpression "Some futures appear to contain much more value
than others")))

(def-instance equality-objection_p4 Proposition
   ((verbalExpression "If killing is wrong because it deprives the
victim of a valuable future some killings would turn out to be much
more wrong than others")))

(def-instance equality-objection_p5 Proposition
   ((verbalExpression "It is counterintuitive to think that some
killings are more wrong than others")))

(def-instance equality-objection_p6 Proposition
   ((verbalExpression "Marquis's argument leads to unacceptable
inequalities")))

(def-instance equality-objection-argument Argument
   ((hasPremise equality-objection_p1 equality-objection_p2 equality-
objection_p3 equality-objection_p4 equality-objection_p5)
    (hasConclusion equality-objection_p6)))

(def-relation-instances
   (expresses paske1994abortion equality-objection-argument)
   (expresses stretton2004deprivation equality-objection-argument)
   (disputes equality-objection-argument deprivation-argument))


;"Since the harm cause to victims varies greatly among killings then
the wrongness of killing arises not from the harm it cause the
victim, but from the killing's violation of the intrinsic worth or
personhood of the victim" [mcmahan2002ethics]

;---------------------------------------------------------------------
-----------------------------------------------
;PSYCHOLOGICAL-CONNECTEDNESS-OBJECTION

(def-instance psychological-connectedness_p1 Proposition
  ((verbalExpression "A being can be seriously harmed by being
deprived of a valuable future only if there are sufficient
psychological connections between the being as it is now and the
being as it will be when it lives out the valuable future")))

(def-instance psychological-connectedness_p2 Proposition
  ((verbalExpression "There are a few psychological connections
between the fetus and its later self")))

(def-instance psychological-connectedness_p3 Proposition
  ((verbalExpression "Depriving the fetus of its future does not
seriously harm it and hence is not seriously wrong")))

(def-instance psychological-connectedness-objection-argument Argument
   ((hasPremise psychological-connectedness_p1 psychological-
connectedness_p2)
    (hasConclusion psychological-connectedness_p3)))

(tell (disputes psychological-connectedness-objection-argument
deprivation-argument))

;---------------------------------------------------------------------
----------------------------------------------------
;BODILY-RIGHTS-ARGUMENT
```

```
(def-instance thomson1971defense_p1 Proposition
   ((verbalExpression "If you wake up in bed next to a famous
violinist you may permissibly unplug yourself from the violinist even
though this will kill him")))

(def-instance thomson1971defense_p2 Proposition
   ((verbalExpression "In disconnecting the violinist you do not
violate his right to life but merely deprive him of the use of your
body to which he has no right")))

(def-instance thomson1971defense_p3 Proposition
   ((verbalExpression "The right to life does not entail the right to
use another person's body")))

(def-instance thomson1971defense_p4 Proposition
   ((verbalExpression "Similarly, even if the fetus has a right to
life, it does not have a right to use the pregnant woman's body")))

(def-instance thomson1971defense_p5 Proposition
   ((verbalExpression "Abortion is in some circumstances permissible
even if the fetus has a right to life")))

(def-instance bodily-rights-argument Argument
   ((hasPremise thomson1971defense_p1 thomson1971defense_p2
thomson1971defense_p3 thomson1971defense_p4)
    (hasConclusion thomson1971defense_p5)))

(def-relation-instances
   (expresses thomson1971defense bodily-rights-argument)
   (supports bodily-rights-argument basic-pro-choice-argument)
   (supports bodily-rights-argument ad_iss11_view2))


;---------------------------------------------------------------------
--------------------------
;TACIT-CONSENT-OBJECTION


(def-instance tacit-consent-objection_p1 Proposition
  ((verbalExpression "The violinist scenario involved a kidnapping so
it is analogous only to abortion after rape")))

(def-instance tacit-consent-objection_p2 Proposition
  ((verbalExpression "In most cases of abortion the pregnant woman
was not raped but had intercourse voluntarily")))

(def-instance tacit-consent-objection_p3 Proposition
  ((verbalExpression "A pregnant woman who has had intercourse
voluntarily has tacitly consented to allowing the fetus to use her
body")))

(def-instance tacit-consent-objection-argument Argument
   ((hasPremise tacit-consent-objection_p1 tacit-consent-
objection_p2)
    (hasConclusion tacit-consent-objection_p3)))

(def-relation-instances
   (expresses warren1973on tacit-consent-objection-argument)
   (expresses steinbock1992life tacit-consent-objection-argument)
   (accepts warren1973on thomson1971defense_p1)
   (accepts steinbock1992life thomson1971defense_p1)
   (disputes tacit-consent-objection-argument bodily-rights-
argument))
```

```
;-------------------------------------------------------------------
-------------------------
;RESPONSIBILITY-OBJECTION

(def-instance responsibility-objection_p1 Proposition
   ((verbalExpression "A pregnant woman who has had intercourse
voluntarily has caused the fetus to stand in need of her body")))


(def-relation-instances
   (expresses beckwith1993politically responsibility-objection_p1)
   (expresses mcmahan2002ethics responsibility-objection_p1)
   (accepts beckwith1993politically thomson1971defense_p1)
   (accepts mcmahan2002ethics thomson1971defense_p1)
   (disputes responsibility-objection_p1 bodily-rights-argument))

;-------------------------------------------------------------------
-------------------------
;STRANGER-VS-OFFSPRING-OBJECTION

(def-instance stranger-v-offspring-objection_p1 Proposition
   ((verbalExpression "The fetus is the pregnant woman's child
whereas the violinist is a stranger")))

(def-relation-instances
   (expresses schwarz1990moral stranger-v-offspring-objection_p1)
   (expresses beckwith1993politically stranger-v-offspring-
objection_p1)
   (expresses mcmahan2002ethics stranger-v-offspring-objection_p1)
   (accepts schwarz1990moral thomson1971defense_p1)
   (disputes stranger-v-offspring-objection_p1 bodily-rights-
argument))

;-------------------------------------------------------------------
-------------------------
;KILLING-VS-LETTING-DIE-OBJECTION

(def-instance killing-v-letting-die-objection_p1 Proposition
   ((verbalExpression "Abortion kills the fetus whereas unplugging
the violinist merely lets him die")))

(def-relation-instances
   (expresses schwarz1990moral killing-v-letting-die-objection_p1)
   (expresses beckwith1993politically killing-v-letting-die-
objection_p1)
   (expresses mcmahan2002ethics killing-v-letting-die-objection_p1)
   (disputes killing-v-letting-die-objection_p1 bodily-rights-
argument))

;-------------------------------------------------------------------
-------------------------
;INTENDING-VS-FORESEEING-OBJECTION

(def-instance intending-v-foreseeing-objection_p1 Proposition
   ((verbalExpression "Abortion intentionally causes the fetus's
death whereas unplugging the violinist merely causes death as a
foreseen but unintended side-effect")))

(def-relation-instances
   (expresses finnis1973rights intending-v-foreseeing-objection_p1)
   (expresses schwarz1990moral intending-v-foreseeing-objection_p1)
   (expresses lee1996abortion intending-v-foreseeing-objection_p1)
   (expresses lee2005wrong intending-v-foreseeing-objection_p1)
   (accepts finnis1973rights thomson1971defense_p1)
```

```
   (accepts lee1996abortion thomson1971defense_p1)
   (accepts lee2005wrong thomson1971defense_p1)
   (disputes intending-v-foreseeing-objection_p1 bodily-rights-
argument))

;-------------------------------------------------------------------
-------------------------
;[Boonin Response]

(def-instance boonin2003defense_p2 Proposition
   ((verbalExpression "The factors that critics appeal to are either
not genuinely morally relevant or are morally relevant but do not
apply to abortion in the way that critics have claimed")))

(def-instance boonin2003defense_p3 Proposition
   ((verbalExpression "Alleged disanalogies between the violinist
scenario and typical cases of abortion do not hold")))

(def-instance boonin2003defense_arg1 Argument
   ((hasPremise boonin2003defense_p2)
    (hasConclusion boonin2003defense_p3)))

(def-relation-instances
  (expresses boonin2003defense boonin2003defense_arg1)
  (disputes boonin2003defense_arg1 tacit-consent-objection-argument)
  (disputes boonin2003defense_arg1 responsibility-objection_p1)
  (disputes boonin2003defense_arg1 stranger-v-offspring-objection_p1)
  (disputes boonin2003defense_arg1 killing-v-letting-die-
objection_p1)
  (disputes boonin2003defense_arg1 intending-v-foreseeing-
objection_p1))
```

APPENDIX D NETDRAW-PROCESSABLE REPRESENTATIONS OF THE DEBATE

This Appendix presents the '.net' files, containing the graph-based representations of the Turing and Abortion debate, were input into the NetDraw tool for cluster analysis.

D.1 Graph-based representation of the Turing debate in '.net' format

```
*Vertices 137
1 "M1_ARG126"
2 "M1_ARG31"
3 "M1_ARG64"
4 "M1_ARG82"
5 "M1_ARG101"
6 "M1_ARG122"
7 "M1_ARG30"
8 "M1_ARG12"
9 "M1_ARG65"
10 "M1_ARG33"
11 "M1_ARG56"
12 "M1_ARG32"
13 "M1_ARG21"
14 "M1_ARG114"
15 "M1_ARG130"
16 "M1_ARG49"
17 "M1_ARG42"
18 "M1_ARG23"
19 "M1_ARG19"
20 "M1_ARG88"
21 "M1_ARG11"
22 "M1_ARG14"
23 "M1_ARG38"
24 "PSS_TENET7"
25 "M1_ARG20"
26 "M1_ARG39"
27 "M1_ARG17"
28 "M1_ARG25"
29 "M1_ARG97"
30 "M1_ARG76"
31 "M1_ARG79"
32 "M1_ARG81"
33 "M1_ARG83"
34 "M1_ARG66"
35 "M1_ARG72"
36 "M1_ARG67"
37 "M1_ARG103"
38 "M1_ARG98"
39 "M1_ARG69"
40 "M1_ARG53"
41 "M1_ARG26"
42 "M1_ARG70"
43 "M1_ARG71"
44 "M1_ARG22"
45 "M1_ARG24"
46 "M1_ARG87"
47 "M1_ARG37"
48 "M1_ARG4"
```

```
49 "M1_ARG5"
50 "M1_ARG75"
51 "M1_ARG104"
52 "M1_ARG8"
53 "PSS_TENET9"
54 "M1_ARG7"
55 "M1_ARG106"
56 "M1_ARG27"
57 "M1_ARG43"
58 "M1_ARG18"
59 "M1_ARG3"
60 "M1_ARG68"
61 "M1_ARG77"
62 "M1_ARG105"
63 "M1_ARG93"
64 "M1_ARG95"
65 "M1_ARG10"
66 "M1_ARG94"
67 "M1_ARG13"
68 "M1_ARG80"
69 "M1_ARG99"
70 "PSS_TENET4"
71 "M1_ARG47"
72 "M1_ARG108"
73 "PSS_TENET1"
74 "PSS_TENET6"
75 "M1_ARG92"
76 "M1_ARG60"
77 "M1_ARG78"
78 "M1_ARG118"
79 "M1_ARG110"
80 "M1_ARG117"
81 "M1_ARG54"
82 "M1_ARG127"
83 "M1_ARG124"
84 "M1_ARG121"
85 "PSS_TENET3"
86 "PSS_TENET8"
87 "M1_ARG116"
88 "M1_ARG123"
89 "M1_ARG111"
90 "M1_ARG120"
91 "M1_ARG51"
92 "M1_ARG100"
93 "M1_ARG102"
94 "M1_ARG29"
95 "M1_ARG35"
96 "M1_ARG52"
97 "M1_ARG41"
98 "M1_ARG58"
99 "M1_ARG74"
100 "M1_ARG73"
101 "M1_ARG62"
102 "M1_ARG90"
103 "M1_ARG63"
104 "M1_ARG89"
105 "M1_ARG91"
106 "M1_ARG6"
107 "M1_ARG9"
108 "M1_ARG55"
109 "M1_ARG34"
110 "M1_ARG112"
111 "M1_ARG113"
112 "PSS_TENET2"
```

```
113 "PSS_TENET5"
114 "M1_ARG96"
115 "M1_ARG125"
116 "M1_ARG1"
117 "M1_ARG40"
118 "M1_ARG36"
119 "M1_ARG48"
120 "M1_ARG44"
121 "M1_ARG28"
122 "M1_ARG2"
123 "M1_ARG59"
124 "M1_ARG61"
125 "M1_ARG115"
126 "M1_ARG131"
127 "M1_ARG128"
128 "M1_ARG107"
129 "M1_ARG109"
130 "M1_ARG46"
131 "M1_ARG50"
132 "M1_ARG15"
133 "M1_ARG16"
134 "M1_ARG45"
135 "M1_ARG57"
136 "M1_ARG85"
137 "M1_ARG86"
*Edges
1 116 1 1 +ADDITIVE
2 12 2 1 +ADDITIVE
3 116 1 1 +ADDITIVE
4 31 1 1 +ADDITIVE
5 38 1 1 +ADDITIVE
6 83 2 1 +ADDITIVE
6 84 1 1 +ADDITIVE
7 2 2 1 +ADDITIVE
7 12 2 1 +ADDITIVE
8 21 1 1 +ADDITIVE
9 103 3 1 +ADDITIVE
10 118 2 1 +ADDITIVE
10 121 1 1 +ADDITIVE
10 95 2 1 +ADDITIVE
11 108 3 1 +ADDITIVE
13 27 1 1 +ADDITIVE
13 18 2 1 +ADDITIVE
13 94 2 1 +ADDITIVE
13 19 3 1 +ADDITIVE
15 126 2 1 +ADDITIVE
16 130 1 1 +ADDITIVE
17 121 1 1 +ADDITIVE
18 27 1 1 +ADDITIVE
18 94 2 1 +ADDITIVE
18 19 3 1 +ADDITIVE
19 94 2 1 +ADDITIVE
19 122 1 1 +ADDITIVE
19 27 1 1 +ADDITIVE
20 66 2 1 +ADDITIVE
20 69 2 1 +ADDITIVE
20 114 2 1 +ADDITIVE
20 75 2 1 +ADDITIVE
20 102 2 1 +ADDITIVE
20 92 2 1 +ADDITIVE
20 93 2 1 +ADDITIVE
20 51 2 1 +ADDITIVE
20 107 2 1 +ADDITIVE
21 122 1 1 +ADDITIVE
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22 122 1 1 +ADDITIVE
23 121 1 1 +ADDITIVE
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23 118 1 1 +ADDITIVE
24 53 2 1 +ADDITIVE
24 86 2 1 +ADDITIVE
25 48 3 1 +ADDITIVE
25 59 1 1 +ADDITIVE
26 118 1 1 +ADDITIVE
26 121 1 1 +ADDITIVE
27 41 2 1 +ADDITIVE
27 122 1 1 +ADDITIVE
27 56 2 1 +ADDITIVE
27 28 2 1 +ADDITIVE
28 56 2 1 +ADDITIVE
28 41 2 1 +ADDITIVE
28 122 1 1 +ADDITIVE
29 125 2 1 +ADDITIVE
29 115 2 1 +ADDITIVE
30 100 2 1 +ADDITIVE
30 99 3 1 +ADDITIVE
30 39 2 1 +ADDITIVE
30 61 2 1 +ADDITIVE
31 32 2 1 +ADDITIVE
33 116 1 1 +ADDITIVE
33 77 1 1 +ADDITIVE
34 115 2 1 +ADDITIVE
34 125 2 1 +ADDITIVE
34 29 2 1 +ADDITIVE
34 46 2 1 +ADDITIVE
35 61 2 1 +ADDITIVE
35 36 1 1 +ADDITIVE
36 116 1 1 +ADDITIVE
37 29 1 1 +ADDITIVE
37 38 1 1 +ADDITIVE
38 29 1 1 +ADDITIVE
39 61 2 1 +ADDITIVE
39 100 2 1 +ADDITIVE
39 42 2 1 +ADDITIVE
39 43 2 1 +ADDITIVE
40 121 1 1 +ADDITIVE
41 56 2 1 +ADDITIVE
41 122 1 1 +ADDITIVE
41 95 2 1 +ADDITIVE
42 30 2 1 +ADDITIVE
42 99 2 1 +ADDITIVE
42 43 2 1 +ADDITIVE
42 61 2 1 +ADDITIVE
42 50 2 1 +ADDITIVE
42 100 2 1 +ADDITIVE
43 61 2 1 +ADDITIVE
43 50 2 1 +ADDITIVE
43 100 2 1 +ADDITIVE
43 30 2 1 +ADDITIVE
43 99 2 1 +ADDITIVE
44 12 2 1 +ADDITIVE
44 45 2 1 +ADDITIVE
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46 115 2 1 +ADDITIVE
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46 125 2 1 +ADDITIVE
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47 23 2 1 +ADDITIVE
47 121 1 1 +ADDITIVE
48 59 1 1 +ADDITIVE
48 49 2 1 +ADDITIVE
49 59 1 1 +ADDITIVE
50 99 3 1 +ADDITIVE
50 100 2 1 +ADDITIVE
50 88 1 1 +ADDITIVE
50 30 2 1 +ADDITIVE
50 39 2 1 +ADDITIVE
50 61 2 1 +ADDITIVE
51 107 2 1 +ADDITIVE
52 58 2 1 +ADDITIVE
52 54 3 1 +ADDITIVE
52 98 2 1 +ADDITIVE
52 135 2 1 +ADDITIVE
54 107 2 1 +ADDITIVE
54 58 2 1 +ADDITIVE
54 133 2 1 +ADDITIVE
54 116 1 1 +ADDITIVE
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61 36 1 1 +ADDITIVE
62 116 1 1 +ADDITIVE
63 46 1 1 +ADDITIVE
63 64 2 1 +ADDITIVE
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65 107 1 1 +ADDITIVE
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67 107 1 1 +ADDITIVE
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68 77 1 1 +ADDITIVE
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72 62 1 1 +ADDITIVE
72 110 2 1 +ADDITIVE
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76 114 2 1 +ADDITIVE
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76 75 2 1 +ADDITIVE
76 102 2 1 +ADDITIVE
77 116 1 1 +ADDITIVE
78 90 2 1 +ADDITIVE
78 125 1 1 +ADDITIVE
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80 87 3 1 +ADDITIVE
80 125 1 1 +ADDITIVE
81 98 2 1 +ADDITIVE
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81 72 2 1 +ADDITIVE
81 116 1 1 +ADDITIVE
81 108 2 1 +ADDITIVE
82 115 1 1 +ADDITIVE
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83 84 1 1 +ADDITIVE
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97 120 2 1 +ADDITIVE
97 91 2 1 +ADDITIVE
97 135 2 1 +ADDITIVE
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123 115 2 1 +ADDITIVE
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124 34 2 1 +ADDITIVE
124 115 2 1 +ADDITIVE
124 46 2 1 +ADDITIVE
124 29 2 1 +ADDITIVE
124 103 2 1 +ADDITIVE
124 125 2 1 +ADDITIVE
125 115 2 1 +ADDITIVE
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126 115 1 1 +ADDITIVE
126 127 3 1 +ADDITIVE
127 15 2 1 +ADDITIVE
127 115 1 1 +ADDITIVE
128 62 1 1 +ADDITIVE
128 89 2 1 +ADDITIVE
128 72 2 1 +ADDITIVE
128 111 2 1 +ADDITIVE
128 79 2 1 +ADDITIVE
128 110 2 1 +ADDITIVE
128 129 2 1 +ADDITIVE
129 111 2 1 +ADDITIVE
129 110 2 1 +ADDITIVE
129 89 2 1 +ADDITIVE
129 62 1 1 +ADDITIVE
129 79 2 1 +ADDITIVE
130 135 2 1 +ADDITIVE
130 96 2 1 +ADDITIVE
130 108 2 1 +ADDITIVE
130 91 2 1 +ADDITIVE
130 116 1 1 +ADDITIVE
130 98 2 1 +ADDITIVE
130 81 2 1 +ADDITIVE
130 131 2 1 +ADDITIVE
131 98 2 1 +ADDITIVE
131 96 2 1 +ADDITIVE
131 11 2 1 +ADDITIVE
131 135 2 1 +ADDITIVE
131 91 2 1 +ADDITIVE
131 116 1 1 +ADDITIVE
131 81 2 1 +ADDITIVE
132 68 2 1 +ADDITIVE
132 107 1 1 +ADDITIVE
132 133 2 1 +ADDITIVE
133 68 2 1 +ADDITIVE
133 116 1 1 +ADDITIVE
134 96 2 1 +ADDITIVE
134 91 2 1 +ADDITIVE
134 131 2 1 +ADDITIVE
134 130 2 1 +ADDITIVE
134 108 2 1 +ADDITIVE
134 81 2 1 +ADDITIVE
134 98 2 1 +ADDITIVE
134 116 1 1 +ADDITIVE
134 135 2 1 +ADDITIVE
135 98 2 1 +ADDITIVE
135 116 1 1 +ADDITIVE
136 33 1 1 +ADDITIVE
136 137 2 1 +ADDITIVE
137 24 2 1 +ADDITIVE
137 74 2 1 +ADDITIVE
137 113 2 1 +ADDITIVE
137 70 2 1 +ADDITIVE
137 85 2 1 +ADDITIVE
137 112 2 1 +ADDITIVE
137 73 2 1 +ADDITIVE
137 33 1 1 +ADDITIVE
137 53 2 1 +ADDITIVE
137 86 2 1 +ADDITIVE
```

D.2 Graph-based representation of the Abortion debate in '.net' format

```
*Vertices 53
1 "BERAL2004_P1"
2 "SINGER2000_P1"
3 "WARREN1982POSTSCRIPT_P4"
4 "BOONIN2003DEFENSE_ARG1"
5 "BACK-ALLEY_P1"
6 "UNWANTED-CHILDREN_P1"
7 "ANIMALISM_P1"
8 "AD_P14"
9 "EQUAL-PARTICIPATION_P1"
10 "POST-ABORTION-SYNDROME_P1"
11 "COUNTER-CONTRACEPTION-OBJECTION-ARGUMENT"
12 "AD_P16"
13 "NATURAL-CAPACITIES-ARGUMENT-2"
14 "MELBYE1997_P1"
15 "NCI2003_P1"
16 "INFANTICIDE-OBJECTION-ARGUMENT"
17 "COUNTER-NATURAL-CAPACITIES-ARGUMENT-2"
18 "TOOLEY1972ABORTION_P1"
19 "CONTRACEPTION-OBJECTION-ARGUMENT"
20 "COUNTER-COMATOSE-PATIENT-OBJECTION-ARGUMENT"
21 "BOONIN2003DEFENSE_P1"
22 "COUNTER-INTERESTS-OBJECTION_P1"
23 "MARQUIS1989WHY_P1"
24 "MCMAHAN2002ETHICS_P1"
25 "SINGER-POJMAN_P1"
26 "PERSONHOOD-PROPERTIES-ARGUMENT"
27 "NATURAL-CAPACITIES_P11"
28 "NATURAL-CAPACITIES-ARGUMENT-1"
29 "KILLING-V-LETTING-DIE-OBJECTION_P1"
30 "STRANGER-V-OFFSPRING-OBJECTION_P1"
31 "RESPONSIBILITY-OBJECTION_P1"
32 "BODILY-RIGHTS-ARGUMENT"
33 "CENTRAL-PRO-CHOICE-ARGUMENT"
34 "NATURAL-CAPACITIES_P9"
35 "NATURAL-CAPACITIES_P10"
36 "NATURAL-CAPACITIES_P8"
37 "AD_P13"
38 "IDENTITY-OBJECTION-ARGUMENT"
39 "MORAL-OPPOSITION-TO-ABORTION-ARGUMENT"
40 "DEPRIVATION-ARGUMENT"
41 "AD_P15"
42 "INTEREST-OBJECTION_P4"
43 "INTERESTS-OBJECTION-ARGUMENT"
44 "TOOLEY1972ABORTION_P2"
45 "WARREN1973ON_P1"
46 "ABORTION-BREAST-CANCER-HYPOTHESIS"
47 "CENTRAL-PRO-LIFE-ARGUMENT"
48 "WARREN1982POSTSCRIPT_ARG1"
49 "COMATOSE-PATIENT-OBJECTION-ARGUMENT"
50 "EQUALITY-OBJECTION-ARGUMENT"
51 "PSYCHOLOGICAL-CONNECTEDNESS-OBJECTION-ARGUMENT"
52 "TACIT-CONSENT-OBJECTION-ARGUMENT"
53 "INTENDING-V-FORESEEING-OBJECTION_P1"
*Edges
2 3 1 1 +ADDITIVE
4 32 1 1 +ADDITIVE
5 32 2 1 +ADDITIVE
5 43 2 1 +ADDITIVE
5 9 2 1 +ADDITIVE
5 33 1 1 +ADDITIVE
```

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5 6 2 1 +ADDITIVE
6 9 2 1 +ADDITIVE
6 43 2 1 +ADDITIVE
6 32 2 1 +ADDITIVE
6 33 1 1 +ADDITIVE
7 40 1 1 +ADDITIVE
8 12 2 1 +ADDITIVE
8 33 1 1 +ADDITIVE
9 43 2 1 +ADDITIVE
9 32 2 1 +ADDITIVE
9 33 1 1 +ADDITIVE
10 47 1 1 +ADDITIVE
10 40 2 1 +ADDITIVE
10 39 2 1 +ADDITIVE
11 23 2 1 +ADDITIVE
11 40 2 1 +ADDITIVE
12 33 2 1 +ADDITIVE
14 1 2 1 +ADDITIVE
14 15 2 1 +ADDITIVE
15 1 2 1 +ADDITIVE
17 44 1 1 +ADDITIVE
18 45 1 1 +ADDITIVE
18 44 3 1 +ADDITIVE
18 25 2 1 +ADDITIVE
18 24 2 1 +ADDITIVE
19 50 2 1 +ADDITIVE
19 38 2 1 +ADDITIVE
19 51 2 1 +ADDITIVE
20 4 2 1 +ADDITIVE
20 50 2 1 +ADDITIVE
20 21 2 1 +ADDITIVE
21 4 2 1 +ADDITIVE
21 43 1 1 +ADDITIVE
22 23 1 1 +ADDITIVE
24 30 2 1 +ADDITIVE
24 45 1 1 +ADDITIVE
24 31 2 1 +ADDITIVE
24 29 2 1 +ADDITIVE
24 44 1 1 +ADDITIVE
25 24 2 1 +ADDITIVE
25 44 1 1 +ADDITIVE
25 20 2 1 +ADDITIVE
25 45 1 1 +ADDITIVE
26 44 2 1 +ADDITIVE
26 52 2 1 +ADDITIVE
26 48 2 1 +ADDITIVE
26 45 3 1 +ADDITIVE
27 28 1 1 +ADDITIVE
27 36 1 1 +ADDITIVE
28 29 2 1 +ADDITIVE
28 30 2 1 +ADDITIVE
28 31 2 1 +ADDITIVE
28 13 2 1 +ADDITIVE
28 53 2 1 +ADDITIVE
29 53 2 1 +ADDITIVE
30 53 2 1 +ADDITIVE
30 29 2 1 +ADDITIVE
31 53 2 1 +ADDITIVE
31 29 2 1 +ADDITIVE
31 30 2 1 +ADDITIVE
32 12 1 1 +ADDITIVE
32 33 1 1 +ADDITIVE
34 28 1 1 +ADDITIVE
34 27 2 1 +ADDITIVE
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34 36 1 1 +ADDITIVE
34 35 2 1 +ADDITIVE
35 36 1 1 +ADDITIVE
35 27 2 1 +ADDITIVE
35 28 1 1 +ADDITIVE
36 53 2 1 +ADDITIVE
36 29 2 1 +ADDITIVE
36 28 3 1 +ADDITIVE
36 30 2 1 +ADDITIVE
37 47 1 1 +ADDITIVE
38 51 2 1 +ADDITIVE
38 50 2 1 +ADDITIVE
39 47 1 1 +ADDITIVE
39 40 2 1 +ADDITIVE
40 23 2 1 +ADDITIVE
40 47 1 1 +ADDITIVE
41 47 1 1 +ADDITIVE
42 21 2 1 +ADDITIVE
42 43 1 1 +ADDITIVE
43 33 1 1 +ADDITIVE
43 32 2 1 +ADDITIVE
44 45 1 1 +ADDITIVE
45 52 2 1 +ADDITIVE
45 48 2 1 +ADDITIVE
46 10 2 1 +ADDITIVE
46 40 2 1 +ADDITIVE
46 39 2 1 +ADDITIVE
46 47 1 1 +ADDITIVE
49 23 2 1 +ADDITIVE
49 29 2 1 +ADDITIVE
49 11 2 1 +ADDITIVE
49 16 2 1 +ADDITIVE
49 30 2 1 +ADDITIVE
49 28 2 1 +ADDITIVE
49 31 2 1 +ADDITIVE
49 40 2 1 +ADDITIVE
49 36 2 1 +ADDITIVE
49 53 2 1 +ADDITIVE
50 51 2 1 +ADDITIVE
52 29 2 1 +ADDITIVE
52 30 2 1 +ADDITIVE
52 31 2 1 +ADDITIVE
52 48 2 1 +ADDITIVE
52 53 2 1 +ADDITIVE
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