# Natural Language Engineering of Argumentation (NaLEA)

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## 1 Introduction

This is a draft proposal for a project on natural language engineering of argumentation (NaLEA), which advances *argumentation technologies* (AT).[3] The chief objective of the project is to produce a constrained computational semantic system which allows two or more participants to carry out an argument in natural language within a given domain over the internet. As such, the system supports automated decision-making that can be used across a variety of domains, though the project focusses on several sample domains to exercise the approach. Given the natural language interface, the system makes automated decision-making accessible to a wider range of participants.

 The original document was prepared by Adam Wyner while at the University of Liverpool. The date on the document reflects the date of minor revisions and generation of the document. In the spring of 2007, Tom van Engers participated in revisions to the proposal and submission as an FP7 application in December 2008. The short version of the application was not accepted. Two workshops were held in conjunction with the preparation of the proposal and around these ideas – Natural Language Engineering of Legal Argumentation at JURIX 2008 and at ICAIL 2009. Many people discussed or commented on the proposal along the way. We thank (in no particular order): Trevor Bench-Capon, Doug Walton, Floriana Grasso, Johan Bos, Ido Dagan, Raquel Mochales Palau, Paul Dunne, Tom van Engers, Maite Taboada, Norbert Fuchs, Anthony Hunter, Marie-Francine Moens, Maarten de Rijke, Stuart Shieber, Manfred Stede, Bojana Dalbelo-Bašić, Marko Tadic, Frank Wilson, Eric Breuker, Katie Atkinson. Apologies if we inadvertantly left someone out.

As a *computational semantic system*, it takes natural language sentences as input, parses them, produces a formal semantic interpretation, and then identifies inconsistencies and draws inferences. However, unlike existing computational semantic systems, NaLELA is geared towards *argumentation* and produces a semantic representation that is input to a formal argumentation system. Such a formal argumentation system allows: defeasible inference (which emphasises the *justification* of statements rather than their *truth*), the calculation of extensions of statements (sets of statements which are consistent within the set, but can be inconsistent with some other set of statements, so representing the different "arguments" by participants), the calculation of a *winning* statement in terms of the statement which has the best justification, and argument graphing.

As a *constrained* system, the project focusses on textual entry, a constrained language (restricting the input vocabulary and grammatical structures), and a predictive editor (guiding the user to only input well-formed expressions). In this regard, primary objective of the project is the development of an *argument support tool in natural language*. While the system is constrained, it is a selected subset of well-formed standard language such as used in a professional setting, being expressive enough in terms of vocabulary and grammatical structures that the targetted users experience a minimal learning curve with maximal ease of use.

This constrained approach is also applied to argumentation and the staged development of a functioning system. In the first stage, users input *explicit* argumentation constructs and indicate the relations between statements in the argument. The constraints on input are systematically reduced, for example, by automating identification of inconsistency or redundancy.

In order to determine just what argument constructs are needed for a natural and intuitive tool at each stage of development, the initial stages of the project take an *empirical, data-oriented* approach, applying computational linguistic text-mining tools and analysis to databases of texts in which arguments are found. From the results of this study, we can determine the relevant argument indicators to use and their relationships.

Argumentation is an *interdisciplinary* subject, cutting across linguistics, computational linguistics, formal logic, computational semantics, and abstract argumentation. The subject has a range of application domains. Therefore, our proposal keeps in mind the range of different perspectives which are brought to the project.

In the following sections we first outline the proposal, its motivation, and its applications. A sections on background literature and the web briefly outline the current state of research on argumentation, indicating how the project contributes to research as well as provides a tool. The section on the work plan outlines the workpackages, tasks, and deliverables.

## 2 NaLEA and the EU

NaLEA can address some of the pressing needs social and economic needs of individuals, organisations, and public administrations in the European Union. At any time, a range of issues are debated concerning political policy, business development, medical treatment, and so on. Examples, which we discuss further in our use cases, are found in email exchanges, document comment, and comment blogs in newspapers. The recorded output of such debates is voluminous, unstructured (meaning it is difficult to determine what parts of the debate relate to other parts or what the outcome is), is not easy to transmit to a wider audience, and does not straightforwardly cross national linguistic boundaries. Given the information output by such debates, only certain key individuals who review the parts of the debate, such as policy makers, are in a position to identify key points, represent the debate, and propose an outcome or solution. Thus, in effect, policy is determined *top-down* as a practical matter; it is unclear to what extent *bottom-up* information is taken into consideration. For example, consider the recent financial crisis in the EU; political, economic, and business experts struggled to understand both the problem and the solution. The citizenry contributed to the discussion via *blog* comments in the press; however, it is unclear what, if any, impact the comments made on the policy outcome. In the end, a small group of policy makers summarised the issues and proposed a solution, which may not take into consideration a range of factors or consequences.

The complexity of information is in large part due to the very nature of the EU as an *open society*, where knowledge is provisional and fallible, where statements can be disputed and alternative view points provided. The EU is by nature a *pluralistic* society which requires the citizenry to participate in open debate, engage in critical thinking, and criticise alternative positions. However, other than at the ballot box and via representatives, the direct voice of the citizenry as a *collective* is muted. Rather, public discourse is constrained by the means to conduct clear and rational discussion and critique; in the absence of the means of communication, public discourse reverts to hierarchical control.

NaLEA is a tool to facilitate debate in an analytic framework across a range of domains and contexts. With NaLEA, stakeholders can individually contribute to the overall construction of the debate, introducing points, counterpoints, and refinements concerning the issue under discussion. Moreover, given inputs from the stakeholders, NaLEA can calculate the alternative positions and their relationships, clarifying just what are the issues and consequences. With support for graphical representations of arguments, stakeholders can more readily identify the structure of the debate, its points of weakness and strength.

The advantages are numerous. Rather than hierarchical presentation of issues and arguments, debates can be non-hierarchical. A range of viewpoints and criticisms can be input, leaving it to NaLEA to calculate the consequences and consistency of statements. Each point of the debate is given due consideration in the overall outcome rather than being lost. As a consequence, better political, economic, business, and medical decisions can be determined more efficiently and effectively by such a *collective* debate, which is also more highly structured, more readily interpretable, and keeps track of every aspect.

A related difficulty in the EU is that given the variety of languages, complex issues are not debated publically across national boundaries. For example, while EU policy makers debated and determined EU financial policy, the citizenry by an large focussed on intra-national discussions within their own linguistic context. Thus, a transnational issue was discussed only at a national level, with little opportunity for international understanding.

NaLEA can address this as well. By translating linguistic expressions of a debate into and out of an abstract logic and argument graph, the debate is given an *a-national* or *a-linguistic* representation. Where the abstract representation of the debate is represented on a publically accessible website, in principle, members of different linguistic communities can argue about the very same issues collectively; the argument graph is at the core and is common to all linguistic representations. Because a controlled language is applied, we can be assured that the same argument is represented.

However, interlinguial argumentation is not itself part of this proposal, which focusses on providing a core tool for argumentation. Interlingual argumentation introduces a host of potential issues and problems which must be addressed in the long run, but which would be a significantly more complex project and potentially hinder development of a tool. We have selected English as the target language for two main reasons: English is a defacto lingua franca of communication among professionals and academics in Europe; it is a language which facilities communication with large economies outside of Europe where English is predominant such as India, Australia, the United States, and Canada; it is a language used for professional, business, and political activities in countries even where English is not predominant such as Brazil or Japan. However, it is not the intention of the project to fix English as the language of the system. Rather languages should be treated *modularly*, allowing other languages (or grammars of languages) to feed into the abstract representation. Given one sample of a language using NaLEA, impetus would be given providing grammars to input into NaLEA in other languages. To test the modularity, the project will have a small test pilot study of at least one other European language. In addition, a novel research area would be opened – comparative argumentation. If it is found that languages significantly vary in terms of how argumentation is conducted, then the NaLEA system can be adapted accordingly.

## 3 Outline of Proposal, Motivation, and Use Cases

Argumentation is the way that people reason collaboratively or competitively on any topic where information, knowledge, or claims conflict or are inconsistent. A debate occurs when two participants each argue for their position; each of their arguments are dynamic (changing over time) and dialectical (involve argument moves against the other participant's argument). In an argument, one justifies one's claim rather than "proves" it as in logic. The winning argument is that argument which has a better justification than another argument. Whereas in a logic which requires consistency among all the claims, in a debate, arguments for different positions co-occur. Argumentation is the means to develop knowledge, which is provisional and fallible.

Currently, there are *abstract* theories of argumentation which do not clearly represent arguments in natural language. There are, as well, graphical representations of argumentation; however, these require manual translation from arguments in natural language into the graphic form, which takes expertise, is time-consuming, and is prone to variation and error. To make *argumentation technologies* useful and productive, we will build a tool which translates from natural language arguments into a formalisation which supports reasoning about arguments.

As a result of this project, we provide a constrained computational semantic approach to argumentation in natural language which enables argumentation technology to be applied in a range of domains and which is available to a spectrum of end-users. Thus, two (or more) participants input claims and counterclaims (have an argument) expressed in natural language, which is then automatically translated into a logical formalism and reasoned with. As argumentation in natural language is highly complex, we decompose the problem into manageable subproblems as well as to restrict and control what sort of natural language phenomena we examine and what sorts of systems we propose. In general, the approach is one of *refinement*, where a solution is approached by a series of steps which take the analysis from coarse-grained and fixed to fine-grained and flexible. A computational semantic approach is one which takes natural language expressions as input, parses them, and then produces a semantic representation which can be used for inference and model checking. To develop the computational semantic system, we take into consideration empirical issues, using data-oriented, text-mining techniques to identify how users argue and what components of argumentation ought to be built into the system.

### 3.1 Constrained

We constrain the project in the following respects.

- We focus on textual natural language rather than spoken language. Not only does this suit applications over the internet, where textual entry is common, but it removes one component of complexity.
- We focus on the development of a tool for argumentation *on input* by a user. While automatic argument recognition has a key role in the project, it is not the guiding objective. Thus, the tool facilitates human-computer interaction.
- We pick restricted domains of application in which argumentation occurs such as insurance claims or legal cases. These are domains with relatively clear and finite ontological domains. Thus, we can constrain what is discussed and how it is discussed. Moreover, in high-value domains, users are more willing to adhere to the (minimal) constraints imposed by the system. Other domains can be added (scientific debate, medical debate, or others).

- The problem is approached in phases, where the initial phases use argumentative templates and explicit indication of argument relationships. Later phases reduce the restrictions on the use of templates.
- The objective of the reduction of the restrictions is to get to a point where natural language arguments are entered without overt templates or argument indication given to the user.
- While we reduce restrictions, we keep to a *controlled* language using a *predictive editor*. A controlled language is an (extensible) subset of a natural language lexicon and syntax; the language should be very natural and expressive, yet restricted. A predictive editor means that users are guided on input for well-formedness; the resulting expressions are syntactically and semantically well-formed; ambiguities are filtered out on input. We adapt extant systems such as *Attempto*.[4]
- We do not model *internal* dialogical aspects such as the beliefs, desires, or intentions of dialogue participants, but only the *external* dialogue which records the claims of the participants and the relationships among the claims.
- We represent natural language semantics with Discourse Representation Theory (DRT), which is a first-order predicate logic that handles discourse relations.[5] The output of DRT is compatible with current argumentation formalisms. We apply existing theorem provers and model checkers.
- We use and develop *extant* argumentation formalisms which address *defeasible reasoning* that is central to argumentation (e.g. [1] and [2]).
- We use and develop *existing* formal approaches to argumentation schemes which can be used to support translation from arguments in natural language to formal representations of arguments (e.g. [3], [4], and [5]).

As a practical matter, we make the *English* language the focus of the project. Note that English is to be translated into and out of a logical representation; the same would hold of other languages. Therefore, we would not need to consider issues of translation between languages, for each language would be translated into and out of the common logical representation. Nonetheless, the structure of the systems ought to be such that in principle, input could be in any language.

We distinguish several sublevels of argumentation following current linguistic analysis of discourse relations and following the distinctions between *argument*, *case*, and *debate* ([6], [4]).

- The syntax and semantics of sentences.
- Intra-sentential discourse relations as found in *Discourse Representation Theory*.
- Argument discourse relations are the relations which indicate what role sentences play in a particular argument and their relationships such as premise,

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[4] See:
http://attempto.ifi.uzh.ch/site/description/

[5] DRT is also output by Attempto. Also see C & C plus Boxer, which is a wide-coverage CCG parser plus computational semantics tools:
http://svn.ask.it.usyd.edu.au/trac/candc/wiki

exception, and conclusion. An argument must cohere around a set of concepts. This level defines well-formedness for an argument.
– Case discourse relations. These are the relations *between* arguments. Arguments in a case support other arguments in a case.
– Debate discourse relations. These are relations *between* cases which have as their final claim a pro and con statement. Arguments in once case attack arguments in another case.

### 3.2 Data-Oriented Aspects

In developing our computational semantic approach to the development of the NaLEA system, we take into consideration and build upon state-of-the-art research on text analytics, which includes identification of the constitutent parts of arguments and their relationships. A component of text analytics is the automated recognition of textual entailment and inconsistency, which is highly relevant to issues of scientific interest that are discussed below. However, rather than incorporate text analytics directly into the argumentation engine itself, we use data-oriented research to specify what our abstract system of argumentation ought to incorporate and reason with. The rationale is that text analytics are bound by spans of text that can be taken into consideration in an analysis; these spans may be too restrictive to represent inter-relationships of arguments. Moreover, we are interested in an argumentation system which is in principle linguistically neutral, while text analytics are grounded in the language under analysis.

### 3.3 Scientific Issues of Interest

Some key scientific problems to be addressed:

– Translating arguments in natural language into a logical representation.
– When are two statements in natural language inconsistent, consistent and related, consistent and yet unrelated? This relies on translating language statements into a logical formalism which can test for inconsistency between *specific* statements relative to a set of statements. To determine *relatedness* of statements, lexical fields and situational frames would be applied.
– How can an argument and a case be modified by later users. For example, if two users are entering statements for their arguments for their case, how can we automatically (as opposed to manually) identify what one person is attacking specifically in the case of another person? By the same token, if one user is updating their case, how can we automatically identify what their statement is in relation to?
– How can we automatically translate natural language arguments via the logical formalism into an argument graph (in keeping with [7]).
– How do we calculate consistent sets of arguments, the relations between the arguments, and the justification of arguments given the available facts and applied rules?

- If we know our domain of knowledge and if we know the arguments, cases, and attack relations, how can we automatically generate counterarguments and critical questions to an argument and given a goal? For example, in an insurance claim, if a claimant reports a car crash, the insurance system ought to ask about evidence to support this claim.
- How can we calculate the *best* argument as the *argument with the best justification*?
- How can we *precompile* implications for reuse at a later point. Thus, if a user enters a statement which is already found in a previous argument, then precompiled inferences ought to be drawn rather than drawing inferences on the fly relative to every statement.
- A comparison and contrast between machine-learning approaches and computational semantic approaches to argumentative reasoning.

The following graph gives an initial overview of the key modules and their relationships. Note that in our approach, the role of the data-oriented, text-mining aspects of the proposal is primarily to empirically specify the sorts and relationships between components of argumentation as found in natural language. However, it may be useful to consider applying data-oriented approaches *within* a language to identify arguments related to the input argument and then input to the semantic interpreter and formal argument graph.

### 3.4 Advantages of the Tool

The advantages of such a tool are:

- The tool *supports decision-making* at an advanced level.
- As a tool in a (controlled language with predictive editor), the "learning curve" to data entry is low (preferably very low and guided). Thus a range of users could input data which is otherwise restricted to experts. Users employed in high-value contexts (insurance, medicine, law, military) should find the input tool unproblematic.
- Given a rich lexicon and expressive sentence forms, the inputs and outputs are well-formed, standard natural language of the sort used in professional settings.
- A highly *flexible, articulated system* for representing and reasoning with the facts and arguments. A greater range of expressions could be used.
- An expressive representation of the facts and arguments can be *searched*. One can discover patterns of claims such as whether or not the argument has previously been used and what the results were.
- Processes of *argument and counterargument can be automated*. One can reduce costs of processing a claim. Ruling out unjustified claims earlier and automatically will save on payouts.
- The tool could be *extended* to other domains. It will be an open, extensible tool.
- Different languages can be added as modules given a controlled language with predictive editor that supports the argumentation forms of the tool.
- The tool uses and builds on existing semantic web blogging tools.

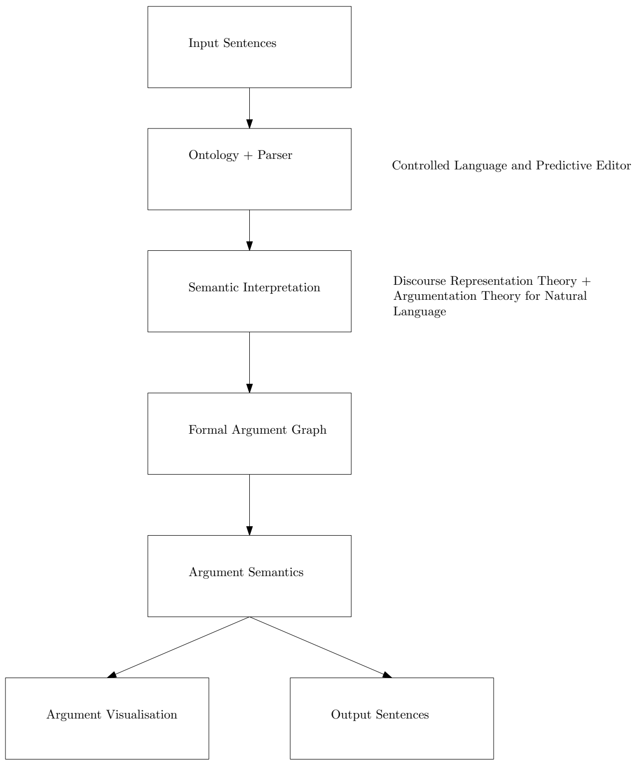


**Fig. 1.** Flow of Input to Output

### 3.5 Use Cases

We will develop a demonstration of the framework in a pilot application for industries and organisations which require user input of disputable facts and claims and which would benefit from automated decision support. The model input format is an interactive *comment blog*, where each participant can enter in a claim or a counterclaim to some other participant's claim.

- Lawyers argue a case in court.
- An individual presents a claim to an insurance company.
- A family discuss what house to buy.
- Medical experts debate what course of treatment to follow.
- People comment on newspaper stories or editorials.
- Business people consider a business proposal.
- Government administrators debate policy.
- Military officers debate what strategy to pursue in a given scenario.
- Scientific argumentation about a phenomena.

Because the range of applications is very broad, we restrict ourselves to disputes in high value, restricted domains such as insurance claims, public policy, or other legal domains where there is a clash of interests or perspectives. The ontologies of the domains ought to be, in principle, knowable and finite so that the argumentation system can reason systematically to clear, justified claims. Where ontologies are not knowable or finite, then some of the reasoning facilities of NaLEA cannot be applied such as the identification of inconsistency or implication.

For illustration, we give a brief public policy example, followed by a medical example to illustrate the potential range of application. While we present an example in a structured way (all arguments for one proposal followed by a rejoinder), the implementation is to allow a range of structures. It is important to emphasise that these are *samples* to illustrate some of the issues that NaLEA will address. Further use cases which are more complex and richer can be provided, will form the basis of the corpus on which data-oriented analysis will be conducted, and will be designed into argument structures that NaLEA can parse and reason with.

**Public Policy** Public administrators are responsible for proposing, debating, assessing, and modifying public policy. In doing so, a range of information and reasoning is used, leading to complex documents about sensitive social matters. In the following Use Case, we consider arguments for and against the US Federal Housing Administration insuring home mortgages in the current credit crisis. We present this in terms of a proposal, then arguments for or against the proposal.

- Proposal P1: The Federal Housing Administration's should pass a bill for $300 billion to insure home mortgages at the greatest risk of foreclosure after holders of the loans agree to reduce principal.
- Arguments for P1
  - Argument A1: P1 will prevent the destabilization of neighborhoods.
  - Argument A2: P1 will prevent further declines in property values.
  - Argument A3: P1 will prevent further threats to the broader economy.
  - Argument A4: Holders of the loans bear some responsibility for the crisis, so therefore should bear some of the cost.
- Arguments against P1
  - Argument A5: P1 puts too much risk with the government.
  - Argument A6: P1 would cost taxpayers too much money.
  - Argument A7: P1 rewards financially risky behaviour because it does not filter out financially irresponsible homeowners.
  - Argument A81: P1 does not address root cause which is that the financial system does not rate and value assets correctly.
- Arguments against A2, A5 and A8
  - Argument A9 against A2: The funding will not prevent further declines in property values.

- Argument A10 against A5: The risk to the government is limited to an estimated 500,000 homeowners.
- Argument A11 against A5: The government will focus only on those at greatest risk of foreclosure.
- Argument A12 against A5: It is better for the government to do something rather than do nothing.
- Argument A13 against A8: The problem is a general, global disregard of risk.

**Medical Treatment** Suppose a medical context where a doctor must formulate a course of treatment for a patient who has a high risk of developing breast cancer. A variety of courses are available as provided by a knowledge base. Even within a given course of treatment, there may be conflicting information concerning its efficacy. For instance, suppose a doctor considers removal of ovaries, but studies which report two different arguments with contrasting results.

– Argument A1: Removal of the ovaries reduces risk of breast cancer by 70%, since this has been reported by clinical trial 1.
– Argument A2: Removal of the ovaries reduces risk of breast cancer by 55%, since this has been reported by clinical trial 2.

Intuitively, A1 and A2 *attack* one another, which must be inferred from linguistic and contextual knowledge. Given that A1 and A2 conflict and no further information is available, it is difficult to know whether removal of the ovaries is or is not efficacious.

To break this situation, the doctor locates further information which introduces a further argument:

– Argument A3: Clinical trial 2 is based on a flawed design.

In effect, A3 attacks A2, leaving A1 as an argument which is not attacked, thereby winning.

Note that this is given the current state of knowledge, for it may be that there is an additional (unknown) argument against A1. The doctor infers that given the current state of knowledge, removing the ovaries would reduce the risk of breast cancer by 70%. This example could be further developed with additional arguments for or against any of the other arguments. For example, an additional argument may point out that clinical trial 2 is based on an unusually large population sample which compensates for the design flaw; this attacks A3. Furthermore, another argument shows that clinical trial 1 was based on an unusually small population sample, which undermines the conclusions. Having attacked the attacker of A2, and attacked A1 independently, we may suppose that A2 is the winner. As with other relationships, these additional attacks must be introduced based on the implications which follow from population samples.

### 3.6 Research Objectives

Our primary research objective for this research programme is:

- Develop and deploy an automated, argumentation-based decision-support tool with a natural language interface. The tool takes input in natural language, translates it into a logic suitable for argumentation, and calculates justified arguments. The output of the calculations can be represented either in an argument graph or in natural language.

In the course of developing and deploying the tool, we have several subsidiary objectives, each of which contributes some specific aspect to our understanding of argumentation in natural language and the development of the tool. Each of these objectives is already well-developed and will be leveraged for the primary objective. In effect, the primary objective will be met by integrating what is known in the subsidiary areas and carry out further research along the same lines in order to fill in what is not known. These objectives are:

- Develop a corpus for argumentation derived from legal cases, debates, meetings, and extant corpora.
- Apply machine learning techniques for recognising arguments, argument structures, and argument relations.
- Identify linguistic indicators of argument and related intuitive issues of argumentation.
- Provide a formal, articulated framework for natural language argumentation.
- Build ontologies for domains of application and for argumentation.
- Design computational semantic tools to formally represent and reason with arguments.

### 3.7 Development Cycle

To achieve our primary research objective, our strategy is to:

- Adopt, adapt, and develop current technologies for translating from natural language to Discourse Representation Structures.
- Use current technologies for theorem proving and consistency checking in first order logic.
- Adopt, adapt, and develop current technologies for reasoning about arguments abstractly.
- Follow a step-wise development strategy from simple, abstract examples of argumentation input to more complex, less abstract examples. In initial phases, we will fix the argument templates and use propositional logic; relationships between arguments would be manually determined; argumentation semantics would be calculated. At a more advanced stage, we use additional argument templates and translations of natural language into first-order logic; we automate argument relationships such as consistency checks. We then systematically add richer argumentation structures, argumentation features, and richer input domains.

– Follow the specifications of argumentation as provided by the subsidiary objectives.
– Test the current state of the system by inputting sample argument structures which are provided by the analysis of the corpus.

### 3.8 Evaluation

Given our step-wise development strategy, we evaluate each stage of the system against data arguments which are comparable to the development arguments that were used to develop that stage of the system. We also conduct *usability* analysis to determine how novice users experience the system. As the development of the tool moves to more advanced stages, it can be made available on the web where individuals can use the system and their behaviour can be monitored. Since the primary objective of the project is an argumentation system that allows users to input arguments over the web, resulting in argument graphs and argument semantics, we do not evaluate the system against the corpus which was used to develop the components of the tool. Rather, we evaluate the system with respect to how users succeed in constructing arguments for or against positions in a manner which fulfills the objective of calculating with arguments in natural language.

## 4 Background

Broadly speaking, there are two main current approaches to argumentation – computational models and more empirically-oriented research. Research in legal argumentation (LA) is a subbranch of computational models. Broadly speaking, researchers approach LA from opposite degrees of abstraction. On the one hand, *theoretically* oriented Argumentation Frameworks (AFs) take arguments as abstract and atomic objects in attack relations ([7], [8], [9], and [4]). It has been claimed that AFs can be used to account for a broad range of issues in non-monotonic reasoning [10], and their formal and computational properties are well understood [11]. Moreover, AFs have been extended in various ways to accommodate a greater range of issues such as modelling the difference between premise attacks, rebuttals, and undercutting ([4], [6], and [12]), modelling judicial contexts [13]), and representing an actual legal case [14]. The main advantage of such approaches is that one can focus on high level generalisations about sets of arguments and the complexity of their relationships. However, there are few such extensions that cover the range of natural argumentation, nor are there automated means to enter natural arguments into an AF and reason with them.

On the other hand, a range of related *empirically* oriented approaches attend to specific argument structures, properties, or elements: syntactic parsing [15], data mining and automatic classification ([16], [17], [18]), argument generation ([19] and [20]), graphic representation [21], XML markups of arguments [22], corpus and mark-ups of meetings ([23] and [24]), text summarization [25], pragma-dialectics ([26]), rhetorical argument structure [27], argument schemes

([3], [28], and [29]), dialogue protocols ([30], [31], [32], [33]), argumentation coding [34], and the identification of inconsistencies ([35] and [36]).

In the area of computational semantics, recent work on recognising inference and calculating entailment outlines the current state and prospects ([37], [38], [39], [40], and [41]). The Recognising Textual Entailment tasks do not address arguments with complex structure or relationships between arguments. While computational semantic approaches [37] translate arguments with several premises and infer a conclusion, there is no dialogical aspect. Nor is the system geared towards a controlled language with predictive editor.

However, there is very little research to systematically translate arguments as they appear in natural language to a formal representation which can be reasoned with (though see [42] and [1] for some inclinations in this direction). All translation of natural arguments to any formalisation is done manually and without a method. Consider an argument from classical logic, such as *Every man is mortal, Socrates is a man, therefore Socrates is mortal* for which we have automated translation systems into first-order logic. In terms of argumentation, the first two statements *Every man is mortal* and *Socrates is a man* are understood to be premises. The last *Socrates is mortal* is understood as the conclusion of the argument. The relationship between the terms is calculated by Discourse Representation Theory. Another (defeasible) example is *Every bird can fly. Tweety is a bird. Therefore, Tweety can fly.* However, there is as yet no automated or systematic method to translate the range of argumentative patterns reported in the literature [3]. Nor is there any way for some other participant in a dialogue to directly counter a particular statement, for example, by countering the first argument *Socrates is not a man* or *Not all birds fly.*

While both approaches are based in natural language argument, neither directly makes use of natural language as the means to input arguments to an argument evaluator, which is the easiest and most familiar mode of expressing arguments, cases, and debates. Indeed, all the difficult *interpretive* work from natural language into the formal representation that is then reasoned with automatically is left to the translator. This is a highly skilled, time-consuming, and error-prone procedure. For argumentation to be useful, it must be made more accessible and reliable. We believe the bridge must be built between the formal and graphical approaches and natural language input. In other words, the end user would simply enter statements in natural language which comprise their argument and which are counter to previous statements; the abstract argument representation and the graphical representation are automatically built from the natural language input via a translation from natural language into a logic. The proposal addresses how this translation would be done, making a useful tool while avoiding a range of complex problems. Broadly, it adopts approaches in *computational semantics*, which have been highly successful in providing translations from multiple statements in natural language into *discourse representation theory*. Our work builds on this approach.

In particular, we adopt and adapt current technologies of controlled languages and predictive editors to translate from natural language to our formalism. In a controlled language, natural language input is (reasonably) constrained in terms of vocabulary, sentence form, and argument form; the predictive editor "guides" the user on input so that the resulting natural language expressions are well-formed. The expressions are then automatically translated to a logic and reasoned with. In this approach, what must be developed are AT versions of the controlled language, predictive editor, and logical translation to an argumentation form. End users need not be highly trained in argumentation.

## 5 Argumentation on the Web

*Argumentation* is a major new research area in Computer Science, Philosophy, and Linguistics judging by recent conferences (COMMA, topics in AAAI-08, and Persuasive), workshops (ArgMAS, ArgNMR), and special editions of the journals *Artificial Intelligence*, *IEEE Intelligent Systems*, and the *International Journal of Intelligent Systems*. Any debate or course of consideration can be understood as an argument: medical staff determining a diagnosis and treatment, lawyers arguing a case before a judge, a couple deciding what house to buy, or politicians debating policy. Current research has not only provided a firm theoretical underpinning to argumentation in *non-monotonic logics*, but also has explored natural language argumentation, philosophical notions of argumentation, and developed some software tools to support representation, analysis, reasoning, and search.

Of particular current interest are efforts to bring *argumentation to the web* using *Semantic Web* tools and techniques. The goal is to provide web-based technology such that users can argue over the web: a user inputs a claim, making it available for debate; and other users add claims pro and con to this initial statement as well as to subsidiary statements. The relationships between the statements are determined on input so that over the course of the debate, a graph is constructed which represents the ways that individual statements *support* or *attack* other statements in the graph. Such a *dialectical* structure or *argumentation framework* could then be used to *draw inferences*, *support queries*, and *provide consistency checks*.

Currently, most such debates occur on the internet as blog comments. However, using commenting facilities, it is very hard to see the "structure" of the debate, to understand the semantic relationships of the various statements, to avoid redundancy, to identify points that need still to be developed, to query, or to apply any reasoning engines. In some systems, debates are supported with specialised software which allows users to represent, exchange, and search for arguments. However, the *expressiveness* of these systems is highly restricted and do not support query or reasoning engines.

*Search* is key in the development of an advanced, argumentation-based tool for online debate. Consider a problem in a medical domain where a doctor wants to contribute some claim to a discussion on a particular patient's course of treatment. For example, the doctor claims that one of the tests given to the patient is unreliable and therefore does not indicate a particular course of treatment. When she does so, she also wants to find claims for or against her claim (if any), thus locating her claim in a larger debate. Currently, she would do so "manually" by consulting colleagues or a written record, and thereby reconstruct the "argument". However, such a manual analysis requires a high-level of skill and knowledge of the area as well as rich information sources; a manual analysis is also error prone, does not provide the "big picture", and does not support automated query or reasoning engines.

An automated argument tool on the internet would help to locate debates related to her claim. Upon entering her claim, she could automatically *search* for claims pro or con which are related to her claim, allowing her (or an automated system) to draw conclusions or decide a course of action. For instance, upon entering her claim, she finds out that the unreliability of the test depends on other factors (so perhaps the test is a good indicator in the current circumstance, but further tests need to be run) or that even if the test is reliable, it would not indicate the course of treatment. Such a tool would overcome a range of disadvantages of a manual search and analysis.

While some software tools already allow argument representation, analysis, reasoning, and search, they operate at a very rough level of granularity and do not support reasoning engines. To be useful, a tool will have to approximate the expressiveness of natural language, for users want to have arguments in a form close to natural language and as articulated as the arguments they wish to make. Furthermore, we want arguments entered in natural language to have a *logical representation* so as to support inference, query, and tests for consistency. Such a logical representation should be founded on a well-developed theory of *non-monotonic reasoning*.

To provide a more fine-grained tool for argumentation using natural language, we propose the application and extension of *control languages* and *predictive editors* to argumentation. Controlled languages and predictive editors use Natural Language Processing (NLP) to guide the user in providing *on input* well-formed expressions on a given topic as specified with respect to an ontology; such tools already exist which not only provide Semantic Web representations of input expressions, but also translate the input expressions into a well-developed discourse logic. They are not yet intended to provide support for full or "free" natural language input, but are initially a tool for constrained, high-value domains such as medicine, law, and policy debate. As natural language processing advances, so too would the sophistication of the tool. One main research aim would be to augment existing tools with inputs for and logical representations of argument, marrying current computational theory on argumentation with current NLP applications and Semantic Web technologies.

## 6 The Proposal

We have identified a gap between these the abstract and empirical approaches to argumentation: AFs support non-monotonic reasoning, but do not take natural language arguments as input, nor do they represent the full spectrum of natural arguments; the empirically oriented approaches do not represent and reason with arguments in AFs. Little work has been done to *narrow* the gap. To do so, develop *both* sides in order to bridge the gap: the natural language input side as well as the AF side. On the AF side, an *articulated argumentation framework* must be provided into which natural arguments can be translated and reasoned with along the lines of ([4] and [13]). On the input side, a parser for natural language arguments must be built. The parse of arguments must be translated in DRT and subsequently into the argumentation formalism. The result will be a *prototype* implementation of a system which represents and reasons with natural arguments, providing natural language input and output.

For the *front-end* natural language input, we build on current computational semantic and linguistic analyses, using *currently available* technology that is compatible with the *Semantic Web*. Such existing systems have the following components: a user enters natural language expressions following a *controlled language*, which supports a subset of the lexicon and syntactically well-formed natural language expressions, along with a *predictive editor* which ensures that only expressions in the controlled language are entered.[6] The expressions can be unambiguously translated into discourse representation structures, a syntactic variant of first-order logic; the structures are translatable into and out of OWL Description Logic [43]. The advantages are that only well-formed expressions are entered, that the representations are computer-processable as *semantic wikis*, that they have a semantic interpretation and can be queried. [7]

On top of front-end, we add the linguistic expressions and semantic interpretations so a user can input arguments and relationships among expressions. Such interpretations are then input to a reasoning engine. While there may be alternative engines, we provide a translation into a *back-end*, which is a formal, articulated machine-processable AF language. We reason with these AF expressions. To accomplish this, we study natural arguments and select key expressions which mark argumentative roles and relationships. We also translate *patterns* of arguments into more expressive AFs. One instantiation of this work would take expressions of a legal case from [14] as input then automatically generate the AF argument graph and its results. We would demonstrate our representation and the system on non-trivial samples of legal argumentation that are of interest to the legal argumentation research community.

It is important to emphasise that as a proof-of-concept, we shall focus on a controlled language for argumentation and user input, not on free text. The tool is envisaged as an *extensible laboratory tool* in which natural arguments can be input, represented, and reasoned with. Moveover, initially, we make several simplifying assumptions. In particular, we do *not* address issues concerning the

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[6] See:
http://www.ics.mq.edu.au/∼rolfs/controlled-natural-languages/
http://attempto.ifi.uzh.ch/acewiki/

[7] Another automatic translation system is C & C with Boxer which is a sophisticated, linguistically well-founded system. However, it would have to be provided with controlled language and predictive editor capabilities.
http://svn.ask.it.usyd.edu.au/trac/candc

full range of issues in *textual entailment* [44], where one is concerned with the alternative syntactic forms for one meaning or the alternative meanings for one syntactic form (ambiguity). For our purposes, we constrain the amount of variablility of forms and meanings. A research question will be how loose can the formal system be without degrading usability. However, it will be part of our objective that the system be *extensible* so that additional linguistic aspects can be incorporated into the system.

Our research will advance our understanding of the abstract and formal approach to argumentation since we will have to add structure in order to accommodate natural argumentation. As well, a formal model will lead to greater understanding of the underlying principles and structure of natural argument, much as formal syntax and logic and have helped us to understand natural language syntax and semantics. The research will be a step towards fully automated reasoning with natural argument. In the context of the research, we will build an application to support argumentation in natural language in a specific domain. However, the tool will be extensible to other domains, so more broadly applicable.

## 7 The Work Plan

We break the research program down into 6 *workpackages*, each of which is subdivided into *tasks*. For each workpackage, we give an overview of the aims of the workpackage, describe the tasks, describe the research methodology, and breakdown the effort per task in person-months.

### WP1: CCS-Argumentation Empirical Analysis

OVERVIEW: *The aim of this workpackage is provide a throughout, a state-of-the-art empirical analyses of a corpus of arguments using computational linguistic, linguistic, and computational semantic approaches. Different approaches are used for comparison and contrast, which identifies key components and their inter-relationships. The central issue is to provide an empirical basis for what needs to be added to a controlled language with predictive editor in a dialogical setting and with features for argumentation.*

TASKS T1:

T1.1 Computational Linguistic Text-mining
(X person-months)

Text-mining approaches to recognising arguments in natural language. This includes the *recognising textual entailment* research and other text-mining research. What are the results, problems, and prospects of statistical and machine learning approaches to argument recognition? How can the features of argumentation be identified automatically? Can "missing" indicators of argumentation structures be automatically filled in. How can these results be applied to argument production? The result is to specify patterns of argumentation. Cohesion within an argument and cohesion between arguments are examined as well as attack between arguments.

T1.2 Linguistic Approaches
(Y person-months)

Linguistic approaches to natural language argumentation. This includes research on rhetorical structure theory and pragma-dialectics. What are the linguistic cues that speakers of a language use to identify argument moves. A close linguistic analysis of sample texts. What are the overt linguistic "indicators" of argumentation? What are the "covert" or inferred indicators of argumentation? How are relations between arguments expressed? Cohesion within an argument and cohesion between arguments are examined as well as attack between arguments. The result is to specify patterns of argumentation.

T1.3 Analysis of Computational Semantic Systems
(Y person-months)

In this task, the range of extant computational semantic systems are compared and contrasted. Key features and functionalities are recommended. They are tested against arguments in the corpus to determine the strengths or weaknesses of each system.
This includes current systems such as *C & C*, *Attempto*, and *RuleBurst Studio*. Currently, *C & C* and *Attempto* both take multiple statements, parse them, and translate them into DRT. *RuleBurst* takes bodies of text, but does not determine discourse anaphor (or similar). Attempto is a controlled language with a predictive editor, while *C & C* has a broader coverage and greater semantic depth, but does not represent a controlled language with predictive editor. *RuleBurst* is a rules engine expressed in natural language with a commercial interface. No current system addresses issues at the core of argumentation. This work package identifies the strengths and weaknesses of these approaches. It considers how the systems could be modified to take into consideration argumentation as well as what features one wants from a system built from scratch.

T1.4 Abstract Argumentation Systems
(Y person-months)

Review abstract argumentation systems, noting where they lack the granularity required for argumentation in natural language ([13], [4], [33], and [1]).

The task specifies what needs to be added to such frameworks to address argumentation in natural language.

DELIVERABLES D1:

D1.1 Corpus

This deliverable is the development of a corpus of arguments and cases that are used in the tasks.

D1.2 Results of Text-mining on the Corpus

This deliverable presents the findings of text-mining applied to the corpus.

D1.3 Results of Linguistic Analysis on the Corpus

This deliverable presents the finds of linguistic analysis of the corpus.

D1.4 Results of Computational Semantic Analysis

This deliverable presents the computational semantic analysis on the corpus.

D1.5 Results of Abstract Argumentation

This deliverable presents the results of the analysis of abstract argumentation systems in terms of how such systems relate to the empirical analysis of abstract argumentation. What needs to be added to abstract systems to represent arguments in natural language.

D1.6 Cross-comparison of Results

This deliverable compares and contrasts the results of the deliverables DA.2-DA.4. The results provide templates or patterns of argumentation, techniques for argument recognition, a toolbox of components of argumentation, and elements that ought to be provided in abstract argumentation systems.

METHODOLOGY: Gather the current research and systems. Build and analyse a corpus. Cross-compare the different approaches.

WORKPACKAGE TOTAL: ? PERSON-MONTHS

**WP2: CCS-Argumentation Design**

<u>OVERVIEW:</u> *The aim of this workpackage is to specify the constrained computational semantic approach to argumentation in natural language given the findings of the previous workpackage. It provides domains in which to argue. It specifies what needs to be added to a controlled language with predictive editor in a dialogical setting and with features for argumentation. We specify ontologies for particular domains of argumentation. Argumentation is provided an ontology along with a syntax and semantics. An abstract argumentation framework is given into which natural language arguments is translated. The relation of the specifications to the computational semantic framework is specified.*

<u>TASKS T2:</u>

T2.1 Building Model Domains
(Y person-months)

Derived from the corpus, we build ontologies and models of several domains in which the tool would be used. This would cover different sorts of domains to test the generality of the argumentation model.

T2.2 Specifying the Argumentation Ontology, Syntax, and Semantics
(Y person-months)

Given the results of the empirical study of argumentation, an argumentation ontology is provided, along with a syntax and semantics with respect to natural language argumentation.

T2.3 Specifying the Abstract Argumentation framework
(Y person-months)

An abstract argumentation framework is provided which takes into account the natural language structures of argumentation.

T2.4 Cohesion and Attack in Argumentation
(Y person-months)

Cohesion within and between natural language arguments is specified; attack between natural language arguments is provided.

T2.5 Specifying the Computational Semantic System
(Y person-months)

The computational semantic system must interface with the model domains, the syntax and semantics of argumentation in natural lanugage, and the abstract argumentation framework into which natural language arguments are translated.

DELIVERABLES D2:

D2.1 Domain models

D2.2 An ontology of argumentation along with a syntax and semantics

D2.3 Papers reporting the abstract argumentation framework

D2.4 An analysis of cohesion and attack in natural language argumentation which is related to the abstract argumentation framework.

D2.5 Papers specifying the computational semantic system.

METHODOLOGY: Based on the empirical analyses and review of the field, specifications for components of the overall computational semantic system are written

WORKPACKAGE TOTAL: ? PERSON-MONTHS

**WP3: CCS-Argumentation Implementation**

OVERVIEW: *The aim of this workpackage is to incrementally develop the software tools that implement the specification. The granularity of the system goes from current coarse-grained to finer-grained functionality. Problems and opportunities identified in this sequential development are used in the next workpackage.*

TASKS T3:

T3.1 Schematic Argumentation
(X person-months)

Existing computational semantic systems are "wrapped" with an argumentation system that is highly structured with input for statements that can already be parsed. In particular, statements are input into boxes that identify premises and conclusions. Users specify what statements attack what other statements. At this level, input arguments are mapped to the abstract argumentation framework and argument semantics are calculated. Argument moves of attack and support (cohesion) between participants must be manually associated. The computational system must translate these arguments into the abstract argumentation framework, which calculates extensions and winning arguments.

T3.2 Unwrapped Argumentation
(X person-months)

The previous constraint on "wrapped" argumentation is relaxed. Participants enter arguments with the controlled language and predictive editor for argumentation. The argument moves are still manually associated.

T3.3 Unwrapped Argumentation with Automated Identification of Cohesion and Attack
(X person-months)

The previous version automates the identification of attacks and support.

DELIVERABLES D3:

D3.1 Schematic Argumentation

D3.2 Unwrapped Argumentation

D3.3 Unwrapped Argumentation with Automated Identification of Cohesion and Attack

METHODOLOGY: This is a sequential workpackage. Initially, the argumentation system is tightly constrained. Then features are added to loosen the constraints to test at each stage the functioning and practicality of the additional components.

WORKPACKAGE TOTAL: ? PERSON-MONTHS

**WP4: CCS-Argumentation Refinement and Extensions**

OVERVIEW: *The aim of this workpackage is to use the problems and opportunities identified in WP1-3 to refine the specification and functionality of the systems as well as to extend the system.*

TASKS T4:

T4.1 Refine the systems in Task 1 by adding in additional elements to the domains and additional syntactic structures.
(X person-months)

T4.2 Extend the system to a novel domain to test how flexible it is.
(X person-months)

DELIVERABLES D4:

D4.1 Report results of T4.1.
(X person-months)

D4.2 Report novel domain and response of the system.
(X person-months)

METHODOLOGY: Consider the problems and opportunities identified in WP2 and refine the specification and the functionality of the system. Add an additional domain.

WORKPACKAGE TOTAL: ? PERSON-MONTHS

**WP4: CCS-Argumentation Validation**

**WP5: Dissemination and Exploitation**

OVERVIEW: *The aim of this workpackage is to conduct experiments with legal staff on the use of the various levels of the system and in the various domains. Each stage of the prototype will be tested; problems and opportunities at each stage can be taken into consideration at the next stage of the prototype. This workpackage also covers publications, presentations, and workshops on the system.*

TASKS T5:

T5.1 Tests on D3.1
(X person-months)

T5.2 Tests on D3.2
(X person-months)

T5.3 Tests on D3.3
(X person-months)

T5.4 Publication and Distribution of Argument Corpus D1.1
(X person-months)

T5.5 Workshop on NaLEA and Related Systems
(X person-months)

DELIVERABLES D5:

D5.1 Report on T5.1
(X person-months)

D5.2 Report on T5.2
(X person-months)

D5.3 Report on T5.3
(X person-months)

D5.4 Report on T5.4
(X person-months)

D5.5 Report on T5.5
(X person-months)

METHODOLOGY: Social science research studies on the functionality of the system are conducted.

WORKPACKAGE TOTAL: ? PERSON-MONTHS

**WP6: Management**

## 8 PART 3: Diagrammatic Project Plan

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