# Discourse-Based Reasoning for Controlled Natural Languages

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**Abstract.** Logic-based controlled natural languages usually provide some facility for compositional representation, minimally including sentence level coordination and sometimes subordination. Although these compositional forms suffice for representing short passages, they can become unwieldy for expressing entire paragraphs and documents. This paper describes an approach to representing larger composite texts in a controlled natural language. This approach, called discourse-based reasoning, integrates rhetorical structure theory with argumentation theory to define a model for defining composite structures and argument strategies in an ontological representation. Rhetorical structures are used to represent controlled texts, and argument strategies are defined for reasoning about interactions between structures. This provides the basis for expressing, summarizing, and interacting with explanatory and argumentative discourse. This would expand the scope of problems that may be addressed using controlled natural languages.

**Keywords:** Controlled Natural Language, Rhetorical Structure Theory, Argumentation, Discourse-Based Reasoning

## 1 Introduction

Logic-based controlled natural languages usually provide some facility for compositional representation. Most well known among these, ACE and PENG define discourse representation structures that support both sentence level coordination and subordination [1, 2], and CLCE, CPL, and E2V support sentence level coordination [3-5]. Although these forms of compositional representation are useful for expressing short passages of a few sentences, they can become unwieldy for expressing entire paragraphs or documents. Techniques are needed for representing longer compositions in a way that is both rhetorically expressive and logically reducible. In response to this need, we are developing a discourse-based representation technology that will support high level rhetorical structures, argumentation strategies, and intertextual synthesis.

Our approach, called Discourse-Based Reasoning (DBR), is based on underlying structures of natural discourse and argumentation theory. DBR draws on Mann and Thompson's Rhetorical Structure Theory (RST) [6], Toulmin's model of argumentation [7], and Perelman and Olbrechts-Tyteca's strategic argumentative processes [8]. The Toulmin model provides a framework for argumentation. RST provides schemas, constraints, and rhetorical relations used in generating discourse structures. The concept of strategic argumentative processes leads to a definition of structural interactions which may be discovered and synthesized within one or more ontologically normalized texts. While DBR has been introduced in some earlier papers [9-11], it has become clear that implementation will require use of a controlled natural language. It seems that controlled languages could use DBR as well.

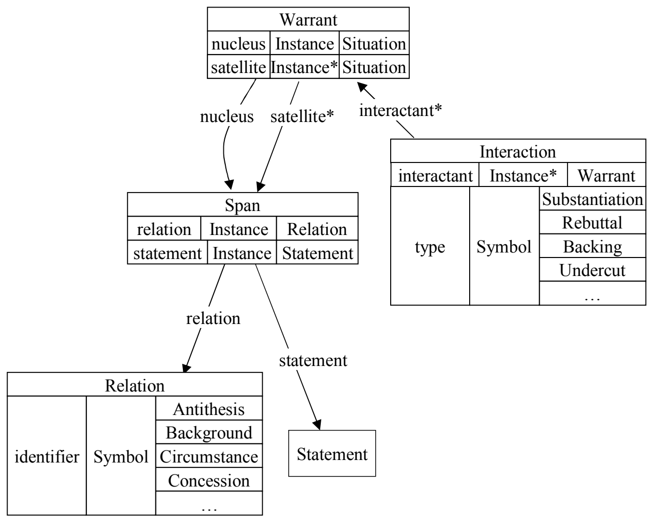


**Fig. 1**. DBR Reasoning Model

## 2 Reasoning Model

The reasoning model defines a mapping between RST and the Toulmin model. This makes it possible to represent argumentative reasoning using RST discourse structures. As shown in Fig. 1, the elements of the model are warrants, spans, statements, relations, and interactions. A *warrant* establishes a set of links between a nucleus and zero or more satellites. The nucleus and its satellites are represented as *spans*. A span consists of a CNL *statement*, and in the case of satellites, the satellite's RST *relation* to its nucleus. In argumentative terms, the nucleus corresponds to a claim, and the satellites corespond to grounds. Each satellite (or ground) links to the nucleus (or claim) by means of a rhetorical relation. That said, it should be noted that while some rhetorical relations are clearly argumentative, or at least inferential, others are merely synthetic, and the reasoning model must take this into account. Examples of inferential relations include Condition, Evidence, Means, Otherwise, and the causal relations. Examples of synthetic relations include Background, Circumstance, Elaboration, Restatement, and Summary. In a synthetic relation, the satellite and nucleus are logically conjunctive, but the nucleus is more salient than the satellite.

This distinction between synthetic and inferential relations supports application of the reasoning process, facilitating both explanatory and argumentative discourse.

*Interactions* define the rules for synthesizing complex structures to create an explanation network. An interaction occurs when a nucleus, satellite, or warrant of one structure can be unified with a nucleus, satellite, or warrant of another structure. Interactions are defined in terms of the possible relationships between warrants, satellites, and nuclei. For example, if the claim of one argument unifies with the ground of another, a substantiation interaction is said to occur. Fig. 2 shows examples of substantiation and concomitance, and Table 1 defines the full set of interactions.

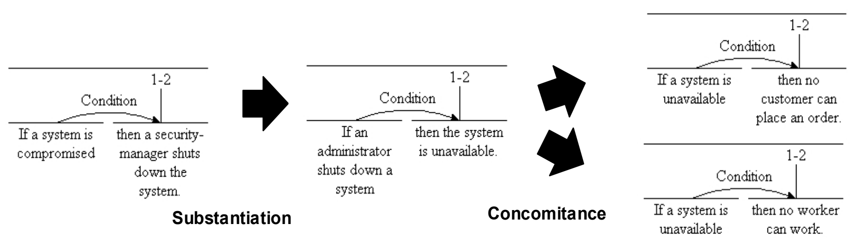


**Fig. 2**. Examples of Interaction Strategies

With this reasoning model it is possible to represent highly expressive explanation networks that may be queried at varying levels of depth. In natural language processing, Marcu [12] and others have shown that salience-based discourse structure may be useful in distilling textual summaries. Further, Marcu integrated a set of metrics that could be used to improve these summaries, such as rhetorical clustering, explicit markers, and structure shape. If techniques such as these are promising for summarizing natural language, it would seem of likely utility for controlled languages as well. Our preliminary experimentation supports this claim. We developed a utility that distills raw summaries with specifiable depth from RST analyses stored in RSTtool markup format, and our results thus far have been encouraging.

## 3 Generating Discourse Structures

For the value of these discourse structures to be realized, it will be necessary to provide an efficient means for their generation. Although parsing discourse relations in CNL may be less difficult than natural language, it is not a trivial problem. The difficulties lie not merely in the complexities of the language, but in the subtleties of the RST relation definitions themselves. Consider for example the distinction between Antithesis and Concession. Antithesis prescribes that the writer has positive regard for the nucleus and that the satellite and nucleus are mutually incompatible, e.g. “Rather than waste time teaching at the university, Charles pursued a lucrative career in the publishing industry.” The Concession relation, on the other hand, prescribes that the writer has positive regard for the nucleus but that there is not necessarily an incompatibility between it and the satellite, e.g. “Although his mother would have preferred that he teach, Charles pursued a lucrative career in the publishing industry.”

Following these definitions it might seem that any instance of the Antithesis relation could also be coded as Concession [13]. Similar difficulties arise when distinguishing Elaboration from Evidence.

For CNL, the answer, it seems to us, is that DBR structures would be created the same way as other CNL discourse structures—namely they would be created as part of the authoring process. For example, Attempto Controlled English supports several discourse representation structures for representing composite sentences, such as conditions, coordinates, and subordinates [1], and the ACE parser is able to recognize these. In a study of automated parsing of natural language texts, Marcu and Echihabi [14] were able to achieve 93% accuracy in recognizing discourse relations for a small subset of relation types. While this success rate is not adequate for CNL, it does suggest that through a combination of refining the RST relation set and extending the set of cue phrases available to CNL authors, it may be possible to develop a hypotactic style that would support automatic DBR structure generation. For example, if we wish to preserve the distinction between Antithesis and Concession, we could specify this through the use of cue words such as *but*, *not*, and *although*:

1 An administrator can *not* verify every system, *but* it is necessary that if a system is a compromised system then the administrator must verify it.

2 *Although* it is possible that an administrator believes that a system is up-to-date, it is not provable that the system is invulnerable.

**Table 1.** Interaction Definitions

| Interaction | Definition |
|---|---|
| **Substantiation**. The claim of one argument is used as the ground of another | **substantiation**(**arg**($G_1$,$C_1$,$W_1$) & **arg**($C_1$,$C_2$,$W_2$)) |
| **Rebuttal**. The claims of two arguments are incompatible | **rebuttal**(**arg**($G_1$,$C_1$,$W_1$) & **arg**($G_2$,$C_2$,$W_2$)) & **incompatible**($C_1$,$C_2$)) |
| **Backing**. An argument substantiates the warrant of another | **backing**(**arg**($G_1$,$C_1$,$W_1$) & **arg**($G_2$,$C_2$,$C_1$)) |
| **Undercut**. The claim of one argument is incompatible with the ground of another | **undercut**(**arg**($G_1$,$C_1$,$W_1$) & **arg**($G_2$,$C_2$,$W_2$) & **incompatible**($C_1$,$G_2$)) |
| **Dissociation**. The claim of one argument disputes the warrant of another | **dissociation**(**arg**($G_1$,$C_1$,$W_1$) & **arg**($G_2$,$C_2$,$W_2$) & **incompatible**($C_1$,$W_2$)) |
| **Convergence**. Two arguments lead to the same claim, with possible accrual | **accrual**(**arg**($G_1$,$C_1$,$W_1$) & **arg**($G_2$,$C_1$,$W_2$)) |
| **Concomitance**. Two arguments use the same ground to establish distinct claims | **concomitance**(**arg**($G_1$,$C_1$,$W_1$) & **arg**($G_1$,$C_2$,$W_2$)) |
| **Confusion**. The grounds of two arguments are incompatible | **confusion**(arg($G_1$,$C_1$,$W_1$) & **arg**($G_2$,$C_2$,$W_2$) & **incompatible**($G_1$, $G_2$)) |

In addition, we may be able to build on this through recognition of syntactically recognizable rhetorical forms, such as sorites, hypothetical syllogism, and dilemma. Paragraph breaks and punctuation cues could also be used to support recognition of larger composite structures [15]. Through a combination of cue phrases, syntactical forms, and layout features, it may be possible to arrive at a composition style that is easy enough for writers to write, readers to read, and automated reasoning systems to process.

## 4 Conclusion

This paper has defined an approach to representing and reasoning about complex composite structures in controlled natural languages. This is accomplished through definition of a reasoning model that synthesizes rhetorical structure theory with Toulmin's argumentative model and Perelman's theory of argument strategy. By defining rules for managing interactions among inferential and synthetic structures, DBR provides the basis for representing, summarizing, and interacting with explanatory and argumentative discourse, and it expands the scope of problems that may be addressed using controlled natural languages. Some anticipated future work includes identification of an experimental RST relation set for CNL, developing a prototype for encoding composite texts, and further definition of the reasoning model.

## References


1. Fuchs, N.E., Kaljurand, K., Kuhn, T.: Discourse representation structures for ACE 6.0. Department of Informatics, University of Zurich, Zurich (2008)
2. Schwitter, R.: English as a formal specification language. Proceedings of the 13th International Workshop on Database and Expert Systems Applications (2002) 228-232
3. Pratt-Hartmann, I.: A two-variable fragment of English. Journal of Logic, Language and Information **12** (2003) 13-45
4. Sowa, J.: Common logic controlled English. (2007)
5. Clark, P., Harrison, P., Jenkins, T., Thompson, J., Wojcik, R.: Acquiring and using world knowledge using a restricted subset of English. FLAIRS (2005) 506–511
6. Mann, W.C., Thompson, S.A.: Rhetorical structure theory: Towards a functional theory of text organization. Text **8** (1988) 243-281
7. Toulmin, S.E.: The uses of argument. Cambridge University Press, Cambridge, UK (1958)
8. Perelman, C., Olbrechts-Tyteca, L.: The new rhetoric: A treatise on argumentation. University of Notre Dame, Notre Dame, IA (1969 [1958])
9. Potter, A.: A discourse approach to explanation aware knowledge representation. In: Roth-Berghofer, T., Schulz, S., Leake, D.B., Bahls, D. (eds.): Explanation-aware computing: Papers from the 2007 AAAI Workshop. AAAI Press, Menlo Park, CA (2007) 56-63
10. Potter, A.: Generating discourse-based explanations. Künstliche Intelligenz **22** (2008) 28-31
11. Potter, A.: Linked and convergent structures in discourse-based reasoning. In: Roth-Berghofer, T., Schulz, S., Bahls, D., Leake, D.B. (eds.): Proceedings of the 3rd International Explanation Aware Computing Workshop (ExaCt 2008), Patras, Greece (2008) 72-83
12. Marcu, D.: The theory and practice of discourse parsing and summarization. MIT Press, Cambridge, MA (2000)
13. Stede, M.: Disambiguating rhetorical structure Research on Language & Computation **6** (2006) 311-332
14. Marcu, D., Echihabi, A.: An unsupervised approach to recognizing discourse relations. Proceedings of the 40th Annual Meeting of the Association for Computational Linguistics (ACL), Philadelphia (2002) 368-375
15. Campbell, K.S.: Coherence, continuity, and cohesion: Theoretical foundations for document design. Lawrence Erlbaum, Hillsdale, NJ (1995)