Ontology Driven Resolution of Bridging References *

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1 Introduction

This paper presents a formal DRT-based approach to bridging reference resolution in line with Van der Sandt's analysis of presuppositions as anaphora ([11]). It is novel because it makes use of an ontology as declarative representation formalism of world knowledge and as backbone of the inference mechanism driving the bridging reference resolution. Within this paper, *bridging* will be understood in line with Asher et al. ([1]) as the phenomenon of a linguistic expression introduced in a text referring to a certain antecedent and both being related in a way which is not explicitely stated. Here follow two examples of bridging out of biochemical texts, which is the domain the author concentrated on [1]:

(1) (Rhombotin 2) <u>Binds to the basic helix-loop protein TAL-1</u>. <This interaction> is critical for the regulation of red blood cell development.

(2) (LBP) <u>Binds to the lipid A moiety of bacterial lipopolysacharides</u> (LPS), [...] <The LBP/LPS complex> seems to interact with the CD14 receptor.

In both cases the referring definite description is related to the antecedent in a way which is not explicitely stated. The relations are respectively *Identity* and *Result* ([7]).

*Thanks to U. Reyle for comments on the first versions of this paper.

[1] In the examples given in this paper, the referring expression will be enclosed in brackets, while the antecedent will appear underlined.

2 The Ontology Driven Approach

An ontology is a specification of a conceptualization, which has to be understood as an abstract representation of the domain we want to model for a certain purpose ([3]). Formally, an ontology will be defined as follows:

Definition 1 (Ontology)
An ontology O is a triple (C,T,D) where C is a set of predicates representing concepts, T is a set of first order logic formulas representing taxonomic relations between the concepts in C and D is a set of first order logic formulas defining the concepts in C in terms of necessary conditions.

In order to reason with such an ontology, a notion of implication between DRSs has been defined by making use of the DRS calculus presented in [6]:

Definition 2 (Implication between DRSs)
A DRS K implies a DRS K' with regard to a DRS $\boxed{K_1 \Longrightarrow K_2}$ *($K \Longrightarrow_{[K_1 \Longrightarrow K_2]} K'$) iff $K \oplus$* $\boxed{K_1 \Longrightarrow K_2}$ *$\oplus K'$ follows logically from $K \oplus$* $\boxed{K_1 \Longrightarrow K_2}$ *as defined by the Generalized Modus Ponens (GMP) in [6] and it is not the case that K' follows from K alone ($K \not\models K'$).*

In order to exploit the taxonomic relations T defined within the ontology, a notion of specialization between DRSs has been introduced. In this sense a DRS K_1 will be a specialization of a DRS K_2 if K_1 represents an ontological concept which is more special than the one represented by K_2:

Definition 3 (Specialization)
A DRS K_1 is a specialization of a DRS K_2 with regard to an ontology O=(C,T,A) ($K_1 <_O K_2$) iff $\exists$ DRS $\boxed{K'_1 \Longrightarrow K'_2}$ *and $[K'_1 \Longrightarrow K'_2]_{PL_1} \in T$ and $K_1 \Longrightarrow_{[K'_1 \Longrightarrow K'_2]} K_2$, where $[K]_{PL_1}$ is the translation of the DRS K to predicate logic as defined in [5].*

In the following, $\leq^*_O$ will denote the reflexive and transitive closure of $<_O$. Now it can be defined what it means for a DRS K' to follow logically from K with regard to an ontology O. Intuitively, a DRS K' will follow from K with regard to the ontology if there is a DRS K'' such that K is more special than K'' and K' follows from K'' by a conceptual definition in D:

Definition 4 (Implication with regard to an ontology)
A DRS K implies a DRS K' with regard to an ontology O=(C,T,A) ($K \Longrightarrow_O K'$) iff $\exists$ DRS $\boxed{K_1 \Longrightarrow K_2}$ *such that $[K_1 \Longrightarrow K_2]_{PL_1} \in D$ and $K \Longrightarrow_{[K_1 \Longrightarrow K_2]} K'$ or $\exists$ DRS K'' such that $K \leq^*_O K''$ and $K'' \Longrightarrow_O K'$*

Though the inference mechanism is a very simple one, an obvious advantage is that reasoning complexity is in the worst case $O(|T|^2)$, i.e. quadratic in the number of taxonomic relations of the ontology. Furthermore, bridging reference resolution can be made determinate without introducing costs for accommodation as in ([4]) or using an additional proof system as in [9], but simply by choosing the shortest path between two concepts with regard to the tree representing the ontology.
Following Van der Sandt and Bos et al., unresolved anaphoric expressions will be represented by α-marked DRSs and merged with the discourse processed so far before being resolved. Resolution can take place in three ways (in this preference order): *linking*, *bridging* and *accommodation* ([2]). Due to space limitations, in this paper only a rather informal definition of the *bridging*-operation is given (the interested reader is referred to [8] for a formal definition as well as a detailed resolution of the examples presented):

Definition 5 (Bridging)
An α-marked DRS K_α will be interpreted as a bridging reference to an accessible DRS K_1 ($K_\alpha \leq K_1$) iff K_1' is an ontological generalization of K_1 ($K_1 \leq_O^* K_1'$) and furthermore K_α is suitable to K_1', where suitability is defined as in [8], or iff K_1' follows logically from K_1 with regard to the ontology ($K_1 \Longrightarrow_O K_1'$), K_α is a specialization of K_α' ($K_\alpha \leq_O^* K_\alpha'$) and furthermore K_α' is suitable to K_1'.

The first part of the disjunction captures the intuition that certain expressions can be referred to later in the discourse in a (ontologically) more general way, such as in example 1. The second part accounts for example 2, where the referring expression can be linked to an antecedent inferred from an accessible DRS.

3 Evaluation and Conclusion

The approach described has been implemented in Prolog within the GenIE system ([10]). A small ontology of 129 concepts has been developed for the domain of molecular biology. Furthermore, a training and a test corpus each consisting of 250 short texts describing the function of a protein have been annotated by hand with DRSs representing ontological concepts. The results of the bridging reference resolution approach on the test corpus measured against the annotation of three different subjects were a recall of 54.54% and a precision of 90.98% ([8]). These results look very promising and show that given a suitable ontology the approach is actually scalable.

References

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