Discourse Representation Theory: Standard Construction Algorithm

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Abstract

This documents summarizes the Standard Construction Algorithm for Discourse Representation Theory (DRT) as presented by Kamp (1981) and Kamp and Reyle (1993). Although other more computationally efficient algorithms have been proposed (Bos, 2008), the aim of this document is to introduce the procedural building of deep semantic representations derived from a syntactic analysis.

1 Introduction

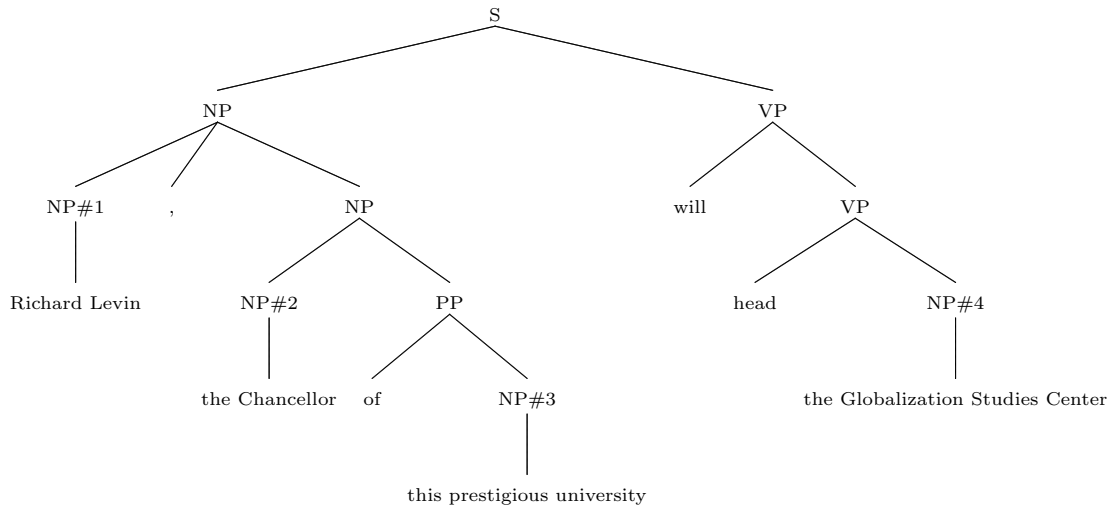
The construction rules of Discourse Representation Structures (DRS) allow to transform a syntactic analysis into a deep semantic structure or a DRS. Each rule in the construction algorithm starts from the identification of a triggering constrain. Applying a given rule consists therefore in replacing the syntactic representation for its corresponding *discourse referents* and *associated conditions*.

The syntactic theory on which was originally based is *Generalized Phrase Structure Theory* (GPSG) presented by Gazdar et al. (1985). The most important syntactic categories included are the following[1] (using the Penn Treebank notation):

- S: Declarative Sentence
- SBAR: Clause introduced by a (possibly empty) subordinating conjunction.
- VP: Verbal Phrase
- NP: Noun Phrase
- ADJP: Adjective Phrase

[1] http://bulba.sdsu.edu/jeanette/thesis/PennTags.html

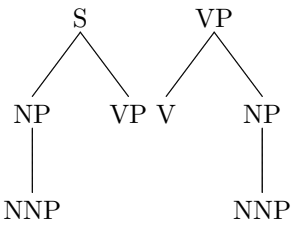
- ADVP: Adverb Phrase
- PP: Prepositional Phrase
- WHNP: Wh-noun Phrase. Introduces a clause with an NP gap
- DT: Determiner
- JJ: Adjective
- NN: Noun
- NNP: Proper Noun
- V: Verbs
- PRP: Pronoun
- RB: Adverb
- IN: Prepositions and subordinating conjunctions



2 Rules

2.1 CR.PN

The *Construction Rule for Proper Names* (CR.PN) is triggered by two syntactic configurations, namely:

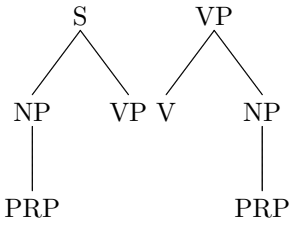


The steps to perform in this rule are following:

1. Introduce a new discourse referent into the universe.
2. Introduce into the condicition set a condition formed by placing the discourse referent in parentheses behind the proper name.
3. Introduce into the condition set a condition obtained by replacing, in the syntactic structure referred to (under 2), the NP-constituent by the new discourse referent.
4. Delete the syntactic structure containing the triggering configuration from the DRS.

2.2 CR.PRO

The *Construction Rule for Pronouns* (CR.PRO) is triggered by the following syntactic analysis:



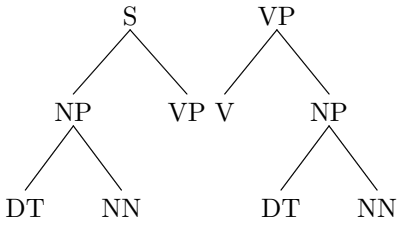
The steps to be performed in the application of this rule are:

1. Introduce a new discourse referent into the universe of the DRS.
2. Introduce a condition obtained by substituting this referent for the NP-node of the local configuration that triggers the rule application in the syntactic structure containing this configuration and delete that syntactic structure.
3. Add a condition of the form $\alpha = \beta$ where α is a **suitable** discourse referent chosen from the universe of the DRS.

How can we define what a **suitable** discourse referent means?

2.3 CR.ID

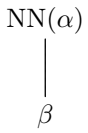
The *Construction Rule for Indefinite Descriptions* (CR.ID) is triggered by the following structures:



This rule involves the following operations:

1. Introduce a new discourse referent.
2. Introduce the result of substituting this discourse referent for the NP-constituent in the syntactic structure to which the rule is being applied.
3. Introduce a condition obtained by placing the discourse referent in parentheses behind the top node of the NP-constituent.

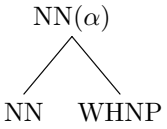
Furthermore, the applicaton of CR.ID needs a rule for Lexical Insertion (CR.LIN), which is triggered by this configuration:



This rule states that we we need to substitute NN(α) into $\beta(\alpha)$

2.4 CR.NRC

In this small fragment of English for which we are introducing construction rules, we will look at one type of subordination, namely, relative clauses. This *Construction Rule for Nominal Relative Clauses* (CR.NRC) is triggered by this syntax:



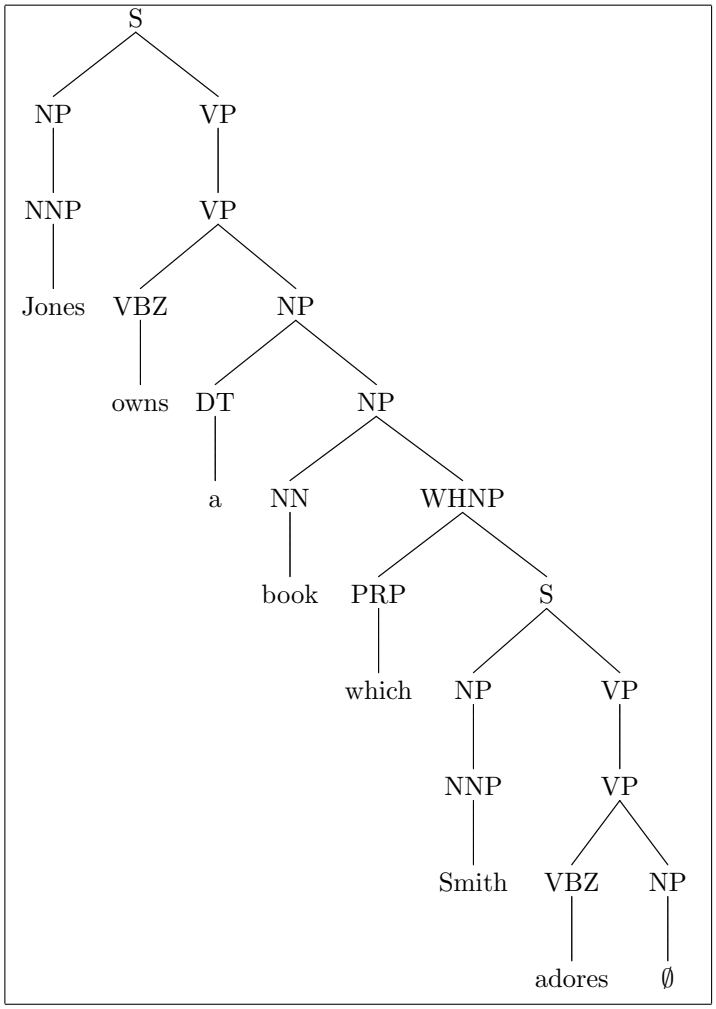
It involves the following steps:

1. Introduce a condition obtained by taking the subtree whose top node is the daughter of the triggering configuration and place α in parentheses behind the top node of this subtree.

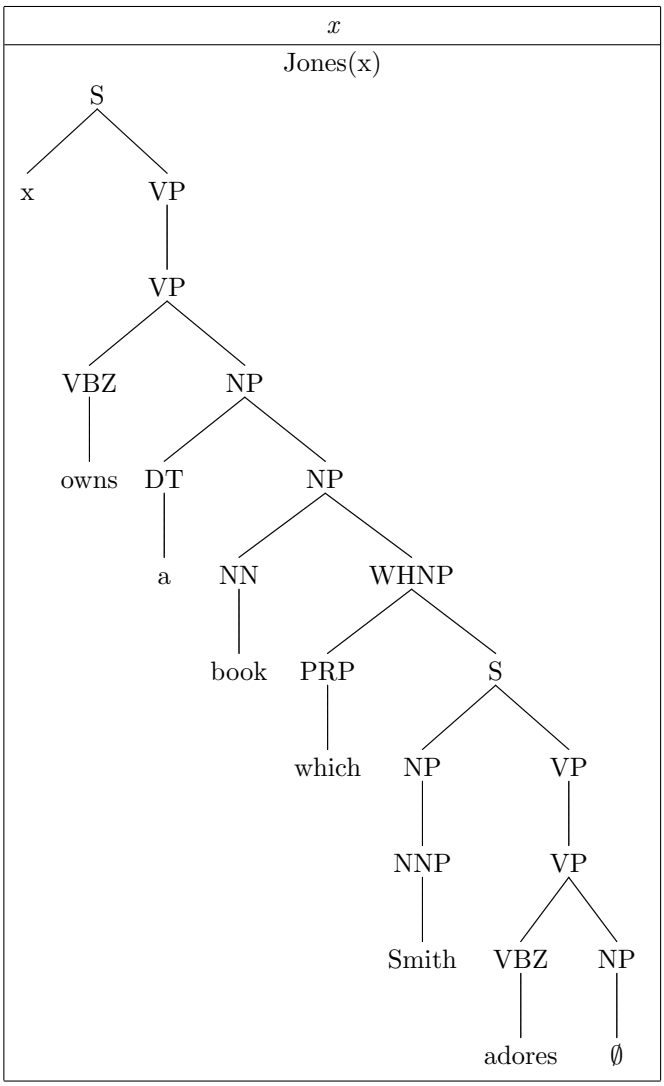
2. Introduce a condition obtained by taking the S-part of that constituent of the DRS-condition whose top node is the RC-node and replace the empty NP-node in that S-part by α.

3 Running Example

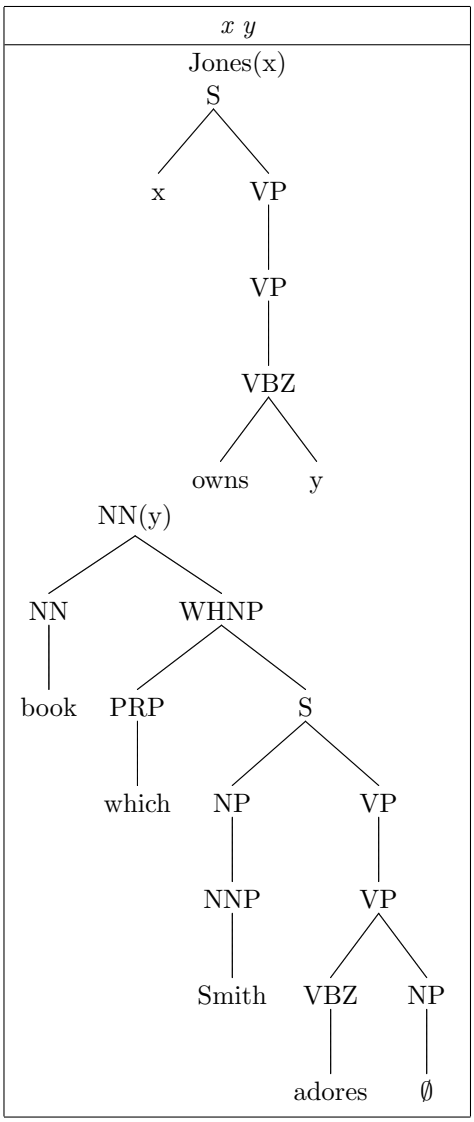
(1) Jones owns a book which Smith adores.



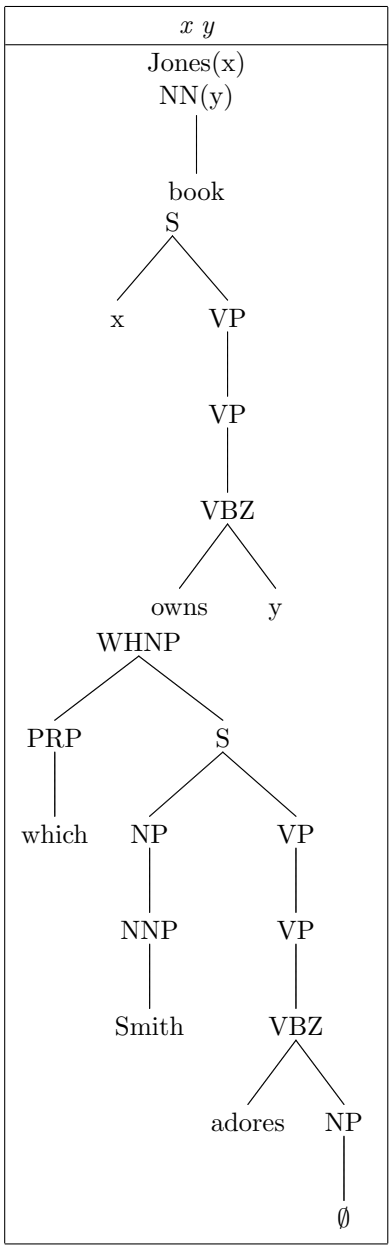
The first step in the DRS construction is by the application of the CR.PN:



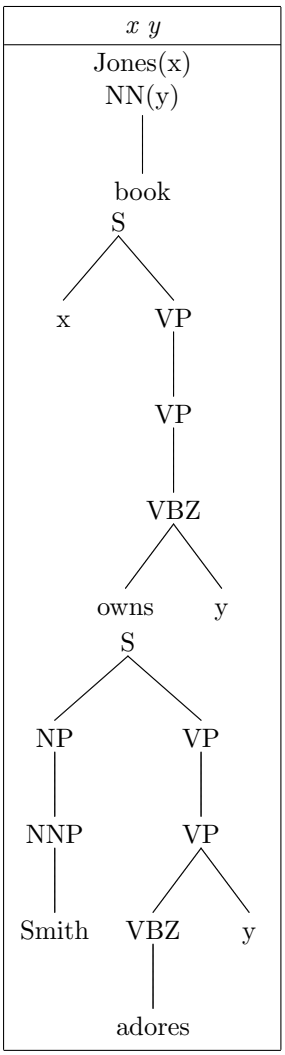
The second step applies CR.ID:



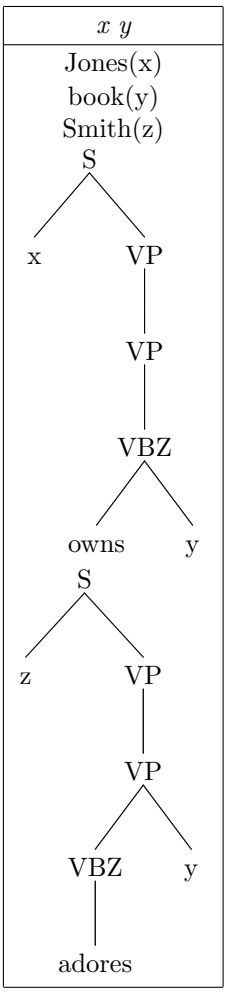
The third step is the application of CR.LIN:



We proceed with the CR.NRC rule:



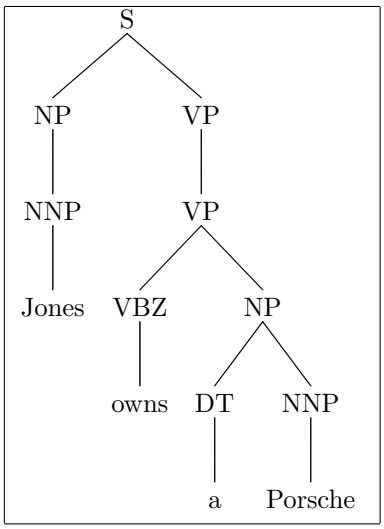
We can further reduce the DRS by applying CR.LIN which creates the DRS-condition **book(y)** and the application of CR.PN creates the condition **Smith(z)**:



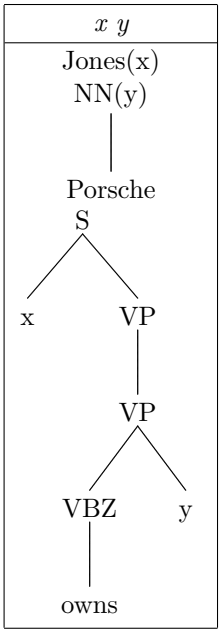
We can easily obtain the final DRS by simplifying the last two conditions:

$x\ y\ z$
Jones(x)
book(y)
Smith(z)
owns(x,y)
adores(z,y)

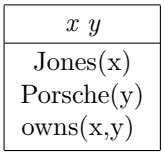
(2) Jones owns a Porsche. It fascinates him.



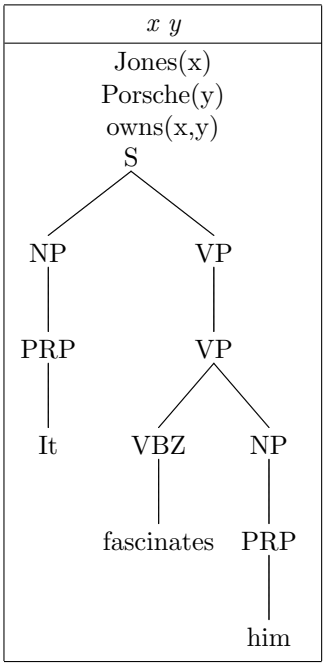
Apply CR.PN, CR.ID and CR.LIN:



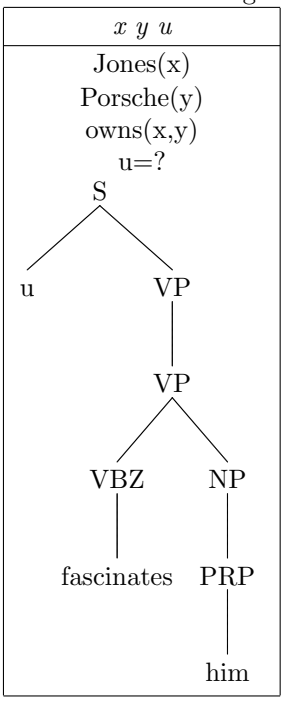
which can be reduced to:



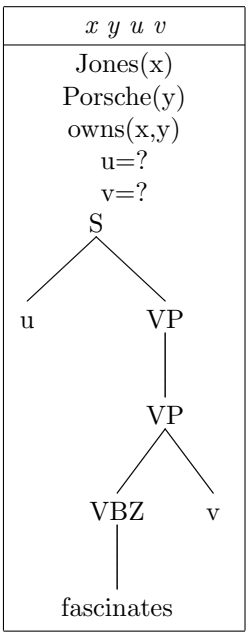
Now, lets incorporate the second sentence of the discourse into our context:



We apply CR.PRO rule to obtain the following DRS:



We apply CR.PRO again:



x y u v
Jones(x)
Porsche(y)
owns(x,y)
u=y
v=x
fascinates(u,v)

AGAIN: How do we identify a suitable antecedent?

4 Construction Algorithm

Input:

a discourse $D = S_1, \ldots, S_i, S_{i+1}, \ldots, S_n$

the empty DRS K_0

Keep repeating for $i = 1, \ldots, n$**:**

(i) add the syntactic analysis $[S_i]$ of (the next) sentence S_i to the conditions K_{i-1}; call the DRS $K_i^\star$. Go to (ii).

(ii) Input: a set of reducible conditions of $K_i^\star$. Keep on applying construction principles to each reducible condition of $K_i^\star$ until a DRS K_i is obtained that only contains irreducible conditions. Go to (i).

5 Exercises (i)

1. Describe the DRS-constructions for the sentences below. Some of those do not have a lot of sense, but they are analysable using DRT. Think of ways in which the algorithm could be modified to block the construction of DRSs for such sentences.

   (a) A man admires a woman. She likes him.

   (b) Buddenbrooks loves Anna Karenina. It fascinates it.

   (c) Buddenbrooks loves Anna Karenina. She fascinates it.

   (d) Buddenbrooks loves a woman. She fascinates him.

   (e) A stockbrocker abhors a stockbrocker. She loves him.

   (f) Jones admires a woman who likes him.

6 Basic Anaphora Resolution

1. Pronominal anaphora resolution is based on the concept of 'accessibility' between DRSs which in turn is based on the idea of 'subordination'.

   DRS B1 is accessible from B2 when B1 = B2 or when B2 is subordinated to B1.

   B2 is subordinated to B1 if and only if:

   i. B2 is immediately subordinated to B1 or
   ii. There is some B such that B is subordinated to B1 and B2 is subordinated to B (transitive closure).

Hence, B2 is **immediately subordinated** to B1 if and only if:

1. B1 contains a condition of the form $\neg B2$; or
2. B1 contains a condition of the form $B2 \vee B$ or $B \vee B2$, for some DRS B; or
3. B1 contains a condition of the form $B2 \rightarrow$ B, for some DRS B; or
4. $B1 \rightarrow B2$ is a condition in some DRS B.

Summarizing, a pronoun that has introduced a new discourse referent (x2) into some DRS B can only be bounded to another discourse referent (x1) if x2 is accessible from x1 (if the DRS in which x2 occurs is subordinated to the DRS in which x1 occurs).

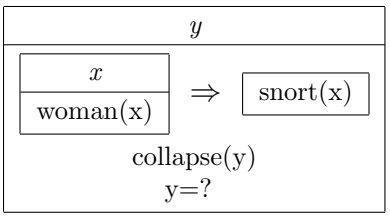
However, there are further constraints on anaphora resolution which Kamp and Reyle (1993) describe as *suitable*. It is relevant to us the fact that such 'suitability' refers to gender, number and NER features.

> Suppose a pronoun has introduced a new discourse referent (say y) into the universe of some DRS B. Then we are only free to add the condition $y = x$ to the condition set of B if x is accessible from y.

(3) A woman snorts. She collapses.

x y
woman(x)
snorts(x)
y=x
collapse(y)

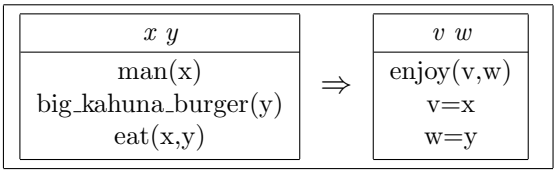
(4) Every woman snorts. She collapses.



(5) If man eats a Kahuna burger, he enjoys it.

$\forall x \forall y[man(x) \wedge big\_kahuna\_burger(y) \wedge eat(x,y) \rightarrow enjoy(x,y)]$

$\exists x[man(x) \wedge \exists y[big\_kahuna\_burger(y) \wedge eat(x,y)] \rightarrow enjoy(x,y)]$



7 Exercises (ii)

1. Predict whether DRT can resolve successfully anaphoric pronouns for the following examples based on the idea of *accessibility*.

   (a) Mia order a five dollar shake. Vincent tasted it.

   (b) Mia did not order a five dollar shake. Vincent tasted it.

   (c) Butch stole a chopper. It belonged to Zed.

   (d) Butch stole a chopper or a motor cycle. It belonged to Zed.

   (e) Butch stole a chopper or a motor cycle. The chopper belonged to Zed.

8 Penn Treebank Tags for English

8.1 Clause Level

- S - simple declarative clause, i.e. one that is not introduced by a (possible empty) subordinating conjunction or a wh-word and that does not exhibit subject-verb inversion.
- SBAR - Clause introduced by a (possibly empty) subordinating conjunction.
- SBARQ - Direct question introduced by a wh-word or a wh-phrase. Indirect questions and relative clauses should be bracketed as SBAR, not SBARQ.
- SINV - Inverted declarative sentence, i.e. one in which the subject follows the tensed verb or modal.
- SQ - Inverted yes/no question, or main clause of a wh-question, following the wh-phrase in SBARQ.

8.2 Phrase Level

- ADJP - Adjective Phrase.
- ADVP - Adverb Phrase.
- CONJP - Conjunction Phrase.
- FRAG - Fragment.
- INTJ - Interjection. Corresponds approximately to the part-of-speech tag UH.
- LST - List marker. Includes surrounding punctuation.
- NAC - Not a Constituent; used to show the scope of certain prenominal modifiers within an NP.
- NP - Noun Phrase.
- NX - Used within certain complex NPs to mark the head of the NP. Corresponds very roughly to N-bar level but used quite differently.
- PP - Prepositional Phrase.
- PRN - Parenthetical.
- PRT - Particle. Category for words that should be tagged RP.
- QP - Quantifier Phrase (i.e. complex measure/amount phrase); used within NP.

- RRC - Reduced Relative Clause.
- UCP - Unlike Coordinated Phrase.
- VP - Verb Phrase.
- WHADJP - Wh-adjective Phrase. Adjectival phrase containing a wh-adverb, as in how hot.
- WHAVP - Wh-adverb Phrase. Introduces a clause with an NP gap. May be null (containing the 0 complementizer) or lexical, containing a wh-adverb such as how or why.
- WHNP - Wh-noun Phrase. Introduces a clause with an NP gap. May be null (containing the 0 complementizer) or lexical, containing some wh-word, e.g. who, which book, whose daughter, none of which, or how many leopards.
- WHPP - Wh-prepositional Phrase. Prepositional phrase containing a wh-noun phrase (such as of which or by whose authority) that either introduces a PP gap or is contained by a WHNP.
- X - Unknown, uncertain, or unbracketable. X is often used for bracketing typos and in bracketing the...the-constructions.

8.3 Word level

- CC - Coordinating conjunction
- CD - Cardinal number
- DT - Determiner
- EX - Existential there
- FW - Foreign word
- IN - Preposition or subordinating conjunction
- JJ - Adjective
- JJR - Adjective, comparative
- JJS - Adjective, superlative
- LS - List item marker
- MD - Modal
- NN - Noun, singular or mass
- NNS - Noun, plural

- NNP - Proper noun, singular
- NNPS - Proper noun, plural
- PDT - Predeterminer
- POS - Possessive ending
- PRP - Personal pronoun
- PRP$ - Possessive pronoun (prolog version PRP-S)
- RB - Adverb
- RBR - Adverb, comparative
- RBS - Adverb, superlative
- RP - Particle
- SYM - Symbol
- TO - to
- UH - Interjection
- VB - Verb, base form
- VBD - Verb, past tense
- VBG - Verb, gerund or present participle
- VBN - Verb, past participle
- VBP - Verb, non-3rd person singular present
- VBZ - Verb, 3rd person singular present
- WDT - Wh-determiner
- WP - Wh-pronoun
- WP$ - Possessive wh-pronoun (prolog version WP-S)
- WRB - Wh-adverb

References

Bos, J. (2008). Wide-Coverage Semantic Analysis with Boxer. In Bos, J. and Delmonte, R., editors, *Semantics in Text Processing. STEP 2008 Conference Proceedings*, volume 1 of *Research in Computational Semantics*, pages 277–286. College Publications.

Gazdar, G., Klein, E., Pullum, G., and Sag, I. (1985). *Generalized Phrase Structure Grammar*. Oxford: Blackwell.

Kamp, H. (1981). A theory of truth and semantic representation. In Stokhof, M., Groenendijk, J., and Janssen, T., editors, *Formal Methods in the Study of Language*, pages 277–322. Mathematisch Centrum, Amsterdam.

Kamp, H. and Reyle, U. (1993). *From Discourse to Logic: Introduction to Modeltheoretic semantics of natural language, formal language and Discourse Representation Theory*. Kluwer Academic Publishers.