Computing adverbial quantifier domains

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Abstract

This paper describes a method for computing the domain of quantification of an adverbially quantified sentence. This method relies on the accommodation of presuppositions in the scope of a quantificational adverb and on the resolution of the domain in context. This paper also describes a computational system for processing such sentences based on this method.

1 Introduction

This paper is concerned with the computation of the logical form of adverbially quantified sentences, which are those sentences modified by an explicit quantificational adverb (qadverb), such as *always, usually, sometimes*, or *never*. The primary challenge in computing the logical form of an adverbially quantified sentence (which we will call a qadverb sentence) is determining the domain of quantification (there are additional challenges associated with interpreting such a logical form, including the strange modal nature and quantificational force of generics, but we are leaving those aside for this paper). We propose that qadverbs quantify over situations which are restricted both by presuppositions of the scope of the qadverb and by context. Furthermore, we propose that such domain restrictions can be computed by a method based on the presupposition resolution algorithm of van der Sandt (1992), and we demonstrate this with a DRT-based grammar and parser based on the system of Blackburn and Bos (1999).

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2 Quantificational adverbs

Qadverbs can function syntactically as either verb phrase (VP) or sentence (S) modifiers:

(1) John usually takes out the trash.

(2) Usually, John takes out the trash.

Semantically, however, we take them to be sentential operators, because they give rise to scope ambiguities with quantified noun phrases (NPs):

(3) Someone usually takes out the trash.

In fact, we take the logical form of a qadverb sentence to be similar to that of a sentence containing a quantified NP. The qadverb, like a quantificational determiner, corresponds to an operator which takes three arguments. The first argument is a discourse referent, which serves as the variable of quantification. The second argument (the restrictor) indicates the domain of quantification; the third argument (the nuclear scope) indicates the predication which is asserted of the members of the domain. In the DRT-based logical form language, the second and third arguments are each a DRS. The variable of quantification is introduced in the restrictor DRS, which is accessible to the nuclear scope DRS, much like the arguments of a conditional operator. For a quantificational determiner, the restrictor is provided by the remainder of the NP, and the nuclear scope, by the remainder of the sentence. For a qadverb, the situation is not so straightforward.

Unlike a quantificational determiner, there is no syntactically determined relationship between a qadverb and constituents which might provide its restrictor. The earliest work on qadverb sentences (starting with Lewis, 1975) focuses on examples in which an *if*- or *when*-clause provides the restrictor:

(4) If a man owns a donkey, he always beats it.

Without such a clause (and sometimes, even with one), any part of a qadverb sentence may map to the restrictor argument. Milsark (1974) provides an oft-cited example:

(5) Typhoons arise in this part of the Pacific.

This sentence has two readings. One is an implausible reading in which the set of typhoons serves as the restrictor argument; on such a reading, it is taken to be a general property of typhoons that they arise in a particular part of the Pacific. In the other, more natural, reading, the restrictor argument is the set of situations involving the indicated part of the Pacific; on such a reading, the occasional arising of a typhoon is taken to be a property of situations in a particular part of the Pacific. De Swart (1991) and Rooth (1985) give examples of sentences in which even an explicit *when*-clause does not necessarily map to the restrictor:

(6) When John was young, he often took walks in the gardens.

(7) John usually shaves when he showers.

In (6), the *when*-clause only serves to set the situation in time. In (7), focal stress determines whether the *when*-clause maps to the restrictor.

Focal stress and explicit *if*- and *when*-clauses are just two of the many factors that have been implicated in the determination of the restrictor argument of a qadverb. Diesing (1992) proposes with her Mapping Hypothesis that it is syntactic structure which is primarily responsible for determining what overt material (in particular, which NPs) in a qadverb sentence is associated with the qadverb restrictor. Her theory requires the syntactic machinery of GB and fails to take into account much of the semantic complexity of the data. Opposed to this syntactic view are those who claim that it is the topic-focus or topic-comment structure of a sentence that determines its division into restrictor and matrix. According to this view, the topic of a qadverb sentence is its restrictor; its focus, the matrix (proponents of this approach include Chierchia, 1992 and Jäger, 1997; see Partee, 1995 for a list of others). This approach is closely related to Rooth's observations on the association of qadverb restrictors with focal stress (exemplified by (7), above). Cohen (1996) proposes that qadverbs quantify over appropriate sets of alternatives which may be generated in a variety of ways, including by focal stress or by presuppositions.

Several other authors have noticed that presuppositions of the scope of a qadverb are incorporated into its restrictor (Schubert and Pelletier 1987; Berman 1991):

(8) John usually beats Marvin at ping pong.

(9) John usually regrets missing a lecture by Chomsky.

Schubert and Pelletier note that in a qadverb sentence with a presuppositional verb, such as *beat*, the qadverb quantifies only over situations which satisfy the presupposition associated with the verb (in the case of (8), situations in which John plays Marvin at ping pong). Berman provides examples for other kinds of presuppositions, such as factives (*regrets* in (9)) and aspectual verbs. The range of presuppositional material considered by Schubert and Pelletier and by Berman is somewhat narrow, and both consider presupposition incorporation to be only a part of the process of determining a qadverb restrictor. When we consider the full range of presuppositions which may be accommodated by a qadverb restrictor, however, we find that most of the overt material which has been claimed to be incorporated into the restrictor consists of presuppositions of the scope.

3 Presuppositions

A wide range of linguistic phenomena gives rise to presuppositions. Keenan (1971) includes as examples of presupposition triggers definite descriptions, factive predicates, cleft constructions, selectional restrictions, temporal subordinate clauses, certain aspectual verbs,

iteratives, and presuppositional adverbs; to this list, van der Sandt (1988) adds focal stress, lexical presupposition, and quantifiers. Additionally, Milsark (1977) and Fodor and Sag (1982) distinguish between two readings of indefinites, one of which corresponds to existential quantification and the other of which is essentially presuppositional. If we simply allow that sentential presuppositions are what determine a qadverb restrictor, we have an account which subsumes the above-mentioned accounts. Explicit *if*- and *when*-clauses fall together with other presupposed subordinate clauses. The NPs with which Diesing is concerned fall into one of the following classes: definite descriptions, which are the paradigm case of presuppositionality; quantified NPs, which are taken to presuppose their domains; and indefinites, which on certain interpretations are presuppositional. The most illustrative cases of topic-focus articulation (cleft constructions and focal stress) are also subsumed as presuppositions.

In order to make our presuppositional theory work, we need a separate account of presuppositions. The most widely accepted account of presuppositional phenomena is that of van der Sandt (1992), which is well-suited to our purposes. Van der Sandt proposes that presuppositions are simply informationally rich anaphors. Like an ordinary anaphor, a presupposition requires an antecedent, and if one is found in the appropriate context, then the presupposition is satisfied. Unlike an ordinary anaphor, though, the inability to find an antecedent does not necessarily lead to failure. Since a presupposition is informationally rich, i.e. it has its own descriptive content, an antecedent may be constructed for it, under the appropriate conditions.

Van der Sandt casts his account in a version of DRT, which allows him to handle projection in configurational terms, using the DRT notion of accessibility. On his analysis, presupposing elements introduce their elementary presuppositions in a local DRS just as anaphoric elements introduce anaphors in the local DRS. Each elementary presupposition must then be resolved, either by binding or accommodation. The resolution process proceeds from the local DRS for an elementary presupposition along its projection line looking for an appropriate referent which can be unified with the elementary presupposition. If one is found, then an anaphoric link is created between the presupposition and its antecedent, and the presupposition has been satisfied by binding. If none is found, the presupposition must be accommodated at some accessible level in which constraints on binding, consistency, informativeness, and efficiency can be satisfied. Accommodation simply consists of copying the presupposition to the embedding DRS.

4 Our treatment of qadverbs

4.1 Theoretical analysis

Following Berman (1987), Heim (1990), and von Fintel (1995), we take qadverbs to be quantifiers over situations (rather than unselective quantifiers or quantifiers over time as

others have proposed), which allows us to restrict both temporally and informationally the entities being quantified over and also allows us to make the connection between qadverb restrictors and presuppositions clearer. Following work by Poesio (1994), we take presuppositions to be situation descriptions which are explicitly associated with a resource situation parameter. This parameter must be bound to a situation, which we call the resource situation. It is with respect to this situation that the truth of the presupposition is evaluated. This notion of resource situations is a generalization of the notion of resource situations for definite descriptions (Barwise and Perry 1983) and quantifiers (Cooper 1995), in which a resource situation provides the context either for verifying the existence and uniqueness of a referent (in the case of a definite description) or for determining the actual, contextually restricted domain of quantification (in the case of a quantifier). The resource situation may be distinct from the situation described by the sentence in which the presupposition occurs. To demonstrate this, Cooper gives an example with two definite descriptions and two quantified NPs. Any nontrivial interpretation requires that the definite descriptions be evaluated with respect to a different situation than the quantifiers.

(10) Every linguist voted for the linguist, and every philosopher, for the philosopher.

We will see in our analysis of qadverb domains that presuppositions introduced in the nuclear scope of a qadverb may also bind to a resource situation distinct from the sentence situation.

We take situations to be entities in the domain of discourse, just like ordinary individuals. We reserve a separate sort of discourse referent to represent situations, however, so that we have both ordinary discourse referents, which are assigned ordinary individuals as values, and situational discourse referents, which represent situations. We further take situations to support descriptions, which are expressed as DRSs. We use the double-colon operator ('::') to indicate the support relation between a situational discourse referent and a DRS. In order to obtain accessibility between different descriptions of the same situation, we require that a situational discourse referent encode its description, as well as the situation it represents. Thus, unlike an ordinary discourse referent, a situational discourse referent is assigned a pair value. One member of the pair is a situation; the other is itself an assignment of discourse referents to entities, which we call an anchoring. This anchoring verifies the description supported by the situational discourse referent, as well as the embedding DRS (to the extent that it does not conflict with the supported DRS). We associate anchorings with referents rather than directly with situations because we do not want a description of a situation to be accessible to another description of the same situation if the two descriptions are associated with different referents which only accidentally refer to the same situation. Accessibility between descriptions of a situation is a property that arises as a result of a situation being referred to in a particular way.

We give here a sketch of the semantics for the three conditions relevant to this paper: support, qadverb, and abstraction. For a more formal and fully worked-out treatment of

the semantics of this situation logic, please see Ahn (tion). In general, we assume standard DRT semantics, but we use partial assignments.

(11) For all assignments g, h, $\langle g, h\rangle \in [\![S :: \text{DRS}]\!]$ iff

1. $g[S]h$
2. $g(S) = \langle \text{sit}, \text{anch1}\rangle$
3. $h(S) = \langle \text{sit}, \text{anch2}\rangle$
4. $\langle \text{anch1}, \text{anch2}\rangle \in [\![\text{DRS}]\!]$
5. sit supports DRS

The first three conditions simply indicate that the support relation is externally dynamic, which is required in order to update the anchoring associated with a situational discourse referent in case the supported DRS introduces new discourse referents. (In order for the anchoring to verify the embedding DRS, as well, we constrain the initial assignments to situational discourse referents; again, see Ahn (tion).) The fourth condition accomplishes the encoding of the supported description by the anchoring. The final condition, that the situation to which the situational discourse referent S refers supports the description given by the DRS, is intentionally left vague. For the purposes of this paper, we are not committed to any particular characterization of situations, although our use of the double-colon operator is intentionally reminiscent of the situation-characterization operators used by Poesio (1994) and Schubert (2000).

A qadverbs takes three arguments: a variable of quantification, a DRS representing the restrictor, and a DRS representing the nuclear scope. In order for the quantification to be non-vacuous, the restrictor DRS must introduce a situational discourse referent identical to the variable of quantification, and both DRSs must include some condition on the referent.

(12) For all assignments g, h, $\langle g, h\rangle \in [\![\text{qadverb}(S, \text{DRS-restr}, \text{DRS-nuclear})]\!]$ iff

1. $g = h$
2. $\text{set1} = \{s \mid \exists k.\langle g, k\rangle \in [\![\text{DRS-restr}]\!] \,\&\, \exists a.k(S) = \langle s, a\rangle\}$
3. $\text{set2} = \{s \mid \exists k, l.\langle g, k\rangle \in [\![\text{DRS-restr}]\!] \,\&\, \langle k, l\rangle \in [\![\text{DRS-nuclear}]\!] \,\&\, \exists a.l(S) = \langle s, a\rangle\}$
4. set1 and set2 are in the quantifier relation corresponding to qadverb

Note that both set1 and set2 are sets of situations and not sets of situation-anchoring pairs and that qadverbs are thus comparing sets of situations.

We use abstraction to introduce sets, following Kamp and Reyle (1993).

(13) For all assignments g, h, $\langle g, h\rangle \in [\![SS = \Sigma S \text{ DRS}]\!]$ iff

1. $g = h$
2. $g(SS) = \{o \mid \exists k.\langle g, k\rangle \in [\![\text{DRS}]\!] \,\&\, k(S) = o\}$

Note that a set abstracting over a situational discourse referent is a set of situation-anchoring pairs and not merely a set of situations. Thus, in subsequent reference to members of such a set, the descriptions used to introduce the sets will be accessible.

We require that a resource situation parameter be bound to an accessible antecedent situational discourse referent whose supported description is consistent with the presupposed DRS. If the discourse referents introduced in the presupposed DRS can be consistently equated with discourse referents in the antecedent DRS, they are thus bound, and the conditions of the presupposed DRS are added to the antecedent DRS. If the discourse referents in the presupposed DRS cannot be bound, they are accommodated, and both the discourse referent introductions and the conditions of the presupposed DRS are added to the antecedent DRS.

As we mentioned above, the domain of quantification of a quantificational determiner is presupposed. A qadverb similarly presupposes its domain of quantification. In both cases, what is presupposed is the existence of a set corresponding to the quantification domain. For a qadverb, the restrictor is taken to presuppose the set of situations over which the qadverb quantifies. Thus, a presupposition in which a set of situations is introduced is generated in the restrictor and associated with a resource situation parameter. The non-presuppositional component of the restrictor simply asserts that the variable of quantification ranges over members of this set. Note that the resource situation parameter is distinct from the variable of quantification.

Since there is no descriptive content initially associated with a qadverb restrictor, the restrictor conditions consist solely of a situational discourse referent (identical with the variable of quantification) associated with an empty DRS. The presupposition resolution process resolves some presuppositions of the nuclear scope with the restrictor by binding the resource situation parameters associated with these presuppositions to this situational discourse referent in the restrictor. This binding of resource situation parameters accounts for the presupposition accommodation observed by Schubert and Pelletier and Berman and also accounts for most of the other overt material which has been claimed to restrict the domain of quantification of qadverbs. The presupposed set of situations which results from this binding process must itself be resolved by binding its associated resource situation parameter with an antecedent in the discourse. It is this resolution which results in the anaphoricity of qadverb domains observed by von Fintel (1995).

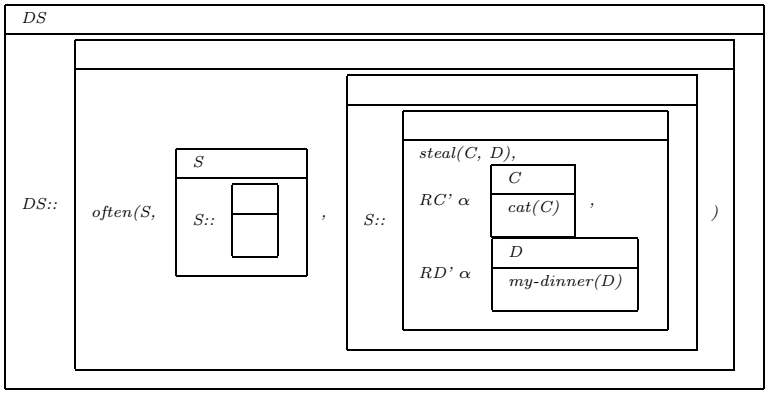
4.2 An example

For example, consider the sentence (14). (We will illustrate one plausible resolution, though there are others.) The initial representation for this sentence (15) introduces a global discourse situation *DS*, which supports the dinner-stealing proposition. The quantificational

condition deriving from the qadverb *often* takes three arguments: S, which is the variable of quantification; the restrictor DRS, which introduces a situational discourse referent S and associates it with an empty description (this description will be filled in through the accommodation of scopal presuppositions), and the nuclear scope DRS, which contains resource situation parameters associated with the presuppositions corresponding to *the cat* and *my dinner*. Resource situation parameters are distinguished by a prime and are associated to a presupposition DRS via the α operator.

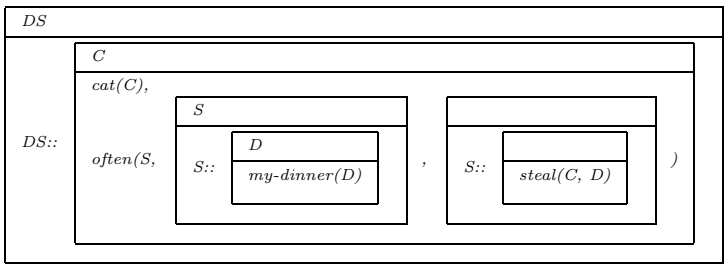
(14) The cat often steals my dinner

(15)



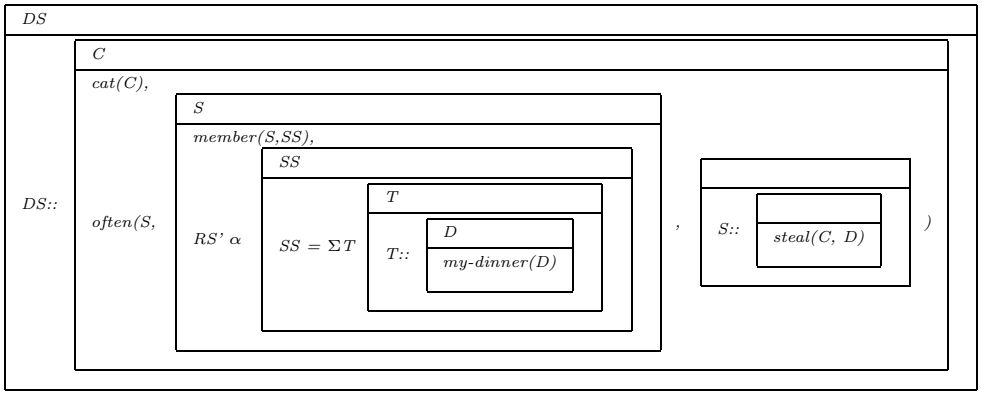
In the representation (16), the presupposition for *the cat* has been accommodated globally by binding *RC'* to *DS* and adding the universe and conditions of *RC'* to the DRS supported by *DS*. The presupposition corresponding to *my dinner* has been accommodated in the restrictor, by binding RD' to the situational discourse referent S in the restrictor and adding the universe and conditions of RC' to the DRS supported by S.

(16)



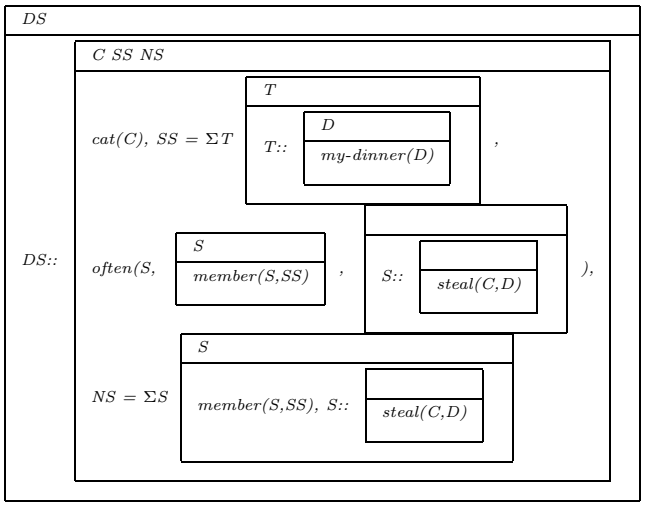
In the representation (17), a new presupposition corresponding to the domain of quantification of the qadverb is computed in the restrictor: SS is the presupposed domain set, and RS' is the resource situation parameter for this presupposition. As a part of the presupposition computation process, the non-presuppositional condition in the restrictor is changed simply to a membership condition.

(17)



The resolution process is completed by binding RS' to DS and adding its conditions to the DRS supported by DS, as well. Also, following Kamp and Reyle (1993), we introduce through abstraction a set of situations, NS, corresponding to the set of situations which is available for later reference, those in which the cat steals my dinner. The resulting representation is (18).

(18)

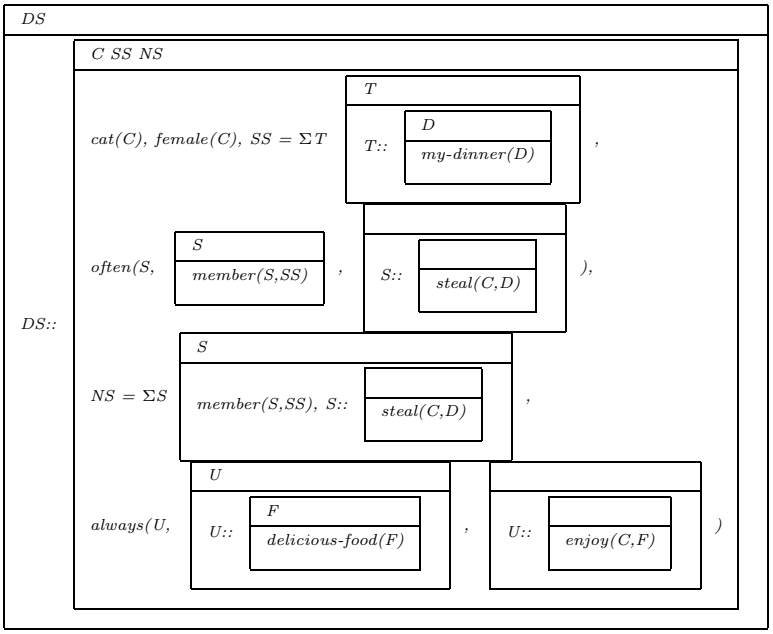


In plain English, this representation indicates a discourse situation DS which is characterized by the existence of three entities: a cat, C, and two sets, SS and NS. The members of SS are those situations in which there is an entity D which is my dinner. Many of the members of this set SS are further characterized by the cat C stealing the dinner entity D associated with member situation. NS is the subset of SS consisting of situations in which the cat C does, in fact, steal the dinner entity D.

The discourse may be continued with sentence (19), which after resolving the presuppositions associated with *she* and *the delicious food*, results in the representation (20).

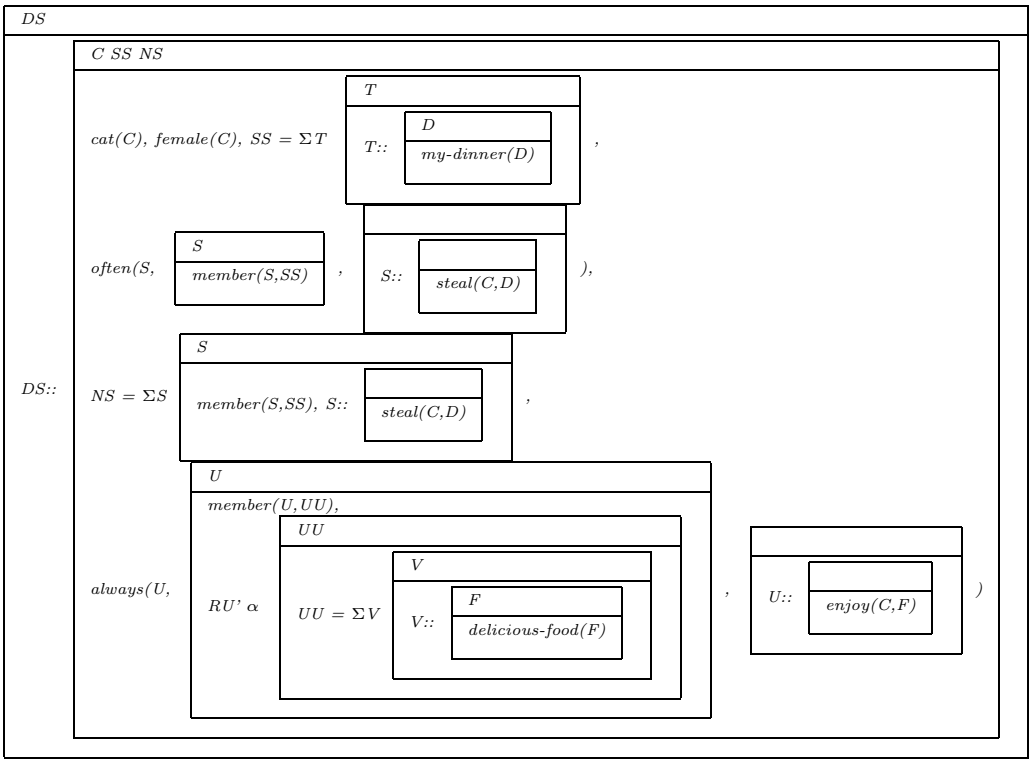
(19) She always enjoys the delicious food.

(20)



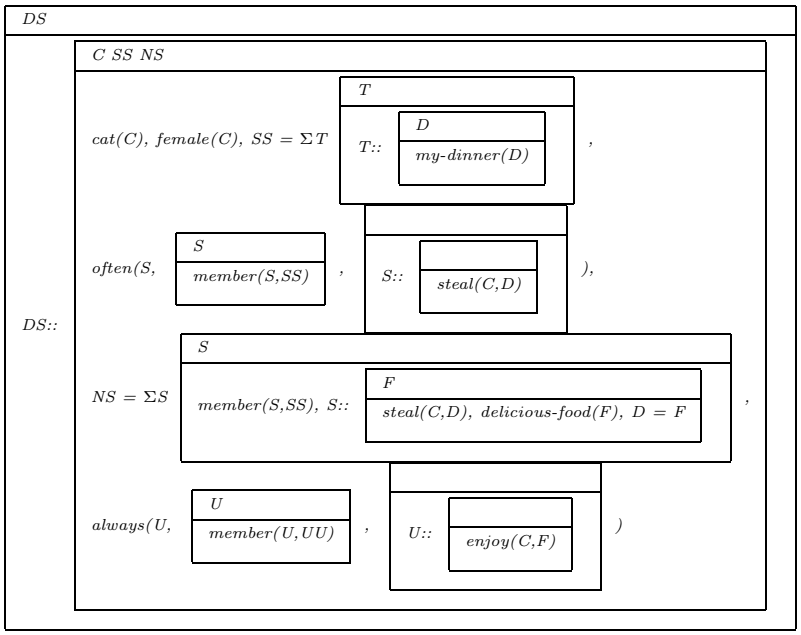
Computing the presupposition associated with the qadverb domain yields the representation (21), in which a set corresponding to the domain UU is introduced and associated with a resource situation parameter RU'.

(21)



The final representation (22) is computed by binding RU' to DS and equating UU to NS. In collapsing the membership conditions for UU and NS, entities which may be consistently equated must be bound, and thus F is bound to D.

(22)



4.3 Further discussion

In the above example, the quantifier domains associated with the qadverbs were resolved by accommodation or by binding. In binding the quantifier domain for *always* to the introduced set for *often*, we equated the two sets. In general, however, the relation between an existing set and a quantifier domain which is bound to it is not equality. Consider the following example:

(23) John ate every piece of fruit in the bowl. Most (of the) oranges were tasty.

In this case, the set of fruit should bind the set of oranges, even though the two sets are not necessarily equal. Instead, the set of oranges should be taken to be a subset of the set of fruit. We see the same situation with qadverb domains:

(24) My friends always vacation in strange places. My best friend John usually goes to Antarctica.

The set of situations accommodated for the first sentence consists of situations in which the speaker's friends go on vacation. The quantifier domain for the second sentence is the set of situations in which John goes somewhere. Clearly, this set should be bound to a subset of the first set—those situations in which John goes on vacation. Thus, we expand the notion of binding to include binding a presupposed set to a subset of an existing set.

As the example (14)-(22) demonstrates, presuppositions arising in the scope of a qadverb are not necessarily resolved with the restrictor. Whether or not a presupposition must be bound to the situational discourse referent introduced in the restrictor depends on a number of factors. Most important, perhaps, is whether or not the sentence is coherent without such binding. Since we claim that a qadverb essentially quantifies over situations (which default to time intervals of contextually determined granularity in the absence of any bound presuppositions), any presuppositions that are resolved at a discourse level superordinate to the quantification must be constant for each of the situations over which the qadverb quantifies. For many presupposed elements, this is not possible. Consider, for example:

(25) The fog usually lifts before noon here.

There cannot be a single, unique instance of fog which repeatedly lifts; instead, the definite description must be bound to the qadverb restrictor, resulting in separate instances of fog for each lifting event. We are still developing a way to formalize this notion of persistence so that it can be used to evaluate possible resolutions.

One shortcoming of our analysis of qadverbs is that it requires the introduction of a set of situations (via an abstraction) to allow for later reference. Geurts and van der Sandt (Geurts and van der Sandt 1999) argue that such an introduction, while it correctly provides an antecedent for reference, does not make accessible any of the dependent discourse referents introduced within the abstraction. Such discourse referents may be referred to in subsequent discourse in a phenomenon called telescoping. Although their objection does not quite hold for our quantification over situations (by requiring that situations encode assignments, we ensure that any dependent discourse referents introduced in the supported DRSs are accessible in later descriptions supported by the same situations), it highlights the fact that the post hoc introduction of nuclear scope sets is an awkward process.

Geurts and van der Sandt instead present an account of quantifier domain restriction which is in spirit very similar to ours, but which uses generalized quantifiers with explicit introduction of both the restrictor and nuclear scope sets. In order to allow non-structural accessibility of discourse referents introduced in the restrictor set description from the nuclear scope set description, they introduce a new kind of entity—a propositional discourse referent—which explicitly refers to a set of embedding functions (or assignments). On their analysis, a quantifier is not a relation between descriptions of sets but between propositional discourse referents, relative to a particular individual discourse referent. The restriction of a domain of quantification by presuppostions of the scope takes place through accommodation, as in our account, but the accommodation process, which is an inherently syntactic process of movement or copying, has to find appropriate landing sites semantically rather than structurally. In our account, the accessibility of individual discourse referents introduced within a situation is handled semantically, by requiring that situations encode assignments, but the essentially syntactic process of accommodation is handled structurally, through the resolution of resource situation parameters according to the traditional DRT

notion of accessibility. Ideally, the entire analysis should be non-representational, and we are considering an approach combining a dynamic logic with generalized quantifiers (van den Berg 1996) and an account of presupposition resolution as abductive inference rather than movement (Krause 1995).

5 Computational implementation

We are presently at work on a small computational system to process qadverb sentences. It is based on the DRT parser in the textbook by Blackburn and Bos (1999), which is focused on the problems of quantifier scope ambiguity and presupposition resolution. Thus far, we have added grammar rules and lexical entries to allow for plural nouns and quantificational adverbs and modified existing rules and entries to associate situational discourse referents with DRSs. We do use the existing notation for presuppositions, which differs somewhat from ours, and have not modified it to associate resource situations with presuppositions. Thus, instead of introducing a presupposition inside the DRS in which its extent begins, a presupposition is introduced via an alpha expression which takes scope over the DRS in which its extent begins.

We have had to modify the presupposition resolution algorithm itself. The original algorithm resolves each presupposition before resolving any presuppositions triggered within its scope; in order for the resource domain of a qadverb to have any descriptive content to be resolved, however, the presuppositions of the nuclear scope (which falls within the scope of the resource domain presupposition) must be resolved first. Also, a resource domain presupposition (both for qadverbs and for quantified NPs, for which we have also added such a presupposition) may be bound either to an existing set or to a subset of an existing set. The semantic macro that produces the semantic portion of the lexical entry for a qadverb is as follows:

```
advSem(Sym, qadv, lambda(P, lambda(X,
       alfa(SS,qresource,
            drs([SS],[set(SS),
                      drs([S],[member(S,SS)])>drs([],[])]),
            drs([],[qcond(Sym,S,drs([S],[S * drs([],[])]),
                                drs([],[S * P@X])])))))))
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Since a qadverb is syntactically a VP operator, its first argument is a predicate, and its second, an individual. The resulting expression is a resource domain presupposition (*SS* is the set of situations) whose scope is the quantificational condition (*Sym* is the translation of the qadverb). Presuppositions arising from $P@X$ (i.e. P applied to X) may be accommodated in the restrictor. Material from the restrictor is copied into the membership conditions of the resource domain, and the resource domain is then resolved.

This system is still a work-in-progress. We have not yet built a mechanism to check consistency when binding sets, and we still have to introduce resource situations into presuppositional expressions to mirror our analysis more closely. Nonetheless, the current system computes qadverb domains in accordance with the theoretical analysis outlined above, using only presuppositional information.

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