Structured Discourse Reference to Propositions

Adrian Brasoveanu
Rutgers University & University of Stuttgart

abrsvn@gmail.com

August 24, 2006
Logic & Language 9
Budapest / Besenyőtelek
The main goal of this presentation is:

to introduce a notion of **structured discourse referents** which, together with a possible-worlds analysis of intensional phenomena,

can account for the interaction of **entailment particles** (e.g. *therefore / hence*) and **modal subordination**.
I. Introduction.

The resulting compositional dynamic system is couched in classical type logic.

It captures the **truth-conditions** of and the **modal** and **individual-level anaphoric connections** established in discourses like:

1. **a.** [A] man cannot live without joy.
   **b.** Therefore, when he is deprived of true spiritual joys, it is necessary that he become addicted to carnal pleasures. (Thomas Aquinas, attributed)
I. Introduction.

The system makes possible an integrated analysis of several phenomena:

- entailment relations established *within* discourse by particles like *therefore* / *hence*;

- 'donkey' anaphora and modal subordination;

- the parallels between anaphora in the individual and modal domains.
I. The Structure of the Presentation.

- The Informal Analysis of the Aquinas discourse.
- The Basic Proposal: Intensional Compositional DRT with Plural Info States (IP-CDRT).
- Conclusion.

For the outline of the formal IP-CDRT analysis, – see pp. 40-44 of the LoLa 9 Proceedings.
II. Informal Analysis of Discourse (1).

1. a. [A] man cannot live without joy.
   b. Therefore, when he is deprived of true spiritual joys, it is necessary that he become addicted to carnal pleasures.

I will focus on only one of the meaning dimensions of this discourse, namely:

the entailment relation established by therefore between the modal premise (1a) and the modal conclusion in (1b).

(for the meaning multidimensionality associated with therefore, see for example Grice (1975) and Potts (2003))
II. Informal Analysis of Discourse (1).

We want to capture:

- the meaning of the entailment particle *therefore*, which:
  - relates the content of the premise (1a) and the content of the conclusion in (1b)
  - requires the latter to be entailed by the former.

The content of a sentence: its truth-conditions, i.e. the set of possible worlds in which the sentence is true.

**Entailment:** content inclusion, i.e. (1a) entails (1b) iff for any world $w$, if (1a) is true in $w$, so is (1b).
II. Informal Analysis of Discourse (1).

And we also want to capture:

- the meanings of premise (1a) and conclusion (1b)

The meaning of a sentence: its context-change potential, which encodes both content (truth-conditions) and anaphoric potential.
II. Informal Analysis of Discourse (1).

Thus, on the one hand, we are interested in the contents of (1a) and (1b).

They are both modal quantifications.

(1a) involves a circumstantial modal base (Kratzer (1981)) and asserts that, in view of the circumstances, i.e. given that God created man in a particular way, as long as a man is alive, he must find some thing or other pleasurable.
II. Informal Analysis of Discourse (1).

(1b) involves the same modal base and elaborates on the preceding modal quantification: in view of the circumstances, if a man is alive and he has no spiritual pleasure, he must have a carnal pleasure.

We need to make the contents of (1a) and (1b) accessible in discourse so that the entailment particle *therefore* can relate them.
II. Informal Analysis of Discourse (1).

On the other hand, we are interested in the anaphoric potential of (1a) and (1b), i.e. in the anaphoric connections between them,

which we need to establish their contents.

These connections are explicitly represented in discourse (2) below, which is intuitively equivalent to (1).
II. Informal Analysis of Discourse (1/2).

2. **a.** If $a_{u1}$ man is alive, he$_{u1}$ must find something$^{u2}$ pleasurable / he$_{u1}$ must have a$^{u2}$ pleasure.

**b.** Therefore, if he$_{u1}$ doesn’t have any$^{u3}$ spiritual pleasure, he$_{u1}$ must have a$^{u4}$ carnal pleasure.

**Indefinites** – introduce a discourse referent (dref) $u_1$, $u_2$ etc., which is represented by a superscript

**Pronouns** – retrieve a dref, which is represented by a subscript.
II. Informal Analysis of Discourse (1/2).

The indefinite *a man* in the antecedent of the conditional in (2a) introduces the dref $u_1$, which is anaphorically retrieved by the pronoun *he* in the antecedent of the conditional in (2b).

This is an instance of **modal subordination** (Roberts (1989)), i.e. an instance of **simultaneous modal** and **individual-level** anaphora (see Frank (1996), Geurts (1999) and Stone (1999)), that is...
II. Informal Analysis of Discourse (1/2).

That is…

the conditional in (2b) covertly 'duplicates' the antecedent of the conditional in (2a), i.e. it asserts that:

if a man is alive and he doesn't have any spiritual pleasure, he must have a carnal one.

I will analyze the simpler and more transparent discourse in (2) instead of the naturally occurring discourse in (1).
II. Summary: The Problem.

When we *compositionally* assign meanings to:
- the modalized conditional in (2a), i.e. the premise,
- the modalized conditional in (2b), i.e. the conclusion,
- the entailment particle *therefore*,

we have to capture:
- the *intuitively correct truth-conditions* of the whole discourse and
- the *modal* and *individual-level anaphoric connections* between the two sentences of the discourse and within each one of them.
III. The Basic Proposal: Intensional Plural CDRT (IP-CDRT).

I introduce a new dynamic system couched in many-sorted type logic, which extends Compositional DRT (CDRT, Muskens (1996)) in two ways.

First: in the spirit of the Dynamic Plural Logic of van den Berg (1996),

I model **information states** $I, J$ etc. as **sets of variable assignments** $i, j$ etc. and

I let **sentences** denote **relations** between such **plural info states**.
III. The Basic Proposal: Intensional Plural CDRT (IP-CDRT).

Second: in the spirit of Stone (1999),

I analyze modal anaphora by means of dref's for static modal objects.

This is in contrast to Geurts (1999) and Frank (1996) among others, who use dref's for contexts (i.e. for info states) to analyze modal anaphora and thus:

(i) complicate the architecture of the system, e.g. the info states are not necessarily well-founded (at least in principle);

(ii) fail to capture the parallel between anaphora and quantification in the individual and the modal domain (see Stone (1999) and Schlenker (2005) among others for more discussion).
III. The Basic Proposal: Intensional Plural CDRT (IP-CDRT).

I call the resulting system Intensional Plural CDRT (IP-CDRT).

IP-CDRT takes the research program in Muskens (1996), i.e. the unification of Montague semantics and dynamic semantics, one step further:

III. The Basic Proposal: Intensional Plural CDRT (IP-CDRT).

We work with a Dynamic Ty3 logic. Following Muskens (1996), we extend Ty2 (Gallin (1975)) with a basic type whose elements are meant to model variable assignments.

Basic types (I ignore the temporal and eventuality domains):
- type $t$: truth-values;
- type $e$: individuals (variables: $x$, $x'$ etc.);
- type $s$: 'variable assignments' (variables: $i$, $j$ etc.);
- type $w$: possible worlds (variables: $w$, $w'$ etc.).
III. The Basic Proposal: Intensional Plural CDRT (IP-CDRT).

- a dref for individuals $u$ is a function of type $se$ from 'assignments' $i_s$ to individuals $x_e$

(\text{the subscripts on terms indicate their type})

Intuitively, the individual $u_{se'i_s}$ is the individual that the 'assignment' $i$ assigns to the dref $u$. 
III. The Basic Proposal: Intensional Plural CDRT (IP-CDRT).

- a dref for possible worlds $p$ is a function of type $sw$ from 'assignments' $i_s$ to possible worlds $w_w$

Intuitively, the world $p_{sw}i_s$ is the world that the 'assignment' $i$ assigns to the dref $p$.

- dynamic info states $I, J, K,…$ are sets of 'variable assignments', i.e. they are of type $st$

A sentence is interpreted as a DRS, i.e. a relation of type $(st)((st)t)$ between an input and an output info state.
III. The Basic Proposal: Intensional Plural CDRT (IP-CDRT).

- an individual dref \( u \) stores a set of individuals with respect to a plural info state \( I \), abbreviated as:

\[
ul := \{u_{se}i_s \mid i_s \in I_{st}\}
\]

- a dref \( p \) stores a set of worlds, i.e. a proposition, with respect to an info state \( I \), abbreviated as:

\[
pl := \{p_{sw}i_s \mid i_s \in I_{st}\}
\]
III. The Basic Proposal: Intensional Plural CDRT (IP-CDRT).

Propositional dref's have two uses:

- they store **contents**, e.g. the content of the premise (2a);

- they store **possible scenarios** (in the sense of Stone (1999)), e.g. the set of worlds introduced by the conditional antecedent in (2a).
III. The Basic Proposal: Intensional Plural CDRT (IP-CDRT).

We use plural info states to store sets of individuals and propositions

instead of simply using dref's for sets of individuals or sets of possible worlds
(their types would be $s(et)$ and $s(wt)$)

because we need to store in our information states both the values assigned to various dref's and the structure associated with those values.
III. The Basic Proposal: Intensional Plural CDRT (IP-CDRT).

To see this, consider the **multiple plural anaphora** in (3) and the **modal subordination** in (4).

3.  
   a. Every\(^u\) man saw a\(^u'\) woman.
   
   b. They\(_u\) greeted them\(_u'\).

4.  
   a. A\(^u\) wolf might\(^p\) enter the cabin.
   
   b. It\(_u\) would\(^p\) attack John.
III. The Basic Proposal: Intensional Plural CDRT (IP-CDRT).

We do not simply have anaphora to sets, but anaphora to **structured** sets:

- if man $m_1$ saw woman $n_1$ and $m_2$ saw $n_2$, (3b) is interpreted as asserting that $m_1$ greeted $n_1$, not $n_2$, and that $m_2$ greeted $n_2$, not $n_1$;

the structure of the greeting is the same as the structure of the seeing.
### III. The Basic Proposal: Intensional Plural CDRT (IP-CDRT)

<table>
<thead>
<tr>
<th>$i$</th>
<th>$u$ (men)</th>
<th>$u'$ (women)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$i_1$</td>
<td>$m_1 (=ui_1)$</td>
<td>$n_1 (=u'i_1)$</td>
</tr>
<tr>
<td>$i_2$</td>
<td>$m_2 (=ui_2)$</td>
<td>$n_2 (=u'i_2)$</td>
</tr>
<tr>
<td>$i_3$</td>
<td>$m_3 (=ui_3)$</td>
<td>$n_3 (=u'i_3)$</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

For each $i \in I$, the man in $i$ saw the woman in $i$. 
III. The Basic Proposal: Intensional Plural CDRT (IP-CDRT).

- similarly, (4b) asserts that, if a wolf entered the cabin, it would attack John,

i.e. if a black wolf $x_1$ enters the cabin in world $w_1$ and a white wolf $x_2$ enters the cabin in world $w_2$, then $x_1$ attacks John in $w_1$, not in $w_2$, and $x_2$ attacks John in $w_2$, not in $w_1$. 
III. The Basic Proposal: Intensional Plural CDRT (IP-CDRT).

For each $i \in I$, the wolf in $i$ entered the cabin in the possible world in $i$. 
III. The Basic Proposal: Intensional Plural CDRT (IP-CDRT).

A plural info state $I$ stores the quantificational structure associated with sets of individuals and possible worlds:

- (3a) requires each variable assignment $i \in I$ to be such that the man $u_i$ saw the woman $u'_i$;
  (3b) elaborates on this structured dependency: for each $i \in I$, the man $u_i$ greeted the woman $u'_i$.

- (4a) outputs an info state $I$ such that, for each $i \in I$, the wolf $u_i$ enters the cabin in the world $p_i$;
  (4b) elaborates on this structured dependency: for each $i \in I$, the wolf $u_i$ to attack John in world $p_i$. 
We also need plural info states to capture structured anaphora between the premise(s) and the conclusion of *therefore* discourses like (5) and (6).

5. a. Every\(u\) man saw a\(u'\) woman.
   b. Therefore, they\(_u\) noticed them\(_u'\).

6. a. A\(u\) wolf might\(p\) enter the cabin.
   b. It\(_u\) would\(p\) see John\(u'\).
   c. Therefore, it\(_u\) would\(p\) notice him\(_u'\).
III. The Basic IP-CDRT Analysis of Discourse (1/2).

7. a. CONTENT$^{p_1}$:
   \[
   \begin{align*}
   \text{if}^{p_2} (a_{u_1} \text{ man}_{p_2} \text{ is alive}_{p_2}); \\
   \text{must}^{p_3}_{p_1, \mu, \omega} (p_2, p_3); \text{ he}_u \text{ has}_{p_3} a_{u_2} \text{ pleasure}_{p_3}.
   \end{align*}
   \]

   b. THEREFORE$^{p_4}_{p^*, \mu^*, \omega^*} (p_1, p_4)$:
   \[
   \begin{align*}
   \text{if}^{p_5} (p_5 \subseteq p_2; \text{ not} (\text{ he}_u \text{ has}_{p_5} a_{u_3} \text{ spiritual pleasure}_{p_5})); \\
   \text{must}^{p_6}_{p_4, \mu, \omega} (p_5, p_6); \text{ he}_u \text{ has}_{p_6} a_{u_4} \text{ carnal pleasure}_{p_6}.
   \end{align*}
   \]

The representation in (7) is basically a network of structured anaphoric connections.
III. The Basic IP-CDRT Analysis of Discourse (1/2).

The conditional in (7a):

- the morpheme *if* introduces a propositional dref $\rho_2$ that stores the content of the antecedent;

we need this distinct dref because the antecedent in (2b) is anaphoric to it (due to modal subordination)
III. The Basic IP-CDRT Analysis of Discourse (1/2).

The conditional in (7a) (ctd.):

- the indefinite *a man* introduces an individual dref $u_1$, which is later retrieved:

  (i) by the pronoun *he* in the consequent of (2a), i.e. by 'donkey' anaphora,

  (ii) by the pronoun *he* in the antecedent of (2b), i.e. by modal subordination.
The conditional in (7a) (ctd.):

- the modal verb *must* in the consequent contributes a tripartite quantificational structure and it relates three propositional dref's: $p_1$, $p_2$ and $p_3$.

$p_1$: it stores the content of the whole modalized conditional.

$p_2$: it was introduced by the antecedent;
    it is anaphorically retrieved by *must*;
    it provides the restrictor of the modal quantification.
III. The Basic IP-CDRT Analysis of Discourse (1/2).

The conditional in (7a) (ctd.):

\( p_3 \): it is introduced by the modal *must*;
it is the nuclear scope of the modal quantification;
the modal verb constrains it to contain the set of *ideal* worlds among the set of \( p_2 \)-worlds…
…ideal relative to the \( p_1 \)-worlds, a *circumstantial* modal base (MB) \( \mu \) and an *empty* ordering source (OS) \( \omega \).

- finally, we test that the set of ideal worlds stored in \( p_3 \) satisfies the remainder of the consequent.
III. The Basic Analysis of Discourse (1/2).

The entailment particle *therefore*:

- it relates *contents* and not meanings;

- it is analyzed as a modal relation expressing *logical consequence*

- thus, discourse (1/2) is analyzed as a modal quantification that relates (the contents of) two embedded modal quantifications, the second of which is modally subordinated to the first.
The entailment particle *therefore* (ctd.):

- *therefore* contributes a **necessity** modal relation and introduces a tripartite quantificational structure:

  the restrictor is $p_1$ (the content of the premise)
  the nuclear scope is the newly introduced dref $p_4$, which stores the set of ideal $p_1$-worlds...

  ... ideal relative to the dref $p^*$ (the dref for the actual world $w^*$), an **empty** MB $\mu^*$ and an **empty** OS $\omega^*$. 
III. The Basic IP-CDRT Analysis of Discourse (1/2).

The entailment particle *therefore* (ctd.):

- the MB $\mu^*$ and the OS $\omega^*$ are **empty** because *therefore* is interpreted as **logical consequence**.

- since $\mu^*$ and $\omega^*$ are empty, the dref $p_4$ is identical to $p_1$. 
The entailment particle *therefore* (ctd.):

- analyzing *therefore* as an instance of modal quantification predicts that we can interpret it relative to different MB's and OS's.

This prediction is borne out.
III. The Basic IP-CDRT Analysis of Discourse (1/2).

The entailment particle *therefore* (ctd.):

- *therefore* expresses **causal consequence** in:

Reviewers are usually people who would have been poets, historians, biographers, etc., if they could; they have tried their talents at one or the other, and have failed; *therefore* they turn critics.

(Samuel Taylor Coleridge, *Lectures on Shakespeare and Milton*)
III. The Basic IP-CDRT Analysis of Discourse (1/2).

The entailment particle *therefore* (ctd.):

- *therefore* seems to express a form of *practical inference* in:

We cannot put the face of a person on a stamp unless said person is deceased. My suggestion, *therefore*, is that you drop dead.

(attributed to J. Edward Day; letter, never mailed, to a petitioner who wanted himself portrayed on a postage stamp)
III. The Basic IP-CDRT Analysis of Discourse (1/2).

The conditional in (7b):

- the conditional in (7b) is interpreted like the conditional in (7a), except that its antecedent is anaphoric to the antecedent of the conditional in (7a), i.e. to the dref \( p_2 \).

- the dref \( p_5 \) is a **structured** subset of \( p_2 \), symbolized as \( p_5 \sqsubseteq p_2 \).
III. The Basic IP-CDRT Analysis of Discourse (1/2).

The conditional in (7b) (ctd.):

- we need the **structured inclusion** $p_5 \subseteq p_2$

  because we want $p_5$ to preserve the structure associated with the $p_2$-worlds,

  i.e. to preserve in $p_5$ the previously established association between the $p_2$-worlds and the $u_1$-men in them.
III. The Basic IP-CDRT Analysis of Discourse (1/2).

The conditional in (7b) (ctd.):

- the modal verb *must* in (7b):
  
  it is anaphoric to \( p_5 \);

  it introduces the set of worlds \( p_6 \) containing all the ideal \( p_5 \)-worlds – ideal relative to the \( p_4 \)-worlds, \( \mu \) and \( \omega \), i.e. the same as the MB and the OS in the premise (7a);

  finally, it checks that in each ideal \( p_6 \)-world, all its associated \( u_1 \)-men have a carnal pleasure.
III. More examples.

IP-CDRT can scale up to account for a wide range of examples.

Consider the modal subordination example in (9) below from Roberts (1996).

9. **a.** You should buy a lottery ticket and put it in a safe place.
   **b.** You’re a person with good luck.
   **c.** It might be worth millions.
III. More examples.

The *might* modal quantification in (9c) is restricted by the **content** of the first conjunct below the modal *should* in (9a),

i.e. it is interpreted as asserting that, given that you're a generally lucky person, **if you buy a lottery ticket**, it might be worth millions.

Crucially, (9c) is not restricted by the content of both conjuncts in (9a) or the set of deontically ideal worlds contributed by *should*. 
III. More examples.

Roberts (1996) proposes to analyze (9c) by accommodating a suitable domain restriction for the quantification contributed by might.

The accommodation procedure (possibly involving syntactic copying operations at the level of Logical Form) is left largely unspecified and unrestricted.

Moreover, it is far from clear that accommodation is the right way to go when the relevant domain restriction is in fact provided by the preceding discourse.
III. More examples.

In contrast, IP-CDRT provides the framework for an analysis of (9c) in terms of **content anaphora**.

An anaphoric analysis of (9c) is desirable because:

- it is (arguably) more restricted than an accommodation account;
- it can capture the connection between (9c) and the preceding discourse, i.e. (9a), in a simple and formally explicit way.
III. More examples.

IP-CDRT provides the kind of formal system that can be extended in the usual ways to account for the diverse range of naturally occurring *therefore* discourses:

- *therefore* can relate two deontic modal quantifications:

10. It is necessary for me to establish a winner image. Therefore, I have to beat somebody.
(attributed to Richard Nixon)
III. More examples.

- *therefore* can be anaphoric to a modal quantification involving a comparative correlative:

11. If you commit a big crime then you are crazy, and the more heinous the crime the crazier you must be. Therefore you are not responsible, and nothing is your fault.

(attributed to Peggy Noonan)
III. More examples.

- *therefore* can interact with VP cataphora:

12. I can, therefore I blog.
   
   (http://normblog.typepad.com/normblog/2006/03/i_can_therefore.html)

- *therefore* can be embedded in an attitude report:
III. More examples.

13. This is the site that Darlene, the woman who emailed me, runs. Her blog is more popular than my blog. You might think that I would therefore not like her, but you would be wrong.

I love Darlene, even if she has the best blogger website address.

(http://whatwouldjb.blogspot.com/2006/04/what-else-would-jesus-blog.html)

This discourse seems to be interpreted as follows:

you might think that [ I would not like her because her blog is more popular than mine ].
IV. Conclusion.

The main contribution of the paper is the introduction of structured discourse referents for individuals and propositions,

formalized in a compositional dynamic system based on classical type logic and in the context of a possible-world analysis of intensional phenomena.

This enables us to account for discourses in which entailment particles interact with multiple modalized conditionals, 'donkey' anaphora and modal subordination.
IV. Conclusion.

The account is part of two larger research programs:

- the unification of Montague semantics and dynamic semantics
  (see Muskens (1996) among others)

- the investigation of the anaphoric and quantificational parallels between the individual and the modal domain
  (see Stone (1999) and Schlenker (2005) among others, building on Partee (1973, 1984)).
IV. Conclusion.

- IP-CDRT extends the empirical coverage of previous account of modal subordination and provides simpler analyses:

It is not clear that Geurts (1996) and Frank (1999) can compositionally analyze discourses like (1/2).

Insofar as they can, the analyses are more complicated because of their discourse referents for info states – which also prevents them from formally capturing the anaphoric and quantificational parallels between the individual and the modal domain.
IV. Conclusion.

The analysis of modal verbs in Stone (1999) does not associate contents with modal quantifications – so the meaning of *therefore* cannot be captured.

IV. Conclusion.

- technically, IP-CDRT simplifies and extends both van den Berg (1996) and Stone (1999)

- compositionality at the sub-sentential / sub-clausal level follows automatically, given that the dynamic system is formulated in type logic; also, standard techniques in Montague semantics (e.g. type-shifting) become available
IV. Conclusion.

- the received wisdom that natural language does not make (discourse) reference to possible worlds as it does to individuals,

the classical expression of which is Montague's IL, where reference to and quantification over possible worlds is only implicit,

is captured by IP-CDRT: even the simplest intensional dref, i.e. a possible-world dref, stores a proposition (a set of worlds) with respect to a plural info state.
In contrast, discourse reference to **propositions**, i.e. to **partially** specified intensional objects, is common:

**entailment particles** involve discourse reference to **contents** (of clauses or of larger discourse segments)

**modal subordination** and **modal anaphora** in general involve discourse reference to **possible scenarios**

And discourse reference to contents and possible scenarios is just discourse reference to **propositions** in two different guises.
IV. Conclusion.

- finally, IP-CDRT over-generates with respect to the kind of propositional anaphoric patterns it allows (almost anything goes)...

... but this is very much like the over-generation problem faced by dynamic systems for individual-level anaphora.
And, just as anaphora resolution in the individual domain requires a much richer theory over and above a basic dynamic system (see for example Grosz et al. (1995) and Asher & Lascarides (2003)),

I expect that various refinements of the IP-CDRT system, e.g. modeling plural info states as sets of stacks and implementing a system of prominence-guided anaphora (following Nouwen (2003) and Bittner (2005) among others) will substantially decrease the over-generation.
Acknowledgments.

I am especially grateful to Maria Bittner, Hans Kamp, Matthew Stone and Roger Schwarzschild for very detailed comments on various versions of this work.

I want to thank Sam Cumming, Donka Farkas, Tim Fernando, Rick Nouwen, Magdalena Schwager, Robert van Rooij, Henk Zeevat and Ede Zimmermann for extensive discussion of the issues addressed here.

I also want to thank the LoLa 9 abstract reviewers for their very helpful comments.

I am indebted to the following people for discussion: Nicholas Asher, Veneeta Dayal, John Hawthorne, Slavica Kochovska, Xiao Li, Cecile Meier, Alan Prince, Jessica Rett, Philippe Schlenker, Adam Sennet, Martin Stokhof, Frank Veltman, Hong Zhou and the SURGE (Rutgers, March 2004, November 2004 and September 2005), GK Frankfurt Colloquium (November 2005) and DIP (Amsterdam, March 2006) audiences.

The support of a DAAD grant during the last stages of this investigation is gratefully acknowledged. The usual disclaimers apply.

Finally, I want to thank László Kálmán for his help with editing and preparing this paper for publication in the LoLa 9 proceedings.
References.

References.