Discourse Representation Theory
an Updated Survey

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Overview

Monday:	*Bottom-up DRS Construction* *Underspecification*	J
Tuesday:	*Presupposition*	J
Wednesday:	*Intensionality*	A
Thurday:	*Propositional Attitudes*	H
Friday:	*Information Structure* *Discussion*	A

Reading: H. Kamp, U. Reyle and J. van Genabith, *Discourse Representation Theory*, Handbook of Philosophical Logic, (ed.) D. Gabbay, Kluwer Academic Press, (rough draft ;-).

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Bottom-Up DRS Construction

- new DRT architecture
- presupposition [Heim,83], [Zeevat,92], [van der Sandt,92]
  - from: obstacle to logical transparency
  - to: centre stage in dynamic semantics
  - presupposition/anaphora: different aspects of single process
- two stage processing architecture:
  - presupposition computation
  - presupposition justification/accommodation

Bottom-Up DRS Construction

The Plan . . .

- “old” top-down DRS construction algorithm [Kamp,81] [Kamp & Reyle,93]
- presupposition (“a taste”)
- underspecification
  - storage [Cooper,83]
  - UDRT [Reyle,92,93]
- presupposition (“main course”)
- “new” bottom-up DRS construction
  - presupposition computation (preliminary representations)
  - presupposition justification/accommodation
- a P-UDRT fragment (generic unification formalism)
- DRT calculus

Top-Down DRS Construction

(1) A delegate^1 arrived. She$_1$ registered.

(2)

x y

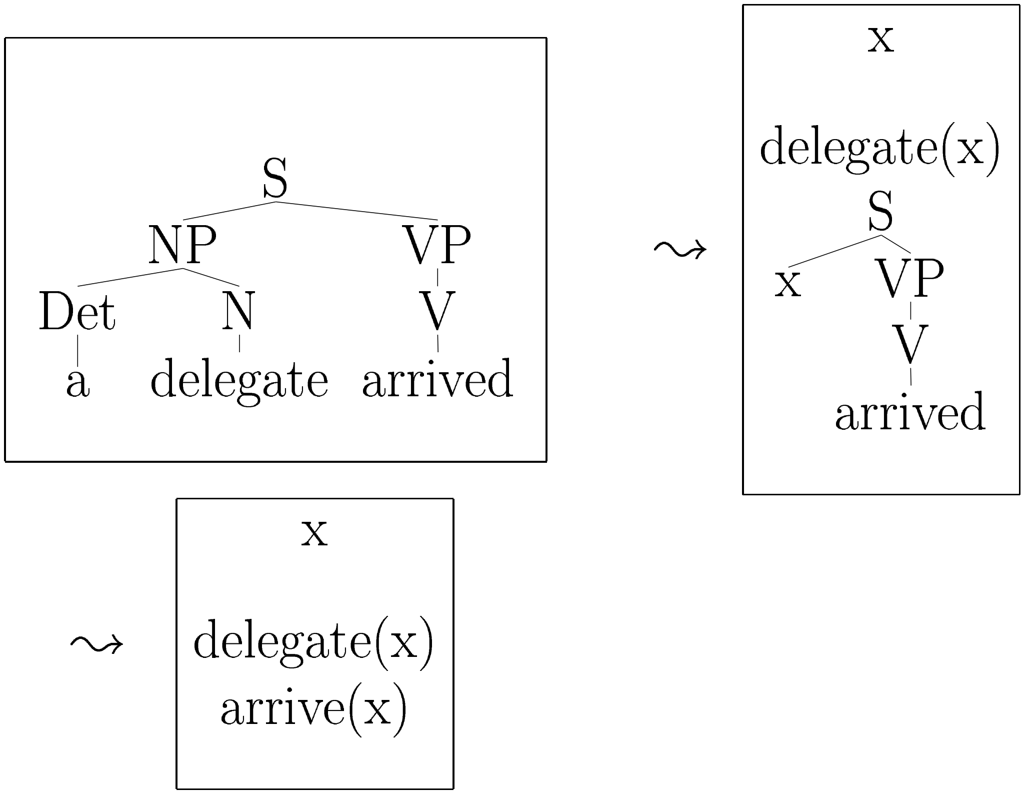
delegate(x)
arrive(x)
register(y)
y = x

Top-Down DRS Construction

DRS construction rules, $\text{CR-NP}_{\text{Indef}}$, $\text{CR-VP}_{\text{InTr}}$, . . . , triggering configurations

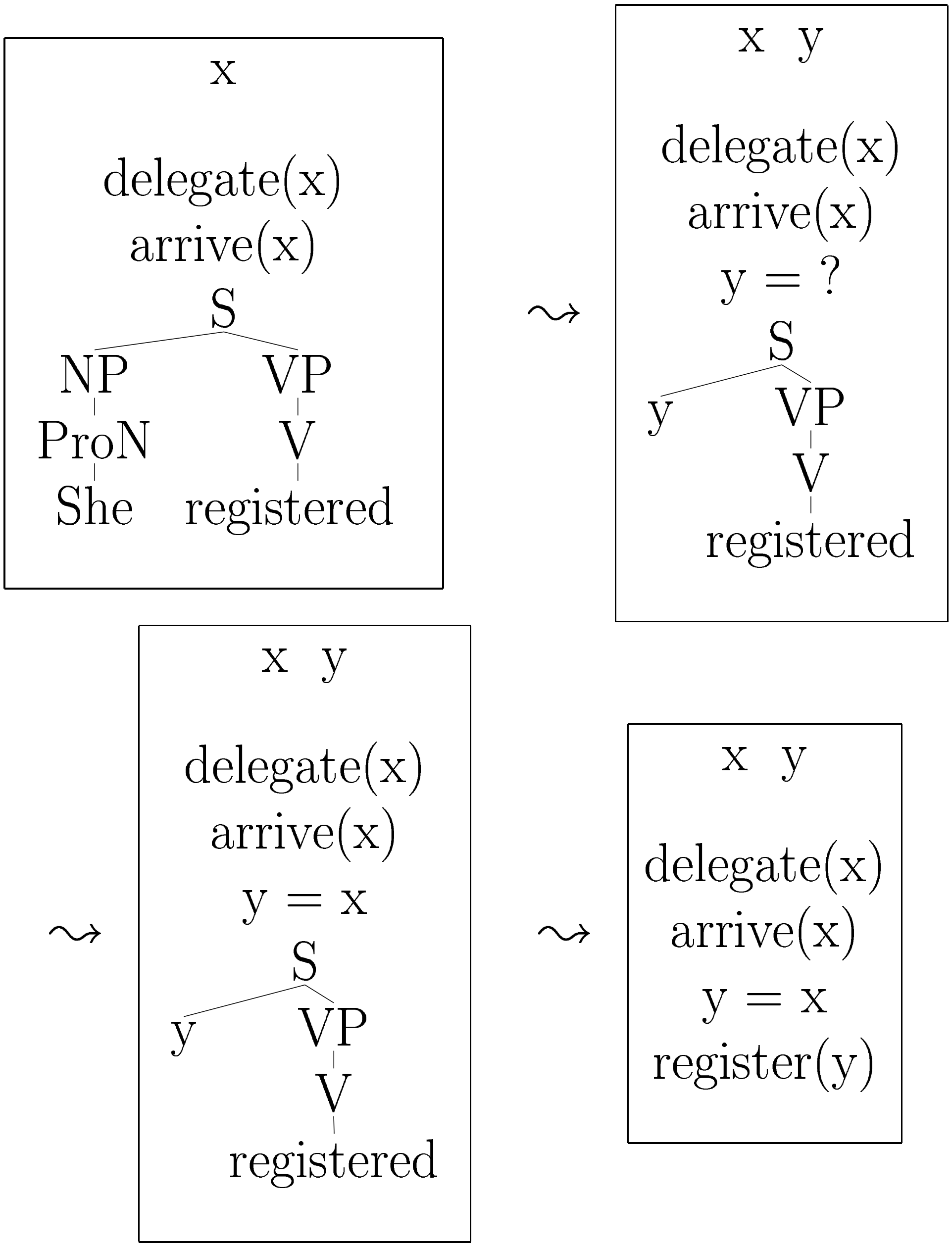
(3) A delegate arrived.

(4)



Top-Down DRS Construction

(5)



Top-Down DRS Construction

- $\langle \underbrace{S_1, \ldots, S_i}_{\mathrm{K}_{1,i}}, S_{i+1} \ldots, S_n \rangle$
- insert tree(S_{i+1}) into context DRS $\mathrm{K}_{1,i}$ as decomposable condition
- construction rules
  - triggering configurations
- rational reconstruction of on-line incremental interpretation by human interpreter
- meaning: instruction to dynamically update mental representation
- meaning: complete(ed) DRSs: truth conditions
- practical and theoretical reasoning

Bottom -Up DRS Construction

Sneak Preview: preliminary DRSs

(6) A delegate[1] arrived. She$_1$ registered.

(7)
$$\boxed{\begin{array}{c} \mathrm{x} \\ \\ \mathrm{delegate(x)} \\ \mathrm{arrive(x)} \end{array}} \quad \left\langle \left\{ \boxed{\begin{array}{c} \underline{\mathrm{y}} \\ \\ \mathrm{fem(y)} \end{array}} \right\}, \boxed{\begin{array}{c} \\ \\ \mathrm{register(y)} \end{array}} \right\rangle$$

context DRS preliminary DRS

Bottom -Up DRS Construction

Presuppositions

- multiple
- nested

Two stage processing architecture:

1. Construction (of P-DRSs)
    - make presuppositions (demands on context) explicit
    - presuppositional/non-presuppositional part
2. Resolution (of presuppositions)
    - presupps. need to be satified by context
    - or context accommodated so that satisfies presupps.

Resolution involves world knowledge . . .

If (2) succeeds presupps "disappear" from P-DRS, merge of non-presupp part with context

Bottom -Up DRS Construction

Sneak Preview (contnd):

(8)

$$\begin{array}{|c|}\hline \text{x} \\ \\ \text{delegate(x)} \\ \text{arrive(x)} \\ \text{fem(x)} \\ \hline \end{array} \quad \uplus \quad \begin{array}{|c|}\hline \text{y} \\ \\ \text{register(y)} \\ \text{y} = \text{x} \\ \hline \end{array}$$

context DRS

non-presuppositional DRS

$$= \begin{array}{|c|}\hline \text{x} \;\; \text{y} \\ \\ \text{delegate(x)} \\ \text{arrive(x)} \\ \text{fem(x)} \\ \text{register(y)} \\ \text{y} = \text{x} \\ \hline \end{array}$$

Underspecification

- ambiguity …
- lexical (POS, word class)

  `following`: V, ADJ, N
- structural

  `unpackable`
  `conservative party leader`
  `crazy sematicists and syntacticians`
  `A saw B with a telescope` …
- semantic (word sense, scope …)

  `bank`
  `every candidate made a crucial mistake`
  `take two pills with a glass of water`
  `every day for three weeks`
  `John rang Tom. He was furious.`
- …
- ambiguities can multiply !

Underspecification

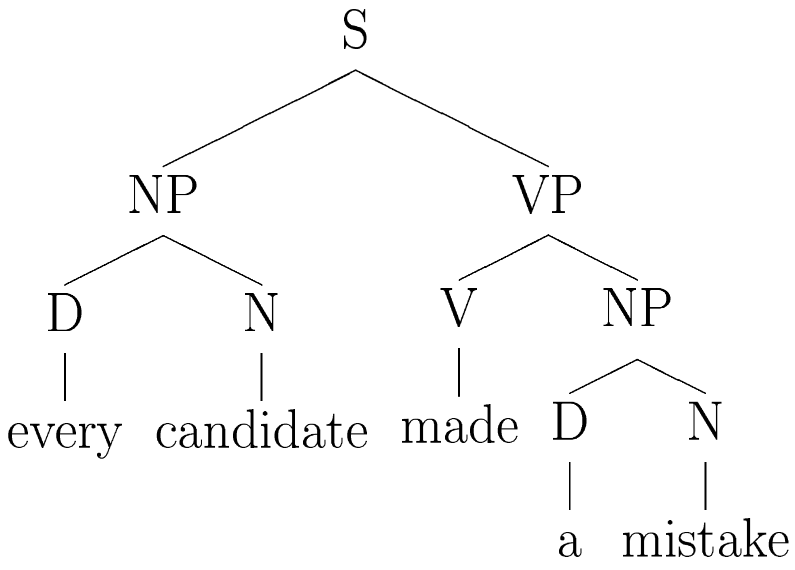
- ambiguity (contnd):
- Montague Grammar: different derivation trees + quantifying in
- Cooper storage (procedure to construct LFs)
  - Keller storage
- underspecification (partial descriptions of LFs)
  - UDRT [Reyle, 92,93, . . .]
  - QLF [Alshawi & Crouch, 92]
  - Hole Semantics [Bos,96], linear logic (glue) semantics [Crouch et. al, 01], Ambiguous Logical forms [Muskens,95],Constraint Language for Lambda Structures (CLLS) [Egg et. al,98], MRS [Copestake et. al, 95], . . .

Cooper Storage

FOPL LF construction:

(9) Every candidate made a mistake.

- $\forall x(cand(x) \rightarrow \exists y(mis(y) \wedge make(x,y)))$
- $\exists y(mis(y) \wedge \forall x(cand(x) \rightarrow make(x,y)))$



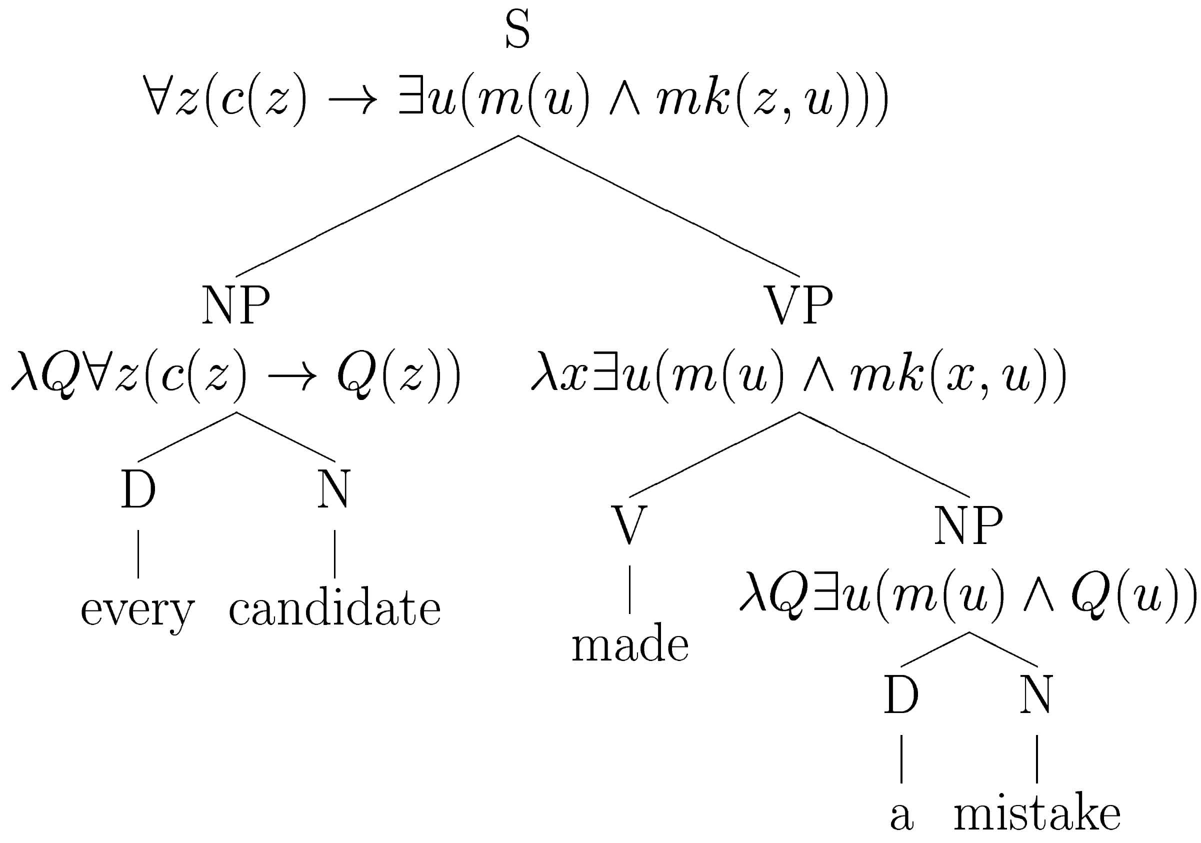
Cooper Storage

FOPL LF construction:

Normally:

Formation	Interpretation
S → NP VP	S° := NP° VP°
NP → D N	NP° := D° N°
VP → V NP	VP° := $\lambda x.$NP°(V° x)
D → a	$\lambda P \lambda Q \exists x (P(x) \wedge Q(x))$
D → every	$\lambda P \lambda Q \forall x (P(x) \rightarrow Q(x))$
N → candidate	$\lambda x.cand(x)$
N → mistake	$\lambda x.mis(x)$
V → made	$\lambda x \lambda y.make(x, y)$

Cooper Storage



Surface scoping only . . .

Cooper Storage

Complicate semantic representation!

- each synactic node is associated with two semantic components
  - Store
  - Core
  - ⟨ Store , Core ⟩
- Store is a set of store elements of the form

  $\langle x_i, \text{Sem}\rangle$

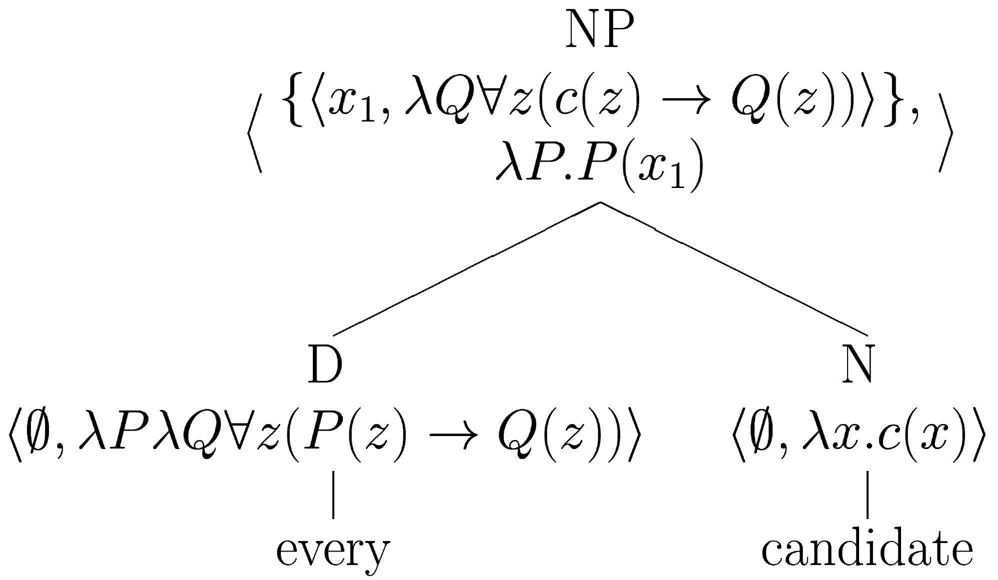
  where x_i is an indexed variable and Sem is a semantic representation (usually of a quantified NP)
- Core is a “dummy” semantic representation containing occurrences of indexed variables

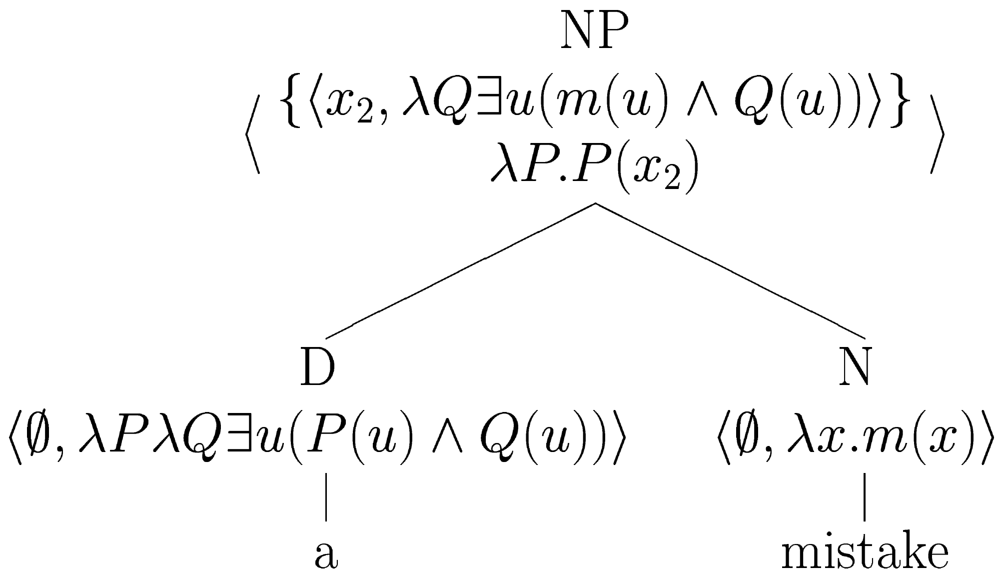
Cooper Storage

Trick: complicate semantic representation
⟨ Store , Core ⟩

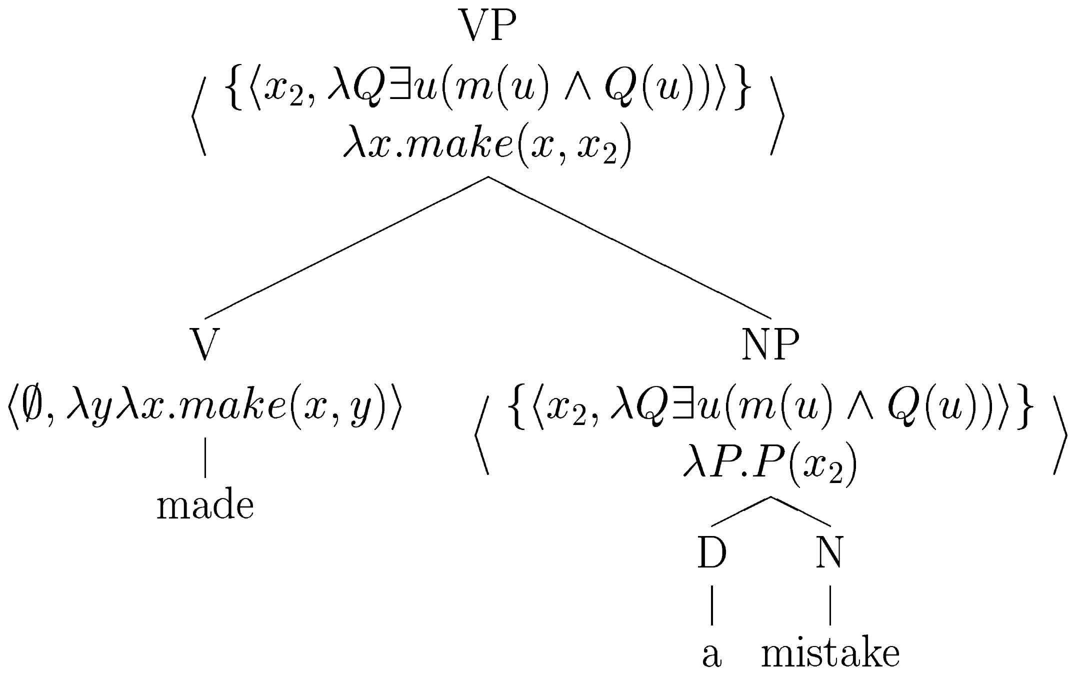
Formation	Interpretation
S → NP VP	$\mathrm{S}^s := \mathrm{NP}^s \cup \mathrm{VP}^s$
	$\mathrm{S}^c := \mathrm{NP}^c \mathrm{VP}^c$
VP → V NP	$\mathrm{VP}^s := \mathrm{V}^s \cup \mathrm{NP}^s$
	$\mathrm{VP}^c := \mathrm{NP}^c \mathrm{V}^c$
NP → D N	$\mathrm{NP}^s := \{ \langle\, x_i \,, \mathrm{D}^c \mathrm{N}^c \,\rangle \}$
	$\mathrm{NP}^c := \lambda P.P(x_i)$
D → a	$\langle \emptyset, \lambda P \lambda Q \exists x(P(x) \wedge Q(x)) \rangle$
D → every	$\langle \emptyset, \lambda P \lambda Q \forall x(P(x) \rightarrow Q(x)) \rangle$
N → candidate	$\langle \emptyset, \lambda x.cand(x) \rangle$
N → mistake	$\langle \emptyset, \lambda x.mis(x) \rangle$
V → made	$\langle \emptyset, \lambda y \lambda x.make(x, y) \rangle$

Cooper Storage

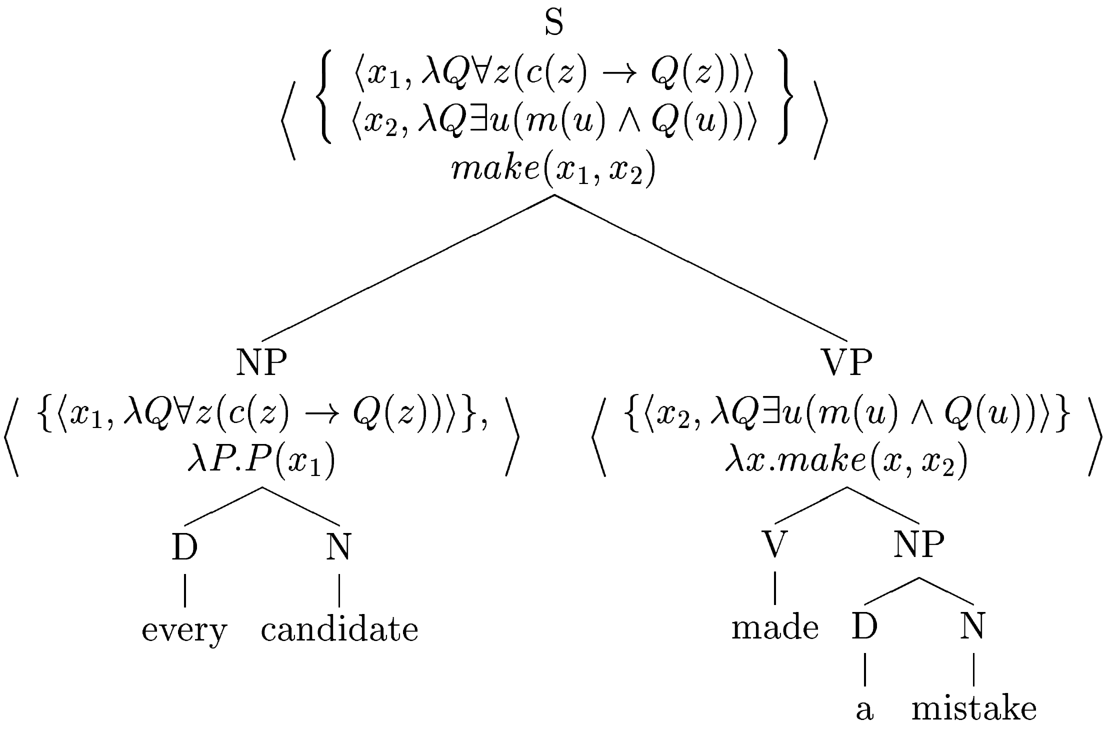




Cooper Storage



Cooper Storage



Cooper Storage

Retrieval:

given $\langle$ Store , Core $\rangle$
where Store = $\{\langle v_1, \mathrm{NP}^\circ_1\rangle, \ldots \langle v_n, \mathrm{NP}^\circ_n\rangle\}$

- repeat until Store = $\emptyset$:
  - Store := Store – $\{\langle v_i, \mathrm{NP}^\circ_i\rangle\}$
  - Core := $\mathrm{NP}^\circ_i(\lambda v_i.\mathrm{Core})$
- write Store

Different orders of retrieval will give different scopes: if $|\mathrm{Store}| = n$ then $n!$ scopes.

A form of underspecification ...

Cooper Storage

- $$\left\langle \begin{array}{c} \left\{ \begin{array}{l} \langle x_1, \lambda Q \forall z(c(z) \rightarrow Q(z))\rangle \\ \langle x_2, \lambda Q \exists u(m(u) \wedge Q(u))\rangle \end{array} \right\} \\ make(x_1, x_2) \end{array} \right\rangle$$
  - $\lambda Q \forall z(c(z) \rightarrow Q(z))(\lambda x_1 . make(x_1, x_2))$
    $\leadsto \forall z(c(z) \rightarrow make(z, x_2))$

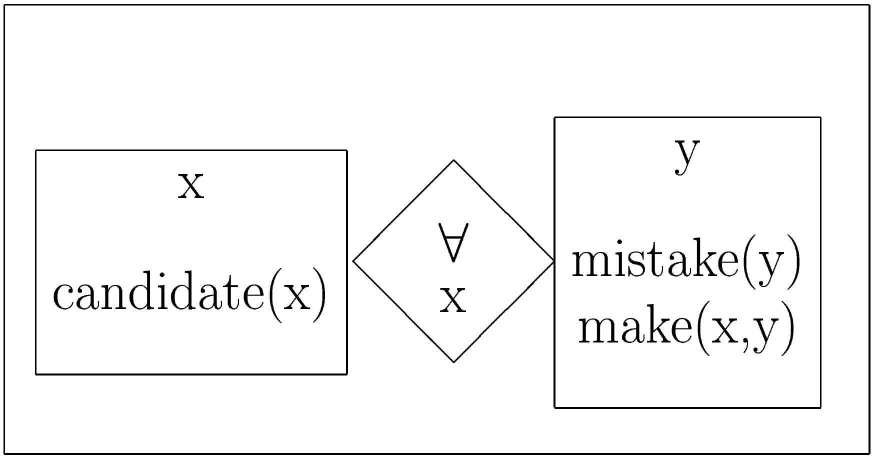
- $$\left\langle \begin{array}{c} \left\{ \langle x_2, \lambda Q \exists u(m(u) \wedge Q(u))\rangle \right\} \\ \forall z(c(z) \rightarrow make(z, x_2) \end{array} \right\rangle$$
  - $\lambda Q \exists u(m(u) \wedge Q(u))(\lambda x_2 . \forall z(c(z) \rightarrow make(z, x_2))$
    $\leadsto \exists u(m(u) \wedge \forall z(c(z) \rightarrow make(z, u)))$

- $$\left\langle \begin{array}{c} \emptyset \\ \exists u(m(u) \wedge \forall z(c(z) \rightarrow make(z, u))) \end{array} \right\rangle$$

A procedure to compute fully scoped LFs.

UDRT

(10) Every candidate made a mistake.



x

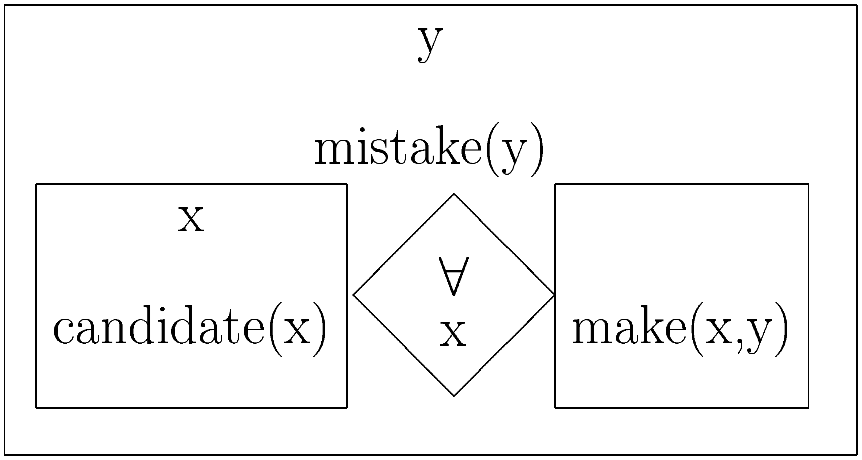
candidate(x)

∀
x

y

mistake(y)
make(x,y)

(∀∃)



y

mistake(y)

x

candidate(x)

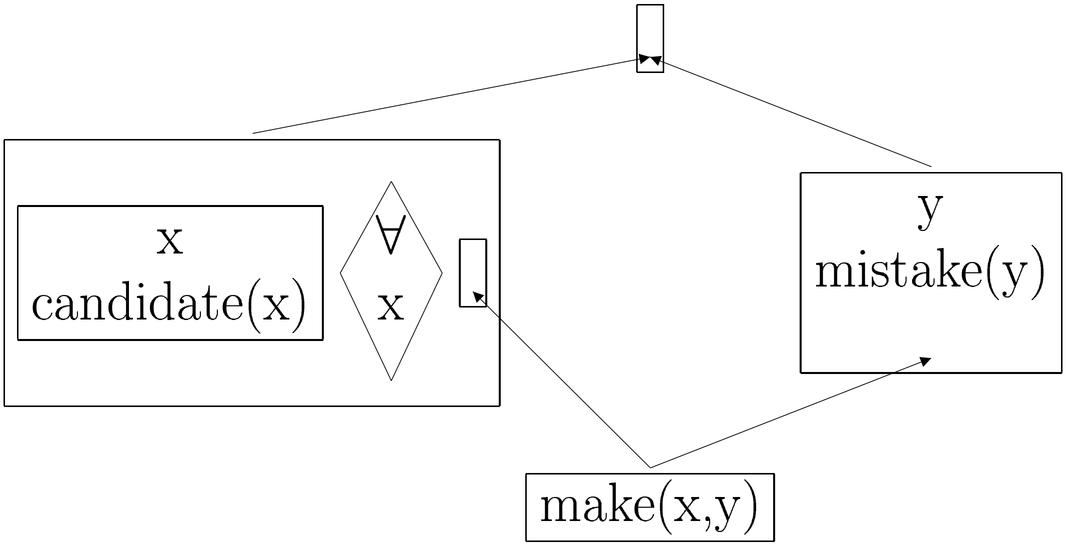
∀
x

make(x,y)

(∃∀)

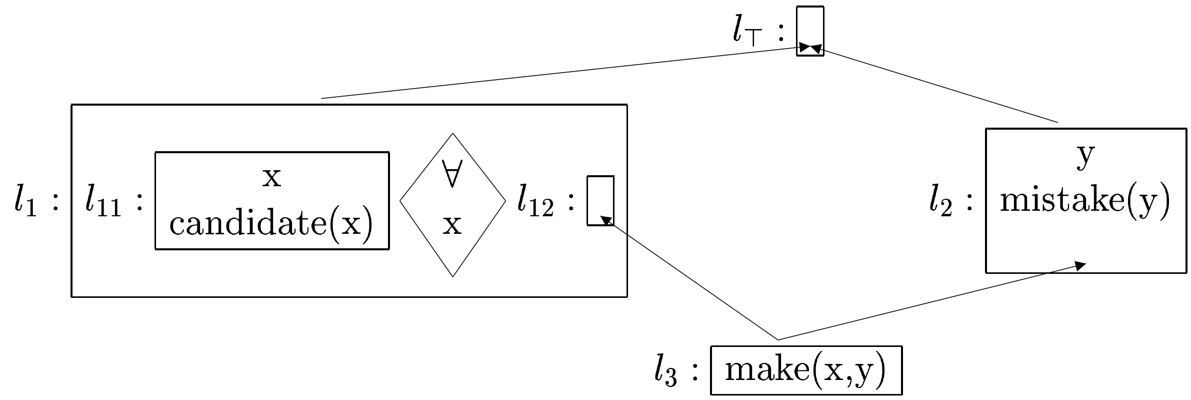
UDRT

(11) Every candidate made a mistake.



- graphical representation of UDRS shows what the two fully scoped reps have in common
- this is not what is constructed in semantics construction . . .
- but **descriptions** of it . . . how? Labels . . .

UDRT



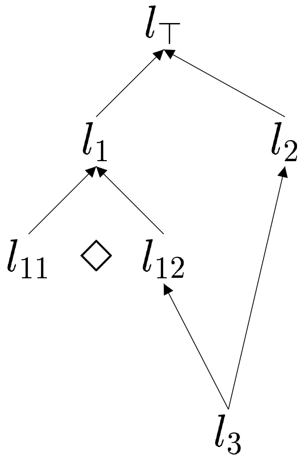
$$\text{UDRS} = \langle \{\text{Structural Constr.}\}, \{\text{Content Constr.}\} \rangle$$

$$\left\langle \begin{array}{c} \{l_1 \leq l_\top, l_2 \leq l_\top, l_3 \leq l_{12}, l_3 \leq l_2\}, \\ \left\{ \begin{array}{c} l_1 : l_{11} \boxed{\forall\ \text{x}} l_{12}, l_{11} : \text{x}, l_{11} : \text{candidate(x)}, \\ l_2 : \text{y}, l_2 : \text{mistake(y)}, l_3 : \text{make(x,y)} \end{array} \right\} \end{array} \right\rangle$$

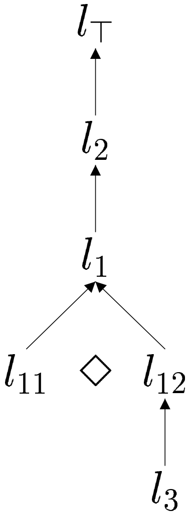
plus closure under transitivity of $\leq$ and subordination constraints induced by complex conditions.

UDRT

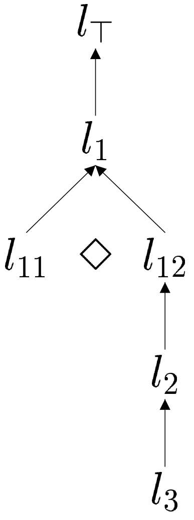
Disambiguation: add structural subordination constraints:



$\cup\{l_1 \leq l_2\} =$



$\cup\{l_2 \leq l_{12}\} =$



Monotonic process (both on representation and interpretation).

UDRT

Satisfiability of dominance constraints (as logical descriptions) NP-hard [Koller, Niehren, Treinen, 01]. *Normal* dominance constraints . . . polynomial algorithms [Althaus et al.,??].

Presupposition

- obstacle to logical transparency
- presuppostion is about interpretation in context
- strongly contributes to text cohesion
- parallels with anaphora ..
- ⇒ presuppostion occupies centre stage in dynamic semantics
- cf. [Heim,83], [van der Sandt,92], [Zeevat,92] . . .

⇒ Motivates architectural changes in the DRT setup (DRS construction).

Two stage process

- presupposition computation
- presupposition resolution

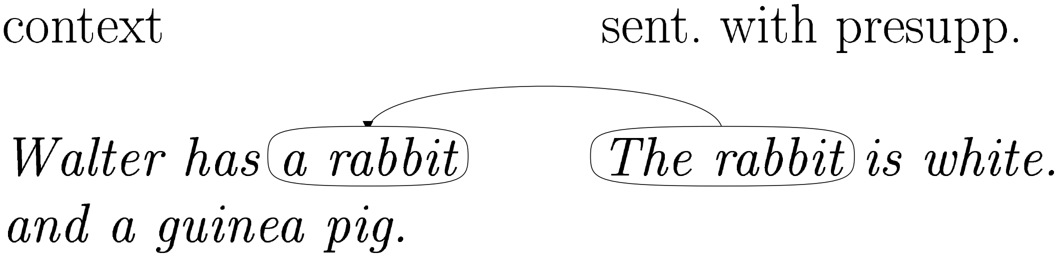
Presupposition

What is presupposition?

- in most general terms: **“a demand/requirement on context”**
- presuppostion triggers
  - lexical/syntactic
    - **`again, also, ...`**
    - **`different, ...`**
    - **`surprise, regret ...`** (factive verbs)
    - definite NPs: definite descriptions, proper names, demonstratives, pronouns
    - ...
- presuppositions need to be
  - satisfied by (local) context
  - (local) context is accommodated
  - or a mix of the two (“justification”)
- projection problem

Presupposition

Definite description "the N_{sg}"



context | sent. with presupp.

Walter has a rabbit and a guinea pig.

The rabbit is white.

Presupposition: (local/relevant) context provides exactly one rabbit (existence and uniqueness) and this is what definite description "*the rabbit*" refers to.

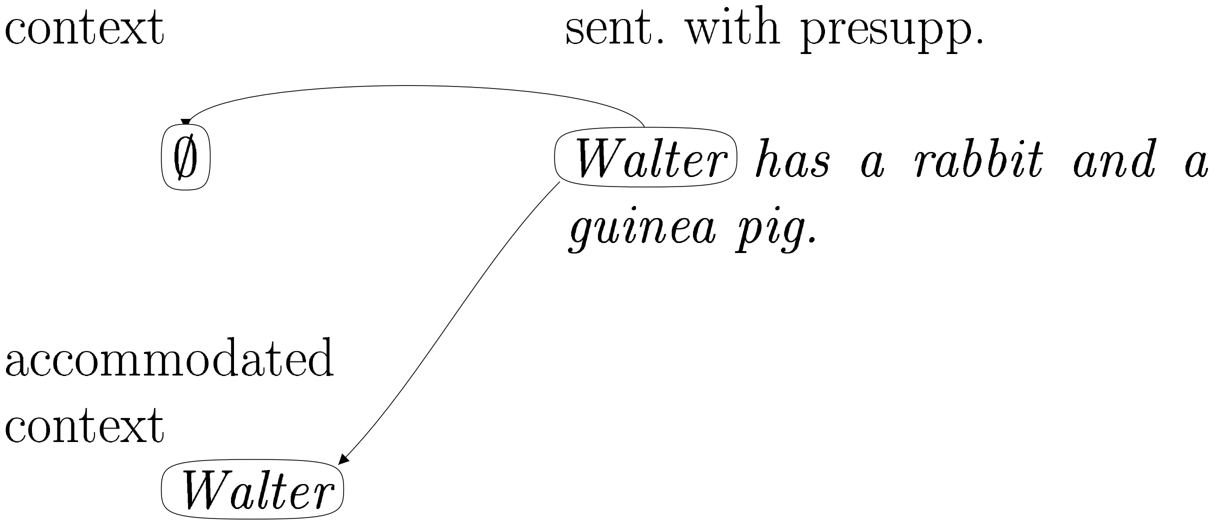
If presupposition not satisfied sentence fails to have truth value.

Here context (together with world knowledge) satisfies presupposition:

$$\mathrm{Cntxt} \vdash_{\mathrm{wk}} \mathrm{Prs}$$

Presupposition

Proper names



context

sent. with presupp.

$\emptyset$

Walter has a rabbit and a guinea pig.

accommodated context

Walter

Presupposition: individual named Walter provided by context.

Accommodation: context is adjusted so that

$$\mathrm{ACC(Cntxt)} \vdash_{\mathrm{wk}} \mathrm{Pres}$$

Presupposition

again

John made a mistake again

Presupposition: John already made a mistake before the mistake talked about here.

Presupposition

Test(s) for presupposition

Negation:

- presuppositions of S are the presuppositions of $\neg$S: $P(S) = P(\neg S)$
- negation "hole" for presuppositions

S : *Walter overfeeds the rabbit.*
P(S) : There is exactly one rabbit.

$\neg$S : *Walter doesn't overfeed the rabbit.*
P($\neg$S) : There is exactly one rabbit.

S : *John made a mistake again.*
P(S) : …

$\neg$S : *John didn't make a mistake again.*
P($\neg$S) : …

Presupposition

Presupposition filtering/projection

Logically complex sentences

S: *If a friend of mine has both a rabbit and a guinea pig, he overfeeds the rabbit.*

P(S) $\neq$ there is exactly one rabbit …

Presupposition absorbed/satisfied by local (sentence internal) context: antecedent of implication.

Basic projection facts follow in dynamic semantics setting [Heim,83].

Presupposition

Presupposition projection/ anaphoric pronouns

S: *Every friend of mine who has a rabbit overfeeds it*

⇒ close parallel between presupposition and anaphoric pronouns [van der Sandt,92], [Zeevat,92]

⇒ instances of same general process

⇒ naturally accounted for in dynamic semantics setting

Presupposition

(12) John owns a rabbit and a cat. **The cat** is overfed.

(13) John made a mistake **again**.

(14) John made a **different** mistake.

(15) Carl is **surprised** that John made a mistake.

(16) If John makes a mistake, **the mistake** is desasterous.

(17) John owns a cat. **It** is overfed.

(18) John is a cat owner. **The cat** is overfed.

(19) ?? John is a cat owner. **It** is overfed.

Presupposition

Consequences for DRT architecture:
Presuppositions have to be

- computed
- justified (i.e. satisfied, accommodated or both)

That suggests a 2-stage processing architecture [van der Sandt,92]. Given a context DRS $K_{1,n}$ for the first n sentences in a discourse we

1. compute a **preliminary DRS** K'_{n+1} for sentence S_{n+1} (in isolation) that makes fully explicit the presuppositional and the non-presuppositional content of S_{n+1}
2. we then justify all presuppositions of DRS K'_{n+1} in the available context (satisfaction or accommodation or both)

If (2) succeeds we merge nonpresuppositional part of K'_{n+1} with $K_{1,n}$ to get updated context $K_{1,n+1}$ for next sentence in discourse.

Presuppositions

Such an architecture is naturally implemented through a bottom-up DRS (or a constraint-based) construction process.

Sources of complexity:

- multiple presuppositions (generated within same sentence)
- nested presuppositions
- interaction with other sources of complexity/ambiguity

⇒ storage mechanisms and UDRSs!

Presuppositions

First some examples of preliminary representations in the pictorial DRS box notation . . .

From sneak preview . . .

(20) A delegate^1 arrived. **She**$_1$ registered.

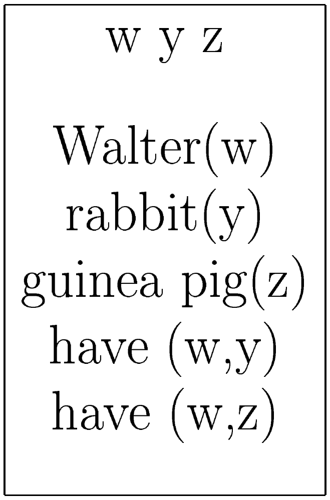
(21)
$$\begin{array}{|c|}\hline \text{x} \\ \\ \text{delegate(x)} \\ \text{arrive(x)} \\ \hline \end{array} \quad \left\langle \left\{ \begin{array}{|c|}\hline \underline{\text{y}} \\ \\ \text{fem(y)} \\ \hline \end{array} \right\}, \begin{array}{|c|}\hline \\ \text{register(y)} \\ \hline \end{array} \right\rangle$$

context DRS preliminary DRS

Presuppositions

(22) Walter has a rabbit and a guinea pig. **The rabbit** is white.

(23)



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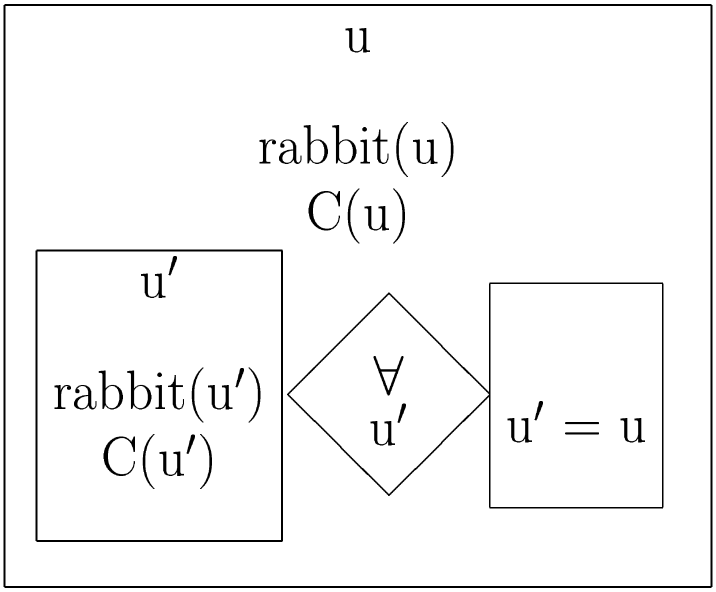


Presuppositions

$$(25)\quad \boxed{\begin{array}{c} \mathrm{u}^{=1} \\ \\ \mathrm{rabbit(u)} \\ \mathrm{C(u)} \end{array}}$$

$$\left\langle \left\{ \left\langle \left\{ \boxed{\begin{array}{c} \underline{\mathrm{C}}\ \mathrm{r} \\ \\ \mathrm{C(r)} \\ \mathrm{rabbit(r)} \end{array}} \right\}, \boxed{\begin{array}{c} \mathrm{u}^{=1} \\ \\ \mathrm{rabbit(u)} \\ \mathrm{C(u)} \end{array}} \right\rangle \right\}, \boxed{\begin{array}{c} \mathrm{v} \\ \\ \mathrm{rabbit(v)} \\ \mathrm{C(v)} \\ \mathrm{white(v)} \end{array}} \right\rangle$$

Aside (justification):

$$\left\langle \left\{ \boxed{\begin{array}{c} \mathrm{u}^{=1} \\ \\ \mathrm{rabbit(u)} \\ \mathrm{u}\in\{\mathrm{w,y,z}\} \end{array}} \right\}, \boxed{\begin{array}{c} \mathrm{v} \\ \\ \mathrm{rabbit(v)} \\ \mathrm{v}\in\{\mathrm{w,y,z}\} \\ \mathrm{white(v)} \end{array}} \right\rangle$$

Presupposition

Aside (justification contnd):

(26)

w y z v

Walter(w)
rabbit(y) ; guinea pig(z) ; rabbit(v)
have (w,y) ; have (w,z)
$v \in \{w,y,z\}$
white(v)

Presupposition

(27) Walter has a rabbit and a guinea pig. **His rabbit** is white.

$$\left\langle \left\{ \left\langle \left\{ \boxed{\begin{array}{c} \underline{\text{x}} \\ \\ \text{male(x)} \\ \text{pers(x)} \end{array}} \right\}, \left\langle \left\{ \boxed{\begin{array}{c} \underline{\text{C}}\ \text{r} \\ \\ \text{C(r)} \\ \text{rabbit(r)} \\ \text{have(x,r)} \end{array}} \right\}, \boxed{\begin{array}{c} \text{u}^{=1} \\ \\ \text{rabbit(u)} \\ \text{C(u)} \\ \text{have(x,u)} \end{array}} \right\rangle \right\rangle \right\}, \boxed{\begin{array}{c} \text{v} \\ \\ \text{rabbit(v)} \\ \text{C(v)} \\ \text{have(x,v)} \\ \text{white(v)} \end{array}} \right\rangle$$

Aside (justification):

$$\boxed{\begin{array}{c} \text{w y z x v} \\ \\ \text{Walter(w)} \\ \text{rabbit(y)} \quad ; \quad \text{guinea pig(z)} \\ \text{have (w,y)} \quad ; \quad \text{have (w,z)} \\ \text{x} = \text{w} \\ \text{rabbit(v)} \\ \\ \text{v} \in \{\text{w,y,z}\} \\ \text{have (x,v)} \\ \text{white(v)} \end{array}}$$

Presupposition

(28) (It is a peculiar fact, but) If Walter has both a rabbit and a guinea pig, **the rabbit** is white.

$$\boxed{\begin{array}{c} w \\ \\ \text{Walter}(w) \\ \boxed{\begin{array}{c} y \quad z \\ \\ \text{rabbit}(y) \quad ; \quad \text{guinea pig}(z) \\ \text{have}(w,y) \quad ; \quad \text{have}(w,z) \\ \end{array}} \Rightarrow K \\ \end{array}}$$

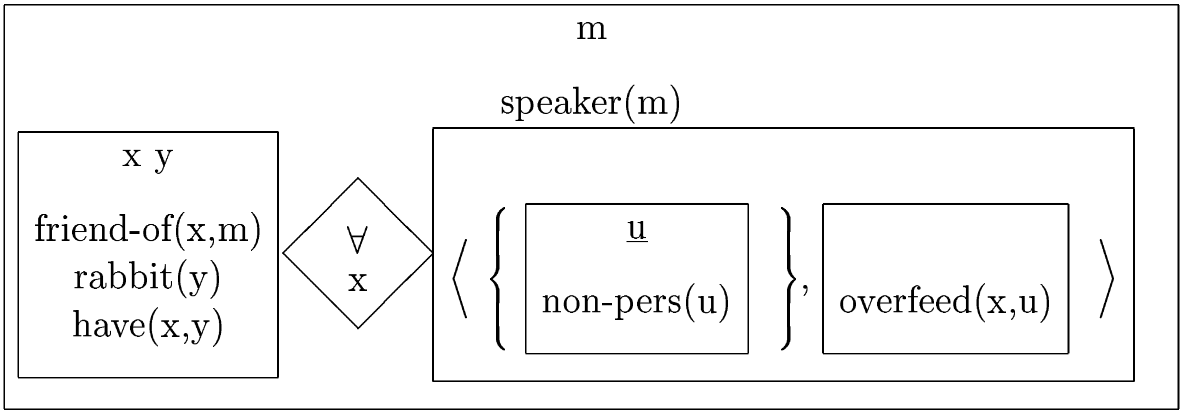
Where K =

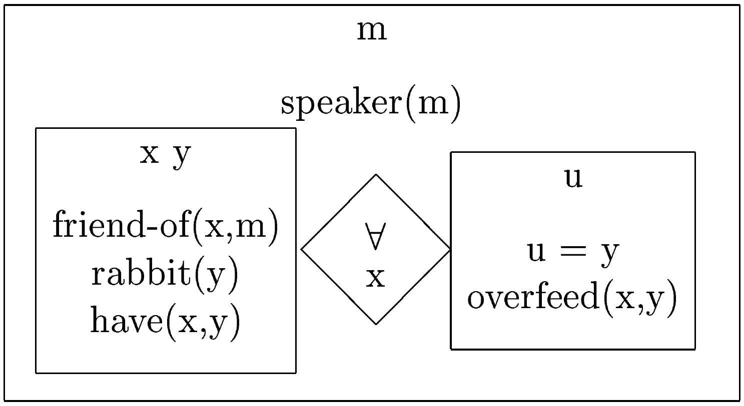
$$\left\langle \left\{ \left\langle \left\{ \boxed{\begin{array}{c} \underline{x} \\ \\ \text{male}(x) \\ \text{pers}(x) \end{array}} \right\}, \left\langle \left\{ \boxed{\begin{array}{c} \underline{C}\ r \\ \\ C(r) \\ \text{rabbit}(r) \\ \text{have}(x,r) \end{array}} \right\}, \boxed{\begin{array}{c} u^{=1} \\ \\ \text{rabbit}(u) \\ C(u) \\ \text{have}(x,u) \end{array}} \right\rangle \right\rangle \right\}, \boxed{\begin{array}{c} v \\ \\ \text{rabbit}(v) \\ C(v) \\ \text{have}(x,v) \\ \text{white}(v) \end{array}} \right\rangle$$

Cf. example 27 previous slide

Presupposition

(29) Every friend of mine who has a rabbit overfeeds **it**.





Presupposition

(30) Bill is **surprised** that **he** is late.

$$\boxed{\begin{array}{c} \text{b} \\ \\ \text{Bill(b)} \\ \left\langle \left\{ \text{K} \right\}, \boxed{\text{be-surpr.(b,}\left\langle \left\{ \boxed{\begin{array}{c} \underline{\text{u}} \\ \\ \text{male(u)} \\ \text{person(u)} \end{array}} \right\}, \boxed{\text{“be-late”(u)}} \right\rangle\text{)}} \right\rangle \end{array}}$$

where K is $\left\langle \left\{ \boxed{\begin{array}{c} \underline{\text{u}'} \\ \\ \text{male(u}'\text{)} \\ \text{person(u}'\text{)} \end{array}} \right\}, \boxed{\text{“be-late”(u}'\text{)}} \right\rangle$

(31) John was late and thats what he told Bill.
Bill isn’t surprised that he was late.

Copying, parallelism (ellipsis)

Presupposition

(32) John made a mistake **again**.

$$\boxed{\begin{array}{c} \text{j} \\ \\ \text{John(j)} \\ \left\langle \left\{ \boxed{\begin{array}{c} \text{t}'\ \text{e}'\ \text{y}' \\ \\ \text{mistake(y}'\text{)} \\ \text{e}'\text{:make(j,y}'\text{)} \\ \text{e}' \subseteq \text{t}' \\ \end{array}} \right\}, \boxed{\begin{array}{c} \text{t e y n} \\ \\ \text{mistake(y)} \\ \text{e:make(j,y)} \\ \text{e} \subseteq \text{t} \\ \text{t} \prec \text{n} \\ \text{t}' \prec \text{t} \\ \end{array}} \right\rangle \end{array}}$$

Presupposition

Presuppositional account of anaphoric properties of tense . . .

(33) Contribution of tense:

$$\begin{array}{ccc} \textit{past} & \textit{pres} & \textit{fut} \\ \boxed{\begin{array}{c} \mathrm{t}_t \\ \\ \mathrm{t}_t \prec \mathrm{n} \\ \\ \end{array}} & \boxed{\begin{array}{c} \mathrm{t}_t \\ \\ \mathrm{t}_t = \mathrm{n} \\ \\ \end{array}} & \boxed{\begin{array}{c} \mathrm{t}_t \\ \\ \mathrm{n} \prec \mathrm{t}_t \\ \\ \end{array}} \end{array}$$

(Preliminary) DRS Construction

- unification based
  - simple, efficient
  - LFG, HPSG, PATR-II …
  - problems: no clean distinction between “unification variables” and “semantic variables”, coordination
  - hacks to get around this in implementations (copying) or complex underlying logic (HPSG)
- lambda calculus based
  - clean
  - bulky …

⇒ simple, generic approach in PATR-II

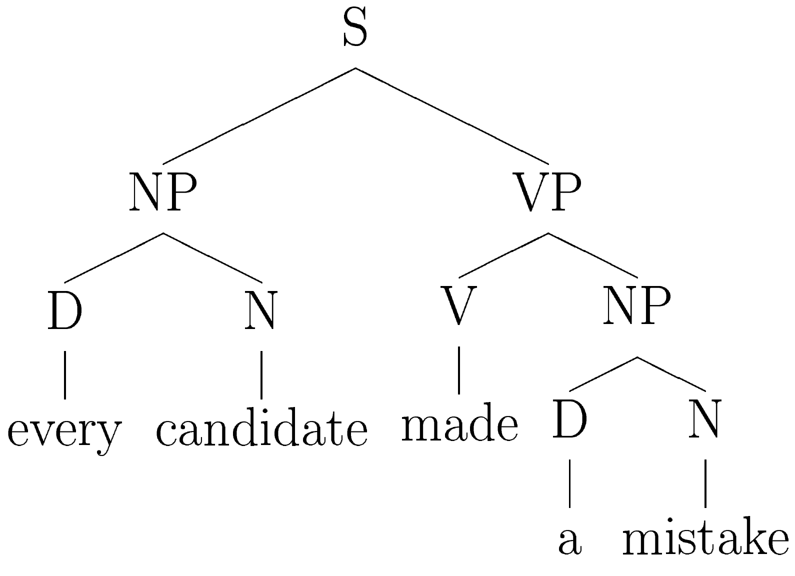
(Preliminary) DRS Construction

- FOPL semantics construction in PATR-II
- UDRS construction in PATR-II
  - UDRT in HPSG [Frank & Reyle,95]
- syntax Preliminary DRSs
  - based on (some basic) DRS language L
  - PR-DRS is DRS of L or pair $\langle \mathcal{K}, \mathrm{K} \rangle$ where $\mathcal{K}$ set of PR-DRSs and K a PR-DRS
  - (preliminary conditions ...)
- P-UDRS (Preliminary UDRS) construction in PATR-II
  - left adjunction of presupposition set to (labelled) content conditions
- construction principles

PATR-II Semantics Construction

(34) Every candidate made a mistake.

- $\forall x(cand(x) \rightarrow \exists y(mis(y) \wedge make(x,y)))$
- $\exists y(mis(y) \wedge \forall x(cand(x) \rightarrow make(x,y)))$



PATR-II Semantics Construction

Need some lexical entries and rules:

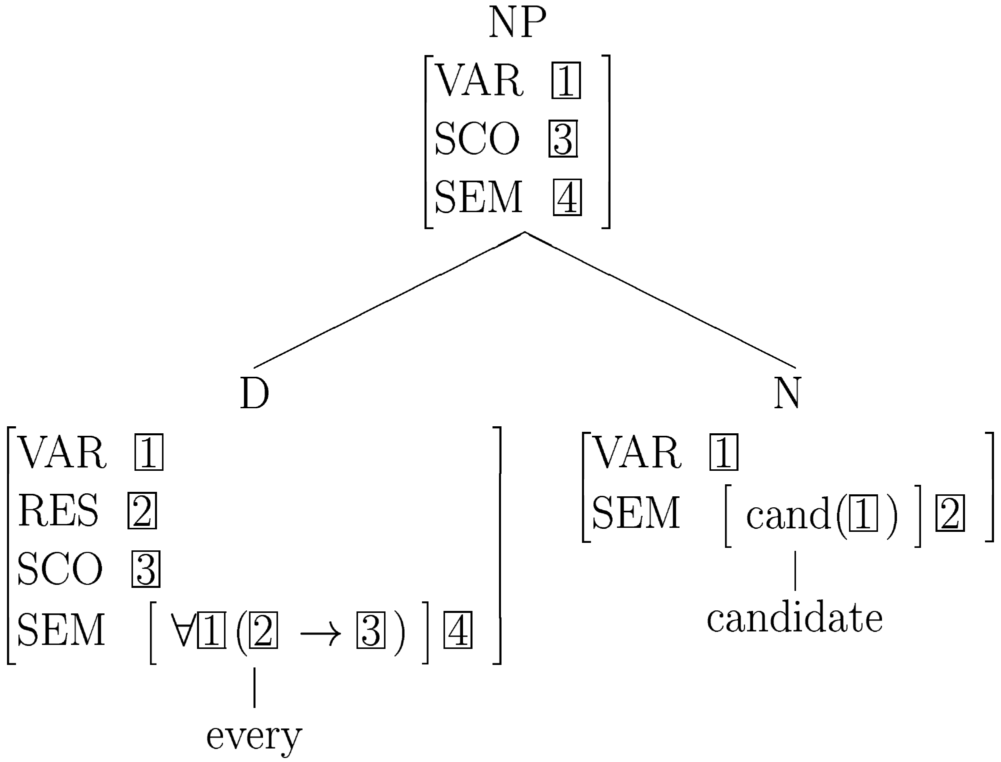
$$\text{N}\begin{bmatrix}\text{VAR} & \boxed{1}\\ \text{SEM} & \text{cand}(\boxed{1})\end{bmatrix} \rightarrow \text{candidate/mistake}$$

$$\text{D}\begin{bmatrix}\text{VAR} & \boxed{1}\\ \text{RES} & \boxed{2}\\ \text{SCO} & \boxed{3}\\ \text{SEM} & \forall\boxed{1}(\boxed{2} \rightarrow \boxed{3})\end{bmatrix} \rightarrow \text{every}$$

$$\text{D}\begin{bmatrix}\text{VAR} & \boxed{1}\\ \text{RES} & \boxed{2}\\ \text{SCO} & \boxed{3}\\ \text{SEM} & \exists\boxed{1}(\boxed{2} \wedge \boxed{3})\end{bmatrix} \rightarrow \text{a}$$

$$\text{NP}\begin{bmatrix}\text{VAR} & \boxed{1}\\ \text{SCO} & \boxed{3}\\ \text{SEM} & \boxed{4}\end{bmatrix} \rightarrow \text{D}\begin{bmatrix}\text{VAR} & \boxed{1}\\ \text{RES} & \boxed{2}\\ \text{SCO} & \boxed{3}\\ \text{SEM} & \boxed{4}\end{bmatrix} \; \text{N}\begin{bmatrix}\text{VAR} & \boxed{1}\\ \text{SEM} & \boxed{2}\end{bmatrix}$$

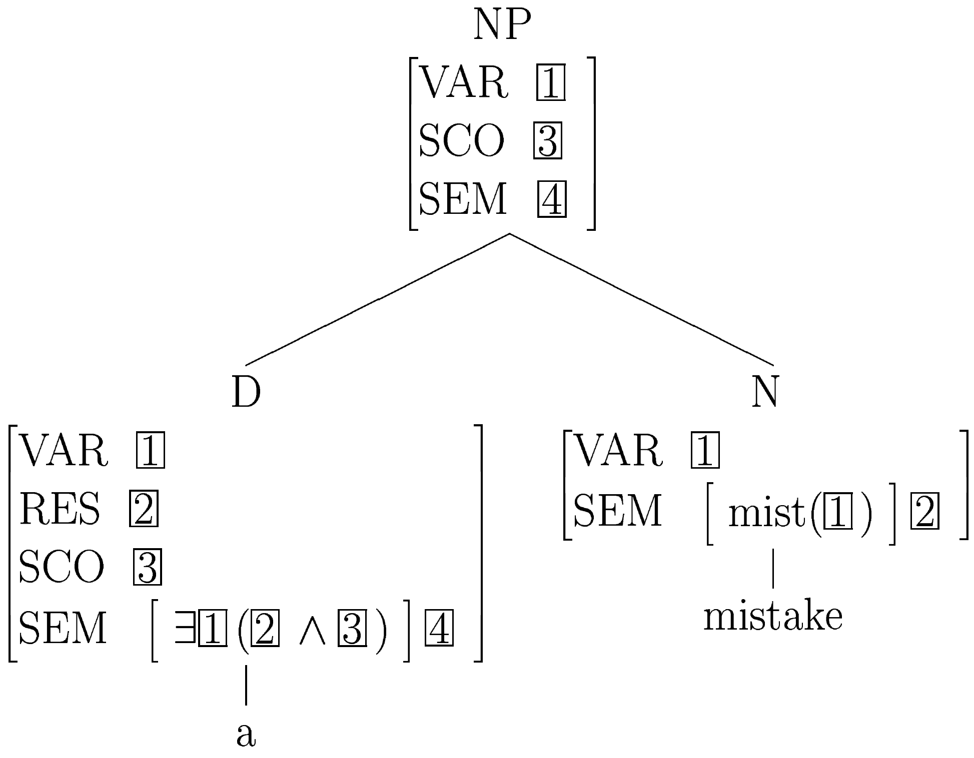
PATR-II Semantics Construction



NP (every candidate)

$$\begin{bmatrix} \text{VAR} & \boxed{1} \\ \text{SCO} & \boxed{3} \\ \text{SEM} & \forall\boxed{1}(\text{cand}(\boxed{1}) \rightarrow \boxed{3}) \end{bmatrix}$$

PATR-II Semantics Construction



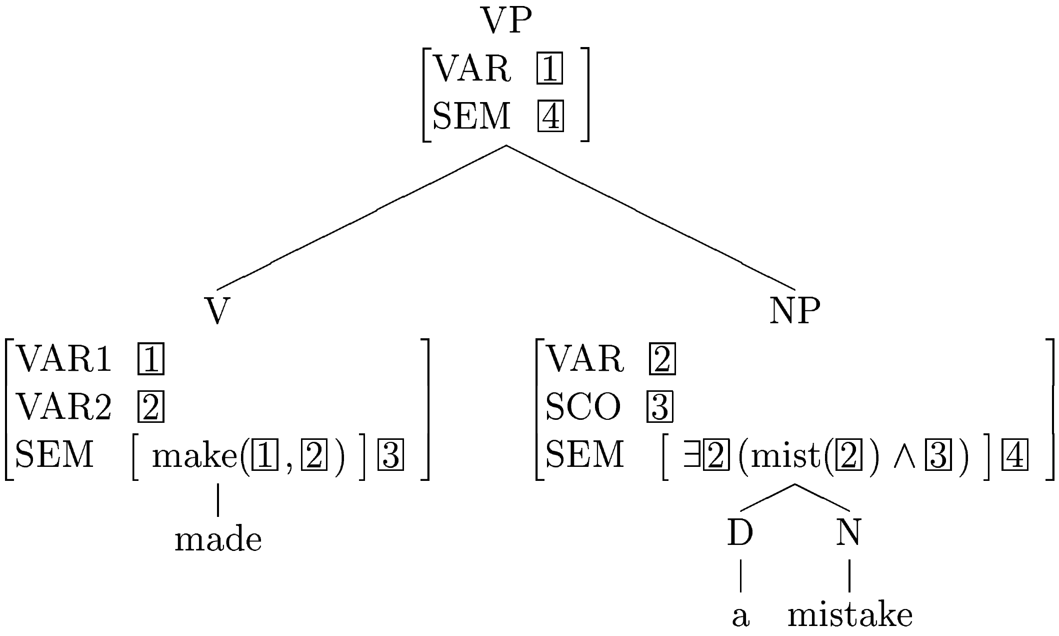
NP (a mistake)

$$\begin{bmatrix} \text{VAR} & \boxed{1} \\ \text{SCO} & \boxed{3} \\ \text{SEM} & \exists\boxed{1}(\text{mist}(\boxed{1}) \wedge \boxed{3}) \end{bmatrix}$$

PATR-II Semantics Construction

$$\mathrm{V}\begin{bmatrix}\mathrm{VAR1} & \boxed{1}\\ \mathrm{VAR2} & \boxed{2}\\ \mathrm{SEM} & \mathrm{make}(\boxed{1},\boxed{2})\end{bmatrix} \rightarrow \mathrm{made}$$

$$\mathrm{VP}\begin{bmatrix}\mathrm{VAR} & \boxed{1}\\ \mathrm{SEM} & \boxed{4}\end{bmatrix} \rightarrow \mathrm{V}\begin{bmatrix}\mathrm{VAR1} & \boxed{1}\\ \mathrm{VAR2} & \boxed{2}\\ \mathrm{SEM} & \boxed{3}\end{bmatrix} \quad \mathrm{NP}\begin{bmatrix}\mathrm{VAR} & \boxed{2}\\ \mathrm{SCO} & \boxed{3}\\ \mathrm{SEM} & \boxed{4}\end{bmatrix}$$

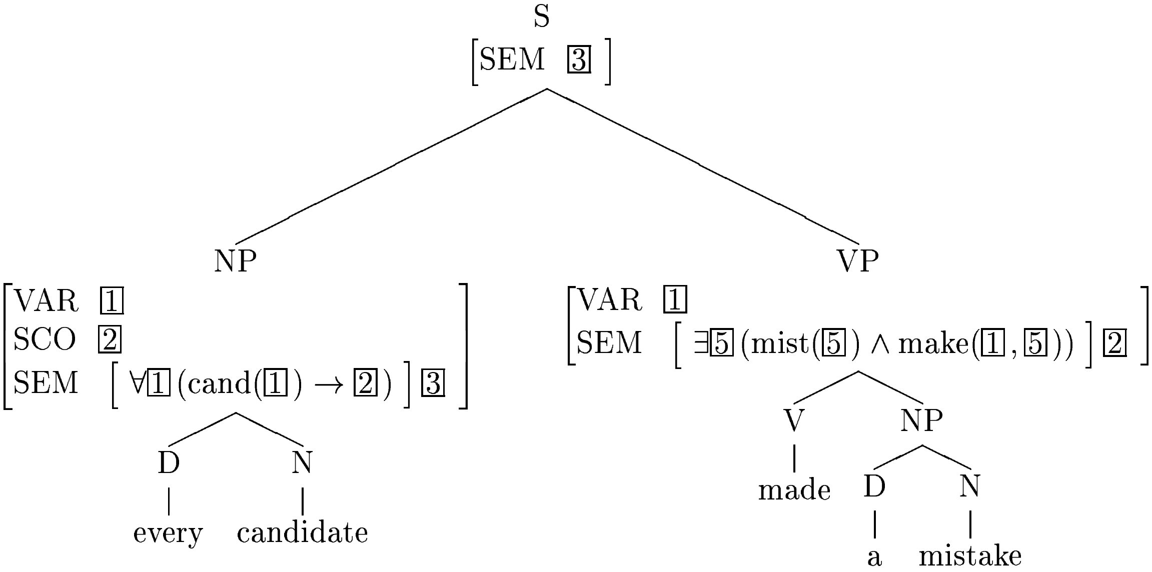


PATR-II Semantics Construction

$$\begin{array}{c}\text{VP (made a mistake)}\\ \begin{bmatrix}\text{VAR} & \boxed{1} \\ \text{SEM} & \exists\boxed{2}\,(\text{mist}(\boxed{2}) \wedge \text{make}(\boxed{1},\boxed{2}))\end{bmatrix}\end{array}$$

PATR-II Semantics Construction

$$\text{S}\left[\text{SEM}\ \ \boxed{3}\right] \rightarrow \text{NP}\begin{bmatrix}\text{VAR} & \boxed{1}\\ \text{SCO} & \boxed{2}\\ \text{SEM} & \boxed{3}\end{bmatrix}\ \ \text{VP}\begin{bmatrix}\text{VAR} & \boxed{1}\\ \text{SEM} & \boxed{2}\end{bmatrix}$$



$$\begin{array}{c}\text{S}\\ \left[\text{SEM}\ \ \forall\boxed{1}\,(\text{cand}(\boxed{1}) \rightarrow \exists\boxed{2}\,(\text{mist}(\boxed{2}) \wedge \text{make}(\boxed{1},\boxed{2})))\right]\end{array}$$

PATR-II Semantics Construction

$$\mathrm{S}\begin{bmatrix}\mathrm{SEM} & \boxed{3}\end{bmatrix} \rightarrow \mathrm{NP}\begin{bmatrix}\mathrm{VAR} & \boxed{1}\\ \mathrm{SCO} & \boxed{2}\\ \mathrm{SEM} & \boxed{3}\end{bmatrix} \quad \mathrm{VP}\begin{bmatrix}\mathrm{VAR} & \boxed{1}\\ \mathrm{SEM} & \boxed{2}\end{bmatrix}$$

$$\mathrm{VP}\begin{bmatrix}\mathrm{VAR} & \boxed{1}\\ \mathrm{SEM} & \boxed{4}\end{bmatrix} \rightarrow \mathrm{V}\begin{bmatrix}\mathrm{VAR1} & \boxed{1}\\ \mathrm{VAR2} & \boxed{2}\\ \mathrm{SEM} & \boxed{3}\end{bmatrix} \quad \mathrm{NP}\begin{bmatrix}\mathrm{VAR} & \boxed{2}\\ \mathrm{SCO} & \boxed{3}\\ \mathrm{SEM} & \boxed{4}\end{bmatrix}$$

$$\mathrm{NP}\begin{bmatrix}\mathrm{VAR} & \boxed{1}\\ \mathrm{SCO} & \boxed{3}\\ \mathrm{SEM} & \boxed{4}\end{bmatrix} \rightarrow \mathrm{D}\begin{bmatrix}\mathrm{VAR} & \boxed{1}\\ \mathrm{RES} & \boxed{2}\\ \mathrm{SCO} & \boxed{3}\\ \mathrm{SEM} & \boxed{4}\end{bmatrix} \quad \mathrm{N}\begin{bmatrix}\mathrm{VAR} & \boxed{1}\\ \mathrm{SEM} & \boxed{2}\end{bmatrix}$$

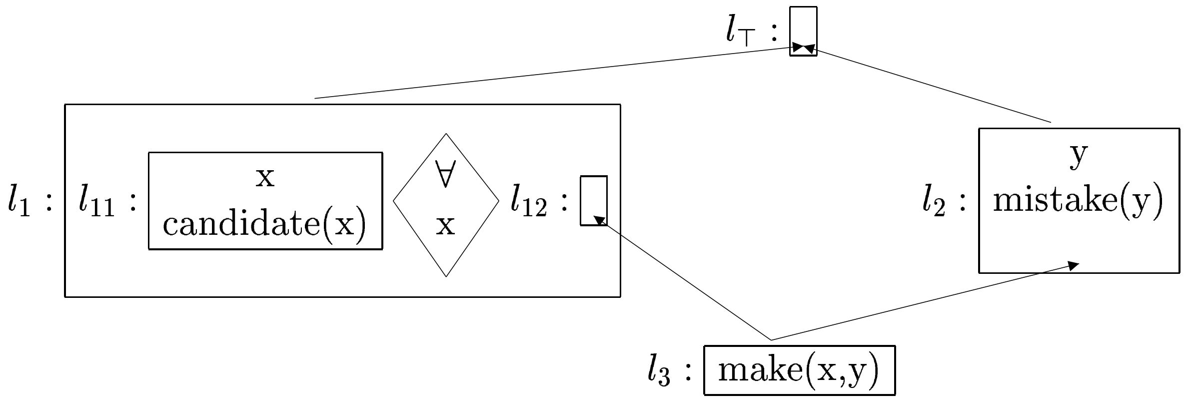
$$\mathrm{N}\begin{bmatrix}\mathrm{VAR} & \boxed{1}\\ \mathrm{SEM} & \mathrm{cand}(\boxed{1})\end{bmatrix} \rightarrow \mathrm{candidate}$$

$$\mathrm{D}\begin{bmatrix}\mathrm{VAR} & \boxed{1}\\ \mathrm{RES} & \boxed{2}\\ \mathrm{SCO} & \boxed{3}\\ \mathrm{SEM} & \forall\boxed{1}(\boxed{2} \rightarrow \boxed{3})\end{bmatrix} \rightarrow \mathrm{every}$$

$$\mathrm{V}\begin{bmatrix}\mathrm{VAR1} & \boxed{1}\\ \mathrm{VAR2} & \boxed{2}\\ \mathrm{SEM} & \mathrm{make}(\boxed{1},\boxed{2})\end{bmatrix} \rightarrow \mathrm{made}$$

PATR-II UDRS Construction

(35) Every candidate made a mistake.



UDRS = ⟨{Structural Constr.}, {Content Constr.}⟩

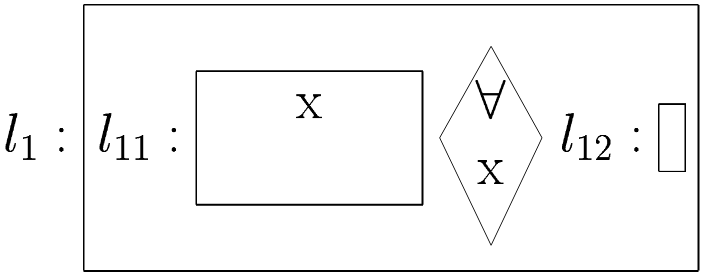
$$\left\langle \begin{array}{c} \{l_1 \leq l_\top, l_2 \leq l_\top, l_3 \leq l_{12}, l_3 \leq l_2\}, \\ \left\{ \begin{array}{c} l_1 : l_{11}\boxed{\forall\ \mathrm{x}}l_{12}, l_{11} : \mathrm{x}, l_{11} : \mathrm{candidate(x)}, \\ l_2 : \mathrm{y}, l_2 : \mathrm{mistake(y)}, l_3 : \mathrm{make(x,y)} \end{array} \right\} \end{array} \right\rangle$$

UDRSs are descriptions of logical forms …

PATR-II UDRS Construction

First some lexical entries …

D → every



$$D \begin{bmatrix} \text{LB} & l_1 \\ \text{RES} & l_{11} \\ \text{SCO} & l_{12} \\ \text{DDR} & \text{x} \\ \text{CC} & \{l_1 : l_{11}\boxed{\forall\ \text{x}}l_{12}, l_{11} : \text{x}\} \\ \text{SC} & \{l_{11} \leq l_1, l_{12} \leq l_{11}\} \end{bmatrix} \rightarrow \text{every}$$

Note that the l_i here are **meta**-variables over label names to aid readability (i.e. each l_i should properly be a tag $\boxed{i}$).

PATR-II UDRS Construction

$$\mathrm{D} \rightarrow \mathrm{a} \qquad l_1\!: \begin{array}{|c|}\hline \mathrm{x} \\ \\ \\ \\ \hline\end{array}$$

$$\mathrm{D} \begin{bmatrix} \mathrm{LB} & l_1 \\ \mathrm{RES} & l_1 \\ \mathrm{SCO} & l_1 \\ \mathrm{DDR} & \mathrm{x} \\ \mathrm{CC} & \{l_1 : \mathrm{x}\} \\ \mathrm{SC} & \emptyset \end{bmatrix} \rightarrow \mathrm{a}$$

$$\mathrm{N} \begin{bmatrix} \mathrm{LB} & l_1 \\ \mathrm{DDR} & \mathrm{x} \\ \mathrm{CC} & \{l_1 : \mathrm{cand(x)}\} \\ \mathrm{SC} & \emptyset \end{bmatrix} \rightarrow \mathrm{candidate}$$

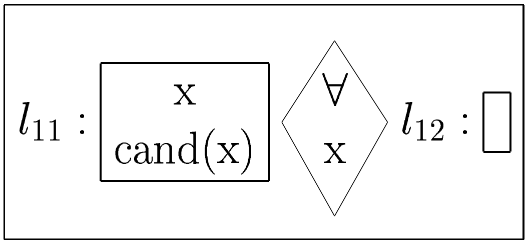
PATR-II UDRS Construction

$$\text{NP}\begin{bmatrix}\text{LB} & \boxed{1}\\ \text{SCO} & \boxed{3}\\ \text{DDR} & \boxed{4}\\ \text{CC} & \boxed{5}\cup\boxed{6}\\ \text{SC} & \boxed{7}\cup\boxed{8}\end{bmatrix} \rightarrow \text{D}\begin{bmatrix}\text{LB} & \boxed{1}\\ \text{RES} & \boxed{2}\\ \text{SCO} & \boxed{3}\\ \text{DDR} & \boxed{4}\\ \text{CC} & \boxed{5}\\ \text{SC} & \boxed{7}\end{bmatrix} \text{N}\begin{bmatrix}\text{LB} & \boxed{2}\\ \text{DDR} & \boxed{4}\\ \text{CC} & \boxed{6}\\ \text{SC} & \boxed{8}\end{bmatrix}$$

$$\text{NP}\begin{bmatrix}\text{LB} & l_1\\ \text{SCO} & l_{12}\\ \text{DDR} & \text{x}\\ \text{CC} & \{l_1 : l_{11}\boxed{\forall\ \text{x}}l_{12}, l_{11} : \text{x}, l_{11} : \text{cand(x)}\}\\ \text{SC} & \{l_{11} \leq l_1, l_{12} \leq l_{11}\}\end{bmatrix}$$

$\rightarrow$ every candidate

NP → every candidate l_1 :



PATR-II UDRS Construction

$$\text{NP}\begin{bmatrix} \text{LB} & l_1 \\ \text{SCO} & l_1 \\ \text{DDR} & \text{x} \\ \text{CC} & \{l_1 : \text{x}, l_1 : \text{mist(x)}\} \\ \text{SC} & \emptyset \end{bmatrix} \rightarrow \text{a mistake}$$

$$\text{NP} \rightarrow \text{a mistake} \qquad l_1\text{:}\boxed{\begin{array}{c} \text{x} \\ \\ \text{mist(x)} \\ \\ \end{array}}$$

PATR-II UDRS Construction

Verbs do a lot of work in this approach …

$$\text{V}\begin{bmatrix}\text{LB} & l_1 \\ \text{CC} & \{l_1 : \text{make}(\boxed{3},\boxed{4})\} \\ \text{SC} & \{l_1 \leq \boxed{1}, l_1 \leq \boxed{2}\} \\ & \\ \text{SUBCAT} & \left\langle \begin{bmatrix}\text{SCO} & \boxed{1} \\ \text{DDR} & \boxed{3}\end{bmatrix}_{\text{S}}, \begin{bmatrix}\text{SCO} & \boxed{2} \\ \text{DDR} & \boxed{4}\end{bmatrix}_{\text{O}} \right\rangle \end{bmatrix}$$

$\rightarrow$ made

$$\text{VP}\begin{bmatrix}\text{CC} & \boxed{1} \cup \boxed{2} \\ \text{SC} & \boxed{3} \cup \boxed{4} \\ \text{SUBCAT} & \langle \boxed{5} \rangle\end{bmatrix} \rightarrow \text{V}\begin{bmatrix}\text{CC} & \boxed{1} \\ \text{SC} & \boxed{3} \\ \text{SUBCAT} & \langle \boxed{5}, \boxed{6} \rangle\end{bmatrix} \text{NP}\begin{bmatrix}\text{CC} & \boxed{2} \\ \text{SC} & \boxed{4}\end{bmatrix}\boxed{6}$$

PATR-II UDRS Construction

$$\mathrm{VP}\left[\begin{array}{ll}
\mathrm{CC} & \{l_2 : \mathrm{y}, l_2 : \mathrm{mist(y)}, l_3 : \mathrm{make}(\boxed{6},\mathrm{y})\} \\
\mathrm{SC} & \{l_3 \leq \boxed{5}, l_3 \leq l_2\} \\
 & \\
\mathrm{SUBCAT} & \left\langle \left[\begin{array}{ll} \mathrm{SCO} & \boxed{5} \\ \mathrm{DDR} & \boxed{6} \end{array}\right]_{\mathrm{S}} \right\rangle
\end{array}\right]$$

→ made a mistake

$$\mathrm{S}\left[\begin{array}{ll} \mathrm{CC} & \boxed{1} \cup \boxed{2} \\ \mathrm{SC} & \boxed{3} \cup \boxed{4} \end{array}\right] \rightarrow \mathrm{NP}\left[\begin{array}{ll} \mathrm{CC} & \boxed{1} \\ \mathrm{SC} & \boxed{3} \end{array}\right]\boxed{5} \quad \mathrm{VP}\left[\begin{array}{ll} \mathrm{CC} & \boxed{2} \\ \mathrm{SC} & \boxed{4} \\ \mathrm{SUBCAT} & \langle \boxed{5} \rangle \end{array}\right]$$

PATR-II UDRS Construction

$$\text{S}\begin{bmatrix}\text{CC} & \left\{\begin{matrix} l_1 : l_{11}\boxed{\forall\ \text{x}}l_{12}, l_{11} : \text{x}, l_{11} : \text{cand(x)}, \\ l_2 : \text{y}, l_2 : \text{mist(y)}, l_3 : \text{make(x,y)} \end{matrix}\right\} \\ \text{SC} & \{l_{11} \leq l_1, l_{12} \leq l_{11}, l_3 \leq l_{12}, l_3 \leq l_2\} \end{bmatrix}$$

→ every candidate made a mistake

$$\text{UDRS} = \langle\{\text{Structural Constr.}\}, \{\text{Content Constr.}\}\rangle$$

$$\left\langle \begin{matrix} \{l_1 \leq l_\top, l_2 \leq l_\top, l_3 \leq l_{12}, l_3 \leq l_2\}, \\ \left\{\begin{matrix} l_1 : l_{11}\boxed{\forall\ \text{x}}l_{12}, l_{11} : \text{x}, l_{11} : \text{candidate(x)}, \\ l_2 : \text{y}, l_2 : \text{mistake(y)}, l_3 : \text{make(x,y)} \end{matrix}\right\} \end{matrix} \right\rangle$$

Spot the difference: a UDRS is an upper semi-lattice . . . use max projection of verb . . .

PATR-II UDRS Construction

$$\text{S}\begin{bmatrix}\text{CC} & \boxed{1}\cup\boxed{2}\\ \text{SC} & \boxed{3}\cup\boxed{4}\end{bmatrix} \rightarrow \text{NP}\begin{bmatrix}\text{CC} & \boxed{1}\\ \text{SC} & \boxed{3}\end{bmatrix}\boxed{5} \quad \text{VP}\begin{bmatrix}\text{CC} & \boxed{2}\\ \text{SC} & \boxed{4}\\ \text{SUBCAT} & \langle\boxed{5}\rangle\end{bmatrix}$$

$$\text{VP}\begin{bmatrix}\text{CC} & \boxed{1}\cup\boxed{2}\\ \text{SC} & \boxed{3}\cup\boxed{4}\\ \text{SUBCAT} & \langle\boxed{5}\rangle\end{bmatrix} \rightarrow \text{V}\begin{bmatrix}\text{CC} & \boxed{1}\\ \text{SC} & \boxed{3}\\ \text{SUBCAT} & \langle\boxed{5},\boxed{6}\rangle\end{bmatrix} \quad \text{NP}\begin{bmatrix}\text{CC} & \boxed{2}\\ \text{SC} & \boxed{4}\end{bmatrix}\boxed{6}$$

$$\text{NP}\begin{bmatrix}\text{LB} & \boxed{1}\\ \text{SCO} & \boxed{3}\\ \text{DDR} & \boxed{4}\\ \text{CC} & \boxed{5}\cup\boxed{6}\\ \text{SC} & \boxed{7}\cup\boxed{8}\end{bmatrix} \rightarrow \text{D}\begin{bmatrix}\text{LB} & \boxed{1}\\ \text{RES} & \boxed{2}\\ \text{SCO} & \boxed{3}\\ \text{DDR} & \boxed{4}\\ \text{CC} & \boxed{5}\\ \text{SC} & \boxed{7}\end{bmatrix} \quad \text{N}\begin{bmatrix}\text{LB} & \boxed{2}\\ \text{DDR} & \boxed{4}\\ \text{CC} & \boxed{6}\\ \text{SC} & \boxed{8}\end{bmatrix}$$

$$\text{D}\begin{bmatrix}\text{LB} & l_1\\ \text{RES} & l_{11}\\ \text{SCO} & l_{12}\\ \text{DDR} & \text{x}\\ \text{CC} & \{l_1 : l_{11}\boxed{\forall\ \text{x}}l_{12}, l_{11} : \text{x}\}\\ \text{SC} & \{l_{11}\leq l_1, l_{12}\leq l_{11}\}\end{bmatrix} \rightarrow \text{every} \quad \text{N}\begin{bmatrix}\text{LB} & l_1\\ \text{DDR} & \text{x}\\ \text{CC} & \{l_1 : \text{cand(x)}\}\\ \text{SC} & \emptyset\end{bmatrix} \rightarrow \text{candidate}$$

$$\text{V}\begin{bmatrix}\text{LB} & l_1\\ \text{CC} & \{l_1 : \text{make}(\boxed{3},\boxed{4})\}\\ \text{SC} & \{l_1\leq\boxed{1}, l_1\leq\boxed{2}\}\\ & \\ \text{SUBCAT} & \left\langle\begin{bmatrix}\text{SCO} & \boxed{1}\\ \text{DDR} & \boxed{3}\end{bmatrix}_{\text{S}}, \begin{bmatrix}\text{SCO} & \boxed{2}\\ \text{DDR} & \boxed{4}\end{bmatrix}_{\text{O}}\right\rangle\end{bmatrix} \rightarrow \text{made}$$

PATR-II P-UDRS Construction

Presuppositions in UDRT - Preliminary UDRS (P-UDRS) construction based on previous UDRS construction.

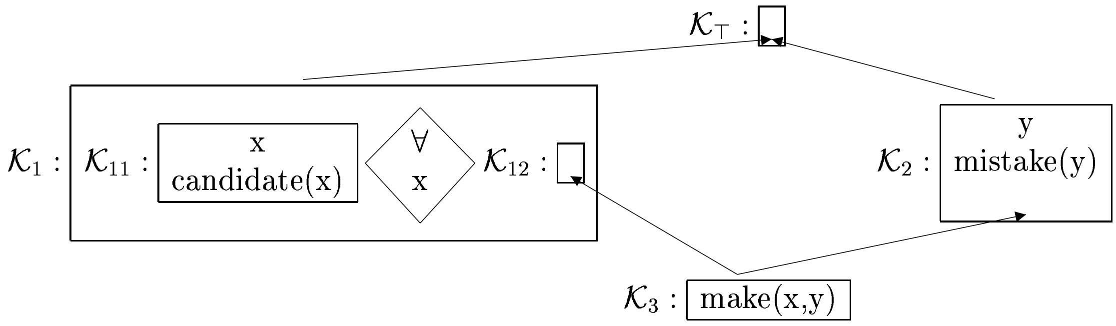
Recall what preliminary DRSs looked like:

- NP → John $\left\langle \left\{ \begin{array}{|c|} \hline \text{x} \\ \text{John(x)} \\ \hline \end{array} \right\}, \begin{array}{|c|} \hline \\ \\ \hline \end{array} \right\rangle$
- NP → the cat $\left\langle \left\{ \begin{array}{|c|} \hline \text{u}^{=1} \\ \text{cat(u)} \\ \hline \end{array} \right\}, \begin{array}{|c|} \hline \text{x} \\ \text{cat(x)} \\ \hline \end{array} \right\rangle$
- . . .

PATR-II P-UDRS Construction

- syntax Preliminary DRSs
  - based on (some basic) DRS language L
  - P-DRS is DRS of L or pair $\langle \mathcal{K}, \mathrm{K} \rangle$ where $\mathcal{K}$ set of P-DRSs and K a P-DRS
  - (preliminary conditions . . .)
- P-UDRS (Preliminary UDRS) construction in PATR-II
  - left adjunction of presupposition set to (labelled) content conditions and sub-DRSs of such conditions
- construction principles

PATR-II P-UDRS Construction



Add set valued PR (presuppostion) feature to representation:

$$\begin{bmatrix} \ldots & \\ \mathrm{CC} & \{\ldots\} \\ \mathrm{SC} & \{\ldots\} \\ \mathrm{PR} & \{\ldots\} \end{bmatrix}$$

Some definite NP examples …

PATR-II P-UDRS Construction

Proper names go into the “top level” DRS universe.

Use designated label $l^\top$.

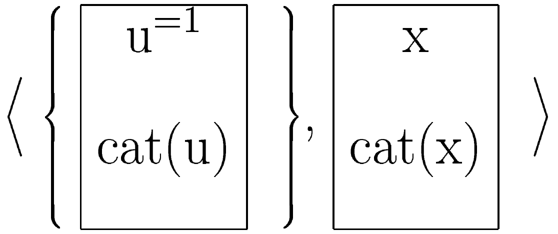
$$\mathrm{NP} \rightarrow \mathrm{John} \left\langle \left\{ \boxed{\begin{array}{c} \mathrm{x} \\ \\ \mathrm{John(x)} \end{array}} \right\}, \boxed{\begin{array}{c} \\ \\ \end{array}} \right\rangle$$

$$\mathrm{NP} \begin{bmatrix} \mathrm{LB} & l^\top \\ \mathrm{SCO} & l^\top \\ \mathrm{DDR} & \mathrm{x} \\ \mathrm{CC} & \emptyset \\ \mathrm{SC} & \emptyset \\ \mathrm{PR} & \left\{ \begin{bmatrix} \mathrm{LB} & l^\top \\ \mathrm{SCO} & l^\top \\ \mathrm{DDR} & \mathrm{x} \\ \mathrm{CC} & \{l^\top : \mathrm{x}, l^\top : \mathrm{John(x)}\} \\ \mathrm{SC} & \emptyset \end{bmatrix} \right\} \end{bmatrix} \rightarrow \mathrm{John}$$

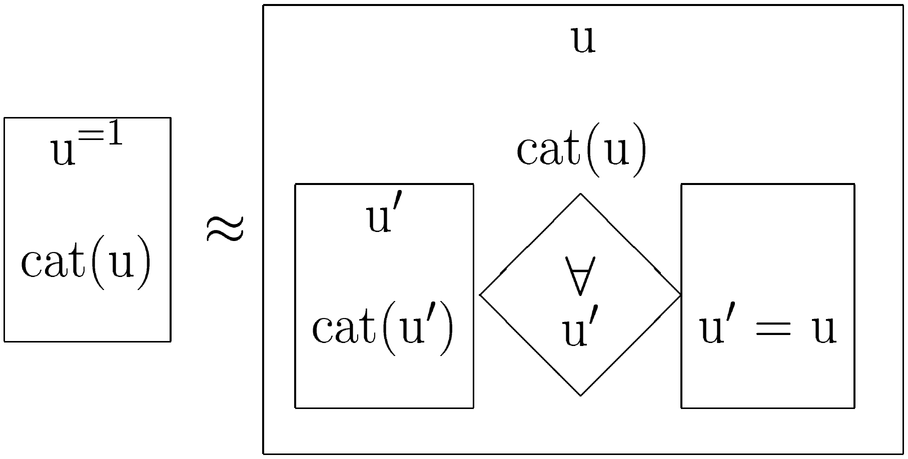
PATR-II P-UDRS Construction

Definite descriptions: existential and uniqueness presuppositions:

NP → the cat



Abbreviation:



PATR-II P-UDRS Construction

How do we implement this? We'll make the determiner (the) do the work . . . :

$$
\mathrm{D}\left[\begin{array}{ll}
\mathrm{LB} & \boxed{1} \\
\mathrm{RES} & \boxed{1} \\
\mathrm{SCO} & \boxed{1} \\
\mathrm{DDR} & \boxed{2} \\
\mathrm{CC} & \{\boxed{1} : \boxed{2}\} \cup \boxed{3} \\
\mathrm{SC} & \boxed{4} \\
\mathrm{PR} & \left\{\left[\begin{array}{ll}
\mathrm{LB} & \boxed{1} \\
\mathrm{SCO} & \boxed{1} \\
\mathrm{DDR} & \boxed{2} \\
\mathrm{CC} & \{\boxed{1} : \boxed{2}^{=1}\} \cup \boxed{3} \\
\mathrm{SC} & \boxed{4}
\end{array}\right]\right\} \\
\mathrm{SUBCAT} & \left\langle \left[\begin{array}{ll}
\mathrm{LB} & \boxed{1} \\
\mathrm{DDR} & \boxed{2} \\
\mathrm{CC} & \boxed{3} \\
\mathrm{SC} & \boxed{4}
\end{array}\right]_{\mathrm{N}} \right\rangle
\end{array}\right] \rightarrow \text{the}
$$

by subcategorising for the noun argument.

PATR-II P-UDRS Construction

$$\mathrm{NP}\begin{bmatrix}\mathrm{LB} & \boxed{1}\\ \mathrm{SCO} & \boxed{2}\\ \mathrm{DDR} & \boxed{3}\\ \mathrm{CC} & \boxed{4}\\ \mathrm{SC} & \boxed{5}\\ \mathrm{PR} & \boxed{7}\end{bmatrix} \rightarrow \mathrm{D}\begin{bmatrix}\mathrm{LB} & \boxed{1}\\ \mathrm{SCO} & \boxed{2}\\ \mathrm{DDR} & \boxed{3}\\ \mathrm{CC} & \boxed{4}\\ \mathrm{SC} & \boxed{5}\\ \mathrm{PR} & \boxed{6}\\ \mathrm{SUBCAT} & \langle\boxed{8}\rangle\end{bmatrix} \mathrm{N}\begin{bmatrix}\ \end{bmatrix}\boxed{8}$$

and $\texttt{copy(}\boxed{6}\texttt{,}\boxed{7}\texttt{)}$ to get an instance of PR with fresh variables …outside pure unification!!

$$\mathrm{NP}\begin{bmatrix}\mathrm{LB} & \boxed{1}\\ \mathrm{SCO} & \boxed{1}\\ \mathrm{DDR} & \boxed{2}\\ \mathrm{CC} & \{\boxed{1} : \boxed{2}, \boxed{1} : \mathrm{cat}(\boxed{2})\}\\ \mathrm{SC} & \boxed{4}\\ \mathrm{PR} & \left\{\begin{bmatrix}\mathrm{LB} & \boxed{5}\\ \mathrm{SCO} & \boxed{5}\\ \mathrm{DDR} & \boxed{6}\\ \mathrm{CC} & \{\boxed{5} : \boxed{6}^{=1}, \boxed{5} : \mathrm{cat}(\boxed{6})\}\\ \mathrm{SC} & \emptyset\end{bmatrix}\right\}\end{bmatrix} \rightarrow \text{the cat}$$

PATR-II P-UDRS Construction

(36) **his rabbit**

$$\left\langle \left\{ \left\langle \left\{ \boxed{\begin{array}{c}\underline{\mathrm{x}}\\ \\ \mathrm{male(x)}\\ \mathrm{pers(x)}\end{array}} \right\}, \left\langle \left\{ \boxed{\begin{array}{c}\underline{\mathrm{C}}\ \mathrm{r}\\ \\ \mathrm{C(r)}\\ \mathrm{rabbit(r)}\\ \mathrm{have(x,r)}\end{array}} \right\}, \boxed{\begin{array}{c}\mathrm{u}^{=1}\\ \\ \mathrm{rabbit(u)}\\ \mathrm{C(u)}\\ \mathrm{have(x,u)}\end{array}} \right\rangle \right\rangle \right\}, \boxed{\begin{array}{c}\mathrm{v}\\ \\ \mathrm{rabbit(v)}\\ \mathrm{C(v)}\\ \mathrm{have(x,v)}\end{array}} \right\rangle$$

simplified:

$$\left\langle \left\{ \left\langle \left\{ \boxed{\begin{array}{c}\underline{\mathrm{x}}\\ \\ \mathrm{male(x)}\\ \mathrm{pers(x)}\end{array}} \right\}, \boxed{\begin{array}{c}\mathrm{u}^{=1}\\ \\ \mathrm{rabbit(u)}\\ \mathrm{have(x,u)}\end{array}} \right\rangle \right\}, \boxed{\begin{array}{c}\mathrm{v}\\ \\ \mathrm{rabbit(v)}\\ \mathrm{have(x,v)}\end{array}} \right\rangle$$

PATR-II P-UDRS Construction

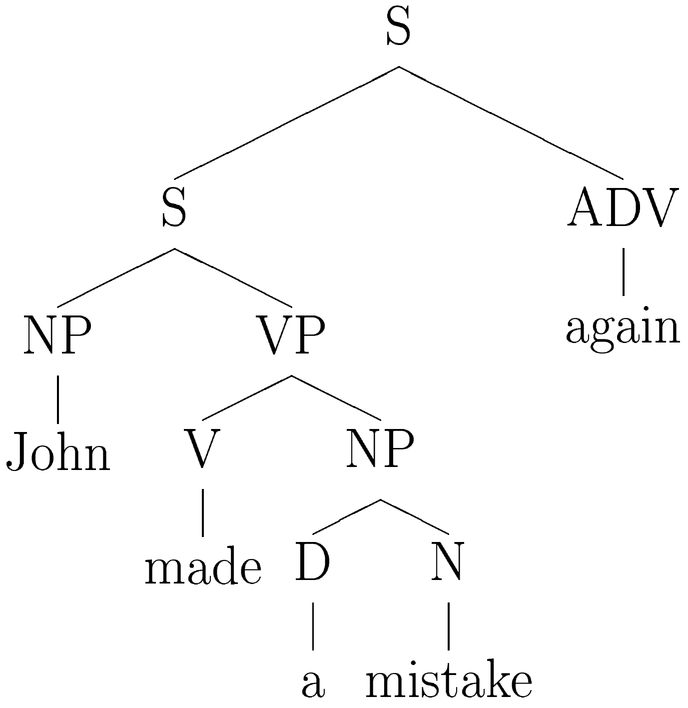
$$
\mathrm{D}\left[\begin{array}{ll}
\mathrm{LB} & \boxed{1} \\
\mathrm{RES} & \boxed{1} \\
\mathrm{SCO} & \boxed{1} \\
\mathrm{DDR} & \boxed{2} \\
\mathrm{CC} & \{\boxed{1} : \boxed{2}, \mathrm{have}(\boxed{6}, \boxed{2})\} \cup \boxed{3} \\
\mathrm{SC} & \boxed{4} \\
\mathrm{PR} & \left\{\left[\begin{array}{ll}
\mathrm{LB} & \boxed{1} \\
\mathrm{SCO} & \boxed{1} \\
\mathrm{DDR} & \boxed{2} \\
\mathrm{CC} & \{\boxed{1} : \boxed{2}^{=1}, \mathrm{have}(\boxed{6}, \boxed{2})\} \cup \boxed{3} \\
\mathrm{SC} & \boxed{4} \\
\mathrm{PR} & \left\{\left[\begin{array}{ll}
\mathrm{LB} & \boxed{7} \\
\mathrm{DDR} & \boxed{6} \\
\mathrm{CC} & \{\boxed{7} : \boxed{6}, \boxed{7} : \mathrm{male}(\boxed{6}), \boxed{7} : \mathrm{pers}(\boxed{6})\}
\end{array}\right]\right\}
\end{array}\right]\right\} \\
\mathrm{SUBCAT} & \left\langle \left[\begin{array}{ll}
\mathrm{LB} & \boxed{1} \\
\mathrm{DDR} & \boxed{2} \\
\mathrm{CC} & \boxed{3} \\
\mathrm{SC} & \boxed{4}
\end{array}\right]_{\mathrm{N}} \right\rangle
\end{array}\right]
$$

→ his

modulo copying!

PATR-II P-UDRS Construction

(37) John made a mistake again.



PATR-II P-UDRS Construction

$$\boxed{\begin{array}{c} \mathrm{j} \\ \\ \mathrm{John(j)} \\ \left\langle \left\{ \boxed{\begin{array}{c} \mathrm{t}' \; \mathrm{e}' \; \mathrm{y}' \\ \\ \mathrm{mistake(y')} \\ \mathrm{e}'\mathrm{:make(j,y')} \\ \mathrm{e}' \subseteq \mathrm{t}' \end{array}} \right\}, \boxed{\begin{array}{c} \mathrm{t\ e\ y\ n} \\ \\ \mathrm{mistake(y)} \\ \mathrm{e:make(j,y)} \\ \mathrm{e} \subseteq \mathrm{t} \\ \mathrm{t} \prec \mathrm{n} \\ \mathrm{t}' \prec \mathrm{t} \end{array}} \right\rangle \end{array}}$$

Implementation (alternative)

P. Blackburn and J.Bos, Representation and Inference for Natural Language, draft at
`http://comsem.org`

P. Blackburn and J.Bos, Working with Discourse Representation Theory, draft at
`http://comsem.org`

DORIS system
`http://www.coli.uni-sb.de/~bos/doris/`

Frank, A. and Reyle, U., Principle Based Semantics for HPSG, Proceedings of the 7th Conference of the EACL, March 27-31, Dublin, 1995, 9–16