A Speaker's Stance Semantics of Discourse

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Plan

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A discourse

Currently, insurers can increase premiums by (levying surcharges if they determine (a driver)$_{\Downarrow_{x}}$ *is more than 50 percent to blame for a collision)*$_{\Downarrow_{e}}$*. (Such penalties)*$_{\Downarrow_{p}}$ $(e \in p)$ *often cost* $0_{\Uparrow_{x}}$ *hundreds of dollars annually for up to six years. (About half of (the 50,000 cases disputed each year)*$_{\Downarrow_{c}}$ $(c \sim p)$*)*$_{\Downarrow_{c_h}}$ $\mathbf{part}^{\sim}_{0.5}(c_h, c)$ *are overturned by the appeals board. (Those drivers)*$_{\Downarrow_{d}}$ $\mathbf{of-concern}(d, c_h)$ *are issued refunds.* [The Boston Globe, March 2, 2009]

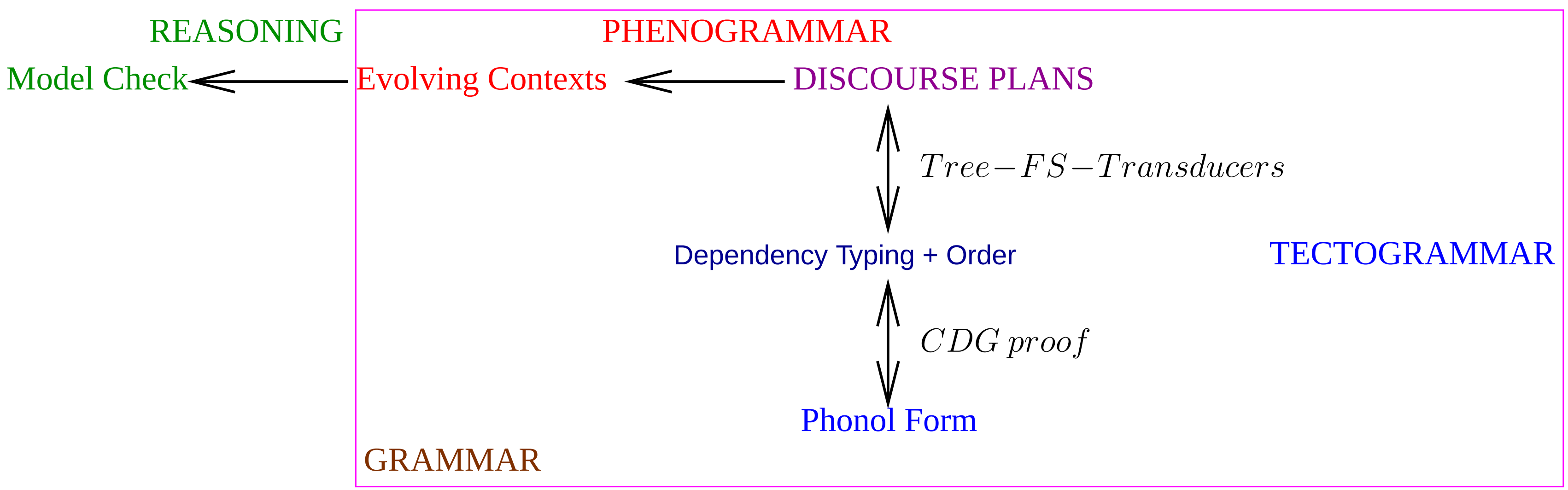
Where does this tagging come from?

It represents elements of speaker's plan of the discourse: a semantic representation of the discourse from the speaker's stance.

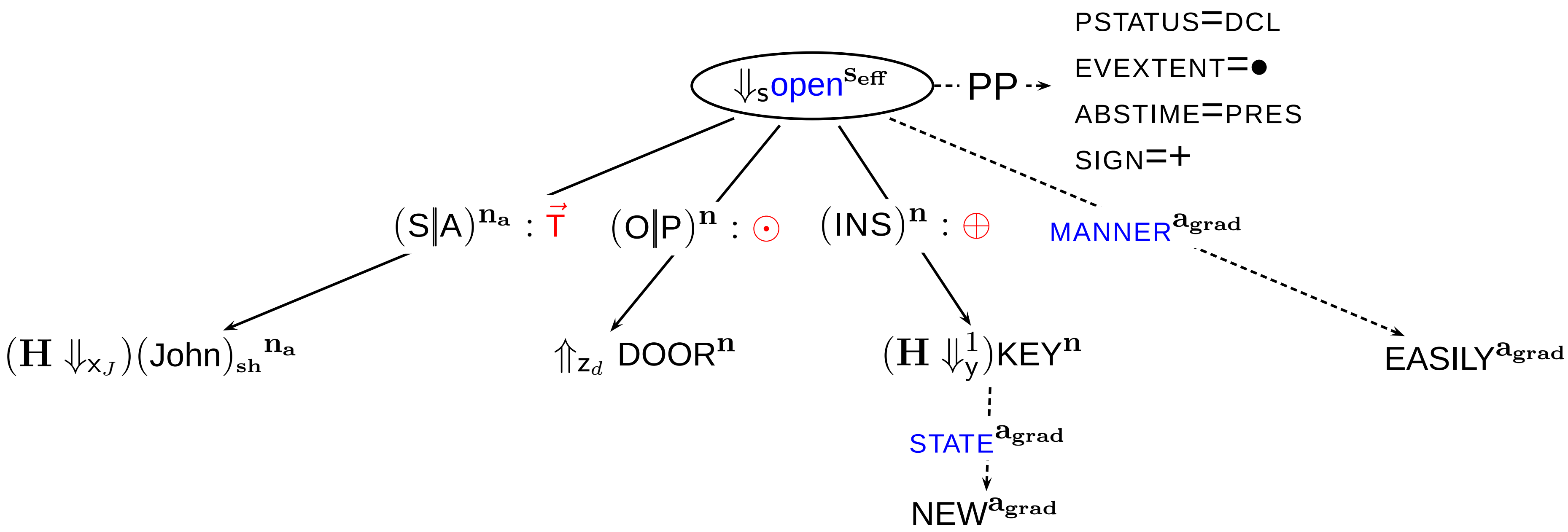
Grammar Architecture

From the speaker's stance :

- the reference is given,
- the facts are postulated,
- to express means:
  - to transform the Discourse Plan into a relational structure (a context) suited for consistency checking,
  - to translate the Discourse Plan into a sequence of syntactic types suited for grammaticality proofs.



DP: Feature tree representation



DP of *John easily opened the door with the new key*

Semantemes are typed:

Primitive types: $\mathbf{n}$ (nominal), $\mathbf{a_{grad}}$ (gradable attributor), $\mathbf{s_{eff}}$ (sentential of effect)

Composite (verbal) types: $((\text{S}\|\text{A})^{\mathbf{n_a}}(\text{O}\|\text{P})^{\mathbf{n}}(\text{INS})^{\mathbf{n}};\ \text{MANNER}^{\mathbf{a_{grad}}} \rightarrow \mathbf{s_{eff}})$ is the type of open.

Sorts: roles of core arguments: S‖A, O‖P, INS,... attributes of circumstantials: STATE, MANNER

When multiple, verbal types are diatheses (one of them is canonical, others are derivative)

PP-attributes: PSTATUS (e.g. DCL: *declarative*), EVEXTENT $\sim$ *aspect* (e.g., ●: *punctual*, (_): *continuous interval*), ABSTIME, RELTIME, etc.

Communicative ranks: $\vec{\text{T}}$: *topic*, ⊙: *focus*, ⊕: *background* assigned to core arguments

Determiners:

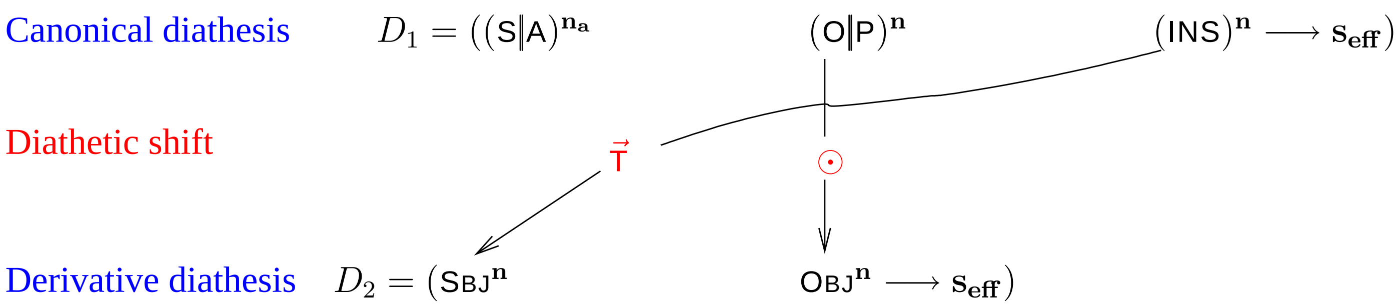
$(\mathbf{H} \Downarrow_{\text{x}}^{k})$ (holistic), $(\mathbf{I} \Downarrow_{\text{x}}^{k} u)$ (individual), $\Uparrow_{\text{x}}$ (objet x); x, y: global, u local references

DP: Verbal Diatheses

open has non-canonical diatheses, e.g.

INS-alternation: $D_{ialt} = (\text{SBJ}^{\mathbf{n}}\text{OBJ}^{\mathbf{n}}; \text{MANNER}^{\mathbf{a_{grad}}} \longrightarrow \mathbf{s_{eff}}),$

derived from the canonical diathesis $((\text{S}\|\text{A})^{\mathbf{n_a}}(\text{O}\|\text{P})^{\mathbf{n}}(\text{INS})^{\mathbf{n}}; \text{MANNER}^{\mathbf{a_{grad}}} \longrightarrow \mathbf{s_{eff}})$ through the diathetic shift of INS-alternation:



To this diathetic shift corresponds:

Argument shift: $\mathbf{d}_{ialt} = \{3 \rightarrow 1, 2 \rightarrow 2\}$ (a bijection from $\{2, 3\}$ to $\{1, 2, 3\}$)

Derivative: $\text{open}[\mathbf{d}_{ialt}]^{(\text{SBJ}^{\mathbf{n}}\text{OBJ}^{\mathbf{n}};\text{MANNER}^{\mathbf{a_{grad}}}\rightarrow\mathbf{s_{eff}})}$

Rank assignments specify argument shifts and, eventually, surface features:

$\vec{\text{T}}$: 1st core arg, $\odot$: 2d core arg, $\oplus$: 3d core arg, $\ominus$: elided arg

Diathetic shifts as Role/Rank assignments:

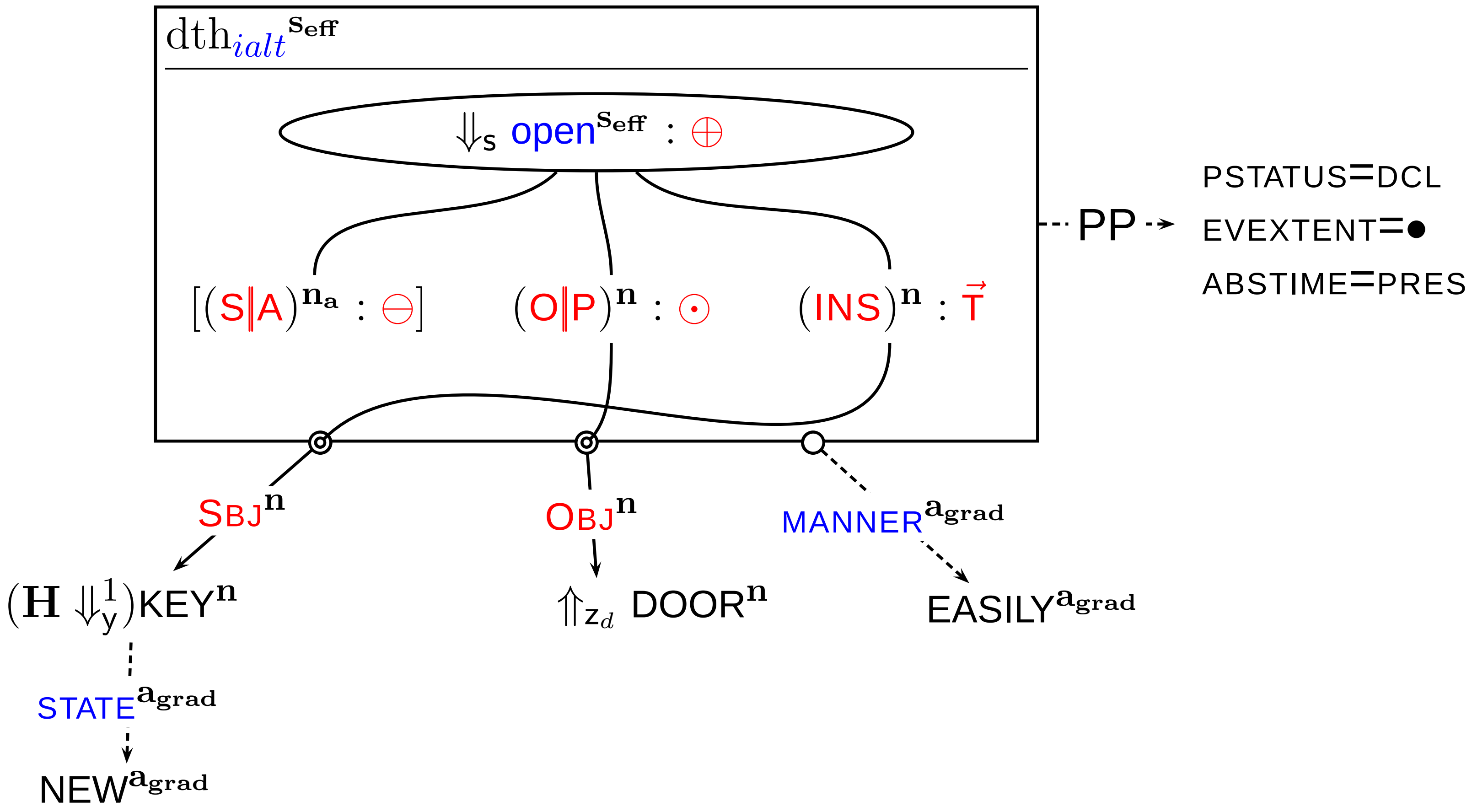
$$(\emptyset \longleftrightarrow (\text{S}\|\text{A})_{\ominus}, \text{SBJ} \longleftrightarrow (\text{INS})_{\vec{\text{T}}}, \text{OBJ} \longleftrightarrow (\text{O}\|\text{P})_{\odot})^{\mathbf{s_{eff}}}$$

DP: Diathetic shifts

EX: *The new key easily opened the door*

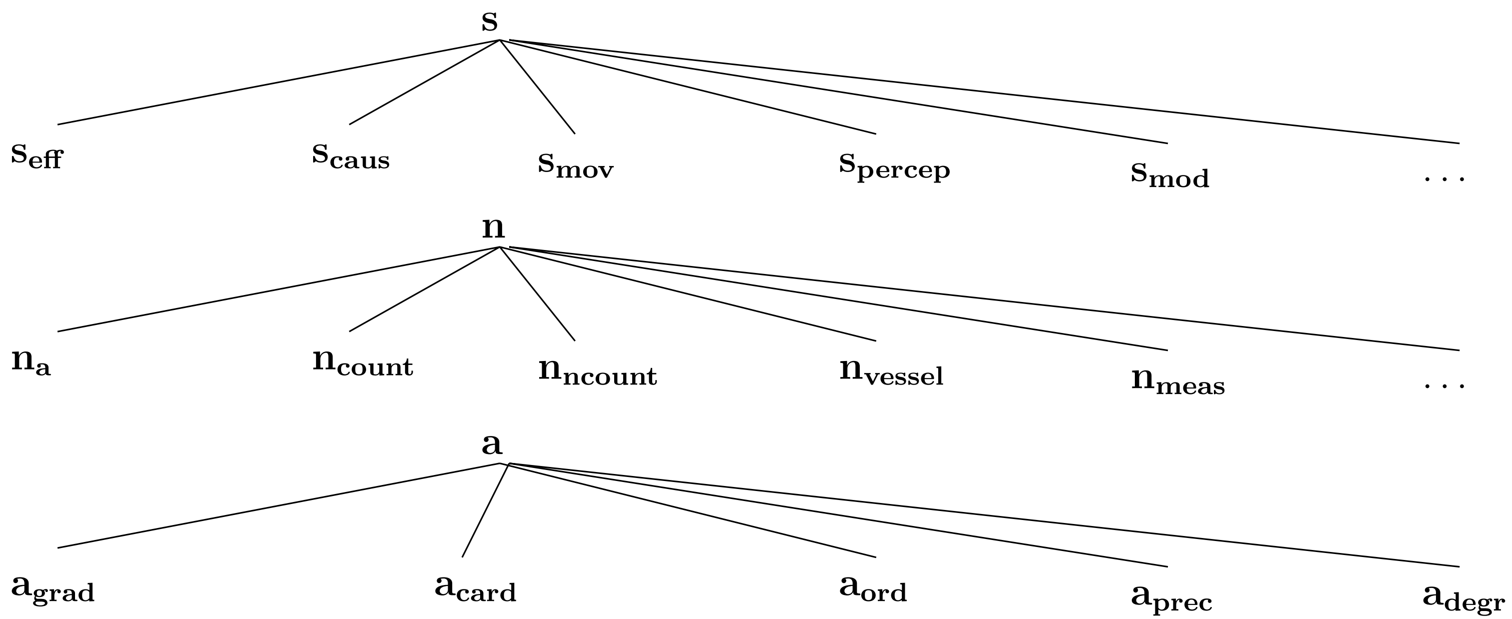
Diathetic shift: $(\emptyset \longleftrightarrow (\mathrm{S}\|\mathrm{A})_{\ominus}, \mathrm{SBJ} \longleftrightarrow (\mathrm{INS})_{\vec{T}}, \mathrm{OBJ} \longleftrightarrow (\mathrm{O}\|\mathrm{P})_{\odot})^{\mathbf{s_{eff}}}$

Derivative: $\mathrm{open}[\mathrm{D}_{ialt}]^{(\mathrm{SBJ}^{\mathbf{n}}\mathrm{OBJ}^{\mathbf{n}};\mathrm{MANNER}^{\mathbf{a_{grad}}} \rightarrow \mathbf{s_{eff}})}$

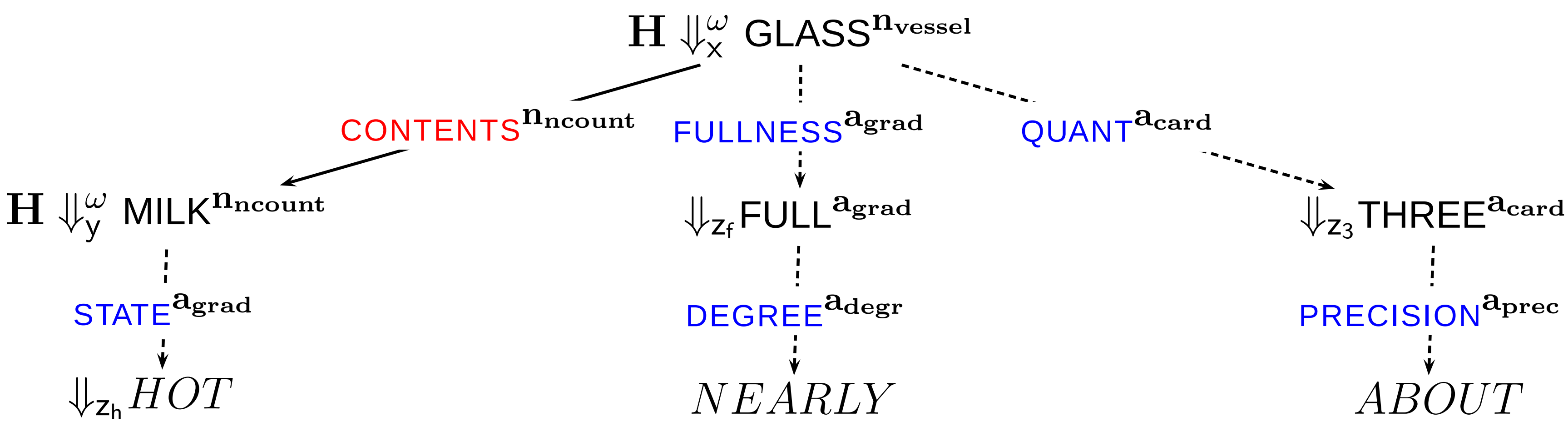


DP: Types

DP are typed. Primitive types are PO through genericity: $\mathbf{u} \preceq \mathbf{v}$ ($\mathbf{u}$ is a kind of $\mathbf{v}$).



EX: MILK$^{(\text{STATE}^{\mathbf{a_{grad}}} \rightarrow \mathbf{n_{ncount}})}$, BOTTLE$^{(\text{CONTENTS}^{\mathbf{n_{ncount}}};\text{FULLNESS}^{\mathbf{a_{grad}}}\text{QUANT}^{\mathbf{a_{card}}} \longrightarrow \mathbf{n_{vessel}})}$



A DP of *about three nearly full glasses of hot milk*.

Lexical Semantics: types and semantemes

DP semantics is defined in a set theory extended with specific constants:
lexical class constants:

$LC = \{L_\alpha \parallel \alpha = W$ is a semanteme or $\alpha = \mathbf{t}$ is a non-attributor primitive type$\}$

global object references: $R_\mathbf{g}$,
local object references: $R_\mathbf{l}$,
objects of type $\mathbf{t}$: $\mathbf{O}^\mathbf{t}$, $\mathbf{O} = \bigcup\limits_{\mathbf{t}} \mathbf{O}^\mathbf{t}$.
$\bot \notin \mathbf{O}$ is an *"uncertain value"*.
Every semanteme W has a unique set code $W^\star$.

$LEX(\mathbf{u})$: DP semantemes of types $(\phi \rightarrow \mathbf{u})$ or $\mathbf{u}$.

Postulate 1. (i) $L_\mathbf{u} \subseteq \mathbf{O}^\mathbf{u}$.
(ii) $\mathbf{u} \preceq \mathbf{v}$ iff $L_\mathbf{u} \subseteq L_\mathbf{v}$.
(iii) $L_W \subseteq L_\mathbf{u}$ for $W \in LEX(\mathbf{u})$.

Postulate 2. $\|o\|$ (extension of an *attributor type object* $o \in \mathbf{O}^\mathbf{u}$, $\mathbf{u} \preceq \mathbf{a}$) is a semanteme code: $\|o\| \in \{W^\star \parallel W \in LEX(\mathbf{u})\}$.

Lexical Semantics: attributes

Postulate 3. Attributes of semantemes depend only on their types: the classes L_W have the same attributes $Att(\mathbf{u})$ for all semantemes $W \in LEX(\mathbf{u})$.

Postulate 4. Every attribute $\mathsf{A} \in Att(\mathbf{u})$ is interpreted by a function on objects:

$$\mathsf{A}^{\mathbf{v}} : \begin{cases} \mathbf{O}^{\mathbf{u}} \rightarrow (\mathbf{O}^{\mathbf{v}} \cup \{\bot\}), & \text{if} \quad Att(\mathbf{v}) \neq \emptyset, \\ \mathbf{O}^{\mathbf{u}} \rightarrow (\{W^{\star} \mid W \in LEX(\mathbf{v})\} \cup \{\bot\}), & \text{if} \quad Att(\mathbf{v}) = \emptyset \end{cases}$$

$\mathbf{v}$, the value type of A, is an attributor type $\mathbf{v} \preceq \mathbf{a}$.

If $Att(\mathbf{u}) = \{\mathsf{A}_1^{\mathbf{v_1}}, \ldots, \mathsf{A}_m^{\mathbf{v_m}}\}$, then the types in $DT(\mathbf{u}) =_{df} \{\mathbf{v}_1, \ldots, \mathbf{v}_m\}$ are immediately dependent on $\mathbf{u}$ (denoted $\mathbf{v}_i \lhd^{imm} \mathbf{u}$).

Postulate 5. The reflexive-transitive closure $\unlhd$ of $\lhd^{imm}$ is a PO (of lexical dependency).
So $\mathbf{v} \unlhd \mathbf{u}$ implies $\mathbf{v} \preceq \mathbf{a}$.

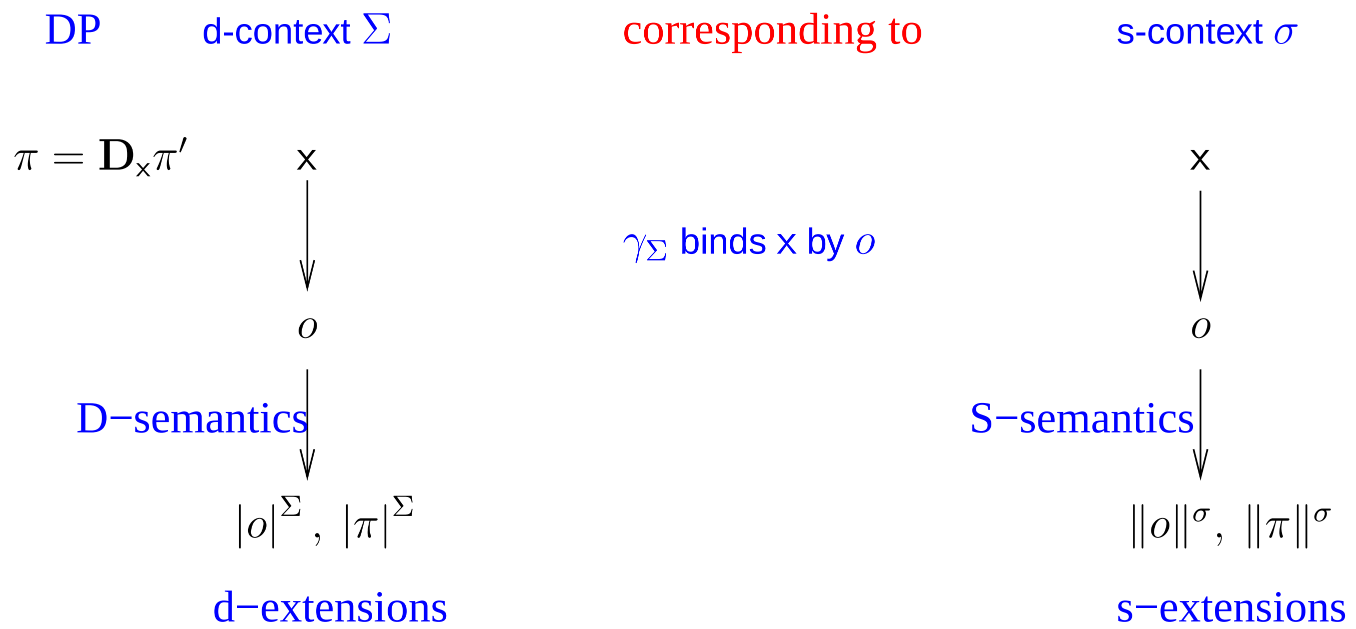
$o.\mathsf{A} =_{df} \|\mathsf{A}(o)\|$: attribute value extension
for $\mathsf{A}(o) \neq \bot$, attributor type objects $o \in \mathbf{O}^{\mathbf{u}}$ ($\mathbf{u} \preceq \mathbf{a}$) and their attributes $\mathsf{A}^{\mathbf{v}} \in Att(\mathbf{u})$.

Contexts

DP have two semantics: dynamic and static, both relative to contexts.
D-context: $\Sigma = (D, I)$, where:
D: finite collection of sets,
I: finite function from $f : D \to D$ with four restrictions:
$\gamma_\Sigma = I \restriction R_{\mathbf{g}}$ (global assignment), $\lambda_\Sigma = I \restriction R_{\mathbf{l}}$ (local assignment),
$\theta_\Sigma = I \restriction \mathbf{O^n}$ (nominal objects' evaluation), $\hbar_\Sigma = I \restriction LC$ (horizon line of Σ).

S-context $\sigma =< \gamma_\Sigma, \lambda_\Sigma, \theta_\Sigma, \hbar_\Sigma >$ corresponds to Σ.

$\gamma_\Sigma(\mathsf{x}) = o$: global reference x is bound with the object o,
$\lambda_\Sigma(u) = s$: local reference u is bound with the set s,
$\theta_\Sigma(o) = s$: nominal type object o has d-extension $|o|^\Sigma = s$,
$\hbar_\Sigma(L_W) = s$: s is the part of the d-extension of L_W accessible in Σ.



Static semantics of primitive DP π

Definition of s-extension $\|\pi\|^{\sigma}$ in s-context $\sigma =< \Gamma, \Lambda, \Theta, H >$

I. Primitive DP.

Lexical classes L_W, $W \notin LEX(\mathbf{a})$: $\|L_W\|^{\sigma} = H(L_W)$

Null plans.

Null nominal DP $\pi = \Downarrow_{\mathsf{x}} 0^{\mathbf{n}}$ (EX: *Testamentary succession*$_{\mathsf{OBJ}:\Downarrow_{\mathsf{x}} 0^{\mathbf{n}}}$ *goes to Mary*),
$\|\pi\|^{\sigma} = \|\Gamma(\mathsf{x})\|^{\sigma}$, where $\|\Gamma(\mathsf{x})\|^{\sigma} = \{\perp\}$.
Null attributor DP $\pi = \Downarrow_{\mathsf{x}} 0^{\mathbf{a}}$ (EX: *happy*$_{\mathsf{DEGREE}:0^{\mathbf{a}_{\mathbf{degr}}}}$ *as goblin*),
$\|\pi\|^{\sigma} = \|\Gamma(\mathsf{x})\|^{\sigma}$, where $\|\Gamma(\mathsf{x})\|^{\sigma} = \perp$.

Shifter DP $\pi = \Downarrow_{\mathsf{x}} (\mathrm{K}^{\mathbf{n}'})_{\mathbf{sh}}$, $\mathbf{n}' \preceq \mathbf{n}$ (EX: $(\textbf{speaker}^{\mathbf{n}_{\mathbf{a}}})_{\mathbf{sh}}$, $(\mathrm{John}^{\mathbf{n}_{\mathbf{a}}})_{\mathbf{sh}}$).
$\|\pi\|^{\sigma} = \|\Gamma(\mathsf{x})\|^{\sigma}$, where $\|\Gamma(\mathsf{x})\|^{\sigma} = \{((\mathrm{K})_{\mathbf{sh}})^{\star}\}$.

Reference DP

$\pi = u^{\mathbf{t}}$ (u a local reference). $\|\pi\|^{\sigma} = \|\Lambda(u)\|^{\sigma}$.
$\pi = \Uparrow_{\mathsf{x}^{\mathbf{t}}}$ (x a global reference). $\|\pi\|^{\sigma} = \|\Gamma(\mathsf{x})\|^{\sigma}$.

Primitive attributor DP

$\pi = W \in LEX(\mathbf{v})$, $\mathbf{v} \preceq \mathbf{a}$, $Att(\mathbf{v}) = \emptyset$ (EX: $\mathrm{VERY}^{\mathbf{a}_{\mathbf{degr}}}$, $\mathrm{ABOUT}^{\mathbf{a}_{\mathbf{prec}}}$).
$\|\pi\|^{\sigma} = W^{\star}$.

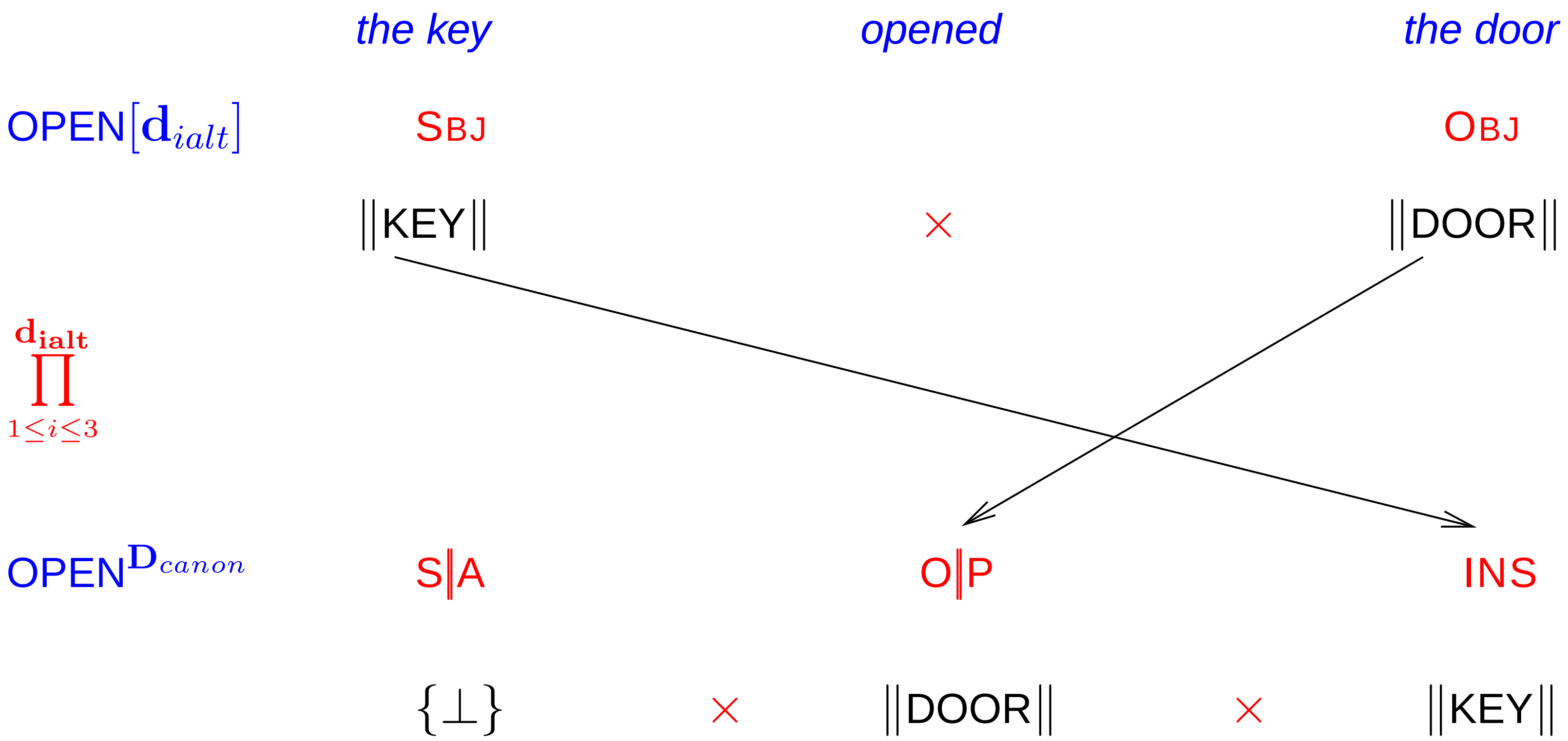
Shifted product for verbals' semantics

Shifted product reduces all verbal's derivatives to the canonical form

DF: For $n \geq k > 0$ an argument shift $d : k \overset{1-1}{\mapsto} n$ and a sequence of sets $s_1, \ldots, s_n$, the shifted product of this sequence (under shift d) is:

$$\prod_{1 \leq i \leq k}^{\mathbf{d}} s_i =_{df} M_1 \times \ldots \times M_n,$$

where $M_i = s_{\mathbf{d}^{-1}(i)}$ for $i \in range(\mathbf{d})$ and $M_i = \{\perp\}$ otherwise.



Static semantics of sentential DP

Unit sentential plans.

$\pi =\Downarrow_{\mathsf{x}} V[\mathbf{d}](\mathsf{R}_1 : \pi_1, \ldots, \mathsf{R}_k : \pi_k, \mathsf{A}_1 : \pi'_1, \ldots, \mathsf{A}_m : \pi'_m)$,
where $\pi'_i =\Downarrow_{\mathsf{x}_i} \pi''_i$, $1 \leq i \leq m$, are composite attributor DP.

$\|\pi\|^\sigma = \|\Gamma(\mathsf{x})\|^\sigma$,

$$\|\Gamma(\mathsf{x})\|^\sigma = \prod_{1 \leq i \leq k}^{\mathbf{d}} \|\pi_i\|^\sigma.$$

$\Gamma(\mathsf{x}) \in \|L_{\mathbf{V}}\|^\sigma$,

$\mathsf{A}_i(\Gamma(\mathsf{x})) = \Gamma(\mathsf{x}_i)$ and $\Gamma(\mathsf{x}).\mathsf{A}_i = \|\pi'_i\|^\sigma$, $1 \leq i \leq m$.

Coordinated sentential plans.

$\pi =\Downarrow_{\mathsf{x}} \mathcal{C}^{(n)}(\pi_1, \ldots, \pi_n)$,
where $n > 1$ and $\pi_i =\Downarrow_{\mathsf{x}_i} \pi'_i$ are unit sentential DP, $1 \leq i \leq n$.

$\|\pi\|^\sigma = \|\Gamma(\mathsf{x})\|^\sigma$, where $\|\Gamma(\mathsf{x})\|^\sigma =< \Gamma(\mathsf{x}_1), \ldots, \Gamma(\mathsf{x}_n) >$ and

$\|\Gamma(\mathsf{x}_i)\|^\sigma = \|\pi'_i\|^\sigma, 1 \leq i \leq n$.

Static semantics of nominal DP

Absolute unit determined DP.

$$\pi = \mathbf{D}_{\mathsf{x}} N(\mathsf{S}_1 : \pi_1, \ldots, \mathsf{S}_k : \pi_k, \mathsf{A}_1 : \pi'_1, \ldots, \mathsf{A}_m : \pi'_m),$$

where $\mathbf{D}_{\mathsf{x}} = (\mathbf{Q} \Downarrow_{\mathsf{x}}^{\mathbf{k}} u)$ is a determiner in which $\mathbf{Q} \in \{\mathbf{H}, \mathbf{I}\}$, $\mathsf{x}^{\mathbf{n}'}$ is a global reference, u is a local reference, $\mathbf{k}$ is a number or ω, $\pi_i = \Downarrow_{\mathsf{x}_i} \hat{\pi}_i, 1 \leq i \leq k$, $\pi'_j = \Downarrow_{\mathsf{y}_j} \hat{\pi}'_j, 1 \leq j \leq m$.

$$\|\pi\|^\sigma = \begin{cases} \{\Gamma(\mathsf{x})\}, & \text{if } \mathbf{Q} = \mathbf{H} \text{ (holistic interpretation), and} \\ \|\Gamma(\mathsf{x})\|^\sigma, & \text{if } \mathbf{Q} = \mathbf{I} \text{ (individual interpretation),} \end{cases}$$

$\|\Gamma(\mathsf{x})\|^\sigma = \Theta(\Gamma(\mathsf{x}))$ (i.e. defined in the corresponding d-context),

$\Gamma(\mathsf{x}) \in \|L_N\|^\sigma$, $\perp \in \|\Gamma(\mathsf{x})\|^\sigma$ and $card(\|\Gamma(\mathsf{x})\|^\sigma) \leq \mathbf{k}$,

$\mathsf{S}_i(\Gamma(\mathsf{x})) = \Gamma(\mathsf{x}_i)$, $1 \leq i \leq k$ (core arguments),

$\mathsf{A}_j(\Gamma(\mathsf{x})) = \Gamma(\mathsf{y}_j)$ and $\Gamma(\mathsf{x}).\mathsf{A}_j = \|\pi'_j\|^\sigma$, $1 \leq j \leq m$ (attributor arguments).

Static semantics of nominal DP

Relativized unit determined nominal DP.

$\pi = \mathbf{D}_{\mathsf{x}}\ \pi_1$, where $\mathbf{D}_{\mathsf{x}}$ = $(\mathbf{Q} \Downarrow^{\mathbf{k}}_{\mathsf{x}\mathbf{r}\mathsf{y}} u)$ is a determiner in which $\mathbf{r} \in \{\grave{\in}, \sim, \subset, /, \ldots\}$, π_1 is a determinerless nominal plan and y is a global reference identifying in the preceding discourse a nominal DP $\mathbf{D}_{\mathsf{y}}\ \pi_0$ with determiner $\mathbf{D}_{\mathsf{y}} = (\mathbf{Q_0} \Downarrow^{\mathbf{k_0}}_{\mathsf{y}} u_0)$

Then $\|\pi\|^{\sigma}$ is as in the preceding case, and the following $\mathbf{r}$-conditions also hold:

$$\begin{cases} \|\mathbf{r}\|^{\sigma}(\Gamma(\mathsf{x}), \Gamma(\mathsf{y})) & \text{if} \quad \mathbf{r} \in \{\sim, \subset, /, \ldots\}, \\ \Gamma(\mathsf{x}) \in \|\Gamma(\mathsf{y})\|^{\sigma},\ \Lambda(u_0) = \{\Gamma(\mathsf{x})\} \text{ and } card(\|\Gamma(\mathsf{y})\|^{\sigma}) \leq \mathbf{k_0} & \text{if} \quad \mathbf{r} = \grave{\in}. \end{cases}$$

Running example: *Every farmer* $_{(\mathbf{I} \Downarrow_{\mathsf{x}_f} u_f)}$ *in the village, who uses a tractor* $_{(\mathbf{I} \Downarrow^{1}_{\mathsf{x}_t} u_t)}$, *has a neighbor* $_{(\mathbf{I} \Downarrow^{1}_{\mathsf{x}_n} u_n)}$ *with whom he shares it* (DP π_1).

Bob $_{(\Downarrow^{1}_{\mathsf{y}_f \grave{\in} \mathsf{x}_f} u'_f)}$ *shares his old harvester* $_{(\mathbf{H} \Downarrow^{1}_{\mathsf{y}_t \grave{\in} \mathsf{x}_t} u'_t)}$ *with Tom* $_{(\Downarrow^{1}_{\mathsf{y}_n \grave{\in} \mathsf{x}_n} u''_n)}$ (DP π_2).

Static semantics of nominal DP

Relative determined nominal DP $\pi = \iota_{\mathsf{R}}(\pi_0 \parallel \hat{\pi}_0)$, where:

$\pi_0 = \mathbf{D}_{\mathsf{x}}\ \pi_0'$ is a unit determined nominal DP, u is the local reference in $\mathbf{D}_{\mathsf{x}}$, R is a role and

$$\hat{\pi}_0 = \Downarrow_{\mathsf{y}} V[\mathbf{d}](\mathsf{R}_1 : \hat{\pi}_1, \ldots, \mathsf{R}_i : u, \ldots, \mathsf{R}_k : \hat{\pi}_k, \mathsf{A}_1 : \hat{\pi}_1', \ldots, \mathsf{A}_m : \hat{\pi}_m')$$

is a sentential plan such that $\mathsf{R}_i = \mathsf{R}$.

Let:

$$I^{\sigma}_{\mathsf{R}}(\hat{\pi}_0) =_{df} \{x \parallel (\exists y_1, \ldots, y_n)(< y_1, \ldots, y_n > \in \|\Gamma(\mathsf{y})\|^{\sigma}\ \&\ x = y_{d^{-1}(i)})\}.$$

Then:

$\|\Gamma(\mathsf{x})\|^{\sigma} = \|\pi_0\|^{\sigma} \cap I^{\sigma}_{\mathsf{R}}(\hat{\pi}_0)$ and

$$\begin{cases} \|\pi\|^{\sigma} = \{\Gamma(\mathsf{x})\}, & \text{if} \quad \mathbf{Q} = \mathbf{H}, \text{ and} \\ \|\pi\|^{\sigma} = \|\Gamma(\mathsf{x})\|^{\sigma}, & \text{if} \quad \mathbf{Q} = \mathbf{I}. \end{cases}$$

If π_0 is relativized (i.e. $\mathbf{D}_{\mathsf{x}} = \mathbf{Q} \Downarrow^{\mathbf{k}}_{\mathsf{x}\mathbf{r}\mathsf{y}} u$), then the $\mathbf{r}$-conditions also hold.

Static semantics of attributor DP

Lexicalized attributor DP.

$\pi = \Downarrow_{\mathsf{x}} W^{\mathbf{t}}(\mathsf{A}_1 : \pi_1, \ldots, \mathsf{A}_m : \pi_m)$ and $\mathbf{t} = (\mathsf{A}_1^{\mathbf{v_1}} \ldots \mathsf{A}_m^{\mathbf{v_m}} \rightarrow \mathbf{u})$, $\mathbf{u} \preceq \mathbf{a}$, and π_i are attributor DP, $1 \leq i \leq m$. Then:

$\|\pi\|^\sigma = \|\Gamma(\mathsf{x})\|^\sigma = W^\star$,

$$\left\{ \begin{array}{lll} \mathsf{A}_i(\Gamma(\mathsf{x})) = \Gamma(\mathsf{x}_i), & \text{if} & \pi_i = \Downarrow_{\mathsf{x}_i} \pi_i', \text{ and} \\ \mathsf{A}_i(\Gamma(\mathsf{x})) = \|\pi_i\|^\sigma & \text{if} & \text{otherwise}, \end{array} \right\} 1 \leq i \leq m,$$

$\Gamma(\mathsf{x}).\mathsf{A}_i = \|\pi_i\|^\sigma$, $1 \leq i \leq m$.

Relative attributor DP.

$\pi = \iota\left(\Downarrow_{\mathsf{x}} 0^{\mathbf{t}} \parallel \pi_1\right)$ where $\mathsf{x}^{\mathbf{u}}$ is a global reference, $\mathbf{u}$ is an attributor type ($\mathbf{u} \preceq \mathbf{a}$), and $\pi_1 = \Downarrow_{\mathsf{y}} \pi_1'$ is a sentential type DP. Then:

$\|\pi\|^\sigma = \|\Gamma(\mathsf{x})\|^\sigma = \perp$,

$\|\pi_1\|^\sigma = \|\Gamma(\mathsf{y})\|^\sigma$,

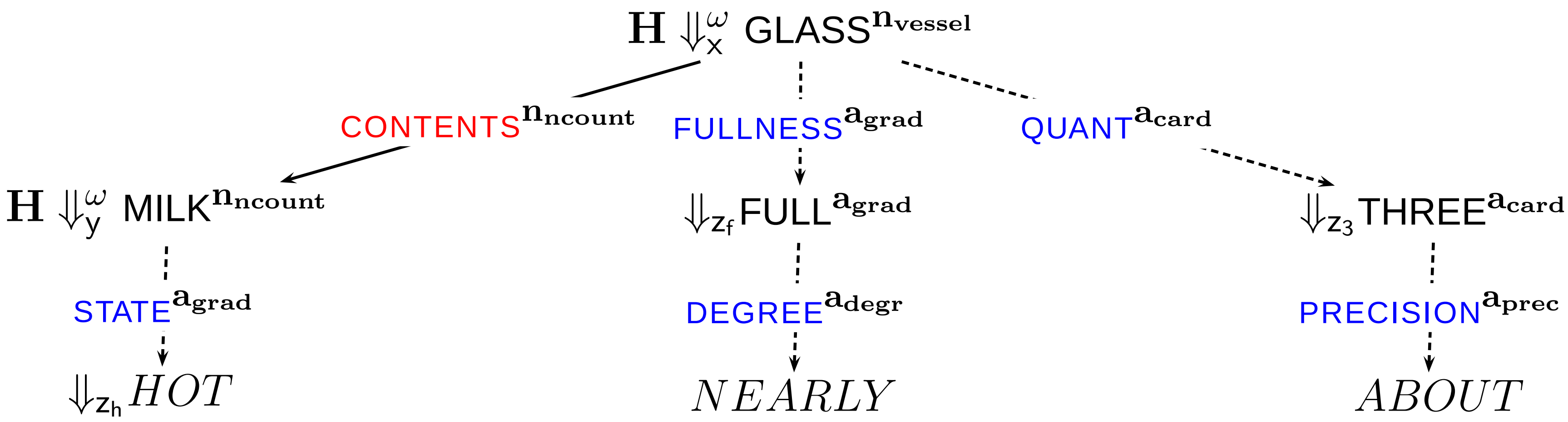
$\|\mathbf{rel}\|^\sigma(\Gamma(\mathsf{x}), \Gamma(\mathsf{y}))$ for a special relation $\mathbf{rel}$.

Ex: *He was so*$_{\Downarrow_{\mathsf{x}}(0^{\mathbf{a_{degr}}})}$ *glad, that ...*.

Static semantics of attributor DP

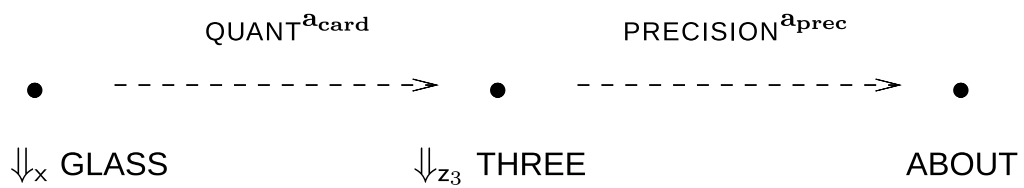
Attributor DP are interpreted by semantic dependencies

EX:



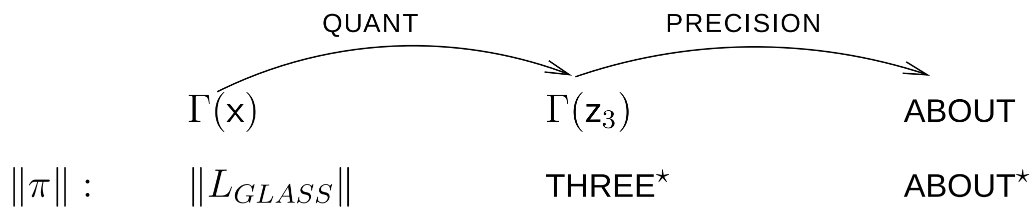
A DP of *about three nearly full glasses of hot milk*.

For the branch:

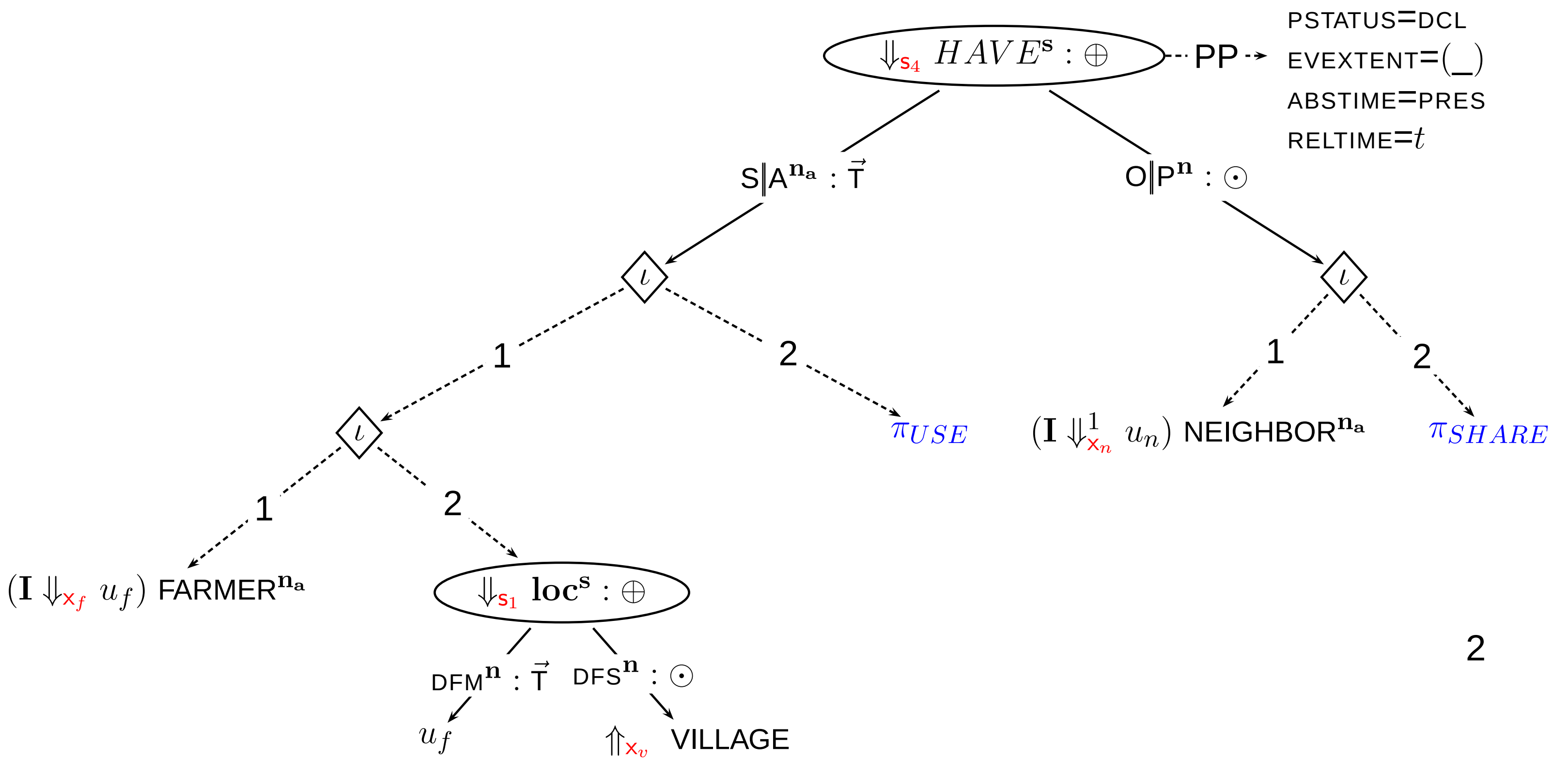


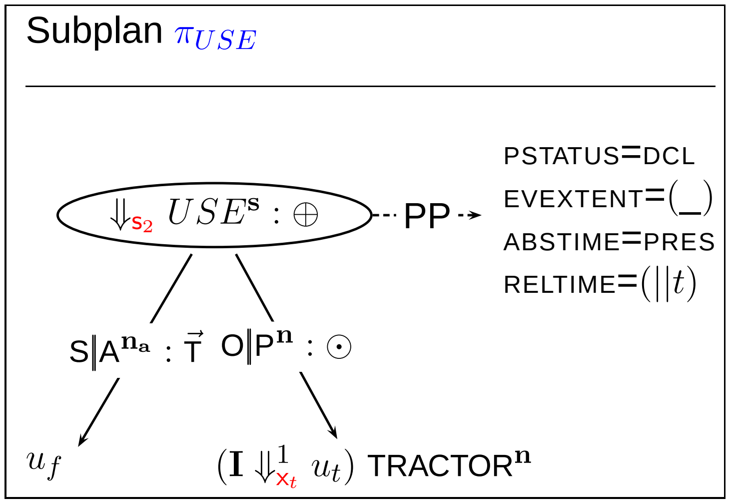
the corresponding attributor constraints are:

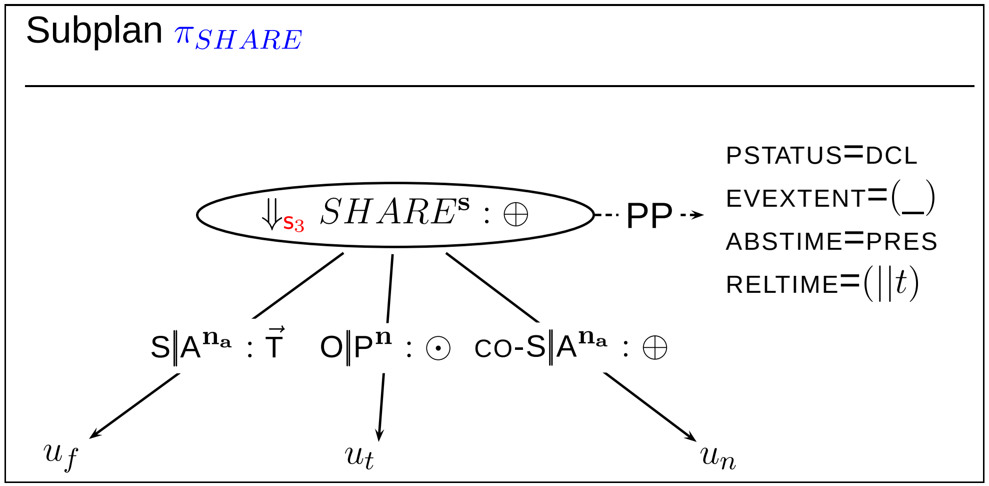
$\text{QUANT}(\Gamma(x)) = \Gamma(z_3)$, $\Gamma(x).\text{QUANT} = \|\Gamma(z_3)\| = \text{THREE}^{\star}$, $\text{PRECISION}(\Gamma(z_3)) = \text{ABOUT}^{\star}$



Discourse example: DP π_1

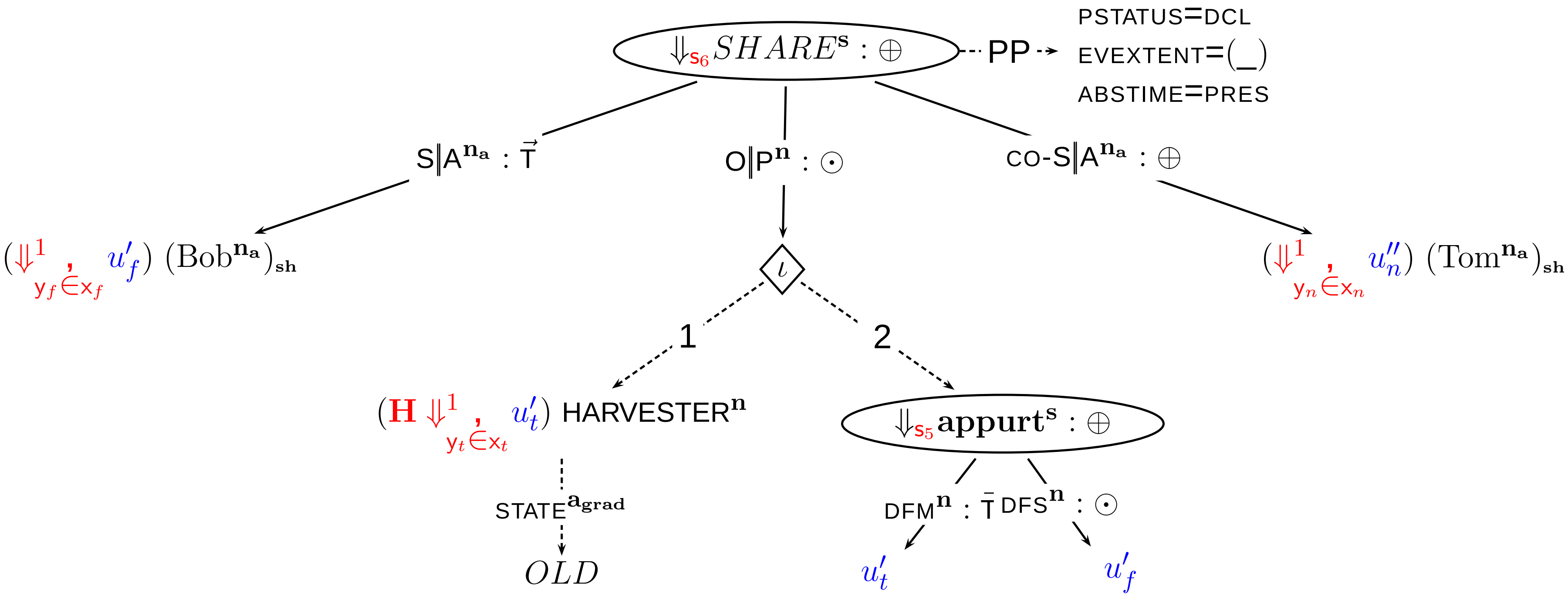






Every farmer in the village, who uses a tractor, has a neighbor with whom he shares it.

Discourse example: DP π_2



Bob shares his old harvester with Tom.

Dynamic DP semantics scheme

Discourse:	δ	$=$	π_1	π_2	$\ldots$	sequence of DP
Translation:			$\downarrow$	$\downarrow$	$\ldots$	
$\mathcal{SRL}$-process:	$\lceil \delta \rceil$	$=$	$\lceil \pi_1 \rceil$	$\lceil \pi_2 \rceil$	$\ldots$	sequence of actions

$\mathcal{SRL}$ (a functional language of stimuli-reaction processes):

1. Primitive actions
   - 1.1 elementary actions α
   - 1.2. stimuli $\alpha = S^{\uparrow x}$ with associated boolean values $b(\alpha)$
   - 1.3. reactions $\alpha = R^{\downarrow x}$
2. Compound actions $f(\alpha_1, \ldots, \alpha_k)$

Constraints on $\lceil \delta \rceil = \phi_1 \ldots \phi_n$:

$\mathbf{p_1}$. if $S^{\uparrow x}$ in ϕ_j, then $R^{\downarrow x}$ in ϕ_i for some $i < j$ ($R^{\downarrow x}$ is a reaction to $S^{\uparrow x}$)

$\mathbf{p_2}$. exactly one reaction ϕ_i to every stimulus in $\lceil \delta \rceil$ ($\phi_i =_{df} rscope(\delta, S^{\uparrow x})$.

Execution of $\lceil \delta \rceil$: $exe(\lceil \delta \rceil) = c_0 \vdash c_1 \vdash \ldots \vdash c_t$

Configurations $c_i = \Sigma_0(\psi_i)\Sigma_i\{\Psi_i\}$:

Σ_i: d-contexts (Σ_0 initial d-conrtext),

Ψ_i is the residual sequence of actions (to be executed starting from Σ_i)

$\psi_i = (\lceil \pi_{i_1} \rceil)^{\Sigma'_1}_{\Sigma_0}(\lceil \pi_{i_2} \rceil)^{\Sigma'_2}_{\Sigma'_1} \ldots (\lceil \pi_{i_k} \rceil)^{\Sigma_i}_{\Sigma'_{k-1}}$: transitions for the DP π_{i_j} of δ whose actions $\lceil \pi_{i_j} \rceil$ are executed by the step i (Σ'_{j-1}: initial, Σ'_j resulting d-contexts).

$c_0 = \Sigma_0(\varepsilon)\Sigma_0\{exe(\lceil \delta \rceil)\}$

$c_t = \Sigma_0(\psi_t)\Sigma_t\{\varepsilon\}$.

Dynamic DP semantics computation

Left-inside-out (lio) computation rules for steps $c \vdash c'$:

Sequential rule. $\Sigma_1(\psi)\Sigma_2\{exe(\phi\Phi)\Psi\} \vdash \Sigma_1(\psi)\Sigma_2\{exe(\phi)exe(\Phi)\Psi\}$.

LIO rule. $\Sigma_1(\psi)\Sigma_2\{exe(f(\alpha_1,\ldots,\alpha_k))\Psi\} \vdash$

$$\Sigma_1(\psi)\Sigma_2\{exe(\alpha_1)\ldots exe(\alpha_k)v(f)(val(\alpha_1),\ldots,val(\alpha_k))\Psi\}.$$

Reactivation rule. For all stimuli $\alpha_{st} = S^{\uparrow x}$, initially $b(\alpha_{st}) = 0$.

if $b(\alpha_{st}) = 0$ **then** $b(\alpha_{st}) := 1$ **and**

$$\Sigma_1(\psi)\Sigma_2\{exe(\alpha_{st})\Psi\} \vdash \Sigma_1(\psi)\Sigma_2\{exe(\alpha_{st})exe(rscope(\delta,\alpha_{st}))\Psi\},$$

if $b(\alpha_{st}) = 1$ **then** $\Sigma_1(\psi)\Sigma_2\{exe(\alpha_{st})\Psi\} \vdash \Sigma_1(\psi(\alpha_{st})_{\Sigma_2}^{\Sigma_2})\Sigma_2\{\Psi\}$.

Elementary action rule. For elementary actions α:

$$\Sigma_1(\psi)\Sigma_2\{exe(\alpha)\Psi\} \vdash \Sigma_1(\psi(\alpha)_{\Sigma_2}^{\Sigma_3})\Sigma_3\{\Psi\}.$$

Call transition rule. For operation calls $v(f)(val(\alpha_1),\ldots,val(\alpha_k))$:

$\Sigma_1(\psi)\Sigma_2\{v(f)(val(\alpha_1),\ldots,val(\alpha_k))\Psi\} \vdash$

$$\Sigma_1(\psi(v(f)(val(\alpha_1),\ldots,val(\alpha_k)))_{\Sigma_2}^{\Sigma_3})\Sigma_3\{\Psi\}.$$

Call reduction rule.

$\Sigma_1(\psi(\alpha_1)_{\Sigma_2}^{\Sigma_2'}\ldots(\alpha_k)_{\Sigma_k'}^{\Sigma_{k+1}'}(v(f)(val(\alpha_1),\ldots,val(\alpha_k)))_{\Sigma_{k+1}'}^{\Sigma_3})\Sigma_3\{\Psi\} \vdash$

$$\Sigma_1(\psi(f(\alpha_1,\ldots,\alpha_k))_{\Sigma_2}^{\Sigma_3})\Sigma_3\{\Psi\}.$$

Reactivation reduction rule. For a stimulus α_{st}:

$$\Sigma_1(\psi(\alpha_{st})_{\Sigma_2}^{\Sigma_2}(rscope(\delta,\alpha_{st}))_{\Sigma_2}^{\Sigma_3})\Sigma_3\{\Psi\} \vdash \Sigma_1(\psi(\alpha_{st})_{\Sigma_2}^{\Sigma_3})\Sigma_3\{\Psi\}.$$

Dynamic semantics

Theorem 1 *Every $\mathcal{SRL}$-process p has a unique successful finite execution $exe(p) = \alpha_1 \ldots \alpha_t$. LIO-computation time of $exe(p)$ is $\mathbf{O}(|\mathsf{p}|^2)$.*

Dynamic semantics of $\delta = \phi_1 \ldots \phi_n$ in a d-context Σ_0 is the sequence:

$$|\delta|_{\Sigma_0} =_{df} (|\pi_1|_{\Sigma_0}^{\Sigma_1}, |\pi_2|_{\Sigma_1}^{\Sigma_2}, \ldots, |\pi_n|_{\Sigma_{n-1}}^{\Sigma_n})$$

computed in the lio-computation

$$\Sigma_0(\varepsilon)\Sigma_0\{exe(\lceil \delta \rceil)\} \vdash^* \Sigma_0((\pi_1)_{\Sigma_0}^{\Sigma_1}(\pi_2)_{\Sigma_1}^{\Sigma_2} \ldots (\pi_n)_{\Sigma_{n-1}}^{\Sigma_n})\Sigma_n \{\varepsilon\}.$$

$|\pi|_{\Sigma}^{\Sigma'}$: d-extension of π in d-context Σ' computed starting from d-context Σ.

To define D-semantics of discourse, it remains:

- to define the translation of DP: $\lceil \pi \rceil$ and
- to define the effect on d-contexts and on d-extensions of
  - $\mathcal{SRL}$ elementary action transitions: $(\alpha)_{\Sigma}^{\Sigma'}$
  - $\mathcal{SRL}$ function call transitions: $(v(f)(val(\alpha_1), \ldots, val(\alpha_k)))_{\Sigma}^{\Sigma'}$

Translation / Execution

$$\lceil \mathsf{TRACTOR} \rceil = \lambda \mathsf{QLGK}.\, \mathbf{jun}_2^1((\mathbf{IF}\ \mathsf{Q} = \mathbf{I}\ \mathbf{THEN}\ \mathbf{ext}\ \mathbf{ELSE}\ \mathbf{set})(\mathbf{gnom^n}(L_{\mathsf{TRACTOR}}, \mathsf{L}, \mathsf{G}, \mathsf{K})), nv(\mathsf{L})^{\downarrow \mathsf{G} \cup})$$

$$\lceil (\mathbf{I} \Downarrow^1_{\mathsf{x}_t} u_t)\mathsf{TRACTOR} \rceil = \lceil \mathsf{TRACTOR} \rceil (\mathbf{I}, u_t, \mathsf{x}_t, 1) =$$

$$\mathbf{jun}_2^1(\ \mathbf{ext}((\mathbf{gnom^n}(L_{\mathsf{TRACTOR}}, u_t, \mathsf{x}_t, 1)),\qquad nv(u_t)^{\downarrow \mathsf{x}_t \cup}\ )$$

$\downarrow$ *exe* $\qquad\qquad \downarrow$ *reaction to*

$$\left\{ \begin{array}{ll} o_t \in \hbar_{\Sigma'}(L_{\mathsf{TRACTOR}}),\ |o_t|^{\Sigma'} = \{\bot\} = \theta_{\Sigma'}(\mathsf{x}_t), & \\ \gamma_{\Sigma'}(\mathsf{x}_t) = o_t,\ \lambda_{\Sigma'}(u_t) = \{\bot\}, & \mathbf{if}\ b(nv(u_t)^{\downarrow \mathsf{x}_t \cup}) = 0 \\ \mathbf{null}, & \mathbf{otherwise} \end{array} \right\} \quad \left\{ \begin{array}{c} add(\mathsf{y}_t)^{\uparrow \mathsf{x}_t \dot{\cup}} \\ \mathbf{if}\ b(nv(u_t)^{\downarrow \mathsf{x}_t \cup}) = 1 \end{array} \right\}$$

$$\lceil (\mathbf{H} \Downarrow^1_{\mathsf{y}_t \in \mathsf{x}_t} u'_t)\mathsf{HARVESTER}(\mathsf{STATE} : \mathsf{OLD}) \rceil (\mathbf{H}, \lceil \mathsf{OLD} \rceil, u'_t, \mathsf{y}_t, 1) =$$

$$\mathbf{jun}_2^1(\ \mathbf{set}((\mathbf{gnom^n}(L_{\mathsf{HARVESTER}}, \lceil \mathsf{OLD} \rceil, u'_t, \mathsf{y}_t, 1)),\qquad add(\mathsf{y}_t)^{\uparrow \mathsf{x}_t \dot{\cup}}\ )$$

$\downarrow$ *exe* $\qquad\qquad \downarrow$ *reactivation of*

$$\left\{ \begin{array}{ll} o_h \in \hbar_{\Sigma''}(L_{\mathsf{HARVESTER}}),\ |o_{hv}|^{\Sigma''} = \{o_{hv}\} = & \\ \theta_{\Sigma''}(\mathsf{y}_t),\ \gamma_{\Sigma''}(\mathsf{y}_t) = o_{hv},\ \lambda_{\Sigma''}(u'_t) = \{o_{hv}\}, & \mathbf{if}\ b(nv(u'_t)^{\downarrow \mathsf{y}_t \cup}) = 0 \\ \mathbf{null}, & \mathbf{otherwise} \end{array} \right\} \quad \left\{ \begin{array}{c} \lceil \pi_1 \rceil = rscope(\delta, add(\mathsf{y}_t)^{\uparrow \mathsf{x}_t \dot{\cup}}) \\ \mathbf{if}\ b(nv(u'_t)^{\downarrow \mathsf{y}_t \cup}) = 1 \end{array} \right\}$$

Reactivation effect. Nominal DP π_1: $\theta_{\Sigma''}(\mathsf{y}_t) = |o_t|^{\Sigma''} = \{\bot, o_{hv}\}, \lambda_{\Sigma''}(u_t) = \{o_{hv}\}$.

$\lceil \mathsf{OLD} \rceil$: Attribute constraints: $\left\{ \begin{array}{l} \mathsf{STATE}(o_{hv}) = o_{old},\ o_{hv}.\mathsf{STATE} = \|o_{old}\| = \mathsf{OLD}^{\star}, \\ \mathsf{DEGREE}(o_{old}) = \bot \end{array} \right.$

Example of lio-computation

Processes: $\lceil \pi_1 \rceil = p_1$:

Context	GRef	Oid	d-Extension elements	LRef	LVal	Attributes	Semanteme
Σ_0	x_v	$o_v \in \mathbf{O^n}$	$(\mathrm{v})^{\star}_{\mathbf{sh}}$				VILLAGE

Table 1. Computation for the first DP π_1 of

Every farmer in the village, who uses a tractor, has a neighbor with whom he shares it.

Example of lio-computation

Processes: $\lceil \pi_1 \rceil = p_1$:

Context	GRef	Oid	d-Extension elements	LRef	LVal	Attributes	Semanteme
Σ_0	x_v	$o_v \in \mathbf{O^n}$	$(\mathrm{v})^{\star}_{\mathbf{sh}}$				VILLAGE
Σ_1	x_f	$o_f \in \mathbf{O^{n_a}}$	$\perp$	u_f	$\{\perp\}$		FARMER

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Every farmer in the village, who uses a tractor, has a neighbor with whom he shares it.

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Processes: $\lceil \pi_1 \rceil = p_1$:

Context	GRef	Oid	d-Extension elements	LRef	LVal	Attributes	Semanteme
Σ_0	x_v	$o_v \in \mathbf{O^n}$	$(\mathrm{v})^{\star}_{\mathbf{sh}}$				VILLAGE
Σ_1	x_f	$o_f \in \mathbf{O^{n_a}}$	$\perp$	u_f	$\{\perp\}$		FARMER
Σ_2	s_1	$o_{loc} \in \mathbf{O^s}$	$<$ DFM : $\perp$, DFS : o_v $>$				**loc**

Table 1. Computation for the first DP π_1 of

Every farmer in the village, who uses a tractor, has a neighbor with whom he shares it.

Example of lio-computation

Processes: $\lceil \pi_1 \rceil = p_1$:

Context	GRef	Oid	d-Extension elements	LRef	LVal	Attributes	Semanteme
Σ_0	x_v	$o_v \in \mathbf{O^n}$	$(\mathrm{v})^{\star}_{\mathbf{sh}}$				VILLAGE
Σ_1	x_f	$o_f \in \mathbf{O^{n_a}}$	$\perp$	u_f	$\{\perp\}$		FARMER
Σ_2	s_1	$o_{loc} \in \mathbf{O^s}$	$<$ DFM : $\perp$, DFS : $o_v >$				**loc**
Σ_3	x_t	$o_t \in \mathbf{O^n}$	$\perp$	u_t	$\{\perp\}$		TRACTOR

Table 1. Computation for the first DP π_1 of

Every farmer in the village, who uses a tractor, has a neighbor with whom he shares it.

Example of lio-computation

Processes: $\lceil \pi_1 \rceil = p_1$:

Context	GRef	Oid	d-Extension elements	LRef	LVal	Attributes	Semanteme
Σ_0	x_v	$o_v \in \mathbf{O^n}$	$(\mathrm{v})^{\star}_{\mathbf{sh}}$				VILLAGE
Σ_1	x_f	$o_f \in \mathbf{O^{n_a}}$	$\bot$	u_f	$\{\bot\}$		FARMER
Σ_2	s_1	$o_{loc} \in \mathbf{O^s}$	$<$ DFM : $\bot$, DFS : $o_v >$				**loc**
Σ_3	x_t	$o_t \in \mathbf{O^n}$	$\bot$	u_t	$\{\bot\}$		TRACTOR
Σ_4	s_2	$o_u \in \mathbf{O^s}$	$<$ S|A : $\bot$, O|P : $\bot >$			o_u.PSTATUS $=$ DCL*, etc.	USE

Table 1. Computation for the first DP π_1 of

Every farmer in the village, who uses a tractor, has a neighbor with whom he shares it.

Example of lio-computation

Processes: $\lceil \pi_1 \rceil = p_1$:

Context	GRef	Oid	d-Extension elements	LRef	LVal	Attributes	Semanteme
Σ_0	x_v	$o_v \in \mathbf{O^n}$	$(\mathrm{v})^{\star}_{\mathbf{sh}}$				VILLAGE
Σ_1	x_f	$o_f \in \mathbf{O^{n_a}}$	$\perp$	u_f	$\{\perp\}$		FARMER
Σ_2	s_1	$o_{loc} \in \mathbf{O^s}$	$<$ DFM : $\perp$, DFS : o_v $>$				**loc**
Σ_3	x_t	$o_t \in \mathbf{O^n}$	$\perp$	u_t	$\{\perp\}$		TRACTOR
Σ_4	s_2	$o_u \in \mathbf{O^s}$	$<$ S‖A : $\perp$, O‖P : $\perp$ $>$			o_u.PSTATUS = DCL*, etc.	USE
Σ_5	x_n	$o_n \in \mathbf{O^{n_a}}$	$\perp$	u_n	$\{\perp\}$		NEIGHBOR

Table 1. Computation for the first DP π_1 of

Every farmer in the village, who uses a tractor, has a neighbor with whom he shares it.

Example of lio-computation

Processes: $\lceil \pi_1 \rceil = p_1$:

Context	GRef	Oid	d-Extension elements	LRef	LVal	Attributes	Semanteme
Σ_0	x_v	$o_v \in \mathbf{O^n}$	$(\mathrm{v})^{\star}_{\mathbf{sh}}$				VILLAGE
Σ_1	x_f	$o_f \in \mathbf{O^{n_a}}$	$\perp$	u_f	$\{\perp\}$		FARMER
Σ_2	s_1	$o_{loc} \in \mathbf{O^s}$	$< \mathrm{DFM} : \perp, \mathrm{DFS} : o_v >$				**loc**
Σ_3	x_t	$o_t \in \mathbf{O^n}$	$\perp$	u_t	$\{\perp\}$		TRACTOR
Σ_4	s_2	$o_u \in \mathbf{O^s}$	$< \mathrm{S}\|\mathrm{A} : \perp, \mathrm{O}\|\mathrm{P} : \perp >$			$o_u.\mathrm{PSTATUS} = \mathrm{DCL}^{\star}$, etc.	USE
Σ_5	x_n	$o_n \in \mathbf{O^{n_a}}$	$\perp$	u_n	$\{\perp\}$		NEIGHBOR
Σ_6	s_3	$o_{sh} \in \mathbf{O^s}$	$< \mathrm{S}\|\mathrm{A} : \perp, \mathrm{O}\|\mathrm{P} : \perp, \mathrm{co\text{-}S}\|\mathrm{A} : \perp >$			$o_u.\mathrm{PSTATUS} = \mathrm{DCL}^{\star}$, etc.	SHARE

Table 1. Computation for the first DP π_1 of
Every farmer in the village, who uses a tractor, has a neighbor with whom he shares it.

Example of lio-computation

Processes: $\lceil \pi_1 \rceil = p_1$:

Context	GRef	Oid	d-Extension elements	LRef	LVal	Attributes	Semanteme
Σ_0	x_v	$o_v \in \mathbf{O^n}$	$(\mathrm{v})^{\star}_{\mathbf{sh}}$				VILLAGE
Σ_1	x_f	$o_f \in \mathbf{O^{n_a}}$	$\perp$	u_f	$\{\perp\}$		FARMER
Σ_2	s_1	$o_{loc} \in \mathbf{O^s}$	$<$ DFM : $\perp$, DFS : $o_v >$				**loc**
Σ_3	x_t	$o_t \in \mathbf{O^n}$	$\perp$	u_t	$\{\perp\}$		TRACTOR
Σ_4	s_2	$o_u \in \mathbf{O^s}$	$<$ S|A : $\perp$, O|P : $\perp >$			o_u.PSTATUS $=$ DCL*, etc.	USE
Σ_5	x_n	$o_n \in \mathbf{O^{n_a}}$	$\perp$	u_n	$\{\perp\}$		NEIGHBOR
Σ_6	s_3	$o_{sh} \in \mathbf{O^s}$	$<$ S|A : $\perp$, O|P : $\perp$, CO-S|A : $\perp >$			o_u.PSTATUS $=$ DCL*, etc.	SHARE
Σ_7	s_4	$o_h \in \mathbf{O^s}$	$<$ S|A : $\perp$, O|P : $\perp >$			o_h.PSTATUS $=$ DCL*, etc.	HAVE

Table 1. Computation for the first DP π_1 of

Every farmer in the village, who uses a tractor, has a neighbor with whom he shares it.

Example of lio-computation

Processes: $\lceil \pi_2 \rceil = p_2$:

Context	GRef	Oid	d-Extension elements	LRef	LVal	Attributes	Semanteme
Σ_8	y_f	$o_B \in \mathbf{O^{n_a}}$	$(\mathrm{Bob})^{\star}_{\mathbf{sh}}$	u'_f	$\{o_B\}$		$(\mathrm{Bob})_{\mathbf{sh}}$

Table 2. Computation for the second DP π_2 of
Bob shares his old harvester with Tom.

Example of lio-computation

Processes: $\lceil \pi_2 \rceil = p_2$:

Context	GRef	Oid	d-Extension elements	LRef	LVal	Attributes	Semanteme
Σ_8	y$_f$	$o_B \in \mathbf{O}^{\mathbf{n_a}}$	$(\mathrm{Bob})^{\star}_{\mathbf{sh}}$	u'_f	$\{o_B\}$		$(\mathrm{Bob})_{\mathbf{sh}}$
react. π_1	x$_f$	o_f	$\perp, o_B$	u_f	$\{o_B\}$		FARMER

Table 2. Computation for the second DP π_2 of

Bob shares his old harvester with Tom.

Example of lio-computation

Processes: $\lceil \pi_2 \rceil = p_2$:

Context	GRef	Oid	d-Extension elements	LRef	LVal	Attributes	Semanteme
Σ_8	y_f	$o_B \in \mathbf{O^{n_a}}$	$(\mathrm{Bob})^{\star}_{\mathbf{sh}}$	u'_f	$\{o_B\}$		$(\mathrm{Bob})_{\mathbf{sh}}$
	x_f	o_f	$\perp, o_B$	u_f	$\{o_B\}$		FARMER
react. π_1	s_2	o_u	$<$ S|A : o_B , O‖P : $\perp$ $>$				USE

Table 2. Computation for the second DP π_2 of

Bob shares his old harvester with Tom.

Example of lio-computation

Processes: $\lceil \pi_2 \rceil = p_2$:

Context	GRef	Oid	d-Extension elements	LRef	LVal	Attributes	Semanteme
Σ_8	y_f	$o_B \in \mathbf{O}^{\mathbf{n_a}}$	$(\mathrm{Bob})^{\star}_{\mathbf{sh}}$	u'_f	$\{o_B\}$		$(\mathrm{Bob})_{\mathbf{sh}}$
	x_f	o_f	$\bot, o_B$	u_f	$\{o_B\}$		FARMER
	s_2	o_u	$<$ S‖A : o_B, O‖P : $\bot >$				USE
react. π_1	s_4	o_h	$<$ S‖A : o_B, O‖P : $o_n >$				HAVE

Table 2. Computation for the second DP π_2 of

Bob shares his old harvester with Tom.

Example of lio-computation

Processes: $\lceil \pi_2 \rceil = p_2$:

Context	GRef	Oid	d-Extension elements	LRef	LVal	Attributes	Semanteme
Σ_8	y_f	$o_B \in \mathbf{O^{n_a}}$	$(\mathrm{Bob})^{\star}_{\mathbf{sh}}$	u'_f	$\{o_B\}$		$(\mathrm{Bob})_{\mathbf{sh}}$
	x_f	o_f	$\bot, o_B$	u_f	$\{o_B\}$		FARMER
	s_2	o_u	$<$ S|A : o_B, O|P : $\bot >$				USE
	s_4	o_h	$<$ S|A : o_B, O|P : $o_n >$				HAVE
Σ_9	y_t	$o_{hv} \in \mathbf{O^n}$	$\bot$	u'_t	$\{o_{hv}\}$	o_{hv}.STATE $=$ OLD*	HARVESTER

Table 2. Computation for the second DP π_2 of

Bob shares his old harvester with Tom.

Example of lio-computation

Processes: $\lceil \pi_2 \rceil = p_2$:

Context	GRef	Oid	d-Extension elements	LRef	LVal	Attributes	Semanteme
Σ_8	y_f	$o_B \in \mathbf{O^{n_a}}$	$(\mathrm{Bob})^{\star}_{\mathbf{sh}}$	u'_f	$\{o_B\}$		$(\mathrm{Bob})_{\mathbf{sh}}$
	x_f	o_f	$\bot, o_B$	u_f	$\{o_B\}$		FARMER
	s_2	o_u	$<$ S|A : o_B, O|P : $\bot >$				USE
	s_4	o_h	$<$ S|A : o_B, O|P : $o_n >$				HAVE
Σ_9	y_t	$o_{hv} \in \mathbf{O^{n}}$	$\bot$	u'_t	$\{o_{hv}\}$	o_{hv}.STATE $=$ OLD*	HARVESTER
react. π_1	x_t	o_t	$\bot, o_{hv}$	u_t	$\{o_{hv}\}$		TRACTOR

Table 2. Computation for the second DP π_2 of

Bob shares his old harvester with Tom.

Example of lio-computation

Processes: $\lceil \pi_2 \rceil = p_2$:

Context	GRef	Oid	d-Extension elements	LRef	LVal	Attributes	Semanteme
Σ_8	y_f	$o_B \in \mathbf{O^{n_a}}$	$(\text{Bob})^{\star}_{\mathbf{sh}}$	u'_f	$\{o_B\}$		$(\text{Bob})_{\mathbf{sh}}$
	x_f	o_f	$\perp, o_B$	u_f	$\{o_B\}$		FARMER
	s_2	o_u	$<$ S|A : o_B, O|P : $\perp$ $>$				USE
	s_4	o_h	$<$ S|A : o_B, O|P : o_n $>$				HAVE
Σ_9	y_t	$o_{hv} \in \mathbf{O^n}$	$\perp$	u'_t	$\{o_{hv}\}$	o_{hv}.STATE $=$ OLD*	HARVESTER
	x_t	o_t	$\perp, o_{hv}$	u_t	$\{o_{hv}\}$		TRACTOR
react. π_1	s_1	o_u	$<$ S|A : o_B, O|P : o_{hv} $>$				USE

Table 2. Computation for the second DP π_2 of

Bob shares his old harvester with Tom.

Example of lio-computation

Processes: $\lceil \pi_2 \rceil = p_2$:

Context	GRef	Oid	d-Extension elements	LRef	LVal	Attributes	Semanteme
Σ_8	y_f	$o_B \in \mathbf{O^{n_a}}$	$(\mathrm{Bob})^{\star}_{\mathbf{sh}}$	u'_f	$\{o_B\}$		$(\mathrm{Bob})_{\mathbf{sh}}$
	x_f	o_f	$\perp, o_B$	u_f	$\{o_B\}$		FARMER
	s_2	o_u	$<$ S|A : o_B, O|P : $\perp >$				USE
	s_4	o_h	$<$ S|A : o_B, O|P : $o_n >$				HAVE
Σ_9	y_t	$o_{hv} \in \mathbf{O^n}$	$\perp$	u'_t	$\{o_{hv}\}$	o_{hv}.STATE $=$ OLD*	HARVESTER
	x_t	o_t	$\perp, o_{hv}$	u_t	$\{o_{hv}\}$		TRACTOR
	s_1	o_u	$<$ S|A : o_B, O|P : $o_{hv} >$				USE
Σ_{10}	s_5	$o_{appurt} \in \mathbf{O^s}$	$<$ DFM : o_{hv}, DFS : $o_B >$				**appurt**

Table 2. Computation for the second DP π_2 of

Bob shares his old harvester with Tom.

Example of lio-computation

Processes: $\lceil \pi_2 \rceil = p_2$:

Context	GRef	Oid	d-Extension elements	LRef	LVal	Attributes	Semanteme
Σ_8	y_f	$o_B \in \mathbf{O^{n_a}}$	$(\text{Bob})^{\star}_{\mathbf{sh}}$	u'_f	$\{o_B\}$		$(\text{Bob})_{\mathbf{sh}}$
	x_f	o_f	$\bot, o_B$	u_f	$\{o_B\}$		FARMER
	s_2	o_u	$< \text{S}\Vert\text{A} : o_B, \text{O}\Vert\text{P} : \bot >$				USE
	s_4	o_h	$< \text{S}\Vert\text{A} : o_B, \text{O}\Vert\text{P} : o_n >$				HAVE
Σ_9	y_t	$o_{hv} \in \mathbf{O^n}$	$\bot$	u'_t	$\{o_{hv}\}$	$o_{hv}.\text{STATE} = \text{OLD}^{\star}$	HARVESTER
	x_t	o_t	$\bot, o_{hv}$	u_t	$\{o_{hv}\}$		TRACTOR
	s_1	o_u	$< \text{S}\Vert\text{A} : o_B, \text{O}\Vert\text{P} : o_{hv} >$				USE
Σ_{10}	s_5	$o_{appurt} \in \mathbf{O^s}$	$< \text{DFM} : o_{hv}, \text{DFS} : o_B >$				**appurt**
Σ_{11}	y_n	$o_T \in \mathbf{O^{n_a}}$	$(\text{Tom})^{\star}_{\mathbf{sh}}$	u'_n	$\{o_T\}$		$(\text{Tom})_{\mathbf{sh}}$

Table 2. Computation for the second DP π_2 of

Bob shares his old harvester with Tom.

Example of lio-computation

Processes: $\lceil \pi_2 \rceil = p_2$:

Context	GRef	Oid	d-Extension elements	LRef	LVal	Attributes	Semanteme
Σ_8	y_f	$o_B \in \mathbf{O^{n_a}}$	$(\mathrm{Bob})^{\star}_{\mathbf{sh}}$	u'_f	$\{o_B\}$		$(\mathrm{Bob})_{\mathbf{sh}}$
	x_f	o_f	$\perp, o_B$	u_f	$\{o_B\}$		FARMER
	s_2	o_u	$<$ S|A : o_B, O|P : $\perp >$				USE
	s_4	o_h	$<$ S|A : o_B, O|P : $o_n >$				HAVE
Σ_9	y_t	$o_{hv} \in \mathbf{O^n}$	$\perp$	u'_t	$\{o_{hv}\}$	o_{hv}.STATE $=$ OLD*	HARVESTER
	x_t	o_t	$\perp, o_{hv}$	u_t	$\{o_{hv}\}$		TRACTOR
	s_1	o_u	$<$ S|A : o_B, O|P : $o_{hv} >$				USE
Σ_{10}	s_5	$o_{appurt} \in \mathbf{O^s}$	$<$ DFM : o_{hv}, DFS : $o_B >$				**appurt**
Σ_{11}	y_n	$o_T \in \mathbf{O^{n_a}}$	$(\mathrm{Tom})^{\star}_{\mathbf{sh}}$	u'_n	$\{o_T\}$		$(\mathrm{Tom})_{\mathbf{sh}}$
react. π_1	x_n	o_n	$\perp, o_T$	u_n	$\{o_T\}$		NEIGHBOR

Table 2. Computation for the second DP π_2 of

Bob shares his old harvester with Tom.

Example of lio-computation

Processes: $\lceil \pi_2 \rceil = p_2$:

Context	GRef	Oid	d-Extension elements	LRef	LVal	Attributes	Semanteme
Σ_8	y_f	$o_B \in \mathbf{O^{n_a}}$	$(\text{Bob})^\star_{\mathbf{sh}}$	u'_f	$\{o_B\}$		$(\text{Bob})_{\mathbf{sh}}$
	x_f	o_f	$\bot, o_B$	u_f	$\{o_B\}$		FARMER
	s_2	o_u	$<$ S|A : o_B, O|P : $\bot >$				USE
	s_4	o_h	$<$ S|A : o_B, O|P : $o_n >$				HAVE
Σ_9	y_t	$o_{hv} \in \mathbf{O^n}$	$\bot$	u'_t	$\{o_{hv}\}$	o_{hv}.STATE $=$ OLD*	HARVESTER
	x_t	o_t	$\bot, o_{hv}$	u_t	$\{o_{hv}\}$		TRACTOR
	s_1	o_u	$<$ S|A : o_B, O|P : $o_{hv} >$				USE
Σ_{10}	s_5	$o_{appurt} \in \mathbf{O^s}$	$<$ DFM : o_{hv}, DFS : $o_B >$				**appurt**
Σ_{11}	y_n	$o_T \in \mathbf{O^{n_a}}$	$(\text{Tom})^\star_{\mathbf{sh}}$	u'_n	$\{o_T\}$		$(\text{Tom})_{\mathbf{sh}}$
	x_n	o_n	$\bot, o_T$	u_n	$\{o_T\}$		NEIGHBOR
react. π_1	s_3	o_{sh}	$<$ S|A : o_B, O|P : o_{hv}, CO-S|A : $o_T >$				SHARE

Table 2. Computation for the second DP π_2 of

Bob shares his old harvester with Tom.

Example of lio-computation

Processes: $\lceil \pi_2 \rceil = p_2$:

Context	GRef	Oid	d-Extension elements	LRef	LVal	Attributes	Semanteme
Σ_8	y_f	$o_B \in \mathbf{O^{n_a}}$	$(\text{Bob})^{\star}_{\mathbf{sh}}$	u'_f	$\{o_B\}$		$(\text{Bob})_{\mathbf{sh}}$
	x_f	o_f	$\bot, o_B$	u_f	$\{o_B\}$		FARMER
	s_2	o_u	$< \text{S}\vert\text{A} : o_B, \text{O}\vert\text{P} : \bot >$				USE
	s_4	o_h	$< \text{S}\vert\text{A} : o_B, \text{O}\vert\text{P} : o_n >$				HAVE
Σ_9	y_t	$o_{hv} \in \mathbf{O^{n}}$	$\bot$	u'_t	$\{o_{hv}\}$	o_{hv}.STATE $=$ OLD*	HARVESTER
	x_t	o_t	$\bot, o_{hv}$	u_t	$\{o_{hv}\}$		TRACTOR
	s_1	o_u	$< \text{S}\vert\text{A} : o_B, \text{O}\vert\text{P} : o_{hv} >$				USE
Σ_{10}	s_5	$o_{appurt} \in \mathbf{O^{s}}$	$< \text{DFM} : o_{hv}, \text{DFS} : o_B >$				**appurt**
Σ_{11}	y_n	$o_T \in \mathbf{O^{n_a}}$	$(\text{Tom})^{\star}_{\mathbf{sh}}$	u'_n	$\{o_T\}$		$(\text{Tom})_{\mathbf{sh}}$
	x_n	o_n	$\bot, o_T$	u_n	$\{o_T\}$		NEIGHBOR
	s_3	o_{sh}	$< \text{S}\vert\text{A} : o_B, \text{O}\vert\text{P} : o_{hv}, \text{CO-S}\vert\text{A} : o_T >$				SHARE
Σ_{12}	s_6	o'_{sh}	$< \text{S}\vert\text{A} : o_B, \text{O}\vert\text{P} : o_{hv}, \text{CO-S}\vert\text{A} : o_T >$			o'_{sh}.PSTATUS $=$ DCL*, etc.	SHARE

Table 2. Computation for the second DP π_2 of

Bob shares his old harvester with Tom.

Properties of DP semantics

1. Dynamic and static DP semantics coincide in the corresponding contexts:

Theorem 2 *Let* $\delta = (\pi_1, \ldots, \pi_n)$ *be a discourse,* Σ_0 *be an initial d-context,* $|\delta|_{\Sigma_0} = (|\pi_1|_{\Sigma_0}^{\Sigma_1}, |\pi_2|_{\Sigma_1}^{\Sigma_2}, \ldots, |\pi_n|_{\Sigma_{n-1}}^{\Sigma_n})$ *be the d-semantics of* δ *relative to* Σ_0 *and* $\sigma_i = < \gamma_{\Sigma_i}, \lambda_{\Sigma_i}, \theta_{\Sigma_i}, \hbar_{\Sigma_i} >$ *be the s-contexts corresponding to d-contexts* Σ_i. *Then* $|\pi_i|_{\Sigma_{i-1}}^{\Sigma_i} = \|\pi_i\|^{\sigma_i}$ *for all* $i, 0 < i \leq n$.

2. DP semantics is incremental:

Upper semilattice of contexts: $\Sigma_1 \leq^\circ \Sigma_2$ iff

$|o|^{\Sigma_1} \subseteq |o|^{\Sigma_2}$ for objects $o \in \mathbf{O}$ and $\hbar_{\Sigma_1}(L) \subseteq \hbar_{\Sigma_2}(L)$ for lexical classes $L \in LC$.

Let Σ_0 be the empty d-context with no objects,

$\delta^\infty = (\pi_1, \pi_2, \ldots)$ be an infinite discourse, $\delta^\infty[n] =_{df} (\pi_1, \ldots, \pi_n)$ and

$|\delta|_{\Sigma_0}^\infty [n] =_{df} (|\pi_1|_{\Sigma_0}^{\Sigma_1}, |\pi_2|_{\Sigma_1}^{\Sigma_2}, \ldots, |\pi_n|_{\Sigma_{n-1}}^{\Sigma_n})$. Then:

Theorem 3 $\Sigma_0 \leq^\circ \Sigma_1 \leq^\circ \Sigma_2 \leq^\circ \ldots$ *is an increasing chain.*

So there is the limit class $|L| =_{df} \bigcup_{i=1}^{\infty} \hbar_{\Sigma_i}(L)$ for every class $L \in LC$

and for every object $o \in \mathbf{O}$, there is such t that $|o| =_{df} |o|^{\Sigma_t} = \bigcup_{i=1}^{t} |o|^{\Sigma_i}$.

Discussion/Conclusion

DP semantics has several distinctive properties:

- it represents the speaker's stance in which referential relations are presumed and facts are postulated,
- it is object-oriented,
- it expresses plurality-through-evidence computed through reactions to stimuli: only the entities witnessing facts in the discourse get to nominals' set-extension,
- it reduces verbal derivatives to the unique canonical form and interprets verbal circumstantials and nominal qualifiers as attribute value constraints (not as properties).

Discussion/Conclusion

Impact of the speaker's stance:

DP semantics treats references using constants and simulates co-reference using special functions and relations on contexts (in contrast with DRT-like semantics (cf. Heim'83, Kamp&Reyle'93,Muskens&Benthem&Visse'97), where references are treated as variables).

Predications are provided in the contexts with their signs. So the polynomial time model checking is possible, but it is not a part of DP semantics.

Renunciation of context consistency has far-reaching implications: in DP semantics, all objects are distinct, co-reference collapses to identity and the Leibniz's indiscernibles' identity principle underlying the extensionality, does not apply. This is why the dynamic DP semantics, which computes the contexts from the discourse, is incremental and polynomial time.

Discussion/Conclusion

Impact of the object-orientation:

DP semantics goes without quantifiers.

Creation of an object: $\gamma(\mathsf{x}) = o$ is an analog of $\exists$ (closer to the natural language "existence": *every entity mentioned in the discourse exists.*

$\mathbf{I}$ and $\mathbf{H}$ correspond to two different concepts of universal quantification. The individual $\mathbf{I}$ is close to $\forall$. The holistic $\mathbf{H}$ was always a problem to express in the traditional logical semantics. It allows to adequately express the meaning of noun phrases as in *John likes* $($*books*$)_{(\mathbf{H}\Downarrow^{\omega}_{\times} u) BOOK}$ and provides a holistic interpretation for mass nominals as in *He needs more* $($*water*$)_{\mathbf{H}\Downarrow^{0}_{\times} WATER}$.

It is due to this "quantifier-freeness" that the static DP semantics is fully compositional (DP-determiners are interpreted *in situ*, i.e. in verbals' argument positions).

Discussion/Conclusion

Extensions of objects being sets, the DP semantics expresses plurality.

- DP-determiners may introduce relations constraining objects in the extension of nominals. In this aspect, their expressive power is comparable with that of the generalized quantifiers formulas expressing plurality (cf. Keenan'96, Keenan&Westerståhl'97):

  EX: A DP for *At least three girls gave* $($*more roses than lilies*$)_{\mathbf{D}_c}$ *to John* may use a cumulative determiner:
  $\mathbf{D}_c = \left(\mathbf{H} \Downarrow^{\omega}_{\mathsf{x}} \left(\mathbf{H} \Downarrow^{\omega}_{\mathsf{y}} \text{ROSE}, \mathbf{H} \Downarrow^{\omega}_{\mathsf{z}} \text{LILIES}\right) (\mathbf{card}(\mathsf{y}) > \mathbf{card}(\mathsf{z}))\right)$.

  EX: Another DP for $(Lincoln)_{(\mathbf{H}\Downarrow^1_{\mathsf{x}} u)(\text{LINCOLN})_{\mathbf{sh}}}$ *was born in 1809.* $(This\ President)_{(\mathbf{H}\Downarrow^1_{\mathsf{y}\sim\mathsf{x}} v)\mathit{PRESIDENT}}$ *was a liberal* uses the *co-reference constraint* $\mathsf{x} \sim \mathsf{y}$ saying that the (different) objects $\gamma(\mathsf{x})$ and $\gamma(\mathsf{y})$ represent the same entity.

- On the other hand, due to the reactivation rule, the DP-semantics expresses an intuitionistic plurality-through-evidence.

Discussion/Conclusion

- Verbals' diatheses make DP very flexible and well adapted to the traditional linguistic semantical representations.
- Due to the interpretation of non-core arguments by constraints on attribute values, the semantical function-argument dependencies in DP semantics do not conflict with the natural surface syntactic dependencies:

  EX: In DP, attributor type semantemes are arguments of nominals, which reflects the surface dependency of modifiers on the modified nouns (cf. the conventional logical semantics, in which, quite the contrary, a nominal object is the argument of the property expressing a noun's modifier).

  This structural conformity has an exact form (Dikovsky'07): Syntactic categorial dependency grammar types and the surface WO may be generated from DP using finite tree transducers.