Semantic Modeling with Frames

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Introductory Course

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HEINRICH HEINE
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SFB 991

Part 4

Formal foundations: extensions

Frame semantics: extensions

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3. Try to retain the idea of minimal model building and consider **frame types** as proper entities of the model/universe.

Frame semantics: extensions

Attribute-value formulas with quantifiers (qAVForm)

$\forall\phi$, $\exists\phi$ ($\phi \in$ AVDesc)

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$\langle V, \mathcal{I}, g \rangle \vDash \forall\phi$ iff $\langle V, \mathcal{I}, g \rangle, v \vDash \phi$ for every $v \in V$

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Frame semantics: extensions

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For $x \notin \text{dom}(g)$ (= set of variables for which g is defined):

$\langle V, \mathcal{I}, g \rangle \vDash \boldsymbol{\forall} x\, \alpha$ iff $\langle V, \mathcal{I}, g' \rangle \vDash \alpha$ for every assignment g' with
$\text{dom}(g') = \text{dom}(g) \cup \{x\}$ and
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Note: $\forall\phi \;\equiv\; \boldsymbol{\forall} x(x \cdot \phi)$, $\exists\phi \;\equiv\; \boldsymbol{\exists} x(x \cdot \phi)$ (with x not occurring in ϕ)

Frame semantics: extensions

Examples

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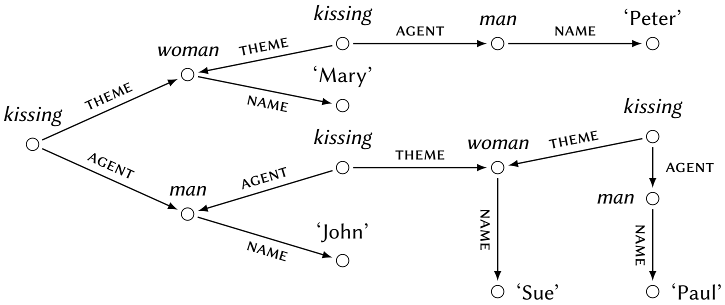

Frame semantics: extensions

Examples

(4) Every man walked into some house.

$$\forall x(x \cdot \mathit{man} \;\rightarrow\; \exists z(z \cdot \mathit{house} \;\wedge\; \exists(\mathit{locomotion} \;\wedge\; \textsc{manner} : \mathit{walking}$$
$$\wedge\; \textsc{actor} \triangleq x \;\wedge\; \textsc{mover} \doteq \textsc{actor}$$
$$\wedge\; \textsc{goal} \triangleq z \;\wedge\; \textsc{path} : (\mathit{path} \;\wedge\; \textsc{endp} : \mathit{region})$$
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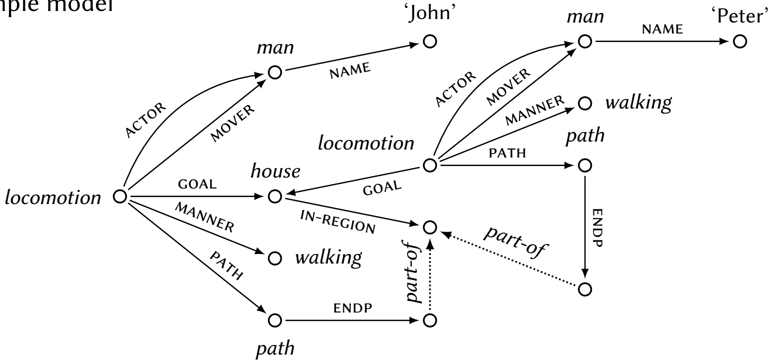
Example model

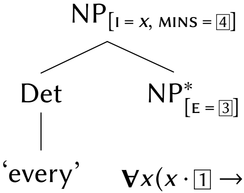


Frame semantics: extensions

An alternative approach to the syntax-semantics interface:

- elementary trees + frames $\rightsquigarrow$
  elementary trees + underspecified AV formulas with
  scope constraints
- unification of frames $\rightsquigarrow$ construction of AV formulas

Example



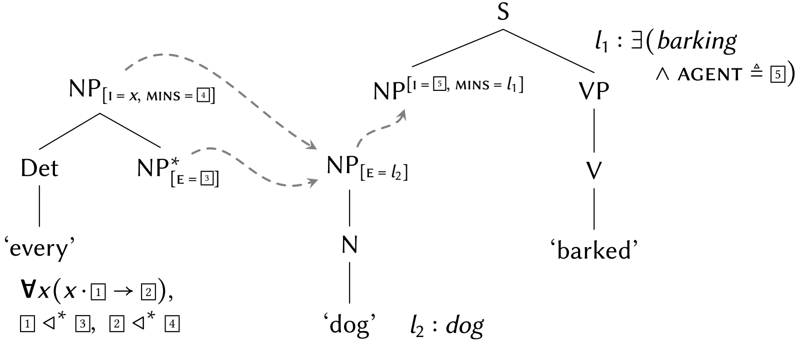
$\forall x(x \cdot \boxed{1} \rightarrow \boxed{2})$,
$\boxed{1} \lhd^* \boxed{3}$, $\boxed{2} \lhd^* \boxed{4}$

($h \lhd^* l$ means that expression l is a **subexpression** of h.)

Frame semantics: extensions

AV logic with quantifiers + underspecification (“hole semantics”)

(5) Every dog barked.



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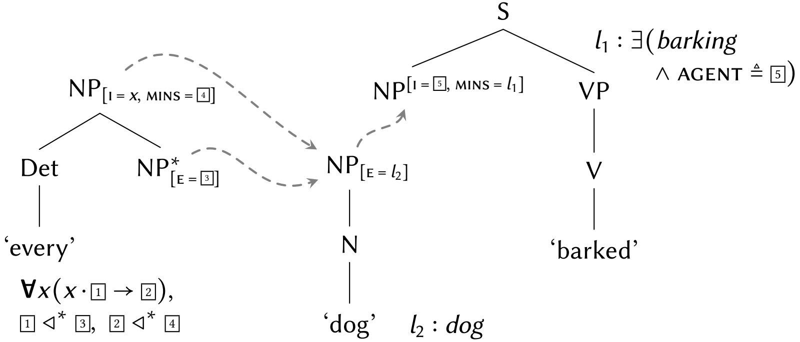

$\rightsquigarrow\ \forall x(x \cdot \boxed{1} \rightarrow \boxed{2}),\ l_2 : dog,\ l_1 : \exists(barking \wedge \text{AGENT} \triangleq x),\ \boxed{1} \triangleleft^{*} l_2,\ \boxed{2} \triangleleft^{*} l_1$

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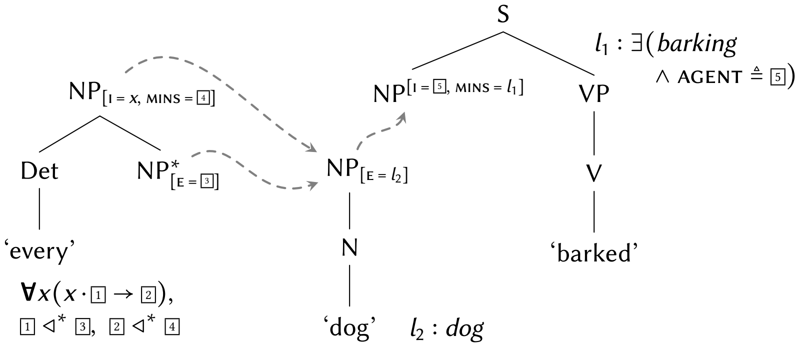

$\rightsquigarrow$ $\forall x(x \cdot [1] \rightarrow [2])$, $l_2 : dog$, $l_1 : \exists(barking \wedge \text{AGENT} \triangleq x)$, $[1] \triangleleft^* l_2$, $[2] \triangleleft^* l_1$

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Alternative: **Hybrid Logic** + **underspecification** ("hole semantics")

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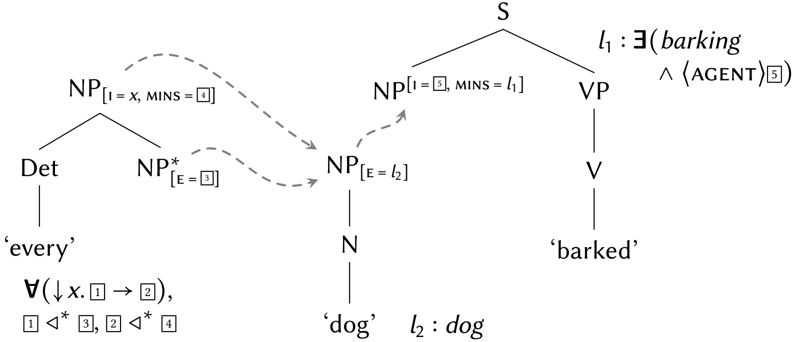

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[from Kallmeyer/Osswald/Pogodalla 2016]

Frame types (sketch)

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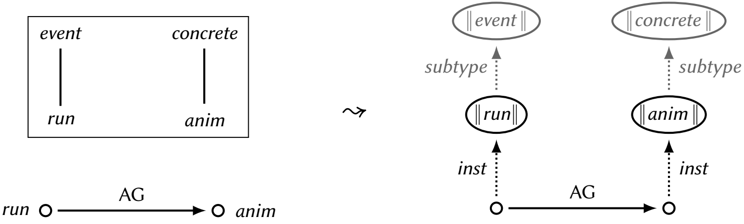
Types as elements of the universe/model



‖*event*‖, ‖*run*‖, etc.: type names (nominals)

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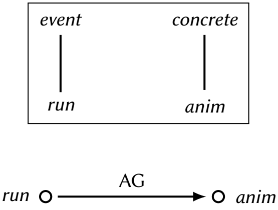
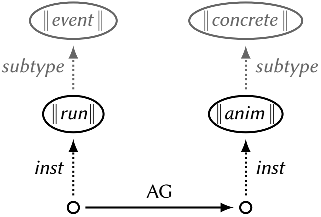


$\rightsquigarrow$

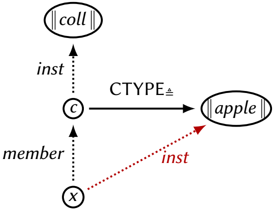


$\|event\|$, $\|run\|$, etc.: type names (nominals)

Types as values of attributes

Example: collections of elements of type T

$c \cdot \text{CTYPE} \triangleq T \wedge x \text{ member } c \rightarrow x \text{ inst } T$



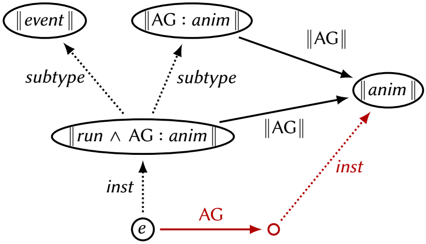
Frame types (sketch)

Complex frame types

Introduce **frame types** like $\|\textsc{p} : t\|$

Frame types can have (canonical) attributes, e.g., $\|\textsc{p} : t\| \cdot \|\textsc{p}\| \triangleq \|t\|$

$n \ \textit{inst} \ \|\textsc{p} : t\| \leftrightarrow n \cdot \textsc{p} \ \textit{inst} \ \|t\|$



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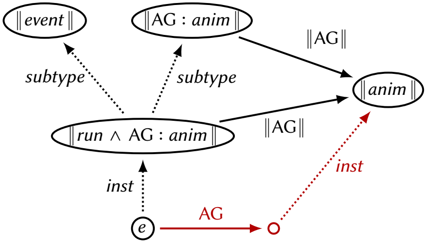
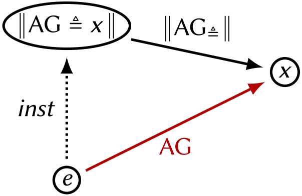


Dependent frame types

n *inst* $\|\text{P} \triangleq x\| \leftrightarrow n \cdot \text{P} \triangleq x$

($\|\text{P} \triangleq x\|$ frame type "dependent" on x)

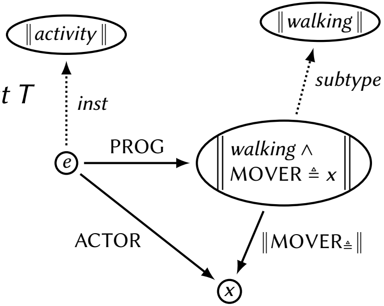


Frame types (sketch)

Example event progression

$$e \cdot \textsc{prog} \triangleq T \wedge e' \textit{ segment } e \rightarrow e' \textit{ inst } T$$

$$e\begin{bmatrix} \textit{activity} \\ \textsc{actor} \;\; x \\ \textsc{prog} \;\; \left\| \begin{bmatrix} \textit{walking} \\ \textsc{mover} \;\; x \end{bmatrix} \right\| \end{bmatrix}$$



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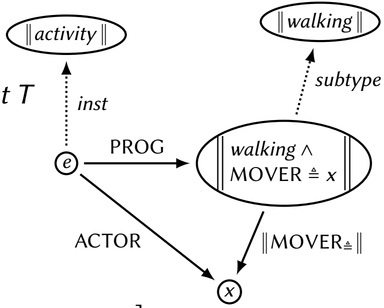

Example scalar change

$$\begin{bmatrix} \textit{progression} & \\ \text{ENTITY} & x \\ \text{PROG} & \left\| \begin{array}{l} \begin{bmatrix} \textit{incremental-change} & \\ \text{ENTITY} & x \\ \text{INITIAL} & \begin{bmatrix} \textit{stage} & \\ \text{ENTITY} & x \\ \text{LENGTH} & \boxed{0} \end{bmatrix} \\ \text{FINAL} & \begin{bmatrix} \textit{stage} & \\ \text{ENTITY} & x \\ \text{LENGTH} & \boxed{1} \end{bmatrix} \end{bmatrix} \\ \textit{lesser}(\boxed{1}, \boxed{0}) \end{array} \right\| \end{bmatrix}$$

Frame types (sketch)

Application atelic and telic interpretation of degree achievements

szárad (‘dry’)

$$
\begin{bmatrix}
\textit{progression} & \\
\textsc{entity} & x \\
\textsc{prog} & \left\| \begin{array}{l}
\begin{bmatrix}
\textit{incremental-change} & \\
\textsc{entity} & x \\
\textsc{init} & \begin{bmatrix} \textit{stage} & \\ \textsc{entity} & x \\ \textsc{moisture} & \boxed{1} \end{bmatrix} \\
\textsc{final} & \begin{bmatrix} \textit{stage} & \\ \textsc{entity} & x \\ \textsc{moisture} & \boxed{2} \end{bmatrix}
\end{bmatrix} \\
\textit{lesser}(\boxed{2}, \boxed{1})
\end{array} \right\|
\end{bmatrix}
$$

meg-szárad (‘dry’)

$$
\begin{bmatrix}
\textit{bounded-event} & \\
\textsc{entity} & x \\
\textsc{prog} & \left\| \begin{array}{l}
\begin{bmatrix}
\textit{incremental-change} & \\
\textsc{entity} & x \\
\textsc{init} & \begin{bmatrix} \textit{stage} & \\ \textsc{entity} & x \\ \textsc{moisture} & \boxed{1} \end{bmatrix} \\
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\end{bmatrix} \\
\textit{lesser}(\boxed{2}, \boxed{1})
\end{array} \right\| \\
\textsc{final} & \begin{bmatrix} \textit{stage} & \\ \textsc{entity} & x \\ \textsc{moisture} & \textit{zero} \end{bmatrix}
\end{bmatrix}
$$

$$\textsc{final} : \textit{stage} \;\wedge\; \textsc{prog}\ \|\textsc{final}\| \triangleq T \;\Rrightarrow\; \textsc{final}\ \textit{inst}\ T$$