Quantifiers in Frame Semantics

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Introduction

Frames are a representation format of conceptual and lexical knowledge.

They are commonly presented as semantic graphs with labelled nodes and edges where nodes correspond to entities (individuals, events, ...) and edges to (functional or non-functional) relations between these entities.
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Frames can be formalized as extended typed feature structures.
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Frames can be formalized as extended typed feature structures.

**Question:** How can we integrate quantification and negation into frames?
Introduction

Goal: A grammar architecture with

1. lexical meaning specifications in Frame Semantics; and
2. a truth-conditional sentential semantics with (generalized) quantifiers
3. an integration of standard approaches (hole semantics, normal dominance constraints) to scope underspecification
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2. a truth-conditional sentential semantics with (generalized) quantifiers
3. an integration of standard approaches (hole semantics, normal dominance constraints) to scope underspecification

Two approaches:

1. Integrating quantifiers into frames with a characterization of their scopal properties Kallmeyer & Richter (2014).
2. Moving from frames to descriptions of frames in a logic that allows to quantify over frame elements (recent joint work with Timm Lichte, Rainer Osswald, Sylvain Pogodalla and Christian Wurm).
A Lexicalized Tree Adjoining Grammar (LTAG, Joshi & Schabes (1997); Abeillé & Rambow (2000)): Finite set of elementary trees. Larger trees are derived via the tree composition operations substitution (replacing a leaf with a new tree) and adjunction (replacing an internal node with a new tree).
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LTAG and Frame Semantics

Syntax semantics interface Kallmeyer & Osswald (2013):

- Link a semantic representation to an entire elementary tree;
- model composition by unifications triggered by substitution and adjunction.
- Semantic representations: frames, expressed as typed feature structures
LTAG and Frame Semantics

Syntax semantics interface Kallmeyer & Osswald (2013):

- Link a semantic representation to an entire elementary tree;
- model composition by unifications triggered by substitution and adjunction.
- Semantic representations: frames, expressed as typed feature structures

```
S
  / \     /     / \   /
 NP_{i=1} VP NP_{i=2} NP_{i=4}
     \ /     \ /     \ /     \
  V  NP_{i=3}  \\
     /       \\
   John  \\
     /     \\
   person
```

---

Semantic representation example:

- **NP_{i=1}** (agent)
  - **NP_{i=3}** (theme)
    - **John**
  - **NP_{i=2}** (agent)
    - **eating**
      - **agent**
      - **theme**
  - **NP_{i=4}** (theme)
    - **pizza**
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Quantificational NPs

Ingredients:

- Quantifier frame types *every, most, two*, etc. capture the relation between the two arguments of binary quantifiers.
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- Quantifier frame: Attribute `RESTR` for the maximal type of objects that the natural language quantifier in question lives on.
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- Attributes \texttt{MAXS} and \texttt{MINS}: in logical terms, characterize the scope window of the quantifier.
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- Embedding of the quantifier frame in a predicate frame: expresses the semantic role of the syntactic constituent.
Quantificational NPs

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- Attributes `MAXS` and `MINS`: in logical terms, characterize the scope window of the quantifier.
- Embedding of the quantifier frame in a predicate frame: expresses the semantic role of the syntactic constituent
- Note: no scope, no interpretation, separate type system
Quantificational NPs

NP \[ I=0, \text{MAXS}=5, \text{MINS}=6 \]

\[ \text{Det} \quad \text{NP}^* [\text{PRED}=2] \]

\[ \text{every} \]

\[ \begin{array}{c}
\text{every} \\
\text{restr} \\
\text{maxs} \\
\text{mins}
\end{array} \]

\[ \begin{array}{c}
0 \\
2 \\
5 \\
6
\end{array} \]

\[ \text{NP}[I=7, \text{MAXS}=8, \text{MINS}=9] \]

\[ \text{NP}[\text{PRED}=10] \]

\[ \text{V} \]

\[ barked \]

\[ \text{N} \]

\[ \text{dog} \]

\[ \text{NP}[I=10, \text{MAXS}=10, \text{MINS}=10] \]

\[ \text{VP} \]

\[ \text{S} \]
Quantificational NPs

\[
\begin{align*}
\begin{bmatrix}
\text{barking} \\
\text{agent}
\end{bmatrix} & \quad \square \\
\begin{bmatrix}
\text{every} \\
\text{restr} & 2 \\
\text{maxs} & 5 \\
\text{mins} & 9
\end{bmatrix} & \quad \square \\
\begin{bmatrix}
\text{dog} \\
2
\end{bmatrix} =
\end{align*}
\]

\[
\begin{align*}
\begin{bmatrix}
\text{barking} \\
\text{agent}
\end{bmatrix} & \quad \square \\
\begin{bmatrix}
\text{every} \\
\text{restr} & 2 \\
\text{maxs} & 5 \\
\text{mins} & 9
\end{bmatrix}
\end{align*}
\]
Underspecified predicate-logical formula for the *barking* frame (dominance constraints in the style of Althaus et al. (2003); Koller et al. (1998)):

```
\[
\begin{align*}
  h_0 : & \quad \text{every} \\
  l_1 : & \quad \text{dog} \\
  l_0 : & \quad \text{barking}
\end{align*}
\]
Underspecified Representations of Truth conditions

Underspecified predicate-logical formula for the *barking* frame (dominance constraints in the style of Althaus et al. (2003); Koller et al. (1998)):

\[
\begin{align*}
  &h_0 \\
  &\vdash l_1 : \text{every} \\
  &\vdash x_1, h_{1,1}, h_{1,2} \\
  \vdash l_2 : \text{dog} &\quad \vdash l_0 : \text{barking} \\
  &\vdash x_1 \\
  &\vdash x_1
\end{align*}
\]

\[
\begin{align*}
  &l_0 : \text{barking}(x_1) \\
  &l_1 : \text{every}(x_1, h_{1,1}, h_{1,2}) \\
  &l_2 : \text{dog}(x_1) \\
  &h_0 \prec l_1, h_{1,1} \prec l_2, h_{1,2} \prec l_0 \\
\end{align*}
\]

Disambiguation:
\[
\begin{align*}
  &h_0 \rightarrow l_1, h_{1,1} \rightarrow l_2, h_{1,2} \rightarrow l_0
\end{align*}
\]
Underspecified Representations of Truth conditions

Task: read off underspecified predicate-logical formulas from frames:
Underspecified Representations of Truth conditions

Task: read off underspecified predicate-logical formulas from frames:

\[
\begin{align*}
&\text{pred} \quad \langle \text{arg}1 \rangle \quad \langle \text{arg}2 \rangle \\
&\quad \vdots
\end{align*}
\]

~

\[l_i : \text{pred}(x_j, x_k, \ldots)\]

with \text{pred} a subtype of \text{eventuality}

\[
\begin{align*}
&\text{quant} \quad \text{restr} \quad \langle \text{pred} \rangle \\
&\quad \text{maxs} \quad \langle \text{l} \rangle \\
&\quad \text{mins} \quad \langle \text{l} \rangle
\end{align*}
\]

~

\[l_i : \text{quant}(x_i, h_{i,1}, h_{i,2}), \quad l_j : \text{pred}(x_i), \quad h_k \triangleleft l_i, h_{i,1} \triangleleft l_j, h_{i,2} \triangleleft l_l \]

with \text{quant} a subtype of \text{generalized-quantifier} and \text{pred} a sub-type of \text{entity}
Underspecified Representations of Truth conditions

Result: underspecified dominance constraints for scope ambiguities

(1) Every boy loves two girls.

Disambiguations:
1. $h_0 \rightarrow l_1, h_{1,1} \rightarrow l_4, h_{1,2} \rightarrow l_3, h_{3,1} \rightarrow l_6, h_{3,2} \rightarrow l_0$
2. $h_0 \rightarrow l_3, h_{1,1} \rightarrow l_4, h_{1,2} \rightarrow l_0, h_{3,1} \rightarrow l_6, h_{3,2} \rightarrow l_1$
Adverbs and scope ambiguities

Case study:
Interaction of operator scope (adverb *again*) with rich structure of semantic frames

(2) Bilbo opened the door again. (ex. from Beck (2005))

Three readings:

a. Bilbo opened the door, and that had happened before. (repetitive reading)

b. Bilbo opened the door, and the door had been opened before.

c. Bilbo opened the door, and the door had been open before. (restitutive reading)
Adverbs and scope ambiguities

Semantics of open (Dowty (1979); Van Valin & LaPolla (1997); Van Valin (2005)):

\[(3) \ [\text{do}(x, \emptyset)] \ \text{CAUSE} \ [\text{INGR open}(y)]\]

Corresponding frame, following Kallmeyer & Osswald (2013); Osswald & Van Valin (2014):

<table>
<thead>
<tr>
<th>causation</th>
</tr>
</thead>
<tbody>
<tr>
<td>cause</td>
</tr>
<tr>
<td>activity</td>
</tr>
<tr>
<td>actor 1</td>
</tr>
<tr>
<td>ingr-of-state</td>
</tr>
<tr>
<td>theme 2</td>
</tr>
<tr>
<td>effect</td>
</tr>
<tr>
<td>result</td>
</tr>
<tr>
<td>state ^ open</td>
</tr>
<tr>
<td>patient 2</td>
</tr>
</tbody>
</table>
Adverbs and scope ambiguities

NP\textsubscript{I=2,MINS=0} \quad VP\textsubscript{E=0,MINS=5} \quad VP\textsubscript{*}[MINS=6,MAXS=7] \quad Adv

\begin{align*}
S & \\
NP & \rightarrow VP \rightarrow V \rightarrow NP \rightarrow V \rightarrow NP \\
V & \rightarrow opened \\
\text{cause} & \rightarrow \text{activity} \rightarrow \text{actor} \\
\text{effect} & \rightarrow \text{ingr-of-state} \rightarrow \text{theme} \\
\text{result} & \rightarrow \text{state} \land \text{open} \rightarrow \text{patient} \\
\text{repetition} & \rightarrow \text{maxs} \rightarrow \text{mins} \\
\text{again} & \rightarrow \\
\end{align*}
Adverbs and scope ambiguities

Frame:

```
causation
cause
0

activity
1
actor
2

ingr-state
4
theme
3

result
5

state\open

patient
3

repetition
8
maxs
7
mins
5
```
Adverbs and scope ambiguities

Frame:

- **causation**
  - cause
  - effect

- **activity**
  - actor

- **ingr-state**
  - theme
  - result

- **state\&open**
  - patient

- **repetition**
  - maxs
  - mins

Dominance constraints:

- $h_7 \cdot l_0 : causation$
- $l_8 : rep$
  - $l_1 : act.$
  - $l_4 : ingr-state$
- $l_5 : open$
  - $x_2$
  - $x_3 \cdot h_5$
  - $x_3$
  - $h_{8,1}$
Adverbs and scope ambiguities

Dominance constraints:

Disambiguations (minimal models of the dominance constraints):

1. repetition(causation(activity(x_2), ingr-state(x_3, open(x_3))))
2. causation(activity(x_2), repetition(ingr-state(x_3, open(x_3))))
3. causation(activity(x_2), ingr-state(x_3, repetition(open(x_3))))
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Hybrid logic for frames

Rel is a set of relational symbols, Prop a set of propositional variables, Nom a set of nominals, and Svar a set of state variables (Stat = Nom ∪ Svar).

The language of formulas is:

\[ \text{Forms} ::= \top \mid p \mid s \mid \neg \phi \mid \phi_1 \land \phi_2 \mid \langle R \rangle \phi \mid \exists \phi \mid @s\phi \mid \downarrow x.\phi \]

where \( p \in \text{Prop}, \ s \in \text{Stat}, \ R \in \text{Rel} \) and \( \phi, \phi_1, \phi_2 \in \text{Forms} \) (Areces & ten Cate (2007)).
Hybrid logic for frames

Rel is a set of relational symbols, Prop a set of propositional variables, Nom a set of nominals, and Svar a set of state variables (Stat = Nom ∪ Svar).

The language of formulas is:

\[
\text{Forms ::= } \top | p | s | \neg \phi | \phi_1 \land \phi_2 | \langle R \rangle \phi | \exists \phi | @_s \phi | \downarrow x. \phi
\]

where \( p \in \text{Prop}, s \in \text{Stat}, R \in \text{Rel} \) and \( \phi, \phi_1, \phi_2 \in \text{Forms} \) (Areces & ten Cate (2007)).

The truth of a formula is given with respect to a specific node \( w \) of a model \( M \) and some assignment \( g \) mapping Stat to the nodes in \( M \).

- \( \exists \phi \) is true in \( w \) if there exists a \( w' \) in \( M \) that makes \( \phi \) true.
- \( @_s \phi \) is true in \( w \) if \( \phi \) is true in the node assigned to \( s \), \( g(s) \).
- \( \downarrow x. \phi \) is true in \( w \) if \( \phi \) is true in \( w \) under the assignment \( g^x_w \).
Hybrid logic for frames

- $\langle \text{AGENT} \rangle \text{man}$ is for instance true at the *locomotion* node.
- $\exists \text{house}$ is true in any node.
- $\langle \text{PART-OF} \rangle \downarrow x.(\text{region} \land \exists (\text{house} \land \langle \text{AT-REGION} \rangle x))$ is true at the endpoint node of the path.
LTAG and hybrid logic

Idea:

- Pair each elementary tree with a set of underspecified HL formulas, which can contain holes and which can be labeled.
- Composition is then triggered by the syntactic unifications arising from substitution and adjunction.
LTAG and hybrid logic

\[ l_2 : \exists (barking \land \langle \text{AGENT}\rangle_4) \]

\[
\begin{aligned}
S & \quad \rightarrow \quad \text{VP} \\
& \quad \rightarrow \quad \text{NP}[\text{MINS} = l_2] \\
& \quad \rightarrow \quad \text{V} \\
& \quad \rightarrow \quad \text{barked} \\
NP & \quad \rightarrow \quad \text{NP}[\text{MINS} = l_1] \\
& \quad \rightarrow \quad \text{N} \\
& \quad \rightarrow \quad \text{dog} \\
\end{aligned}
\]

\[
\begin{aligned}
\text{every} & \quad \rightarrow \quad \text{NP}[\text{MINS} = 3] \\
& \quad \rightarrow \quad \text{ Det } \quad \rightarrow \quad \text{NP}[\text{MINS} = 2] \\
& \quad \rightarrow \quad \forall (\downarrow x.5 \rightarrow 6), \\
& \quad \rightarrow \quad 5 \triangleleft 2, \ 6 \triangleleft 3 \\
\end{aligned}
\]
LTAG and hybrid logic

\[
S \\
\quad \rightarrow \ NP_{\text{[MINS = } l_2]} \quad \rightarrow \ NP_{\text{[MINS = } l_1]} \\
\quad \rightarrow \ NP_{\text{[I=x, MINS = 3]}} \\
\quad \rightarrow \ Det \quad \rightarrow \ NP_{\text{[MINS = 2]}} \\
\quad \rightarrow \ every \\
\quad \rightarrow \ \forall (\downarrow x.5 \rightarrow 6), \\
\quad \rightarrow \ 5 \triangleleft^* 2, 6 \triangleleft^* 3 \\
\quad \rightarrow \ l_1 : \text{dog} \\
\quad \rightarrow \ l_2 : \exists (\text{barking} \land \langle \text{AGENT} \rangle x), \\
\quad \rightarrow \ 5 \triangleleft^* l_1, 6 \triangleleft^* l_2
\]
Atelicity and telicity and *for*-adverbials

(4) Bilbo swam for one hour

(5) Bilbo knocked at the door for ten minutes

- In (4), the verb denotes an activity and is thus immediately compatible with the *for*-adverbial.
- In (5), the verb denotes a punctual event, and, hence, calls for additional adjustments in order to be compatible with *for*-adverbials.

⇒ (5) is interpreted as describing a sequence or iteration of knockings.
Atelicity and telicity and *for*-adverbials

Semantics of *for*-adverbials following Champollion (2013):

\[(6) \; \lambda P \lambda I [\text{AT}(P, I) \land \text{hours}(I) = 1 \land \forall J [J \in R_{I}^{\text{short}(I)} \rightarrow \text{AT}(P, J)]]\]

In other words, a *for*-adverbial can only apply to an event *P* if we can fix a partition of the entire time interval such that in each of the smaller intervals, *P* holds as well.

- *swim* can be directly used as *P*.
- In the case of *knock*, one has to apply an iteration operator first (*knock*), and the result can then become the argument of (6).
Atelic events

\[ l_1 : 3, \]
\[ l_2 : 4, \]
\[ l_3 : \text{swimming} \]
\[ \land \langle \text{AGENT} \rangle 2, \]
\[ 3 \triangleleft^* l_2, 4 \triangleleft^* l_3 \]
\[ \text{Bilbo} \]
\[ \land \langle \text{NAME} \rangle \text{Bilbo} \]
\[ @_i \text{person} \]

\[ \text{NP}_{[1=2]} \]
\[ \text{VP}_{[p = l_3, \text{TOP} = 3]} \]
\[ \text{V} \]
\[ \text{swam} \]
\[ \text{VP}^*_{[p = 6, \text{TOP} = 0]} \]
\[ \text{PP} \]
\[ l_4 : \downarrow e.\text{progression} \text{ for one hour} \]
\[ \land \langle \text{DURATION} \rangle \text{one-hour} \]
\[ \land \forall (\langle \text{SEGMENT-OF} \rangle e \to 6), \]
\[ 0 \triangleleft^* l_4 \]
Atelic events

This yields the underspecified representation:

(7) \( @_i \text{person} \wedge \langle \text{NAME} \rangle \text{Bilbo}, \)
\( l_1 : \exists 3, \ l_2 : 4, \)
\( l_4 : \downarrow \text{e.progression} \wedge \langle \text{DURATION} \rangle \text{one-hour} \wedge \forall (\langle \text{SEGMENT-OF} \rangle e \rightarrow l_3), \)
\( l_3 : \text{swimming} \wedge \langle \text{AGENT} \rangle i, \)
\( 3 \triangleleft^* l_4, \ 3 \triangleleft^* l_2, \ 4 \triangleleft^* l_3 \)
Atelic events

This yields the underspecified representation:

(7) \( \Diamond_i \text{person} \land (\text{NAME}\; \text{Bilbo}) \),
\[
\begin{align*}
l_1 : & \; \exists 3, \; l_2 : 4, \\
l_4 : & \; e.\text{progression} \land (\text{DURATION}\; \text{one-hour} \land \forall(\langle \text{SEGMENT-OF} \rangle e \rightarrow l_3)), \\
l_3 : & \; \text{swimming} \land \langle \text{AGENT} \rangle i, \\
& \; 3 \prec l_4, \; 3 \prec l_2, \; 4 \prec l_3
\end{align*}
\]

After disambiguation, one obtains:

(8) \( \Diamond_i \text{person} \land (\text{NAME}\; \text{Bilbo}) \land \exists \downarrow e.(\text{progression} \land (\text{DURATION}\; \text{one-hour} \land \\
\forall(\langle \text{SEGMENT-OF} \rangle e \rightarrow \text{swimming} \land \langle \text{AGENT} \rangle i))) \)
Atelic events

This yields the underspecified representation:

(7) \( \bigcirc_i \text{person} \land \langle \text{NAME} \rangle \text{Bilbo}, \)
\[ l_1 : \exists [3], \ l_2 : 4, \]
\[ l_4 : \downarrow e. \text{progression} \land \langle \text{DURATION} \rangle \text{one-hour} \land \forall (\langle \text{SEGMENT-OF} \rangle e \rightarrow l_3), \]
\[ l_3 : \text{swimming} \land \langle \text{AGENT} \rangle i, \]
\[ 3 \triangleleft^* l_4, \ 3 \triangleleft^* l_2, \ 4 \triangleleft^* l_3 \]

After disambiguation, one obtains:

(8) \( \bigcirc_i \text{person} \land \langle \text{NAME} \rangle \text{Bilbo} \)
\[ \land \exists \downarrow e. (\text{progression} \land \langle \text{DURATION} \rangle \text{one-hour} \land \]
\[ \forall (\langle \text{SEGMENT-OF} \rangle e \rightarrow \text{swimming} \land \langle \text{AGENT} \rangle i)) \]

Additional constraint lifting \( P \) to the entire event:

(9) \( \forall (\downarrow e. \text{progression} \rightarrow \langle \text{SEGMENT-OF} \rangle e) \)
Punctual events

Accounting for (5):
We adopt a more general type *nq-event* which is a supertype of *progression* and *iteration* and which is intended to capture non-quantized event types in the sense of Krifka (1998).

\[
\forall (nq\text{-event} \leftrightarrow \text{iteration} \lor \text{progression}) \\
\forall (\text{iteration} \rightarrow \neg \text{progression})
\]
Punctual events

Accounting for (5):
We adopt a more general type \textit{nq-event} which is a supertype of \textit{progression} and \textit{iteration} and which is intended to capture \textit{non-quantized} event types in the sense of Krifka (1998).

\begin{align*}
(10) \quad & \forall (nq\text{-}event \leftrightarrow iteration \lor progression) \\
& \forall (iteration \rightarrow \neg progression)
\end{align*}

Additional constraints on iterations and progressions concerning the possible types of their segments:

\begin{align*}
(11) \quad & \forall (\langle \text{SEGMENT}-\text{OF} \rangle \text{iteration} \rightarrow \text{bounded}) \\
& \forall (\text{punctual} \rightarrow \text{bounded}) \\
& \forall (\langle \text{SEGMENT}-\text{OF} \rangle \text{progression} \rightarrow \neg \text{bounded})
\end{align*}
Punctual events

\[ l_1 : \exists [3], \]
\[ l_2 : knocking \land \langle \text{AGENT} \rangle [2] \land \langle \text{PATIENT} \rangle [4], \]
\[ 3 \triangleleft^* l_2 \]

\[ S \]
\[ \text{NP}[1=2] \quad \text{VP}_{p = l_2, \ top = 3} \]
\[ \text{NP}[1=i] \]
\[ \text{Bilbo} \]
\[ \land \langle \text{NAME} \rangle \text{Bilbo} \]
\[ \text{NP}[1=i] \]
\[ \text{knocked} \]
\[ \text{PP}[1=4] \]
\[ \text{VP}^*_{p = 6, \ top = 0} \]
\[ \text{VP} \]
\[ \text{PP} \]
\[ \text{VP}^*_{p = 6, \ top = 0} \]
\[ \text{for ten minutes} \]
\[ \text{NP}[1=i] \]
\[ \text{at the door} \]
\[ \text{PP}[1=j] \]
\[ \text{at the door} \]
\[ \text{PP}[1=j] \]
\[ \land \langle \text{DURATION} \rangle \text{ten-minutes} \]
\[ \land \forall(\langle \text{SEGMENT-OF} \rangle e \rightarrow 6) , \]
\[ 0 \triangleleft^* l_4 \]
Punctual events

Result:

(12) $\exists^3,\!
\begin{align*}
  l_2 & : \textit{knocking} \land \langle \textit{AGENT} \rangle i \land \langle \textit{PATIENT} \rangle j, \\
  l_4 & : \downarrow \textit{e.nq-event} \land \langle \textit{DURATION} \rangle \textit{ten-minutes} \land \forall (\langle \textit{SEGMENT-OF} \rangle e \rightarrow l_2), \\
  @_i \langle \textit{person} \land \langle \textit{NAME} \rangle \textit{Bilbo} \rangle, \\
  @_j \textit{door}, \\
  3 \triangleleft^* l_2, 3 \triangleleft^* l_4
\end{align*}$
Punctual events

Result:

(12) $\exists^{3}$,

\[ l_2 : knocking \land \langle AGENT \rangle i \land \langle PATIENT \rangle j, \]
\[ l_4 : \downarrow e.nq-event \land \langle DURATION \rangle ten-minutes \land \forall (\langle SEGMENT-OF \rangle e \rightarrow l_2), \]
\[ @i(person \land \langle NAME \rangle Bilbo), \]
\[ @j door, \]
\[ 3 \ll^* l_2, 3 \ll^* l_4 \]

After disambiguation:

(13) $\exists (\downarrow e.nq-event \land \langle DURATION \rangle ten-minutes$
\[ \land \forall (\langle SEGMENT-OF \rangle e \rightarrow knocking \land \langle AGENT \rangle i \land \langle PATIENT \rangle j) \)
\[ \land @i(person \land \langle NAME \rangle Bilbo) \land @j door \]
Punctual events

Result:

\[(12) \exists [3],\]
\[\begin{align*}
  &l_2 : knocking \land \langle \text{AGENT} \rangle i \land \langle \text{PATIENT} \rangle j, \\
  &l_4 : \downarrow e.nq-event \land \langle \text{DURATION} \rangle ten-minutes \land \forall (\langle \text{SEGMENT-OF} \rangle e \rightarrow l_2), \\
  &\forall i (person \land \langle \text{NAME} \rangle \text{Bilbo}), \\
  &\forall j (\text{door}), \\
  &3 \triangleleft^* l_2, 3 \triangleleft^* l_4
\end{align*}\]

After disambiguation:

\[(13) \exists (\downarrow e.nq-event \land \langle \text{DURATION} \rangle ten-minutes \\
  \land \forall (\langle \text{SEGMENT-OF} \rangle e \rightarrow knocking \land \langle \text{AGENT} \rangle i \land \langle \text{PATIENT} \rangle j)) \\
  \land \forall i (person \land \langle \text{NAME} \rangle \text{Bilbo}) \land \forall j (\text{door})\]

With our constraints, \( e \) in (13) is necessarily of type iteration.
Outline

1. Introduction
   - Motivation
   - LTAG and Frame Semantics

2. Approach 1: Integrating quantifiers into frames
   - Frames for quantificational NPs
   - Truth conditions and underspecification
   - Adverbs and scope ambiguities

3. Approach 2: Using hybrid logic for quantification over frame elements
   - Hybrid logic for frames
   - LTAG and hybrid logic
   - For-adverbials and atelic/telic events

4. Conclusion
Approach 1 (Kallmeyer & Richter (2014))

- adds quantifier frames to Frame Semantics
- defines translation from frames to underspecified semantic representations
Conclusion

Approach 1 (Kallmeyer & Richter (2014))

- adds quantifier frames to Frame Semantics
- defines translation from frames to underspecified semantic representations
- grammar architecture: LTAG comprising Frame Semantics with fine-grained lexical decompositions of situations as frames
- supports a well-defined logical semantics with quantificational and intensional operators
Approach 2 (Kallmeyer, Lichte, Osswald, Pogodalla, Wurm)

- takes frames to be our representations of the world
- uses a hybrid logic in order to talk about frames
Conclusion

Approach 2 (Kallmeyer, Lichte, Osswald, Pogodalla, Wurm)

- takes frames to be our representations of the world
- uses a hybrid logic in order to talk about frames
- the hybrid logic allows quantification over subevents
- the constraints one can formulate concerning frame types allow to account for the behaviour of *for*-adverbials
- underspecification of types and of immediate dominance in the formula allow in particular an analysis without an explicite iteration operator
- consequently, in (5) the events that *for* quantifies over are single knockings while the entire event is an iteration
Conclusion

(14) every student in the room talked

Question: how do we picture the situation described in (14)?
Conclusion

(14) every student in the room talked

Question: how do we picture the situation described in (14)?

Approach 1:
(14) every student in the room talked

Question: how do we picture the situation described in (14)?

Approach 1:

```
student
```

Approach 2:

```
student student student student student student
```

```
talking talking talking talking talking talking
```

```
AGENT AGENT AGENT AGENT AGENT
```

```
```
Conclusion

Question: What is the status of the frames?

Approach 1: Truth conditions are read off the frame, i.e., the frame is constructed first. The frame is supposed to be a conceptual representation that leaves the exact truth conditions underspecified.

Approach 2: The frame is the model. First, truth conditions (HL formulas) are constructed that are then evaluated on the frame. The HL formula is underspecified; it specifies a class of possible frames as its models.


