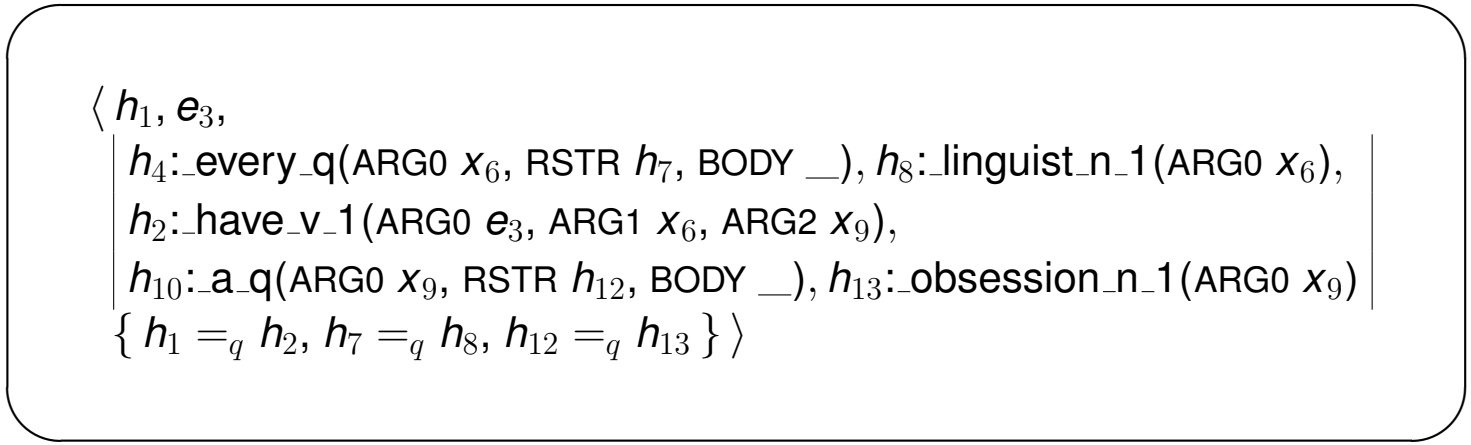


Taking (Out) Scope

On the History of Scope Underspecification and its Use to Date

Jan Tore Lønning & Stephan Oepen

Department of Informatics, University of Oslo

From Logical Forms to Dependency Graphs

$\langle\, h_1, e_3,$
$\quad \big| \; h_4$:_every_q(ARG0 x_6, RSTR h_7, BODY _), h_8:_linguist_n_1(ARG0 x_6),
$\quad\; h_2$:_have_v_1(ARG0 e_3, ARG1 x_6, ARG2 x_9),
$\quad\; h_{10}$:_a_q(ARG0 x_9, RSTR h_{12}, BODY _), h_{13}:_obsession_n_1(ARG0 x_9) $\big|$
$\quad \{\, h_1 =_q h_2,\ h_7 =_q h_8,\ h_{12} =_q h_{13} \,\} \,\rangle$

EDS: Elementary Depedency Structures (Oepen et al., 2002)

- Eliminate logical variables: one graph node for each elementary predication;
- relation names (predicate constants) become node labels, e.g. _have_v_1;
- node identities determined by *distinguished variable*; except for quantifiers;
- one dependency edge for each instantiated argument role (excluding ARG0);
- dependency target determined by argument variable; view $=_q$ as equations.

Conversion Result for Our Running Example

$\langle\, h_1, e_3,$
$\quad \lvert\, h_4$:_every_q(ARG0 x_6, RSTR h_7, BODY __), h_8:_linguist_n_1(ARG0 x_6),
$\quad\ \ h_2$:_have_v_1(ARG0 e_3, ARG1 x_6, ARG2 x_9),
$\quad\ \ h_{10}$:_a_q(ARG0 x_9, RSTR h_{12}, BODY __), h_{13}:_obsession_n_1(ARG0 x_9) $\rvert$
$\quad \{\, h_1 =_q h_2,\ h_7 =_q h_8,\ h_{12} =_q h_{13} \,\} \,\rangle$

Conversion Result for Our Running Example

$\langle\, h_1, e_3,$
$\quad | \; h_4$:_every_q(ARG0 x_6, RSTR h_7, BODY __), h_8:_linguist_n_1(ARG0 x_6),
$\quad\;\; h_2$:_have_v_1(ARG0 e_3, ARG1 x_6, ARG2 x_9),
$\quad\;\; h_{10}$:_a_q(ARG0 x_9, RSTR h_{12}, BODY __), h_{13}:_obsession_n_1(ARG0 x_9) $|$
$\quad \{\, h_1 =_q h_2,\, h_7 =_q h_8,\, h_{12} =_q h_{13} \,\} \,\rangle$

$\{\, e_3$
$\quad$ _1:_every_q(BV x_6)
$\quad$ x_6:_linguist_n_1
$\quad$ e_3:_have_v_1(ARG1 x_6, ARG2 x_9)
$\quad$ _2:_a_q(BV x_9)
$\quad$ x_9:_obsession_n_1
$\}$

Conversion Result for Our Running Example

$\langle\, h_1, e_3,$
$\quad | \; h_4$:_every_q(ARG0 x_6, RSTR h_7, BODY __), h_8:_linguist_n_1(ARG0 x_6),
$\quad h_2$:_have_v_1(ARG0 e_3, ARG1 x_6, ARG2 x_9),
$\quad h_{10}$:_a_q(ARG0 x_9, RSTR h_{12}, BODY __), h_{13}:_obsession_n_1(ARG0 x_9) $|$
$\quad \{\, h_1 =_q h_2, h_7 =_q h_8, h_{12} =_q h_{13} \,\} \,\rangle$

$\{$ $_3$
$\quad _1$:_every_q(BV $_2$)
$\quad _2$:_linguist_n_1
$\quad _3$:_have_v_1(ARG1 $_2$, ARG2 $_5$)
$\quad _4$:_a_q(BV $_5$)
$\quad _5$:_obsession_n_1
$\}$

Conversion Result for Our Running Example

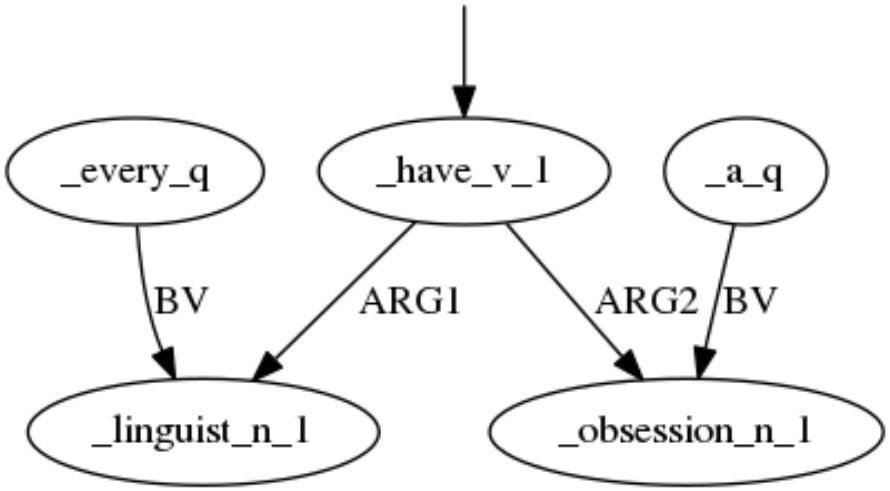
$\langle\, h_1, e_3,$
$\quad \lvert\, h_4$:_every_q(ARG0 x_6, RSTR h_7, BODY _), h_8:_linguist_n_1(ARG0 x_6),
$\quad h_2$:_have_v_1(ARG0 e_3, ARG1 x_6, ARG2 x_9),
$\quad h_{10}$:_a_q(ARG0 x_9, RSTR h_{12}, BODY _), h_{13}:_obsession_n_1(ARG0 x_9) $\rvert$
$\quad \{\, h_1 =_q h_2,\ h_7 =_q h_8,\ h_{12} =_q h_{13} \,\} \,\rangle$

$\{\, e_3$
$\quad _1$:_every_q(BV x_6)
$\quad x_6$:_linguist_n_1
$\quad e_3$:_have_v_1(ARG1 x_6, ARG2 x_9)
$\quad _2$:_a_q(BV x_9)
$\quad x_9$:_obsession_n_1
$\}$

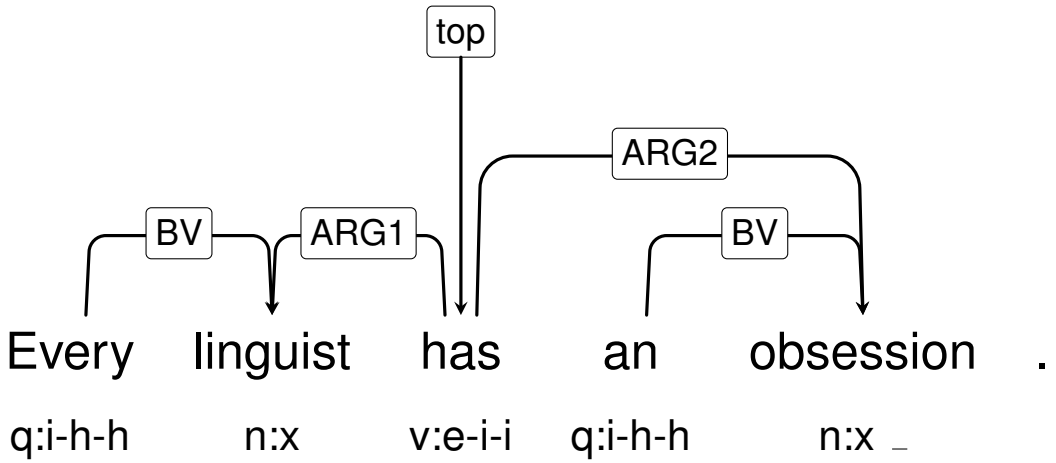
```
(e3 / _have_v_1
 :ARG1 (x6 / _linguist_n_1 :BV-of (_1 / _every_q))
 :ARG2 (x9 / _obsession_n_1 :BV-of (_2 / _a_q)))
```

Conversion Result for Our Running Example

$\langle\, h_1, e_3,$
$\quad \big| \; h_4$:_every_q(ARG0 x_6, RSTR h_7, BODY __), h_8:_linguist_n_1(ARG0 x_6),
$\quad\; h_2$:_have_v_1(ARG0 e_3, ARG1 x_6, ARG2 x_9),
$\quad\; h_{10}$:_a_q(ARG0 x_9, RSTR h_{12}, BODY __), h_{13}:_obsession_n_1(ARG0 x_9) $\big|$
$\quad \{\, h_1 =_q h_2,\ h_7 =_q h_8,\ h_{12} =_q h_{13} \,\} \,\rangle$



Aside: Further Reduction to Bi-Lexical Dependencies



Ivanova et al. (2012): DELPH-IN MRS-Derived Dependencies (DM)

- Lossy reduction of EDS graph: only surface tokens available as nodes;
- (some) construction semantics as edge labels; coarse argument frames;
- argument sharing: graph re-entrancies; vacuous words: unattached nodes;
- designated *top* node (not root): semantic head, highest-scoping predicate.

Argument Disambiguation for Shared Labels

I saw Kim run very quickly.

$\langle\, h_1, e_3,$
h_4:pron(ARG0 x_5), h_6:pronoun_q(ARG0 x_5, RSTR h_7, BODY __),
h_2:_see_v_1(ARG0 e_3, ARG1 x_5, ARG2 h_9),
h_{10}:proper_q(ARG0 x_{12}, RSTR h_{11}, BODY __), h_{14}:named(ARG0 x_{12}, CARG *Kim*),
h_{15}:_run_v_1(ARG0 e_{16}, ARG1 x_{12}),
h_{15}:_very_x_deg(ARG0 e_{17}, ARG1 e_{18}), h_{15}:_quick_a_1(ARG0 e_{18}, ARG1 e_{16})
$\{\, h_1 =_q h_2,\ h_7 =_q h_4,\ h_9 =_q h_{15},\ h_{11} =_q h_{14} \,\}\, \rangle$

- Multiple predications can share their label, e.g. in non-scopal modification;

→ What should be ARG2 on _see_v_1 node? Intuitively, the 'main' predication.

- structural disambiguation heuristics: *semantic head* as the core concept.

EDS: Argument Disambiguation for Shared Labels

I saw Kim run very quickly.

$\{\ e_3$
x_5:pron
$\_1$:pronoun_q(BV x_5)
e_3:_see_v_1(ARG1 x_5, ARG2 e_{16})
$\_2$:proper_q(BV x_{12})
x_{12}:named(Kim)
e_{16}:_run_v_1(ARG1 x_{12})
e_{17}:_very_x_deg(ARG1 e_{18})
e_{18}:_quick_a_1(ARG1 e_{16})
$\}$

Non-Scopal Modification vs. Predicative Use

I believe that the angry dog is fierce.

$$\langle\, h_1, e_3,$$
$$\left|\begin{array}{l} h_4{:}\mathsf{pron}(\mathsf{ARG0}\ x_5),\ h_6{:}\mathsf{pronoun\_q}(\mathsf{ARG0}\ x_5,\ \mathsf{RSTR}\ h_7,\ \mathsf{BODY}\ \_), \\ h_2{:}\mathsf{\_believe\_v\_1}(\mathsf{ARG0}\ e_3,\ \mathsf{ARG1}\ x_5,\ \mathsf{ARG2}\ h_9), \\ h_{10}{:}\mathsf{\_the\_q}(\mathsf{ARG0}\ x_{12},\ \mathsf{RSTR}\ h_{13},\ \mathsf{BODY}\ \_),\ h_{14}{:}\mathsf{\_dog\_n\_1}(\mathsf{ARG0}\ x_{12}), \\ h_{14}{:}\mathsf{\_angry\_a\_at}(\mathsf{ARG0}\ e_{15},\ \mathsf{ARG1}\ x_{12},\ \mathsf{ARG2}\ \_), \\ h_{17}{:}\mathsf{\_fierce\_a\_1}(\mathsf{ARG0}\ e_{18},\ \mathsf{ARG1}\ x_{12}) \end{array}\right|$$
$$\{\, h_1 =_q h_2,\ h_7 =_q h_4,\ h_9 =_q h_{17},\ h_{13} =_q h_{14} \,\} \,\rangle$$

Non-Scopal Modification

- Non-scopal modifiers ‘conjoin’ (in terms of scope position) with their head;
- e.g. attributive adjectives, prepositional phrase modifiers, relative clauses.

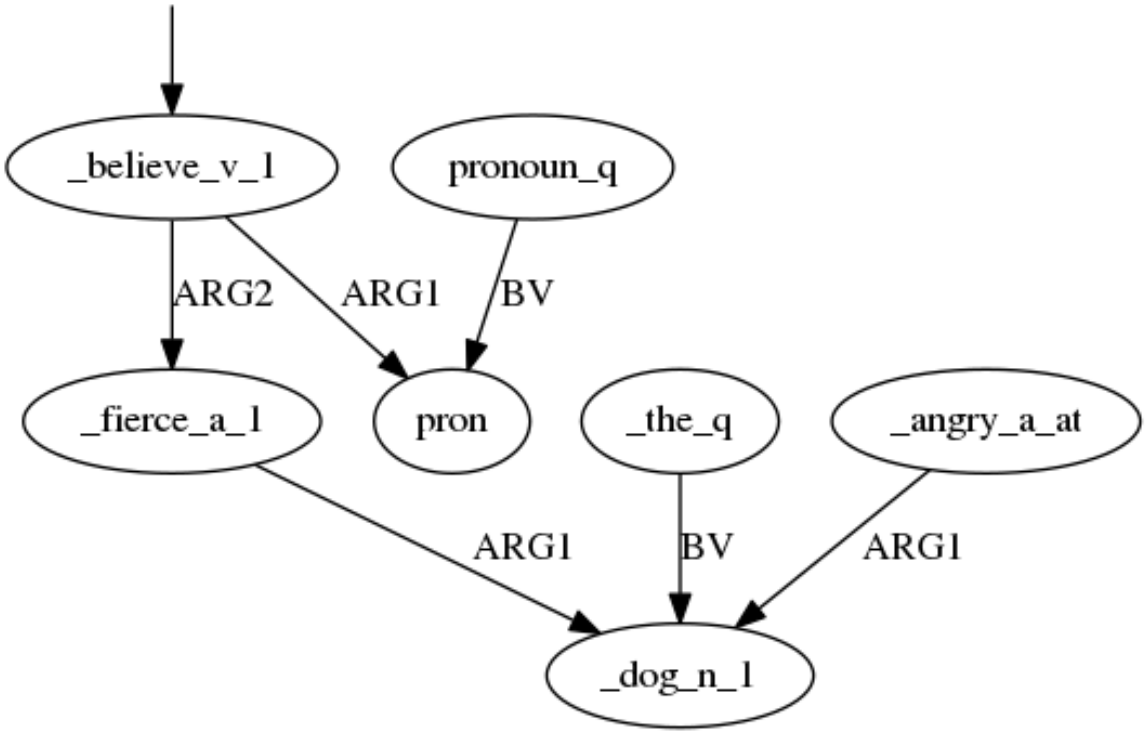
EDS: Non-Scopal Modification vs. Predicative Use

I believe that the angry dog is fierce.

{ e_3
  x_5:pron
  $\_1$:pronoun_q(BV x_5)
  e_3:_believe_v_1(ARG1 x_5, ARG2 e_{18})
  $\_2$:_the_q(BV x_{12})
  e_{15}:_angry_a_at(ARG1 x_{12})
  x_{12}:_dog_n_1
  e_{18}:_fierce_a_1(ARG1 x_{12})
}

EDS: Non-Scopal Modification vs. Predicative Use

I believe that the angry dog is fierce.



‘Radical Reification’ of Scopal Arguments

I saw that Kim didn’t run very quickly.

$\langle\, h_1, e_3,$
h_4:pron(ARG0 x_5), h_6:pronoun_q(ARG0 x_5, RSTR h_7, BODY __),
h_2:_see_v_1(ARG0 e_3, ARG1 x_5, ARG2 h_9),
h_{10}:proper_q(ARG0 x_{12}, RSTR h_{11}, BODY __), h_{14}:named(ARG0 x_{12}, CARG *Kim*),
h_{15}:neg(ARG0 e_{17}, ARG1 h_{16}), h_{18}:_run_v_1(ARG0 e_{19}, ARG1 x_{12}),
h_{18}:_very_x_deg(ARG0 e_{20}, ARG1 e_{21}),
h_{18}:_quick_a_1(ARG0 e_{21}, ARG1 e_{19})
$\{\, h_1 =_q h_2,\ h_7 =_q h_4,\ h_9 =_q h_{15},\ h_{11} =_q h_{14},\ h_{16} =_q h_{18} \,\}\, \rangle$

- ‘Propositional’ arguments always treated as scopal, introduced by $=_q$;
- eventualities as ‘direct’ arguments only with non-scopal modification.

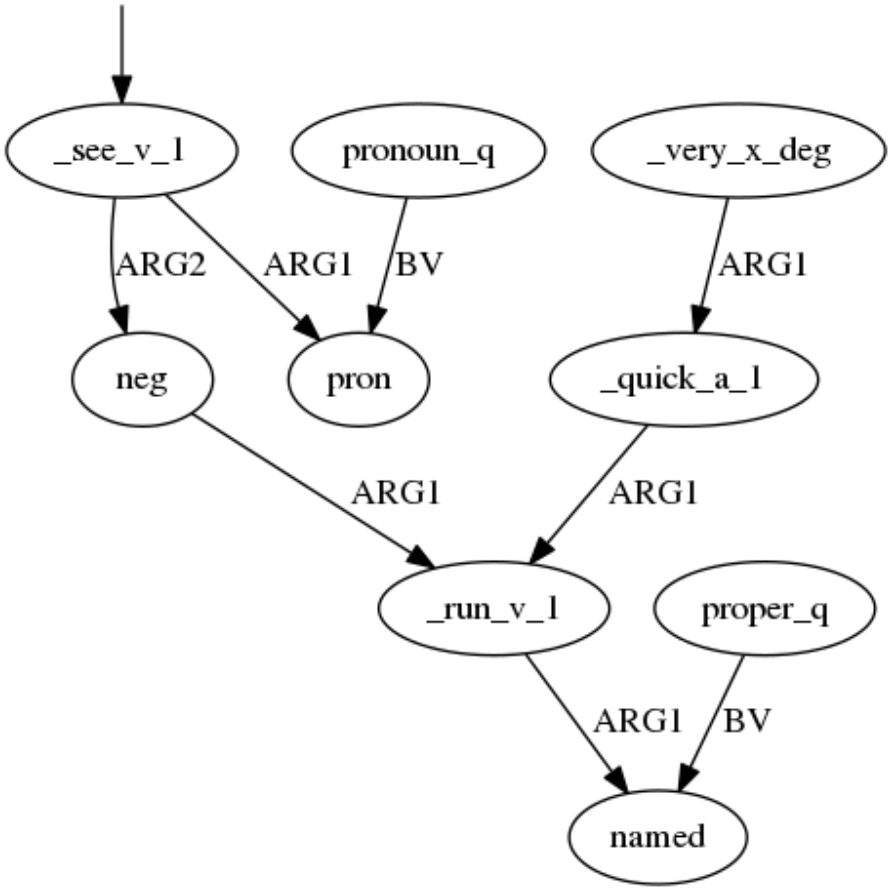
EDS: ‘Radical Reification’ of Scopal Arguments

I saw that Kim didn’t run very quickly.

$\{ e_3$
x_5:pron
$\_1$:pronoun_q(BV x_5)
e_3:_see_v_1(ARG1 x_5, ARG2 e_{17})
$\_2$:proper_q(BV x_{12})
x_{12}:named(Kim)
e_{17}:neg(ARG1 e_{19})
e_{19}:_run_v_1(ARG1 x_{12})
e_{20}:_very_x_deg(ARG1 e_{21})
e_{21}:_quick_a_1(ARG1 e_{19})
$\}$

EDS: ‘Radical Reification’ of Scopal Arguments

I saw that Kim didn’t run very quickly.



Interim Summary: Information Lost in Conversion

Label Equalities

- Logical conjunction of groups of predications (aka non-scopal modification);

$\rightarrow$ need to distinguish non-scopal modifiers from other types of predications.

Interim Summary: Information Lost in Conversion

Label Equalities

- Logical conjunction of groups of predications (aka non-scopal modification);

$\rightarrow$ need to distinguish non-scopal modifiers from other types of predications.

Scopal vs. Non-Scopal Arguments

- Distinction between argument types: logical variables vs. handles (and $=_q$);
- should be formally distinguished, but ERG uses polymorphous predicates;

$\rightarrow$ need to distinguish scopal vs. non-scopal argument positions (eventualities).

Interim Summary: Information Lost in Conversion

Label Equalities

- Logical conjunction of groups of predications (aka non-scopal modification);

$\rightarrow$ need to distinguish non-scopal modifiers from other types of predications.

Scopal vs. Non-Scopal Arguments

- Distinction between argument types: logical variables vs. handles (and $=_q$);
- should be formally distinguished, but ERG uses polymorphous predicates;

$\rightarrow$ need to distinguish scopal vs. non-scopal argument positions (eventualities).

Quantifiers and Their Restriction

- 'Dual' relation in MRS: ARG0 (instance variable) and RSTR (handle and $=_q$);

$\rightarrow$ highly schematic: RSTR always $=_q$ to label of nominal head; BODY unbound.

Interim Summary: Information Lost in Conversion

Contrasting EDS and DMRS

$\{\ e_3$
$\quad \_1$:_the_q(BV x_6)
$\quad e_9$:_angry_a_at(ARG1 x_6)
$\quad x_6$:_dog_n_1
$\quad e_3$:_fierce_a_1(ARG1 x_6)
$\}$

$\{\ e_3$
$\quad \_1$:_the_q(RSTR/H x_6)
$\quad e_9$:_angry_a_at(ARG1/EQ x_6)
$\quad x_6$:_dog_n_1
$\quad e_3$:_fierce_a_1(ARG1/NEQ x_6)
$\}$

- Copestake (2009) extends EDS with an information 'overlay' on edges;
- record label equalities and mark scopal (handle-mediated) arguments;
- sometimes adds new, undirected 'overlay-only' edges for label equality.

Interim Summary: Information Lost in Conversion

Contrasting EDS and DMRS

{ e_3
  _1:_the_q(BV x_6)
  e_9:_angry_a_at(ARG1 x_6)
  x_6:_dog_n_1
  e_3:_fierce_a_1(ARG1 x_6)
}

{ e_3
  _1:_the_q(RSTR/H x_6)
  e_9:_angry_a_at(ARG1/EQ x_6)
  x_6:_dog_n_1
  e_3:_fierce_a_1(ARG1/NEQ x_6)
}

- Copestake (2008) extends EDS with an information 'overlay' on edges;
- record label equalities and mark scopal (handle-mediated) arguments;
- sometimes adds new, undirected 'overlay-only' edges for label equality.

→ clever extension, but at increased formal and conceptual complexity.

Rediscovering Scope Underspecification

I saw that Kim didn't run very quickly.

$\{ e_3$
x_5:pron
$\_1$:pronoun_q(BV x_5)
e_3:_see_v_1(ARG1 x_5, ARG2 e_{17})
$\_2$:proper_q(BV x_{12})
x_{12}:named(Kim)
e_{17}:neg(ARG1 e_{19})
e_{19}:_run_v_1(ARG1 x_{12})
e_{20}:_very_x_deg(ARG1 e_{21})
e_{21}:_quick_a_1(ARG1 e_{19})
$\}$

Rediscovering Scope Underspecification

I saw that Kim didn't run very quickly.

$\{ e_3$
x_5:pron
$\_1$:pronoun_q(BV x_5)
e_3:_see_v_1(ARG1 x_5, ARG2 e_{17})
$\_2$:proper_q(BV x_{12})
x_{12}:named(Kim)
e_{17}:neg(ARG1 e_{19})
e_{19}:_run_v_1(ARG1 x_{12})
e_{20}:_very_x_deg(ARG1 e_{21})
e_{21}:_quick_a_1(ARG1 e_{19})
$\}$

Rediscovering Scope Underspecification

I saw that Kim didn't run very quickly.

{ e_3
  x_5:pron
  $\_1$:pronoun_q(BV x_5)
  e_3:_see_v_1(ARG1 x_5, ARG2 e_{17})
  $\_2$:proper_q(BV x_{12})
  x_{12}:named(Kim)
  e_{17}:neg(ARG1 e_{19})
  e_{19}:_run_v_1(ARG1 x_{12})
  e_{20}:_very_x_deg(ARG1 e_{21})
  e_{21}:_quick_a_1(ARG1 e_{19})
}

Rediscovering Scope Underspecification

I saw that Kim didn't run very quickly.

$\{\ e_3$
x_5:pron
$\_1$:pronoun_q(BV x_5)
e_3:_see_v_1(ARG1 x_5, ARG2 e_{17})
$\_2$:proper_q(BV x_{12})
x_{12}:named(Kim)
e_{17}:neg(ARG1 e_{19})
e_{19}:_run_v_1(ARG1 x_{12})
e_{20}:_very_x_deg(ARG1 e_{21})
e_{21}:_quick_a_1(ARG1 e_{19})
$\}$

Rediscovering Scope Underspecification

I saw that Kim didn't run very quickly.

$\{ e_3$
x_5:pron
$\_1$:pronoun_q(BV x_5)
e_3:_see_v_1(ARG1 x_5, ARG2 e_{17})
$\_2$:proper_q(BV x_{12})
x_{12}:named(Kim)
e_{17}:neg(ARG1 e_{19})
e_{19}:_run_v_1(ARG1 x_{12})
e_{20}:_very_x_deg(ARG1 e_{21})
e_{21}:_quick_a_1(ARG1 e_{19})
$\}$

Rediscovering Scope Underspecification

I saw that Kim didn't run very quickly.

$\{ e_3$
x_5:pron
$\_1$:pronoun_q(BV x_5)
e_3:_see_v_1(ARG1 x_5, ARG2 e_{17})
$\_2$:proper_q(BV x_{12})
x_{12}:named(Kim)
e_{17}:neg(ARG1 e_{19})
e_{19}:_run_v_1(ARG1 x_{12})
e_{20}:_very_x_deg(ARG1 e_{21})
e_{21}:_quick_a_1(ARG1 e_{19})
$\}$

Rediscovering Scope Underspecification

I saw that Kim didn't run very quickly.

$\{ e_3$
x_5:pron
$\_1$:pronoun_q(BV x_5)
e_3:_see_v_1(ARG1 x_5, ARG2 e_{17})
$\_2$:proper_q(BV x_{12})
x_{12}:named(Kim)
e_{17}:neg(ARG1 e_{19})
e_{19}:_run_v_1(ARG1 x_{12})
e_{20}:_very_x_deg(ARG1 e_{21})
e_{21}:_quick_a_1(ARG1 e_{19})
$\}$

Walking the 'Spine': A Deterministic Procedure

'General' (Framework-Specific) Assumptions

- Eventualities as arguments only to non-scopal modifiers; otherwise *scopal*;
- (almost) all scopal arguments subordinated by own $=_q$ handle constraint;
- quantifiers bind ($=_q$) their RSTR to label of 'nominal'; leave BODY unbound.

EDS to MRS: The Basic Procedure

- Trivially transform the input EDS into a (not well-formed) 'skeletal' MRS;
- 'walk' the graph: determine *spine* as set of nodes reachable from the top;
- introduce scopal sub-ordination ($=_q$) for eventualities in argument position;
- non-scopal modifiers 'hang off' the spine: take spinal nodes as arguments;
- introduce label equalities for the non-scopal modifiers $\rightarrow$ recursely restart.

Scopal Sub-Ordination of Non-Scopal Modifiers

The dog that didn't bark is fierce.

$\{\ e_3$
$\quad \_1$:_the_q(BV x_6)
$\quad x_6$:_dog_n_1
$\quad e_{10}$:neg(ARG1 e_{12})
$\quad e_{12}$:_bark_v_1(ARG1 x_6)
$\quad e_3$:_fierce_a_1(ARG1 x_6)
$\}$

Scopal Sub-Ordination of Non-Scopal Modifiers

The dog that didn't bark is fierce.

$\{\ e_3$
$\quad \_1$:_the_q(BV x_6)
$\quad x_6$:_dog_n_1
$\quad e_{10}$:neg(ARG1 e_{12})
$\quad e_{12}$:_bark_v_1(ARG1 x_6)
$\quad e_3$:_fierce_a_1(ARG1 x_6)
$\}$

Scopal Sub-Ordination of Non-Scopal Modifiers

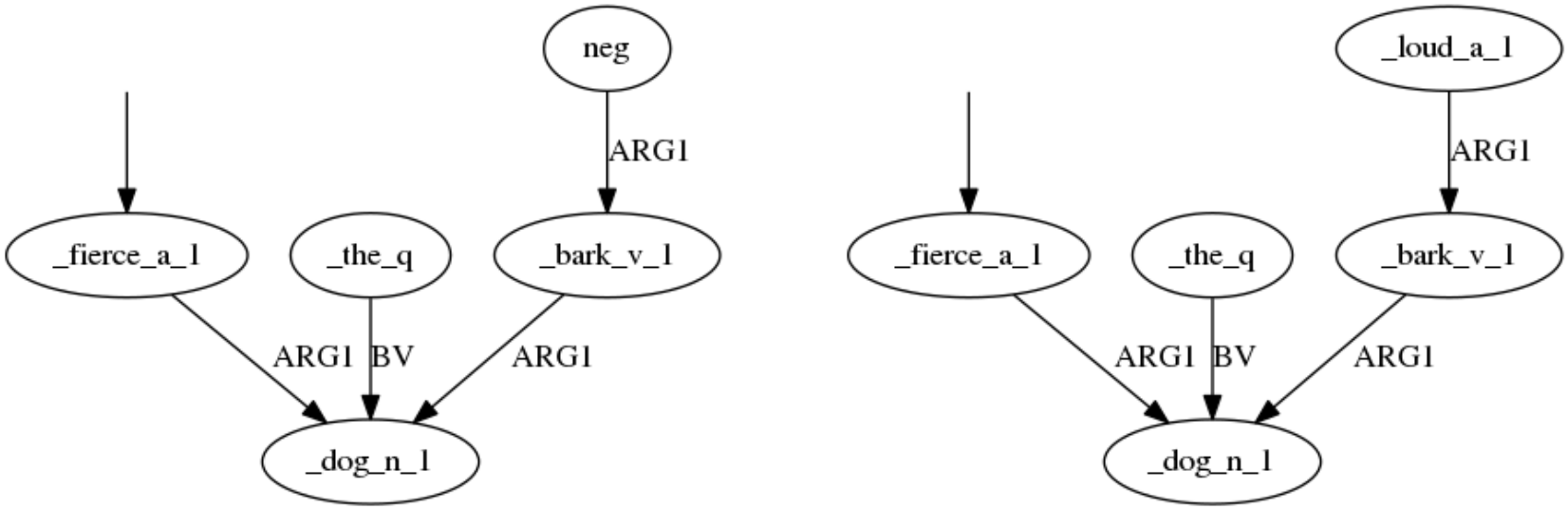
The dog that didn't bark is fierce.

$\{\ e_3$
$\quad \_1$:_the_q(BV x_6)
$\quad x_6$:_dog_n_1
$\quad e_{10}$:neg(ARG1 e_{12})
$\quad e_{12}$:_bark_v_1(ARG1 x_6)
$\quad e_3$:_fierce_a_1(ARG1 x_6)
$\}$

Vs. Non-Scopal Modification of Non-Scopal Modifier

The dog that didn't bark is fierce.

The dog that barked loudly is fierce.



Starting to Introduce Grammar-Specific Information

- Know scopal sub-ordinators: fixed list from SEM-I plus 'tensed' propositions.

Testing Reversibility of the Conversion: Realization

Work in Progress

- Generate from EDSs (or DMs); compare to results with full MRS as input;
- 'spinal' traversal implemented semi-declaratively as MRS transfer grammar;

$\rightarrow$ encouraging initial results: four items in MRS test suite appear problematic.

Testing Reversibility of the Conversion: Realization

Work in Progress

- Generate from EDSs (or DMs); compare to results with full MRS as input;
- 'spinal' traversal implemented semi-declaratively as MRS transfer grammar;

→ encouraging initial results: four items in MRS test suite appear problematic.

Twenty three dogs bark.

Two hundred twenty dogs bark.

$$\langle\, h_1, e_3,$$
$$\left|\begin{array}{l} h_8{:}\mathsf{card}(\mathsf{ARG0}\ e_9, \mathsf{ARG1}\ x_5, \mathsf{CARG}\ \mathit{20}), \\ h_{10}{:}\mathsf{plus}(\mathsf{ARG0}\ i_{12}, \mathsf{ARG1}\ x_5, \mathsf{ARG2}\ h_8, \mathsf{ARG3}\ h_{11}), \\ h_{11}{:}\mathsf{card}(\mathsf{ARG0}\ i_{13}, \mathsf{ARG1}\ x_5, \mathsf{CARG}\ \mathit{3}), \\ h_{10}{:}\mathsf{\_dog\_n\_1}(\mathsf{ARG0}\ x_5) \end{array}\right|$$
$$\{\, h_6 =_q h_{10}, h_1 =_q h_2 \,\}\, \rangle$$

Testing Reversibility of the Conversion: Realization

Work in Progress

- Generate from EDSs (or DMs); compare to results with full MRS as input;
- 'spinal' traversal implemented semi-declaratively as MRS transfer grammar;

$\rightarrow$ encouraging initial results: four items in MRS test suite appear problematic.

The dog barked, didn't it?

$$\langle\, h_1, e_3,$$
$$\left|\begin{array}{l} h_8{:}\_\text{dog\_n\_1}(\text{ARG0 } x_6), \\ h_2{:}\text{ne\_x}(\text{ARG0 } e_{16}, \text{ARG1 } h_9, \text{ARG2 } h_{11}), \\ h_2{:}\text{id}(\text{ARG0 } e_{17}, \text{ARG1 } x_6, \text{ARG2 } x_{15}), \\ h_{18}{:}\text{pron}(\text{ARG0 } x_{15}) \end{array}\right|$$
$$\{\, h_{20} =_q h_{18},\ h_7 =_q h_8,\ h_1 =_q h_2 \,\} \,\rangle$$

Testing Reversibility of the Conversion: Realization

Work in Progress

- Generate from EDSs (or DMs); compare to results with full MRS as input;
- 'spinal' traversal implemented semi-declaratively as MRS transfer grammar;

$\rightarrow$ encouraging initial results: four items in MRS test suite appear problematic.

The number five bothers Browne.

$$\langle\, h_1, e_3, \left| \begin{array}{l} h_2{:}\text{appos}(\text{ARG0 } e_6, \text{ ARG1 } x_5, \text{ ARG2 } x_4), \\ h_{10}{:}\text{\_number\_n\_of}(\text{ARG0 } x_5), \\ h_{14}{:}\text{card}(\text{ARG0 } x_4, \text{ ARG1 } i_{15}, \text{ CARG } 5) \end{array} \right| \\ \{\, h_1 =_q h_2 \,\} \,\rangle$$

Questions to the Audience