Multiword expressions as dependency subgraphs

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Resurgent interest

- resurgent interest in Dependency Grammar (DG) (Tesnière 59; Sgall et al. 86; Mel'čuk 88)
- core DG concepts incorporated into most grammar formalisms, also phrase structure-based (HPSG, LFG, TAG)
- new DG-based grammar formalisms (Nasr 95; Heinecke et al. 98; Bröker 99; Gerdes and Kahane 01; Kruijff 01; Joshi and Rambow 03)

A controversy

- assume a *1:1-correspondence* between words and nodes in the dependency graph?
- simplifies the formalization of DGs substantially
- but: *breaks* when modeling *semantics*
- e.g. *multiword expressions* (MWEs): one semantic node corresponds to more than one word

Weakening the 1:1-assumption

- most DG grammarians interested in semantics have *weakened* the 1:1-assumption
- Tesnière: *nuclei* group together sets of nodes
- Sgall et al: *deletion* of solely syntactically motivated nodes
- Mel'čuk: *paraphrasing rules*
- but: these attempts to weaken the 1:1-correspondence have not yet been formalized declaratively

Extensible Dependency Grammar (XDG)

- new grammar formalism (Debusmann et al. 04) based on *Topological Dependency Grammar* (TDG) (Duchier and Debusmann 01)
- *declaratively* formalized
- formalization used directly in the *XDG solver* for parsing and generation

XDG and the 1:1-assumption

- XDG solving *efficient* at least for our *smaller-scale* handwritten example grammars
- but: good results hinge substantially on the *1:1-correspondence*
- as XDG has been created to cover not only syntax but also semantics, we have no choice: we *must weaken* the 1:1-correspondence too

Weakening the 1:1-assumption for XDG

- in this talk, we show *how to weaken the 1:1-assumption for XDG*, without sacrificing the potential for efficient parsing and generation
- *new layer of lexical organization* called *groups*, above the basic XDG lexicon
- groups describe *MWEs* as *tuples of dependency subgraphs*

Overview

1. Introduction
2. *Extensible Dependency Grammar (XDG)*
3. Groups
4. Compilation
5. Conclusions

Extensible Dependency Grammar (XDG)

- new grammar formalism (Debusmann et al. 04)
- characterizes linguistic structure along arbitrary many *dimensions*
- all dimensions correspond to dependency graphs, sharing the same set of nodes but having different edges

Well-formedness conditions

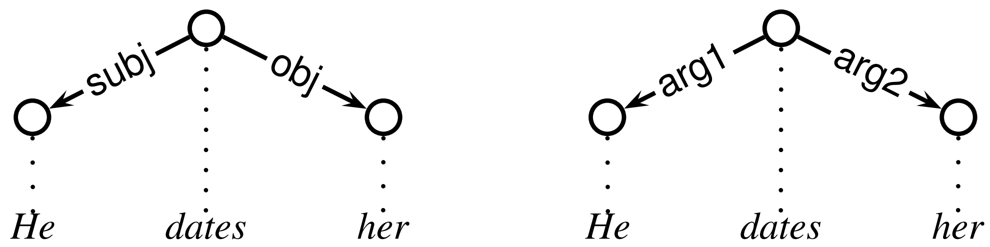
- well-formedness conditions determined by *principles*
- principles can be *one-dimensional* (applying to a single dimension only), or *multi-dimensional* (constraining the relation between several dimensions)
- basic one-dimensional principle: *valency*
- basic multi-dimensional principle: *linking* (syntactic realization of semantic arguments)

The lexicon

- XDG is *highly lexicalized*
- *lexical entries* serve as the *parameters* for the principles
- since a lexical entry constrains all dimensions simultaneously, it can also help to *synchronize* the various dimensions

Example analysis

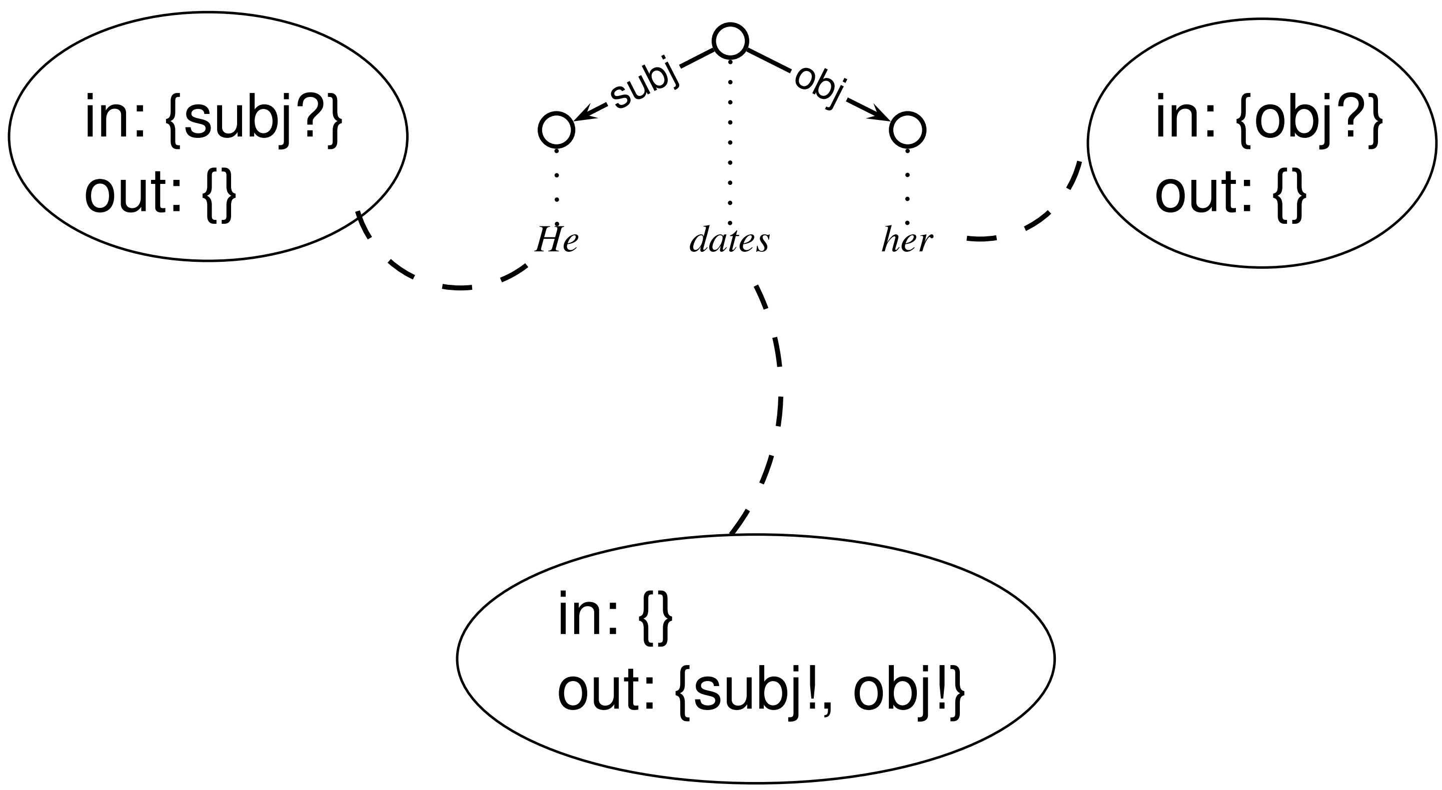
- two-dimensional XDG analysis of *"He dates her"* (syntax left, semantics right):



- used principles:
  1. *syntactic valency*
  2. *semantic valency*
  3. *linking*

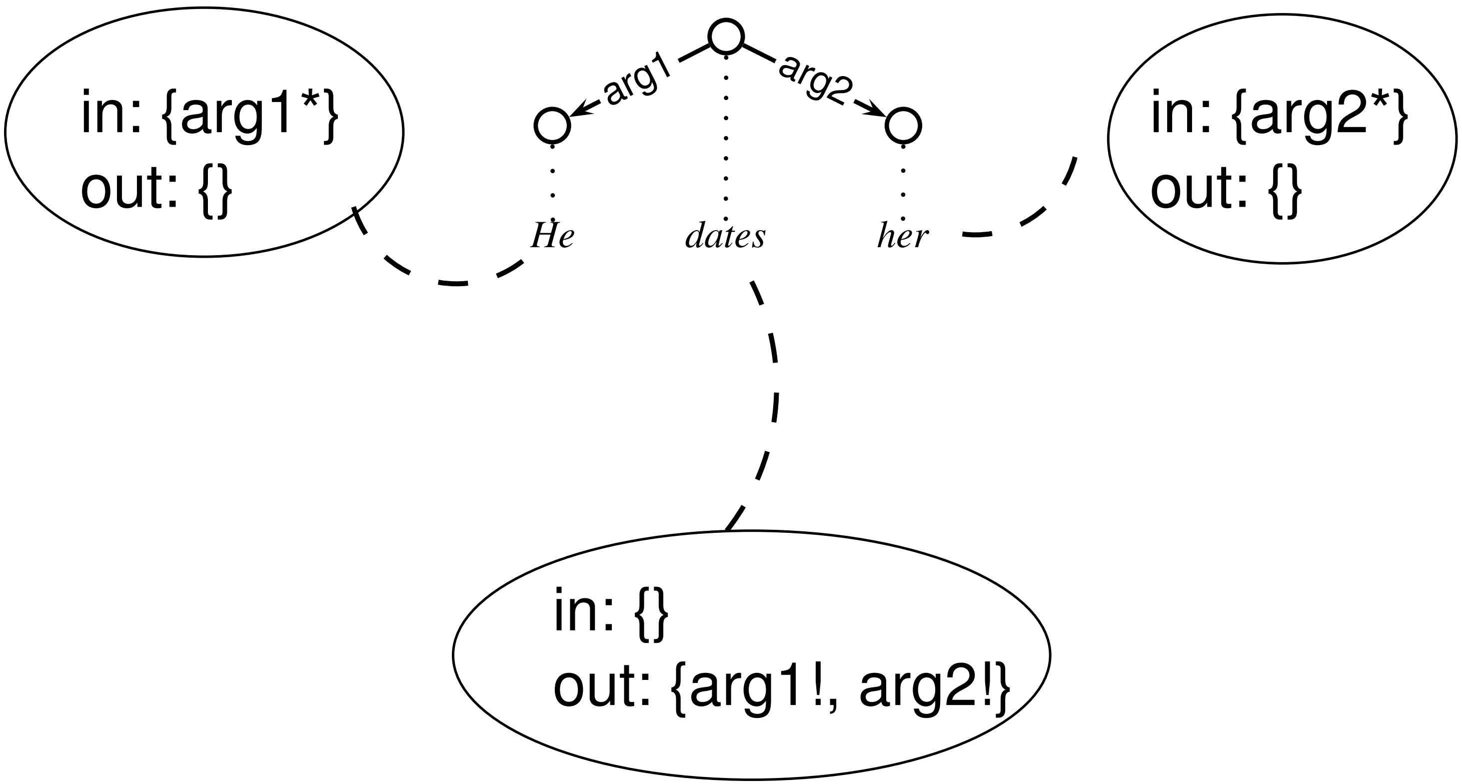
1. Syntactic valency

- syntactic analysis:



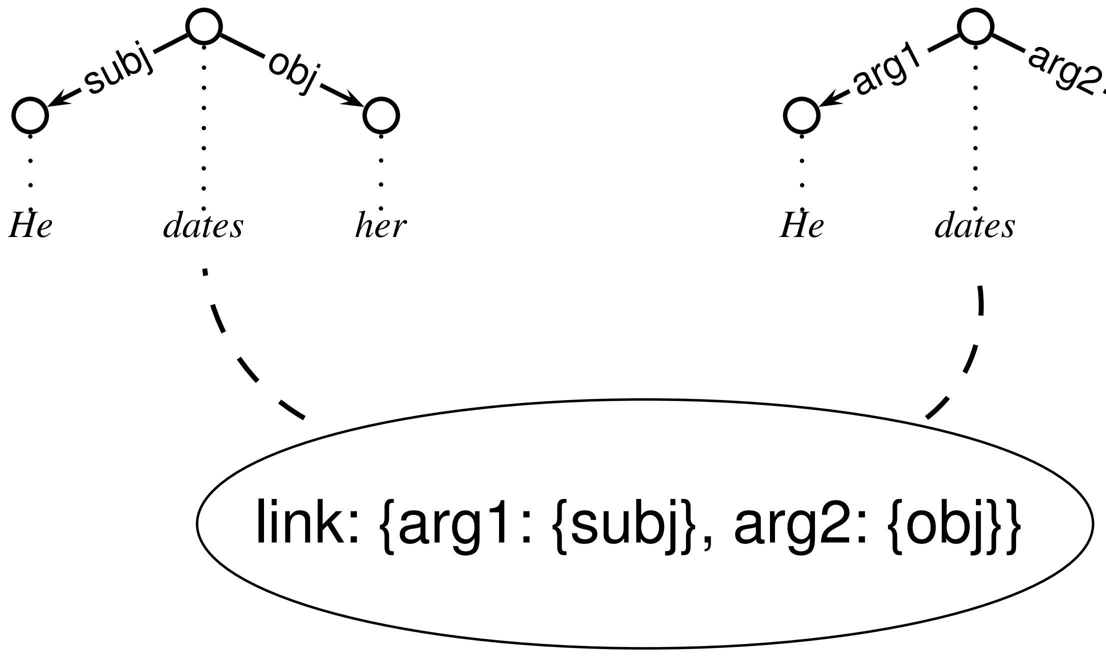
2. Semantic valency

- semantic analysis:



3. Linking

- semantic and syntactic analyses:



Parsing and generation

- *XDG solver*
- implements a declarative axiomatization of XDG as a constraint satisfaction problem (Duchier 03)
- XDG solving is *NP-complete* (Koller and Striegnitz 02)
- average-case complexity polynomial for smaller-scale handwritten grammars
- research on XDG solving of large-scale grammars in progress

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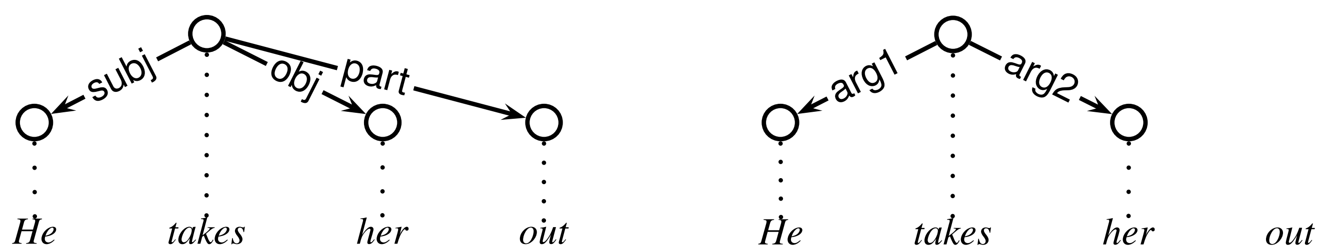
MWEs as contiguous substrings?

- example paraphrase:
  1. *"He dates her."*
  2. *"He takes her out."*
- XDG analysis:



- i.e. we *cannot* treat MWEs as *contiguous* word strings: *"takes out"* interrupted by object *"her"*

MWEs as dependency subgraphs!

- instead, we implement the *continuity hypothesis* (Kay and Fillmore 99)
- idea: model MWEs as *dependency subgraphs*
- new layer of lexical organization: *groups*
- a group is a *tuple of dependency subgraphs* covering one or more node
- each of the *components* correspond to a *dimension*

Example groups

- group for *“dates”*:

- group for *“takes out”*:

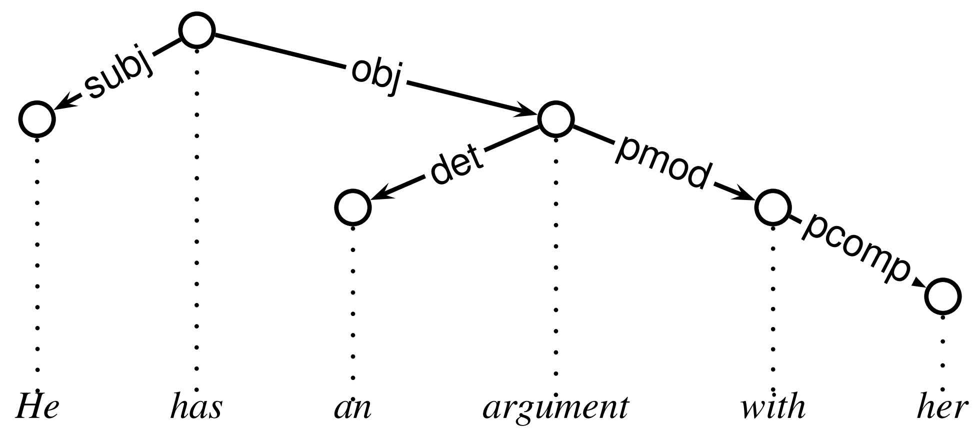
- groups can leave out nodes present in the syntax in the semantics (here: *“out”*)

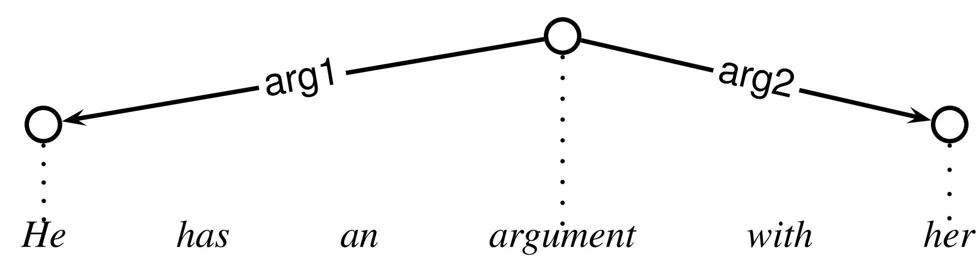
Support verbs

- more complicated paraphrase:
  1. *"He argues with her."*
  2. *"He has an argument with her."*
- in 2., *"has"* is a *support verb*; the semantic head of the construction is the noun *"argument"*

XDG analysis

- XDG analysis of the support verb construction:

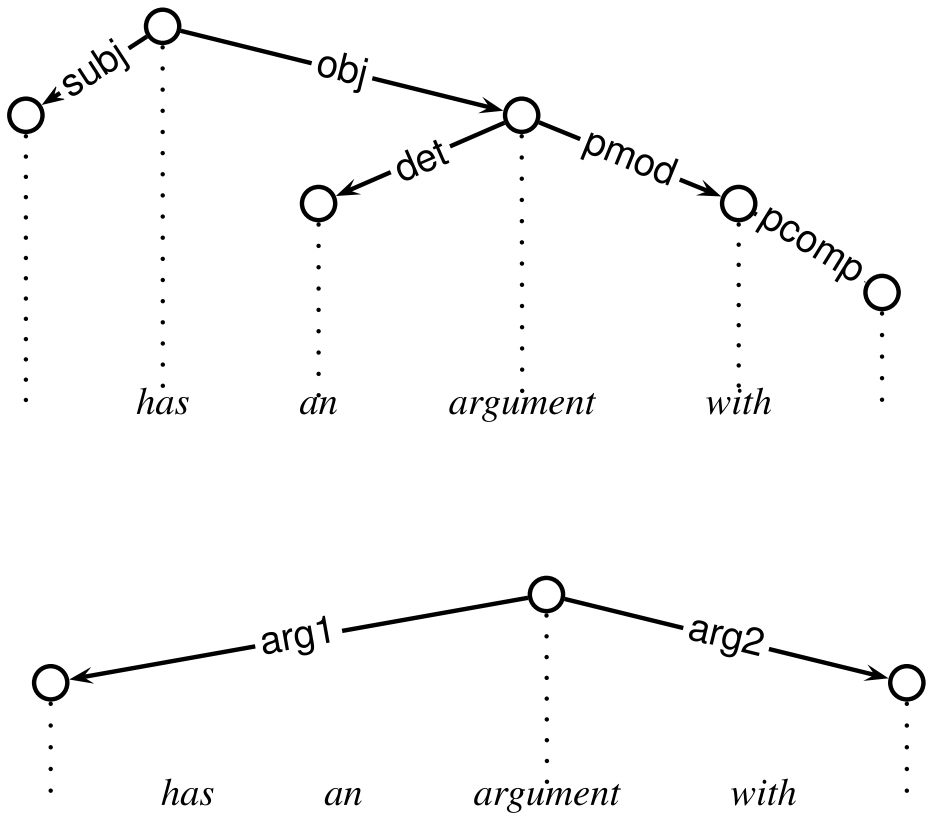




- interdependencies: *"argument"* is the object of *"has"* in the syntax, but the semantic head in the semantics

Groups

- groups for the support verb construction:



Groups are nice

- groups can capture difficult constructions such as the support verb construction quite elegantly
- key aspect: *multi-dimensionality*, describing tuples of dependency subgraphs over a *shared* set of nodes
- sharing: helps to express *interdependencies* between the different dimensions
- groups can be regarded as a declarative formalization of Mel'čuk's *paraphrasing rules* (Mel'čuk 96)
- or as a realization of the *extended domain of locality* of TAG (Joshi 87) for DG

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Compilation

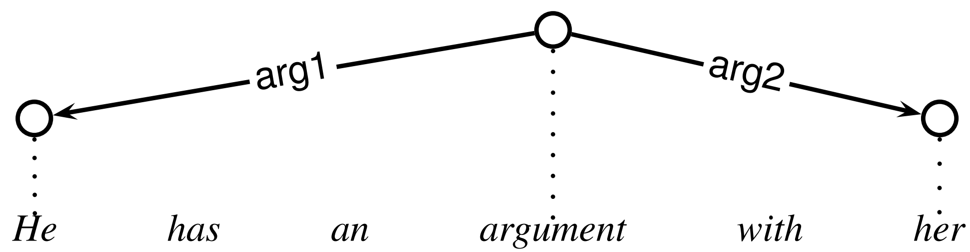
- groups are a *conservative* extension to XDG
- can be *compiled* into simple XDG lexical entries for individual words
- benefit: we can *retain* XDG in its entirety, including the XDG solver for *parsing* and *generation*
- three steps:
  1. node deletion
  2. dependency subgraphs
  3. group coherence

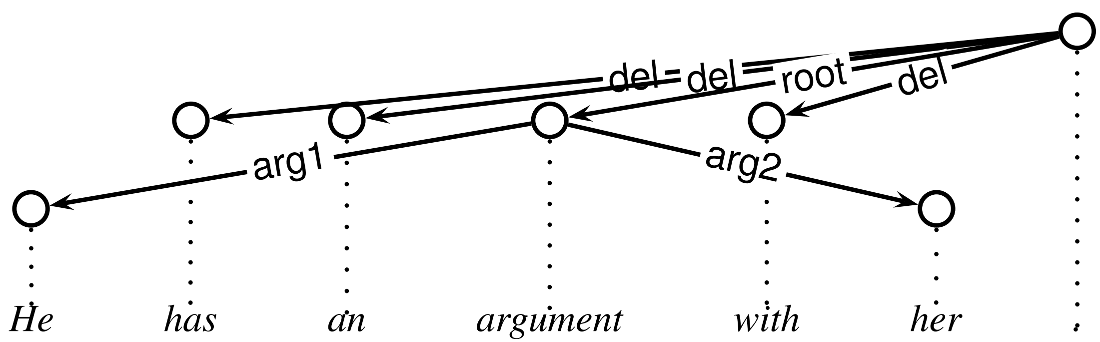
1. Node deletion

- on each dimension, *each word* must correspond to precisely *one node* in the dependency graph
- the *groups* shown above clearly *violate* this assumption: nodes present in the syntax were omitted in the semantics
- idea: accommodate deletion of nodes by introducing an *additional root node* in each analysis

Node deletion example

- example:





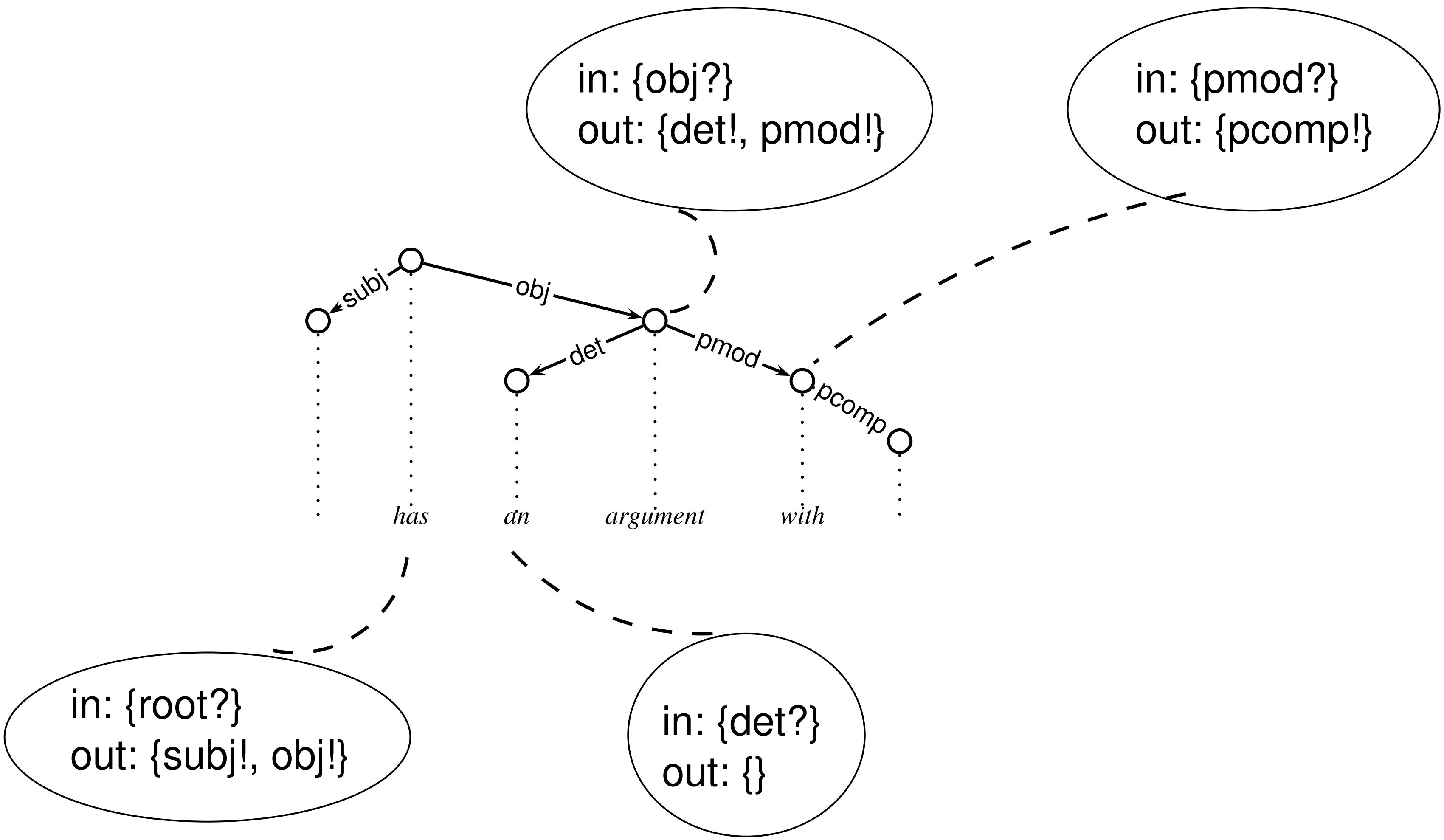
- old root = *root*-daughter of the new root
- deleted nodes = *del*-daughters

2. Dependency subgraphs

- second step: compile dependency subgraphs into lexical entries for individual words
- idea: use valency (*in* and *out* features)

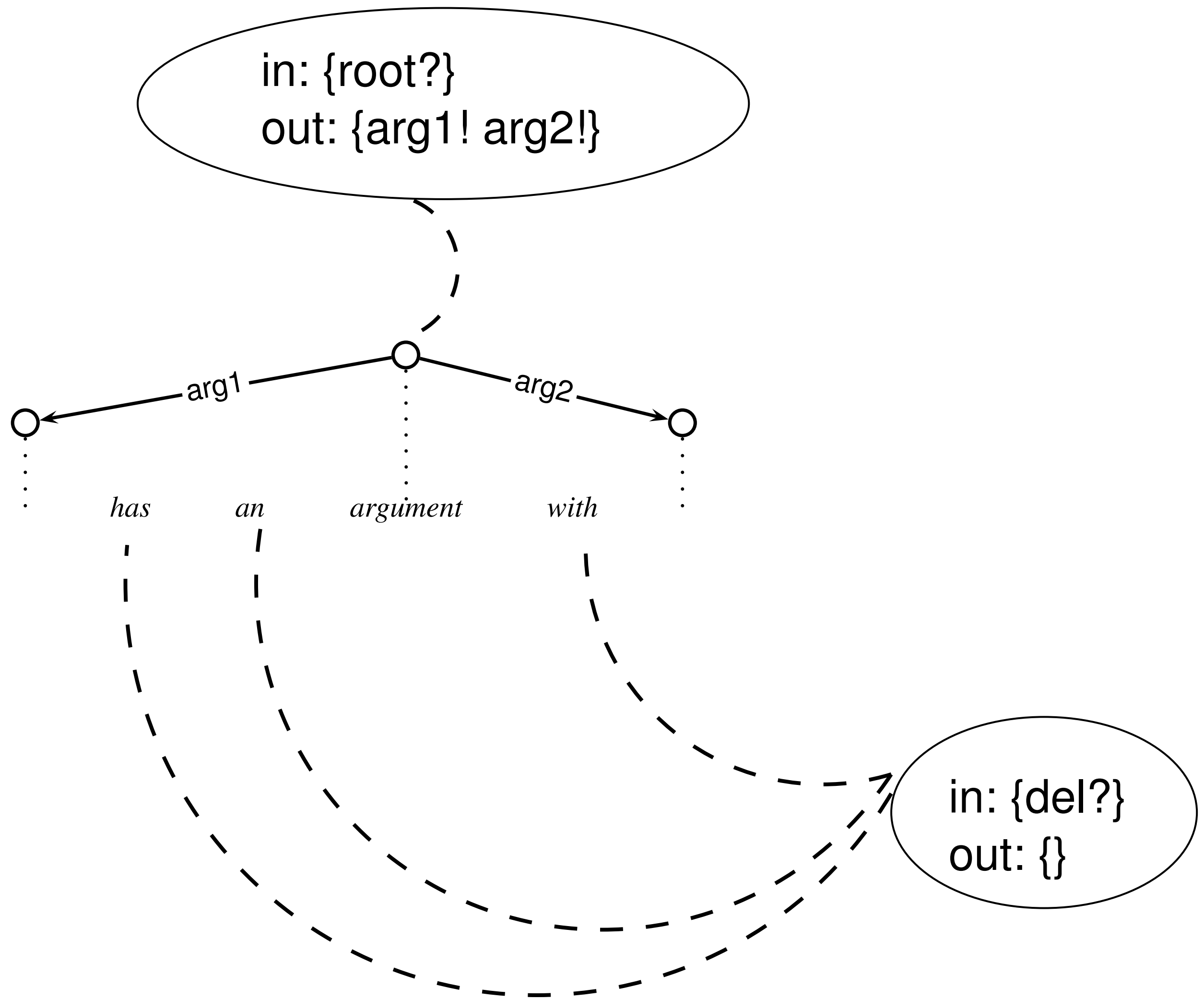
Dependency subgraphs example (1/2)

- syntax:



Dependency subgraphs example (2/2)

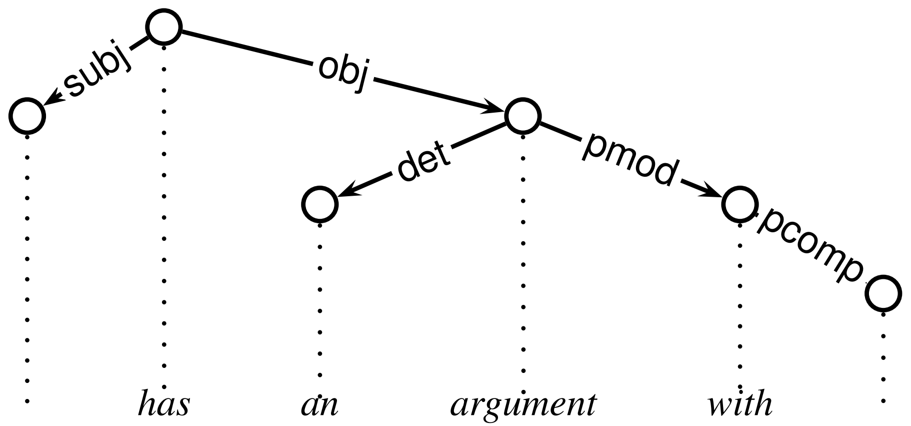
- semantics:



3. Group coherence

- ensure that *inner group nodes stay together*
- each node has feature denoting its *group ID*
- group IDs must match for each edge within a group
- expressed by a lexicalized principle

Group coherence example



- *“an”*, *“argument”* and *“with”* are inner nodes
- group IDs must match for the endpoints of the *obj*, *det* and *pmod* edges

Parsing

- for parsing, we use the existing XDG solver *unchanged*

Generation

- we can use the *same group lexicon* as for *parsing*
- caveat: need to introduce a finite set of *extra nodes* to fill up the groups
- to realize a semantic literal s, introduce as many nodes as the largest group which verbalizes s
- assume *argue'* can be realized either by *"argue with"* (2) or *"has an argument with"* (4): introduce 4 nodes

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Conclusions

- groups allow to weaken the 1:1-correspondence between nodes and words in XDG
- new layer of lexical organization
- powerful enough to handle complicated MWEs (e.g. support verb constructions)
- benefits:
  1. conservative extension: we can retain XDG in its entirety, including the XDG solver
  2. we can use the same group lexicon for both parsing and generation

Open questions

- integration of groups and the metagrammatical functionality of the XDG lexicon for individual lexical entries
- how does this all scale up to large-scale grammars?