Graph-Based Meaning Representations:

Design and Processing

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1

Foundations: Semantics

What do we Mean by ‘Meaning’?

Abrams gave Browne a book.

Abrams gave a book to Browne.

Browne was given a book by Abrams.

A book was given to Browne by Abrams.

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→ close paraphrases: convey the 'same meaning' (in unmarked contexts).

Sentence vs. Speaker Meaning

Linguistic semantics does not furnish a characterization of the interpretation of utterances in use, which is what one finally needs for natural language understanding applications—rather, it (mostly) provides a characterization of conventional content, that part of meaning determined by linguistic form. [...] In order to interpret correctly, one must exploit further knowledge sources [...]: domain knowledge, common sense, communicative purpose, extralinguistic tasks, assumptions of interlocutors about each other. (?, ?, p. 134)

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He wants to be seen by her. vs. *He wants her to see him.*

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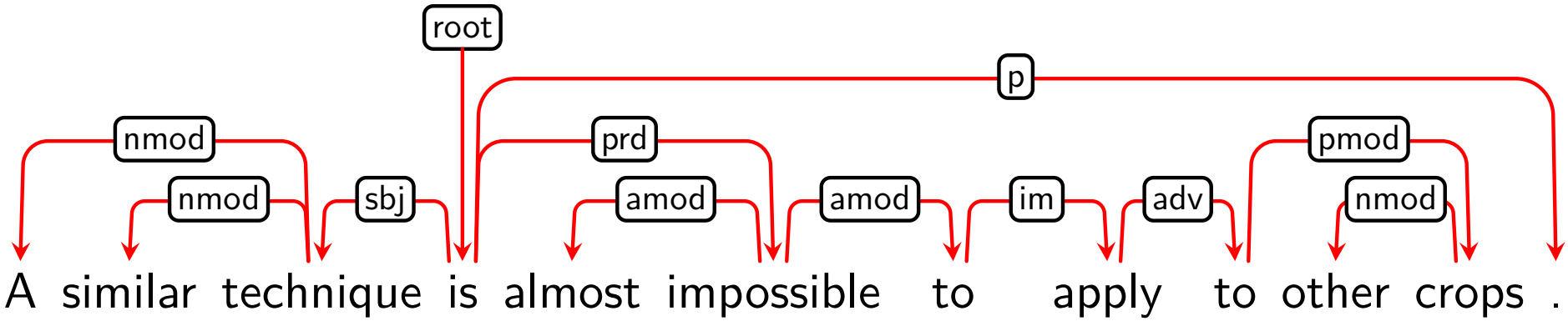
Sherlock saw the suspect with the binoculars.

Syntactic Trees vs. Semantic Graphs [WSJ #0209013]



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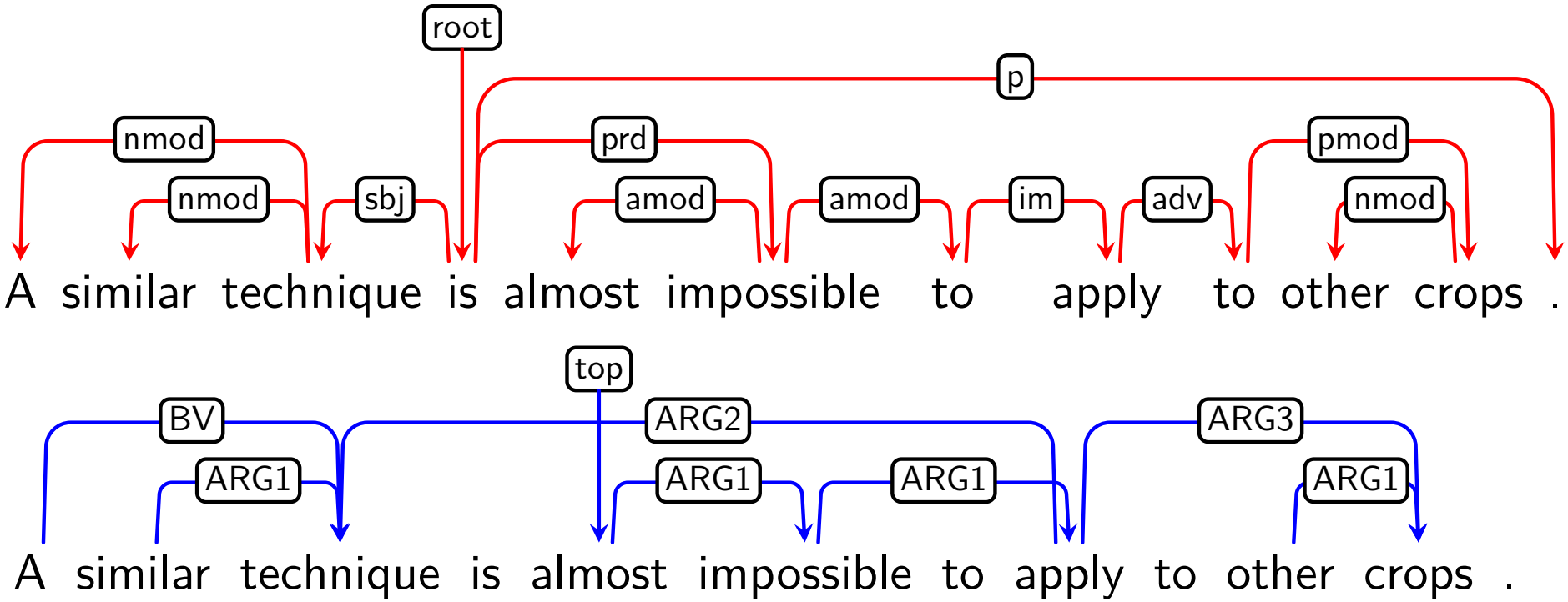

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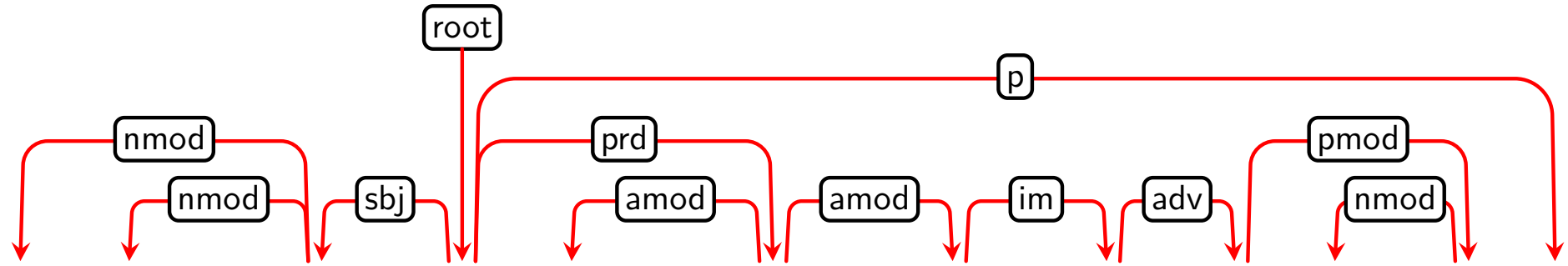

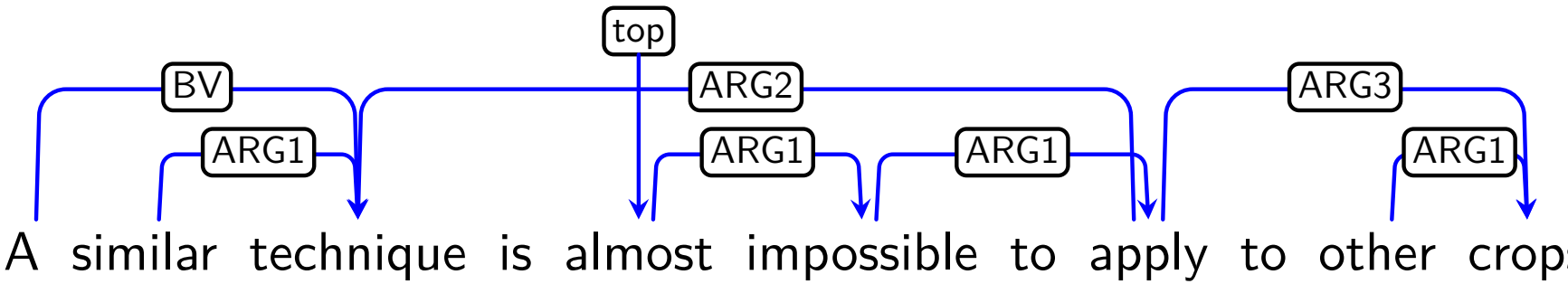

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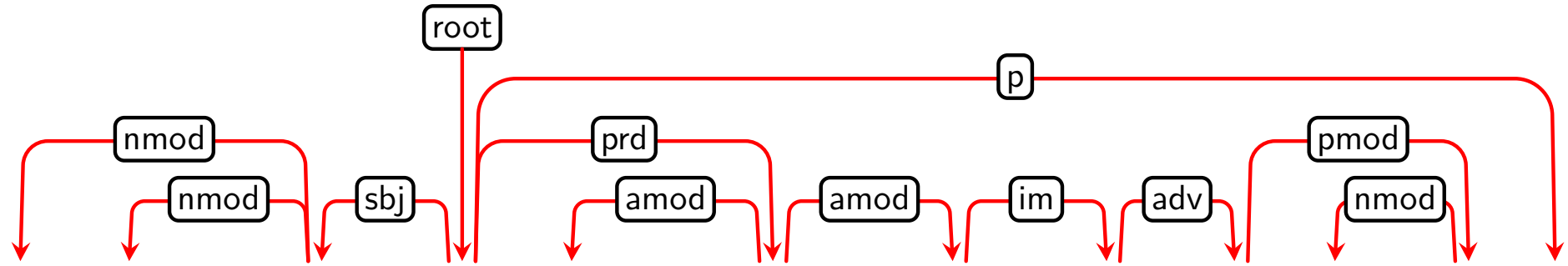

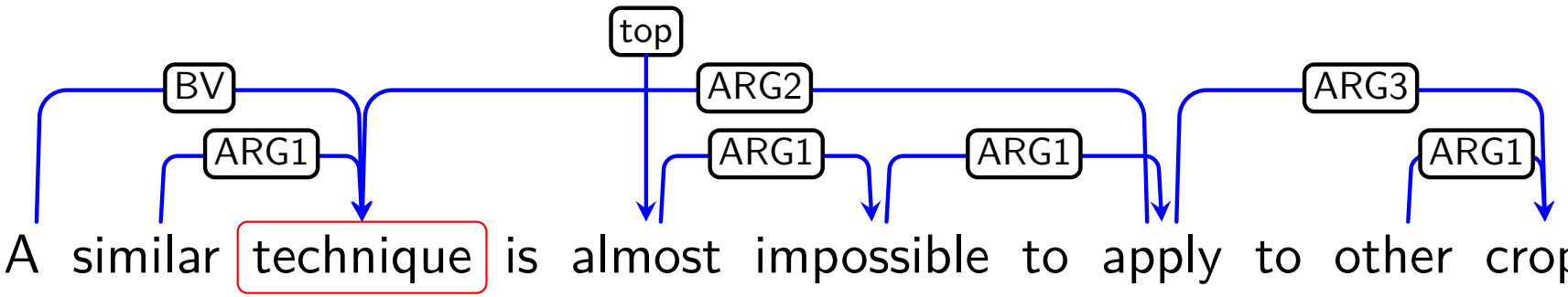

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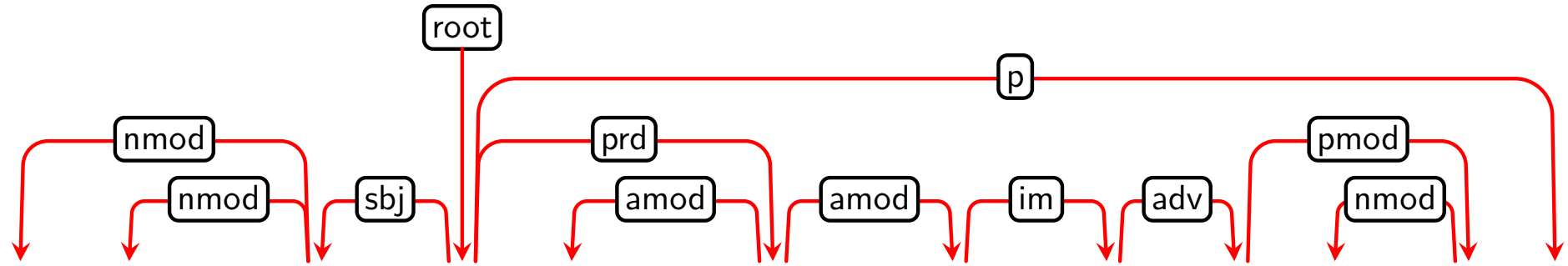

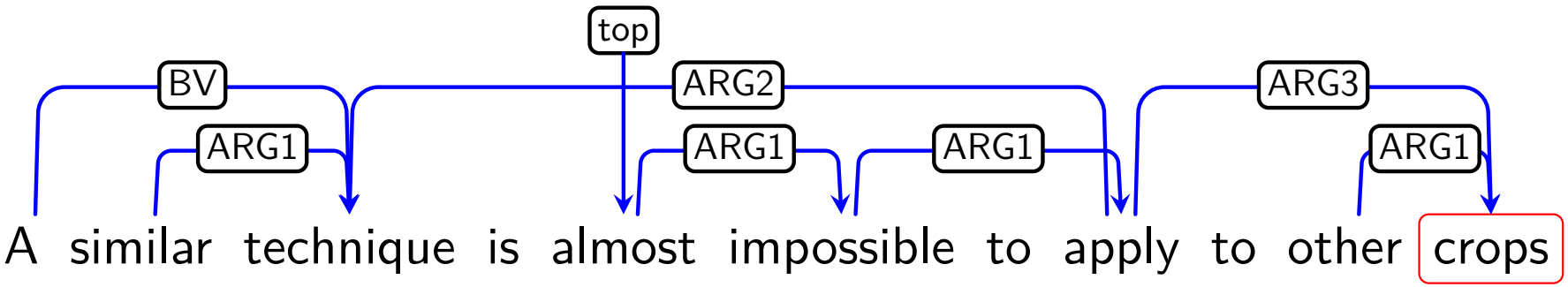

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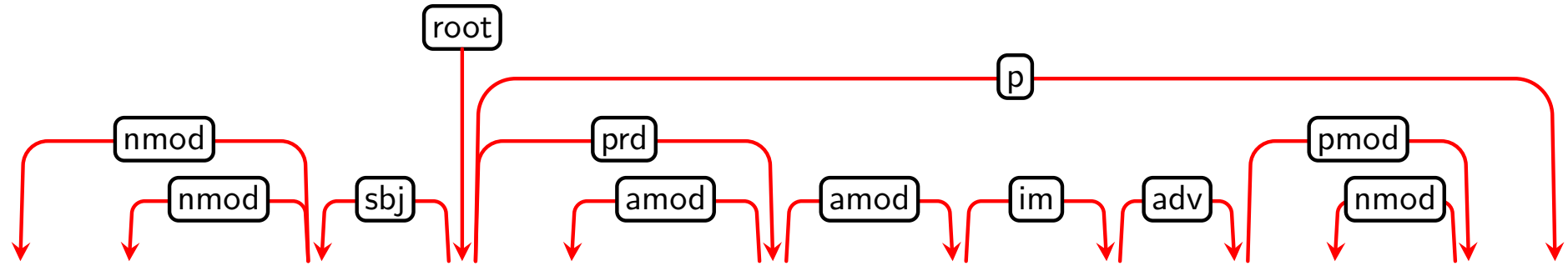

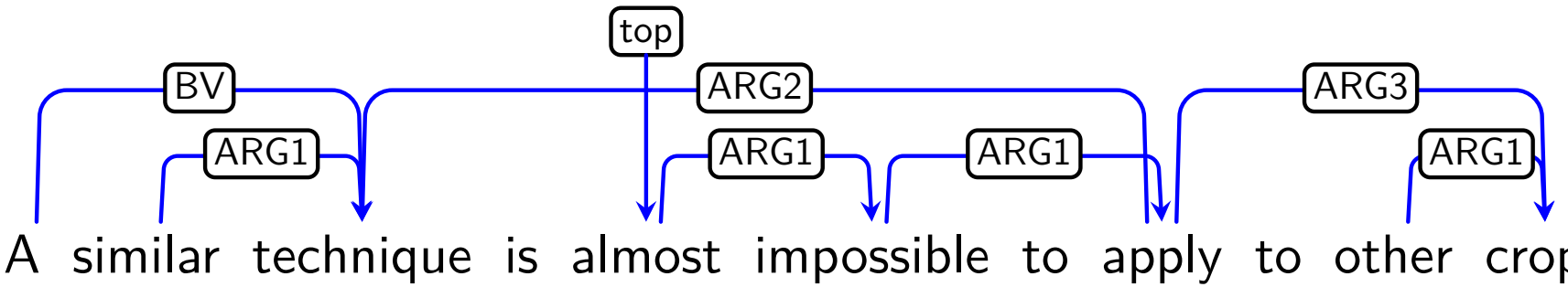

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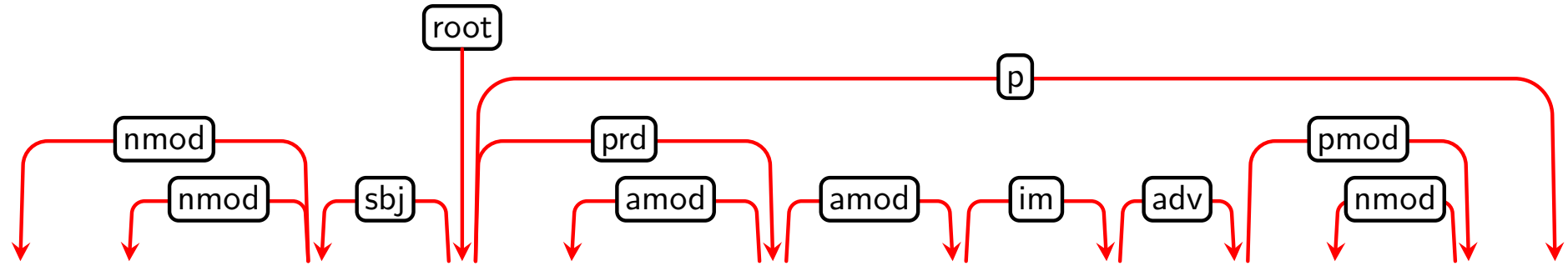

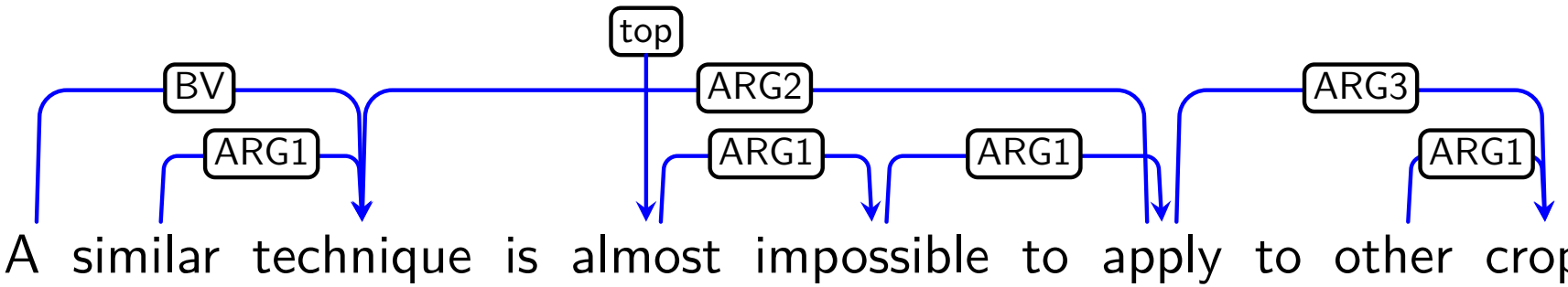

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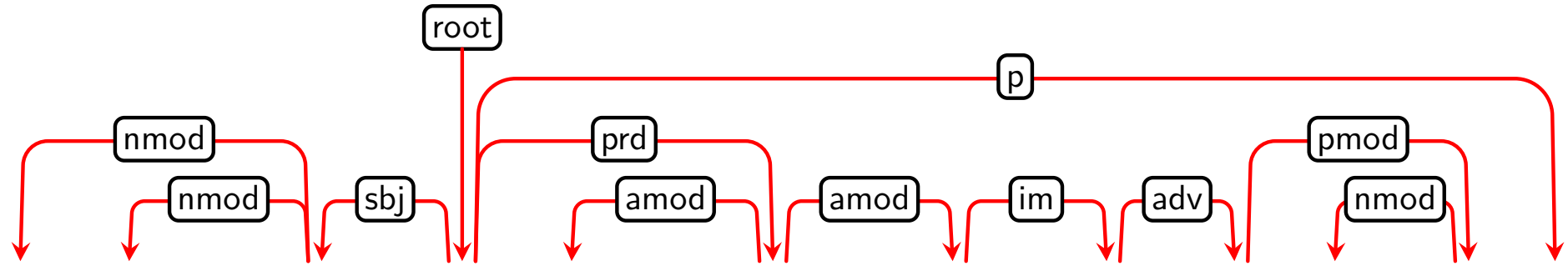

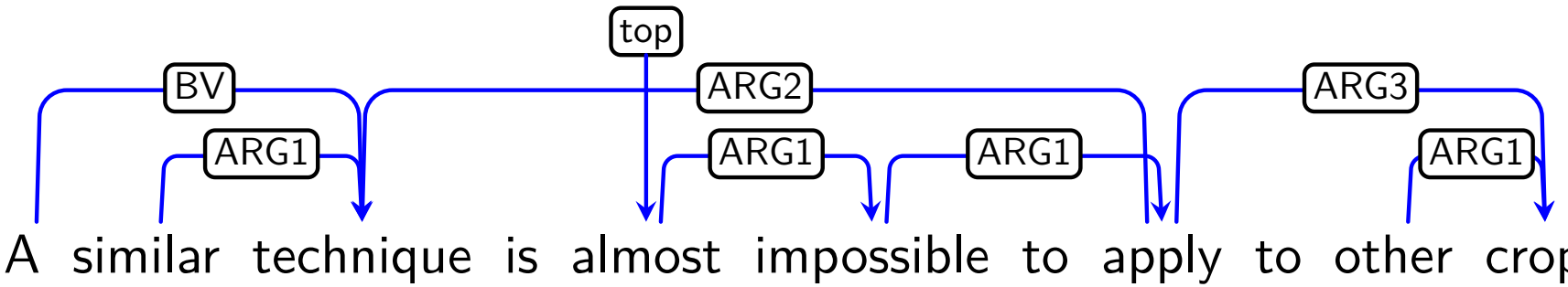

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Different Desiderata (and Levels of Abstraction)

- Grammaticality (e.g. subject–verb agreement) vs. relational structure.

Semi-Formally: Trees vs. Graphs

Structural Wellformedness Conditions on Trees

- Unique root, connected, single parent, free of cycles; maybe: projective;

→ all nodes (but the root) reachable by unique directed path from root.

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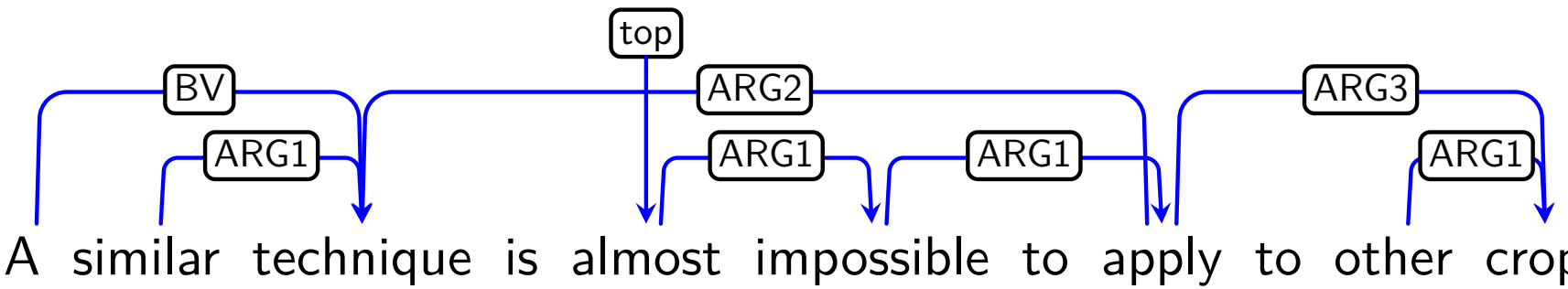

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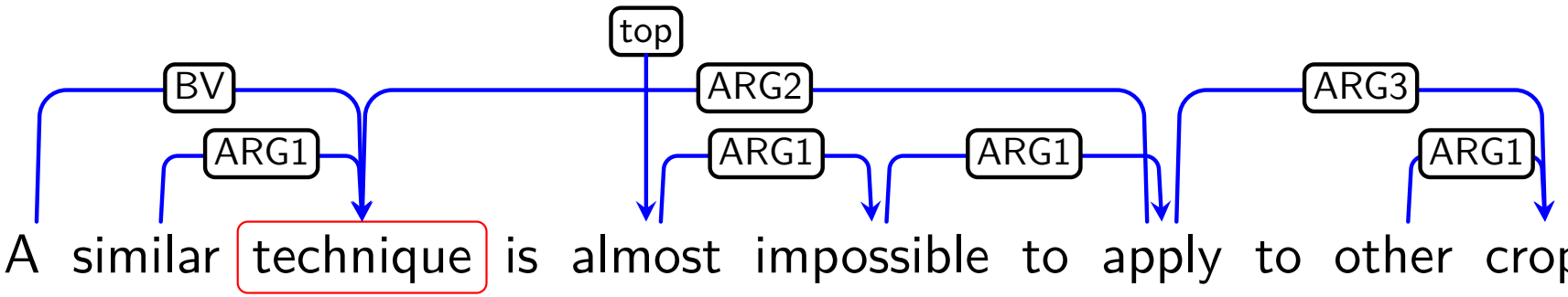

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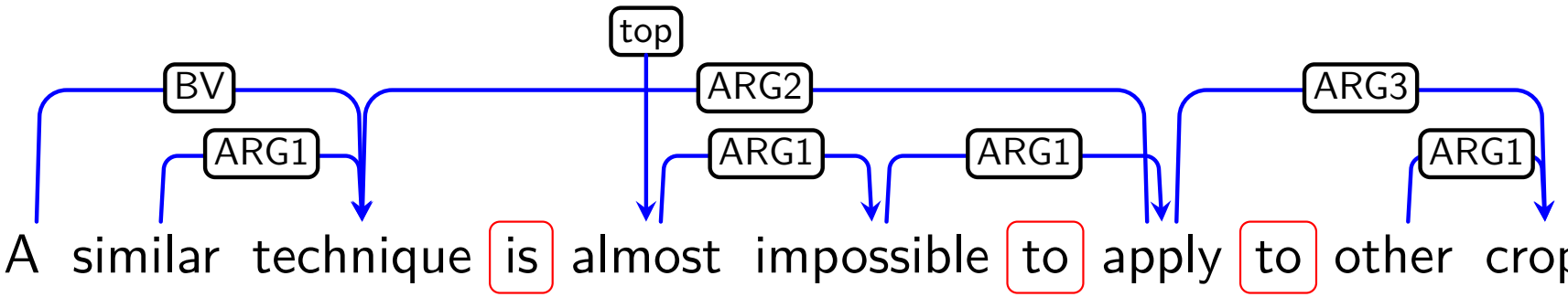

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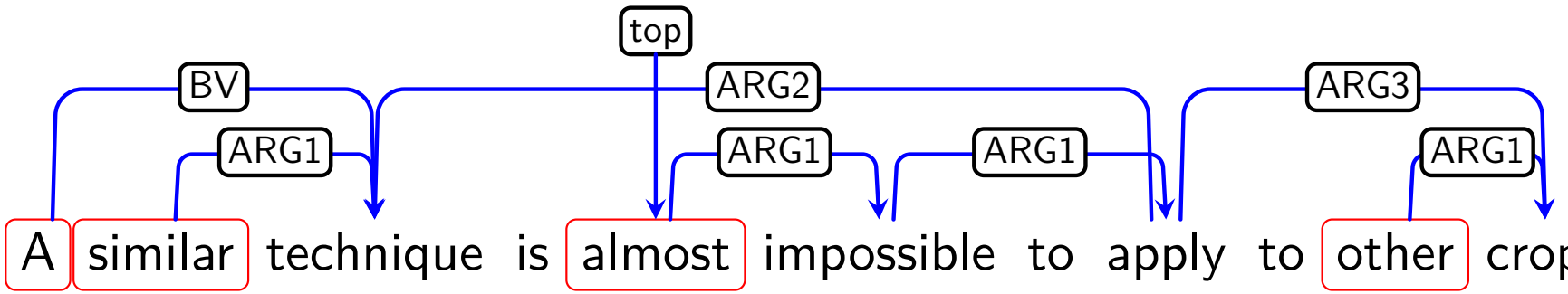

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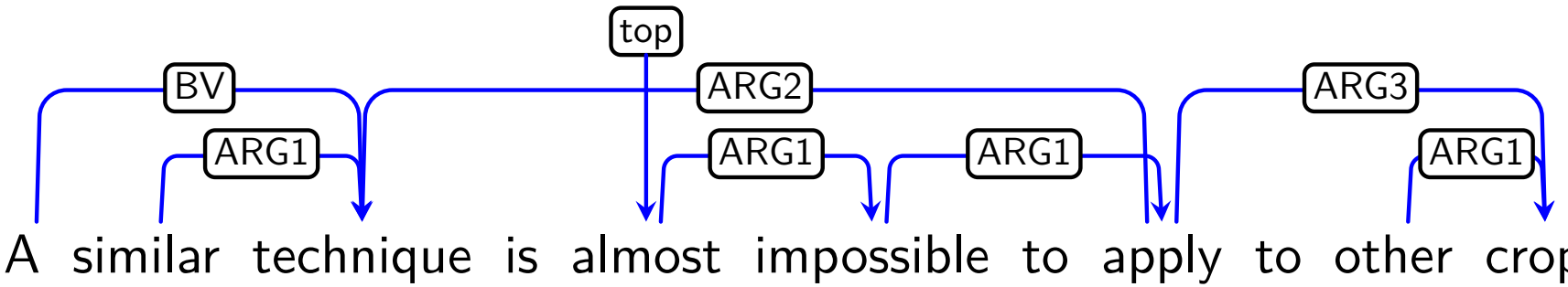

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→ massive growth in modeling and algorithmic complexity (NP-complete).

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Syntax: Head–Dependent Relations

- Heads license and govern, e.g. verbs, relational nouns, prepositions;
- complements include subjects, objects, obliques, clausal arguments;
- adjuncts add information, e.g. adjectives, adverbials, relative clauses:

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- Prepositions *on* or *in* as two-place relations, e.g. temporal or locative.

Reflections on Predicate–Argument Structure

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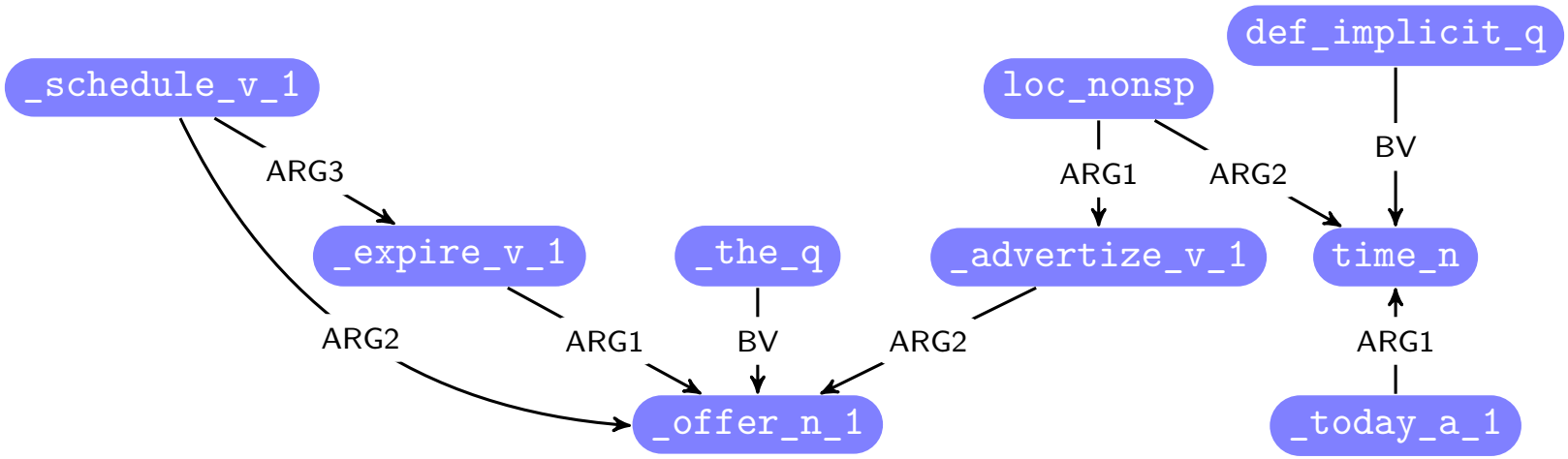

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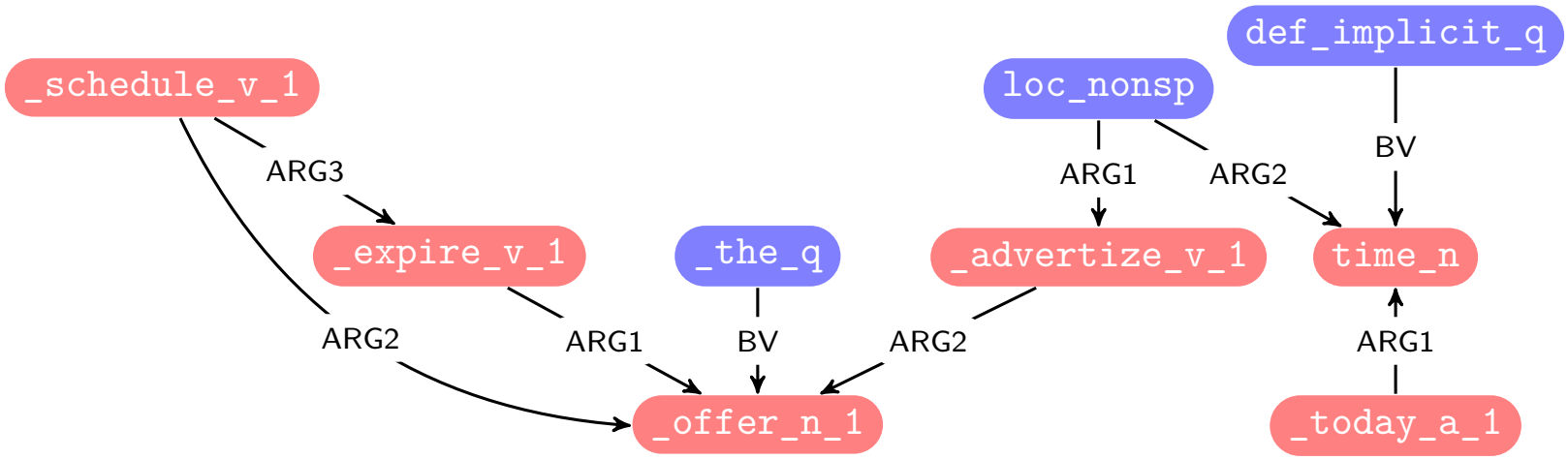

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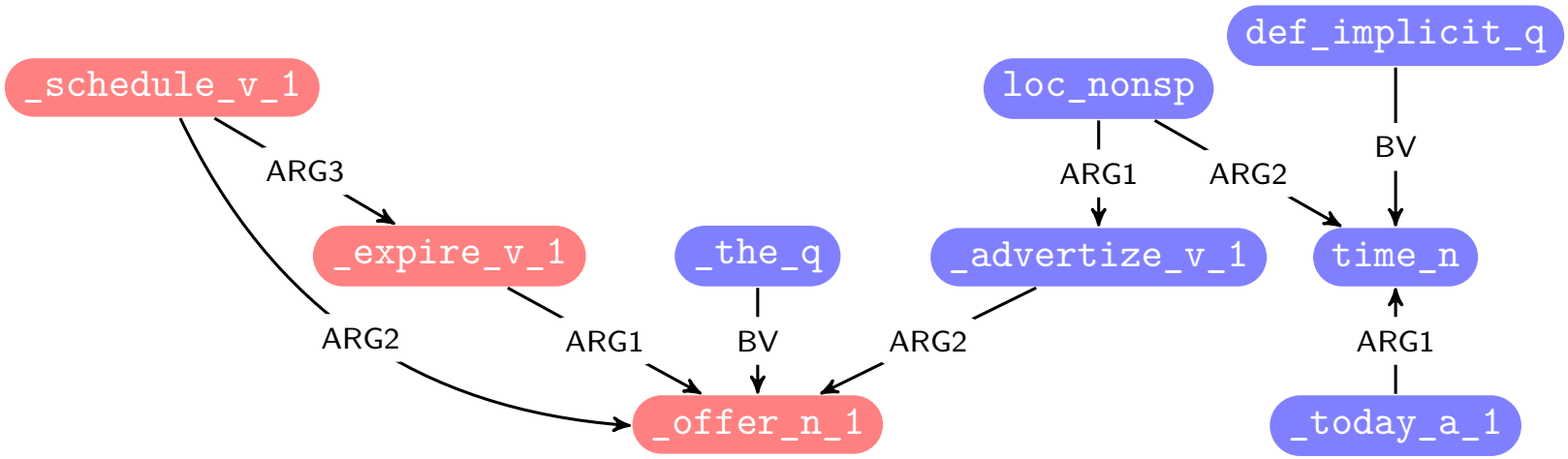

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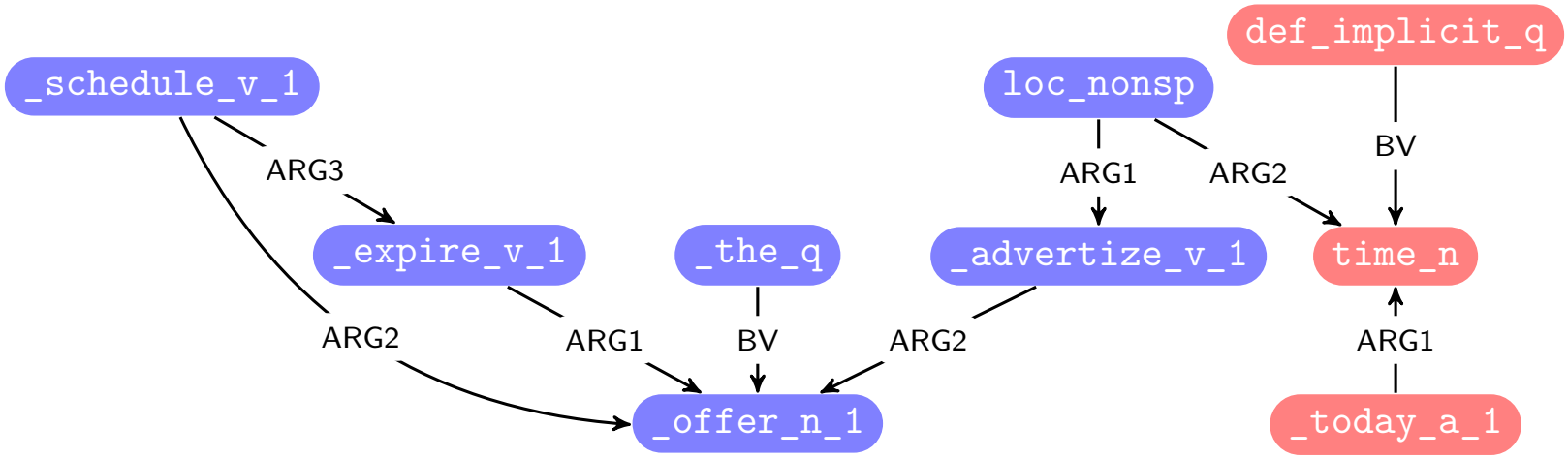

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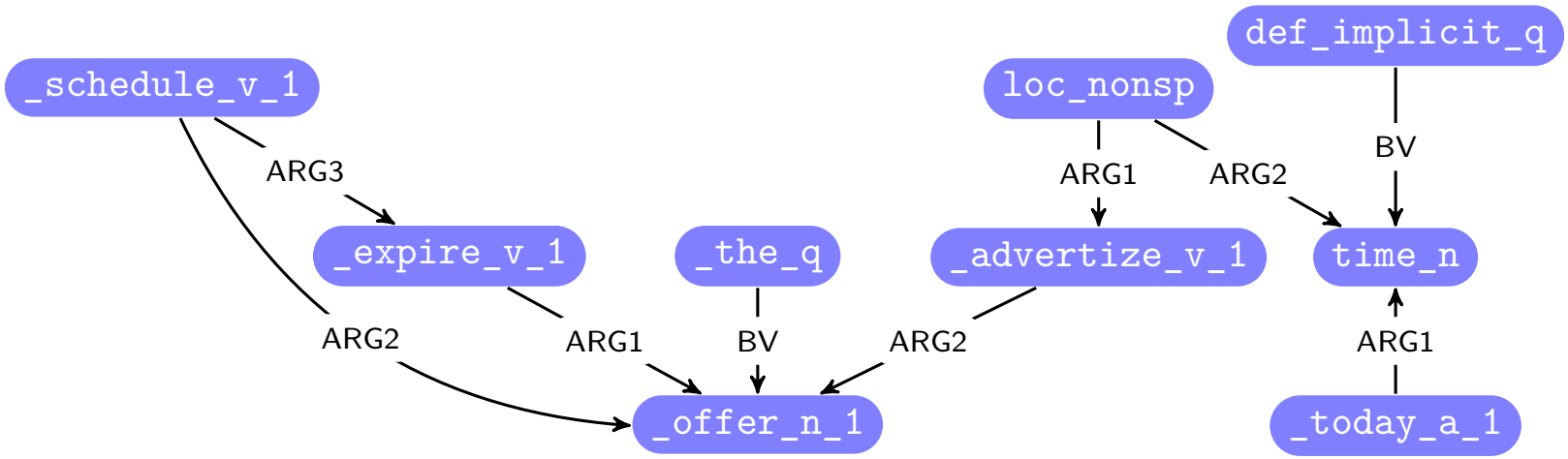

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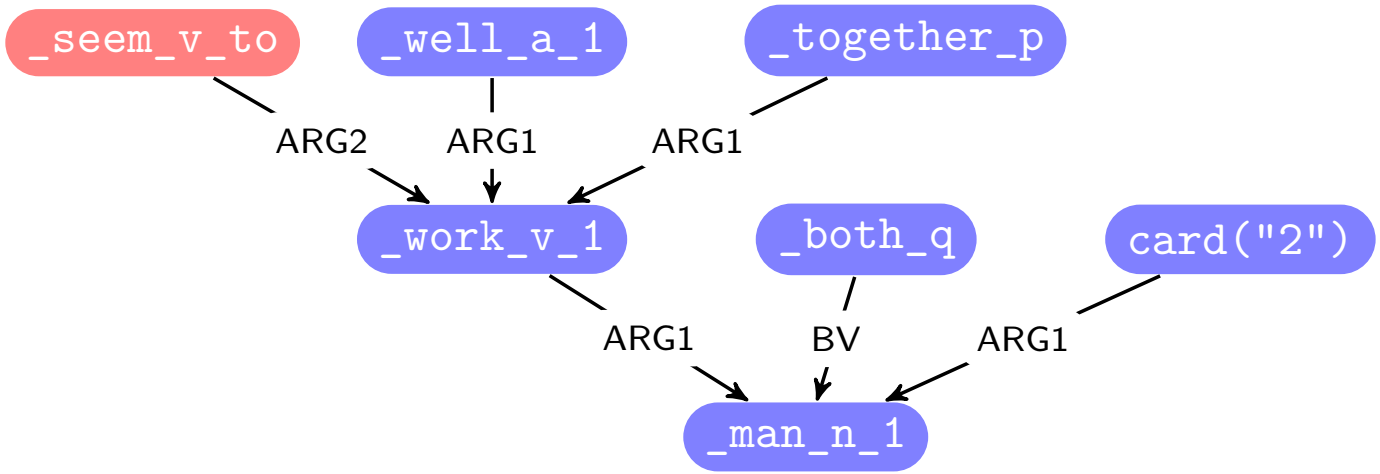
Mismatches between Syntax and Semantics



Both men seem to work well together. [WSJ #0109043]

- Discord between head–dependent and predicate–argument relations;
- syntactic subject of *seem* is a semantic argument of its complement;

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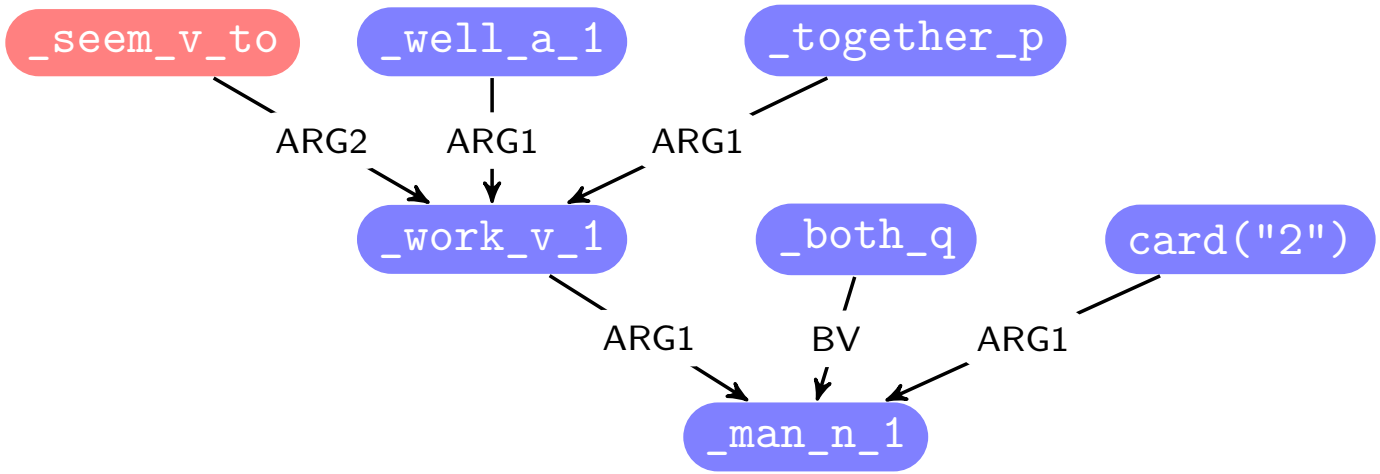

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- Discord between head–dependent and predicate–argument relations;
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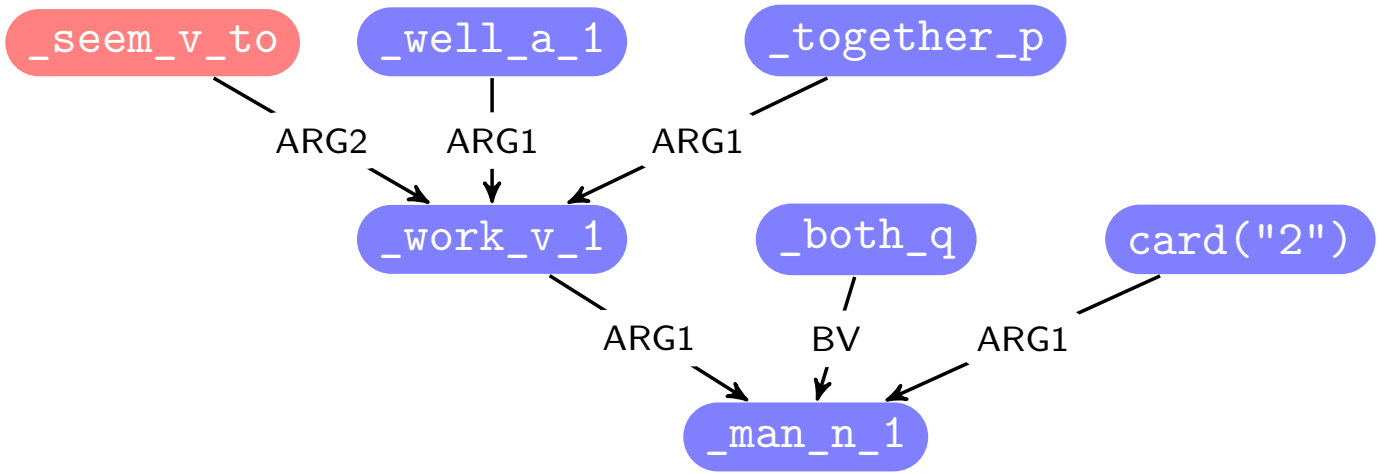
Mismatches between Syntax and Semantics



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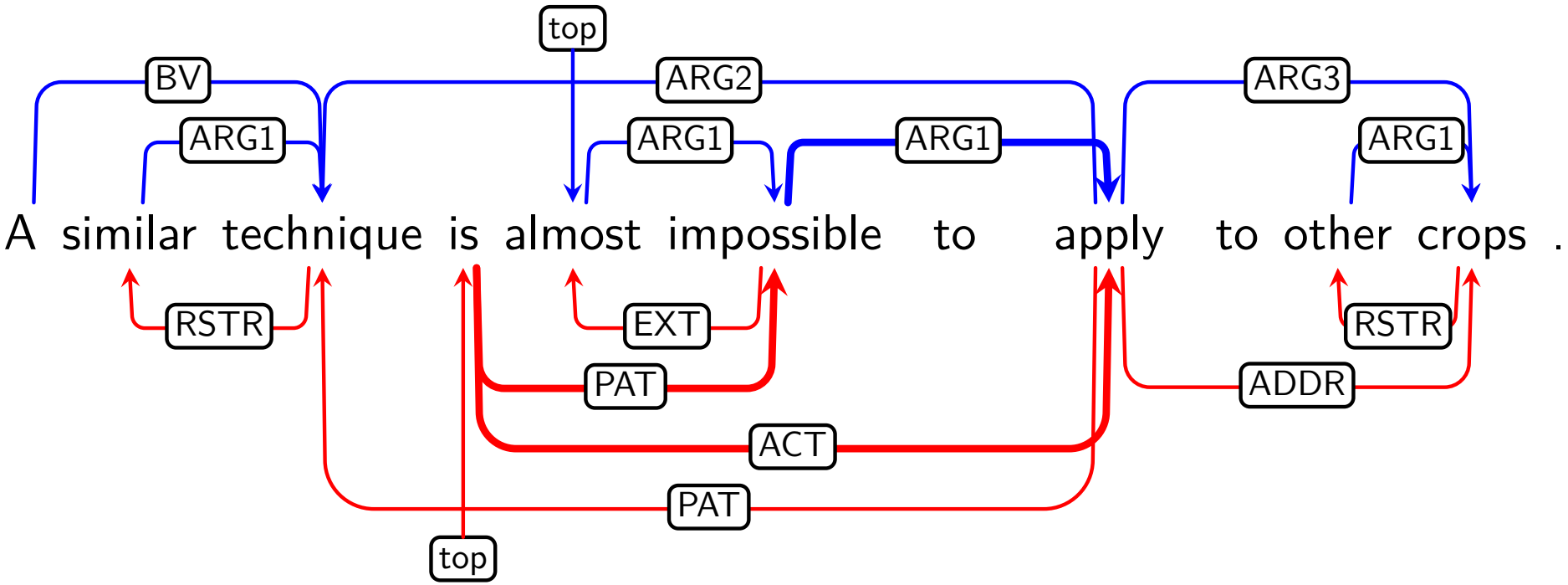
- specific semantic framework requires many interacting design decisions;
- divergent views already at the level of which words are content-bearing;
- for example, the predicative copula: *the fierce dog* vs. *the dog is fierce*.



Example Design Decisions: Coordination

- No less frequent: coordinate structures (sometimes called parataxis);
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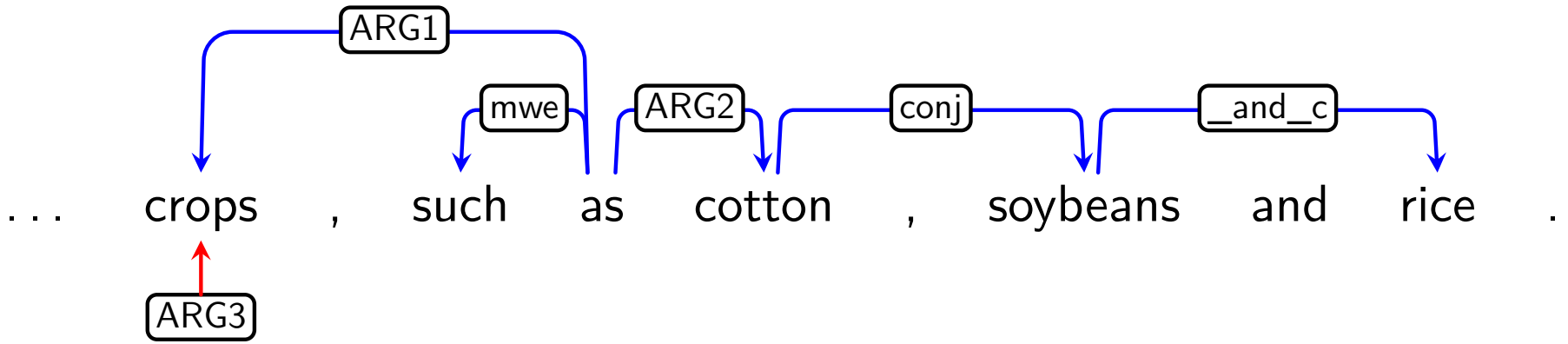

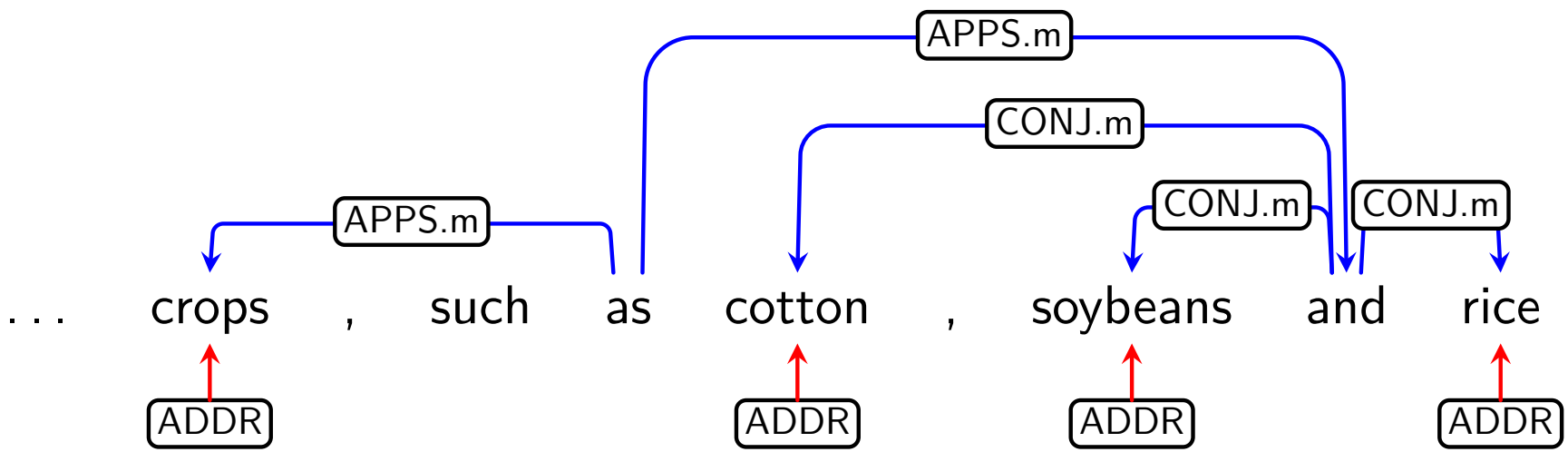

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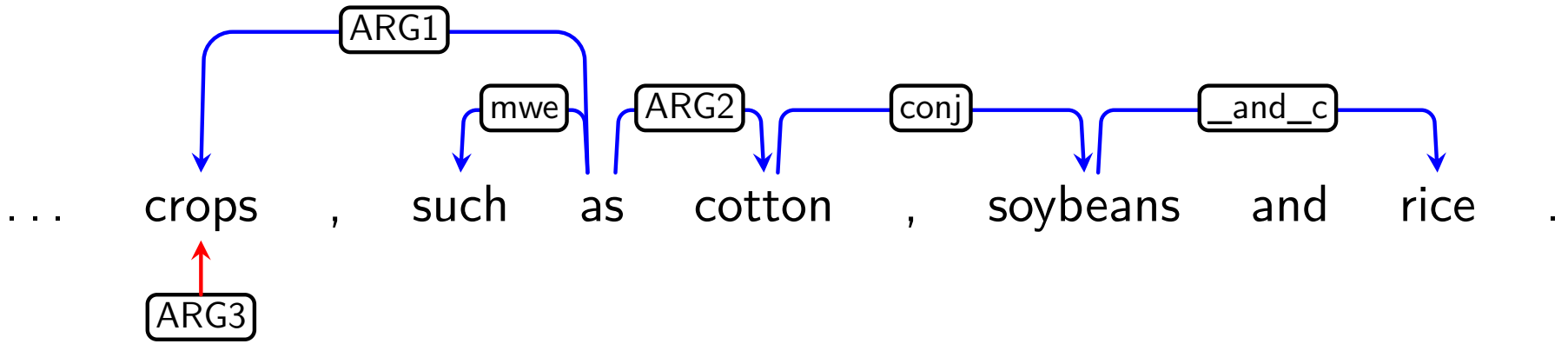
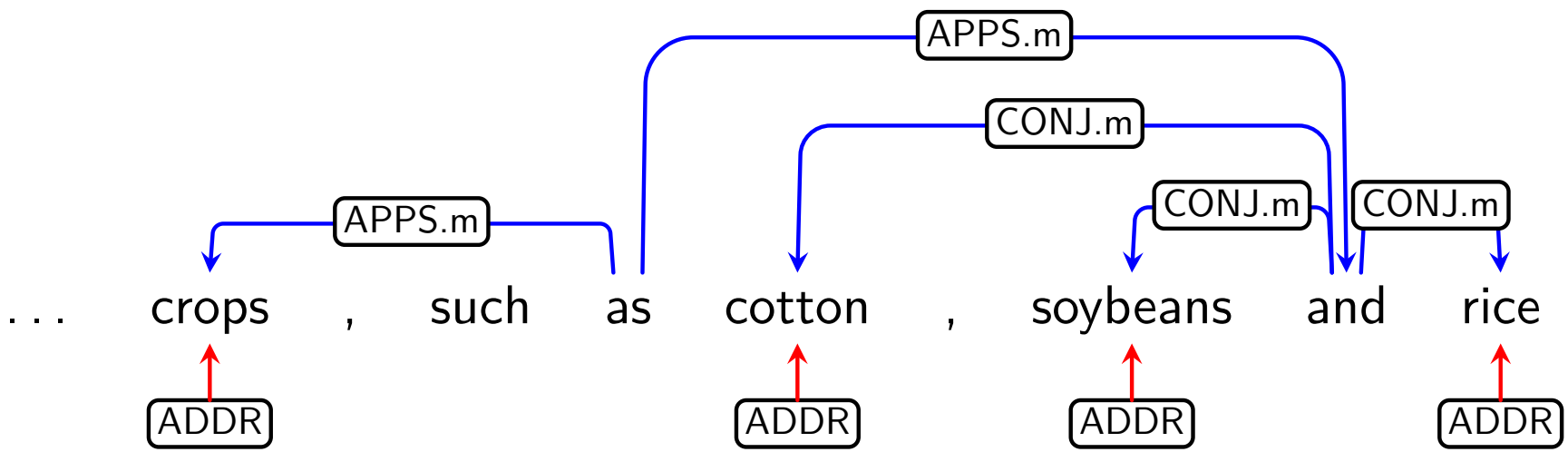
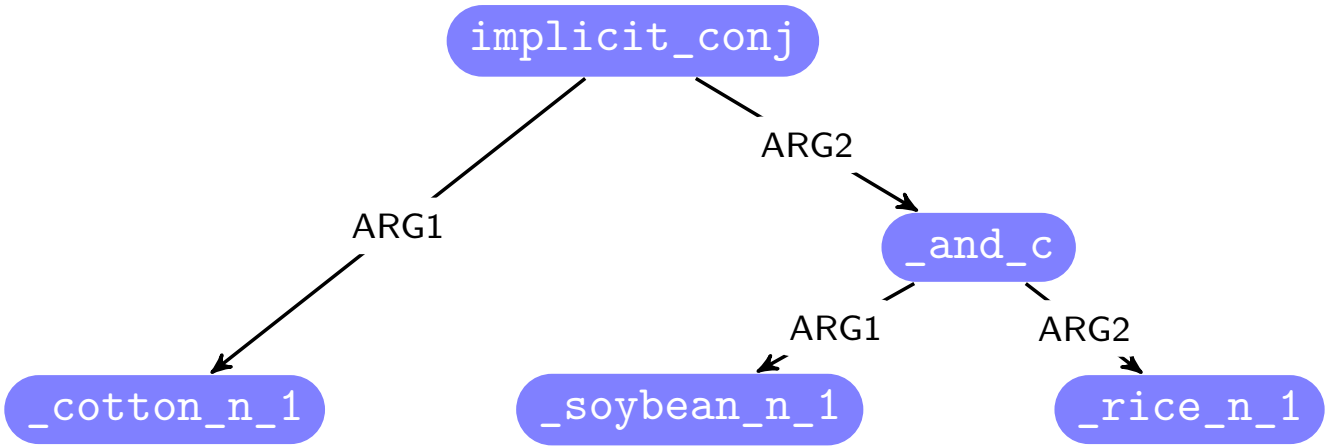
- intuitively, a kind of 'grouping'; how to represent the group as a whole?





Further Variations on Coordination

cotton, soybeans, and rice



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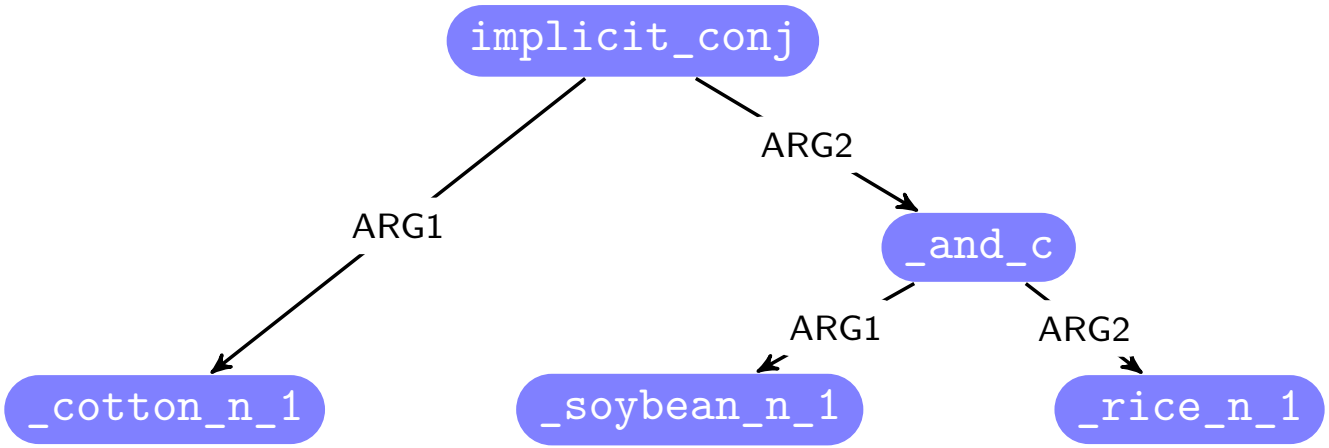

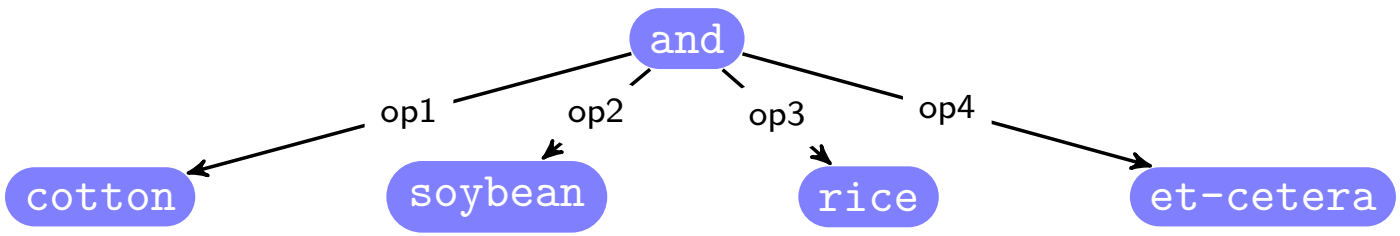

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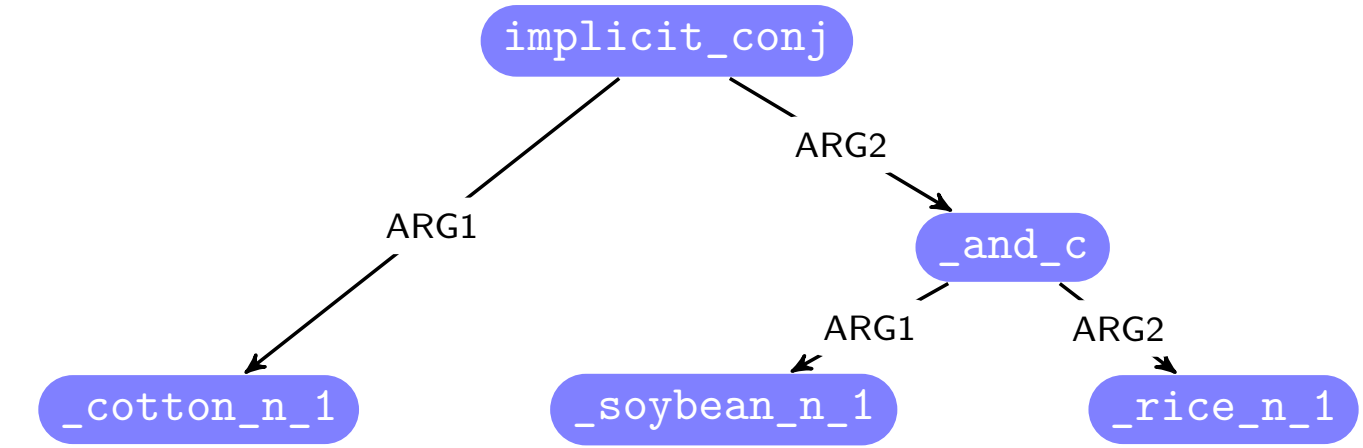

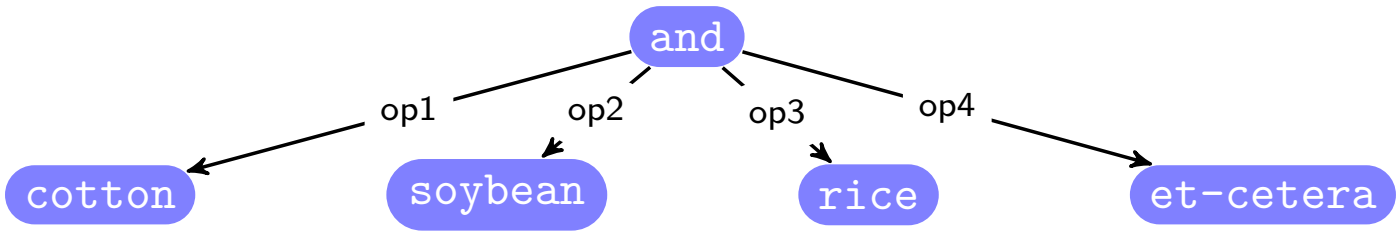

? (?): nine distinct syntactico-semantic dependency patterns.

Background: Partial Predicate–Argument Structures

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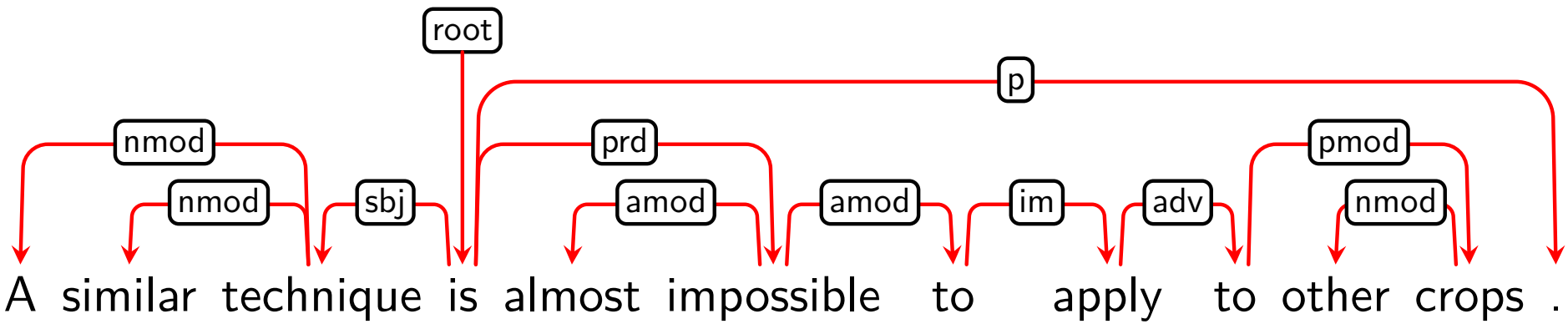

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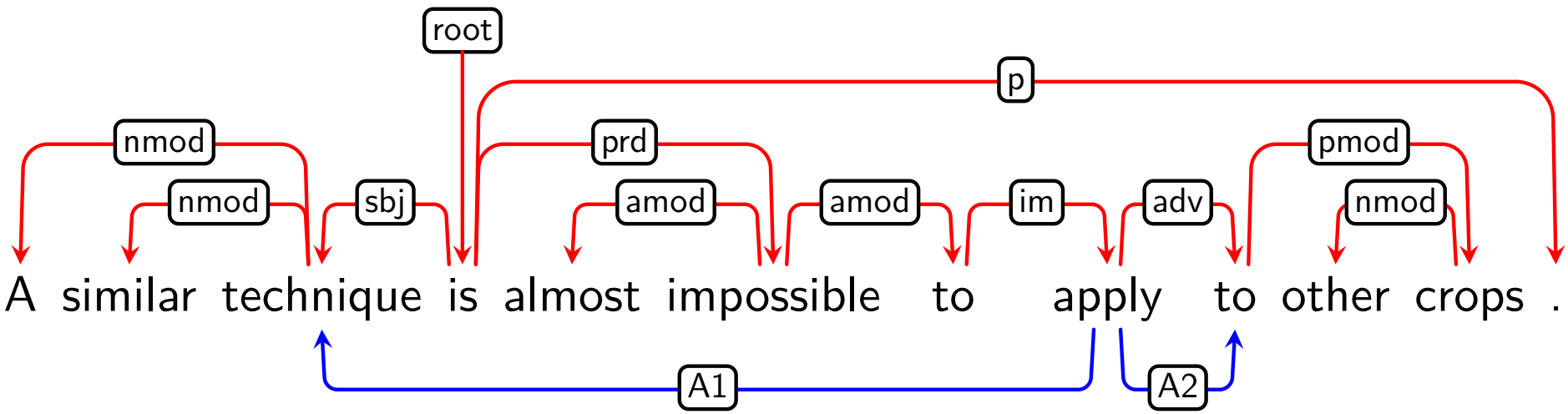

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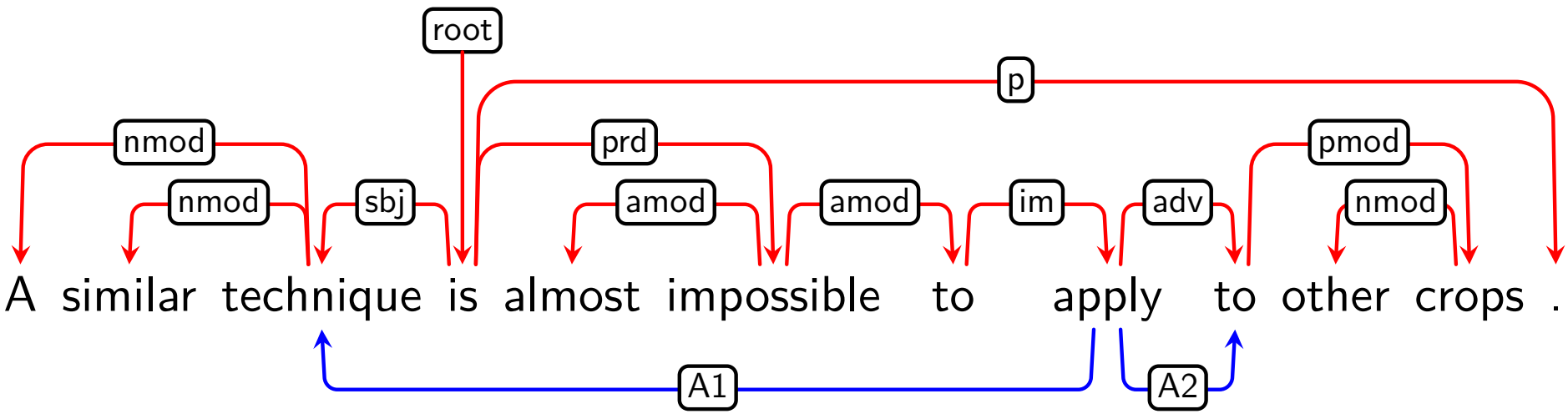

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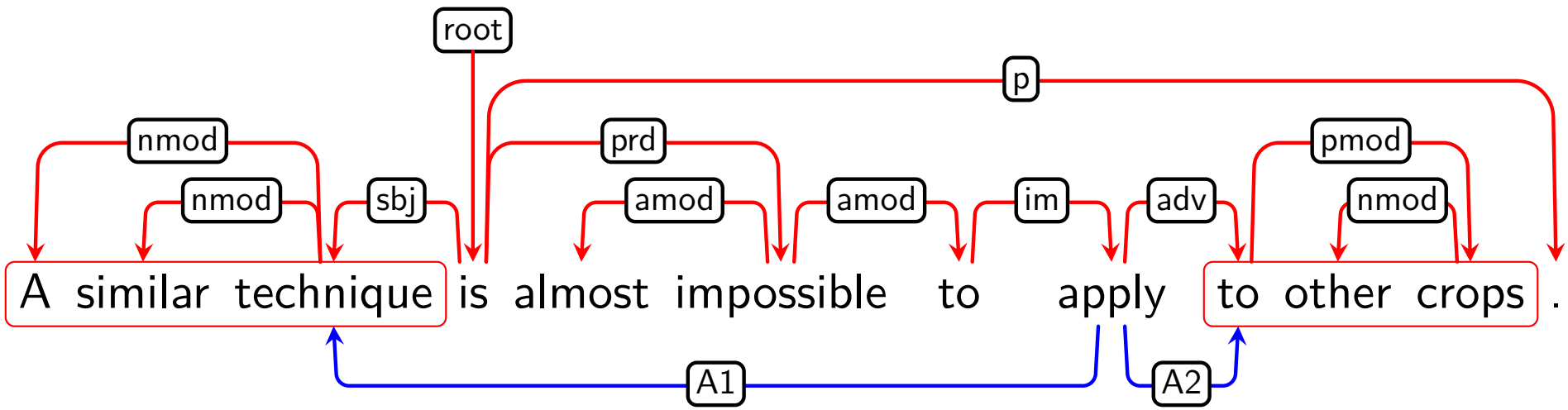

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- conversion to bilexical dependency graphs, head selection from syntax.

Beyond Predicate–Argument Structure

Many NL expressions add logical structure
on top of the predicate-argument structure.

Negation

- John does not eat cookies.
- John said that Mary does not like cookies.
  vs. John did not say that Mary likes cookies.

Quantification

- Every boy likes cookies.
- Every boy ate a cookie.
- *All funny jokes are short.* vs. *All short jokes are funny.*
- Israel stood still as eight soldiers from all branches of the military carried the coffin to the burial ground.

FraCaS: An Early 'Meaning Bank'

Fracas #074

P1	All/most Europeans can travel freely within Europe.
Q	Can all/most Europeans who reside outside of Europe travel freely within Europe?
H	All/most Europeans who reside outside of Europe can travel freely within Europe.

- EU project on computational semantics in the mid-1990s.
- Collected 346 (non-)entailment sentence tuples.
- Also annotated with popular semantic representations of the time (predicate logic, DRT, etc.); but the annotations were lost.

Presupposition and Focus

Certain semantic phenomena supply meaning beyond the truth conditions of the sentence.

Presupposition

- A presupposition of a sentence is a piece of meaning that survives even if the sentence is negated.
- Today I took my cat to the vet.
  Today I didn't take my cat to the vet.
  Did you take your cat to the vet today?

Focus

- A focused phrase implicitly evokes alternatives of which the predication is false.
- YOUR children don't hate school.
  Your CHILDREN don't hate school. ...

Word Senses

The words in a sentence may be ambiguous with respect to their senses. The semantic annotation may or may not choose to disambiguate.

Senses of *plant* in Wordnet

- plant-1: works, industrial plant (buildings for carrying on industrial labor) "they built a large plant to manufacture automobiles"
- plant-2: flora, plant life ((botany) a living organism lacking the power of locomotion)

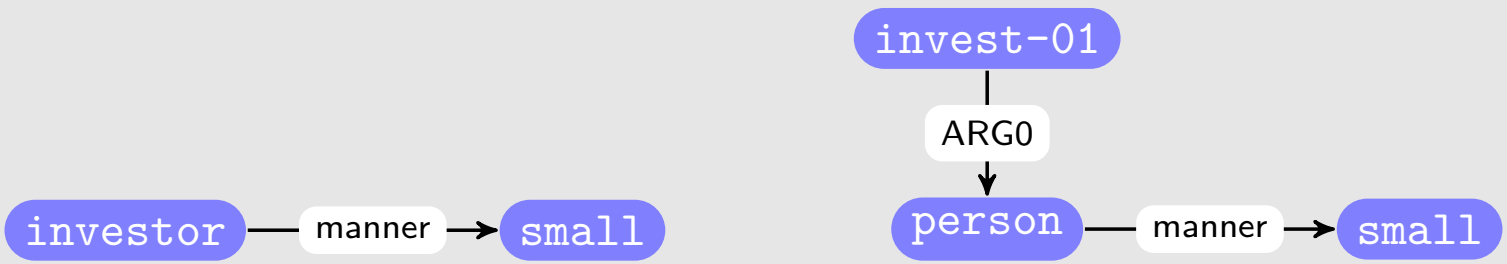
Senses of *keep* in Propbank

- keep.01(ARG0:Keeper, ARG1:thing-kept): "The Herald kept its old-time Hearst readership."
- keep.02(ARG0:causer-of-continued-action, ARG1:continued-entity, ARG2:continued-state-or-action): "The captain kept the crew loyal."

Lexical Decomposition

The meanings of individual words can have internal structure, which the semantic annotation may or may not represent.

How to represent “small investor”?



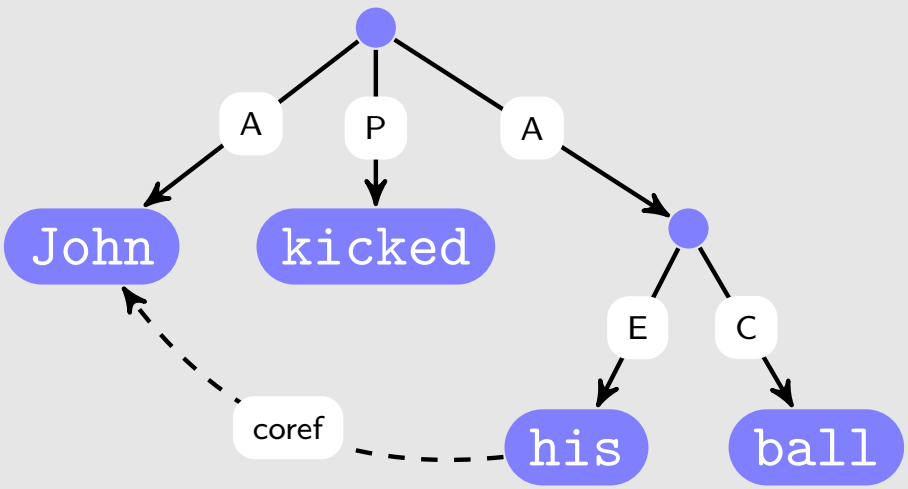
Anaphoric Coreference

The meaning of an anaphoric expression depends on the context in which it occurs (within the sentence; across sentences).

Examples

- John kicked his ball.
- He wants her to see him.

Modeling choices



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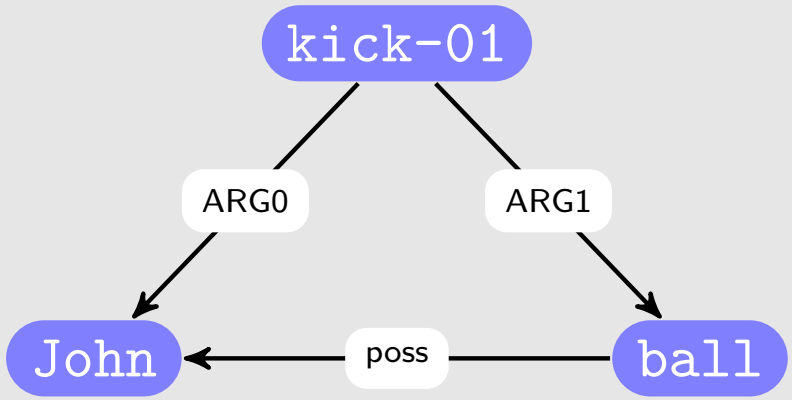

AMR

Summary: Facets of Linguistic Meaning

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- Word sense differentiation
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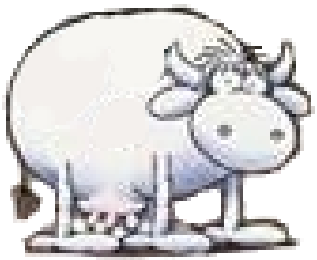
- Grounding (in world; in picture; in Wikipedia; . . .)
- Tense and aspect
- Information structure
- Discourse structure
- . . . and many others . . .

Compositionality

dotted + **cow** = **dotted cow**


(Example by Jan van Eijck)

The Principle of Compositionality

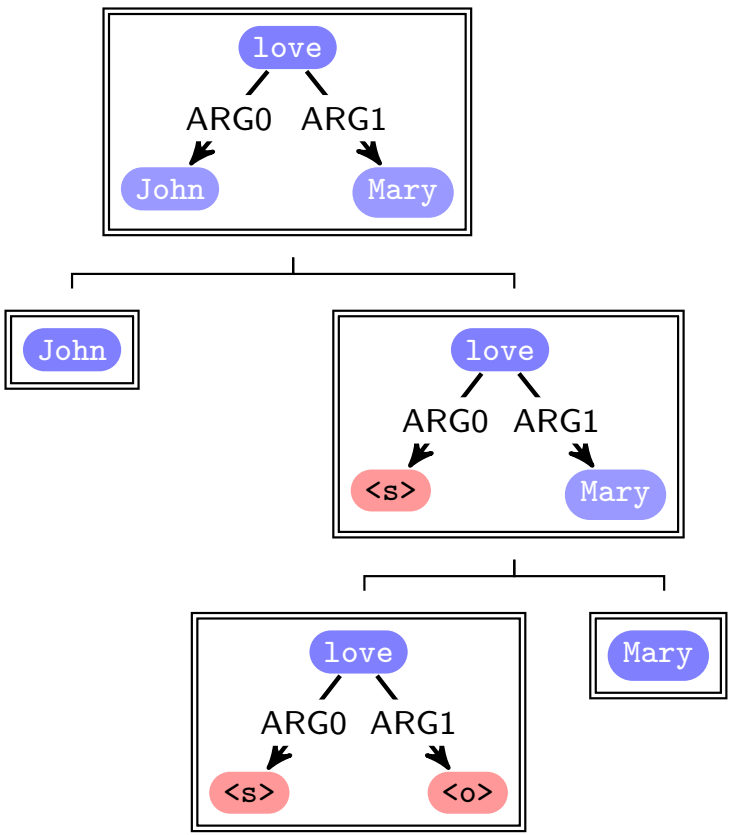
The meaning of an expression is a function of the meanings of its parts and of the way they are syntactically combined. *B. Partee*

Compositionality

Not all semantic phenomena lend themselves easily to a compositional analysis.

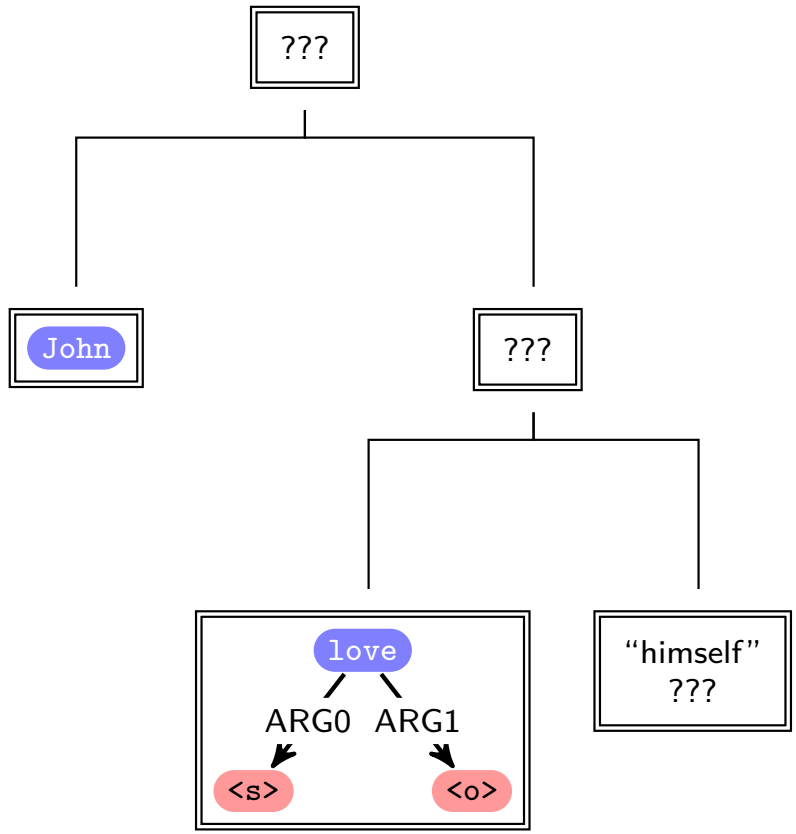
Predicate–argument structure

"John loves Mary."



Coreference

"John loves himself."



2 Foundations: Basic Graph Theory

3

Semantic Graphbanks

4

Semantic Parsing Approaches

5

Using Semantic Structure

6 Conclusions Outlook

References I