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Delexicalized Cross-lingual Transfer of Statistical Syntactic Parsers for Automatic Analysis of Low-resourced Natural Languages

Charles University in Prague
Faculty of Mathematics and Physics
Institute of Formal and Applied Linguistics

CGI FIT ČVUT, Praha, 6 May 2016

Outline

- Introduction to linguistic analysis
- MSTParser and its delexicalization
- Single-source delexicalized parser transfer
  - KL_{cpos3} language similarity
- Multi-source delexicalized parser transfer
  - treebank concatenation
  - parse tree combination
  - model interpolation
- Future work: lexicalization

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Introduction to linguistic analysis

- The boy likes travelling by train very much.

Tokenization

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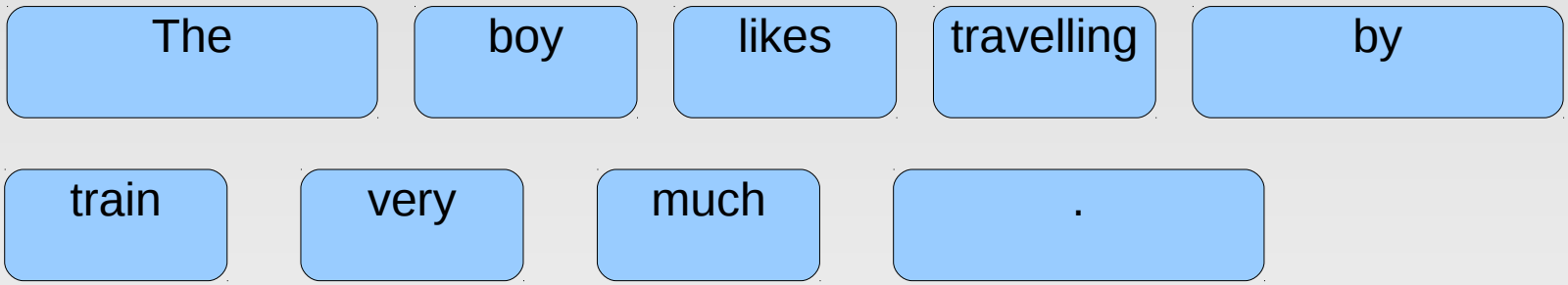

Part-of-speech tagging

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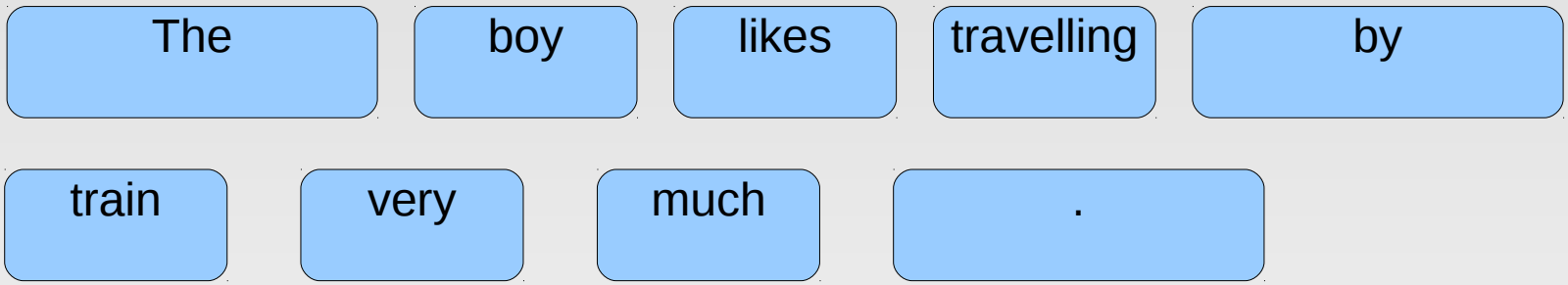

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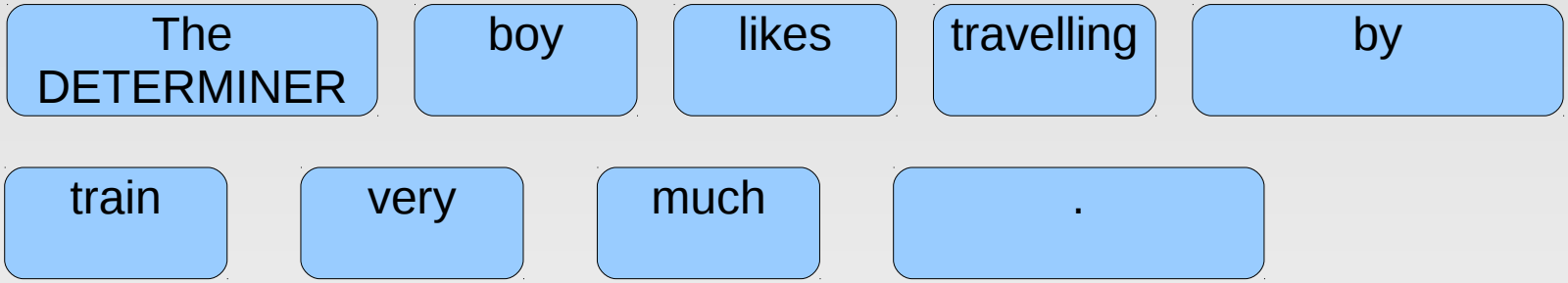

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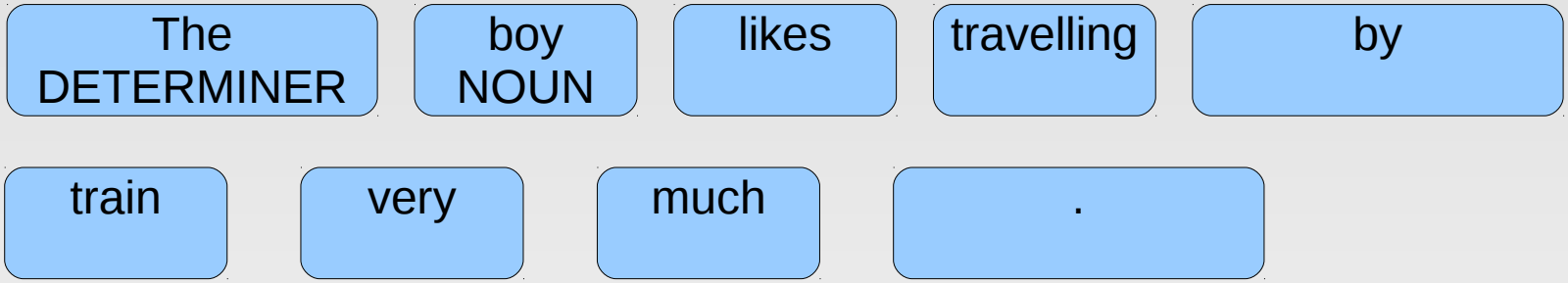

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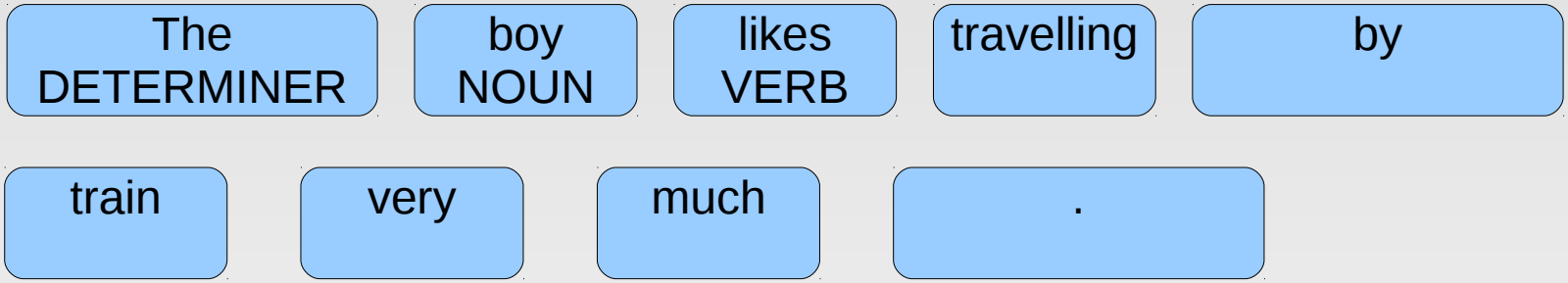

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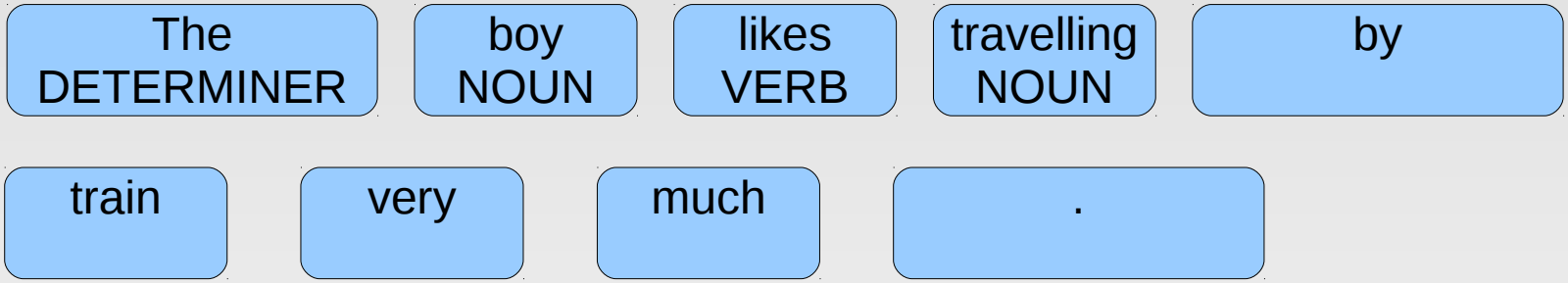

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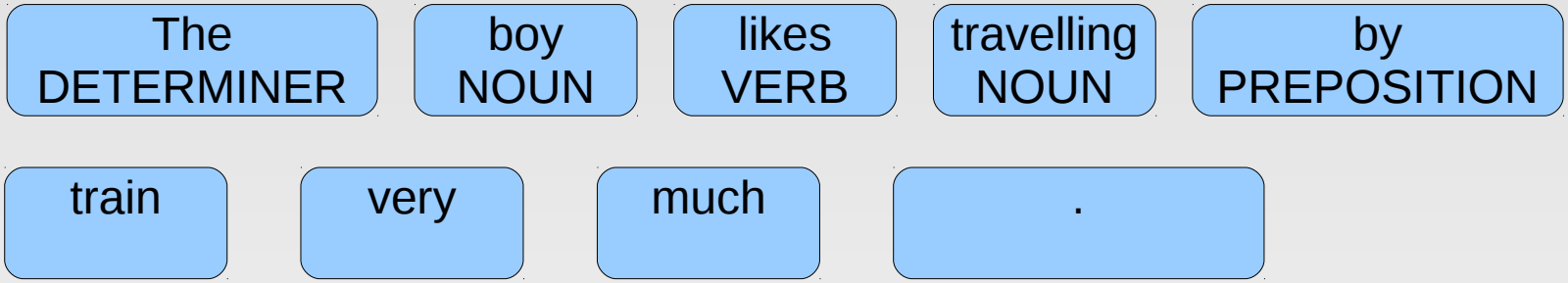

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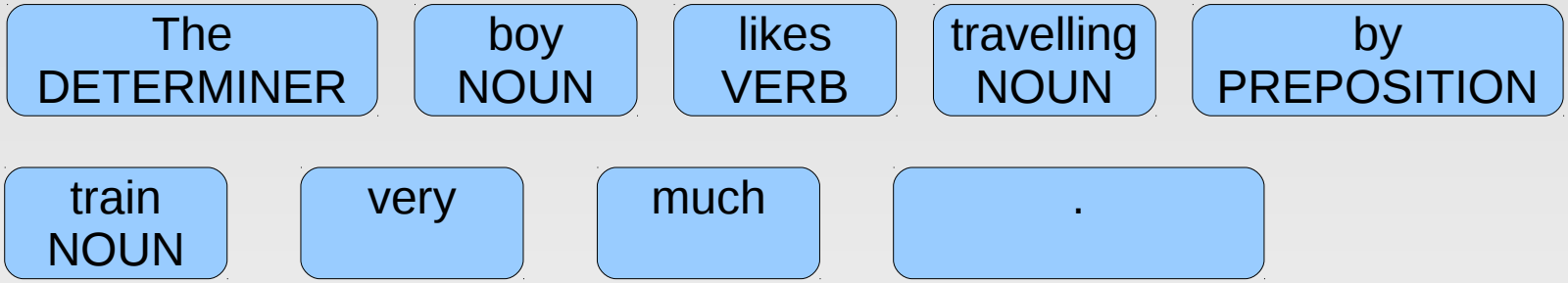

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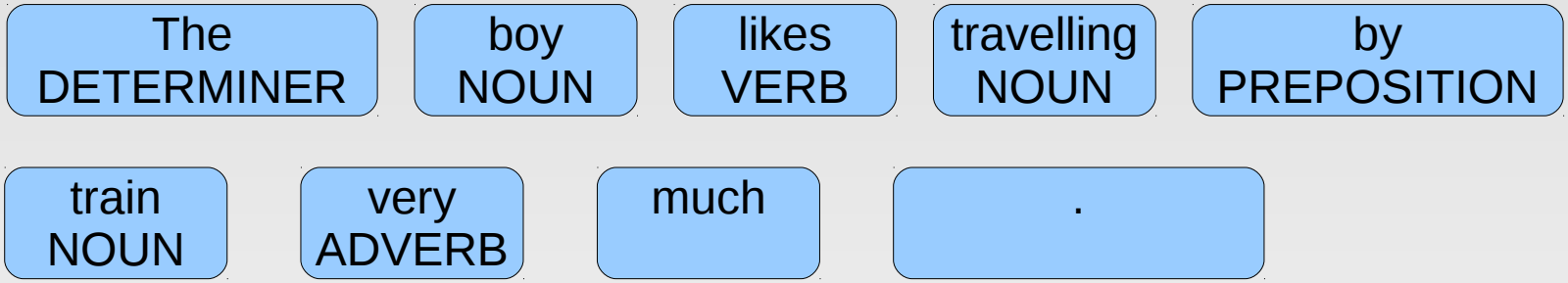

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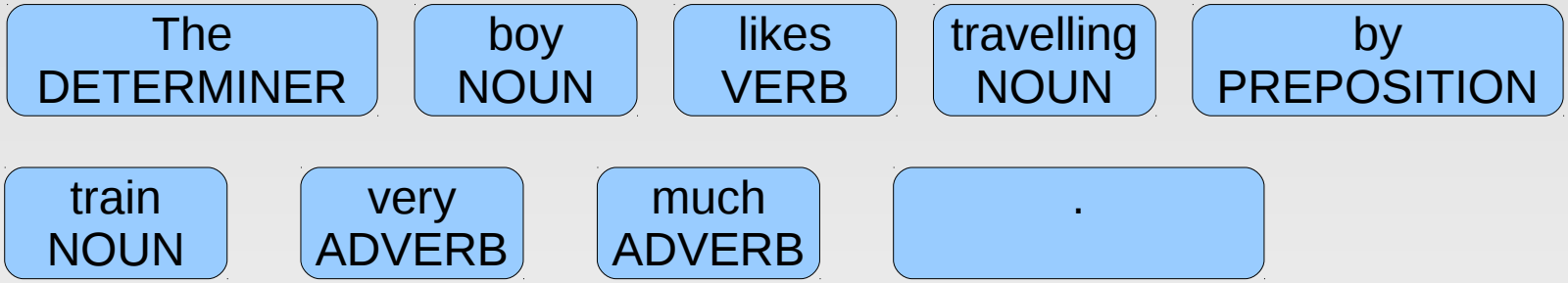


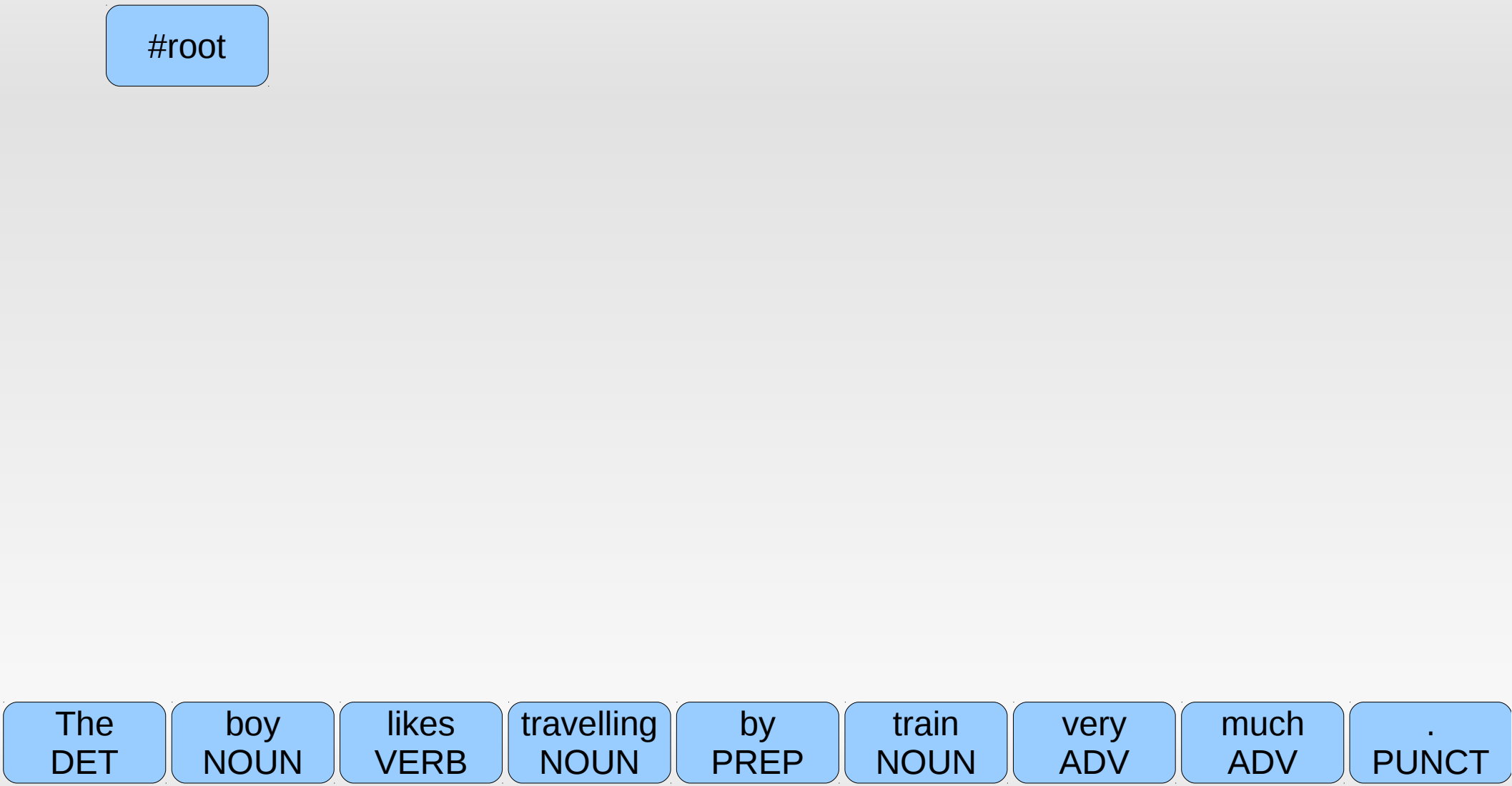
Part-of-speech tagging

- The boy likes travelling by train very much.

The DETERMINER	boy NOUN	likes VERB	travelling NOUN	by PREPOSITION

train NOUN	very ADVERB	much ADVERB	. PUNCTUATION

Syntactic parsing



Syntactic parsing

The	boy	likes	travelling	by	train	very	much
DET	NOUN	VERB	NOUN	PREP	NOUN	ADV	ADV

Syntactic parsing

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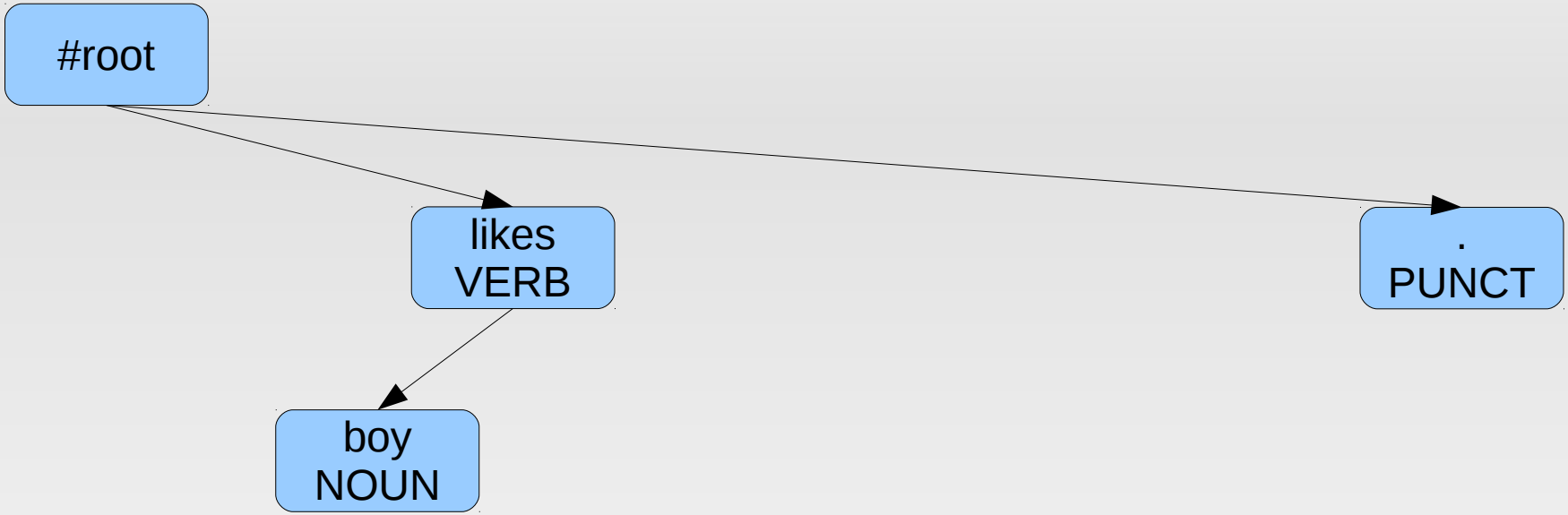

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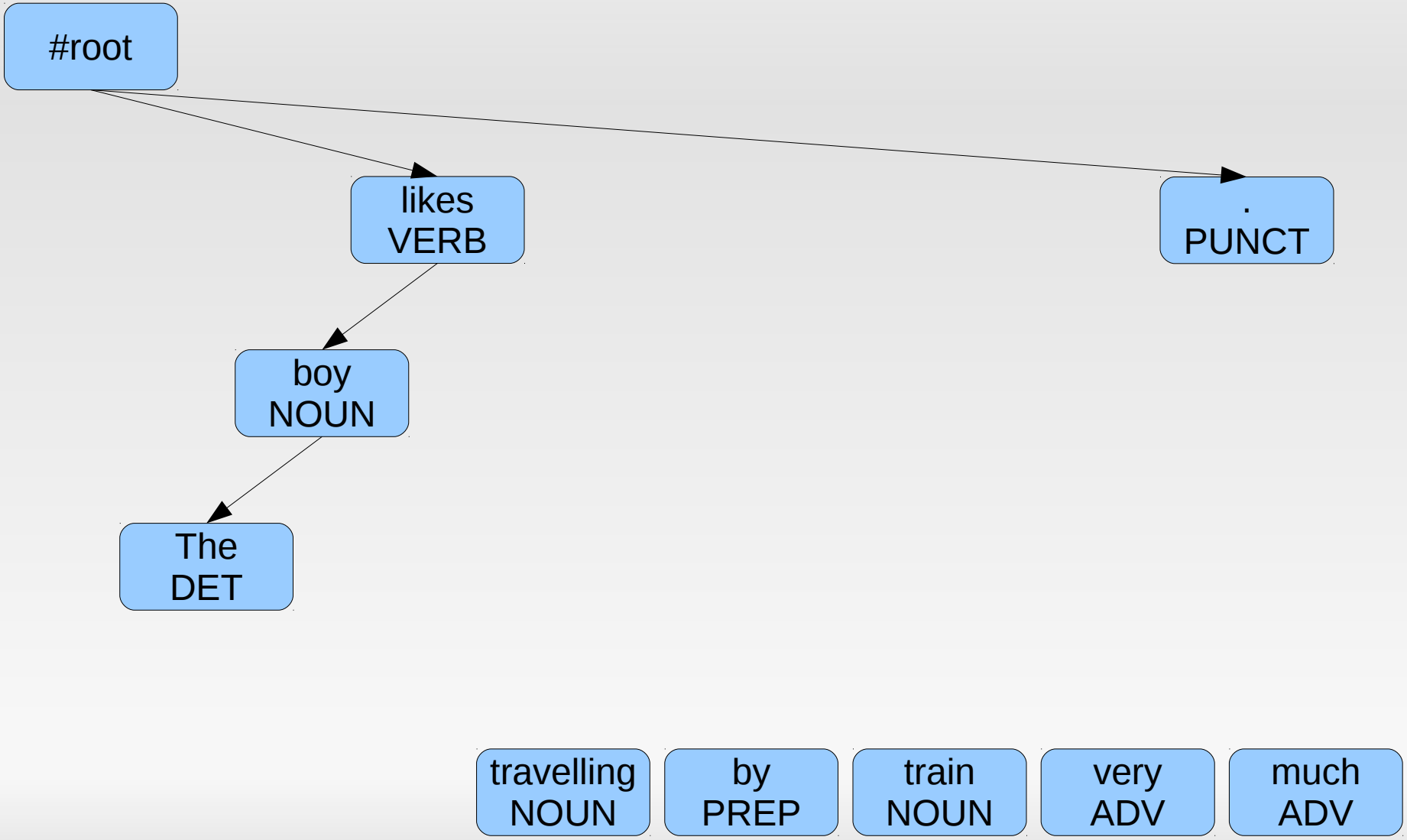

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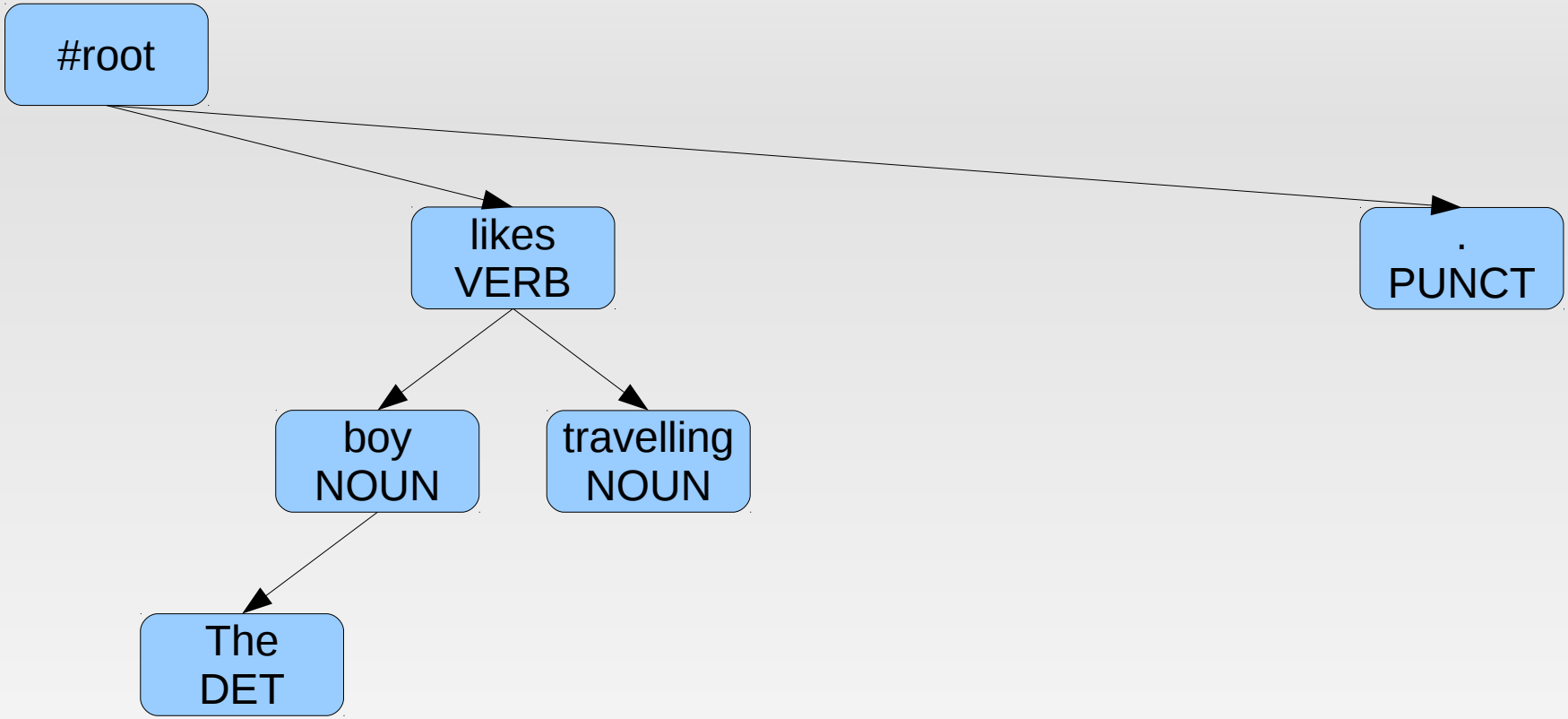

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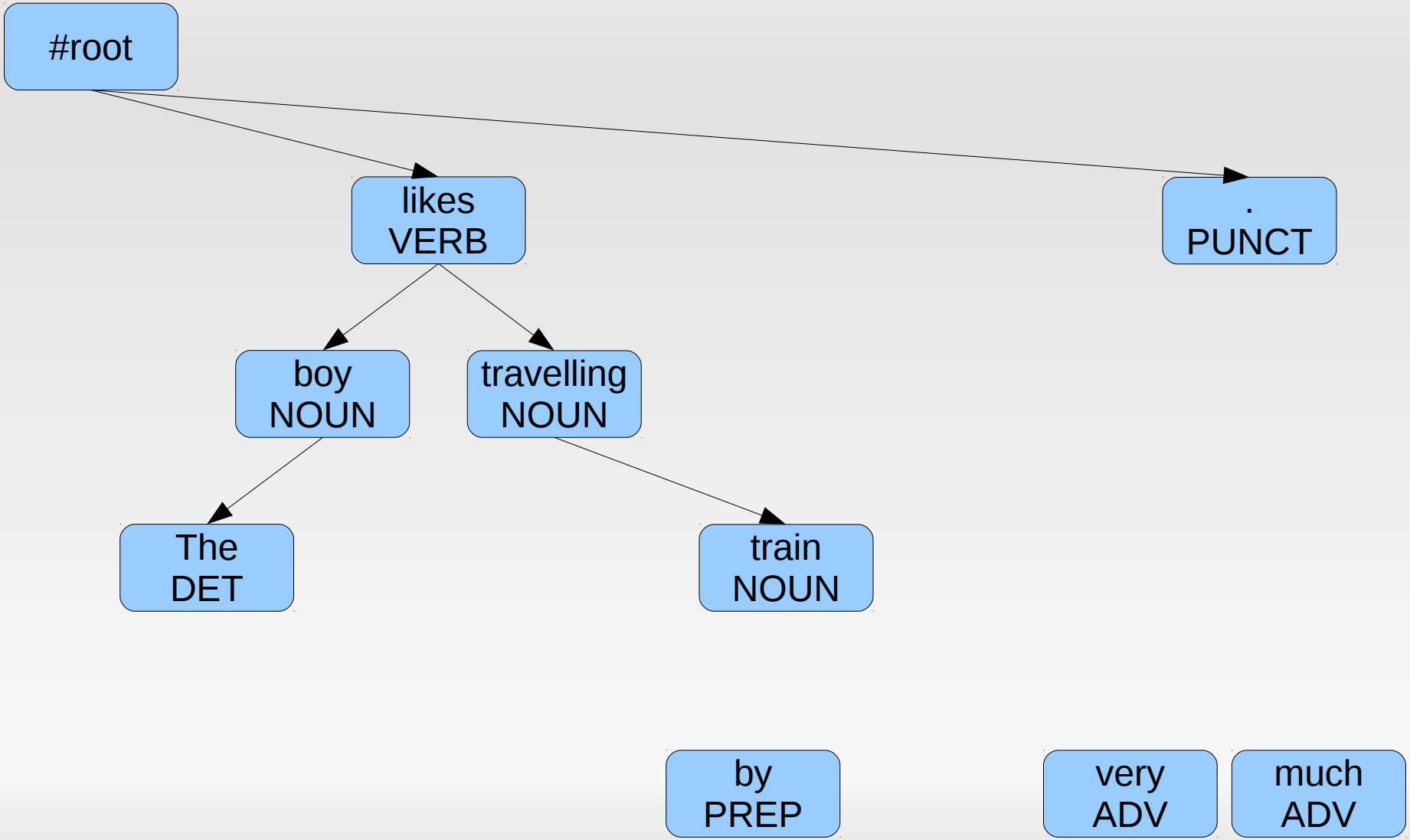

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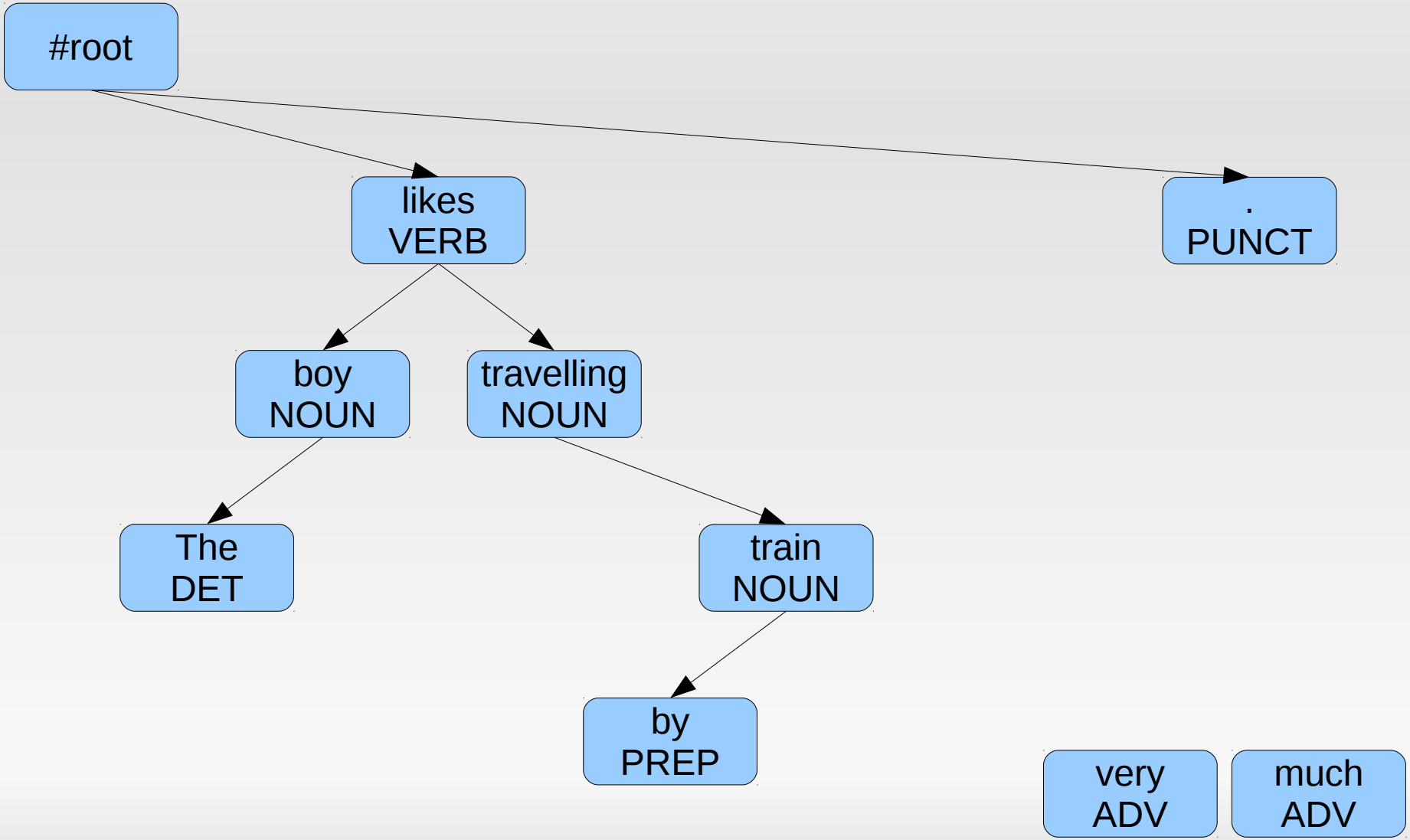

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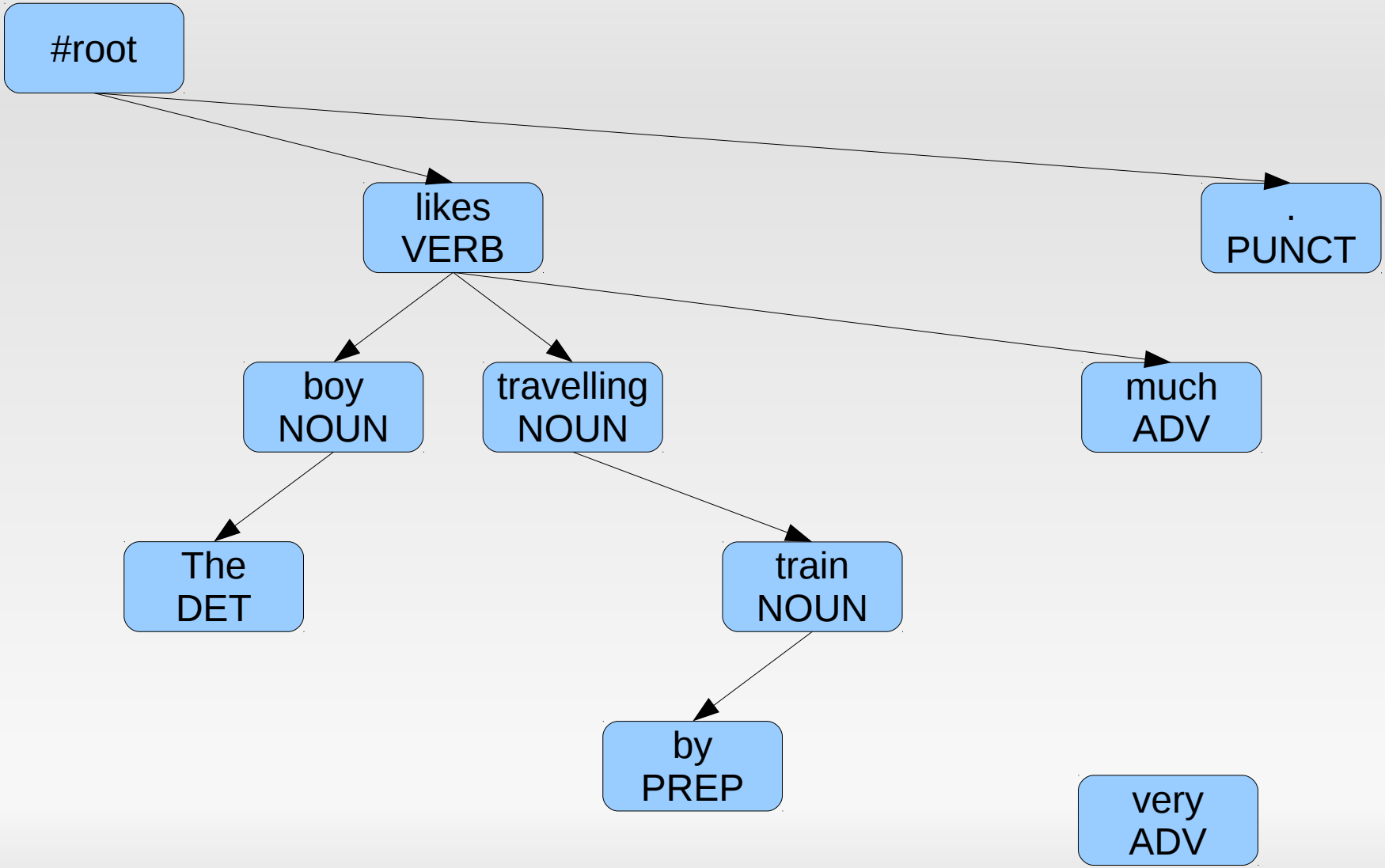

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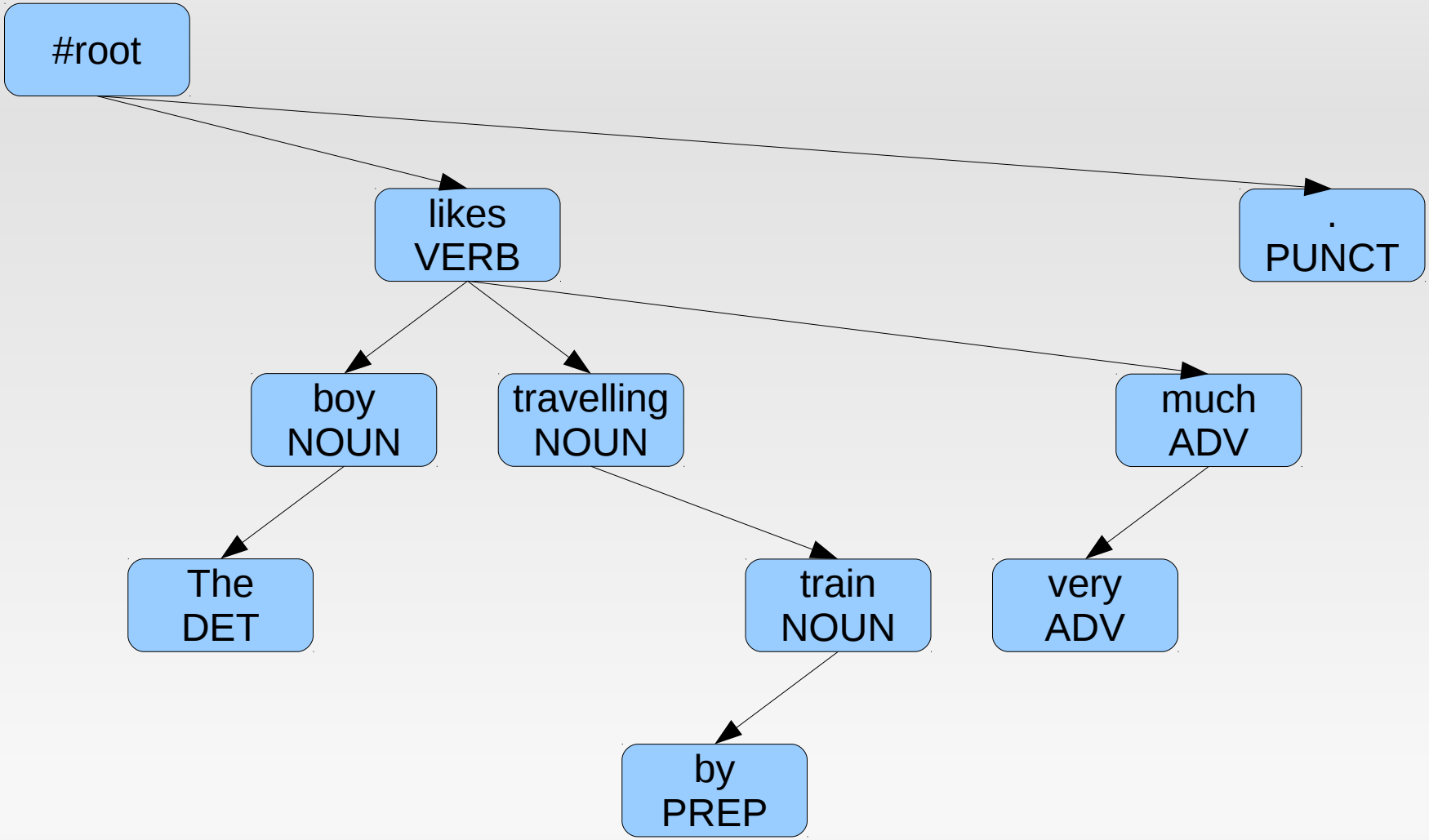

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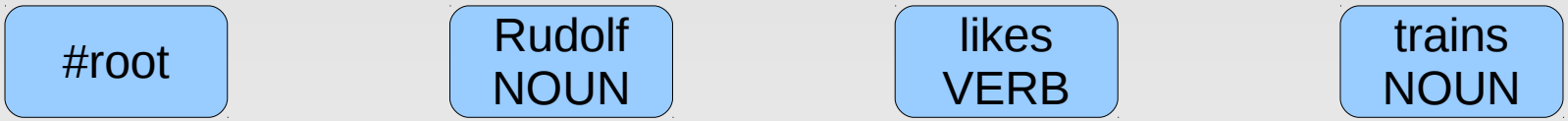
Maximum Spanning Tree Parser



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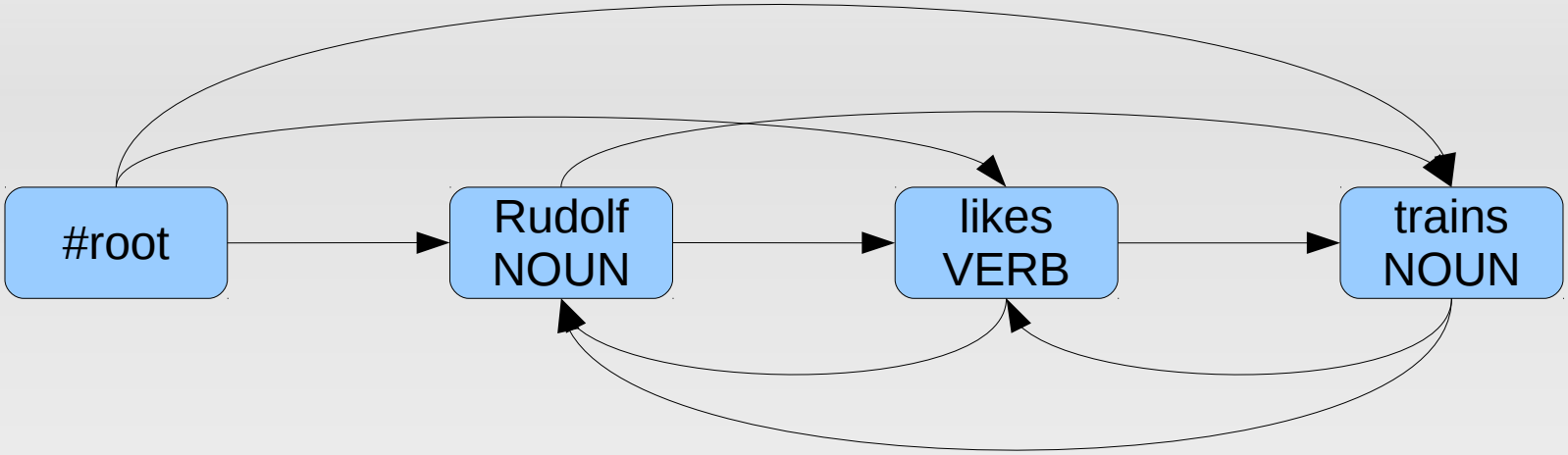

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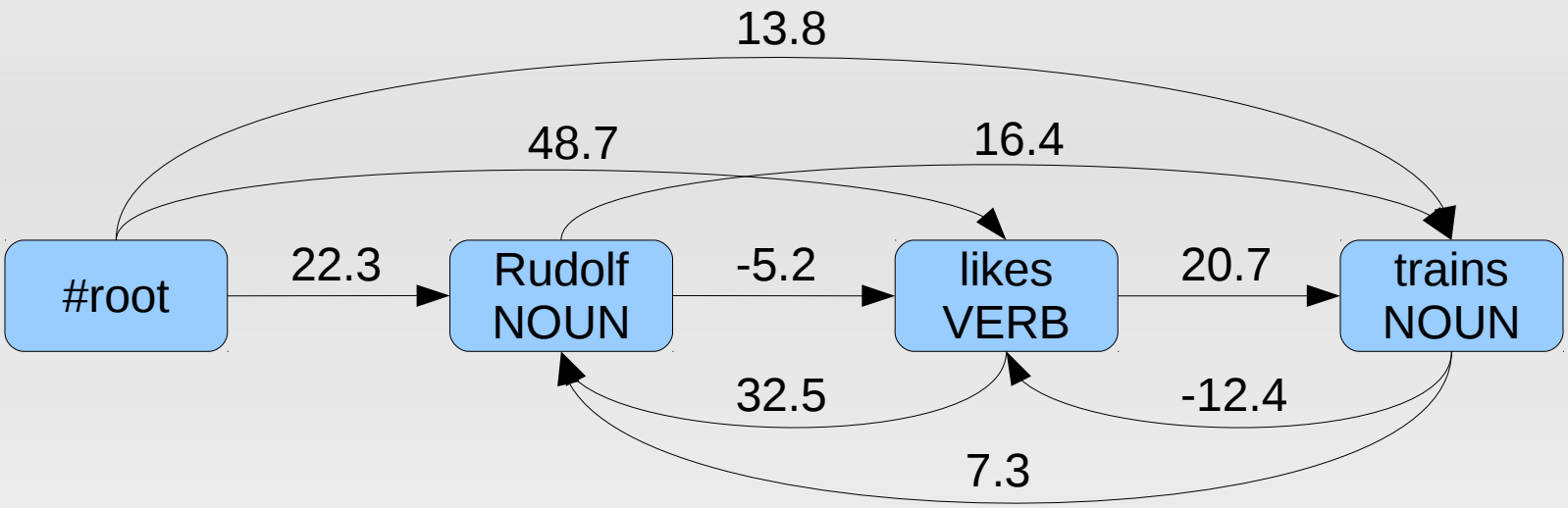
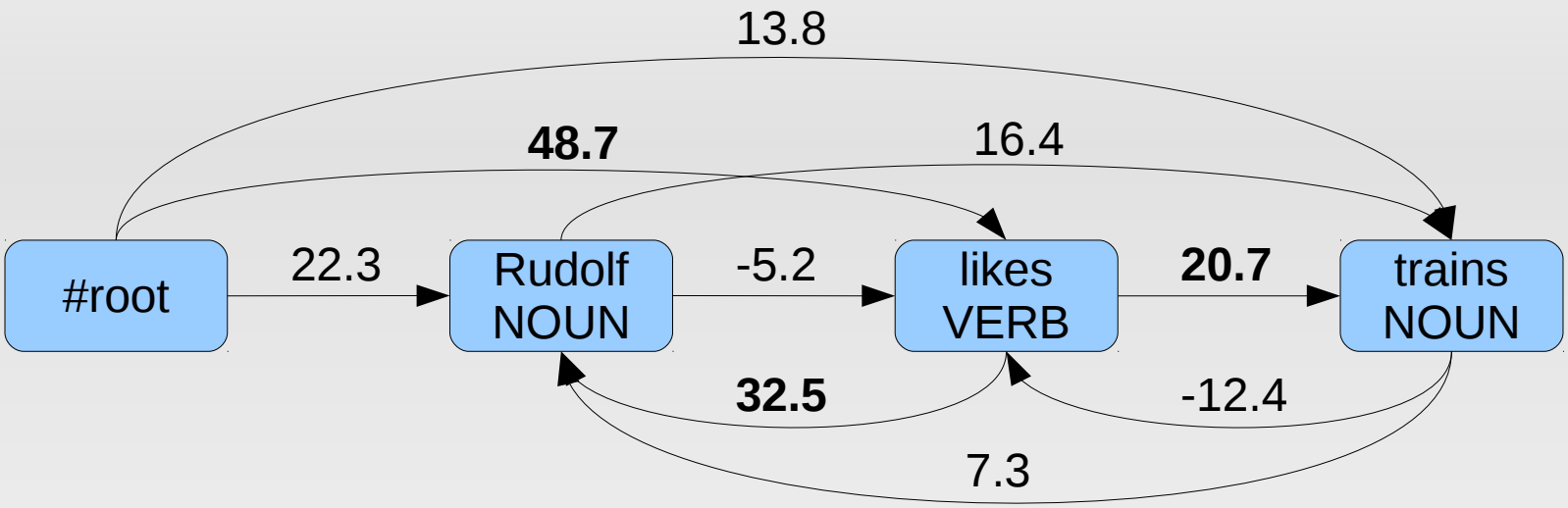
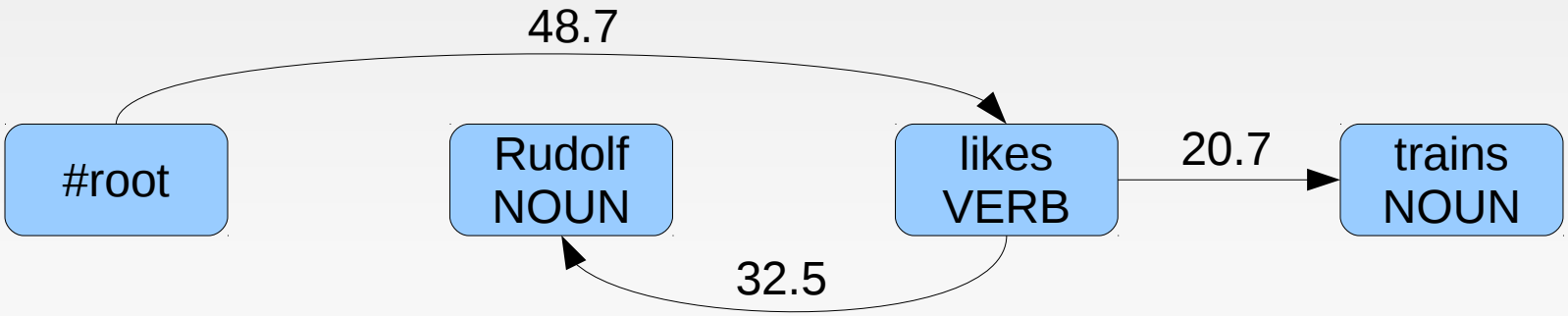


- weighting model trained on annotated data
- features – for edge nodes and their neighbours
  - lexical: word form (“likes”), word lemma (“like”)
  - morphological: part-of-speech tag (“VERB”)
  - signed distance of nodes (#root → likes: “+2”)

Maximum Spanning Tree Parser



- Chu-Liu-Edmonds MST algorithm



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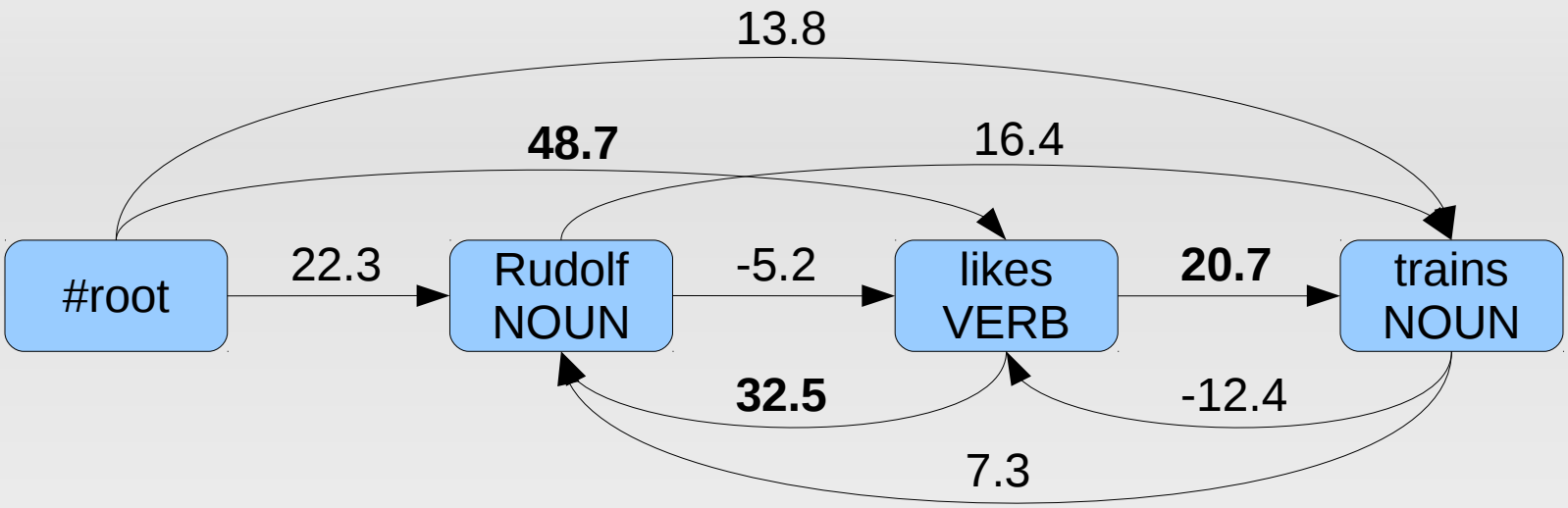
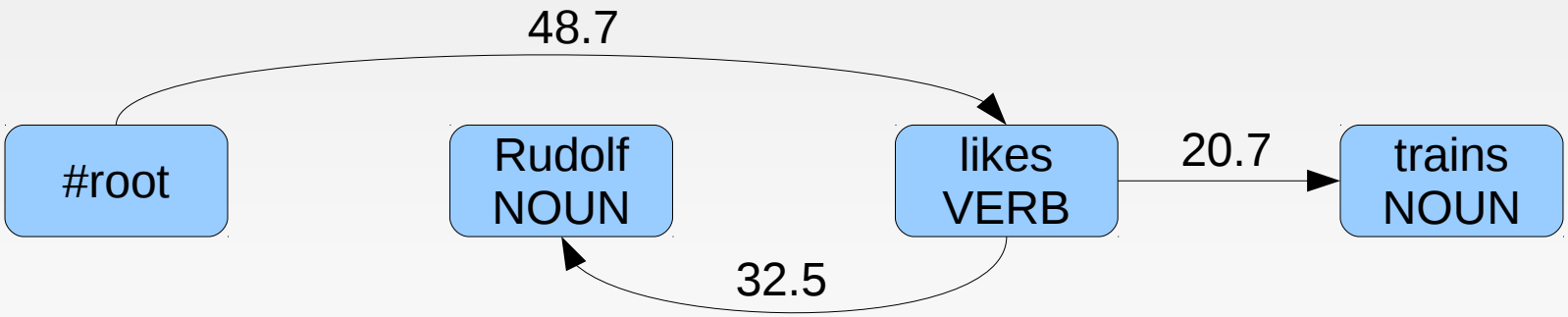
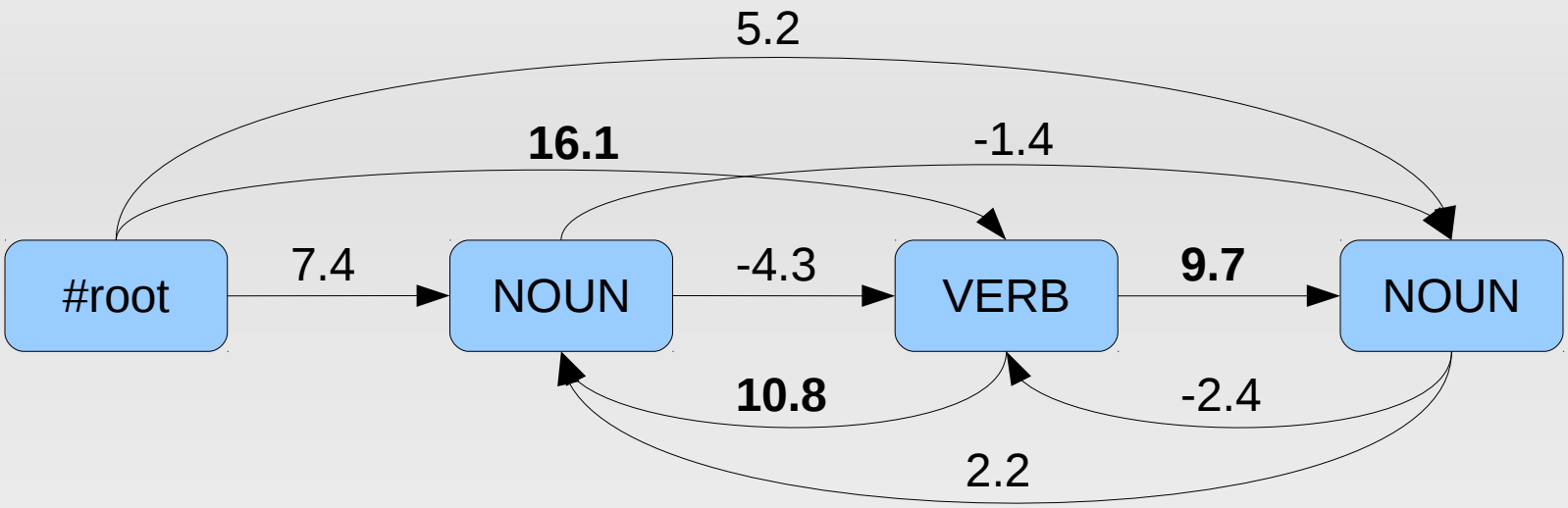
  - requires training data (treebank) or a grammar
  - there are ~100 treebanks (manually annotated)
  - there are ~7 000 languages
  - + various domains, language evolution...
- semi-supervised parsing
  - utilize existing resources, avoid new annotations
    - treebanks for other languages (HamleDT: 30 languages)
    - unannotated data (here: part-of-speech tagged)

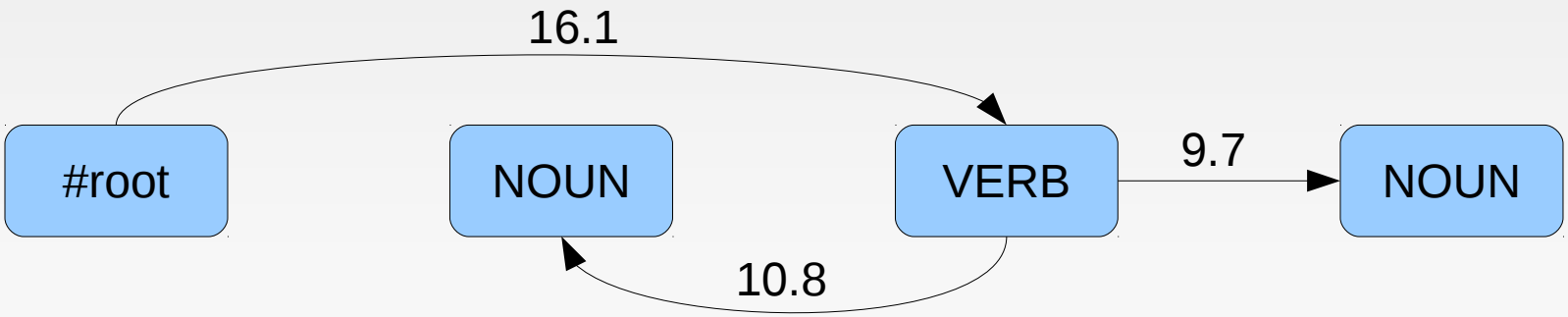
Lexicalized MSTParser





Delexicalized MSTParser





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Single-source delex parser transfer

- (Zeman and Resnik, 2008)
- train a delexicalized parser on a **source** language treebank (e.g. Czech)
- apply it to a **target** language, without a treebank but with a POS tagger (e.g. Slovak)

Utilizing multiple treebanks

- HamleDT: 30 harmonized treebanks
- How do we choose the source treebank?
- Can we use more/all source treebanks?

Choosing the source treebank

- src should be as similar to tgt as possible
  - World Atlas of Language Structures (WALS)
    - language family, word order properties...

Choosing the source treebank

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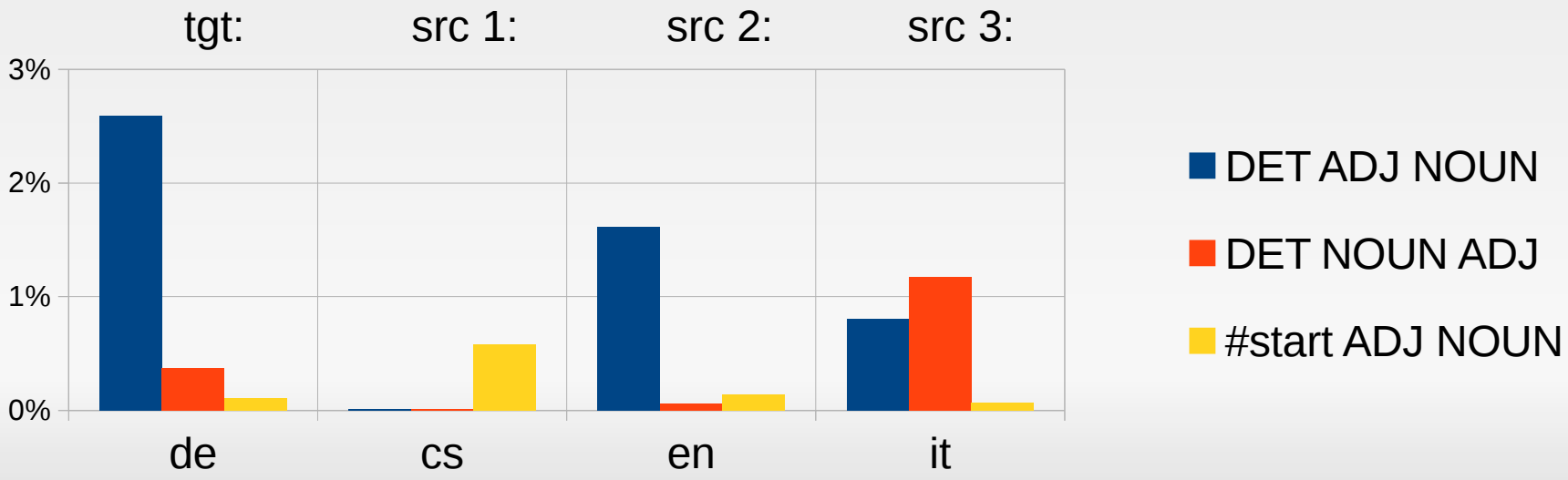
  - $KL_{cpos\ 3}$ (***tgt***, ***src***): Kullback-Leibler divergence of POS trigram distributions



$KL_{cpos\ 3}$

$$cpos^3 = \langle cpos_{i-1}, cpos_i, cpos_{i+1} \rangle$$

$$f(cpos^3) = \frac{count(cpos^3)}{|corpus|}$$

$$KL_{cpos^3}(tgt, src) = \sum_{\forall cpos^3 \in tgt} f_{tgt}(cpos^3) \cdot \log\left(\frac{f_{tgt}(cpos^3)}{f_{src}(cpos^3)}\right)$$

Sample of results (HamleDT)

Target lang.	$KL_{cpos\ 3}$ selected src		Oracle (best possible src)
	lang.	UAS	
Bengali	Telugu	66.7	✓
Czech	Slovak	65.8	✓
Danish	Slovenian	42.1	+13.3 English
German	English	56.8	✓
Slovak	Slovenian	58.4	+ 3.3 Czech
Tamil	Turkish	31.1	+22.4 Hindi

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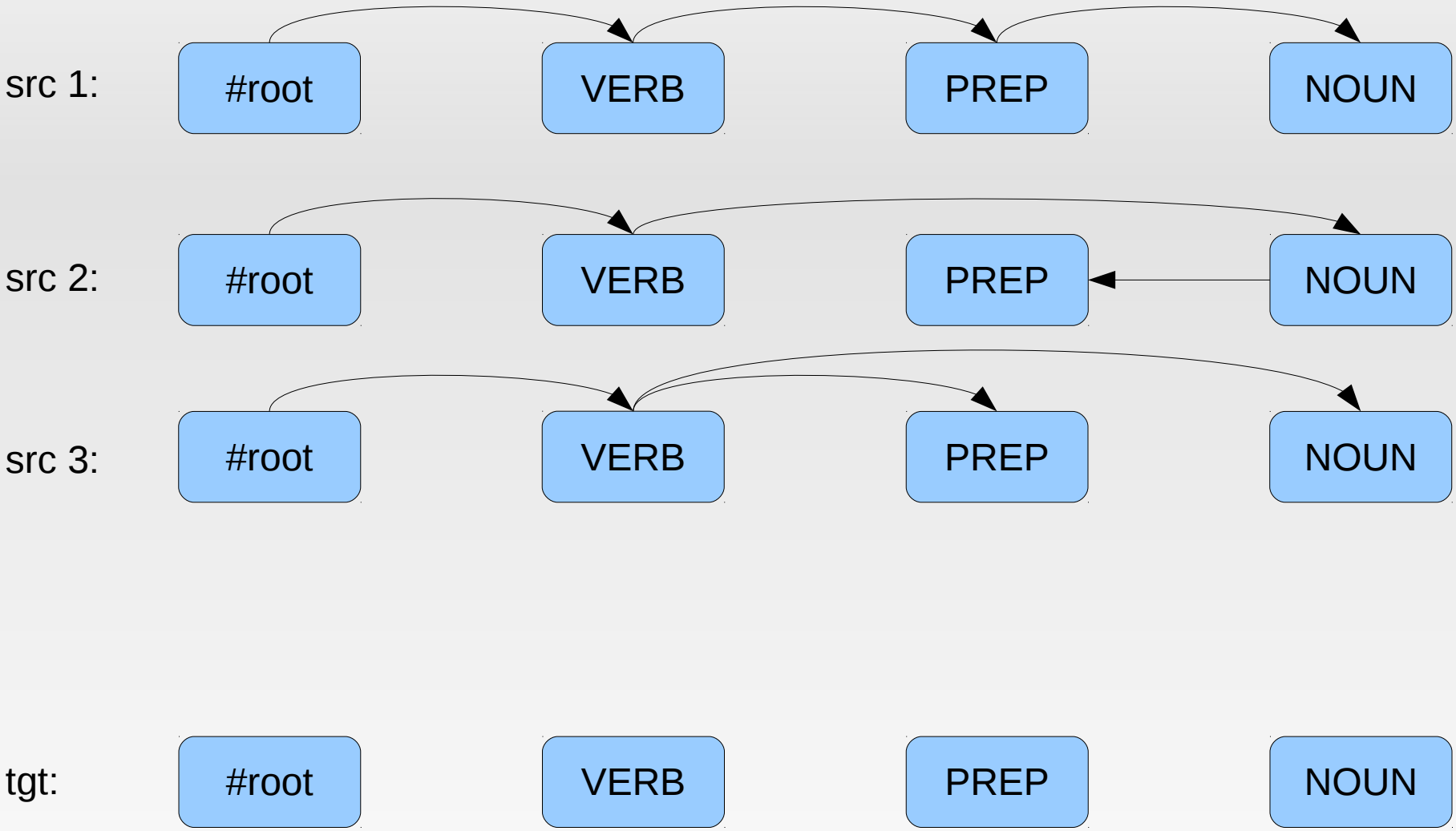
Multi-source delex parser transfer

- treebank concatenation
  - concatenate all source treebanks
  - train one delexicalized parser on the multi-treebank
  - apply the parser to the target text

Multi-source delex parser transfer

- treebank concatenation (baseline)
  - train a parser on concatenation of all treebanks
- parse tree combination
  - train a separate parser for each source treebank
  - separately apply each parser to target text
  - use parser voting and MST algorithm to find the final analysis

Parse tree combination



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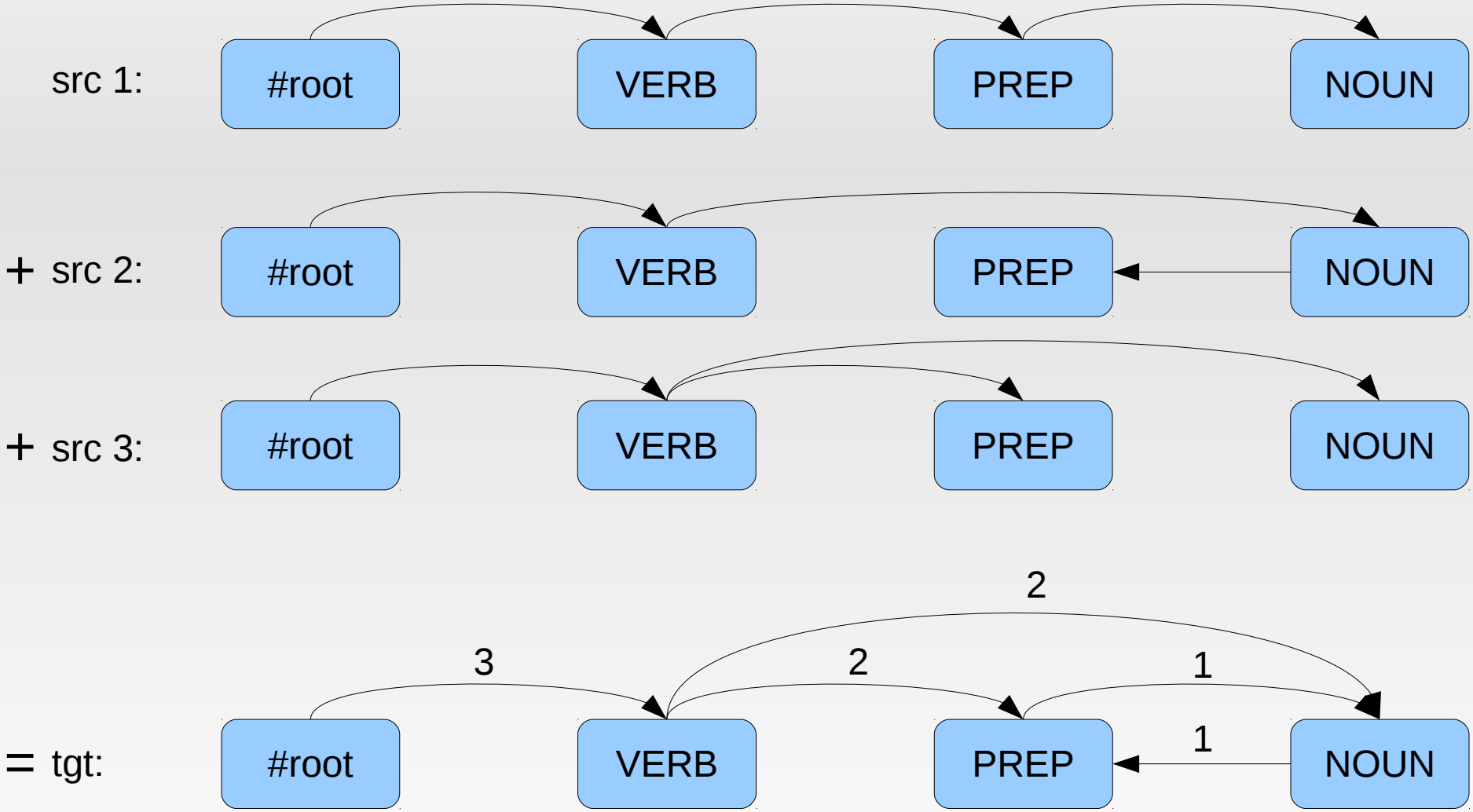

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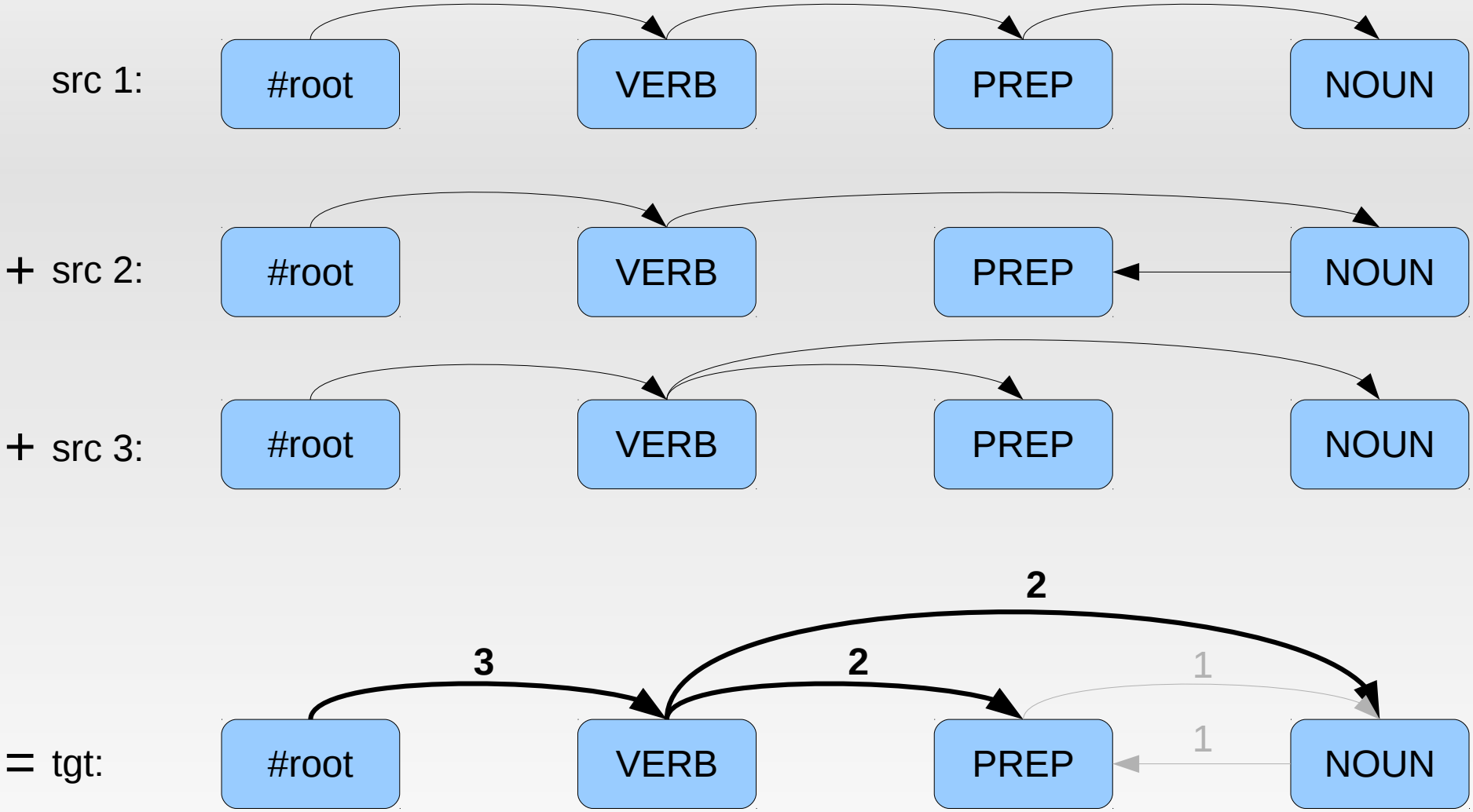
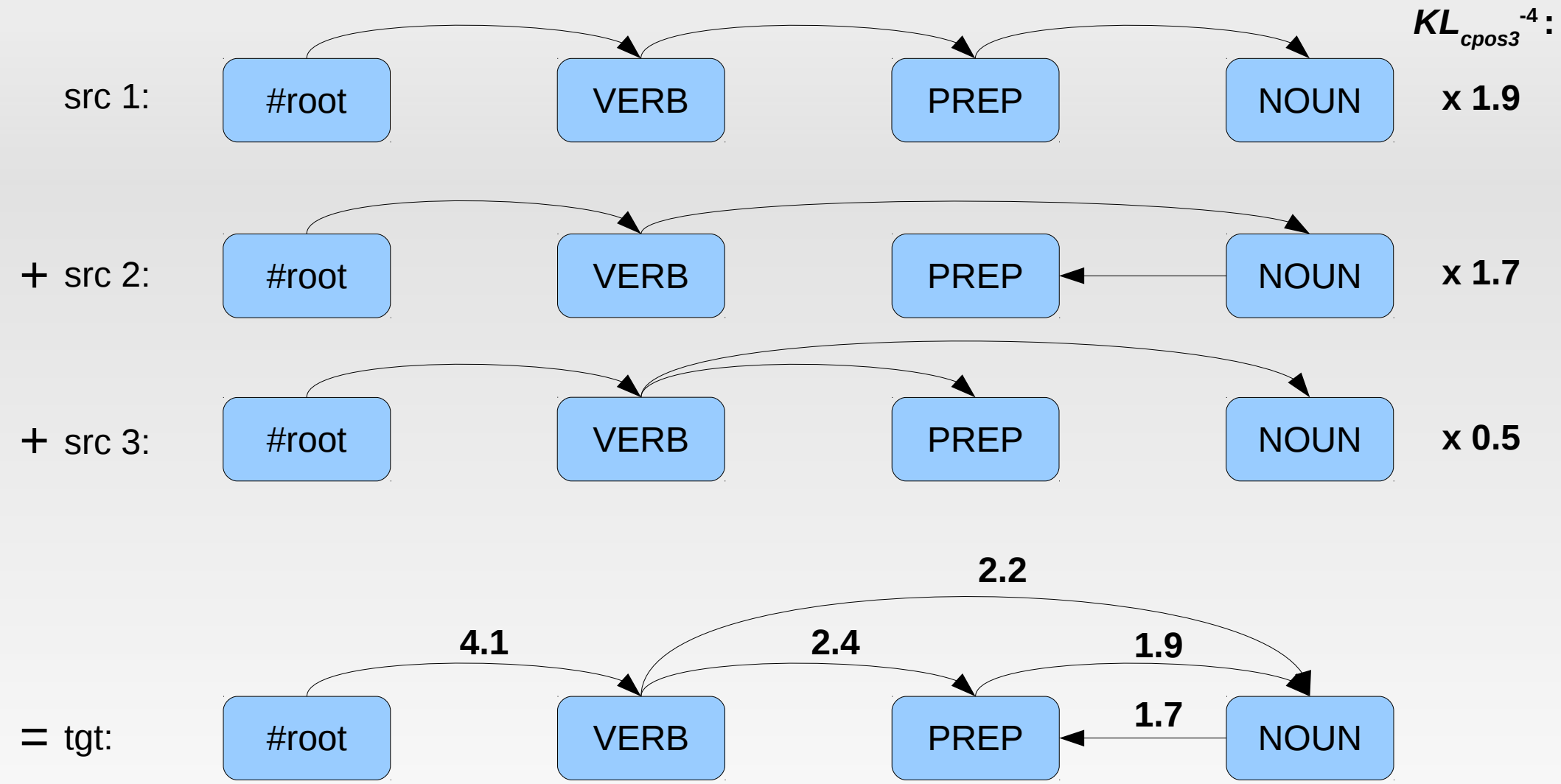


Weighted parse tree combination



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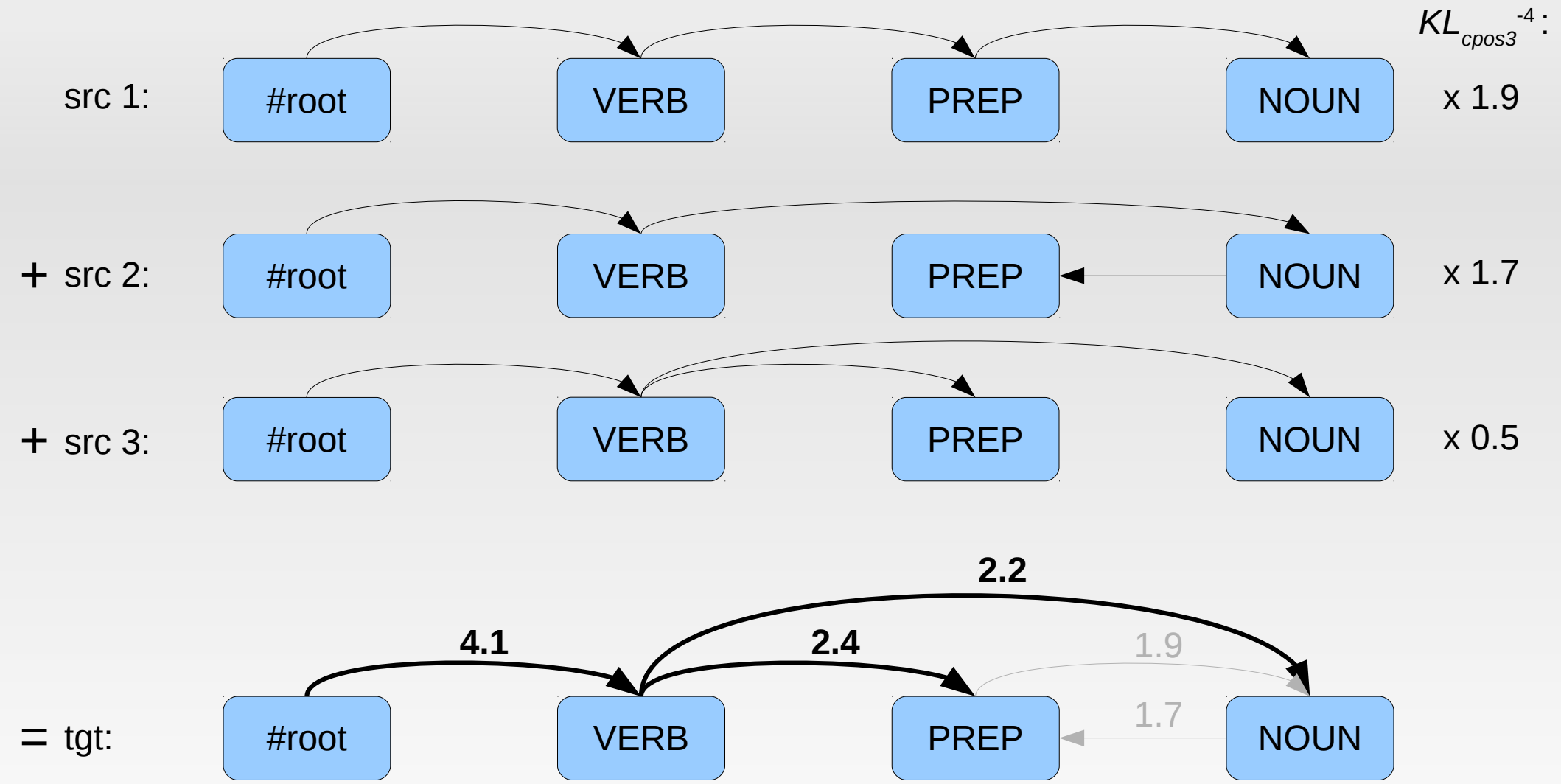
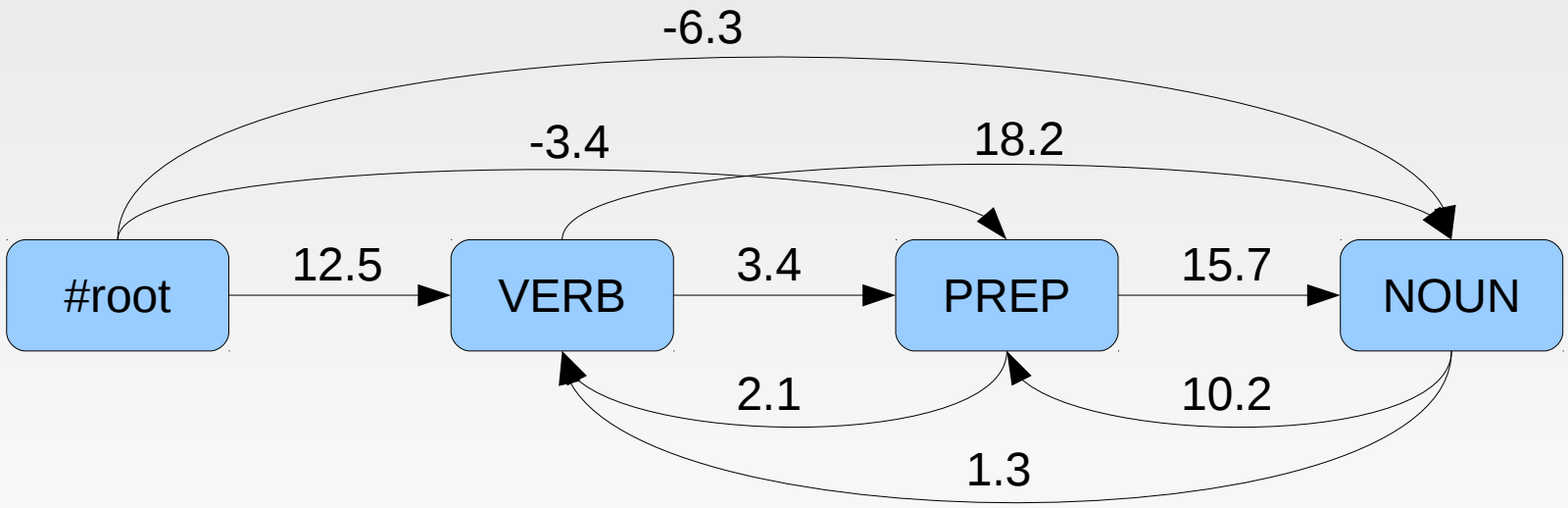


Multi-source delex parser transfer

- treebank concatenation (baseline)
  - train a parser on concatenation of all treebanks
- parse tree combination
  - combine separate src parsers via voting and MST
- parser model interpolation
  - train a parser for each source treebank
  - interpolate the trained models into a combined model
  - apply the parser with the combined model to the target text

Parser model interpolation

- motivation: maybe the parser is more sure with some edges than other?
- the score assigned to the edge might show that
  - MSTParser before running the MST algorithm:



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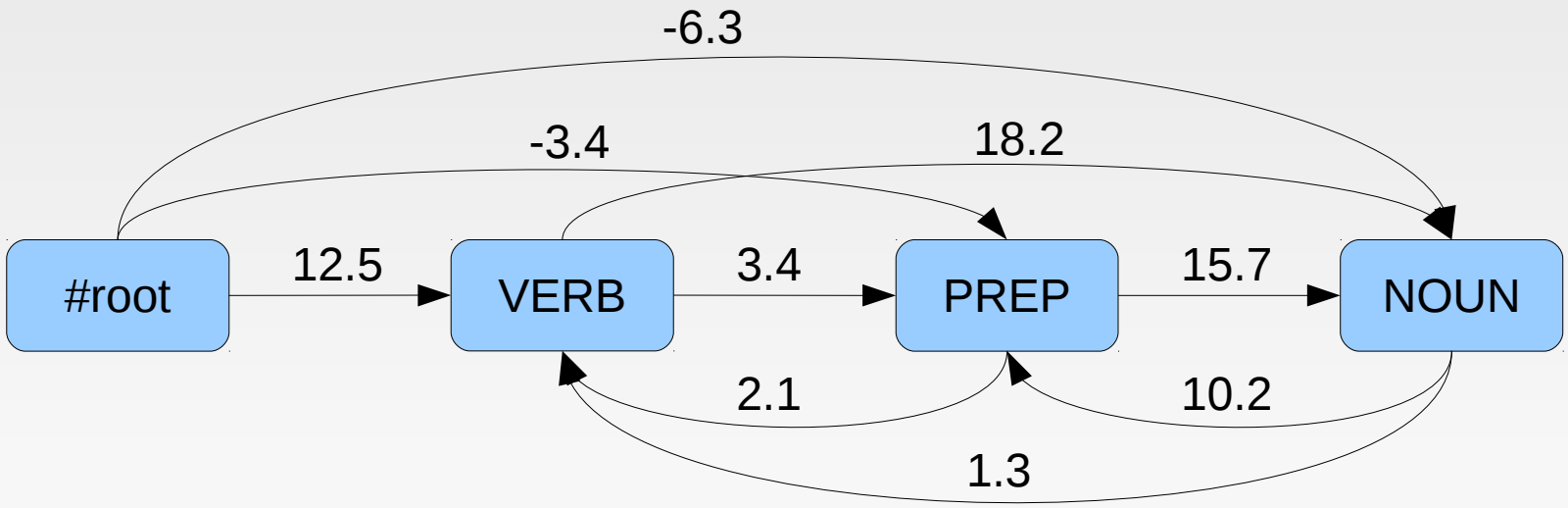

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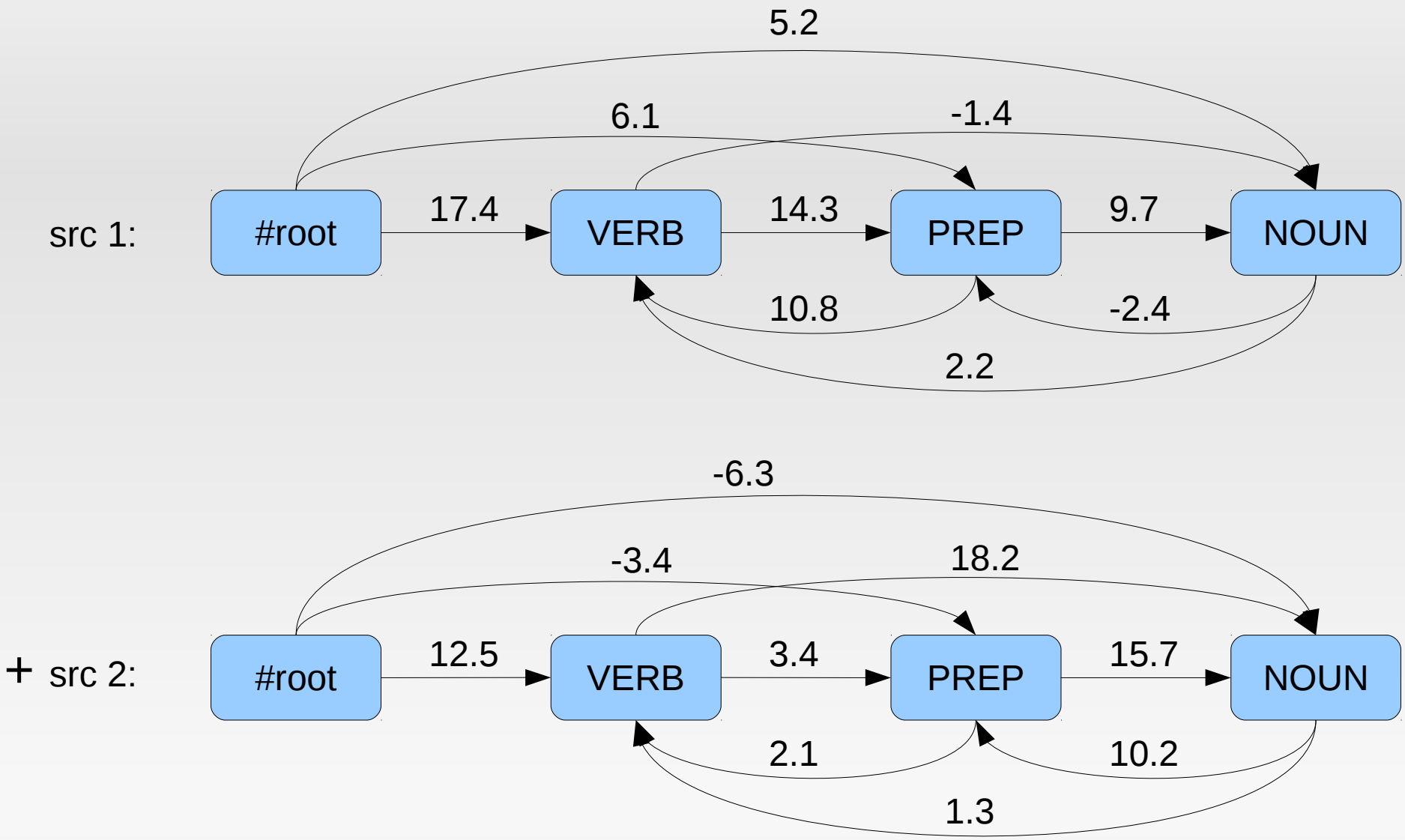
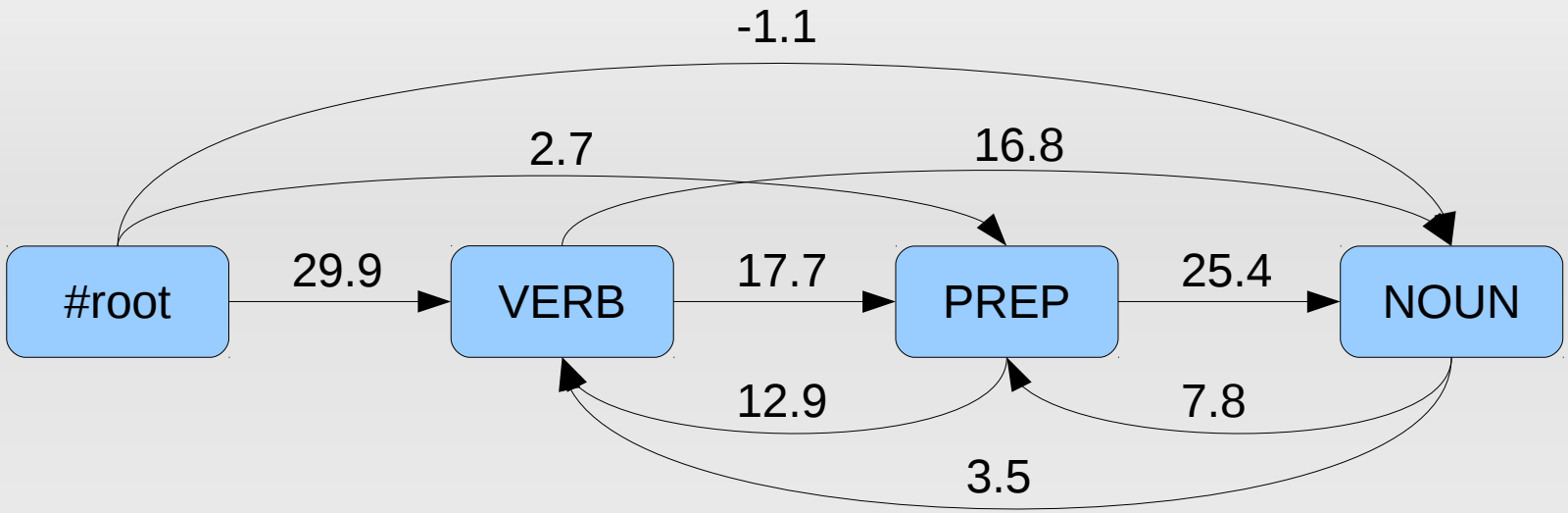


- score normalization!

Parser model interpolation

= **tgt (Σ):**



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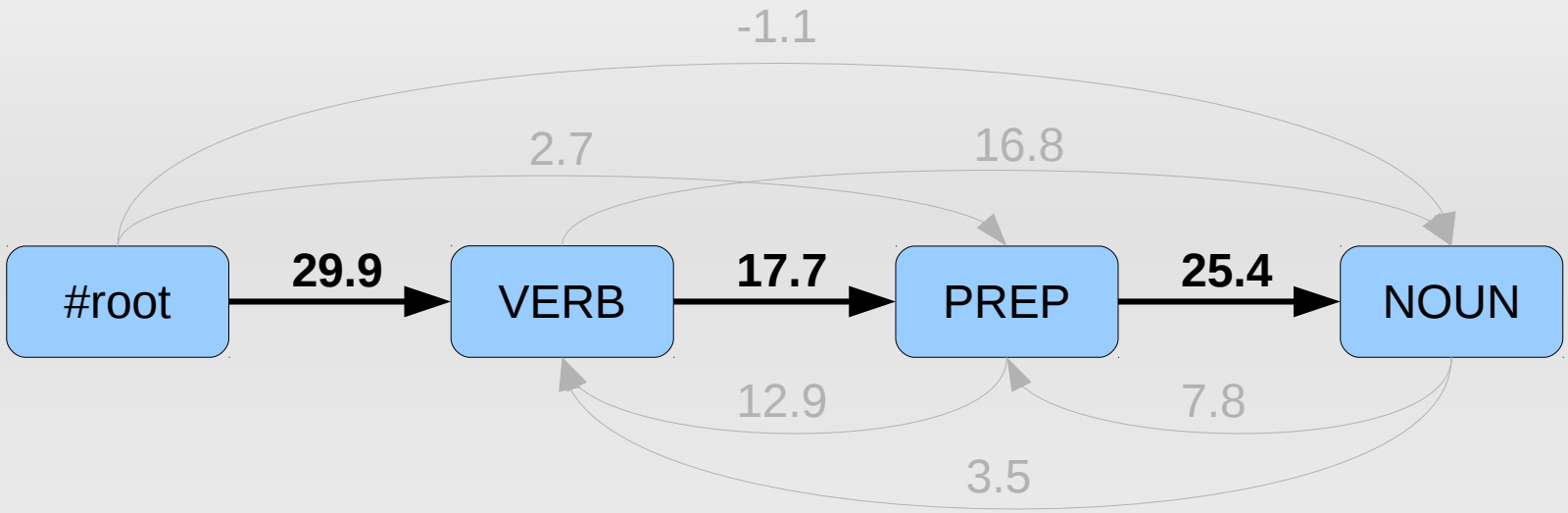
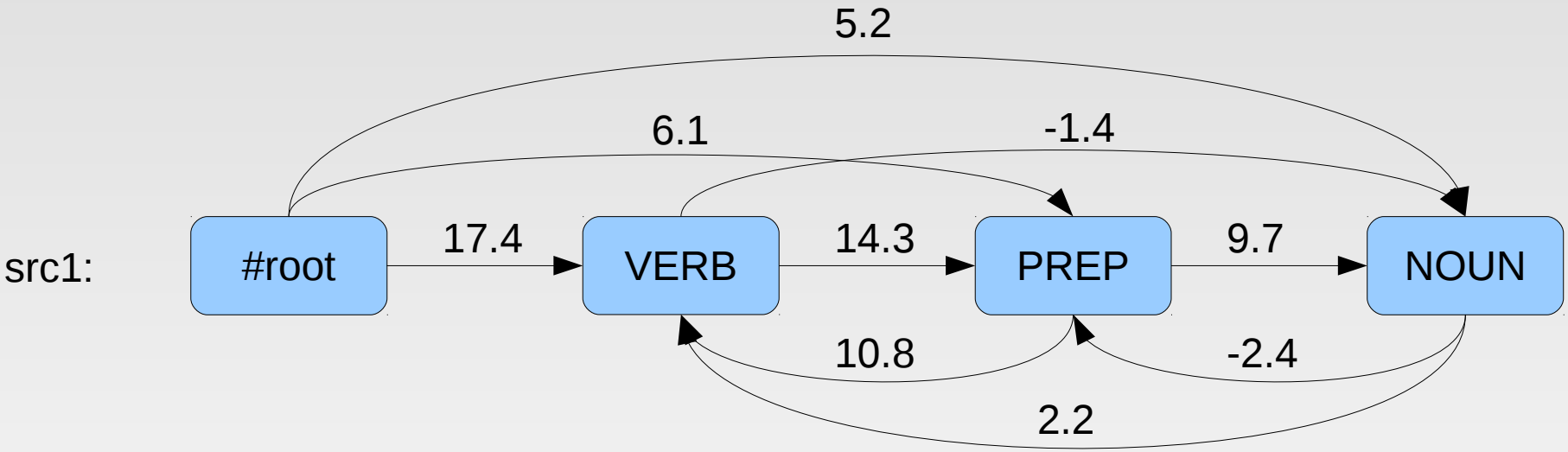


Weighted parser model interpol.

- multiply each edge score with KL_{cpos3}^{-4} (*tgt*,*src*)



KL_{cpos3}^{-4} (*tgt*, *src1*) = 0.5

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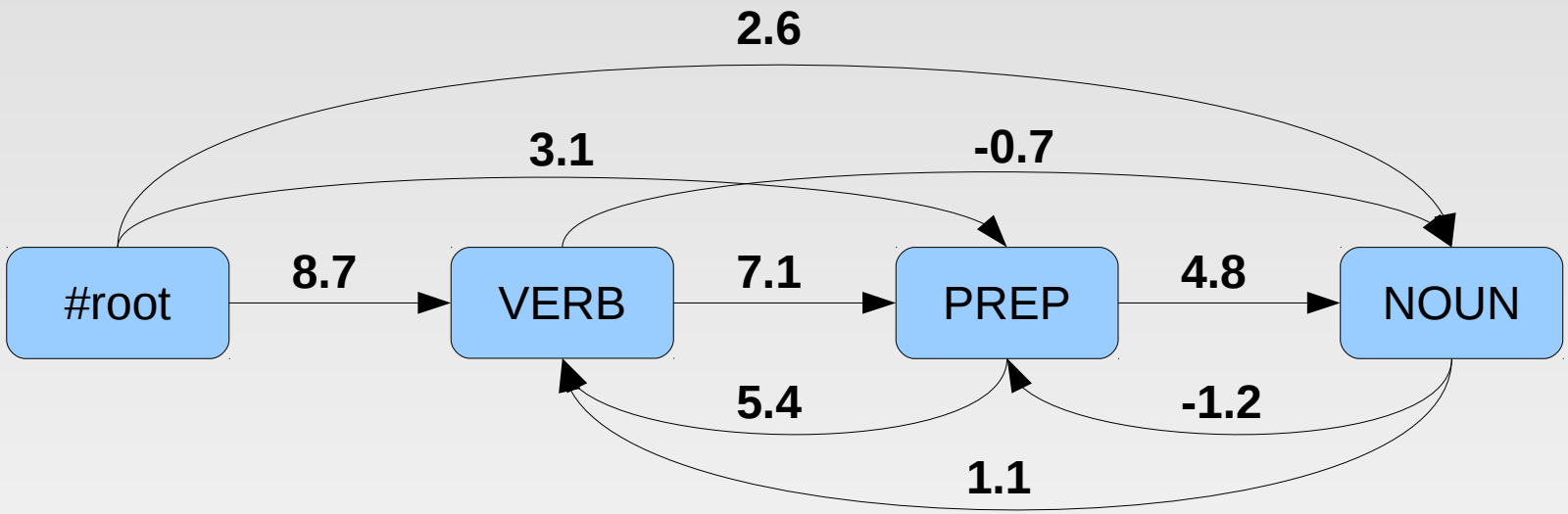

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  - edge score = $\mathbf{w}_{int} \cdot \mathbf{f}$

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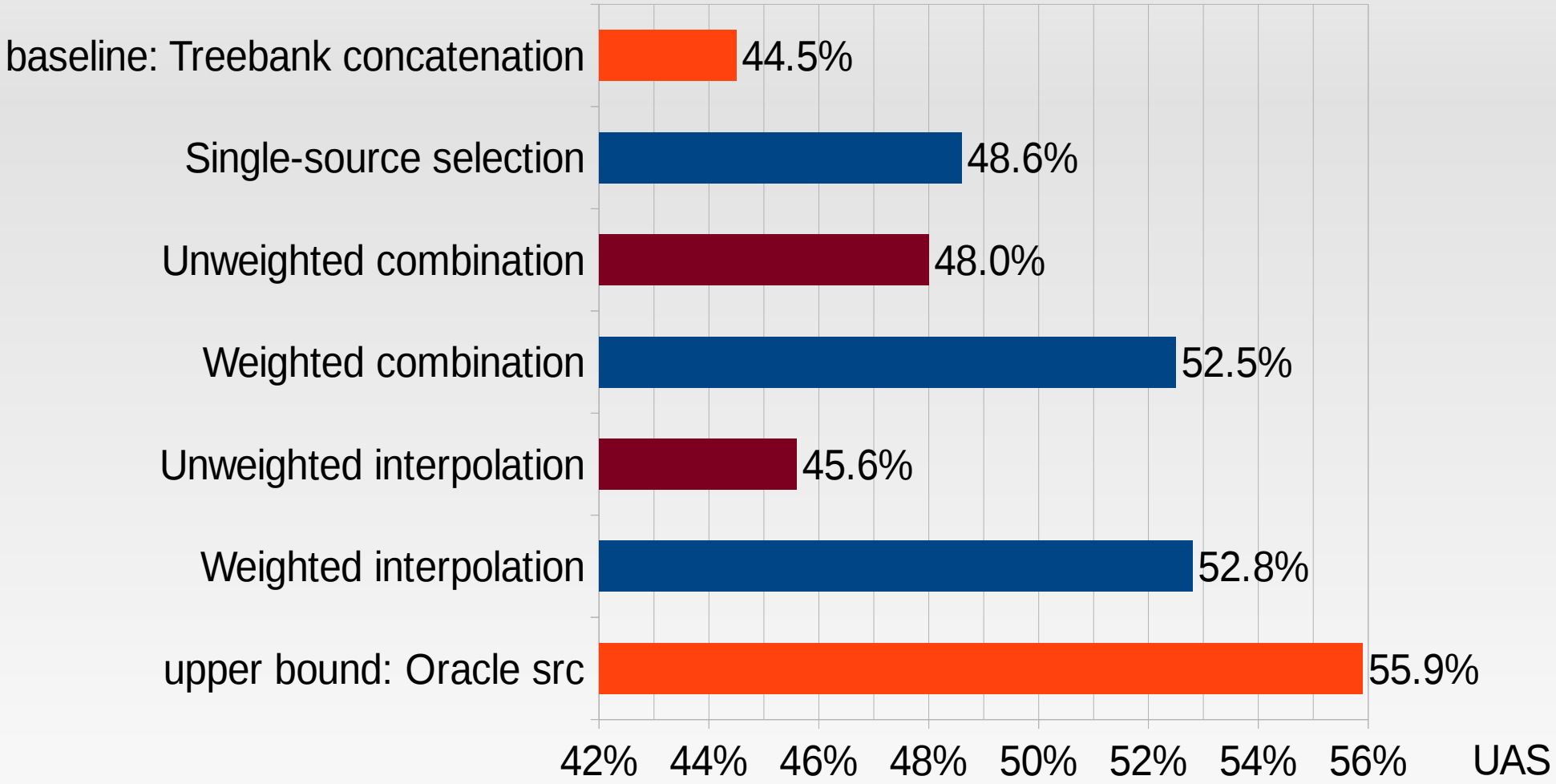
  - edge score = $\sum_{src} (\mathbf{w}_{src} \cdot \mathbf{f}) = (\sum_{src} \mathbf{w}_{src}) \cdot \mathbf{f}$
  - interpolated model $\mathbf{w}_{int} = (\sum_{src} \mathbf{w}_{src})$
  - edge score = $\mathbf{w}_{int} \cdot \mathbf{f}$
- weighted model interpolation: $KL_{cpos3}^{-4}(tgt, src)$
  - edge score = $\sum_{src} (KL_{src} \cdot \mathbf{w}_{src} \cdot \mathbf{f}) = (\sum_{src} KL_{src} \cdot \mathbf{w}_{src}) \cdot \mathbf{f}$
  - interpolated model $\mathbf{w}_{int} = (\sum_{src} KL_{src} \cdot \mathbf{w}_{src})$

Average UAS over 18 test TBs

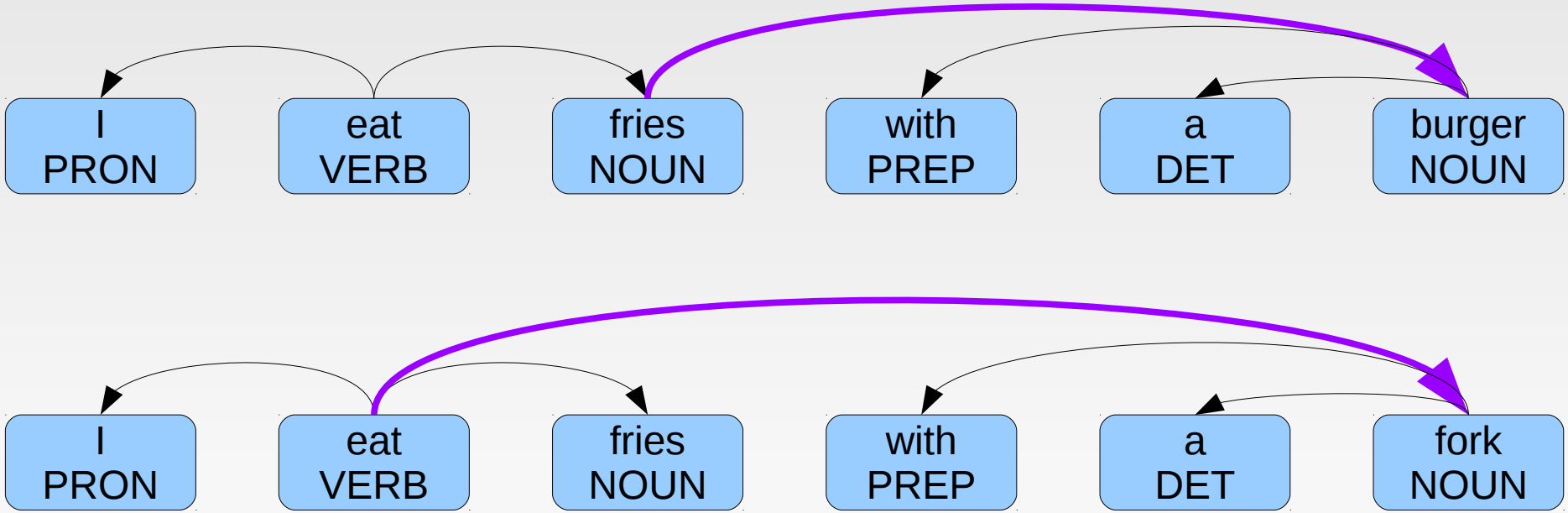


Outline

- Introduction to linguistic analysis
- MSTParser and its delexicalization
- Single-source delexicalized parser transfer
  - KL_{cpos3} language similarity
- Multi-source delexicalized parser transfer
  - treebank concatenation
  - parse tree combination
  - model interpolation
- **Future work: lexicalization**

Future work: lexicalization

- lexical features (words) are important
  - supervised parsers UAS: ~85% lex, ~75% delex
  - but they are language-specific (unlike POS tags)



Machine translation lexicalization

- parse tree transfer
  - translate target sentence to source language
  - parse translated sentence by source parser
  - transfer source parse tree to target sentence
- treebank transfer
  - translate source treebank to target language
  - transfer parse trees from source treebank to translated treebank
  - train target parser on transferred treebank

Machine translation lexicalization

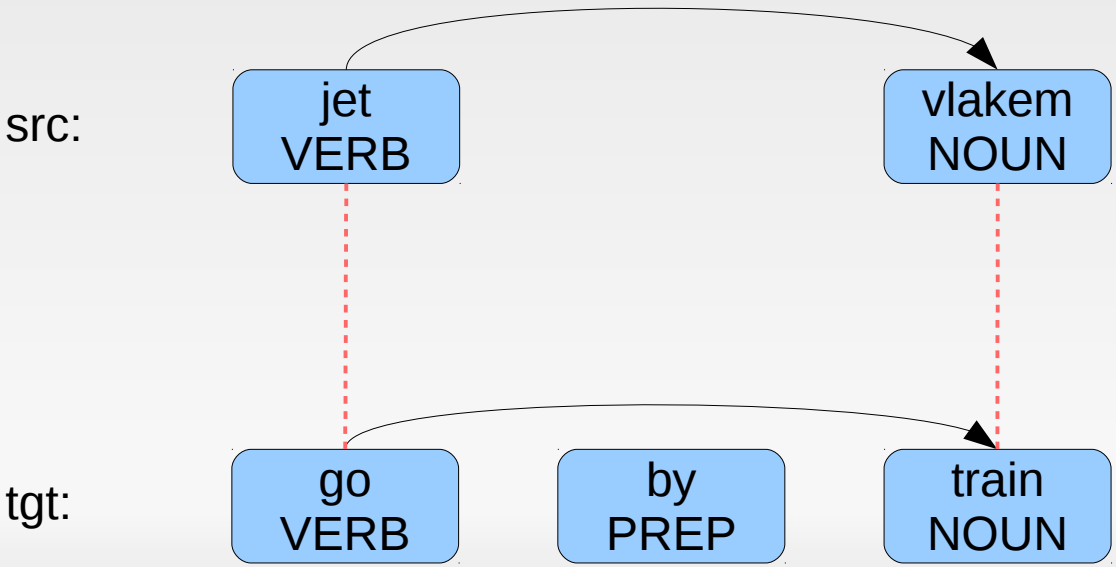
- parse tree transfer
  - transfer translated source parse tree to target sentence
- treebank transfer
  - train target parser on transferred translated source TB

Problem 1: translation

- parse tree transfer
  - transfer **translated** source parse tree to target sentence
- treebank transfer
  - train target parser on transferred **translated** source TB
- problems with machine translation
  - high-quality often available only to/from English
  - for low-resourced languages often low quality
    - requires **large** amounts of bilingual texts

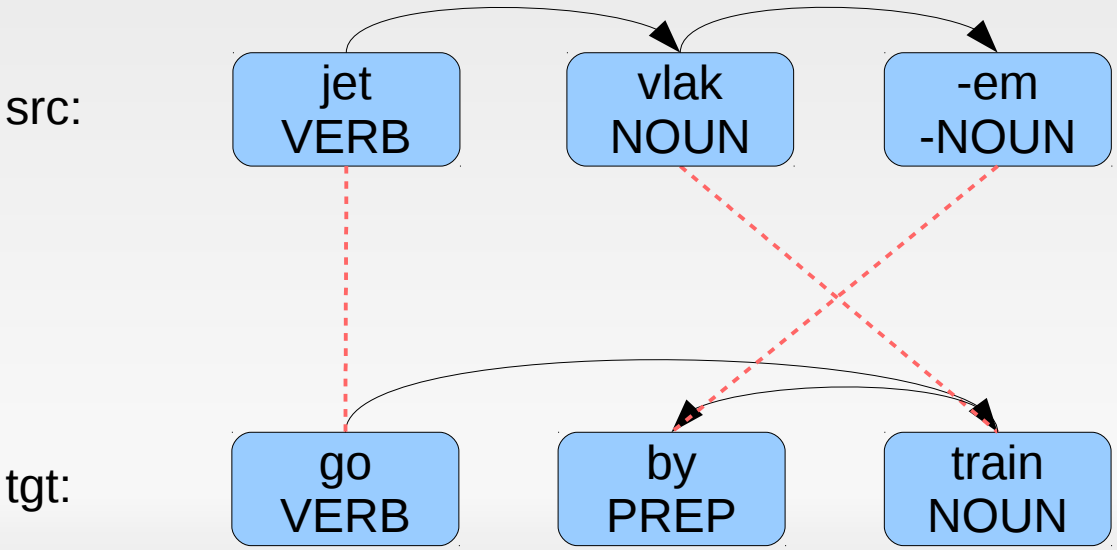
Problem 2: transfer

- parse tree transfer
  - **transfer** translated source parse tree to target sentence
- treebank transfer
  - train target parser on **transferred** translated source TB



Solution (to both): morphs?

- morphs could get closer to 1:1 correspondence
  - especially if segmentation and alignment done jointly
- translation via morphs could do with less data
  - split rare complex words into frequent simple morphs



Joint segmentation and alignment?

- given a corpus of bilingual sentences
- morph segmentation and alignment, so that
  - alignment is close to 1:1
  - aligned morphs have similar meaning
- Bayesian approach?
  - maximize probability of bilingual morphs
    - P(“-em : by”) ~ count(“-em : by”)
  - also account for alignment fertility, alignment fluency, lexical roots vs auxiliary morphs distinction

Conclusion

- Parsing of low-resourced natural languages
- Single-/Multi-source delexicalized parser transfer
  - parse tree combination
  - MSTParser model interpolation
  - KL_{cpos3}: language similarity for src selection/weighting
- Future work: Lexicalization
  - machine translation
  - morph splitting and alignment

Thank you for your attention

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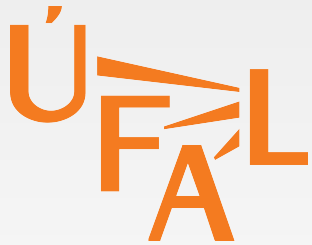
Delexicalized Cross-lingual Transfer of Statistical Syntactic Parsers for Automatic Analysis of Low-resourced Natural Languages

Charles University in Prague
Faculty of Mathematics and Physics
Institute of Formal and Applied Linguistics



http://ufal.mff.cuni.cz/rudolf-rosa/