Improving Tree-to-Tree Translation with Packed Forests

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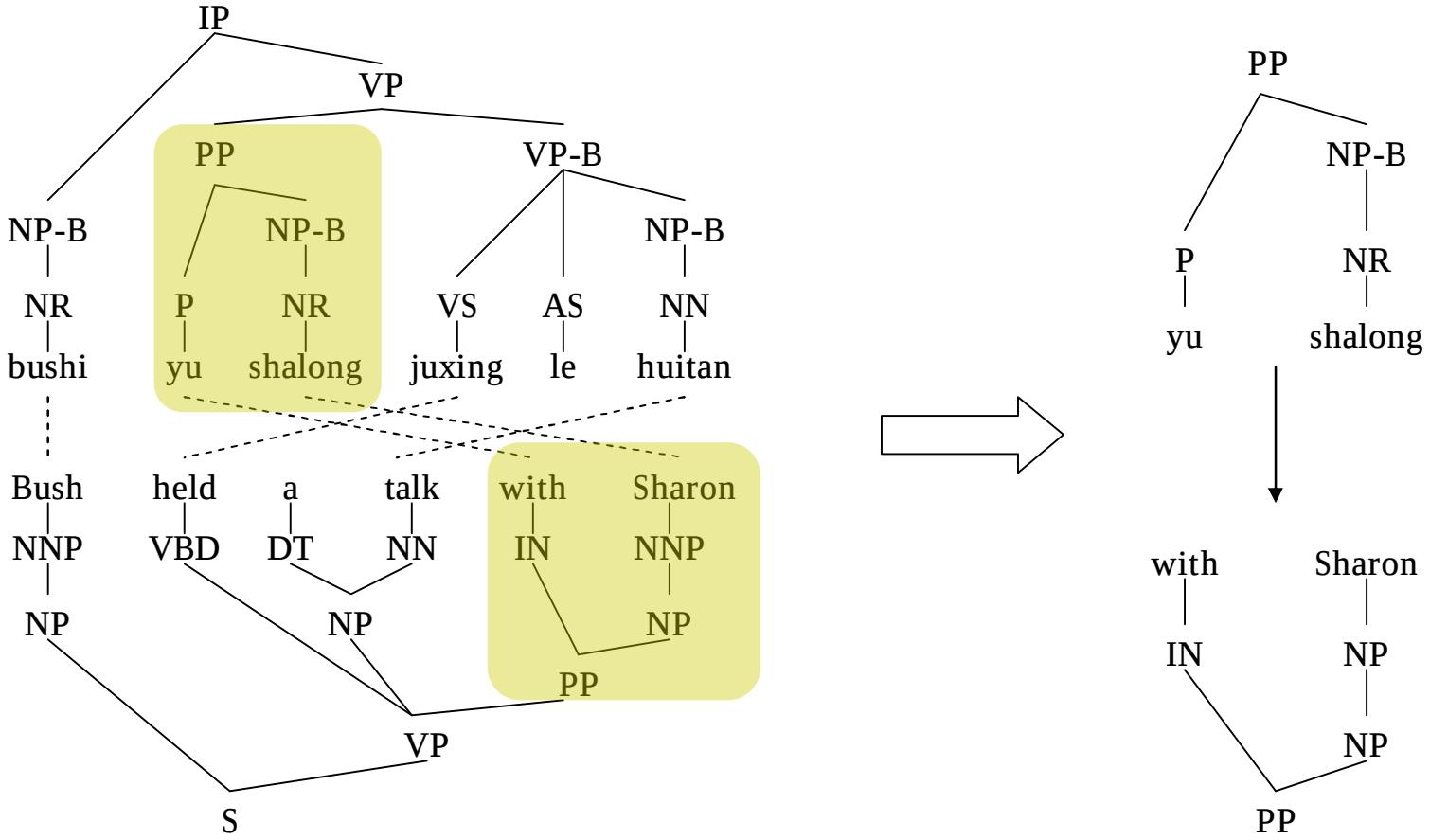
Tree-to-Tree Translation

- Tree-to-Tree (e.g., Eisner 2003, Zhang et al., 2008)



Tree-to-Tree Translation

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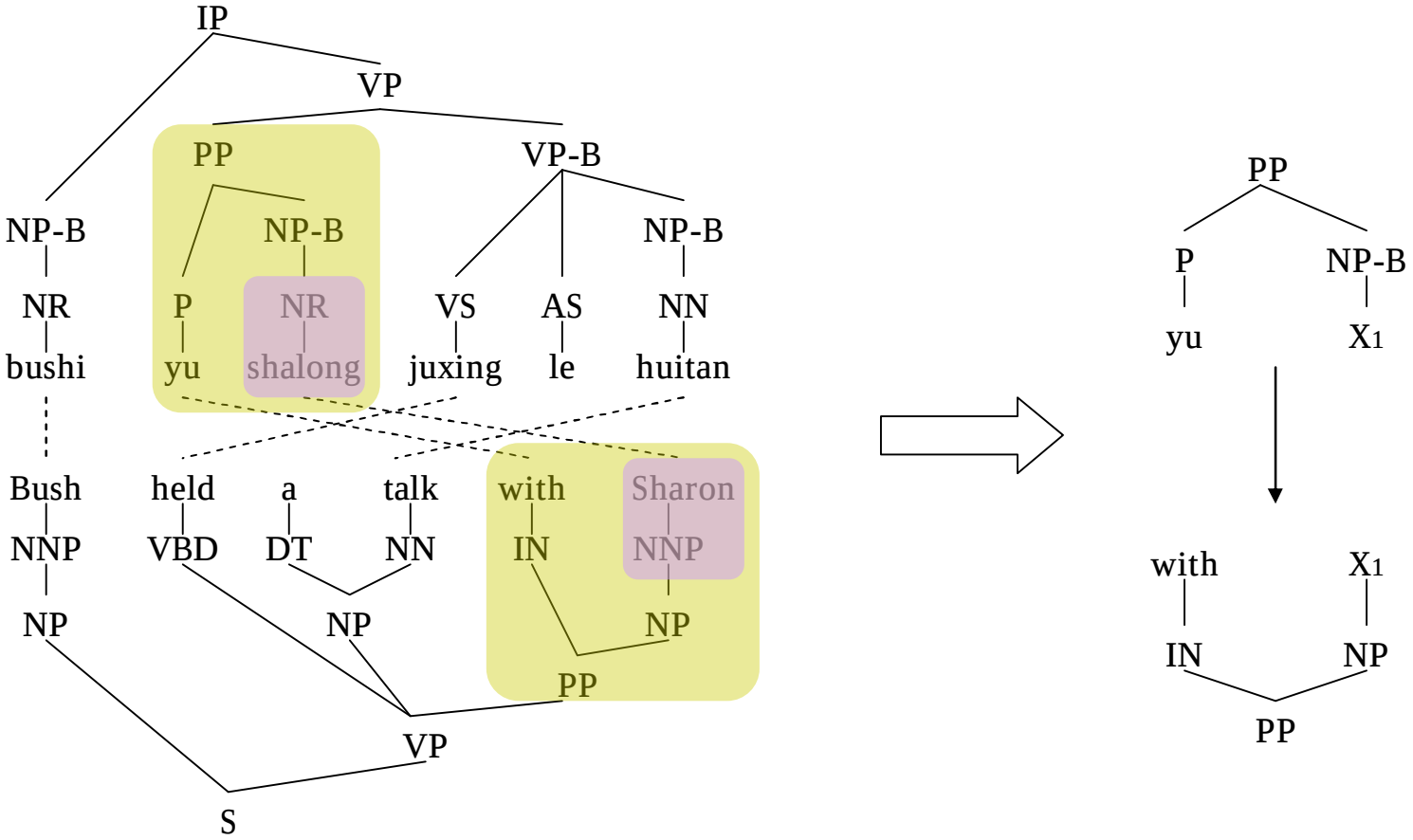
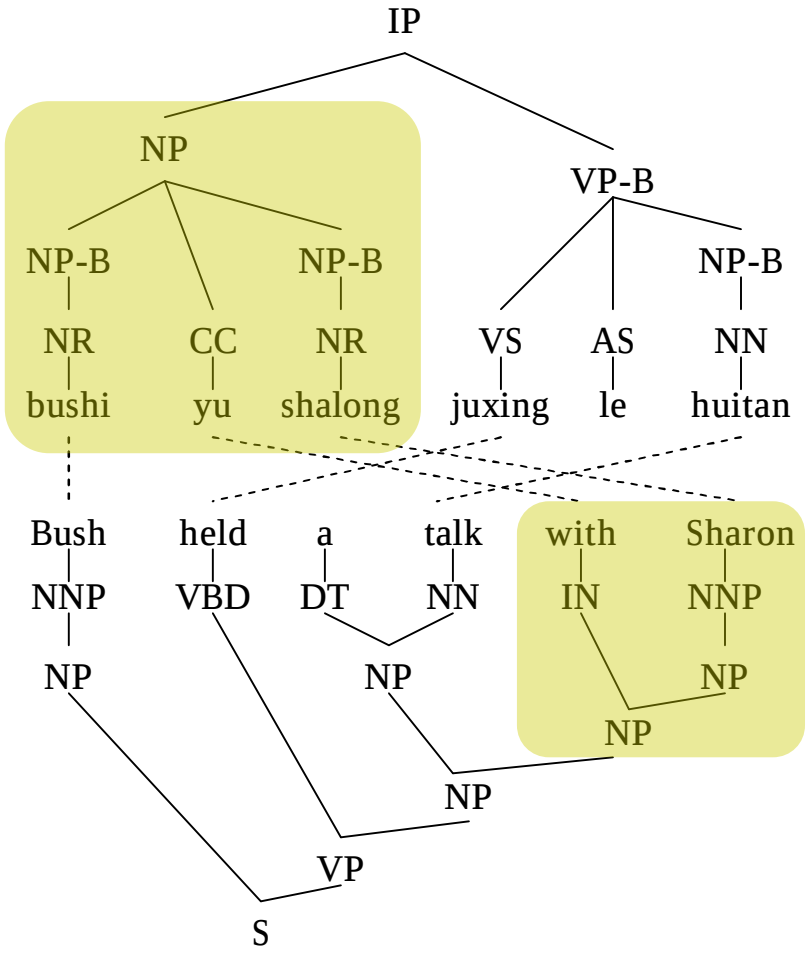


Challenges

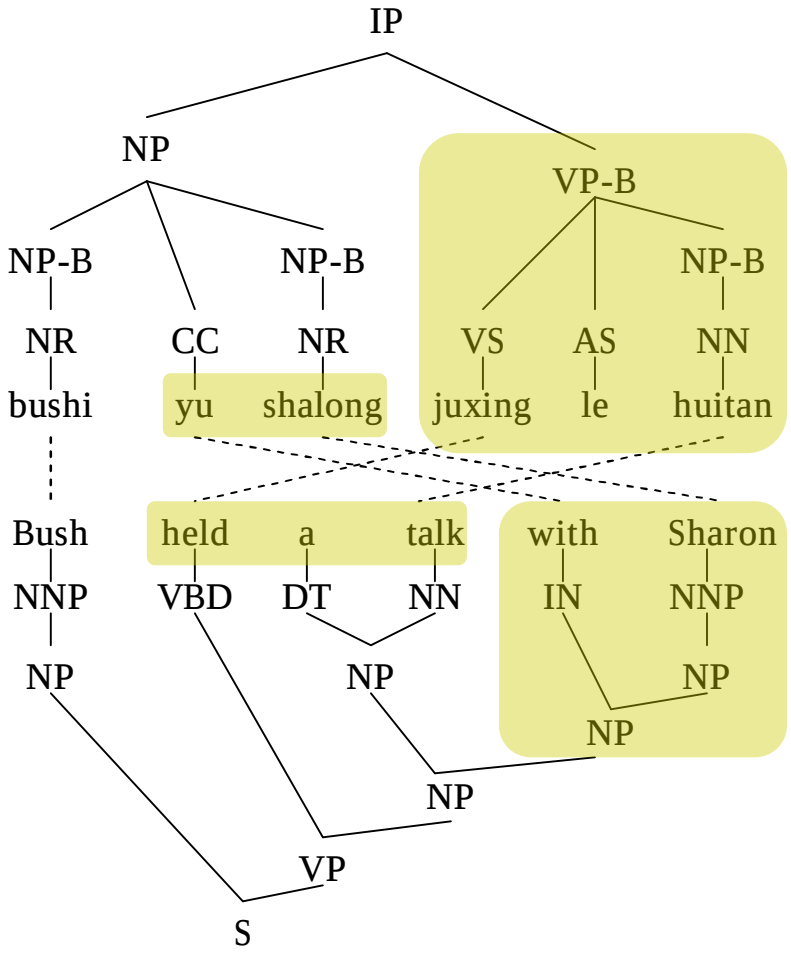
- Tree-to-tree approaches face two major challenges:
  - most vulnerable to parsing error
  - poorest rule coverage

Parsing Error

both trees can be ill-formed!



Rule Coverage



This Work

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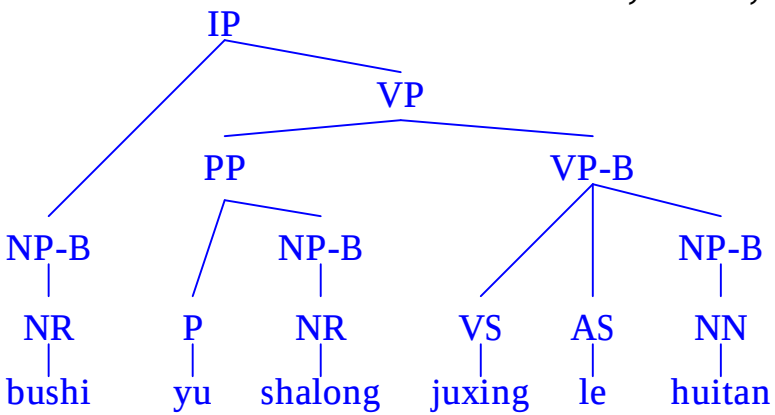
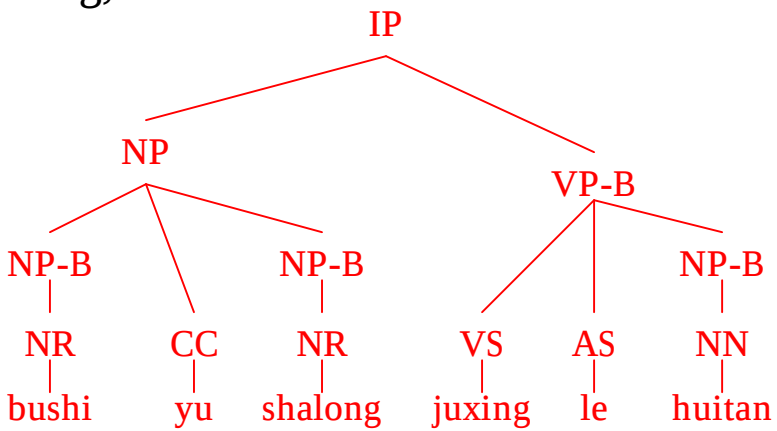
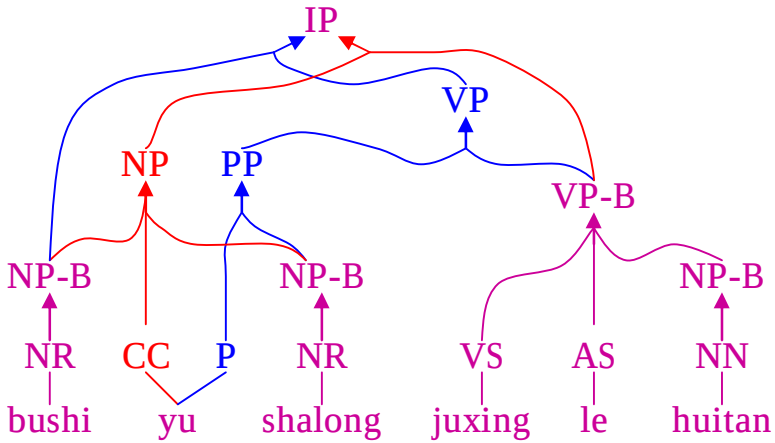
- We replace 1-best trees with packed forests to alleviate the two problems:
  - parsing error
  - rule coverage
- Our approach outperforms the tree-based system dramatically (+3.6) and achieves comparable performance with Moses.

Packed Forest

Tomita, 1985; Billot and Lang, 1989

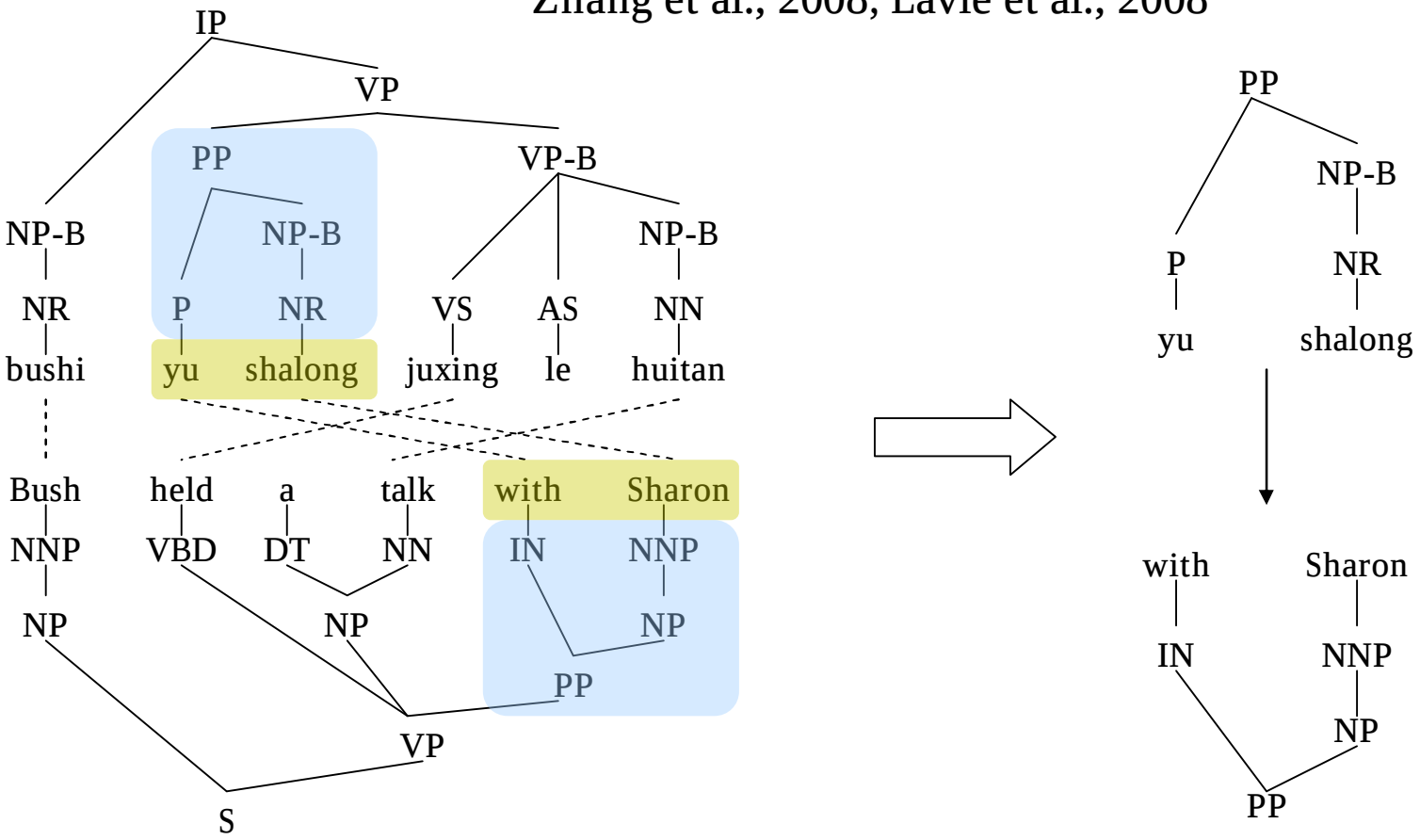




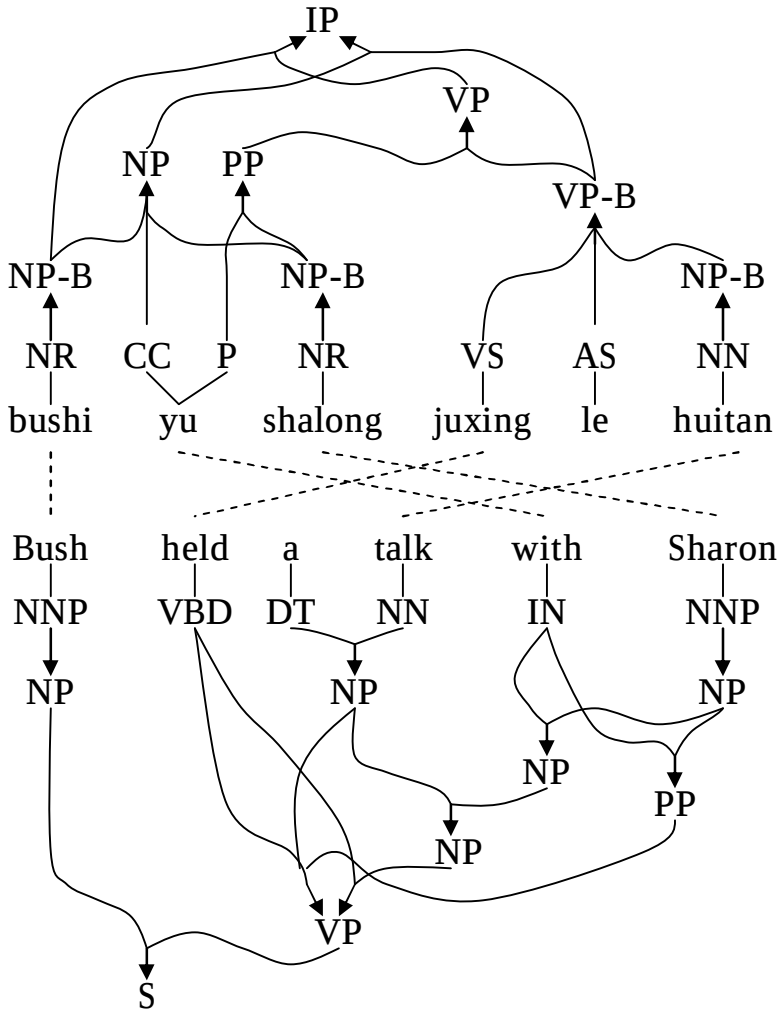


Tree-based Rule Extraction

Zhang et al., 2008; Lavie et al., 2008



Forest-based Rule Extraction



Forest-based Rule Extraction

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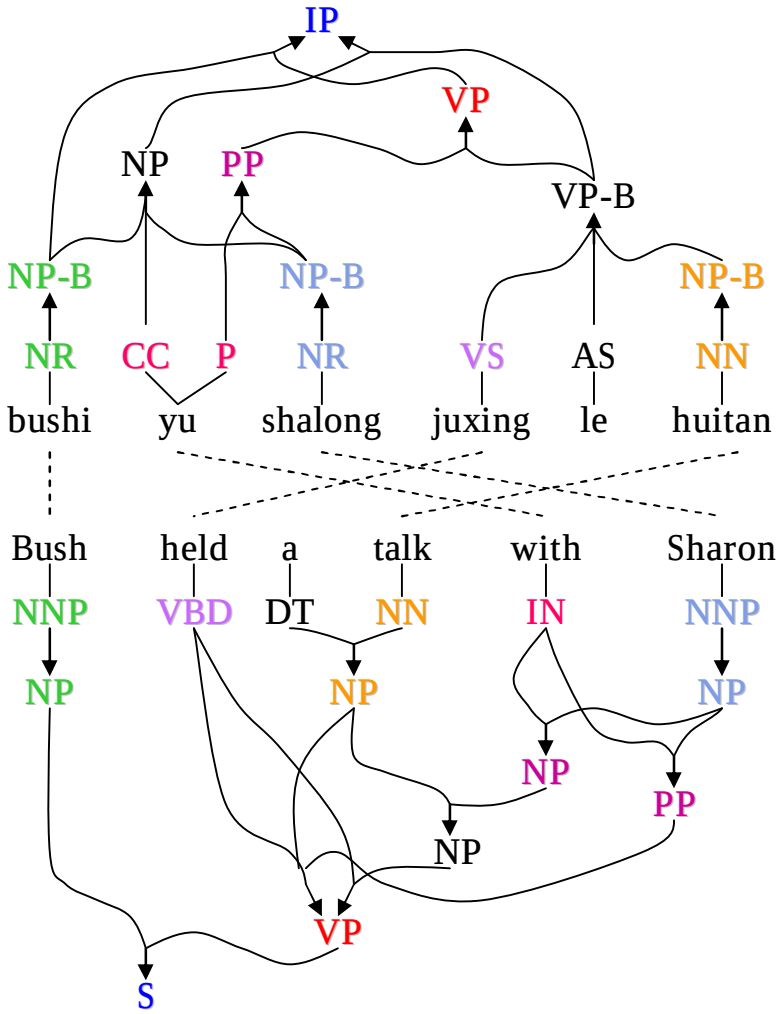
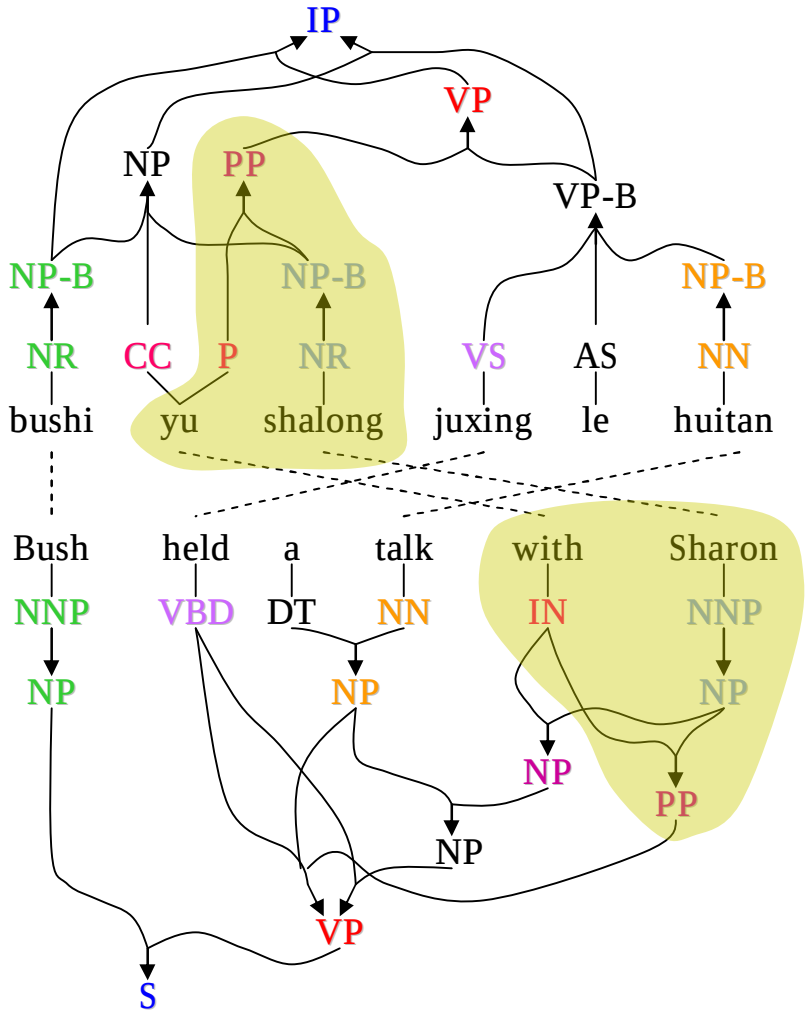
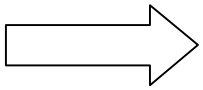
- Following GHKM (Galley et al., 2004), our extraction method invovles three steps:
  - identify the correspondence between nodes
  - identify minimal rules
  - get composed rules

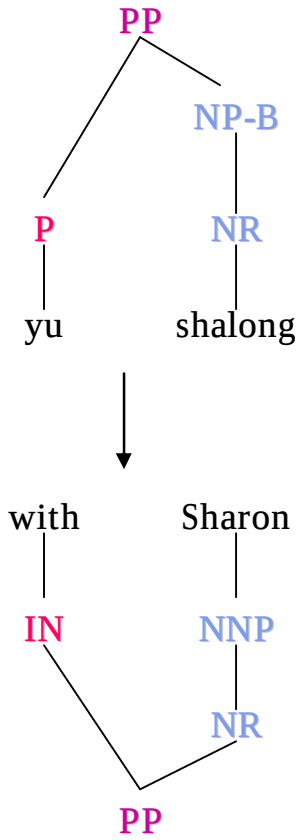
Frontier Nodes



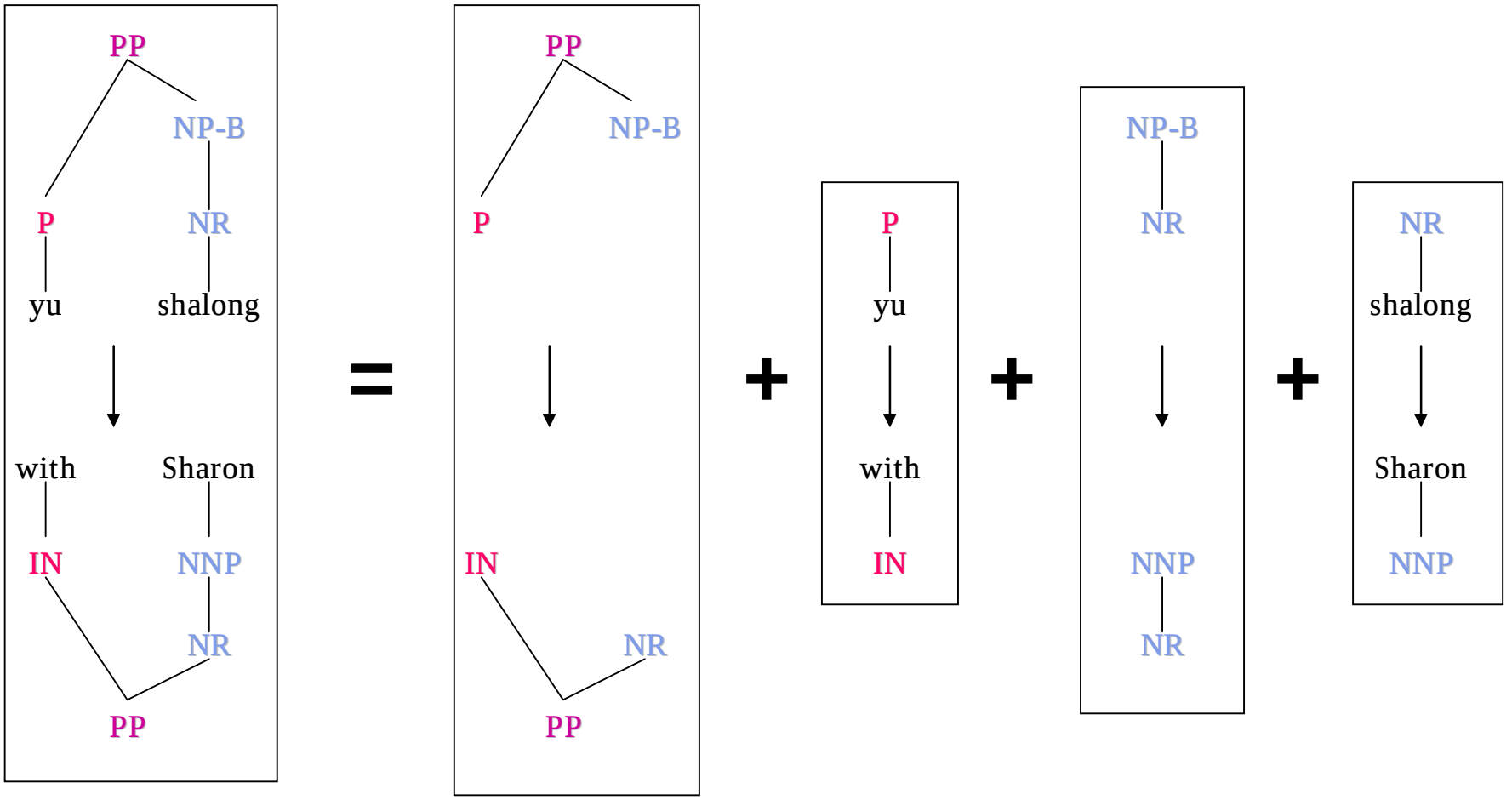
Identify Tree Pairs







Decomposition



Frontier Trees and Tree Pairs

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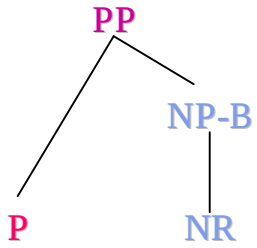
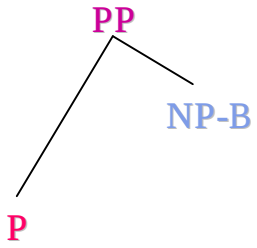
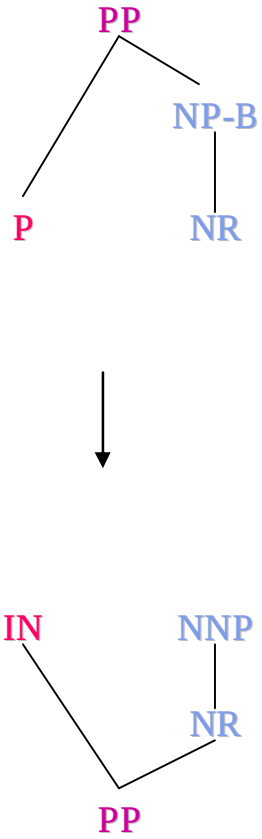
frontier tree



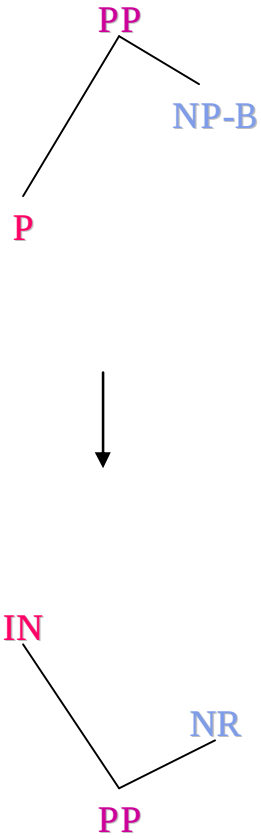
minimal frontier tree



frontier tree pair

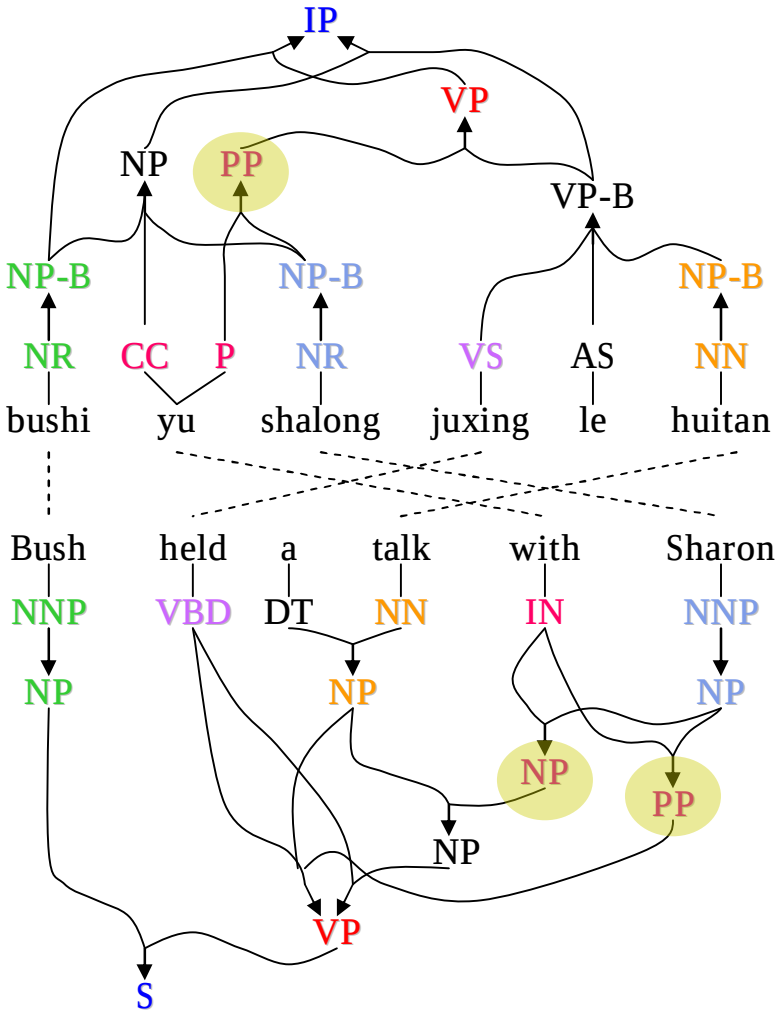


minimal frontier tree pair



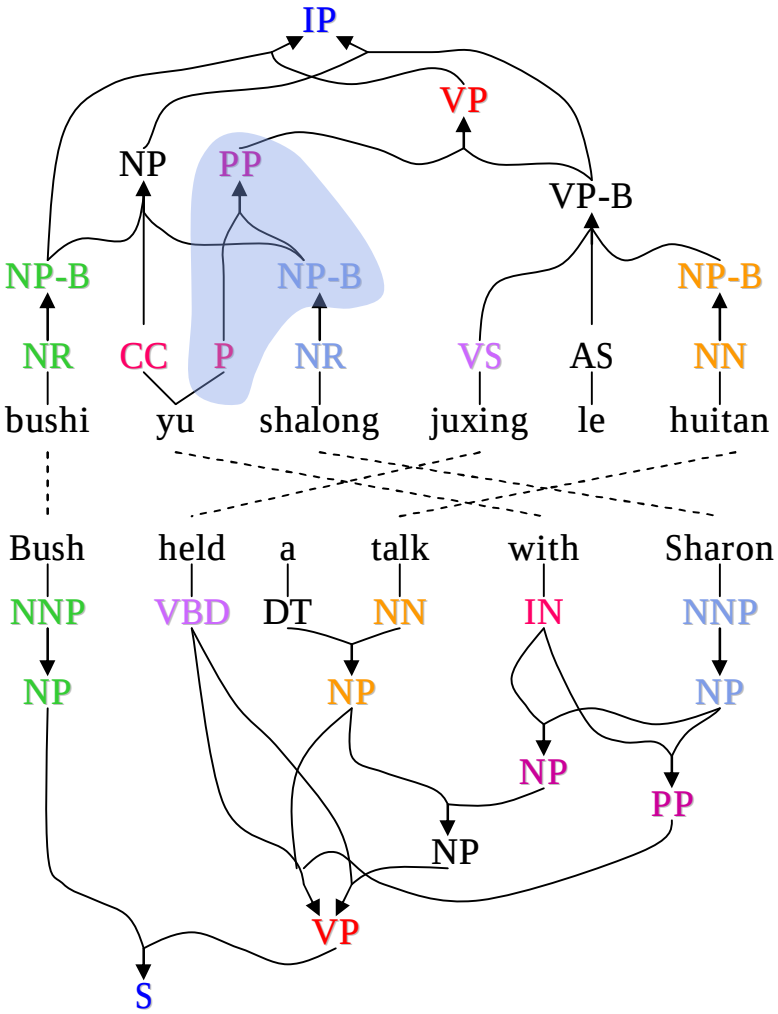
Identify Tree Pairs for the Node PP

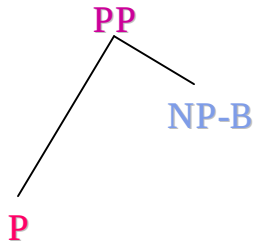
step 1: identify corresponding frontier nodes



Identify Tree Pairs for the Node PP

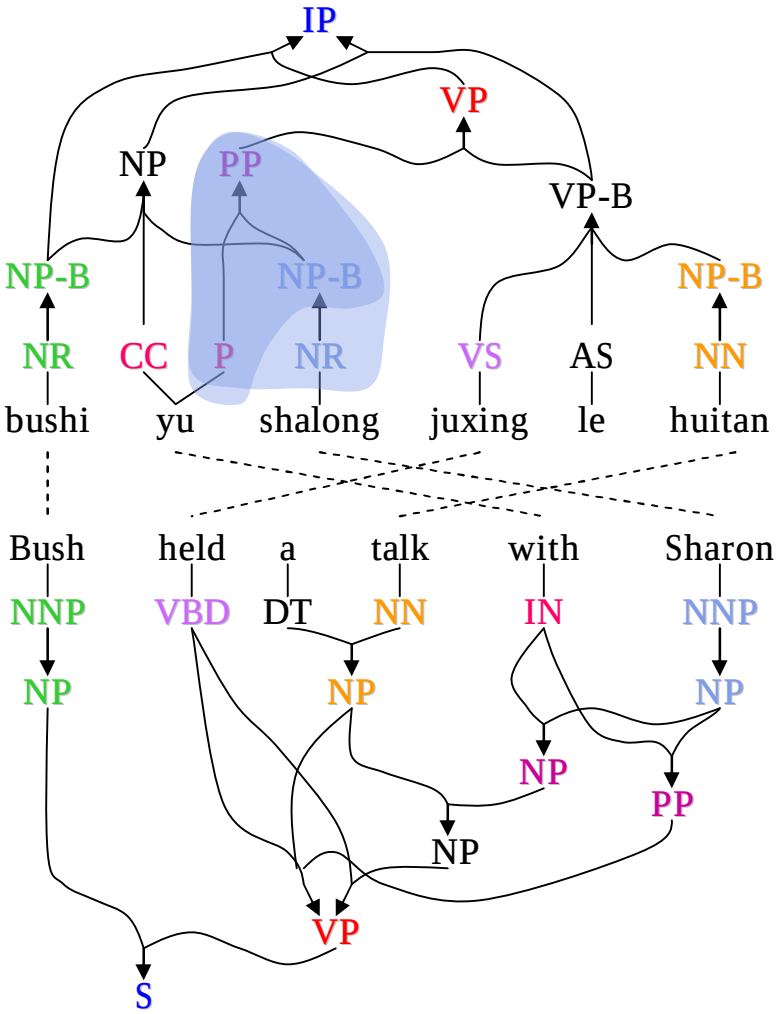
step 2: identify frontier trees for each node

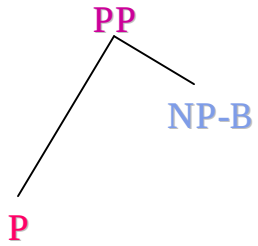


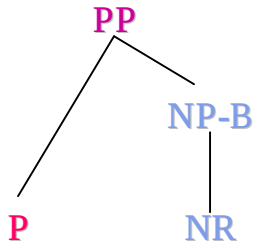


Identify Tree Pairs for the Node PP

step 2: identify frontier trees for each node







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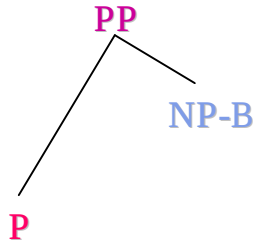
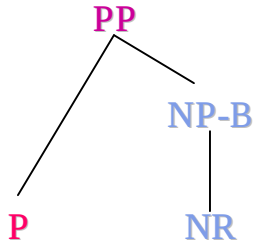
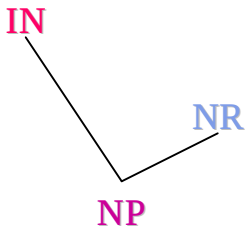
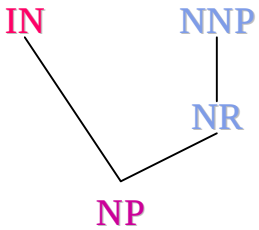
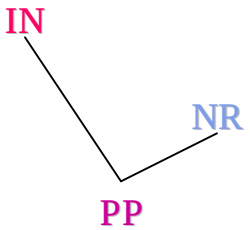
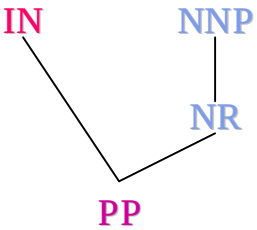






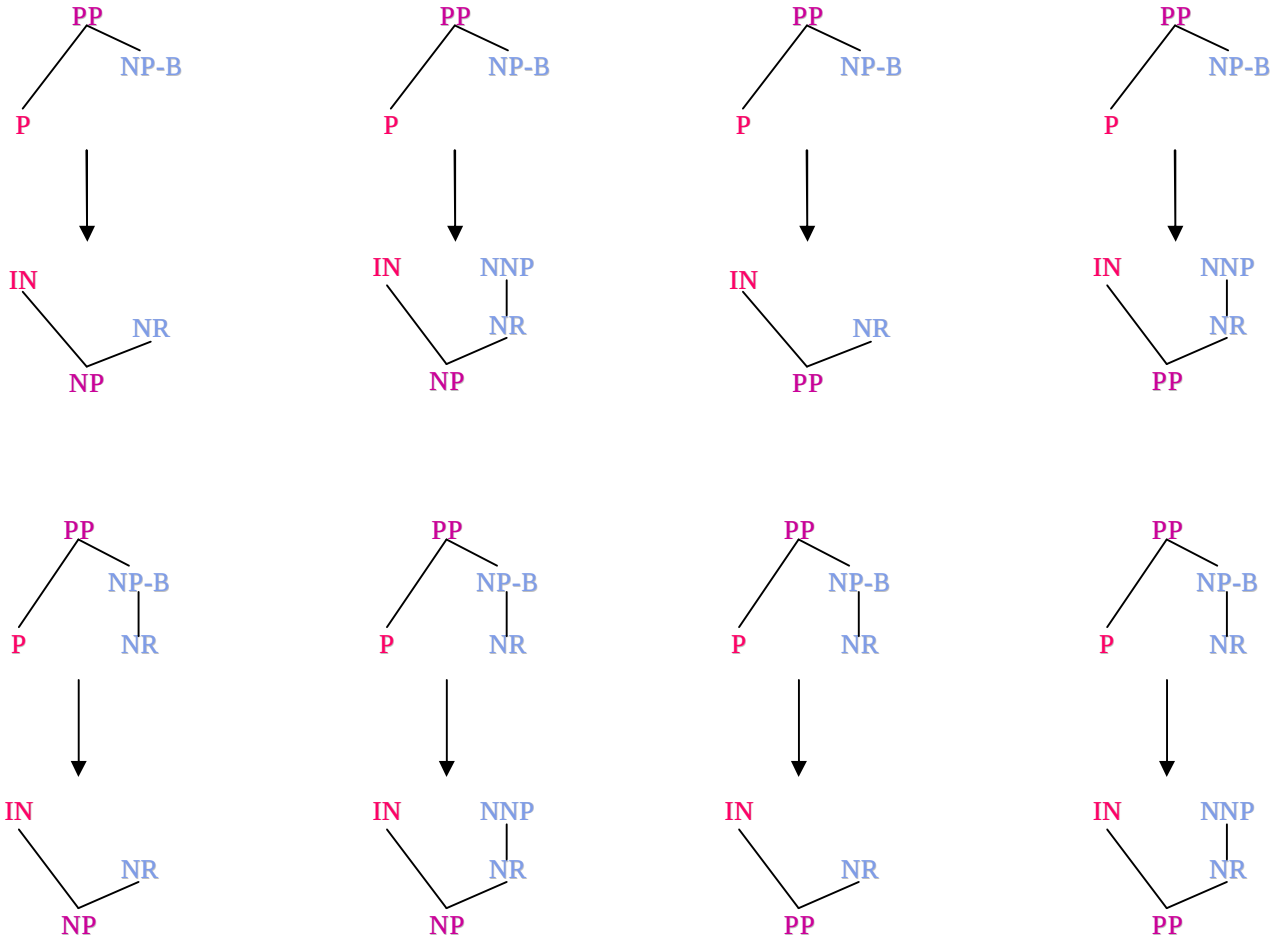






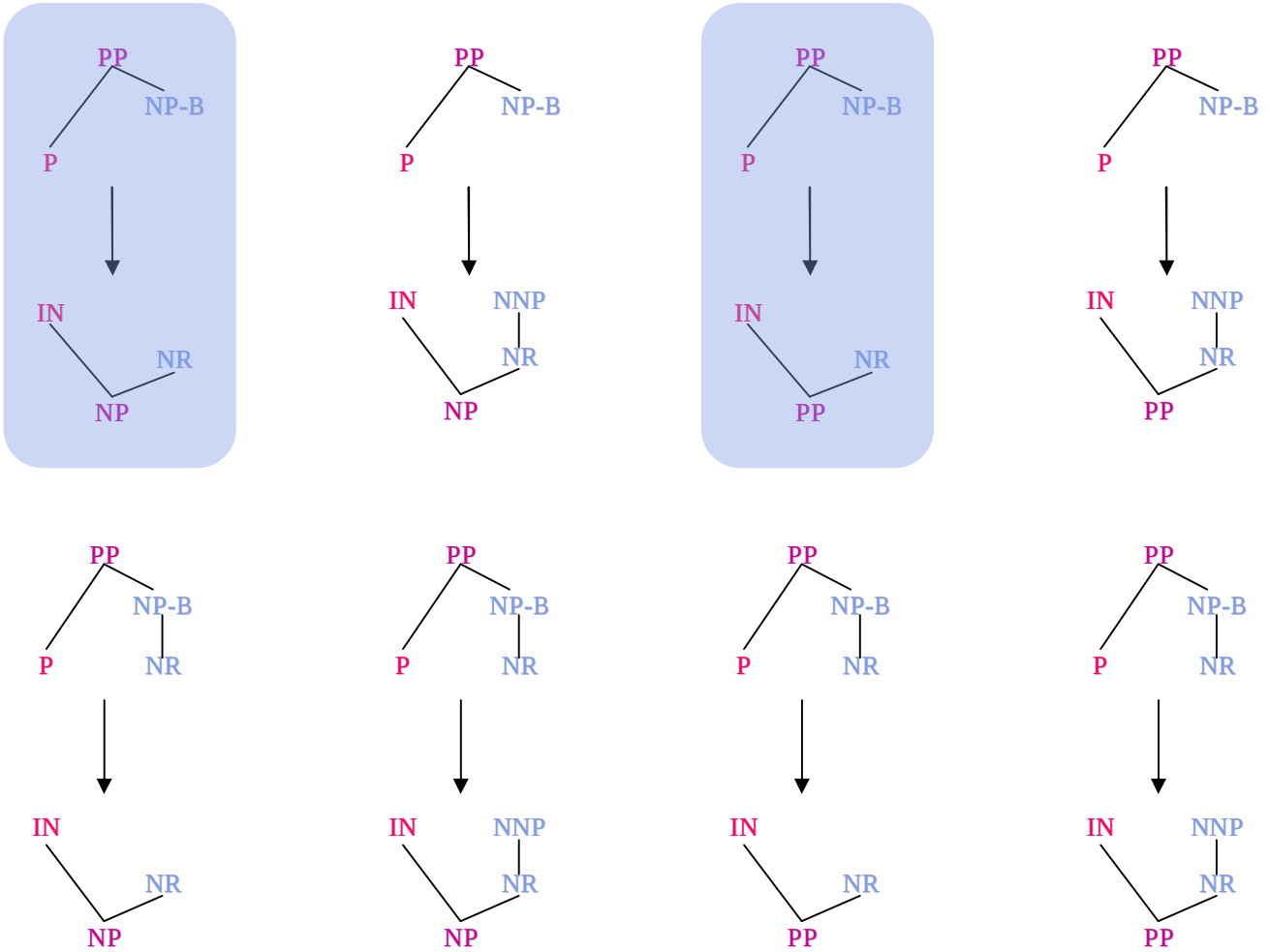
Identify Tree Pairs for the Node PP

step 3: build frontier trees pairs



Identify Tree Pairs for the Node PP

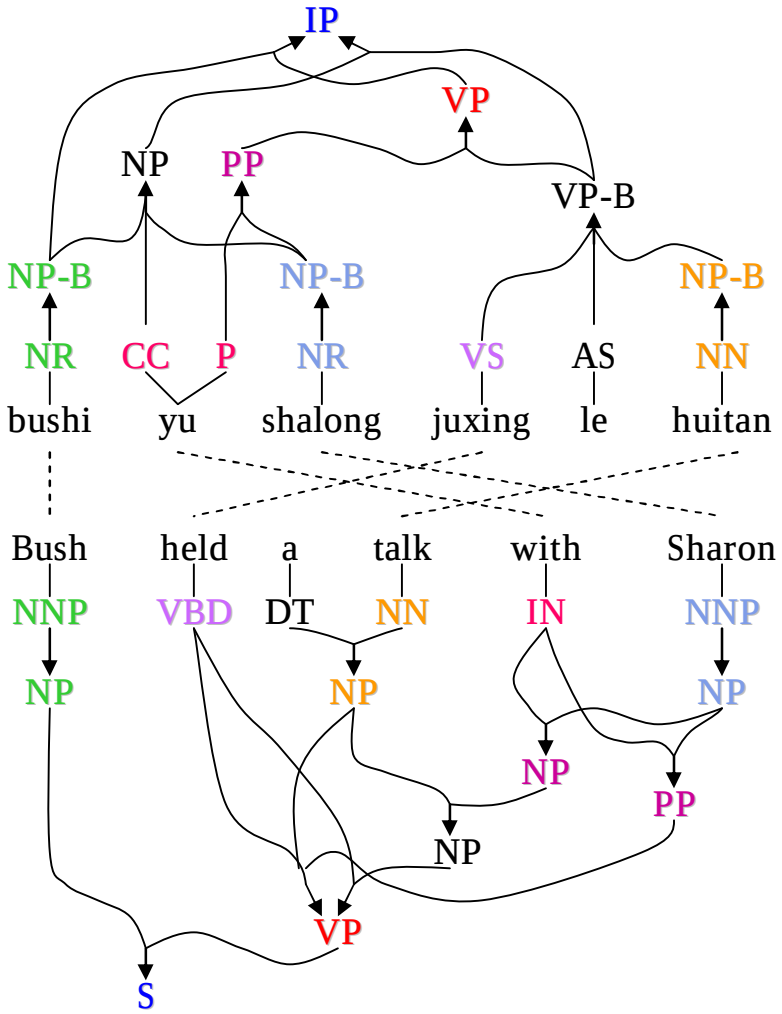
step 4: identify minimal frontier trees pairs



Difficulty in Finding Tree Pairs

A minimal frontier tree pair is not necessarily a pair of minimal frontier trees

Difficulty in Finding Tree Pairs



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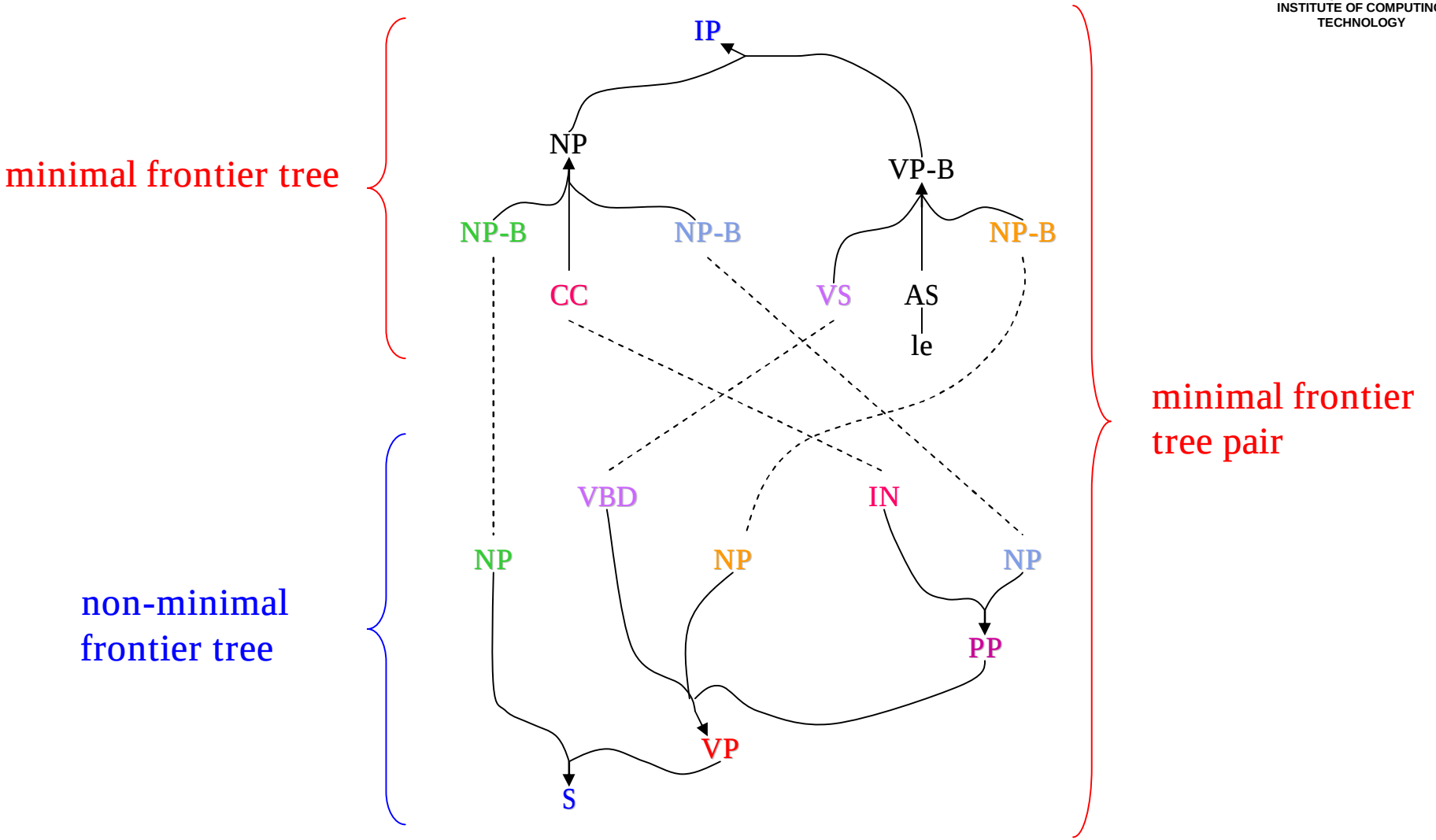
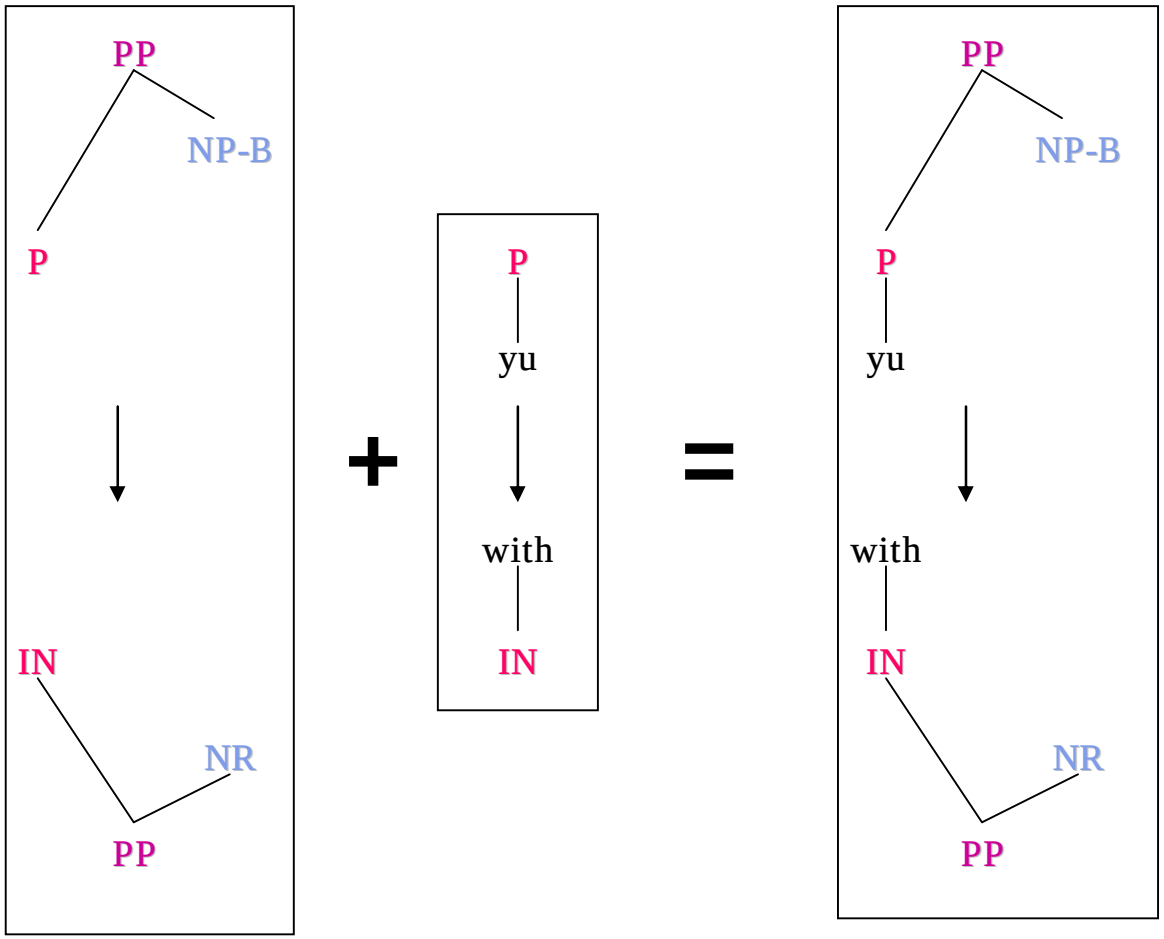


Get Composed Rules



Experiments

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- Chinese-to-English translation
- Training set: 31K sentence pairs with 840K Chinese words and 950K English words
- Language Model: 3-gram trained on the English side
- Development set: NIST 2002
- Test set: NIST 2005
- Metric: case-insensitive BLEU4

Tree-based Vs. Forest-based

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p	avg. trees	# of rules	BLEU4
0	1	74K	20.21
2	238.94	105K	21.65
5	5.78M	348K	23.36
8	65.9M	574K	23.73
10	105M	743K	23.85

Extraction and Decoding Time

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p	avg. trees	extraction	decoding
0	1	1.26	6.76
2	238.94	2.35	8.52
5	5.78M	6.34	14.87
8	65.9M	8.51	19.78
10	105M	10.21	25.81

extraction: milliseconds / sentence pair

decoding: seconds / sentence

Comparison with Moses

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training	Moses	this work
840K+950K	23.66	23.85
7.39M+9.41M	30.43	30.59

Conclusion

- Packed forests help alleviate two problems that tree-to-tree approaches face:
  - negative impact of parsing mistakes on translation quality
  - poor rule coverage

Thanks!