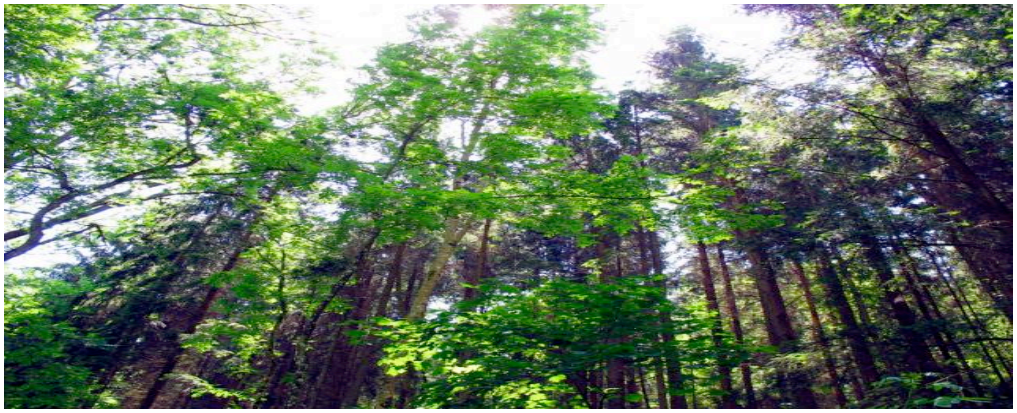
Forest-Based Translation



Haitao Mi
Institute of Computing Technology

Liang Huang
University of Pennsylvania

Qun Liu
Institute of Computing Technology

ACL 2008 talk, Columbus, OH, June 2008
prepared and presented by L. H.

Two Approaches in Syntax MT

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- string-based (Wu 97; Chiang 05; Galley et al 06)
  - parse the source-language string
    - with a synchronous grammar
  - generate translations accordingly

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Bushi yu Shalong juxing le huitan

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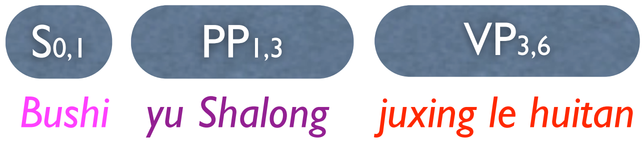

$S_{0,1}$ $PP_{1,3}$ $VP_{3,6}$

Bushi *yu Shalong* *juxing le huitan*

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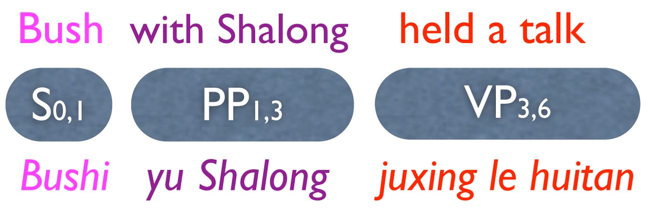

Bush with Shalong held a talk

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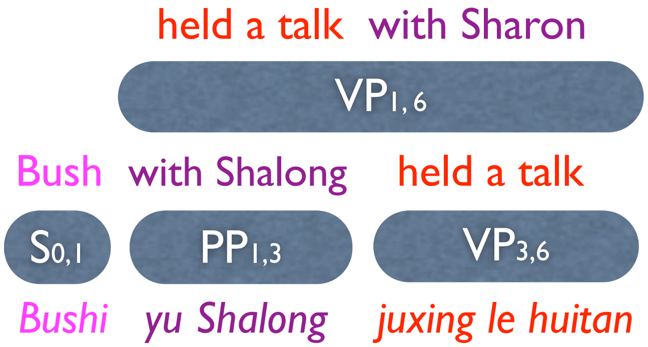

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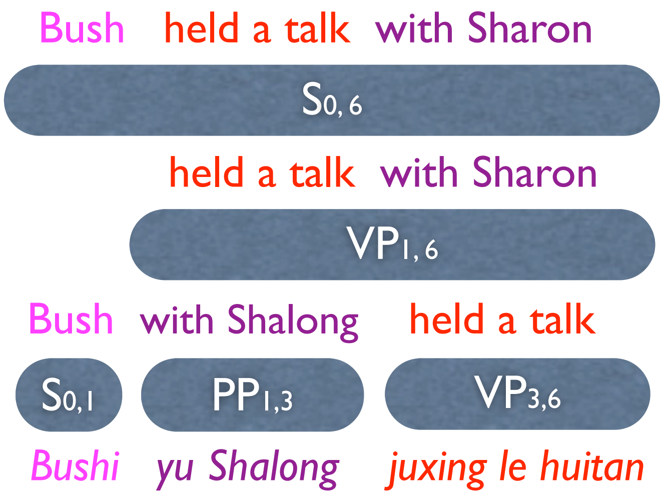
Bush held a talk with Sharon
$S_{0,6}$
held a talk with Sharon
$VP_{1,6}$
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$S_{0,1}$
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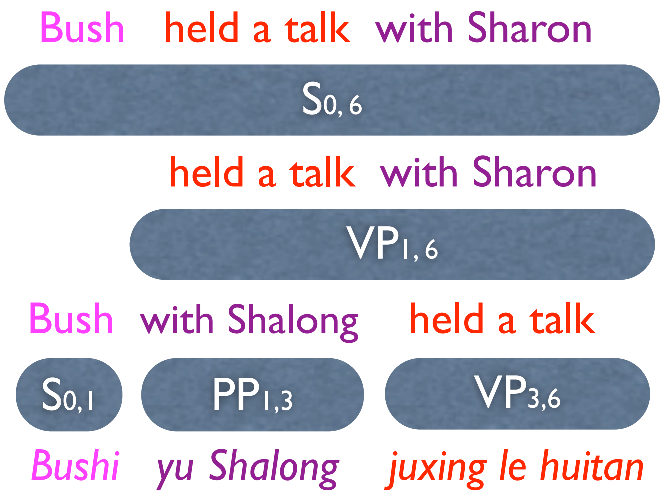

- tree-based (Quirk et al 05; Liu et al 06; Huang et al 06)
  - start from source-language parse tree
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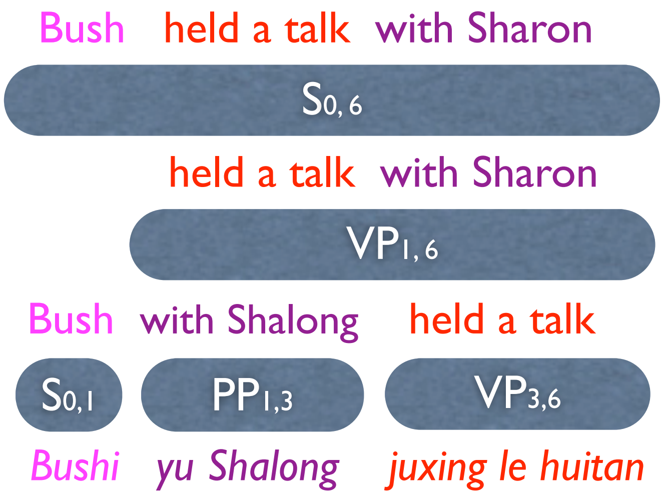
  - faster decoding; more expressive translation grammar
  - Problem: commits to 1-best parse tree! => *k*-best trees?

Two Approaches in Syntax MT



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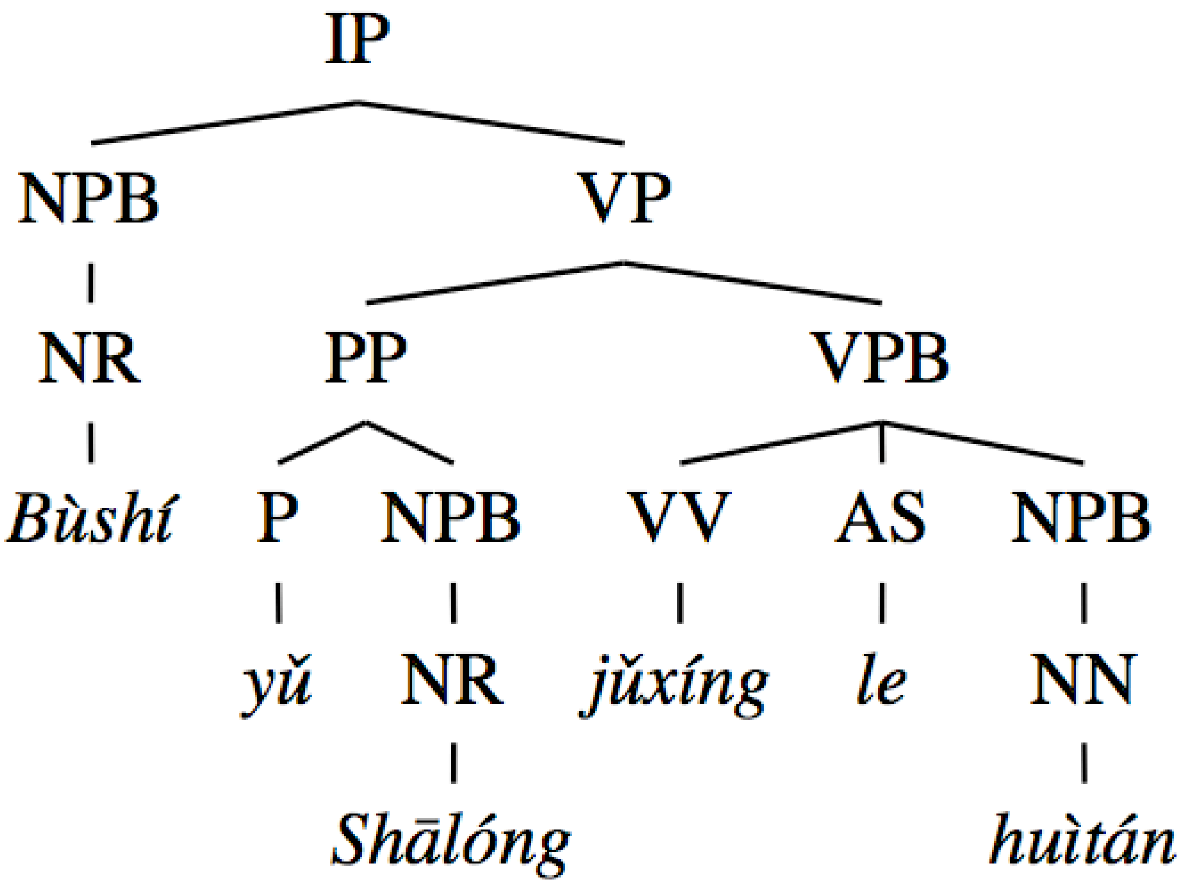
- Idea: use a parse forest! Results: ~2 Bleu points better

Outline

- Tree-based Translation
- Forest-based Translation
  - Parse Forest
  - Translation on Parse Forest
  - Integrating Language Model on Translation Forest
- Experiments

Tree-based Translation

- get 1-best parse tree; then convert to English



(Galley et al., 2004; Liu et al., 2006; Huang et al., 2006)

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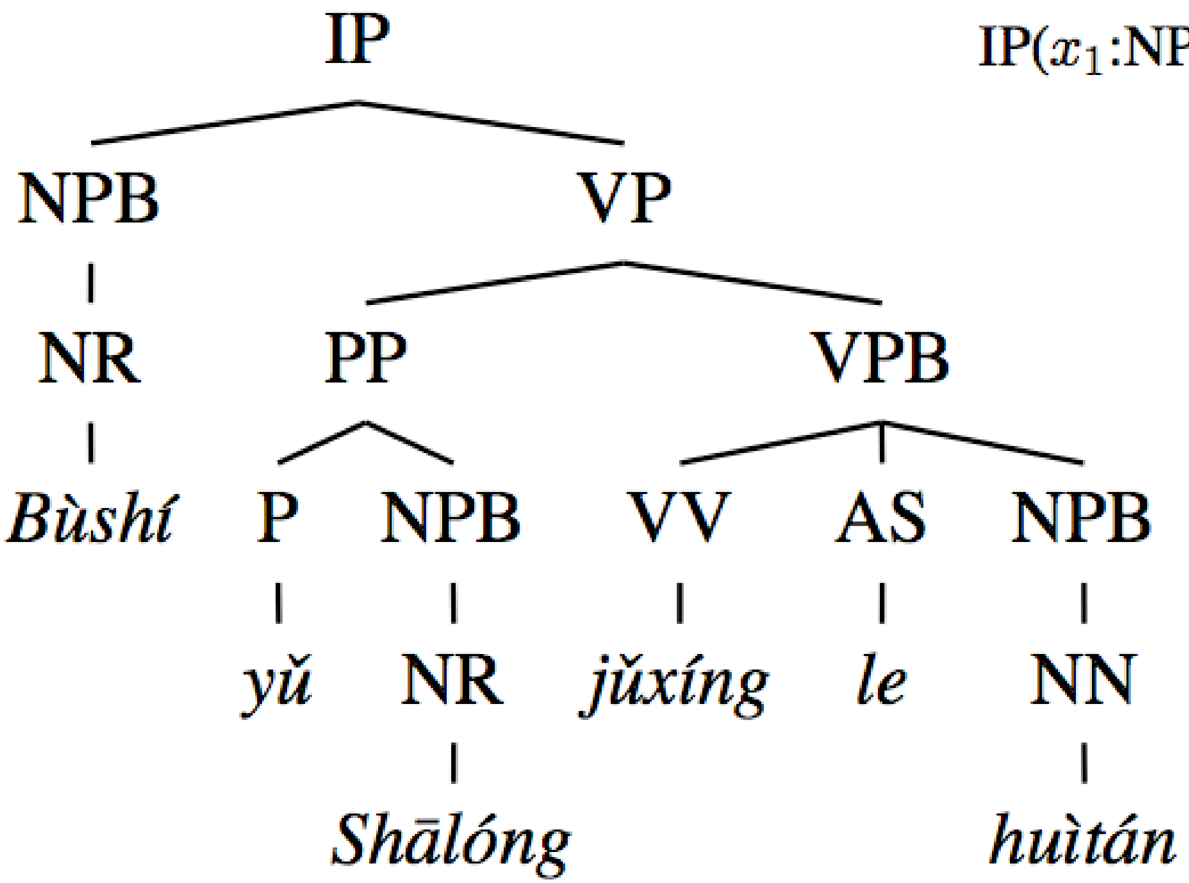

$\mathrm{IP}(x_1\mathrm{:NPB}\ x_2\mathrm{:VP}) \rightarrow x_1\ x_2$

(Galley et al., 2004; Liu et al., 2006; Huang et al., 2006)

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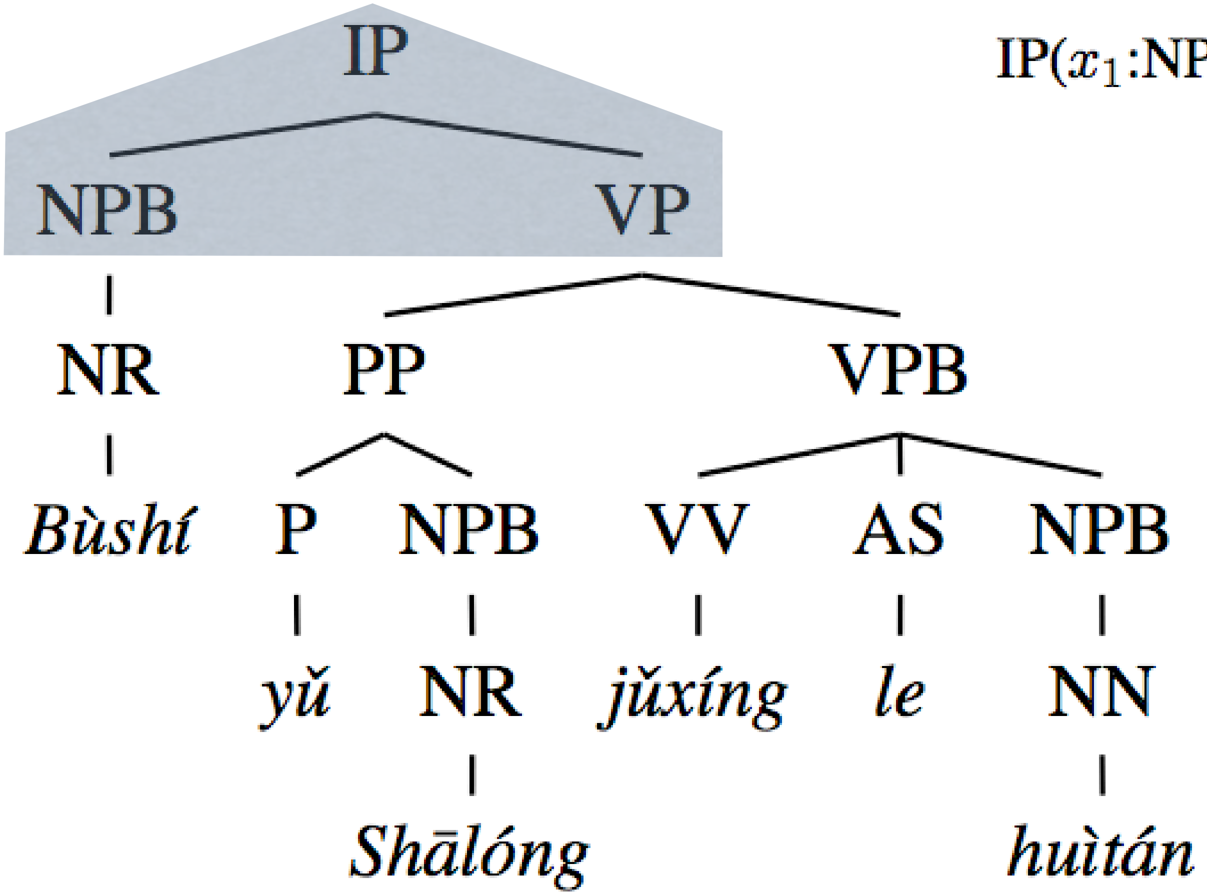

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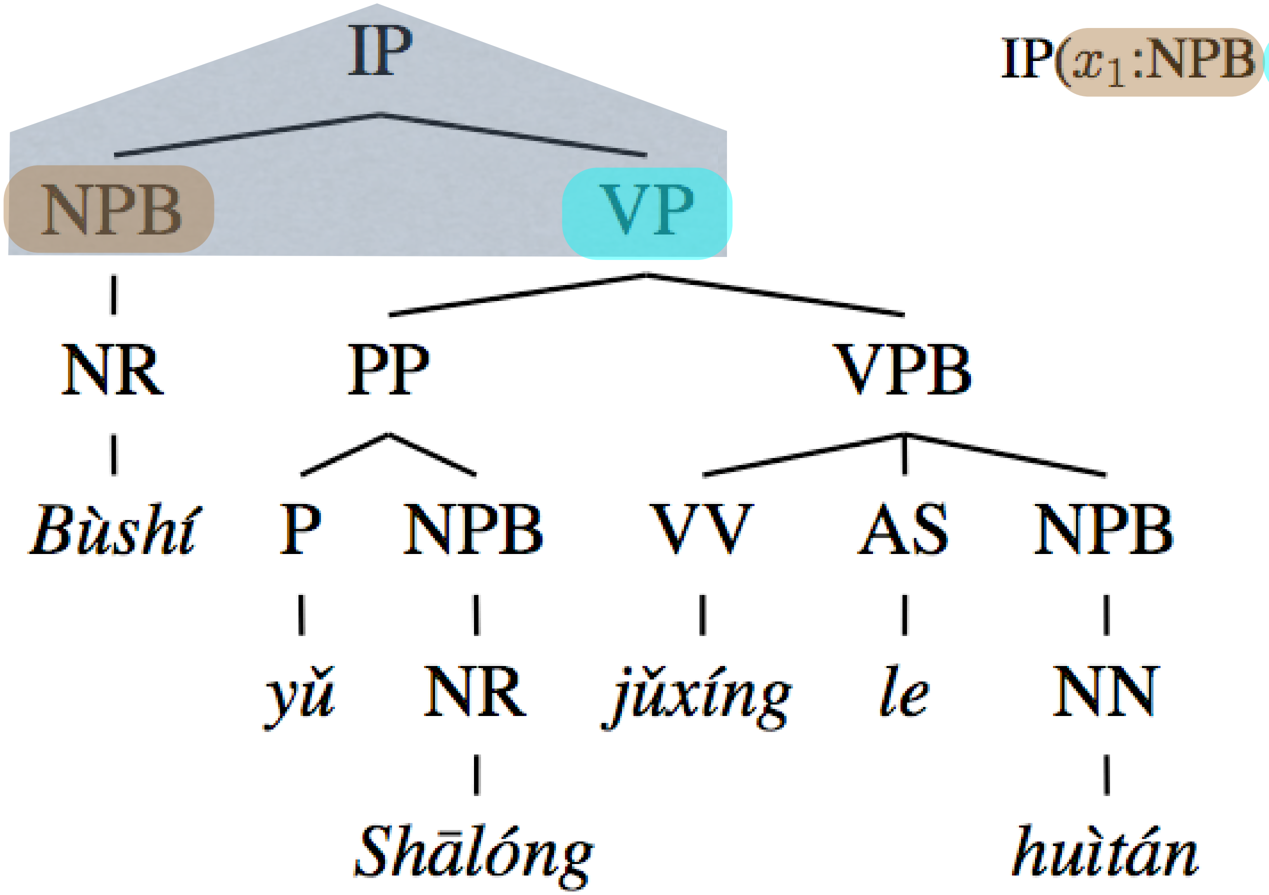

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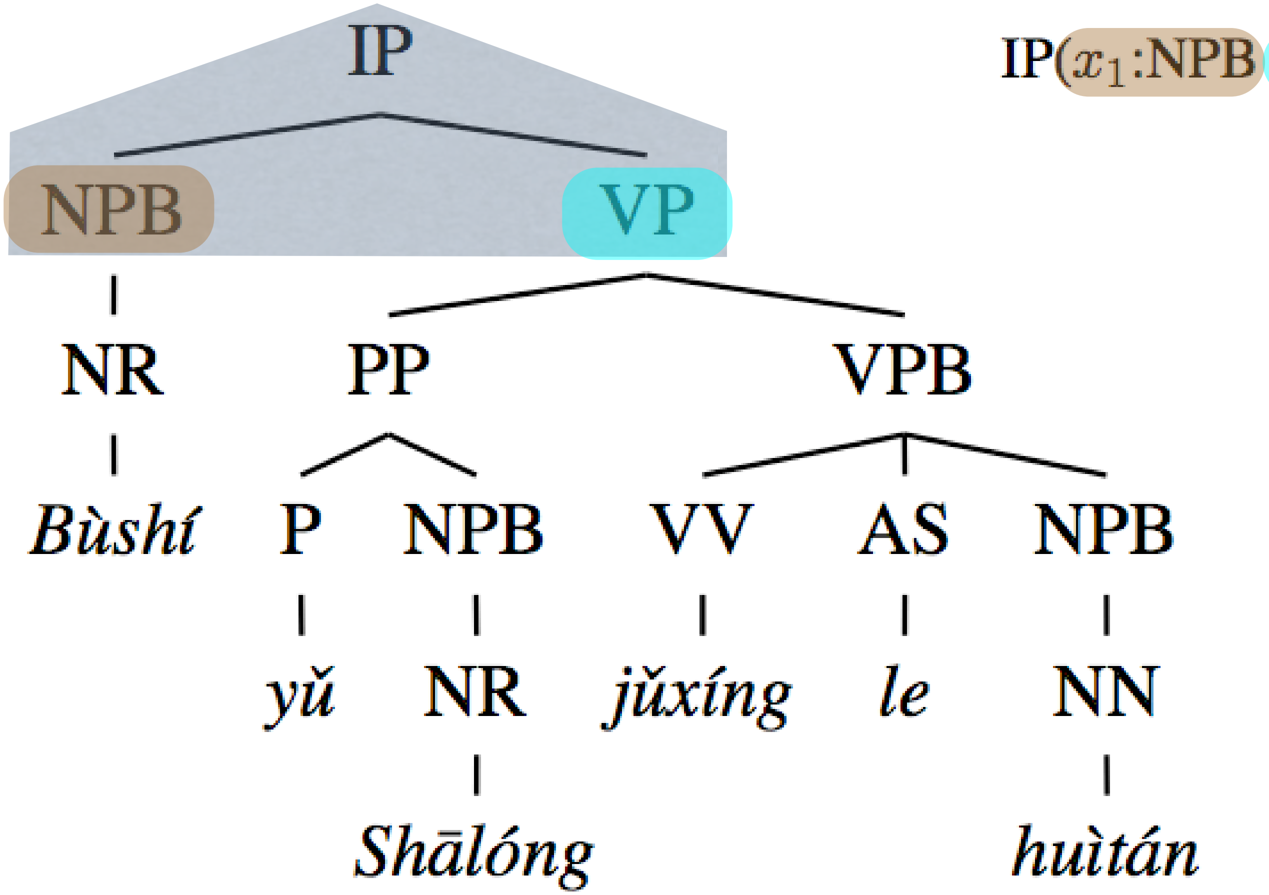

IP(x_1:NPB x_2:VP) → x_1 x_2

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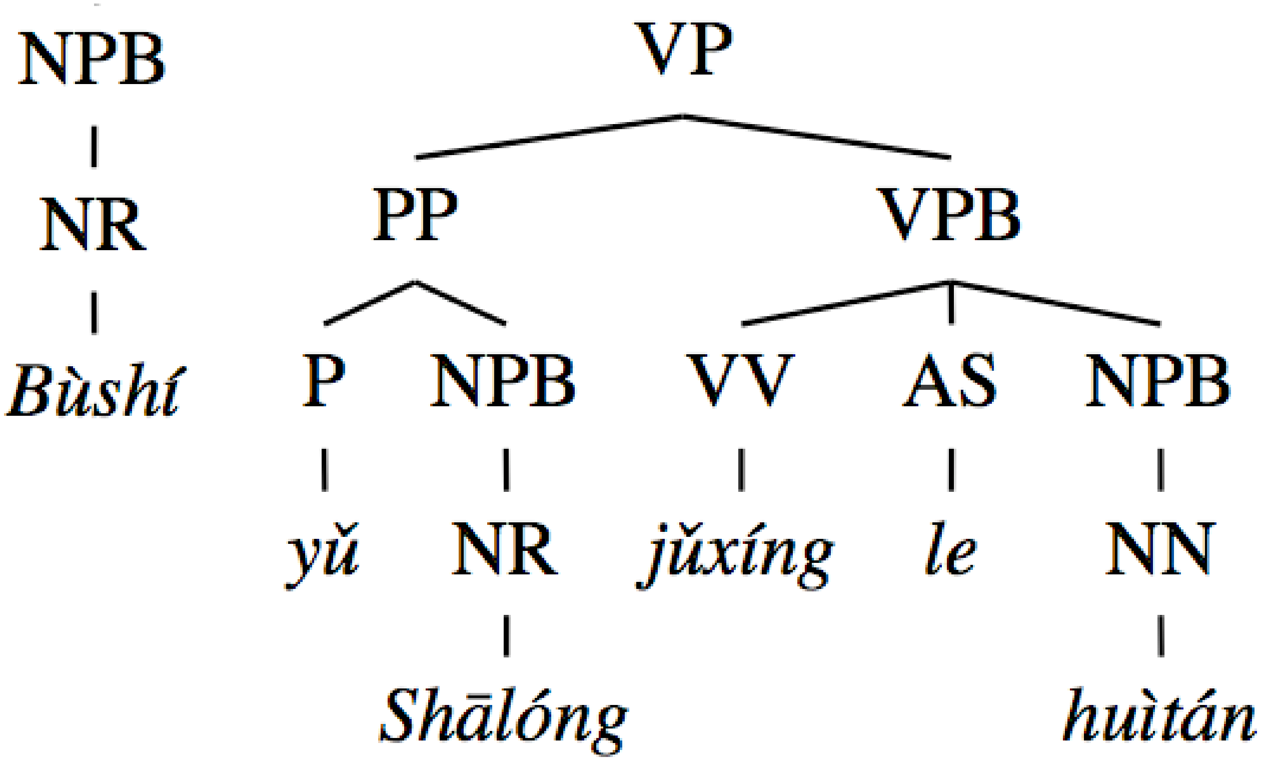
Tree-based Translation

- recursively solve unfinished subproblems



(Liu et al 06; Huang et al 06)

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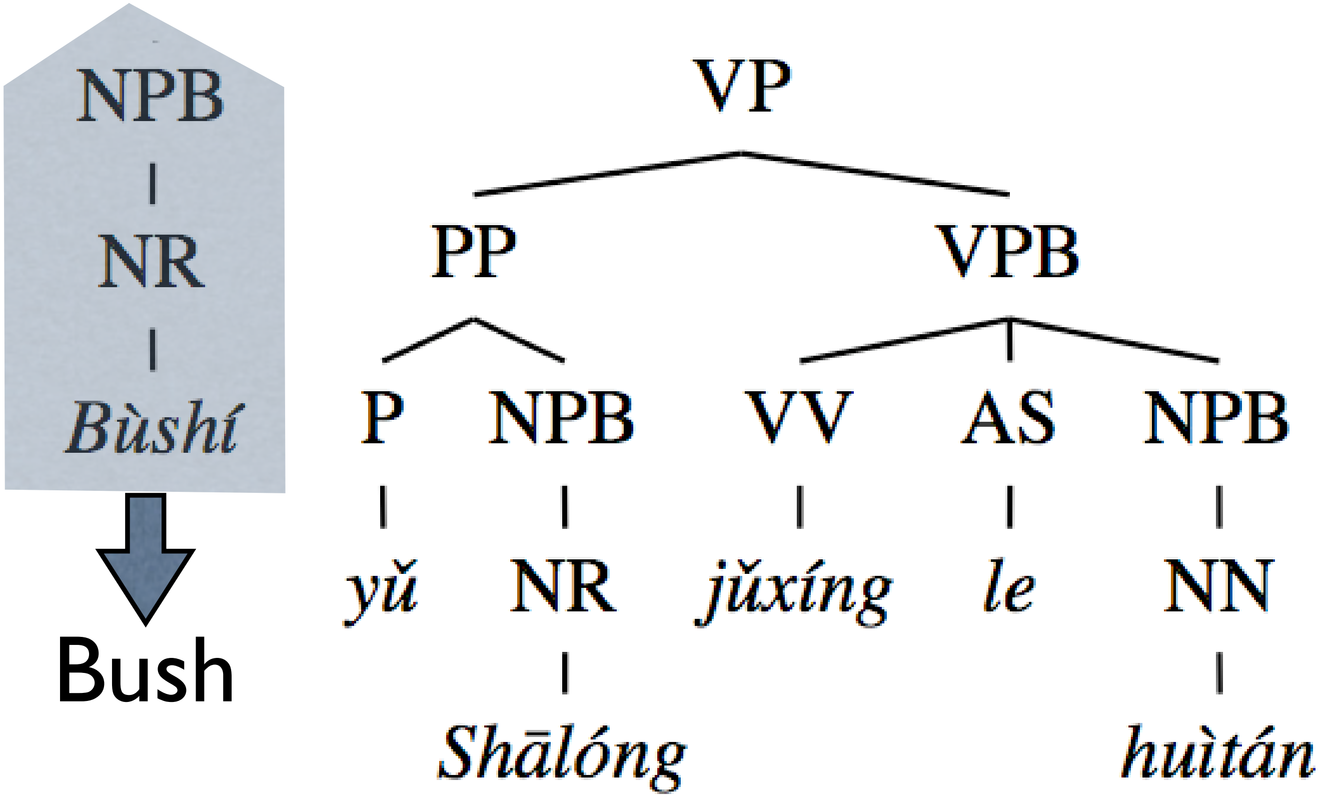
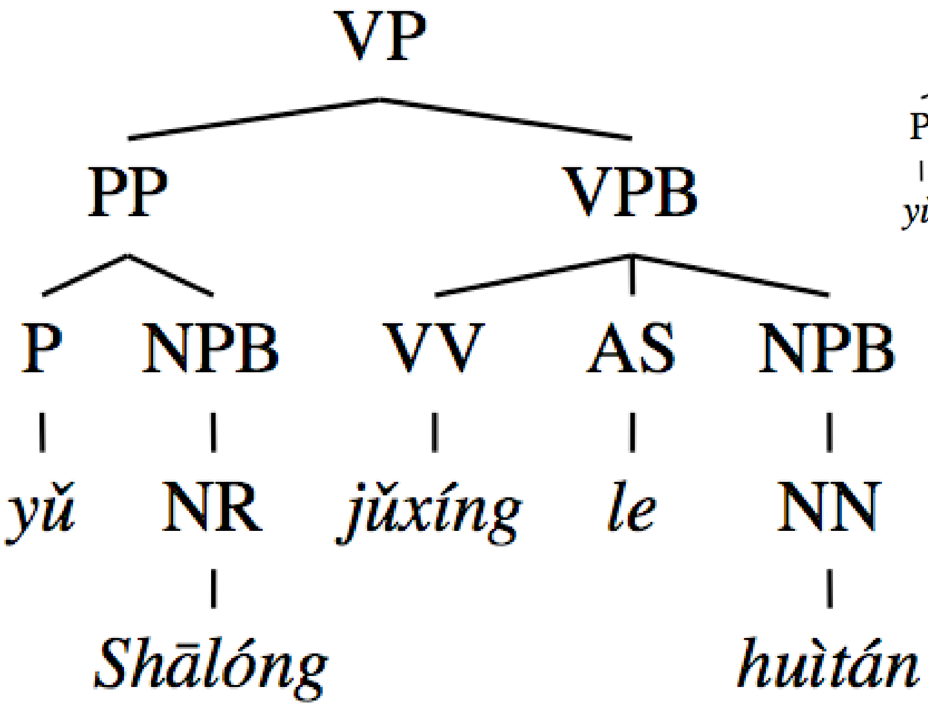


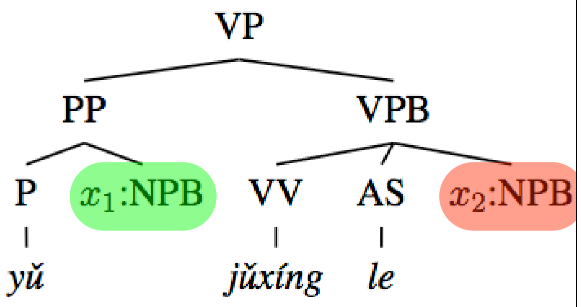
(Liu et al 06; Huang et al 06)

Tree-based Translation

- pattern-match tree-to-string translation rules

Bush





→ held x_2 with x_1

(Liu et al 06; Huang et al 06)

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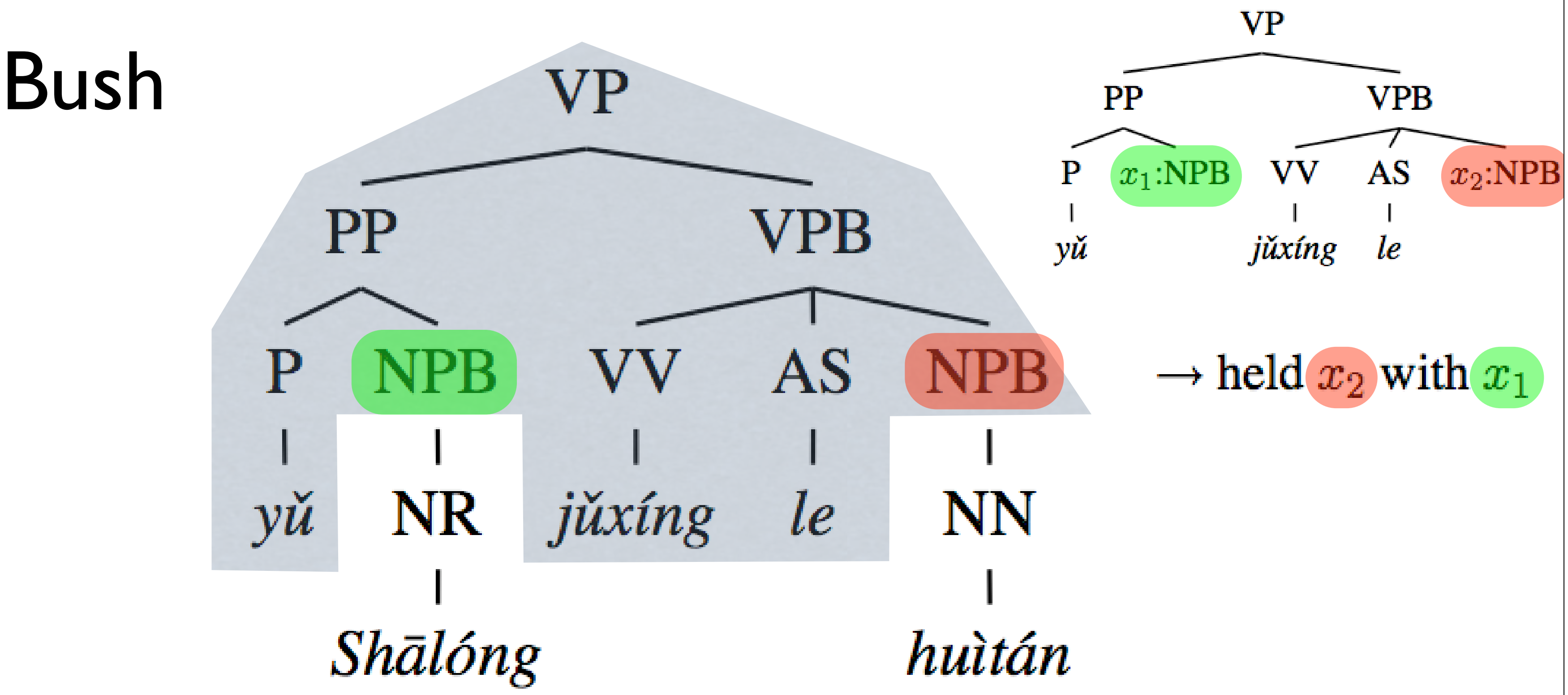

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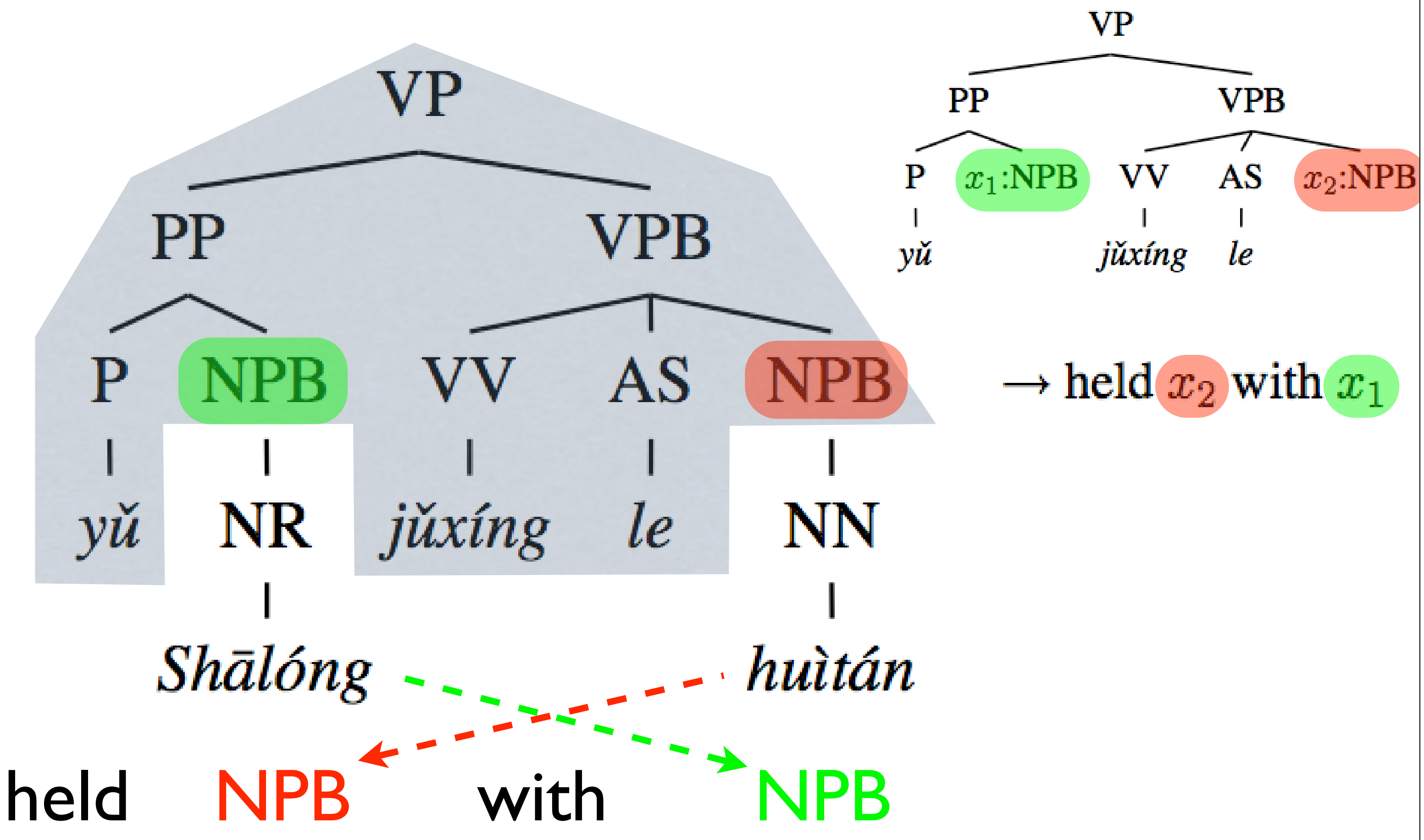
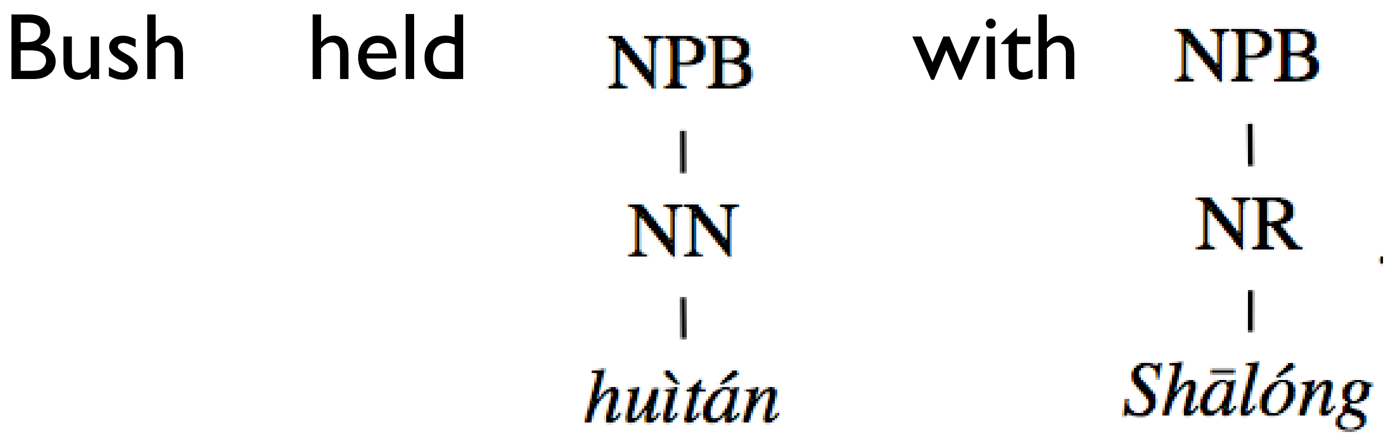


(Liu et al 06; Huang et al 06)

Tree-based Translation

- continue pattern-matching



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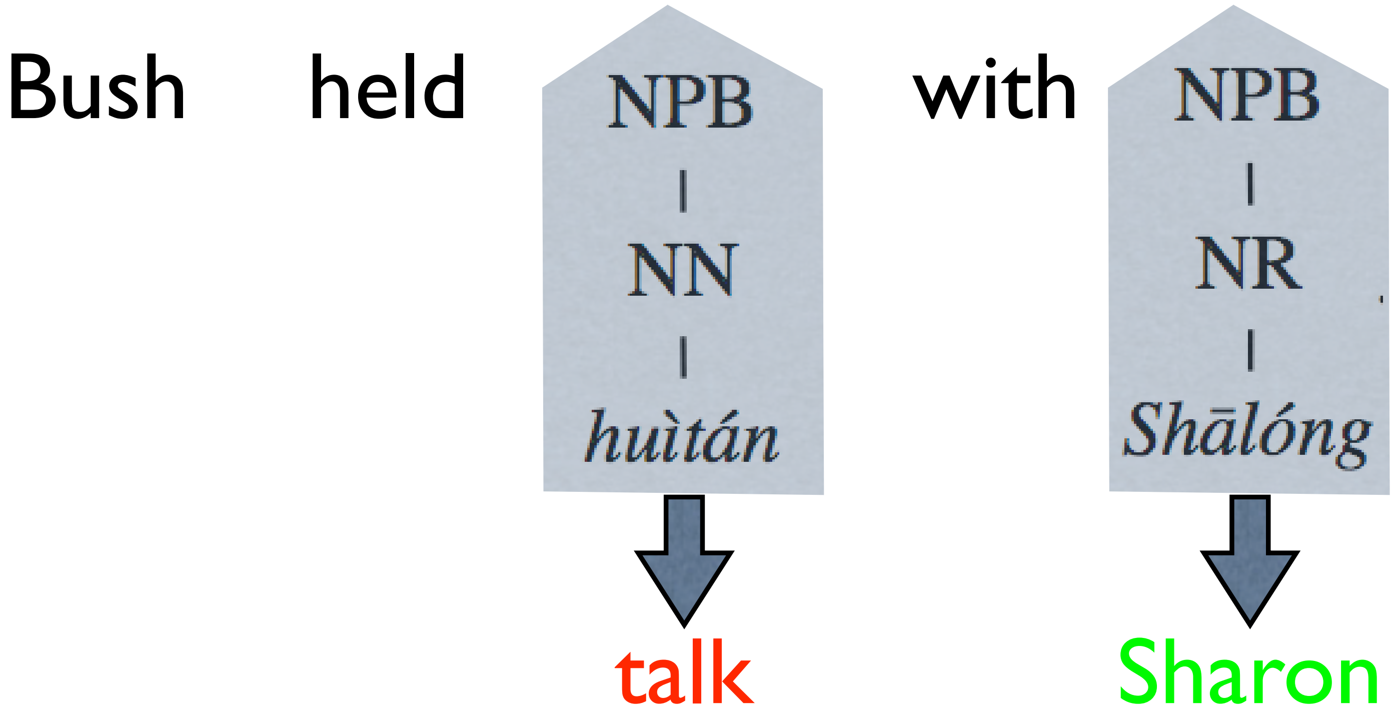


Bush held with

talk Sharon

(Liu et al 06; Huang et al 06)

Tree-based Translation

- continue pattern-matching

Bush held a talk with Sharon

(Galley et al 04; Liu et al 06; Huang et al 06)

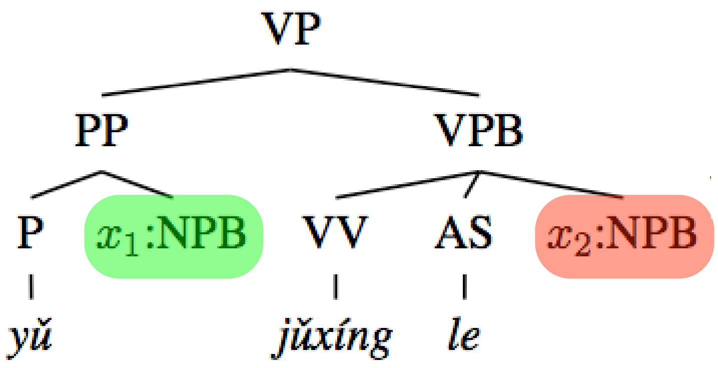
Tree-based Translation

- continue pattern-matching

Bush held a talk with Sharon

pros: simplicity, faster decoding, expressive grammar, no need for binarization, ...

cons: commits to 1-best tree



$\rightarrow$ held x_2 with x_1

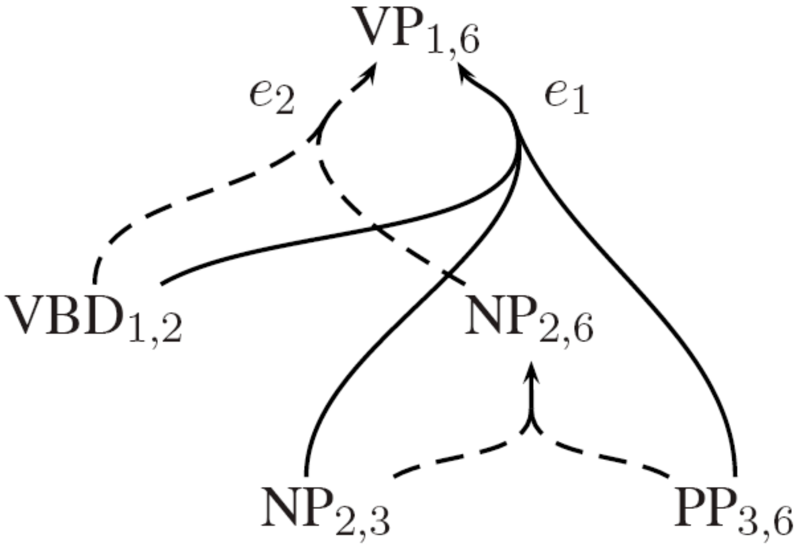
(Galley et al 04; Liu et al 06; Huang et al 06)

Forest-based Translation

using a packed parse forest to direct the translation

Packed Forest

- a compact representation of many parses
  - by sharing common sub-derivations
  - polynomial-space encoding of exponentially large set



$$e_1 \quad \frac{\mathrm{VBD}_{1,2} \quad \mathrm{NP}_{2,3} \quad \mathrm{PP}_{3,6}}{\mathrm{VP}_{1,6}}$$

$_0$ I $_1$ saw $_2$ him $_3$ with $_4$ a $_5$ mirror $_6$

(Klein and Manning, 2001; Huang and Chiang, 2005)

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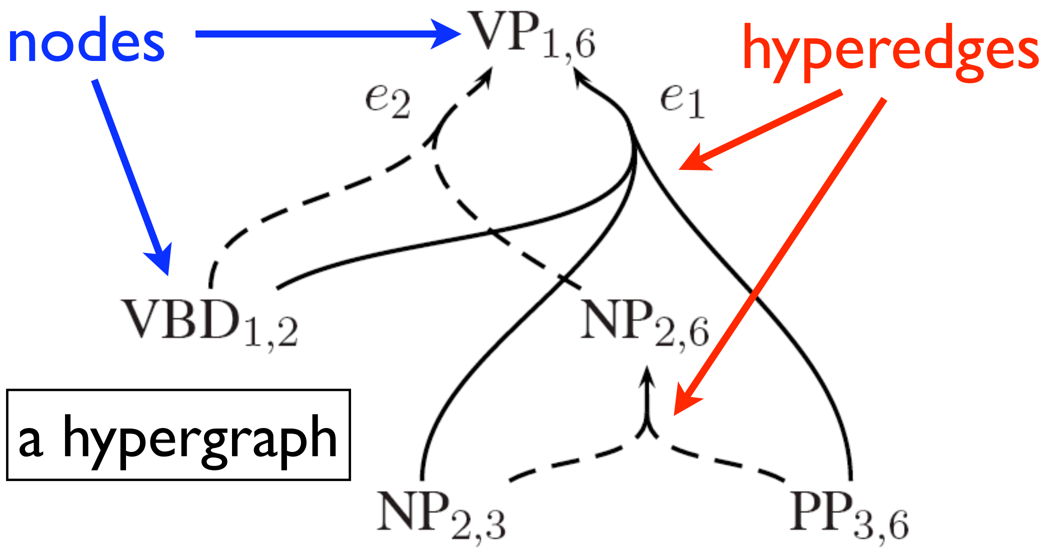

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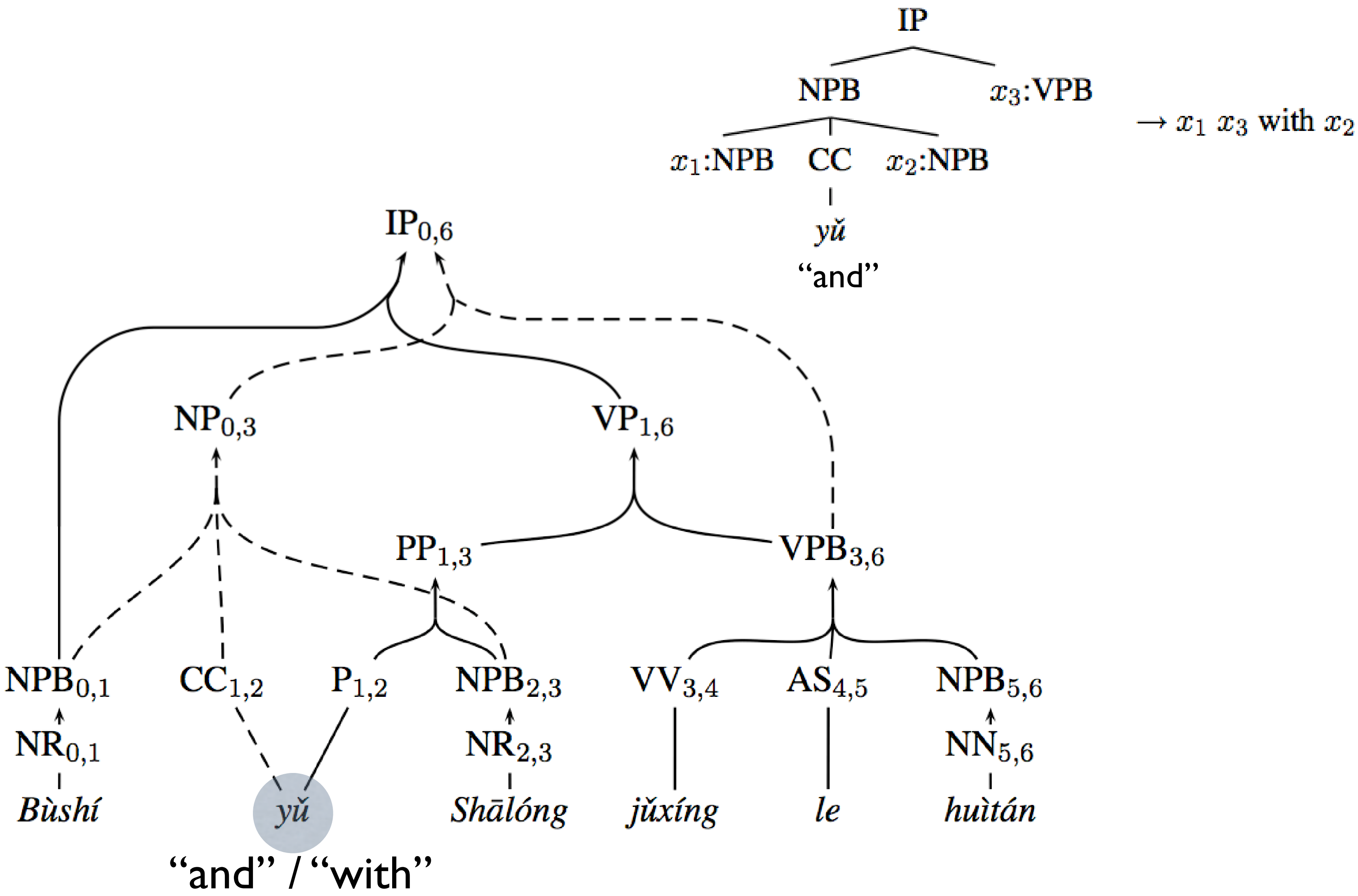
Pattern-Matching on Forest



(Chris Quirk, p.c.)

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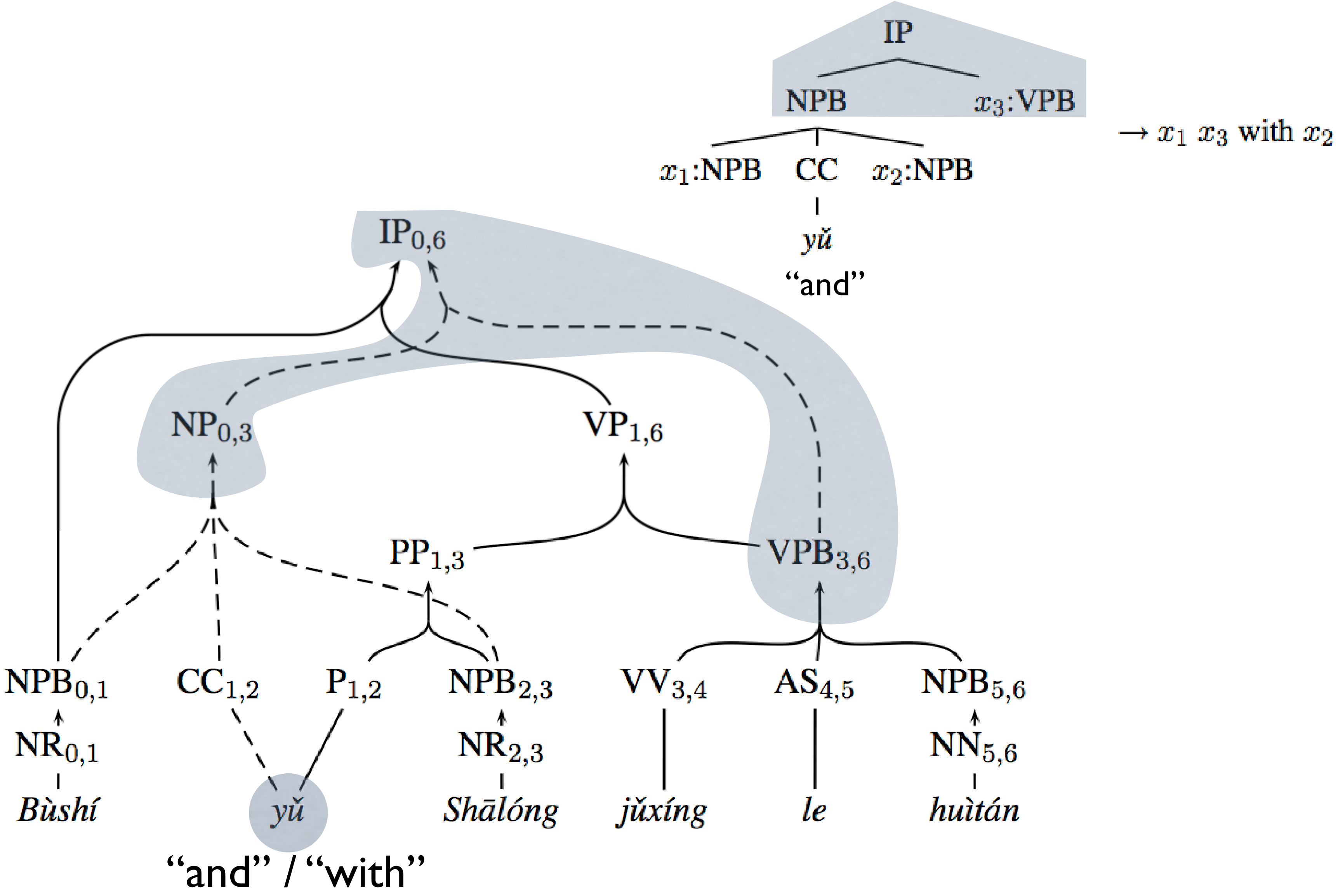

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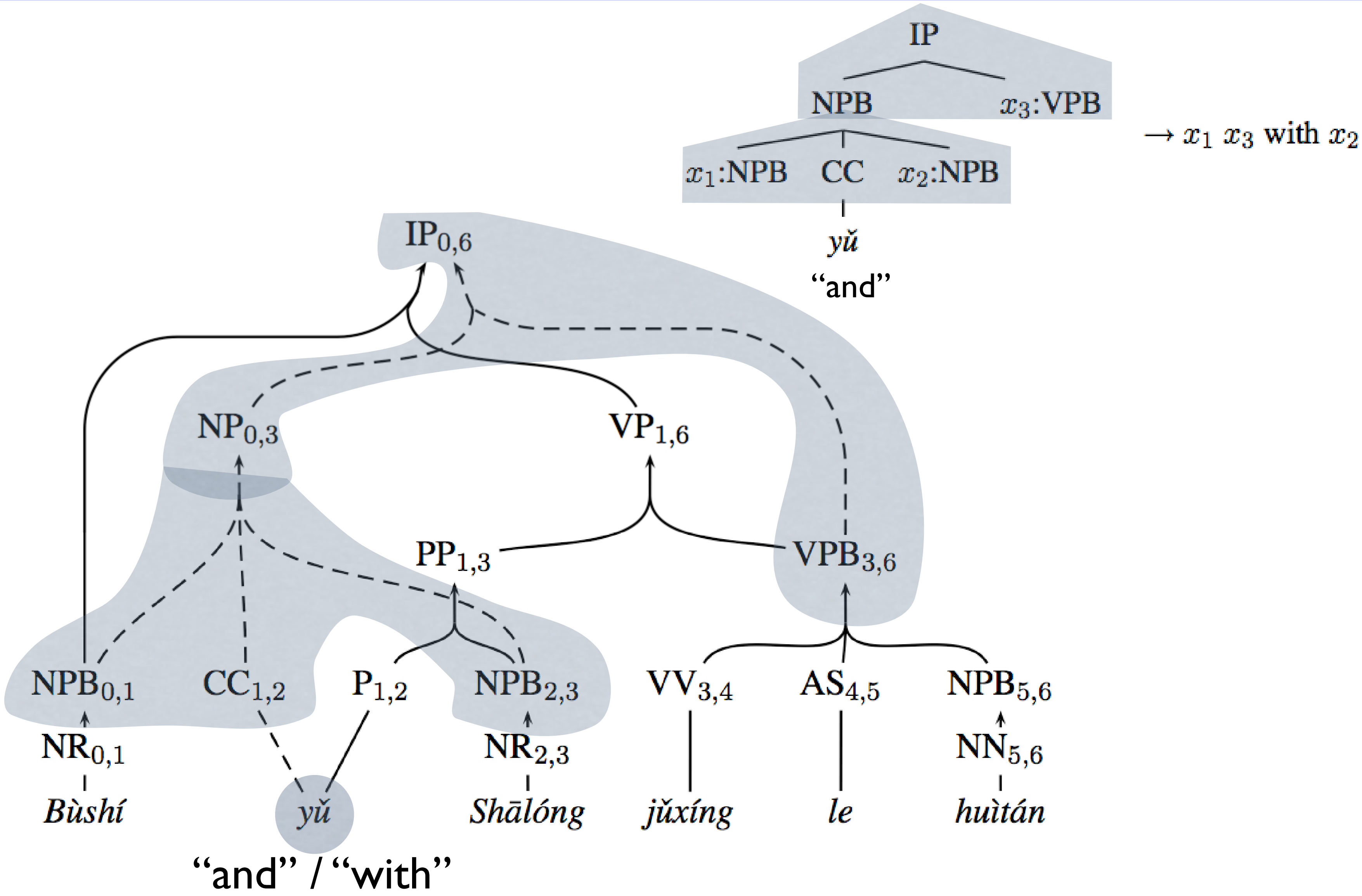

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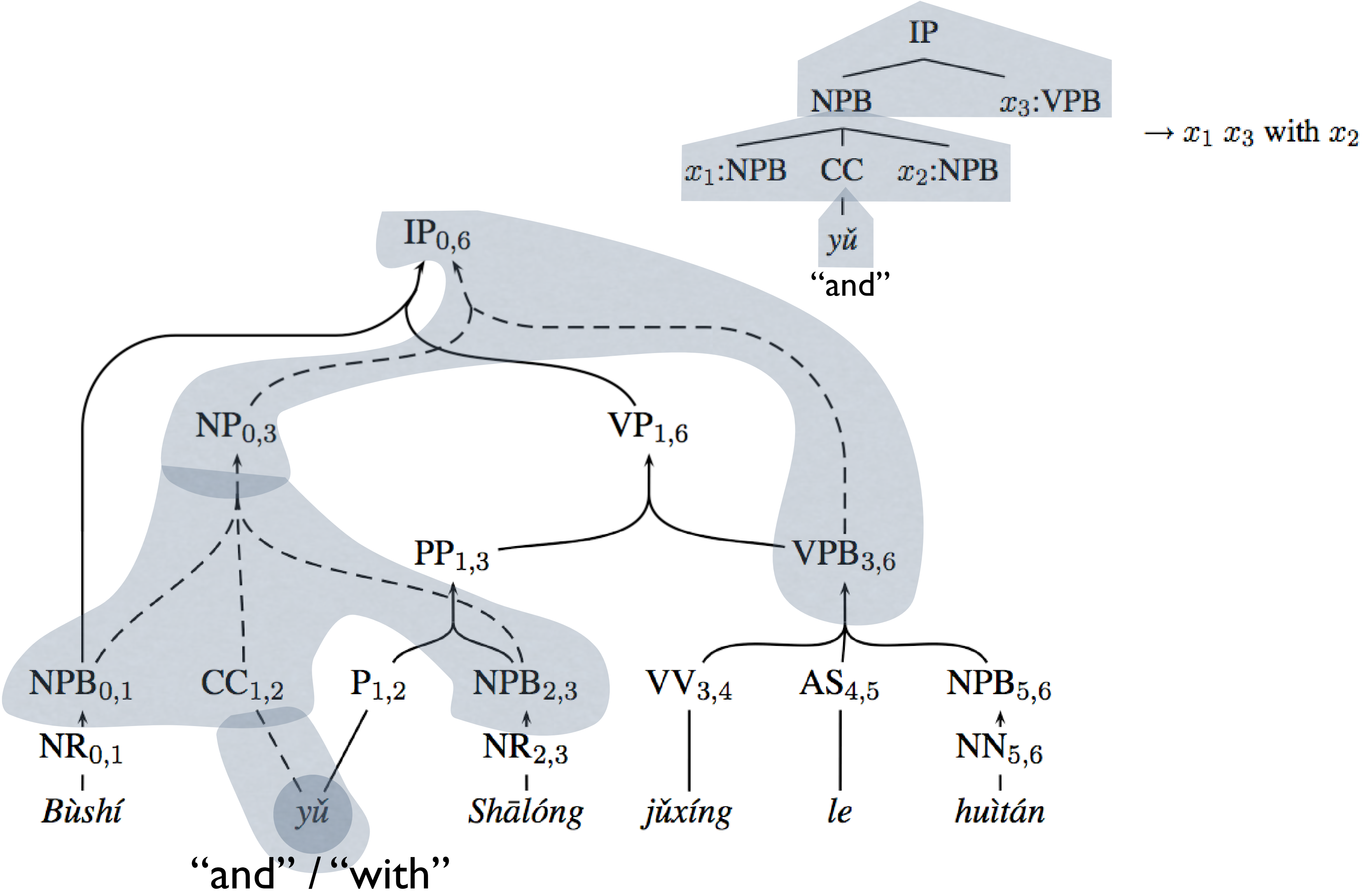

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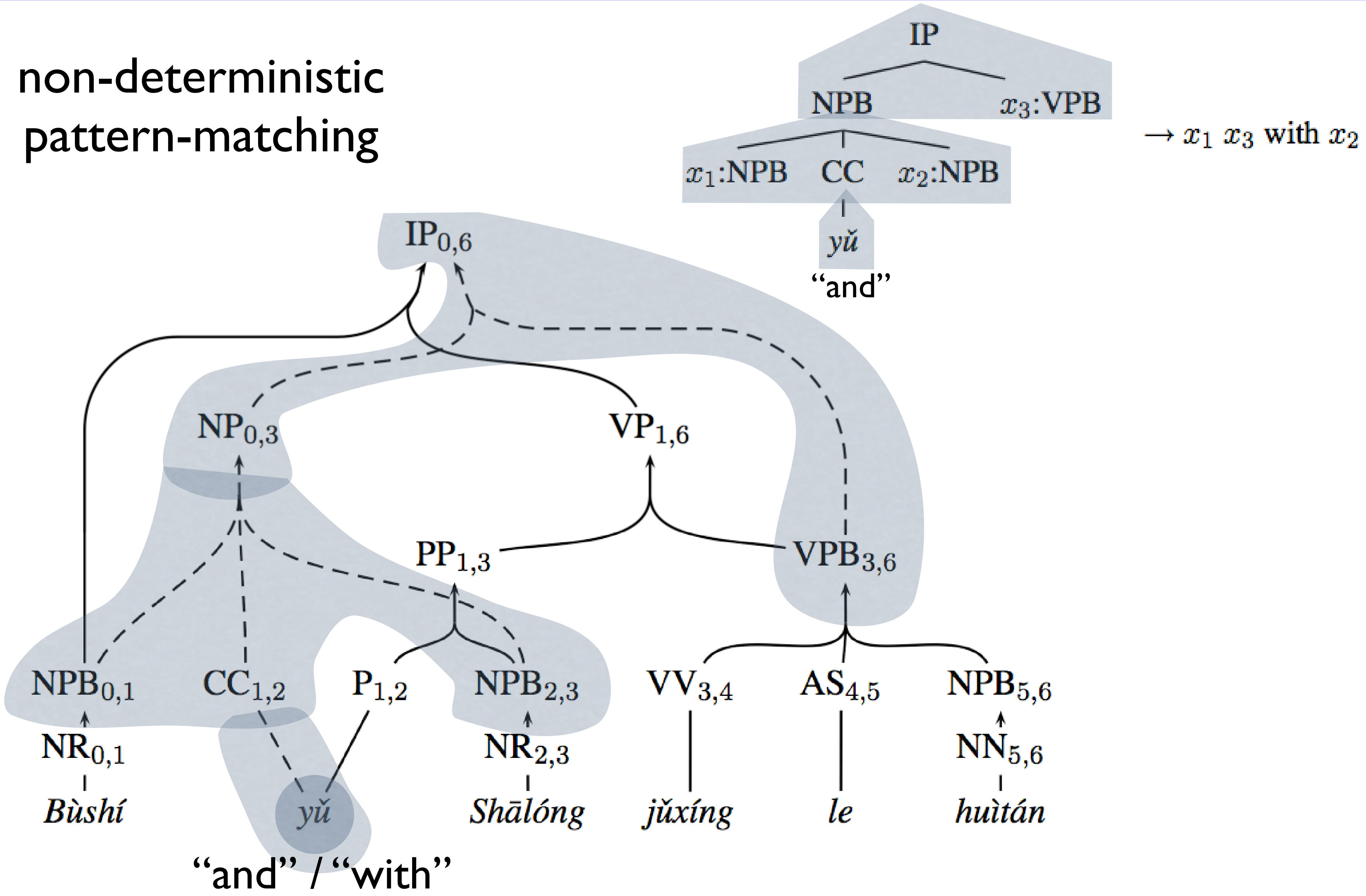
Pattern-Matching on Forest

non-deterministic
pattern-matching



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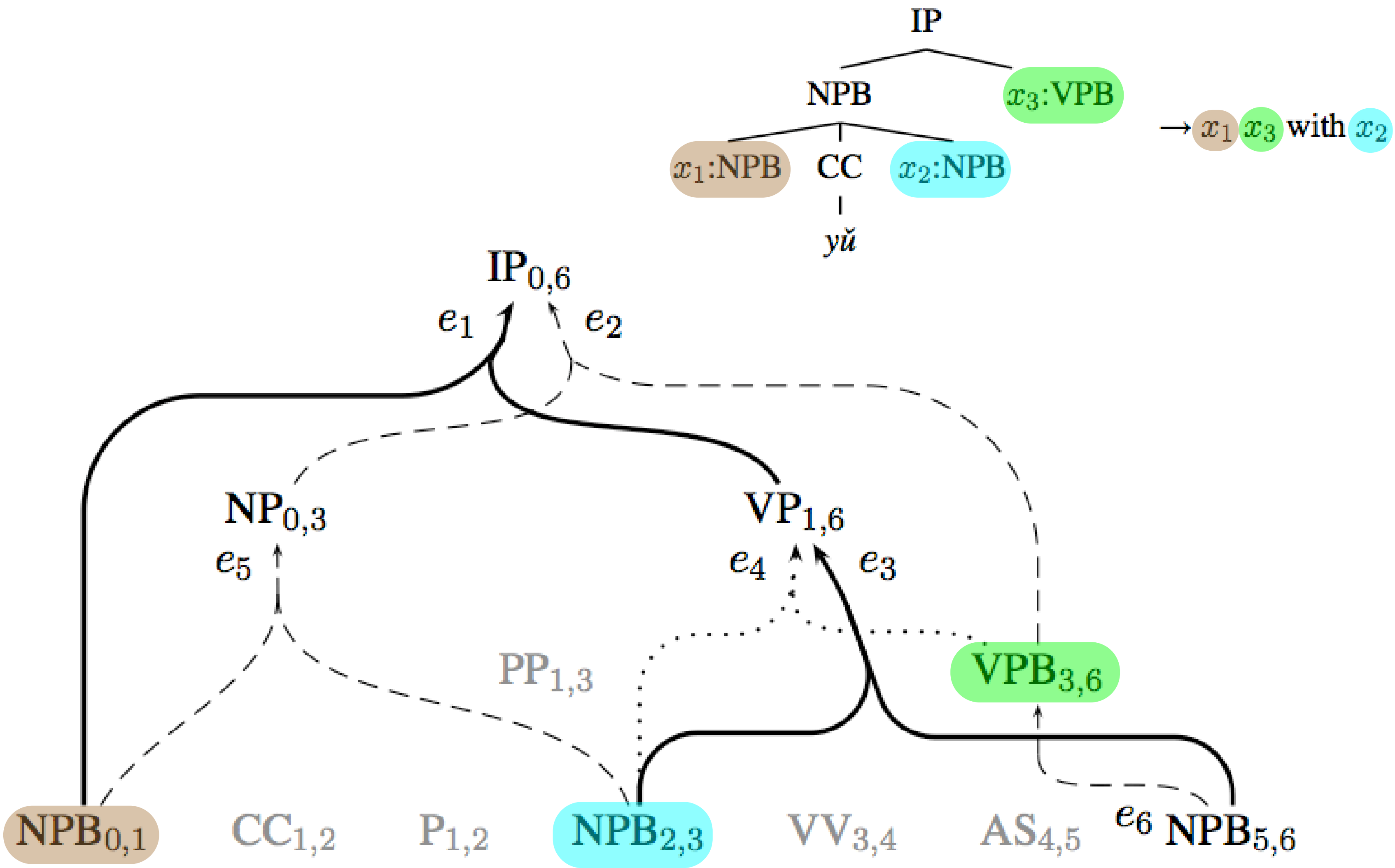
Translation Forest



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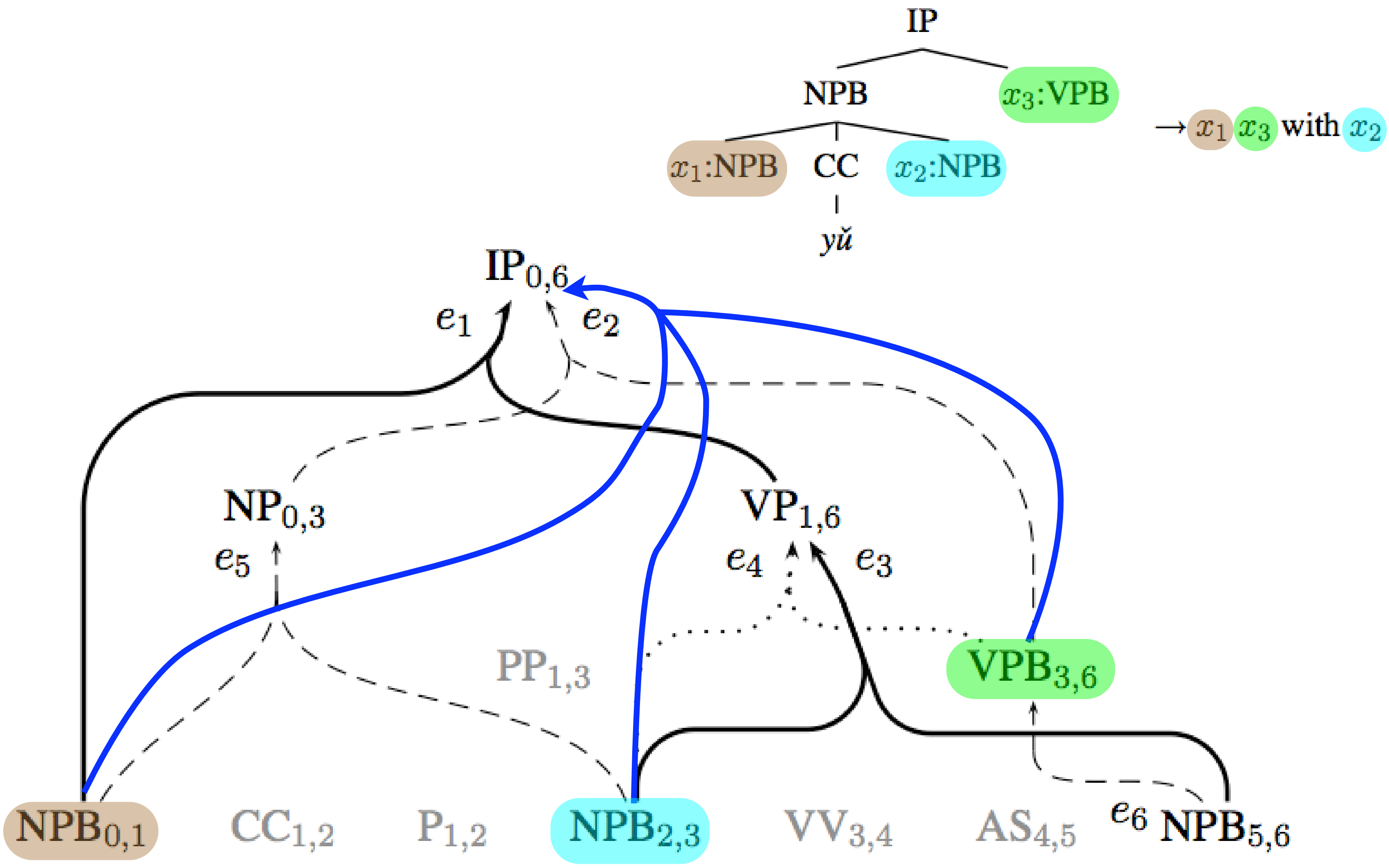

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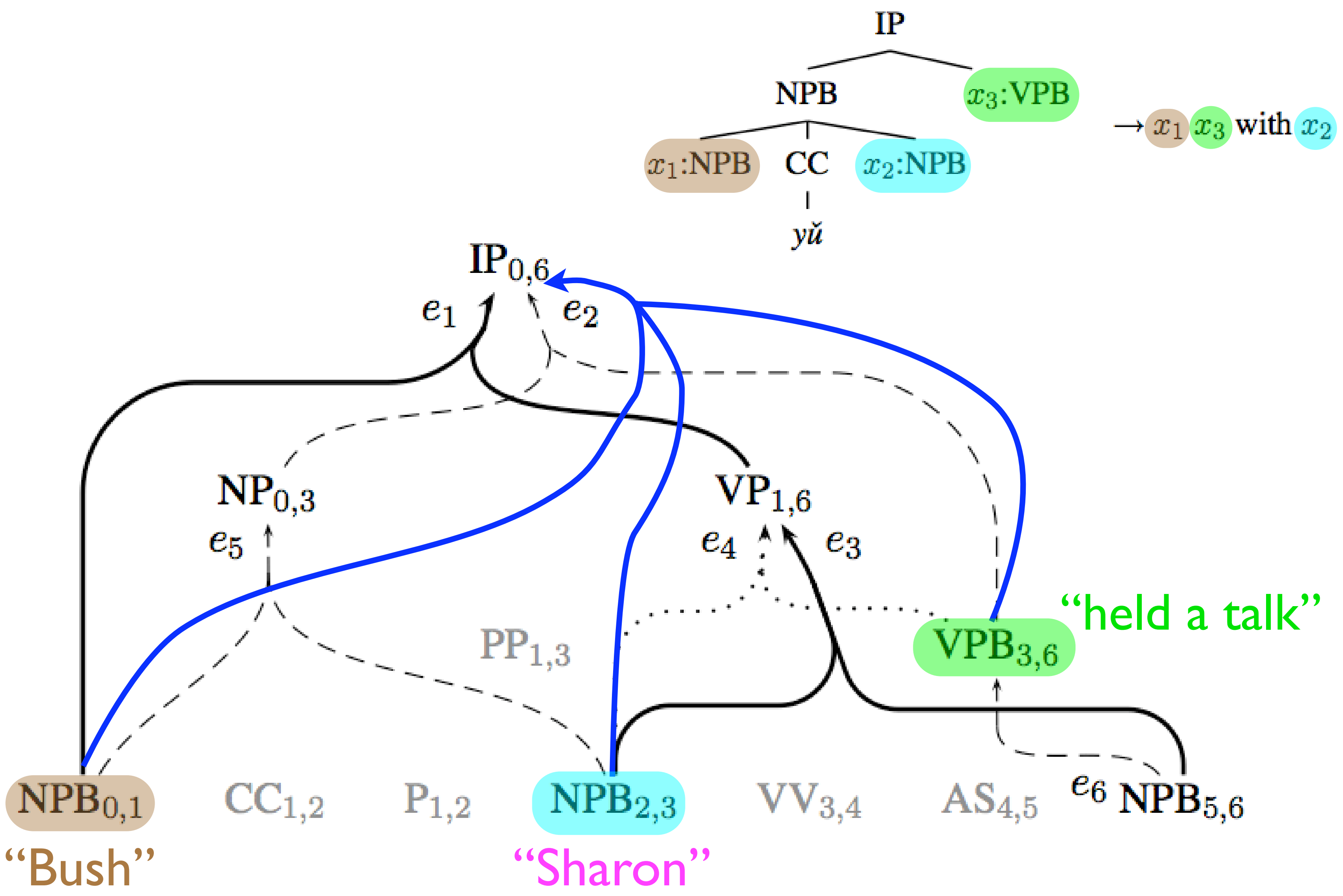

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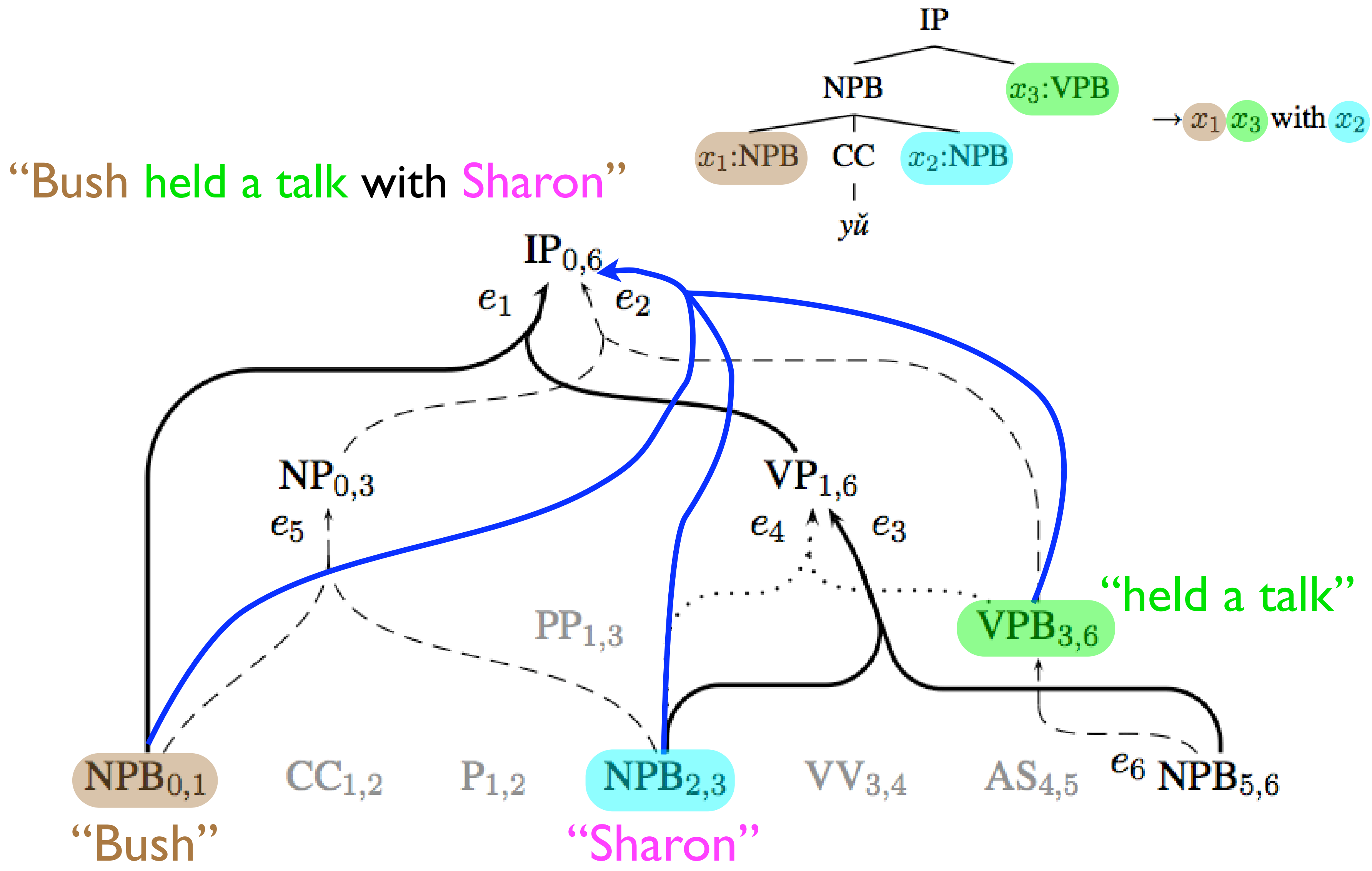
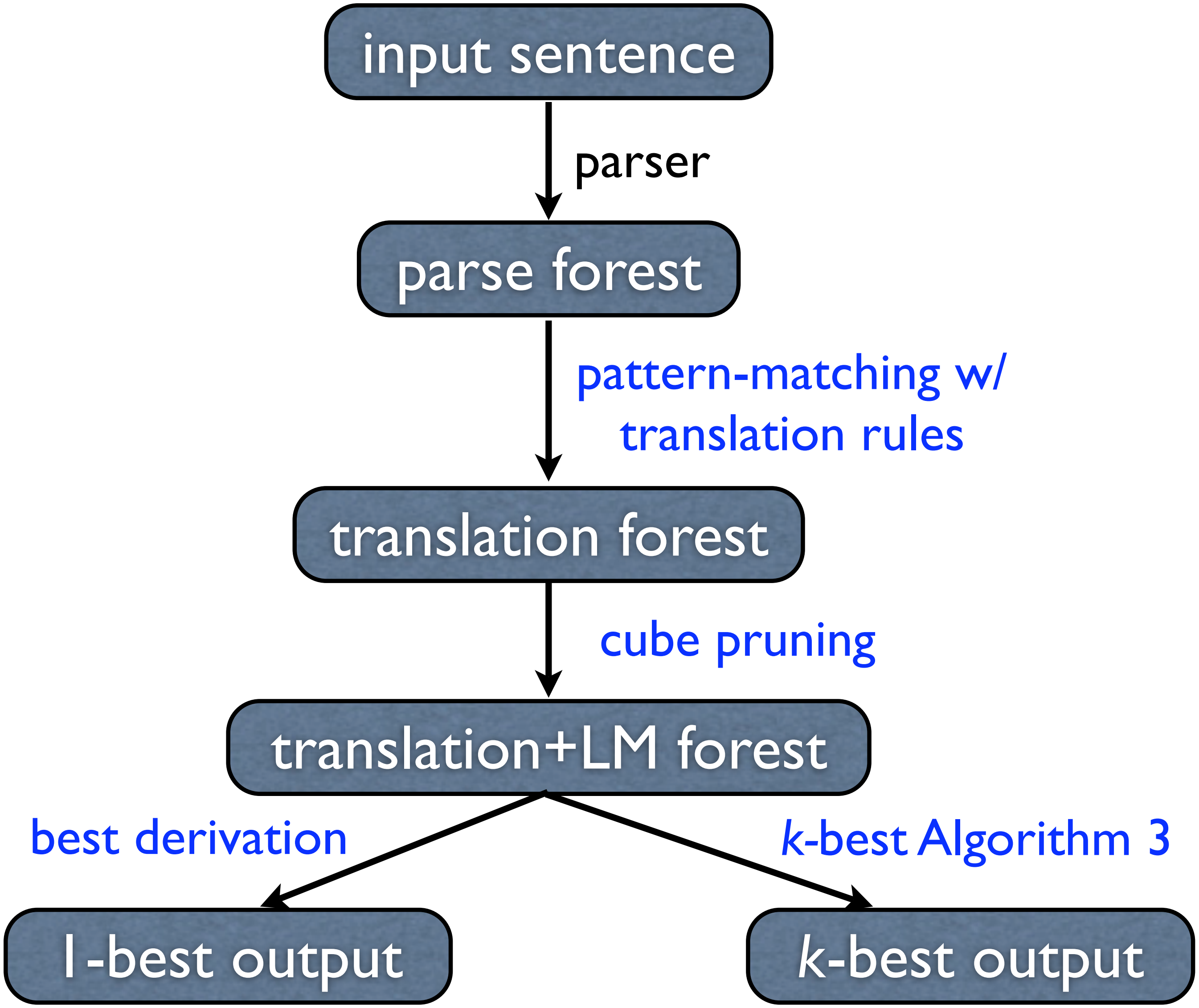


"Bush held a talk with Sharon"

Decoding with Language Model

- decoding with *n*-gram language model
  - is just intersecting a finite-state machine with the translation forest
  - result in the finer-grained "translation+LM forest"
- we use *cube pruning* (Chiang 07; Huang and Chiang 07) to speed up the intersection
- for *k*-best translations (e.g., in MERT)
  - just run *k*-best Algorithms 3 (Huang and Chiang 05) on the translation+LM forest

The Whole Pipeline



input sentence

parser

parse forest

pattern-matching w/ translation rules

translation forest

cube pruning

translation+LM forest

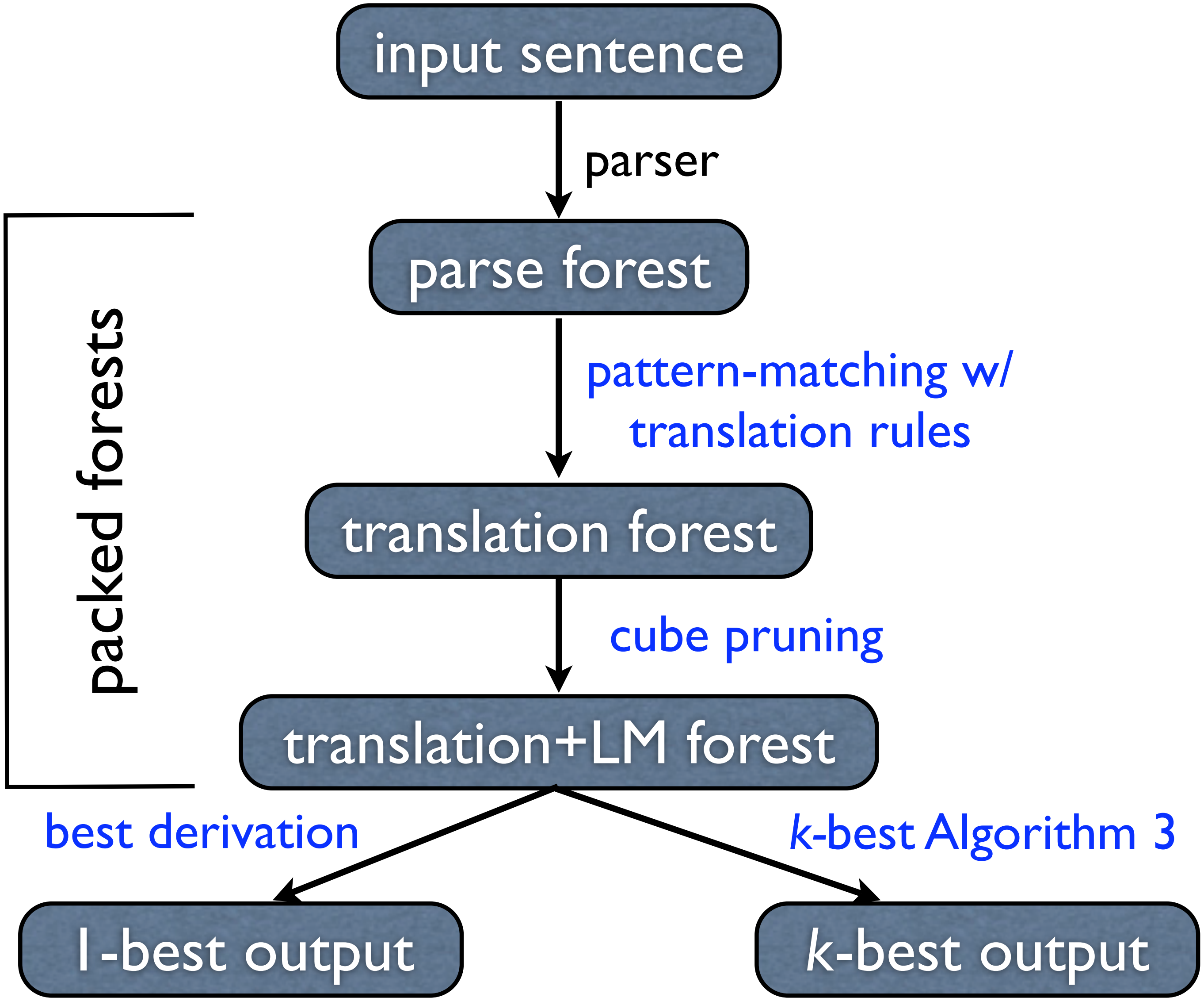
best derivation

k-best Algorithm 3

1-best output

k-best output

The Whole Pipeline



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translation+LM forest

packed forests

best derivation

k-best Algorithm 3

1-best output

k-best output

Experiments

both small-scale and large-scale experiments on Chinese-to-English translation

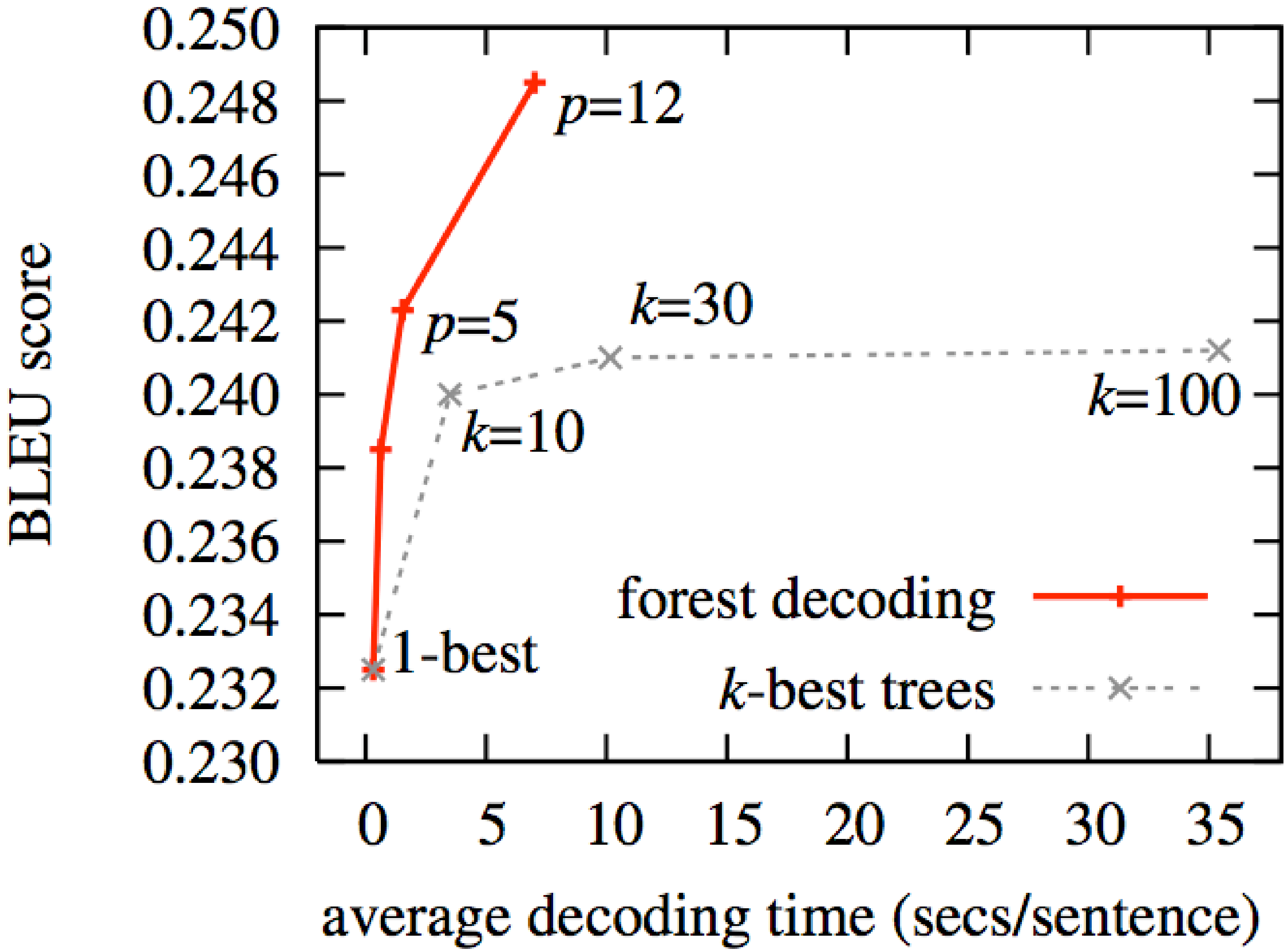
Small-Scale Experiments

- Chinese-to-English translation
  - on a tree-to-string system similar to (Liu et al, 2006)
- 31k sentences pairs (0.8M Chinese & 0.9M English words)
- GIZA++ aligned
- Chinese-side parsed by the parser of Xiong et al. (2005)
- rules extracted using algorithm of Galley et al. (2004; 2006)
  - 346k tree-to-string translation rules
- trigram language model trained on the English side
- dev: NIST 2002 (878 sent.); test: NIST 2005 (1082 sent.)

Results (BLEU)

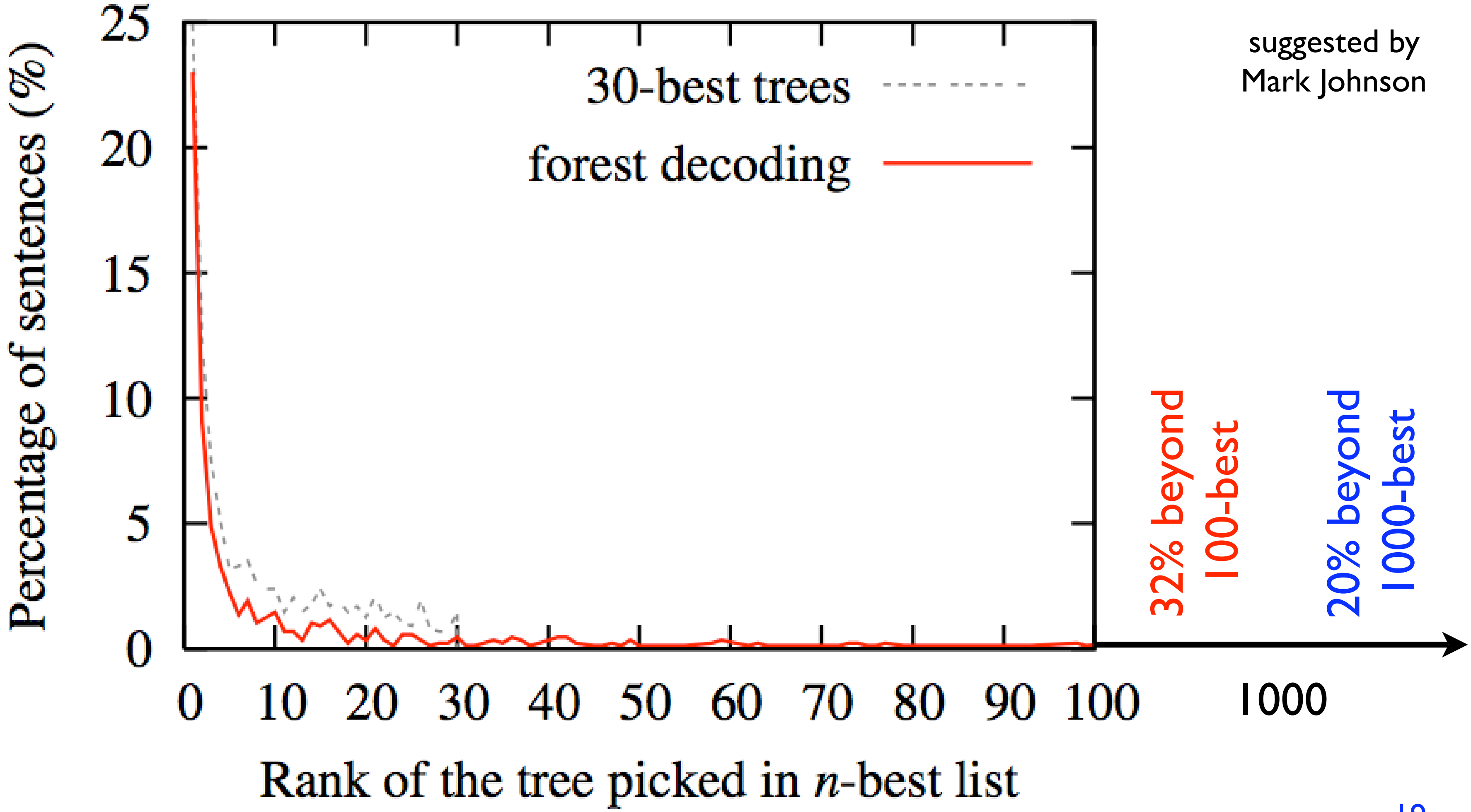
- Pharaoh (Koehn, 2004) -- 0.2182
- 1-best tree decoding -- 0.2302
- 30-best trees decoding -- 0.2410
- forest-based decoding -- 0.2485
  - 1.8 Bleu over than 1-best, significant ($p < 0.01$)
  - forests from a modified version of the Chinese parser, similar to Huang (2008)
  - forests pruned by an Inside-Outside-style algorithm
  - even faster than 30-best trees!

k-best trees vs. forest-based



forest as virtual ∞-best list

- how often is the *i*th-best tree picked by the decoder?



suggested by
Mark Johnson

Large-Scale Experiments

- 2.2M sentence pairs (57M Chinese and 62M English words)
- larger trigram models (1/3 of Xinhua Gigaword)
- also use bilingual phrases (BP) as flat translation rules
  - phrases that are consistent with syntactic constituents
- forest enables larger improvement with BP

	T2S	T2S+BP
1-best tree	0.2666	0.2939
30-best trees	0.2755	0.3084
forest	0.2839	0.3149
improvement	1.7	2.1

Conclusion and Future Work

- forest: a compact representation of ambiguities
- compromise between tree-based and string-based
  - combining the advantages of both
    - fast decoding, but does not commit to 1-best trees
    - separate translation grammar (STSG) from parsing (CFG)
- very simple idea, but works well in practice
  - ~2 Bleu points better than 1-best tree decoding
  - ~1 Bleu points better than 30-best trees, and faster!
- future work: use forest in rule-extraction also

Forest is your friend in machine translation.

stay tuned for another "forest-based" talk
on parsing tomorrow morning

Thank you!

Acknowledgments: Chris Quirk, Kevin Knight,
Mark Johnson, Yang Liu, ...