Discontinuous Parsing with an Efficient and Accurate DOP Model

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This talk

Parsing with . . .

- discontinuous constituents:
  Linear Context-Free Rewriting Systems (LCFRS)
- treebank fragments:
  Data-Oriented Parsing (DOP)
  Tree-Substitution Grammar (TSG)

Discontinuous constituents

Example:

- Why did the chicken cross the road?
- The chicken crossed the road to get to the other side.

Discontinuous trees

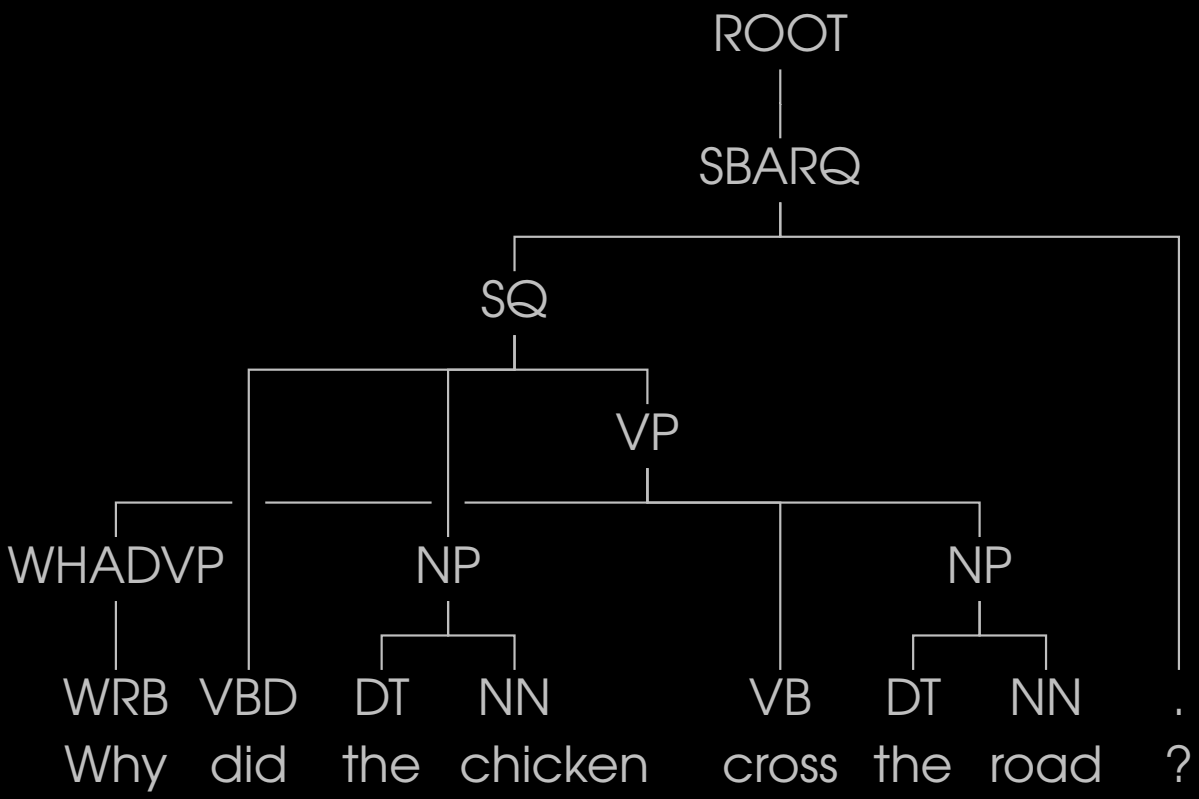


Figure : A discontinuous tree not found in the Penn treebank.

Discontinuous constituents

Motivation:

- Flexible word-order
- Capture argument structure
- Combine information from constituency & dependency structures
- Information is available in treebanks (German, Dutch, English after conversion).

Discontinuous trees

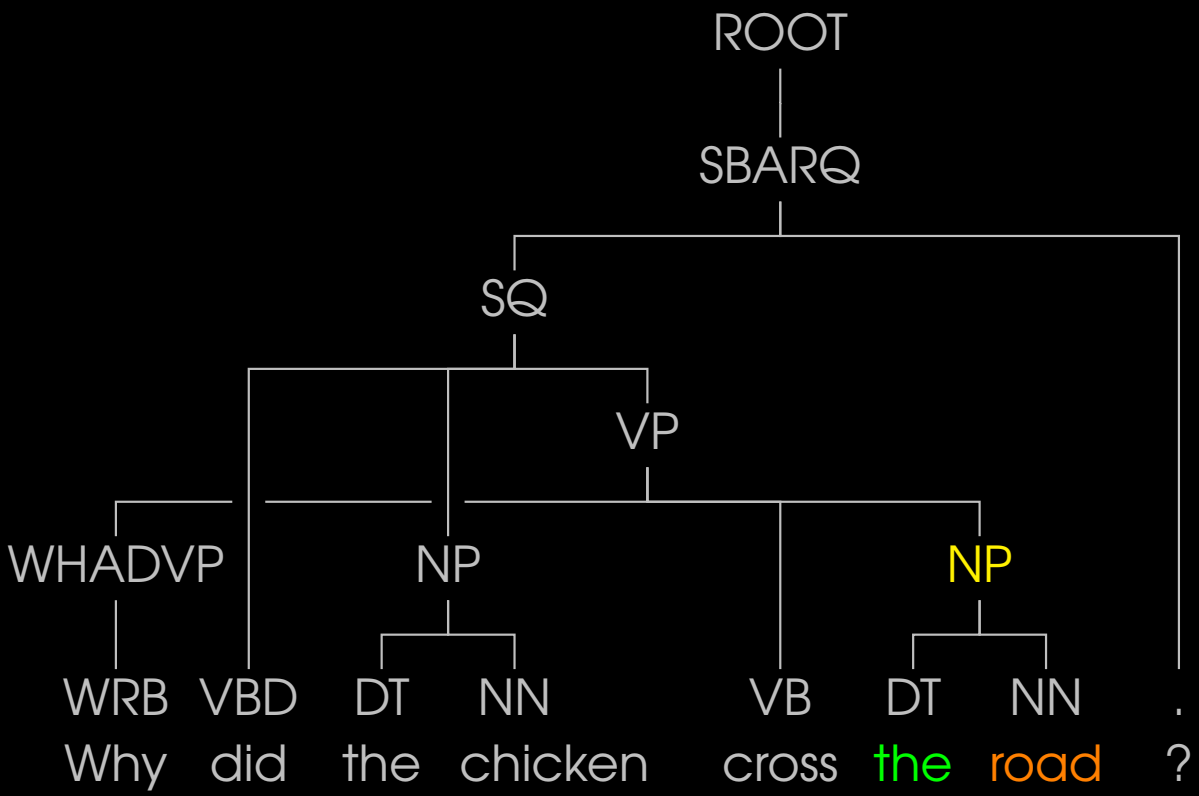
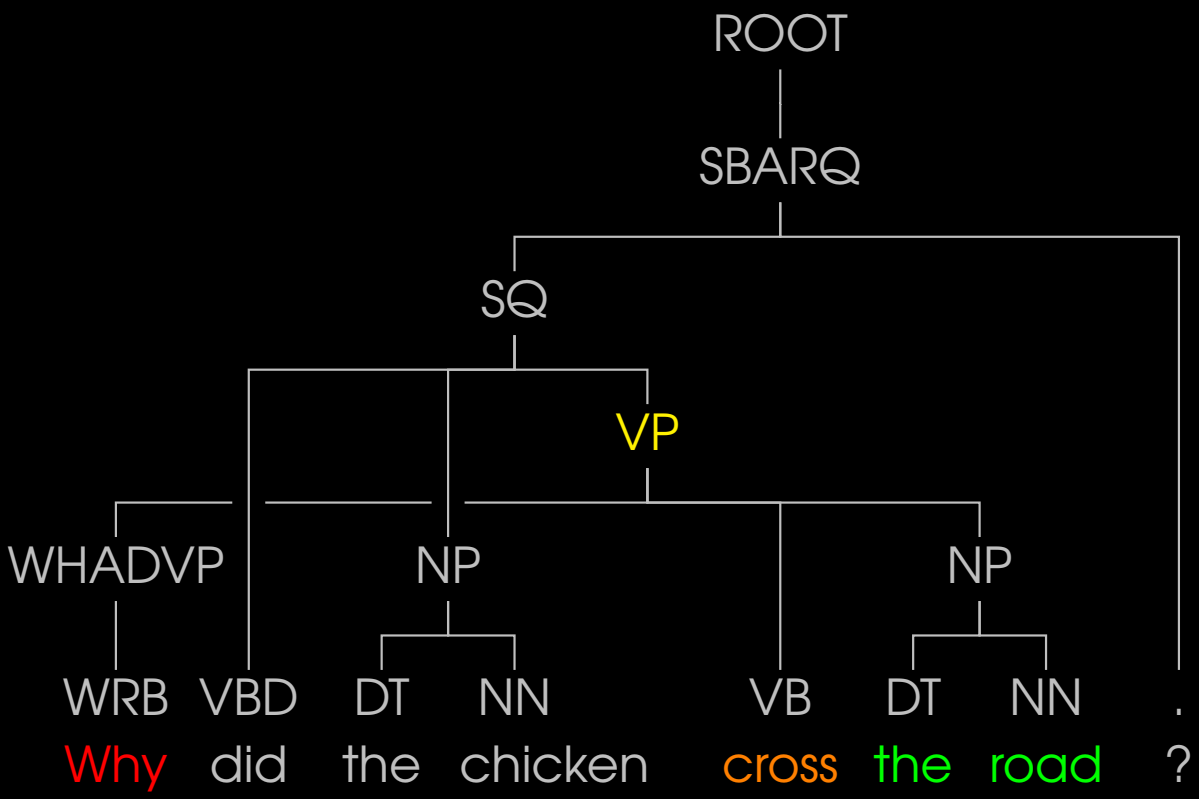


Figure : A discontinuous tree not found in the Penn treebank.

Context-Free Grammar (CFG)

$NP(ab) \rightarrow DT(a)\ NN(b)$

Discontinuous trees



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Linear Context-Free Rewriting System (LCFRS)

$$VP_2(a, bc) \rightarrow WHADVP(a)\ VB(b)\ NP(c)$$

Discontinuous trees

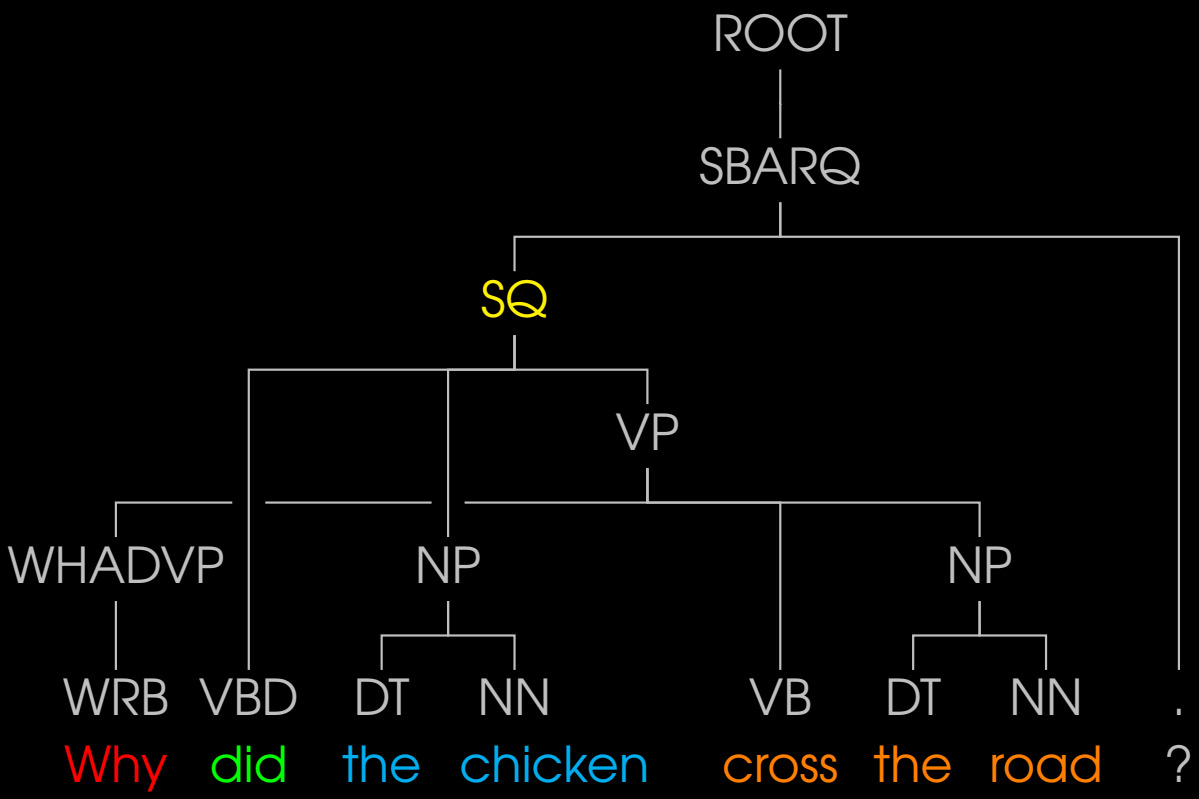


Figure : A discontinuous tree not found in the Penn treebank.

Linear Context-Free Rewriting System (LCFRS)

$$VP_2(a, bc) \rightarrow WHADVP(a)\ VB(b)\ NP(c)$$
$$SQ(abcd) \rightarrow VBD(b)\ NP(c)\ VP_2(a, d)$$

Linear Context-Free Rewriting Systems

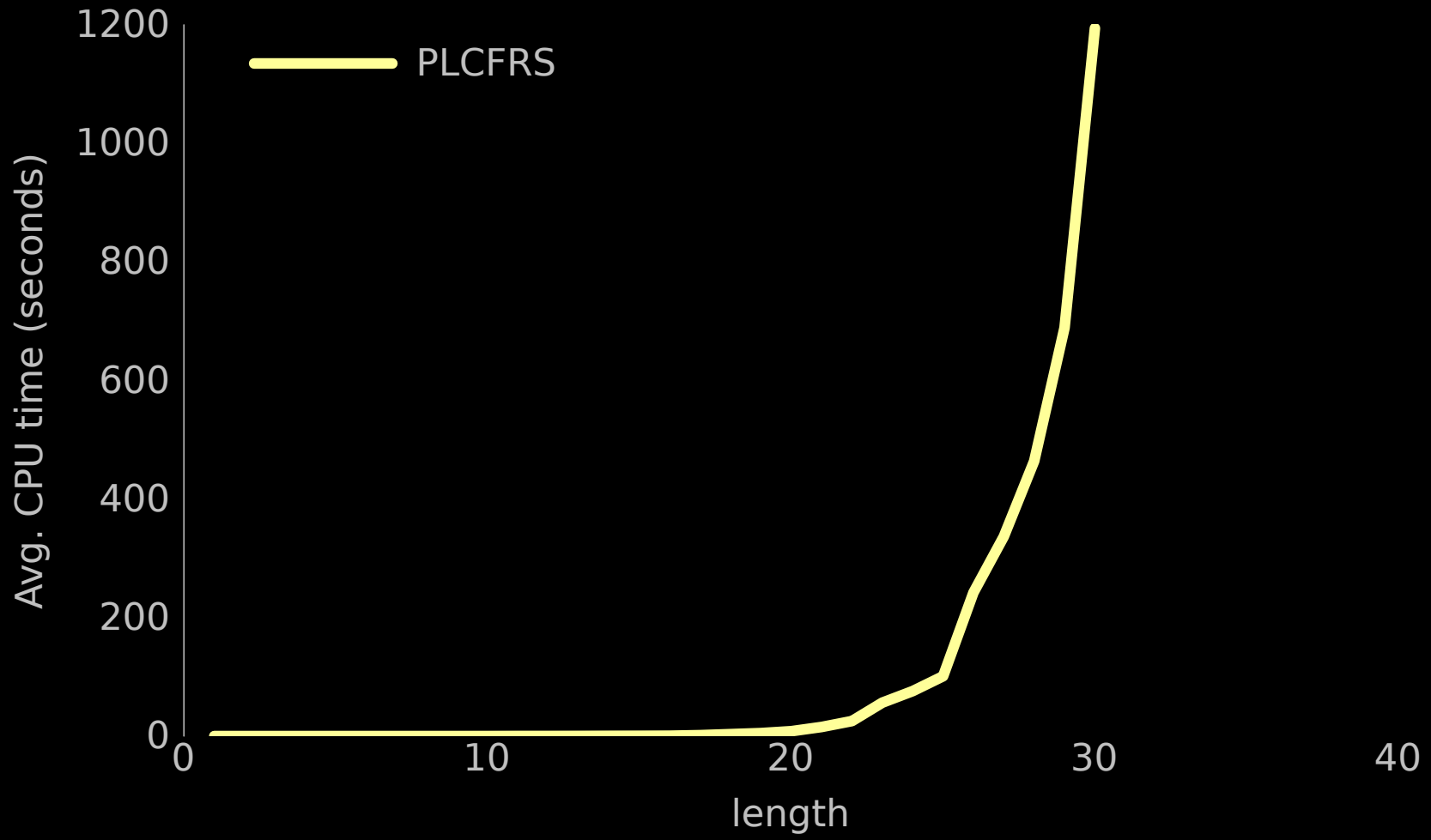
- Mildly context-sensitive grammar formalism
- Can be parsed with tabular parsing algorithm
- Agenda-based probabilistic parser for LCFRS (Kallmeyer & Maier 2010);
  extended to produce k-best derivations
- Parsing a binarized LCFRS has polynomial complexity:

$$\mathcal{O}(n^{3\varphi})$$

where φ is the maximum number of components covered by a non-terminal (fan-out).

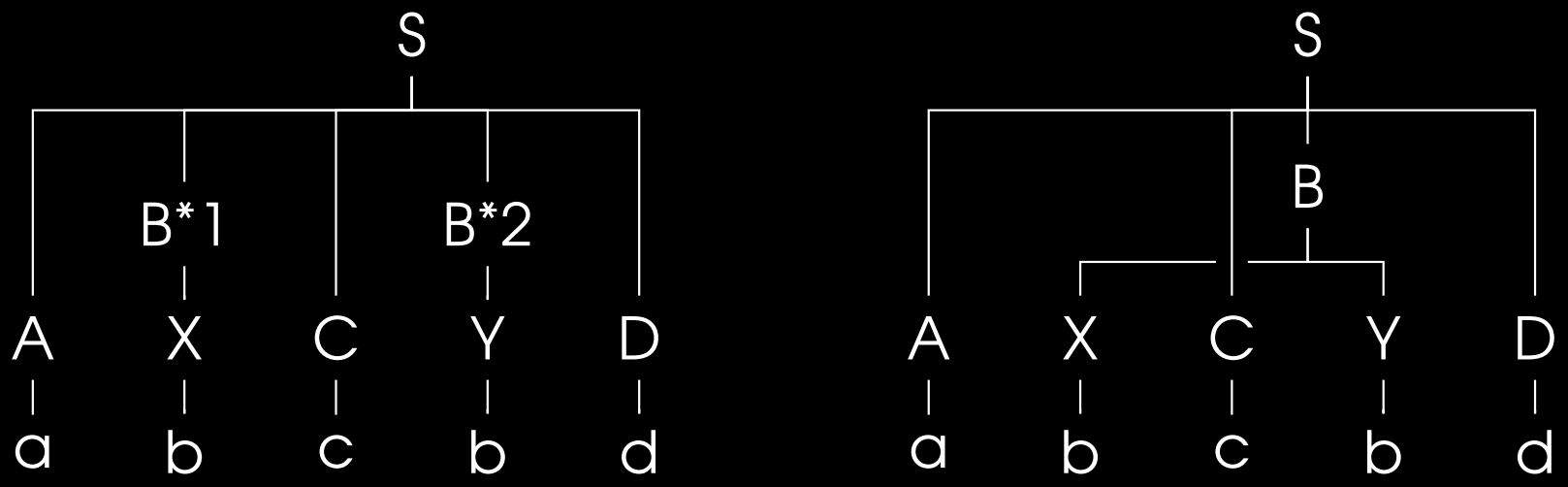
Kallmeyer & Maier (2010). Data-driven parsing with probabilistic linear context-free rewriting systems.

But . . .



Negra dev. set, gold tags

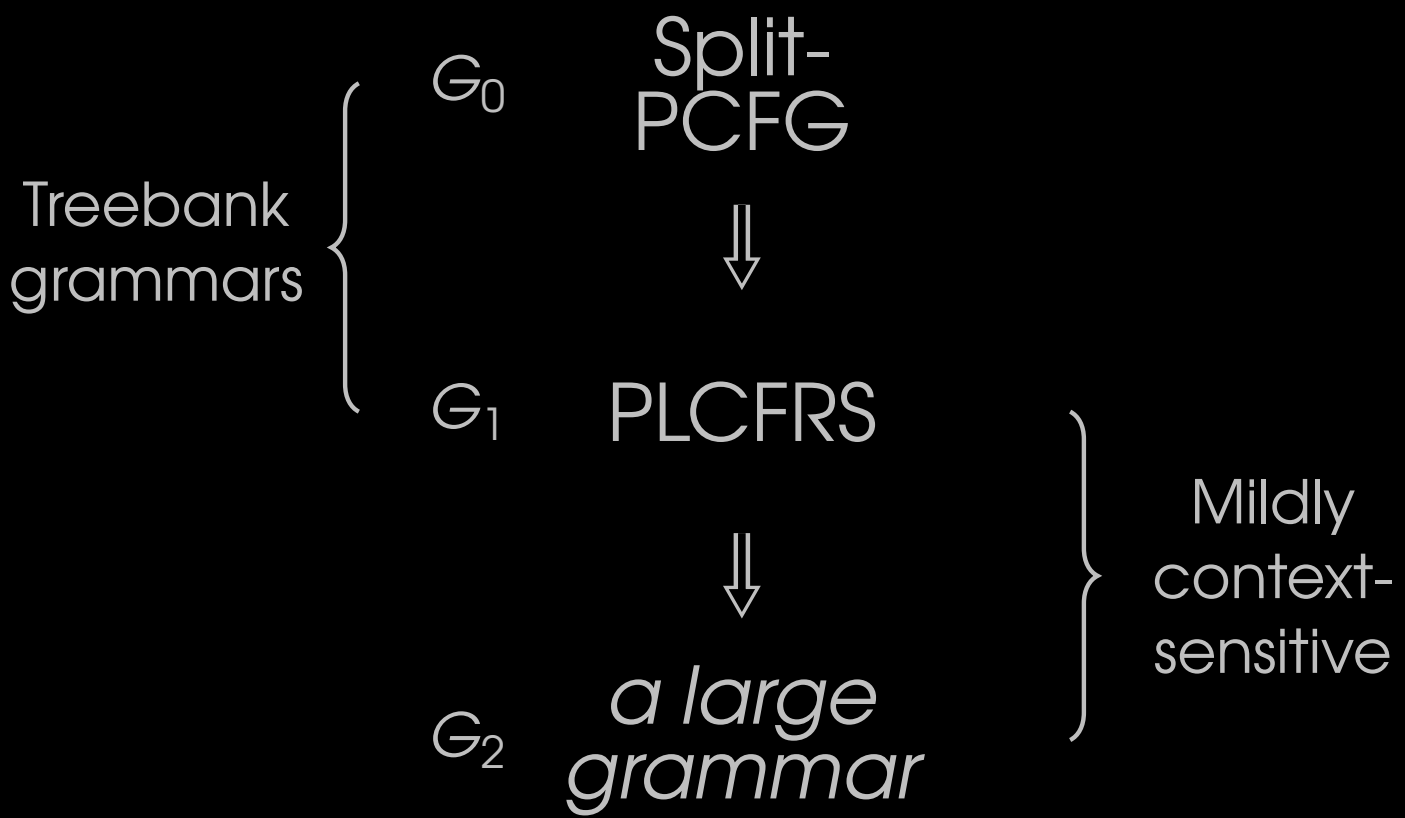
PCFG approximation of PLCFRS



- Transformation is reversible
- Increased independence assumption:
  $\Rightarrow$ every component is a new node
- Language is a superset of original PLCFRS
  $\Rightarrow$ coarser, overgenerating PCFG (`split-PCFG')

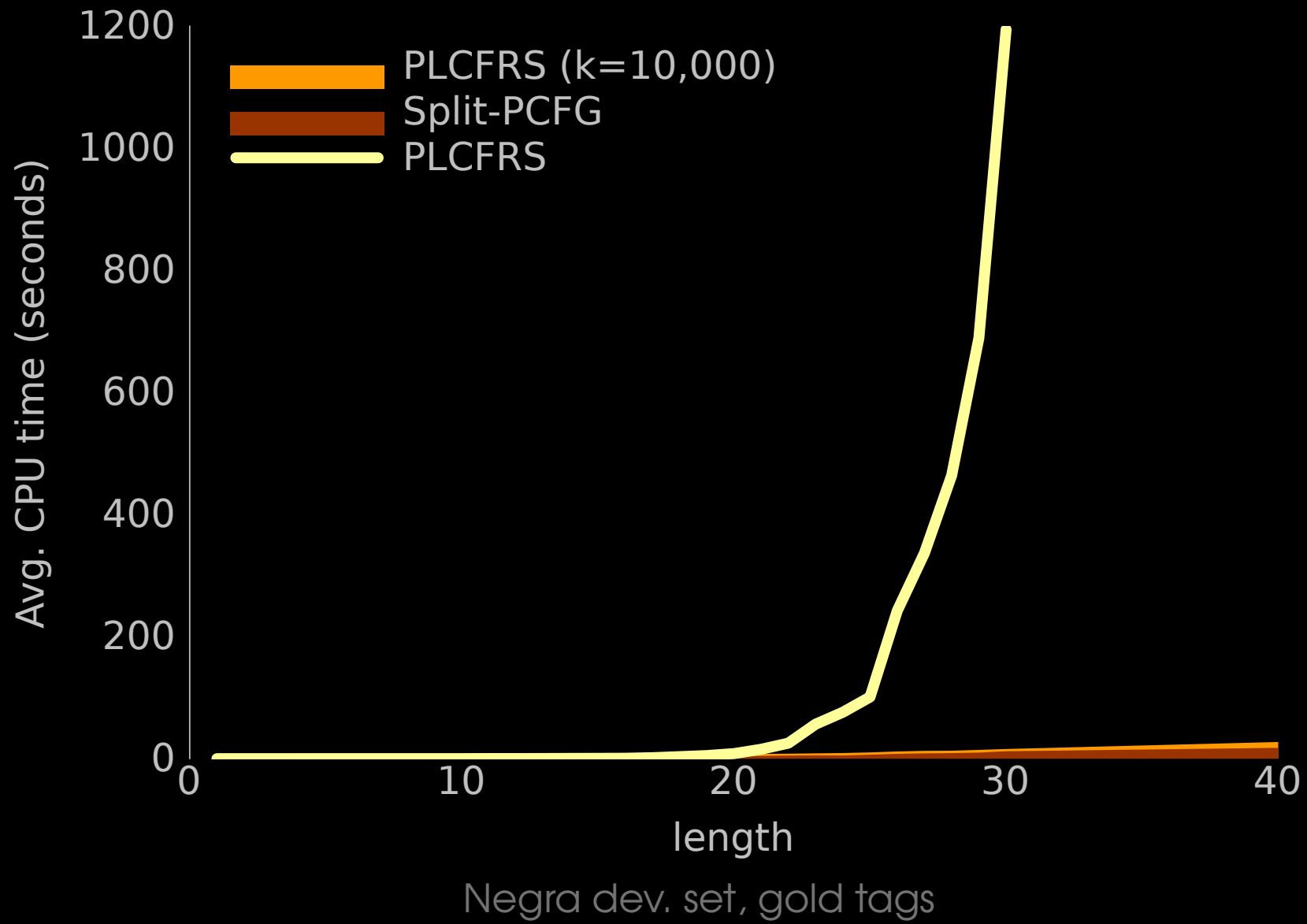
Boyd (2007). Discontinuity revisited.

Coarse-to-fine pipeline



prune parsing with G_{m+1} by only considering items in k-best G_m derivations.

With coarse-to-fine



Negra dev. set, gold tags

Data-Oriented Parsing

Treebank grammar

trees $\Rightarrow$ productions + rel. frequencies

$\Rightarrow$ problematic independence assumptions

Data-Oriented Parsing (DOP)

trees $\Rightarrow$ fragments + rel. frequencies

fragments are arbitrarily sized chunks from the corpus

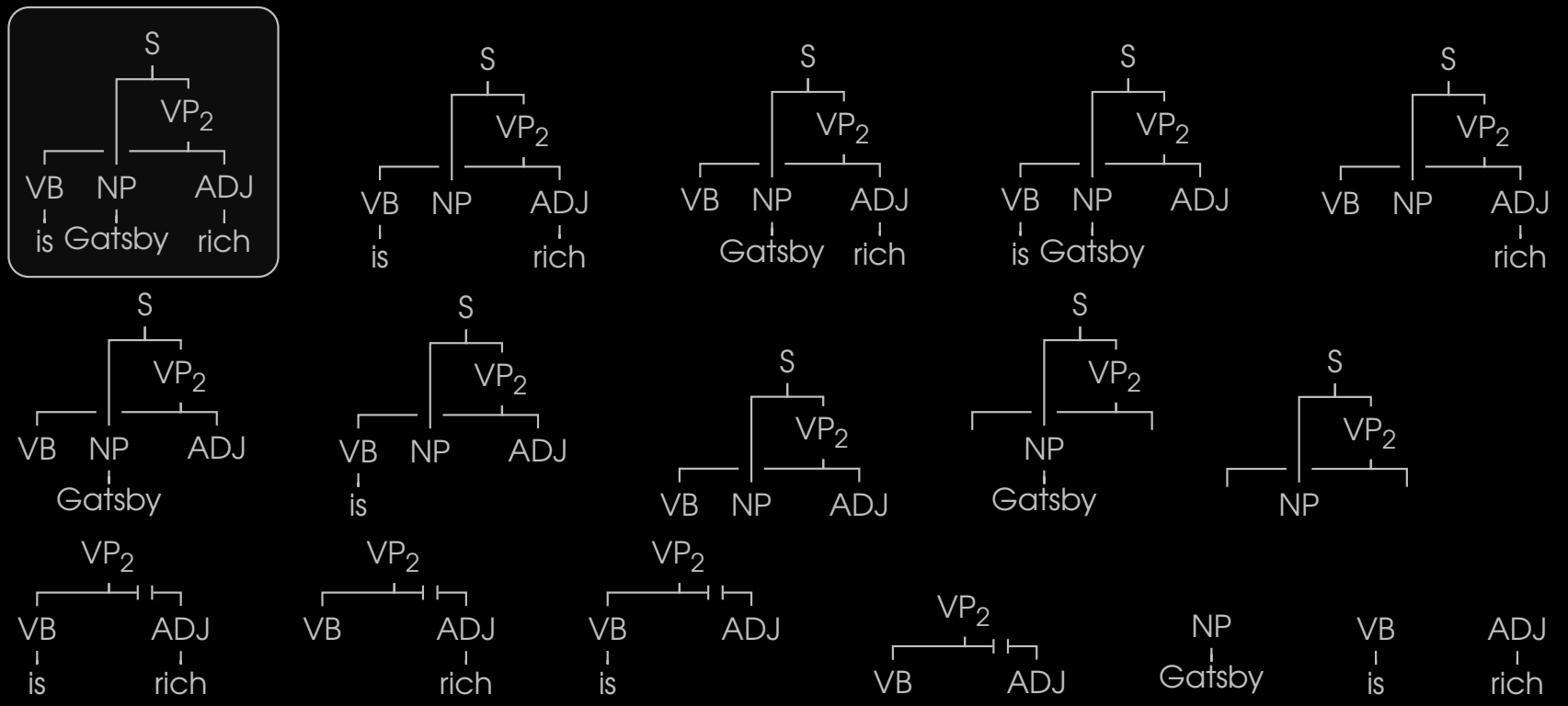
consider all possible fragments from treebank

. . . and "let the statistics decide"

Scha (1990): Lang. theory and lang. tech.; competence and performance

Bod (1992): A computational model of language performance

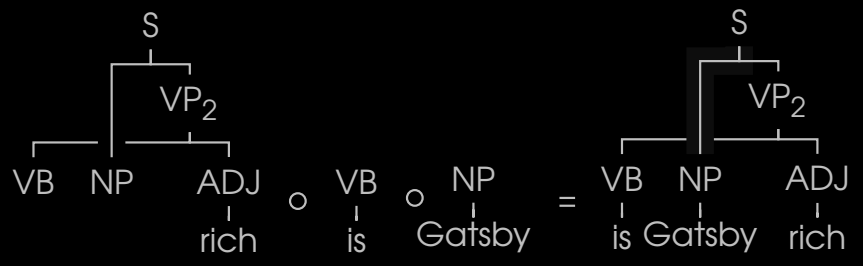
DOP fragments



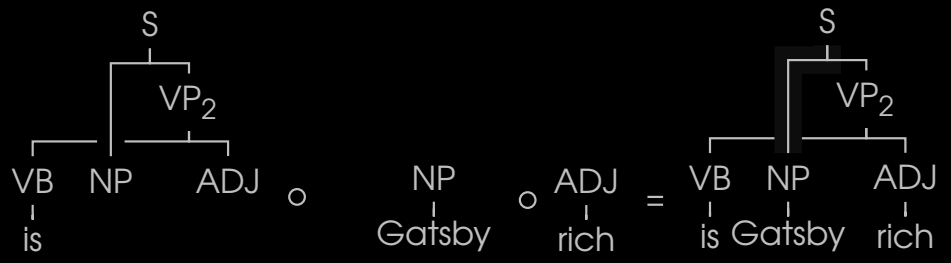
$$P(f) = \frac{\text{count}(f)}{\sum_{f' \in F} \text{count}(f')} \text{ where } F = \{ f' \mid root(f') = root(f) \}$$

Note: discontinuous frontier non-terminals mark destination of components

DOP derivation



$P(d) = 0.2$



$P(d) = 0.3$

Derivations for this tree $P(t) = 0.5$

$$P(d) = P(f_1 \circ \cdots \circ f_n) = \prod_{f \in d} p(f)$$

$$P(t) = P(d_1) + \cdots + P(d_n) = \sum_{d \in D(t)} \prod_{f \in d} p(f)$$

DOP implementation issues

Exponential number of fragments
due to all-fragments assumption

- Can use DOP reduction (Goodman 2003);
  weight of fragments spread over many productions
- Can restrict number of fragments
  by depth or frontier nodes &c.,
  $\Rightarrow$ but: not data-oriented!

Goodman (2003): Efficient parsing of DOP with PCFG-reductions

Double-DOP

- Extract fragments that occur at least twice in treebank
- For every pair of trees, extract maximal overlapping fragments
- Can be extracted in linear average time
- Number of fragments is small enough to parse with directly

Sangati & Zuidema (2011). Accurate parsing w/compact TSGs: Double-DOP

From fragments to grammar

- Fragments mapped to unique rules, relative frequencies as probabilities
  - Remove internal nodes, leaves root node, substitution sites & terminals $X \rightarrow X_1 \ldots X_n$
- Reconstruct derivations after parsing

Sangati & Zuidema (2011). Accurate parsing w/compact TSGs: Double-DOP

Preprocessing

- Remove function labels
- Binarize w/markovization (h=1, v=1)
- Simple unknown word model
  - Rare words replaced by features (model 4 from Stanford parser)
  - Reserve probability mass for unseen (tag, word) pairs

Results w/Double-DOP

	F1 %
DOP reduction	74.3
Double-DOP	

(Negra dev set $\leq$ 40 words, gold tags)

Results w/Double-DOP

	F1 %
DOP reduction	74.3
Double-DOP	76.3

(Negra dev set $\leq$ 40 words, gold tags)

Also: parsing 3$\times$ faster, grammar 3$\times$ smaller

Results w/Double-DOP

	k=50 F1 %	k=5000 F1 %
DOP reduction	74.3	73.5
Double-DOP	76.3	

(Negra dev set $\leq$ 40 words, gold tags)

What if we reduce pruning?

Results w/Double-DOP

	k=50 F1 %	k=5000 F1 %
DOP reduction	74.3	73.5
Double-DOP	76.3	77.7

(Negra dev set $\leq$ 40 words, gold tags)

What if we reduce pruning?
$\Rightarrow$ For Double-DOP, performance does not deterioriate with expanded search space.

Main Results: test sets

Parser, treebank	$\|w\|$	POS	F1	EX
GERMAN				
vanCra2012, Negra	≤ 40	100	72.3	33.2
#KaMa2013, Negra	≤ 30	100	75.8	
this paper, Negra	≤ 40	100	**76.8**	**40.5**
this paper, Negra	≤ 40	96.3	74.8	38.7
HaNi2008, Tiger	≤ 40	97.0	75.3	32.6
this paper, Tiger	≤ 40	97.6	**78.8**	**40.8**

KaMa: Kallmeyer & Maier (2013) (different test set);
vanCra: van Cranenburgh (2012); HaNi: Hall & Nivre (2008).

Main Results: test sets

ENGLISH				
#EvKa2011, disc. WSJ	< 25	100	79.0	
this paper, disc. WSJ	≤ 40	96.6	**85.6**	31.3
SaZu2011, WSJ	≤ 40		87.9	33.7

EvKa: Evang & Kallmeyer (2011) (different test set);
SaZu: Sangati & Zuidema (2011).

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SaZu2011, WSJ	≤ 40		87.9	33.7
DUTCH				
this paper, Alpino	≤ 40	85.2	65.9	23.1
this paper, Lassy	≤ 40	94.6	77.0	35.2

EvKa: Evang & Kallmeyer (2011) (different test set);
SaZu: Sangati & Zuidema (2011).

Can DOP handle discontuinity without LCFRS?

Split-PCFG

⇓

PLCFRS

⇓

PLCFRS Double-DOP

77.7 % F1

41.5 % EX

Split-PCFG

⇓

Split-Double-DOP

Can DOP handle discontuinity without LCFRS?

Split-PCFG

⇓

PLCFRS

⇓

PLCFRS Double-DOP

77.7 % F1

41.5 % EX

Split-PCFG

⇓

Split-Double-DOP

78.1 % F1

42.0 % EX

Answer: Yes!

Fragments can capture discontinuous contexts

Conclusions

- Multilingual results for discontinuous parsing, w/automatic assignment of tags

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- Not necessary to parse beyond CFG!
  $\Rightarrow$ Increase amount of context
  through fragments / labels

Conclusions

- Multilingual results for discontinuous parsing, w/automatic assignment of tags
- All fragments vs. selected fragments
  - Explicit representation of recurring fragments with Double-DOP leads to better sample of derivations than parsing with all fragments
- Not necessary to parse beyond CFG!
  $\Rightarrow$ Increase amount of context through fragments / labels
  - LCFRS could be exploited for other things than discontinuity: adjunction, synchronous parsing, ...

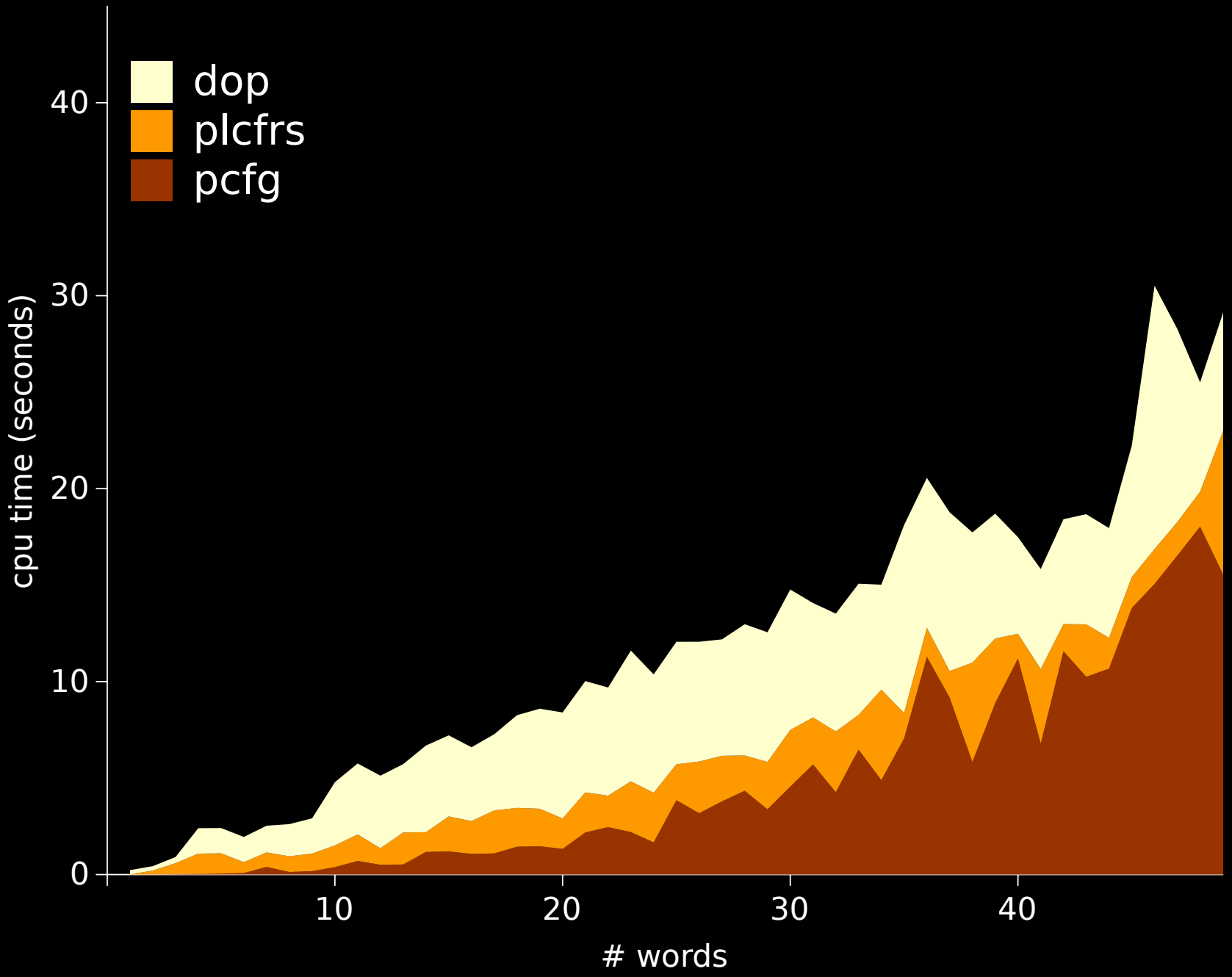
THE END

Codes: `http://github.com/andreasvc/disco-dop`

Wait . . . there's more

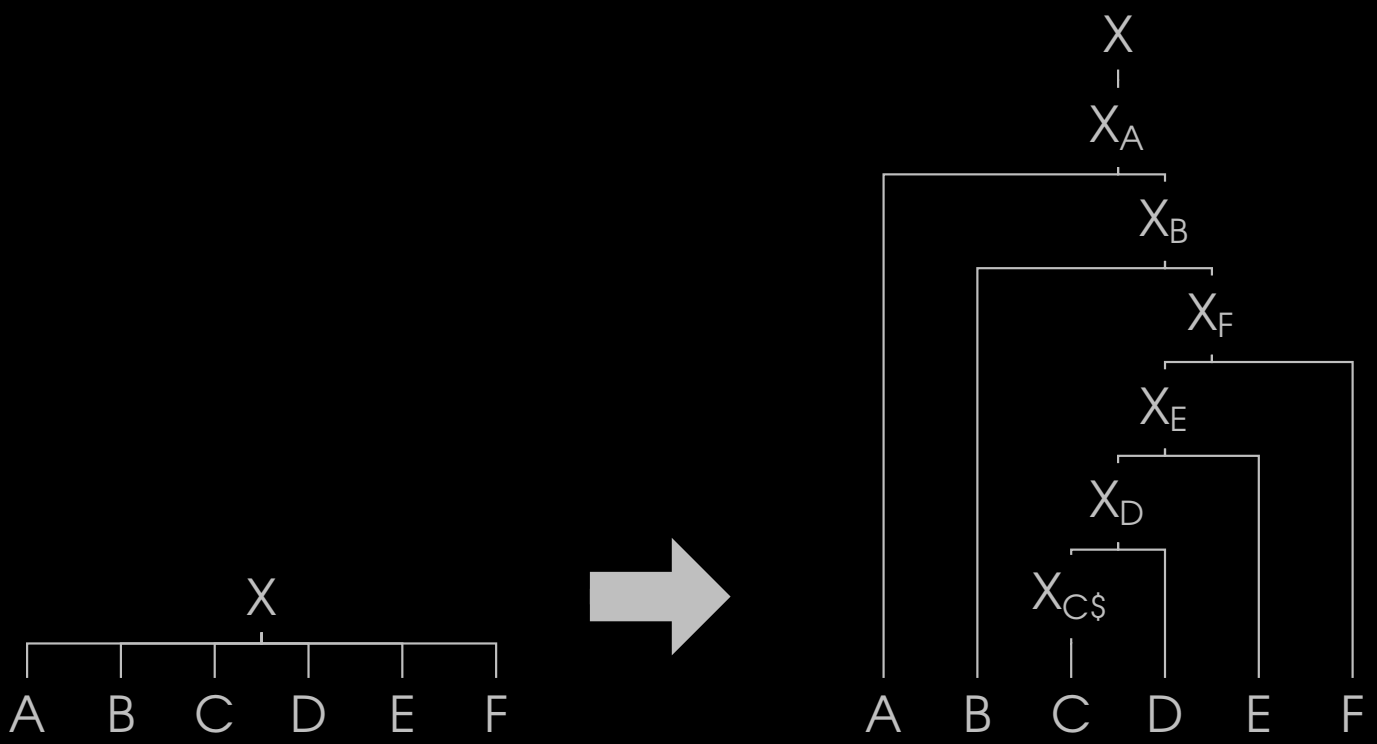
BACKUP SLIDES

Efficiency (Negra dev set)



Binarization

- mark heads of constituents
- head-outward binarization (parse head first)
- no parent annotation: $v = 1$
- horizontal Markovization: $h = 1$



Klein & Manning (2003): Accurate unlexicalized parsing.

Parser setup

```
traincorpus='wsj02-21.export',
testcorpus='wsj24.export',
corpusdir='../../dptb',
stages=[
    dict(
        name='pcfg', mode='pcfg',
        split=True, markorigin=True,
    ),
    dict(
        name='plcfrs', mode='plcfrs',
        prune=True, splitprune=True, k=10000,
    ),
    dict(
        name='dop', mode='plcfrs',
        prune=True, k=5000,
        dop=True, usedoubledop=True, m=10000,
        estimator='dop1', objective='mpp',
    ),
],
[...]
```

Web-based interface