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Bottom-Up Transfer in EBMT

Vincent Vandeghinste &
Scott Martens
Centre for Computational Linguistics
Katholieke Universiteit Leuven

Project: PaCo-MT

Parse and Corpus-based Machine Translation

- 3 year project (2008-2011), 500K€
- Sponsored by STEVIN program of the Dutch Language Union
- NL ⇔ EN NL ⇔ FR
- Consortium partners
  - CCL – KULeuven
  - Alfa-Informatics – RUGroningen
  - OneLiner bvba Translation Services

Project: AMASS++

Advanced Multimedia Alignment and Structured Summarization

- 4 year project (2007-2010),
- Sponsored by IWT: Innovation and Technology Institute of Flanders
- CCL provides translational components
- Consortium partners
  - CCL – KULeuven
  - ESAT-Visics KULeuven
  - LIIR – KULeuven
  - EDM – University of Hasselt

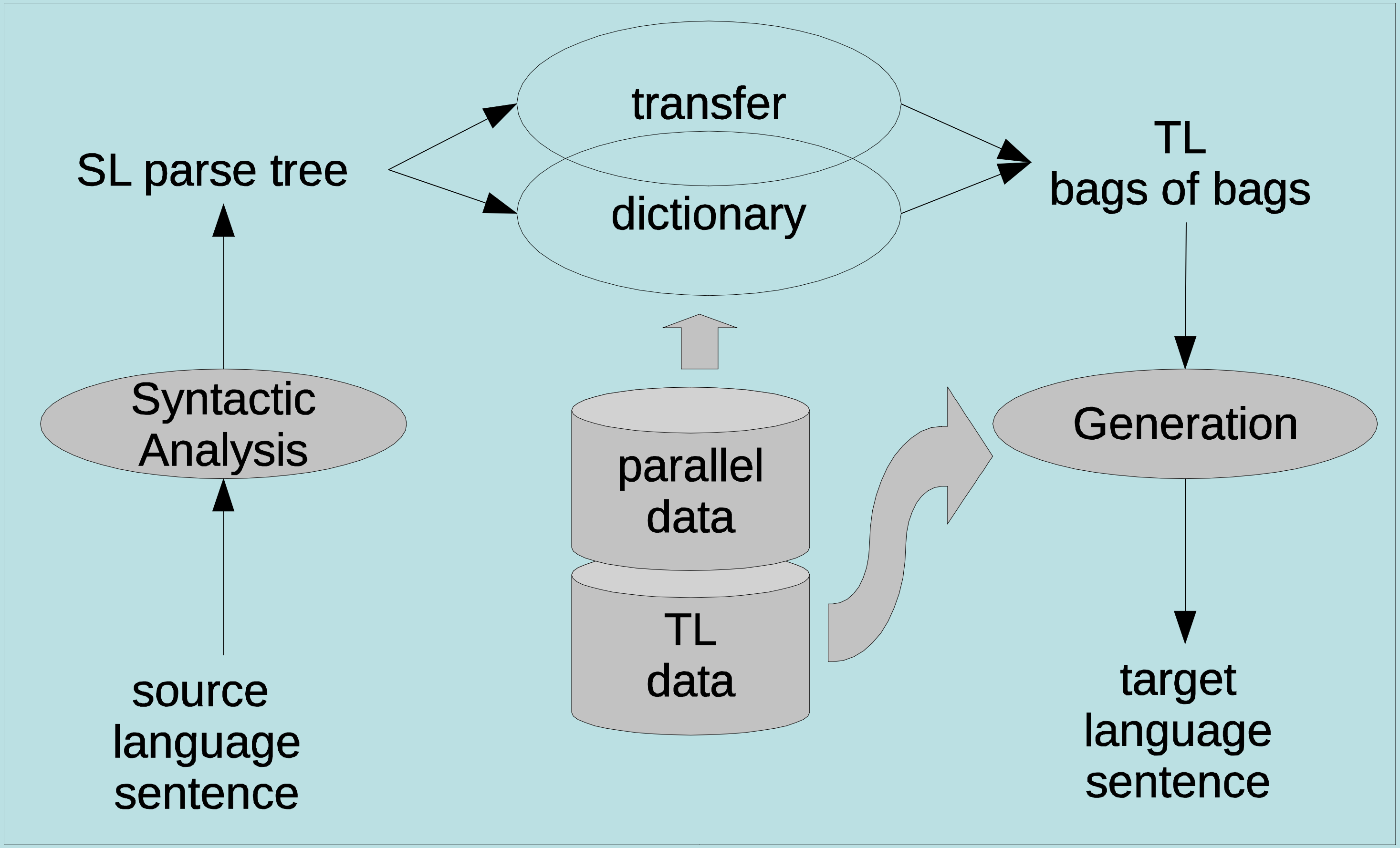
System Description

- **Hybrid MT**: Stochastic Example-based Transfer System
- Automatic *transfer rule induction* based on parallel treebanks
- Automatic *dictionary extraction* (lexical rules) from parallel treebanks
- Reusing existing tools as much as possible

Similar Approaches

- **Data-Oriented Translation** (Poutsma, Hearne)
- Transfer Rules resemble Galley et al. (2004;2006), but no explicit rule extraction: virtual rules
- Synchronous CFG (Ambati et al. 2009)
- Synchronous Tree-Substitution Grammars (Zhang et al. 2007)

PaCo-MT


transfer
dictionary
SL parse tree
TL
bags of bags
Syntactic
Analysis
parallel
data
TL
data
Generation
source
language
sentence
target
language
sentence

Syntactic Analysis

- Dutch
  - Alpino parser (van Noord 2006)
  - Phrase structure + dependencies
- English
  - Stanford parser (Klein & Manning 2003)
  - Phrase structure + dependencies
- French
  - Not in this paper

From Source to Target

Requires

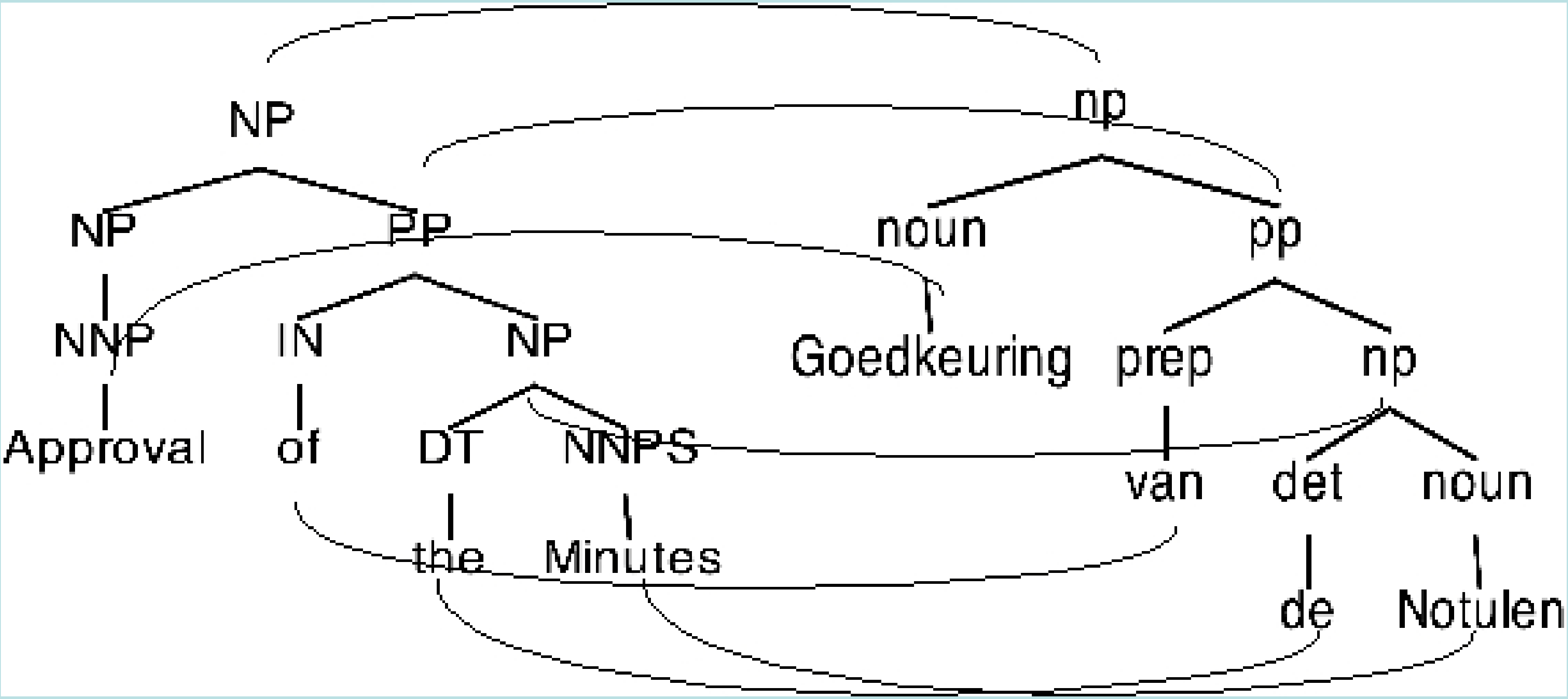
- A parallel corpus (Europarl, DGT, TMs)
- Alignment at the sentence level
- Alignment at the word level (Giza++)
- Source language parser
- Target language parser

From Source to Target

Alignment at the tree level: Sub-sentential alignment (node alignment)

- Lexicalized: Each tree pair, sub-tree pair, word pair
  - an example translation pair
  - dictionary entry
- Not lexicalized: Each tree pair, sub-tree pair
  - an example translation rule
  - a transfer instance
- **Tiedemann & Kotzé** (2009): A Discriminative Approach to Tree Alignment (RANLP09)

Example Alignment



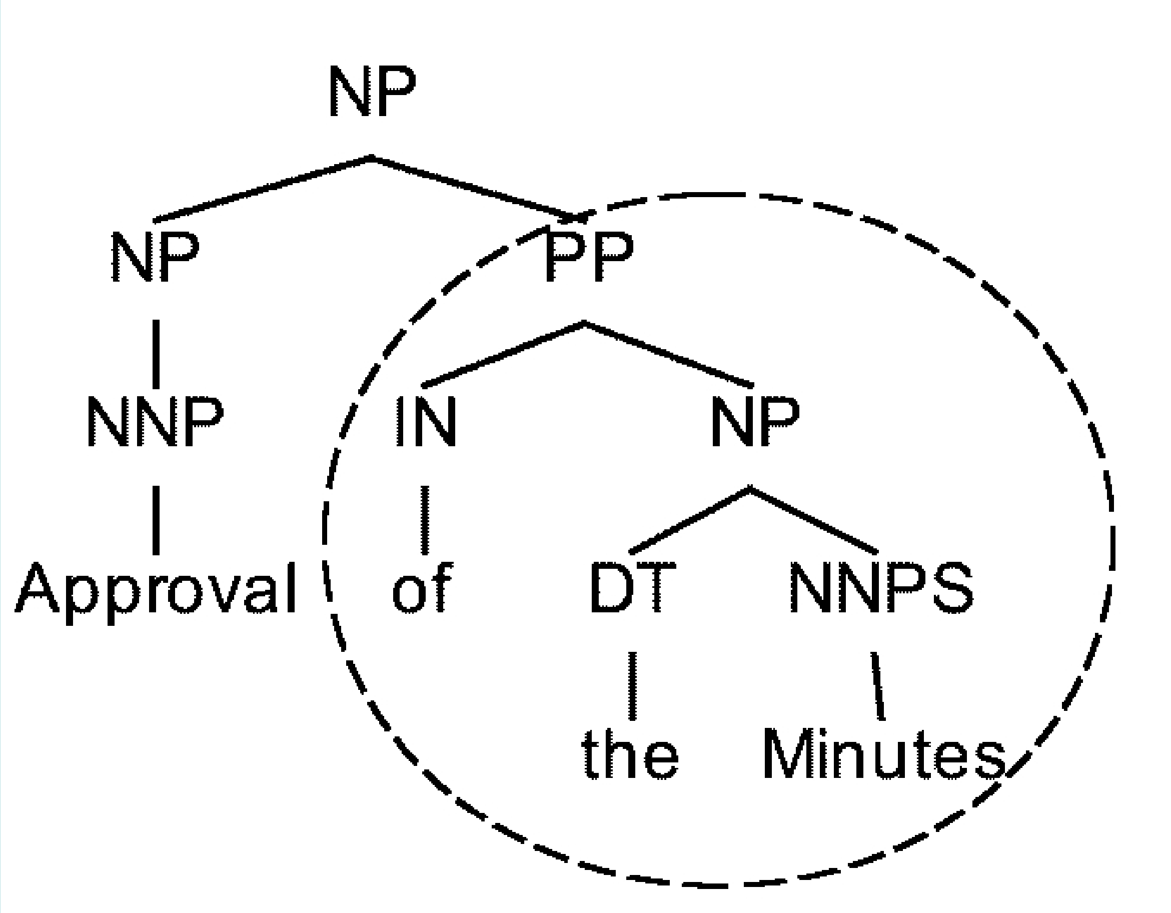
Bottom-Up Transfer

- Top Down transfer does not work: cf. Vandeghinste & Martens (2009)
- Bottom-up:
  - Starting with translations of words and phrases
  - Structural translations on the basis of translations discovered at the bottom
- Confidently translate words and phrases,
- Use those translations to constrain the choice of structures above.
- Errors propagate upwards, not downwards

Virtual Rules

- Consult the treebank on the fly
- Lexicalized translations: An entire phrase from the source parse tree appears in the treebank:
  - Trees are reordered so that the children of each node in the tree appear in fixed lexicographic order (ignoring original word order)
  - Trees are rewritten as strings (depth first order)
  - If subtrees in SL parse are identical to subtrees in treebank then there is a substring in the converted treebank that is identical

Bottom-up Subtree



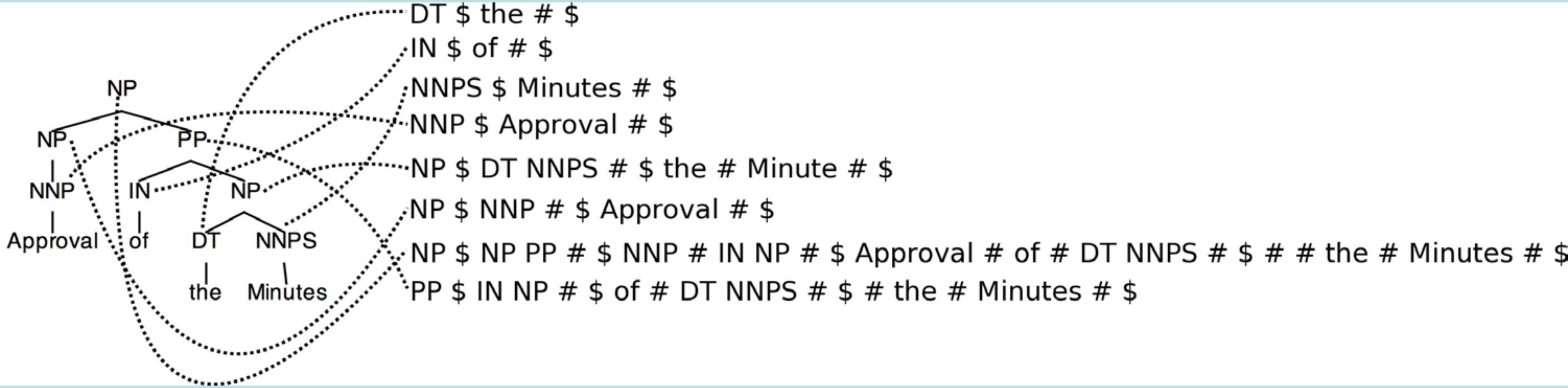
Bottom-up Subtree Matching

- Similar to subsentential translation memory:
  - Each match is to a linguistically motivated phrase
  - When a match is found, the aligned target language subtree is used in the translation
- Finding string matches: suffix array
  - Identifies matches in indexed string in sublinear time
  - Converting the subtree discovery problem into a string matching problem

Transfer of the upper portions of the tree

- Generalization of the rule construction method from Vandeghinste & Martens (2009)
- Converting trees into strings in a breadth-first method

Breadth-first String Representation



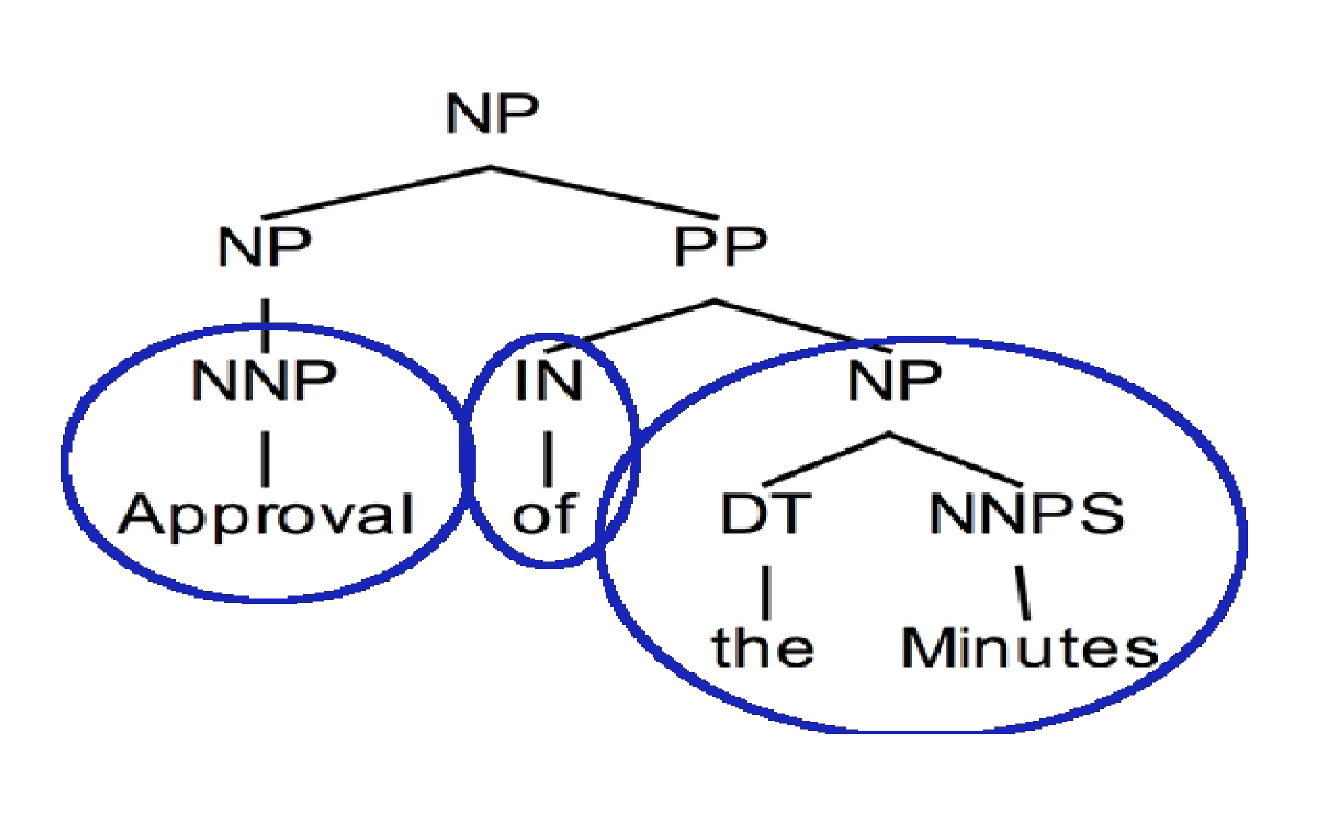
DT $ the # $
IN $ of # $
NNPS $ Minutes # $
NNP $ Approval # $
NP $ DT NNPS # $ the # Minute # $
NP $ NNP # $ Approval # $
NP $ NP PP # $ NNP # IN NP # $ Approval # of # DT NNPS # $ # # the # Minutes # $
PP $ IN NP # $ of # DT NNPS # $ # the # Minutes # $

# indicates exhaustion of the children of some node
$ indicates exhaustion of the nodes at a particular depth in the tree

- One-to-one correspondence of strings with subtrees
- If any two subtrees are identical from the root down to some depth, these string representations share a common prefix
- By sorting them, we can quickly match any subtree in a new parse tree down to a fixed depth

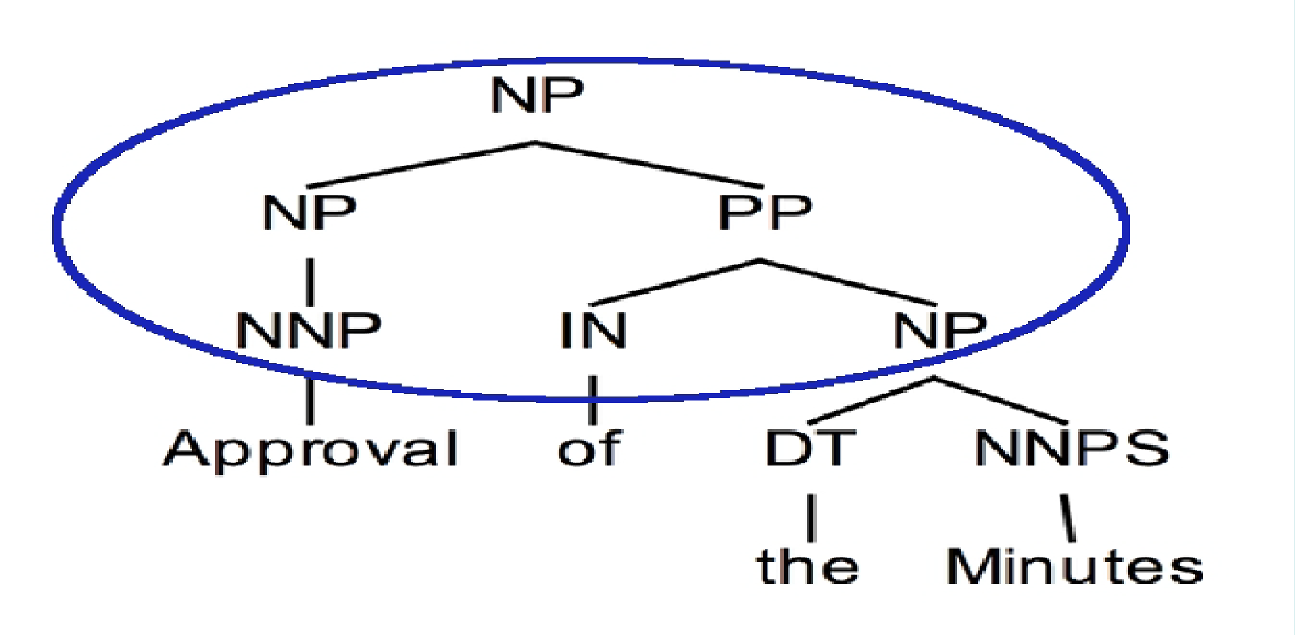
Matching the source tree with the examples

- Bottom-up matching finds all phrases and words that have matches in the treebank



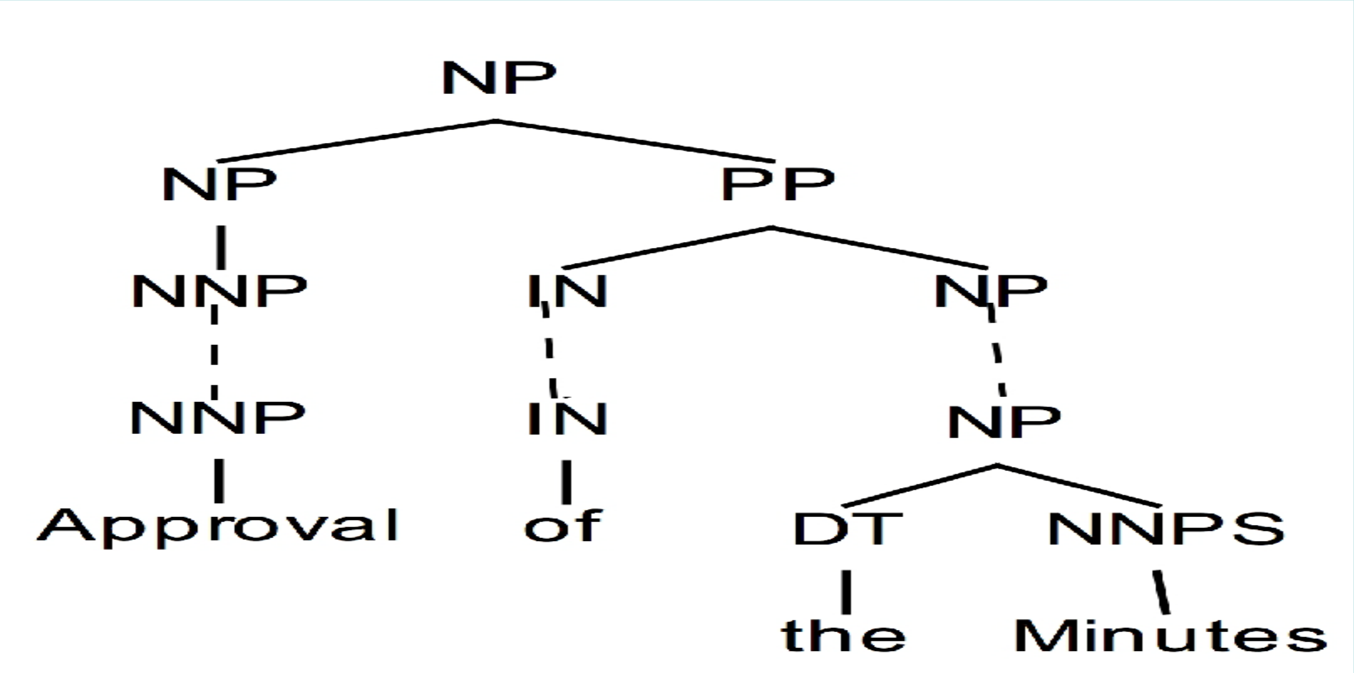
Matching the source tree with the examples

- Top-down matching looks for structures in the source language treebank matching the remaining part of the translation



Matching the source tree with the examples

- Each top-down match is finally connected to the bottom-up matches



Target Language Generation

- In transfer rules: no ordering of children
- **Optimal surface ordering using a large target language treebank**

  Vandeghinste (2009). Tree-Based Target Language Modeling. EAMT
- Additional lexical selection

Target Language Generation

- On a large TL corpus, we extract CFG rules on different abstraction levels
  - Dependency relations (REL)
  - Syntactic Category labels / Parts-of-speech (CAT)
  - CAT + REL
  - CAT + REL + Token
- For every node in the TL tree, we check if we find a rewrite rule at the most concrete level, cascading down to more abstract levels if we don’t find a solution
- Still in the process of determining the optimal ordering from concrete to abstract

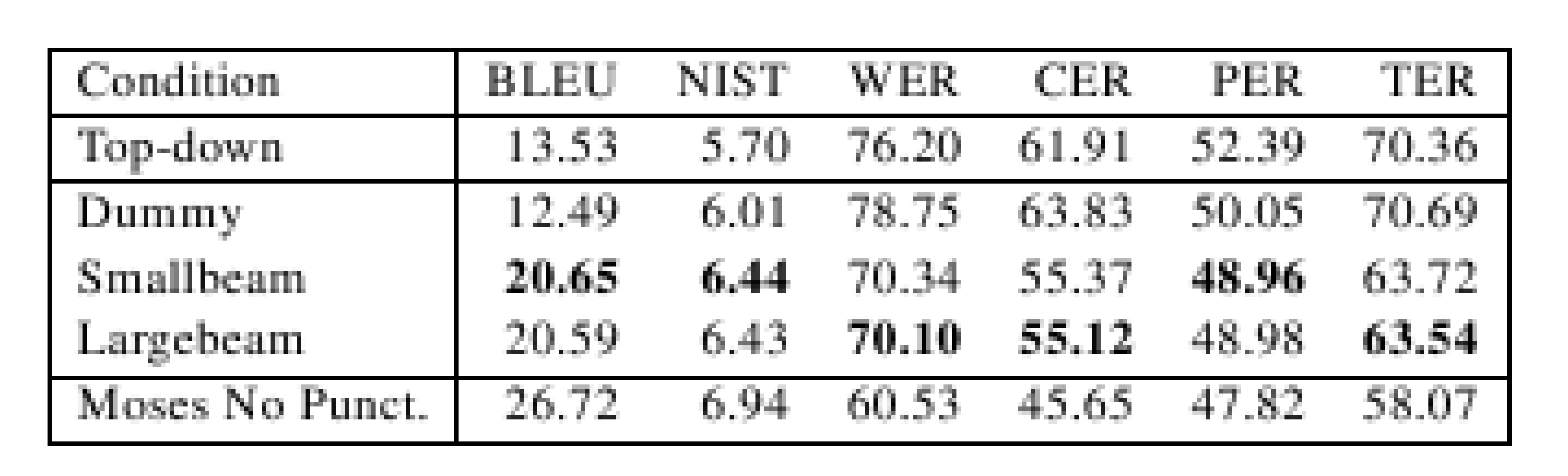
Target Language Generation

- We estimate the probability of different orderings, selecting the most probable, by looking at the frequency of occurrence in the training data
- When f=0, generate all permutations
- Recursively ordering all the nodes in the tree to generate several surface forms of the unordered target language tree

Experiment

- Test set of 500 Dutch sentences with 2 reference translations
- Independent variables:
  - Dummy transfer (only lexical transfer rules)
  - Small vs. large beam
- Compared with top-down (Vdg & M 2009)
- Compared with Moses without punct.

Results



Condition	BLEU	NIST	WER	CER	PER	TER
Top-down	13.53	5.70	76.20	61.91	52.39	70.36
Dummy	12.49	6.01	78.75	63.83	50.05	70.69
Smallbeam	**20.65**	**6.44**	70.34	55.37	**48.96**	63.72
Largebeam	20.59	6.43	**70.10**	**55.12**	48.98	**63.54**
Moses No Punct.	26.72	6.94	60.53	45.65	47.82	58.07

- 52.7 % relative improvement compared to Top-down
- PER metric marginally worse than Moses: lexical selection is ‘good’
- Dummy gives an indication of the influence of structural transfer
- Difference in beam width in TLG is neglectable

Conclusions & Future

- Lexical selection is good
  - We have solutions for some of the problems of our system which are not yet reflected in these results
- Influence of structural transfer is large and positive
  - Partial subtree matching
  - Different parameter settings
  - Should improve the coverage of the induced rules
- Improvements to the virtual transfer rule system
  - Too slow now
  - Using sampling in many cases
  - Subtree indexing to reduce this time

Conclusions & Future

- Regular Tree Grammar
  - Weakly equivalent in generation capacity to a CFG
  - Tree Adjoining Grammar and other subsets of tree grammars are available and might be better
- Improvement in Alignment Quality
  - Realigning the data is computationally heavy
- Try out different language pairs
  - EN -> NL
  - NL -> FR
  - FR -> NL
- Enlarging the treebanks