A Unified Framework for phrase-based, Hierarchical and Syntax SMT

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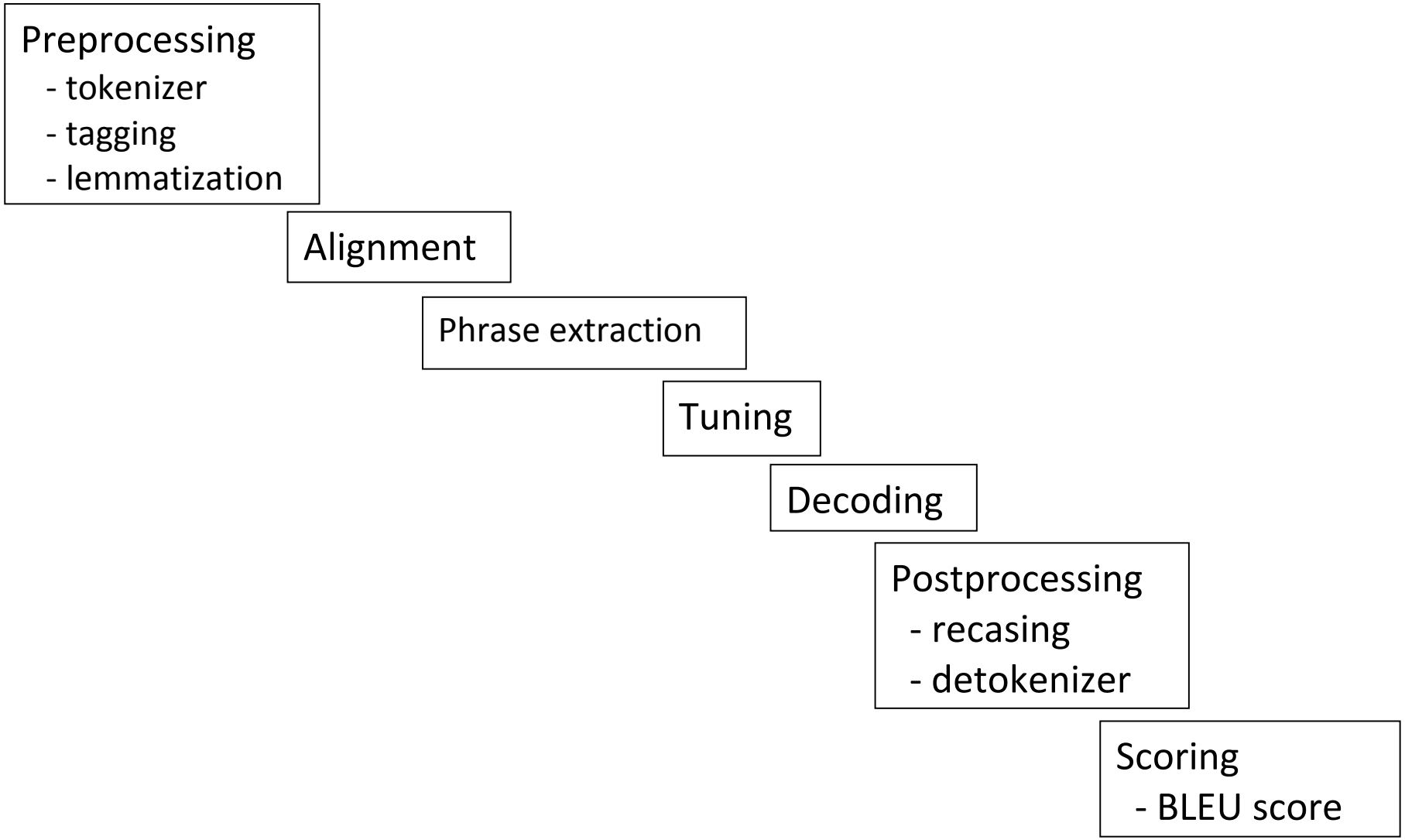
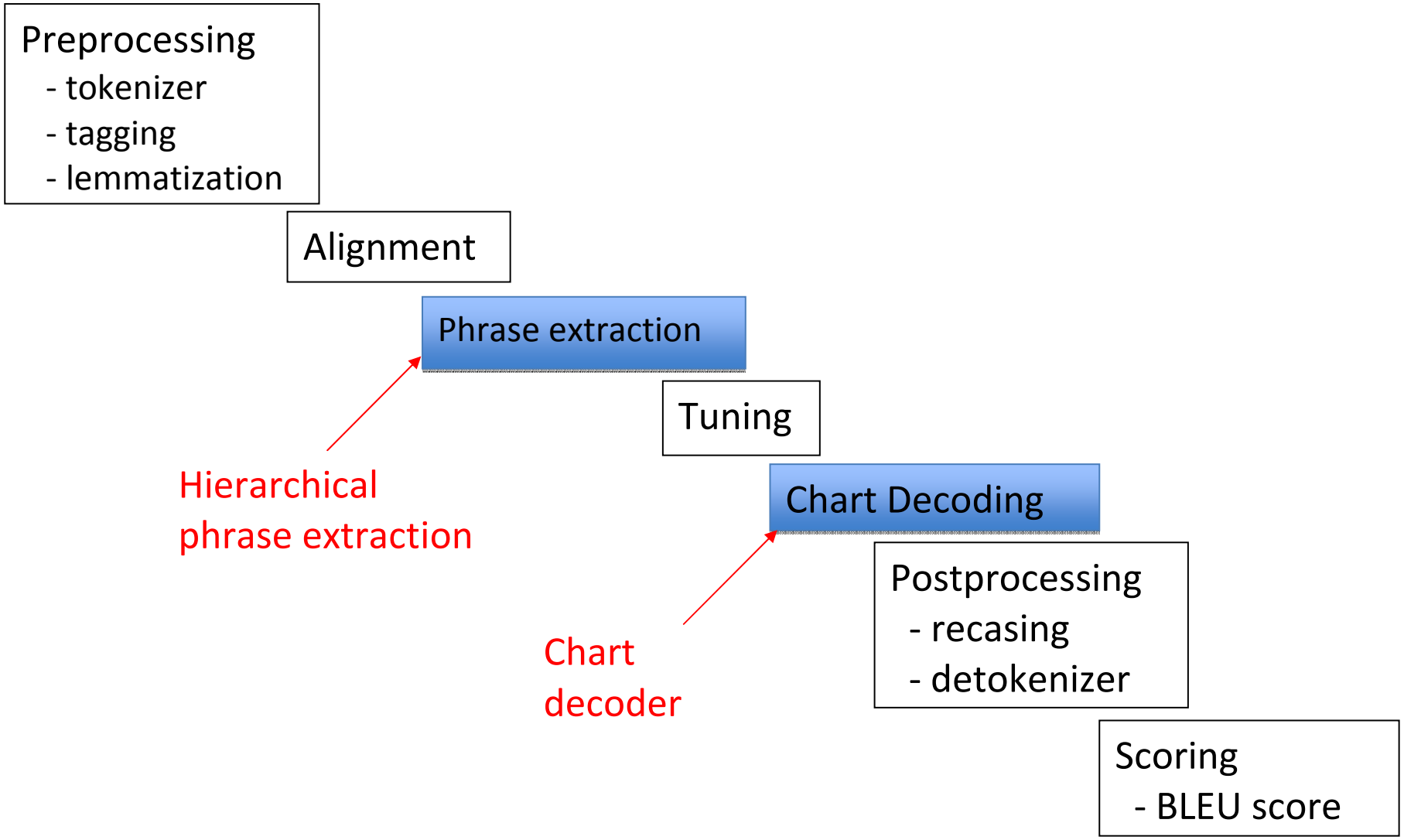
Decoding methods

- Phrase Based
  - Alignment Template System (Och 2004)
  - Pharaoh (Koehn 2003)
  - Moses (Koehn et al 2007)
- Hierarchical
  - Hiero (Chiang 2007)
  - ITG (Wu 1997)
- Syntactic
  - ISI (Yamada and Knight 2001)
  - SAMT (Zollmann 2006)

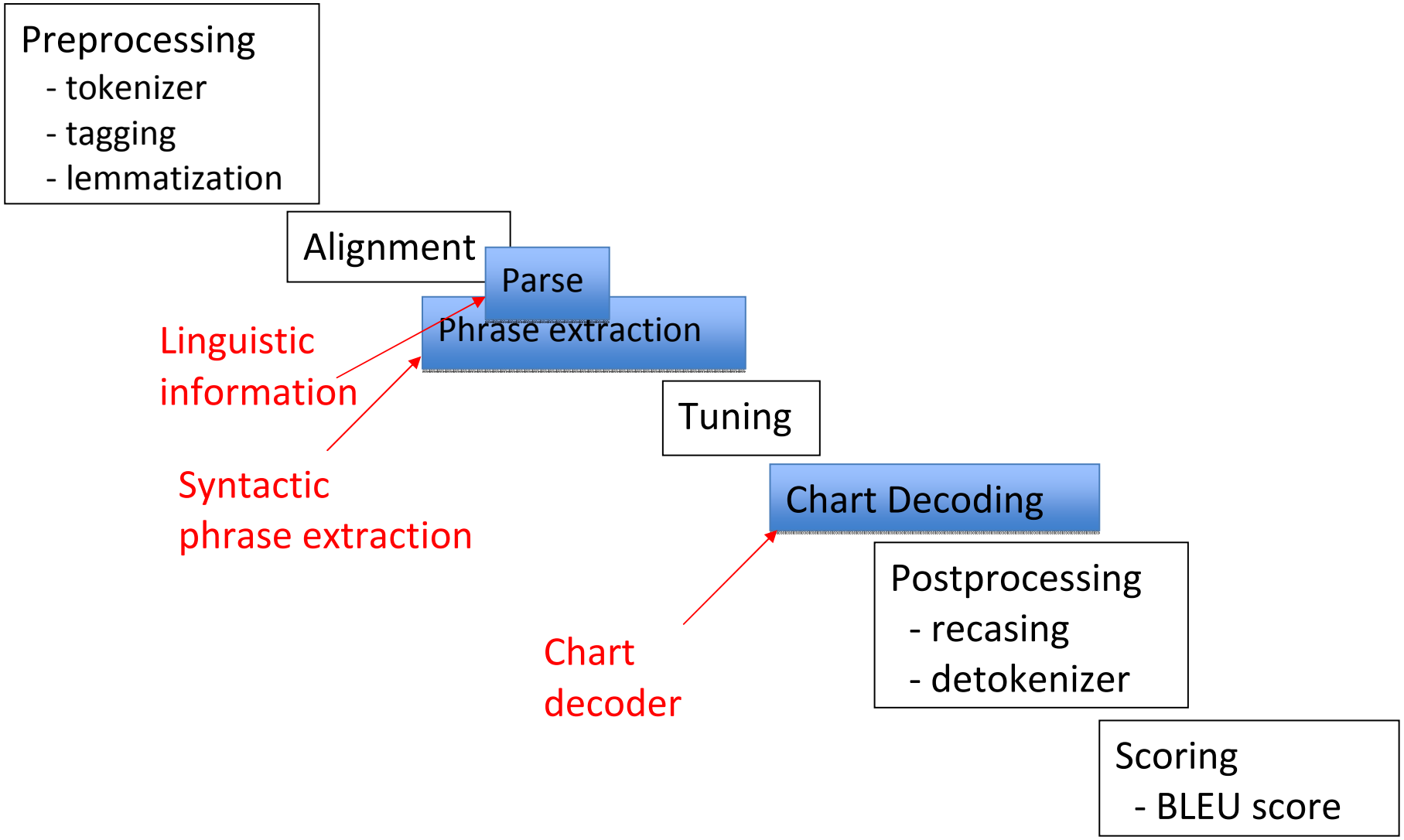
Phrase-based Decoding Pipeline



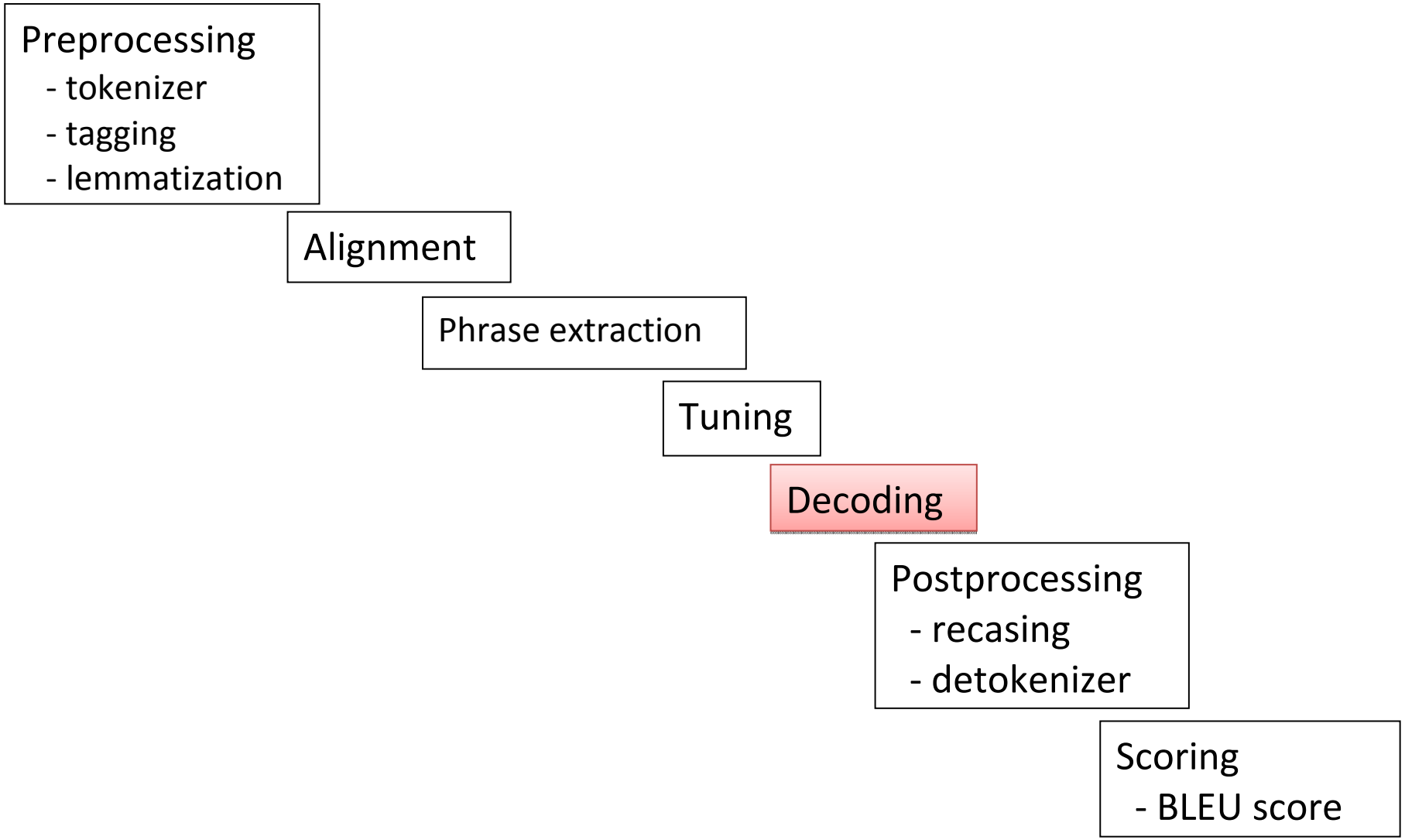
Hierarchical Decoding Pipeline



Syntactic Decoding Pipeline



Decoding


Preprocessing
- tokenizer
- tagging
- lemmatization
Alignment
Phrase extraction
Tuning
Decoding
Postprocessing
- recasing
- detokenizer
Scoring
- BLEU score

Phrase-Based

- Translate contiguous phrases

  assumes || geht davon aus, dass
  with regard to || bezüglich
  translation system ||
  Übersetzungssystem

- Finite state machine decoding
  - Stack based
  - Beam search

Hierarchical

- Discontiguous phrases

  X → take X_1 into account || berücksichtigt X_1
  X → must explain X_1 || muss X_1 erklaren
  X → either X_1 or X_2 || entweder X_1 oder X_2

- CKY+ decoding algorithm
  - chart decoding
  - simultaneous parsing and generation

Syntax

- Discontiguous phrases
- Labeled non-terminals

  VP → take NP_1 into account || berücksichtigt NP_1
  VP → must explain NP_1 || muss NP_1 erklaren
  S → either S_1 or S_2 || entweder S_1 oder S_2

- CKY+ decoding

Similarities

- Trained using aligned corpus
- Phrase tables
- Linear scoring
- N-best list for weight tuning
- Dynamic programming
- Language model context

Phrase-based decoder

- Base functionality
  - Incremental scoring
  - LM context
  - Dynamic programming
  - Search graph
- Decoding
  - Stacks
    - 1 stack for number of words covered
    - Future cost for better intra-stack comparison.
  - Search strategy
    - Bottom up, least number of words first

Hierarchical decoder

- Base functionality
  - Incremental scoring
  - LM context
  - Dynamic programming
  - Search graph
- Decoding
  - Stacks
    - 1 stack for each source contiguous coverage
  - Search strategy
    - Bottom up, smallest span first

Syntax decoder

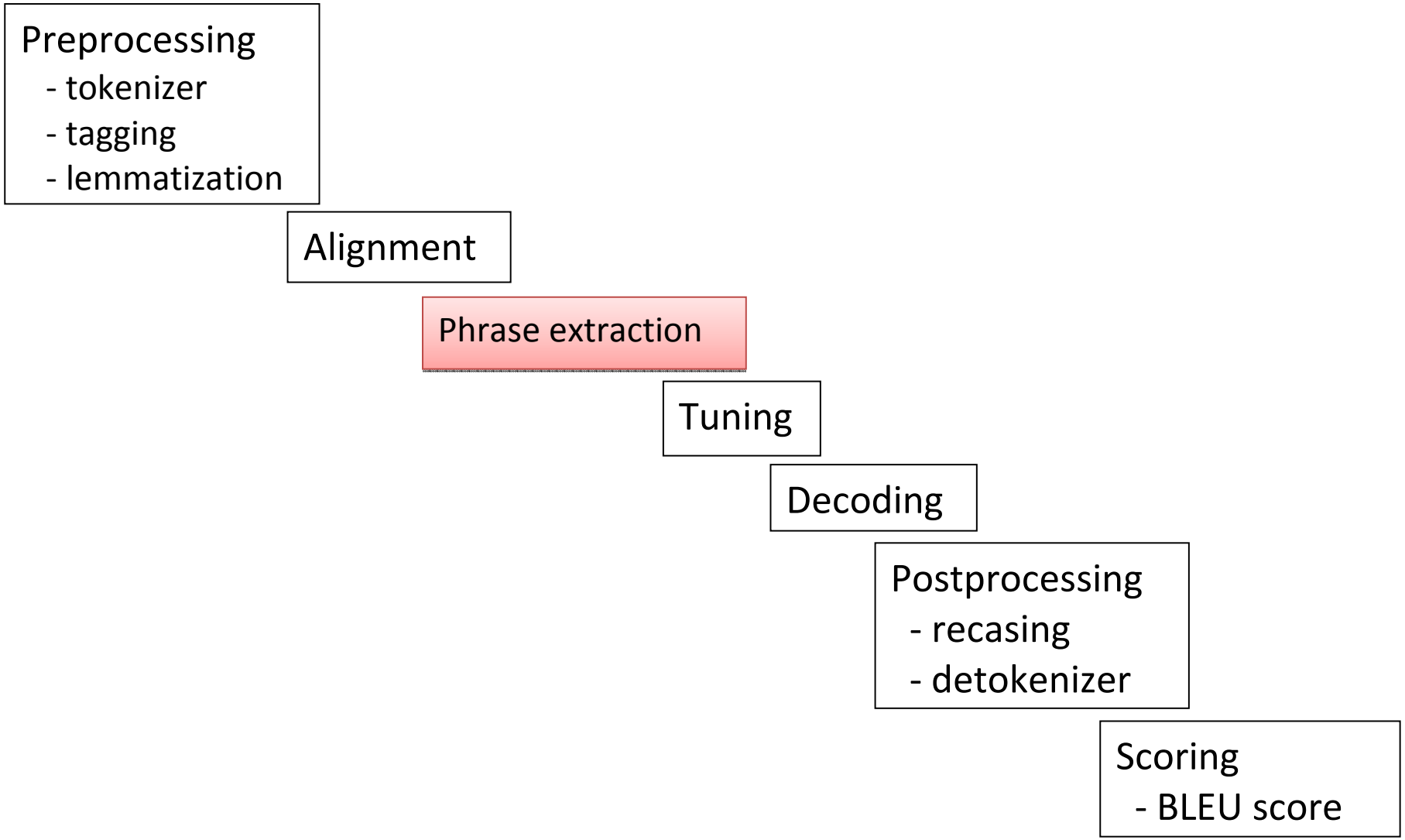
- Base functionality
  - Incremental scoring
  - LM context
  - Dynamic programming
  - Search graph
- Decoding
  - Stacks
    - 1 stack for each non-terminal, for each source contiguous coverage
  - Search strategy
    - Bottom up, smallest span first

Inherited from the Moses decoder

- Factored word representation
- Multiple language models
- Multiple phrase tables

- Multiple implementations of LM and phrase tables

Phrase-based Decoding Pipeline



Phrase-based rule extraction

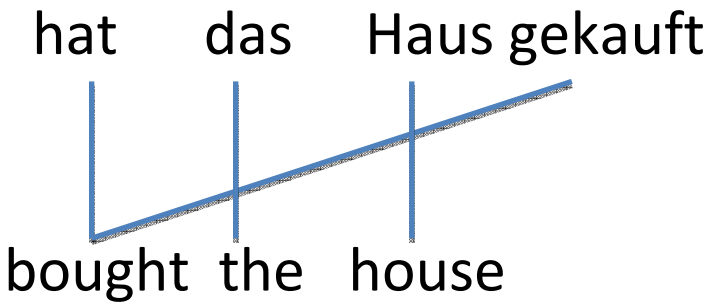
- Heuristic algorithms
  - Phrase extraction
- Probability estimates
  - Phrase and lexical probabilities
  - Smoothing
- Filtering

Hierarchical rule extraction

- Heuristic algorithms
  - Phrase extraction
  - Replace subphrases with non-terminals
- Probability estimates
  - Phrase and lexical probabilities
  - Smoothing
- Filtering

Hierarchical rule extraction

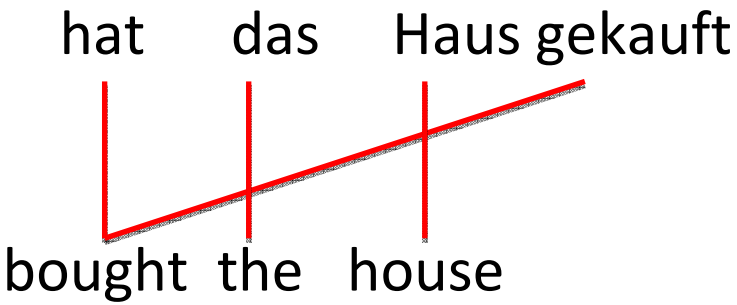
Alignment



Extracted Phrase

Hierarchical rule extraction

Alignment

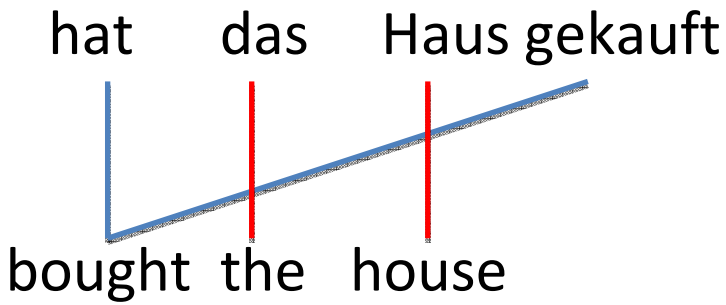


Extracted Phrase

X → Ich hat das Haus gekauft || bought the house

Hierarchical rule extraction

Alignment



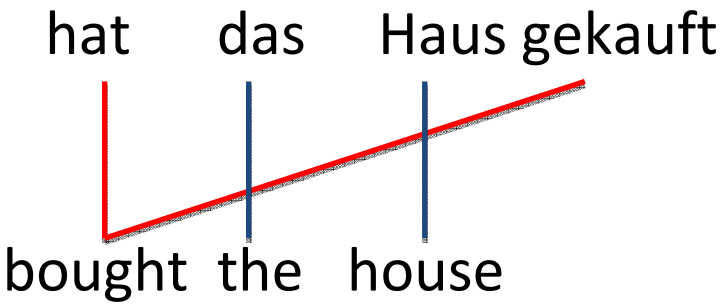
Extracted Phrase

X → hat das Haus gekauft || bought the house

X → das Haus || the house

Hierarchical rule extraction

Alignment



Extracted Phrase

X → hat das Haus gekauft || bought the house

X → das Haus || the house

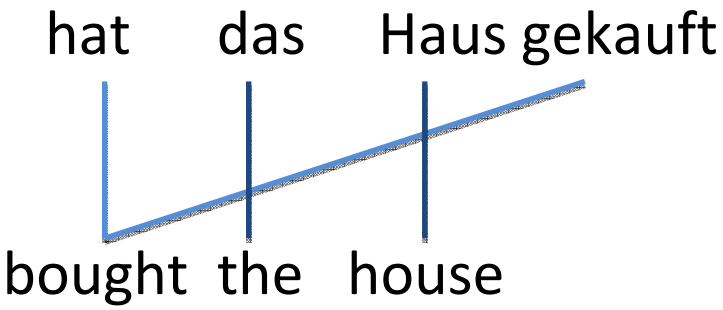
X → hat X gekauft || bought X

Syntactic rule extraction

- Heuristic algorithms
  - Phrase extraction
  - Replace subphrases with non-terminals
    - New rule
  - Labeled non-terminals
    - Constrain extraction
  - merge non-terminal symbols - SAMT
  - Binarization
- Probability estimates
  - Phrase and lexical probabilities
  - Smoothing
- Filtering

Syntactic rule extraction

Alignment



Extracted Phrase

X → hat das Haus gekauft || bought the house

X → das Haus || the house

X → hat NP gekauft || bought NP

Results

German-English

- WMT09 new commentary corpus
  - 82k sentences
  - 1.8m German, 1.7m English words

Model	Rule count	BLEU %
Phrase-based	6.2m	13.0
Hierarchical	59.1m	12.9
Target syntax	2.2m	12.5
SAMT syntax	35.1m	12.9

Summary

- Extend Moses toolkit
  - Synchronous CFG formalism
    - Hierarchical
    - Syntactic decoding
  - Decoding algorithm
  - Rule extraction
- Re-use mature SMT pipeline
- Comparison of different decoding models
  - Use the same training data
  - Use the same translation & language models
- Merge different models