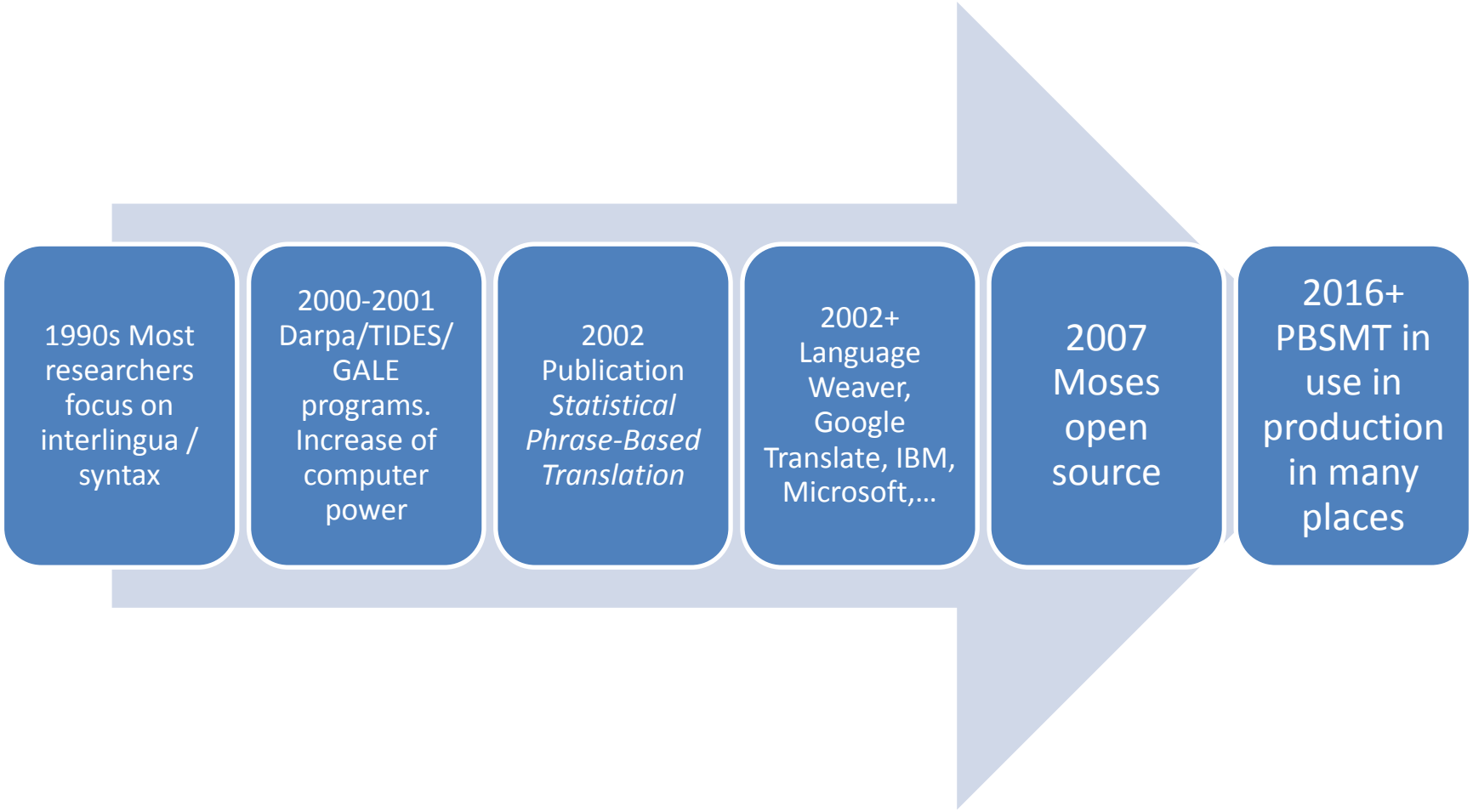
Lecture 4.2: Phrase-based SMT

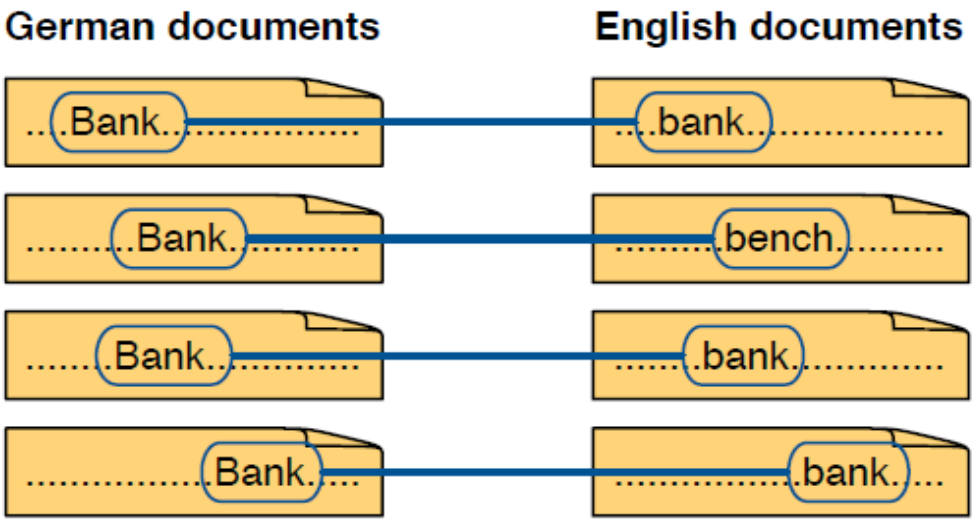
Phrase based SMT: history



Introduction to Statistical Machine Translation

SMT : how does it work ?

- Learning from data (sentence-aligned translated texts)



- New machine translation systems can be built automatically

Courtesy of Philipp Koehn, Professor at The Johns Hopkins University

Extract lexical translations

- Collect statistics
- Estimate a (lexical) probability distribution
- Alignments
- Learning lexical translation models

Courtesy of Philipp Koehn, Professor at The Johns Hopkins University

Word-based MT

- One English word must be translate to one foreign word
- It just does not work!

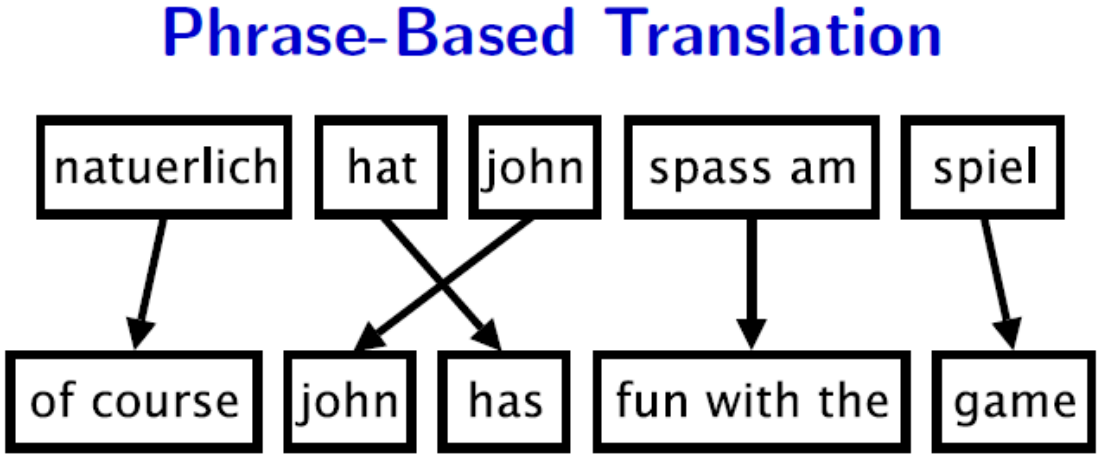
=> Phrase translation is needed

  - [en] I am => [es] soy
  - [en] the day before yesterday => [hi] परसों (*parson)*
  - [en] headache => [fr] mal de tête

When it all started

- *Statistical Phrase-Based Translation (2002) Philipp Koehn , Franz Josef Och , Daniel Marcu*
  - *Philipp Hoehn built Moses*
  - *Franz Josef Och built Google Translate*
  - *Daniel Marcu created* LanguageWeaver company (now SDL Language Weaver)

Phrase-based translation in a nutshell



- Foreign input is segmented in phrases
  - any sequence of words, not necessarily linguistically motivated
- Each phrase is translated into English
- Phrases are reordered

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Theory behind PBSMT

- Translating from language *f* to language *e* (***f***rench - ***f***oreign into ***e***nglish)
- Find the best English sentence out of a French one
- $\tilde{e} = \arg\max_{e \in e^*} p(e|f)$

English translation is the translation having the highest probability "English knowing French"

- $p(e|f) = \frac{p(f|e)p(e)}{p(f)}$ (Bayes' rule)
- $\tilde{e} = \arg\max_{e \in e^*} p(f|e)p(e)$

$\Rightarrow$Replace it by: finding the best English sentence knowing the probability of French to be translated as such combined with "best fluent English"

- $\tilde{e} = \arg\max_{e \in e^*} p(f|e)p(e)$
- $p(f|e)$ → Phrase table (phrase translation probabilities)
- $p(e)$→Language model (probability of being “good” English)

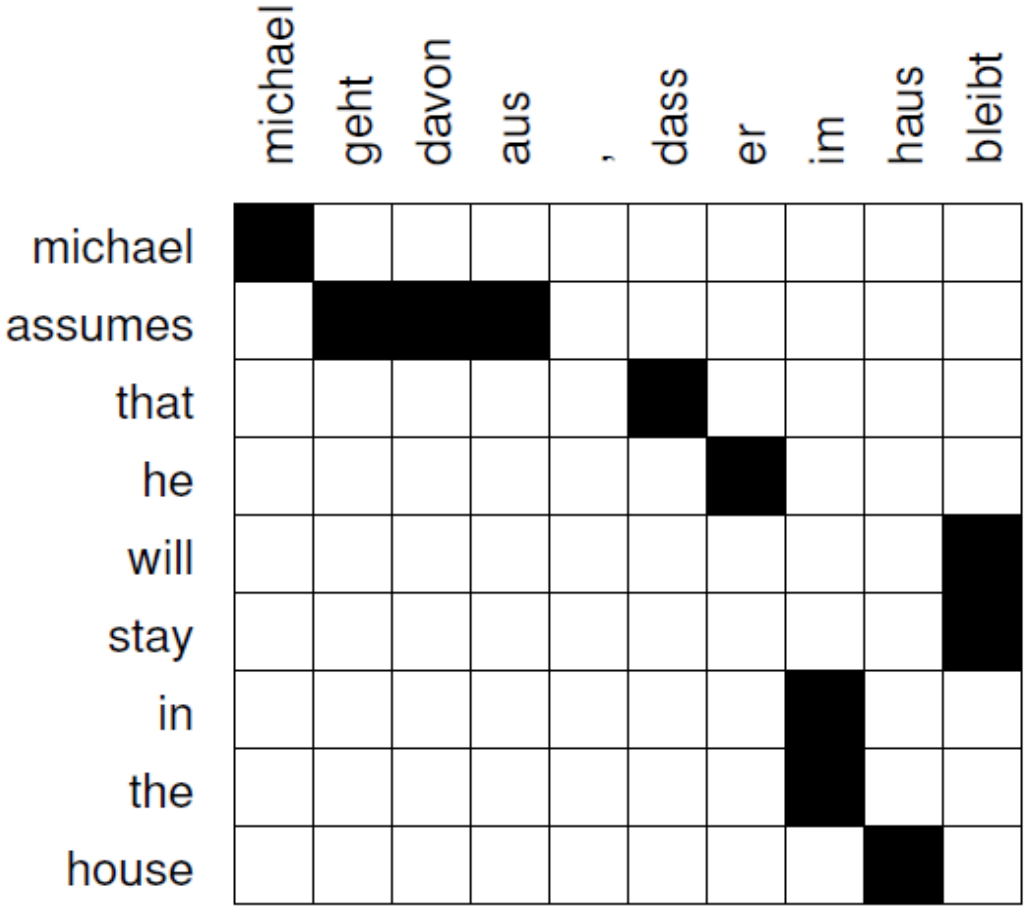
Lexical translation (word)

- How to translate a word → look up in dictionary

  Haus ➔ house, building, home, household, shell

- Multiple translations
  - some more frequent than others
  - for instance: house, and building most common
  - special cases: Haus of a snail is its shell

From aligned words to aligned phrases



Preparing the data : word alignment

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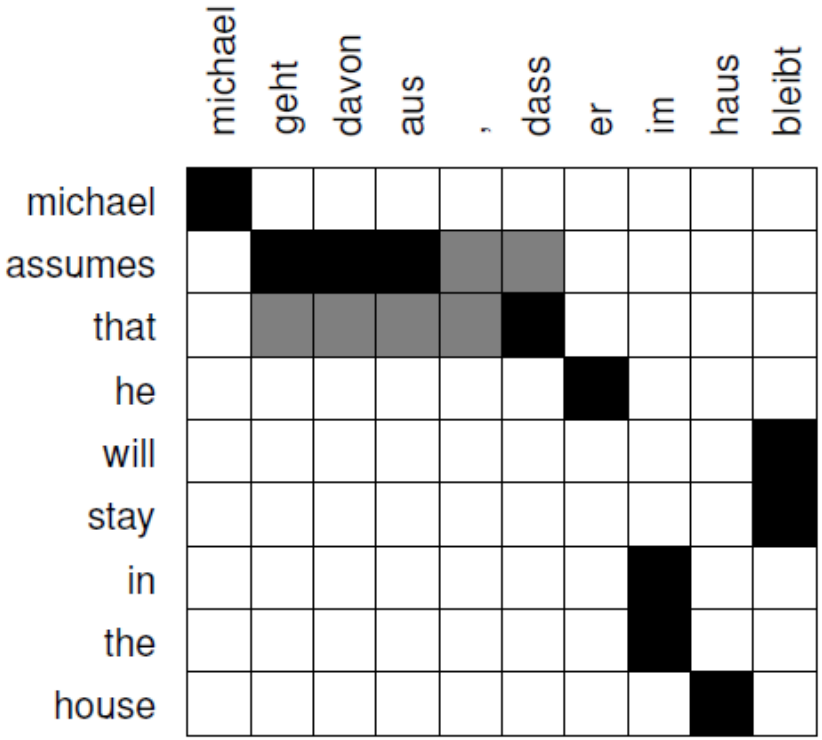
Extracting Phrases from Data



Given a word alignment: extract phrase pairs, estimate probabilities

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From parallel phrases to probabilities

Phrase Translation Table

- Phrase Translations for "den Vorschlag"

English	$\phi(e\|f)$	English	$\phi(e\|f)$
the proposal	0.6227	the suggestions	0.0114
's proposal	0.1068	the proposed	0.0114
a proposal	0.0341	the motion	0.0091
the idea	0.0250	the idea of	0.0091
this proposal	0.0227	the proposal ,	0.0068
proposal	0.0205	its proposal	0.0068
of the proposal	0.0159	it	0.0068
the proposals	0.0159	...	...

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Language model

Language Model

- **Language models** answer the question: How likely is a string of English words good English?
  - the house is big → good
  - the house is xxl → worse
  - house big is the → bad
- Given: English words $W = w_1, w_2, w_3, ..., w_n$ — *what is* $p(W)$?
- Limited history: only previous k words matter (here: k=2)

$$p(w_1, w_2, w_3, ..., w_n) = p(w_1)\ p(w_2|w_1)\ p(w_3|w_2)...p(w_n|w_{n-1})$$

- Models trained on large amounts of monolingual text (billions of words)

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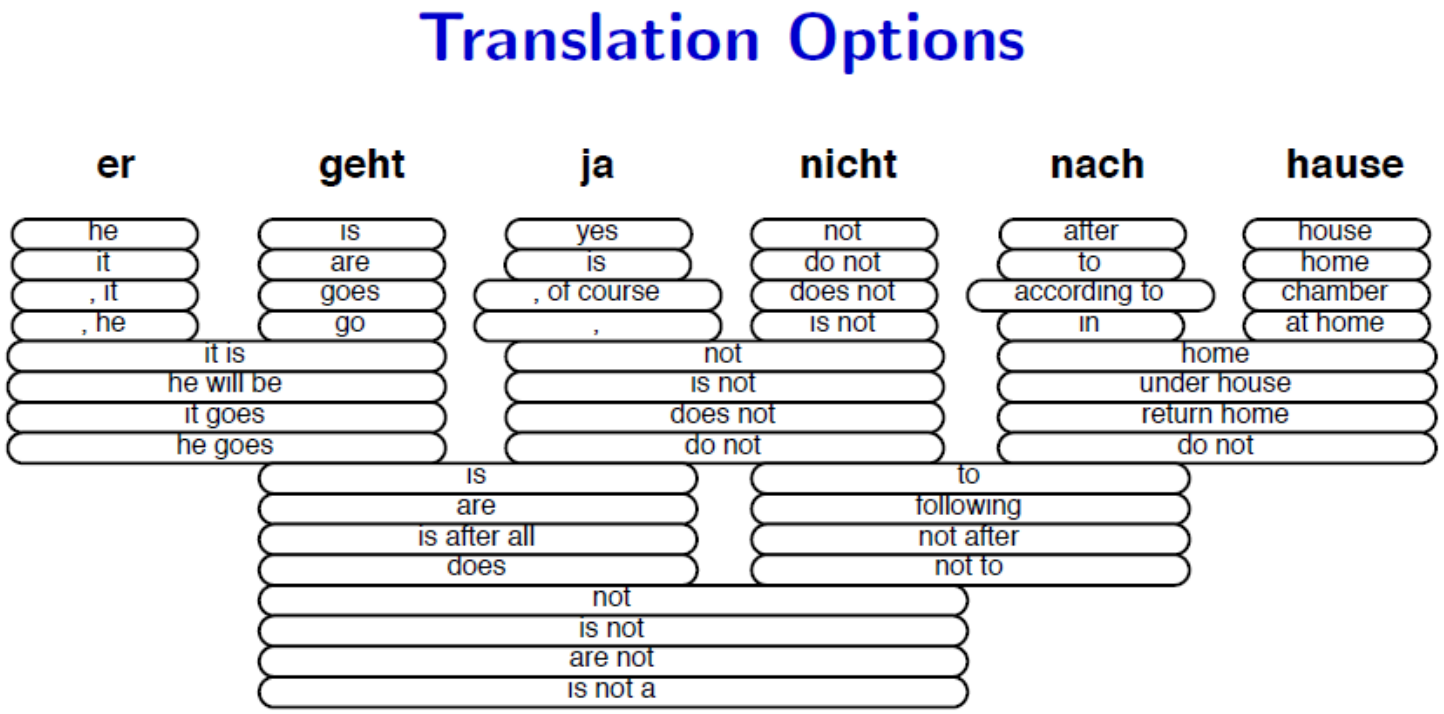
SMT : how does it work ?



- Task: find the right output phrases, put them in the right order

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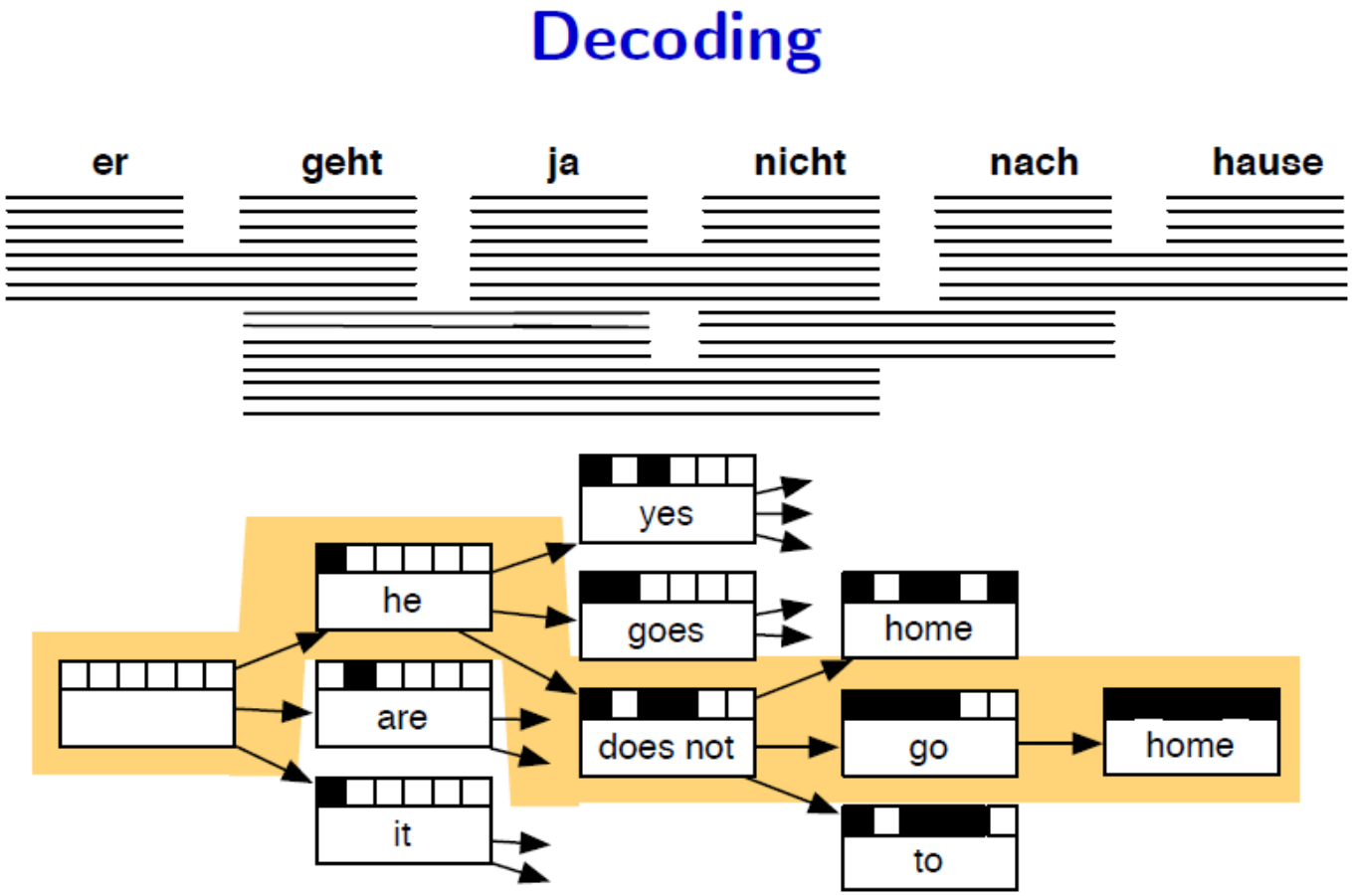
SMT : how does it work ?



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Different open-source software

- Moses: SMT (PBSMT+tree-based), C++ - Perl/Unix
- Joshua: SMT (tree-based) Java
- Cdec: SMT (tree-based) C++/Unix
- Jane: (PBSMT+tree-based), **RWTH Aachen University, C++/Unix**
- Phrasal: PBSMT, Standford, Java
- Apertium: rule-based machine translation platform, C++/Windows-Unix
- Nematus: Neural MT open source, Python

See http://fosmt.org/, https://en.wikipedia.org/wiki/Comparison_of_machine_translation_applications