FST Trimming: Ending Dictionary Redundancy in Apertium

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Introduction and background
FST's in the Apertium pipeline
The Problem: Redundant data
A Solution: trim on compile
Implementation of lt-trim
Preprocessing the bilingual dictionary
Intersection
lt-trim in use
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Outline of talk

Introduction and background

Implementation of `lt-trim`

Ending Dictionary Redundancy

Conclusion

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Introduction and background

- Apertium: Free/Open Source, Rule-based Machine Translation platform
- Goals include:
  - supporting lesser-resourced languages
  - wide coverage
  - post-editable output
  - reusable resources
- Language data (dictionaries, etc.) typically organised in language *pairs* (Catalan-Spanish, Portuguese-Spanish, etc.)
  - historically: each with its own copy of monolingual data

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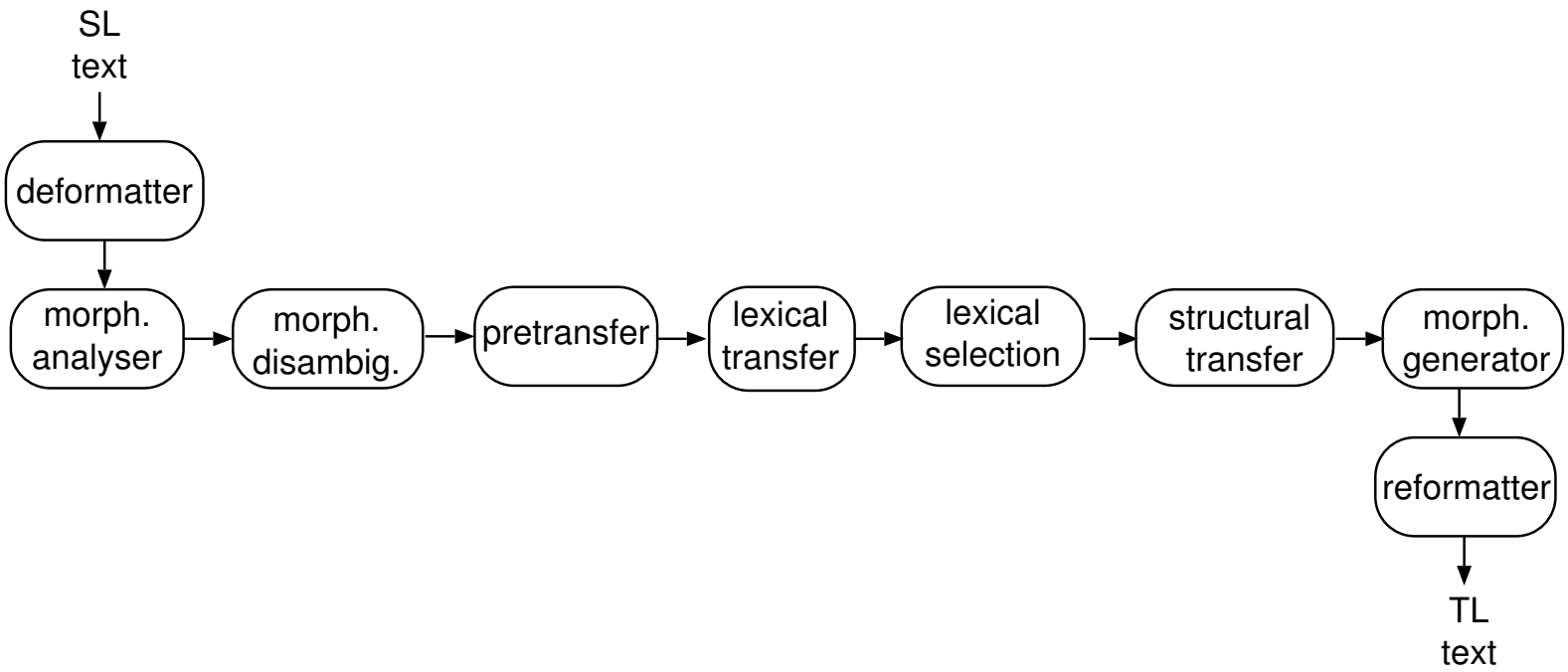
Apertium pipeline architecture

- lttoolbox Finite State Transducers used for, among others:
  - morph. analysis: ‘fishes’ to `fish<n><pl>/fish<vblex><pres>`
  - lex. transfer: `fish<n><pl>` to `fisk<n><m><pl>`
  - morph. generation: `fisk<n><m><pl><def>` to ‘fiskane’



Multiword support

lttoolbox FST's support a variety of multiwords

An lttoolbox "lexical unit" is one token, and can be:

- simple non-multi-words: 'fish'
- simple space-separated words: 'hairy frogfish' as a single token
- multiwords with **inner inflection**: 'takes out', analysed as `take<vblex><pri><p3><sg># out`, converted to `take# out<vblex><pri><p3><sg>` before lexical transfer

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Multiword support

- **joined** multiwords: ‘they’ll’;
  analysed as single token
  `prpers<prn><subj><p3><mf><pl>+will<vaux><inf>`,
  then split into two tokens
  `prpers<prn><subj><p3><mf><pl>` and
  `will<vaux><inf>` before lexical transfer
- **compounds**: ‘frogfish’;
  analysed as single token `frog<n><sg>+fish<n><pl>`,
  then split into two tokens `frog<n><sg>` and `fish<n><pl>`
  before lexical transfer

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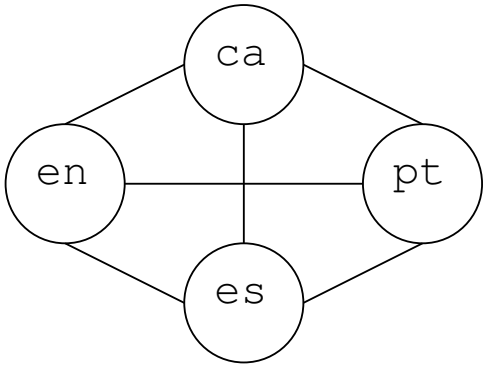
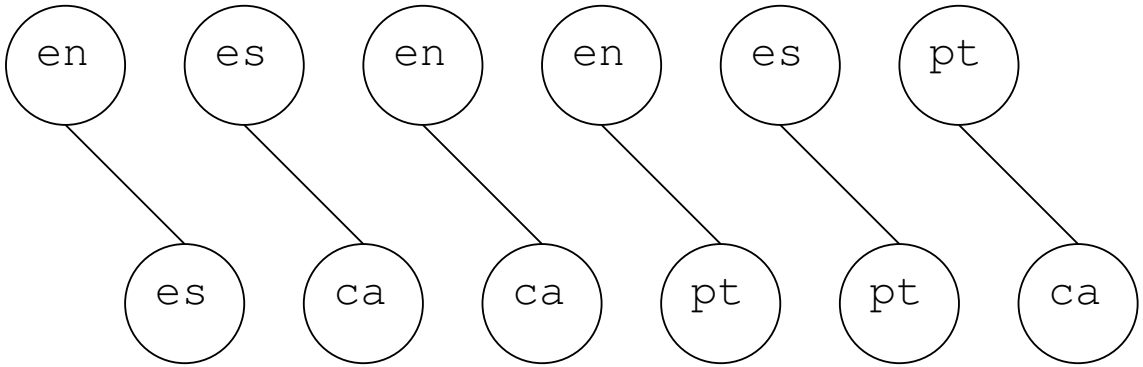
Multiword support

- combinations (space-separated + joined + inner inflection): ‘creure-ho que’,
  analysed as single token
  `creure<vblex><inf>+ho<prn><enc><p3><nt># que`,
  then moved and split into two tokens
  `creure# que<vblex><inf>` and
  `ho<prn><enc><p3><nt>` before lexical transfer

The Problem: Redundant data



Ideal number of monodixes with four languages



Current number of monodixes with pairs of four languages

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Words in analyser but missing from lexical transfer can be problematic:

- ‘fishes’ to ‘@fish’: loses the inflection
- ‘gikk til hundene’ “went to the dogs” to ‘went to @hund’ “went to dog”: losing the inflection hides the idiomatic meaning
- ‘öldürmedi’ “did not kill” to ‘@öl’ “kill”: loses the *negation*
- lexical transfer is also tag transfer – structural transfer thus needs exceptions for half-translated tags

But, most importantly, multiword tokenisation means that

‘He takes out the trash’ translates to ‘Han @take out søpla’ *even though both ‘take’-‘ta’ and ‘out’-‘ut’ are in the bilingual dictionary*.

Adding more words makes the translator worse!

A Solution: trim on compile

Compile a *trimmed* analyser-FST containing only those entries from original analyser FST that would pass through bilingual FST.

- FSA's closed under intersection: FSA1 ∩ FSA2 = FSA3
- Similarly, we can compose-intersect FST's:
  output-side of FST1 ∩ input-side of FST2 = FST3

Goal: One big monolingual source dictionary, trimmed during compile to language-pair specific analysers.
Dictionaries in HFST instead of lttoolbox can trim already (but it breaks with compounds!).
Most Apertium dictionaries use lttoolbox.

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Our tool needs some exceptions to compose-intersect:

- Append `.*` (any-symbol loop) to bilingual FST
  - Lexical transfer only needs a match on the start of the string
- Reorder `#`-multiwords in bilingual FST
  - so they look like analyser (else they won't match)
- Let `+` in analyser mean transition-to-start in bilingual FST
  - since single token `a+b` in analyser is split into two tokens `a b` before lexical transfer

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Digression: Some Apertium dictionaries use HFST instead of lttoolbox.

Trimming with standard HFST commands works for most but not all such dictionaries.

Again multiword issues: compounds.

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Implementation of `lt-trim`

Tool takes two compiled FST's, produces a new, *trimmed* FST

1. Preprocess bilingual FST
   1.1 "Prefixing": Append any-symbol loop
   1.2 Reorder #-multiwords
2. Depth-first intersection of output-side of analyser with input-side of bilingual FST
   - with an exception on seeing +

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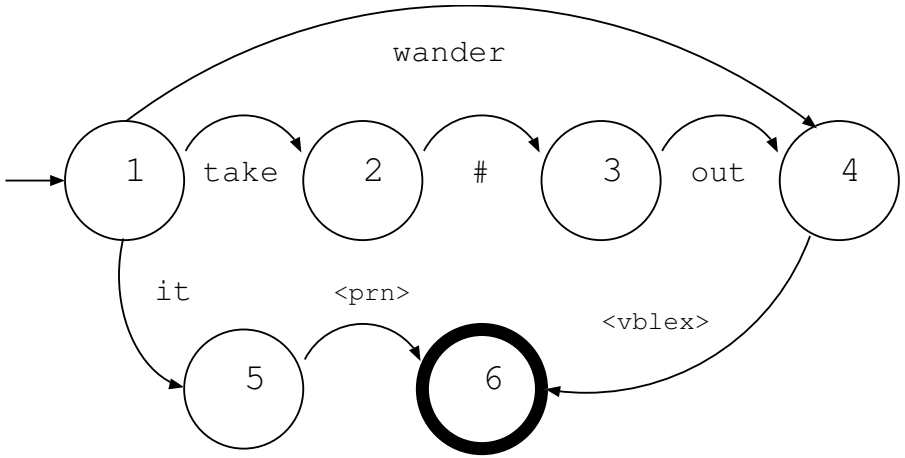
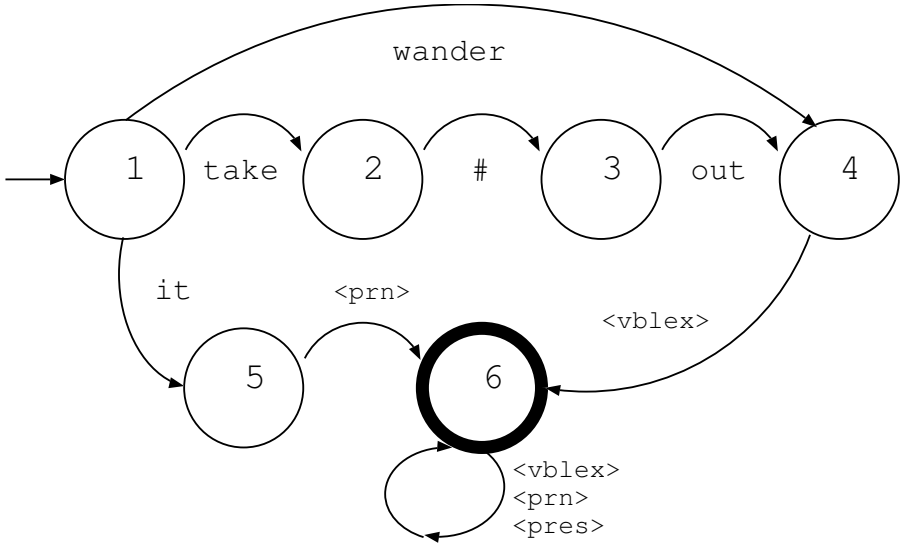
Prefixing bilingual FST



Input bilingual FST (letter transitions compressed to single arcs)



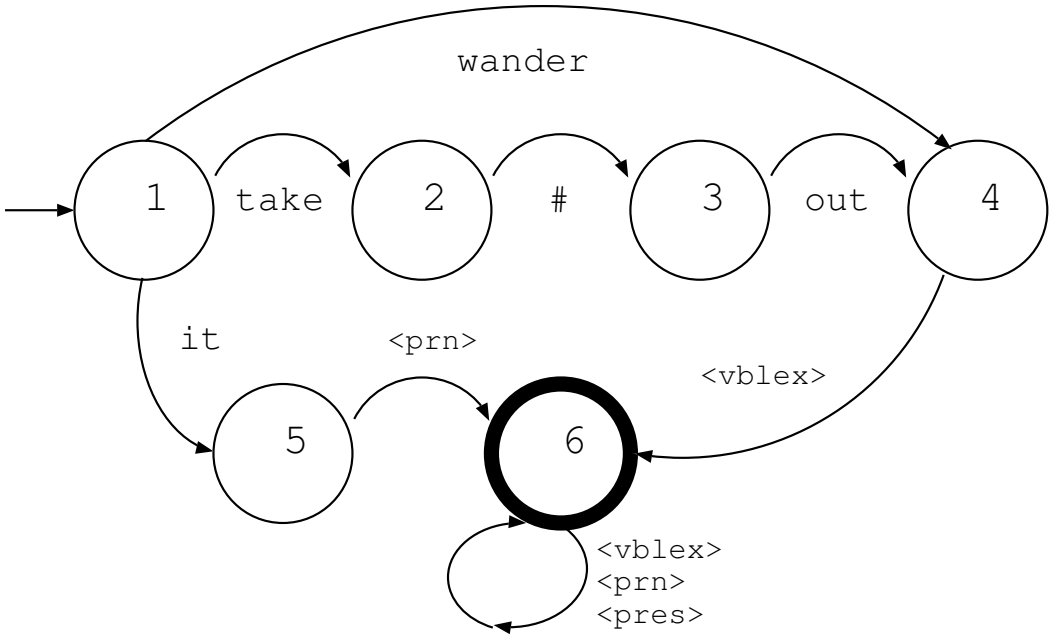
“Prefixed” bilingual FST (any-symbol loop appended)

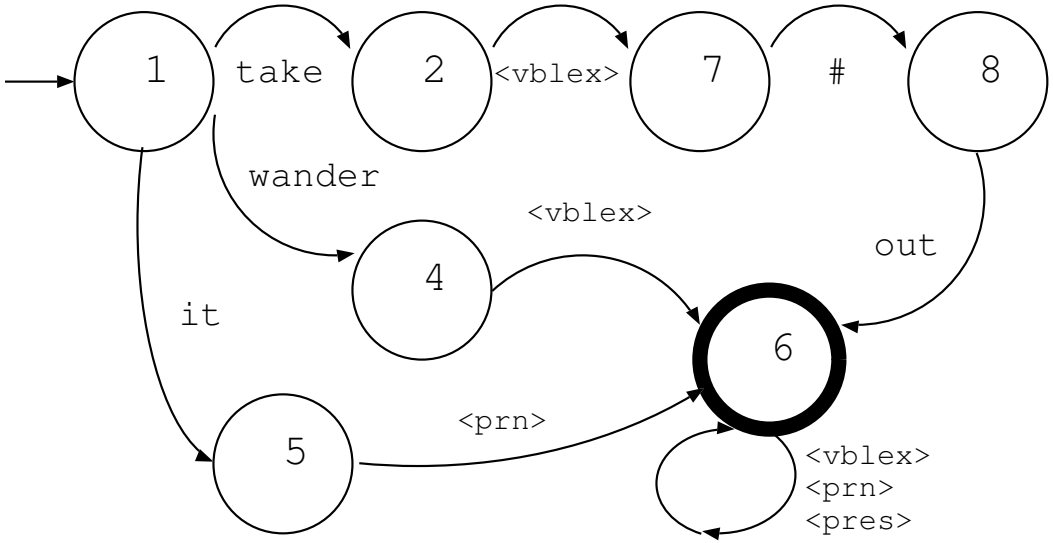
Moving uninflected lemma parts in bilingual FST

Want `take# out<vblex>` to become `take<vblex># out`, so

1. Depth-first traverse bilingual FST
2. On seeing a #, replace the transition *t* with results of $\mathrm{copyWithTagsFirst(t)}$
3. Function $\mathrm{copyWithTagsFirst(t)}$ builds a new partial FST where any tag sequence and uninflected lemma parts have swapped places

Moving uninflected lemma parts in bilingual FST





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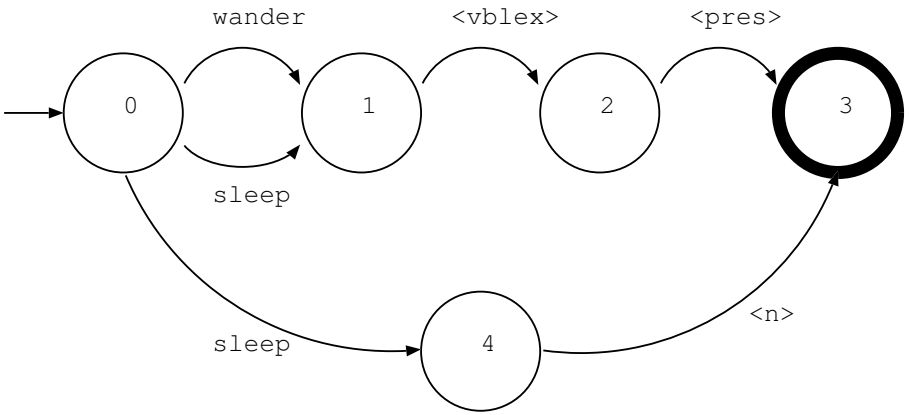
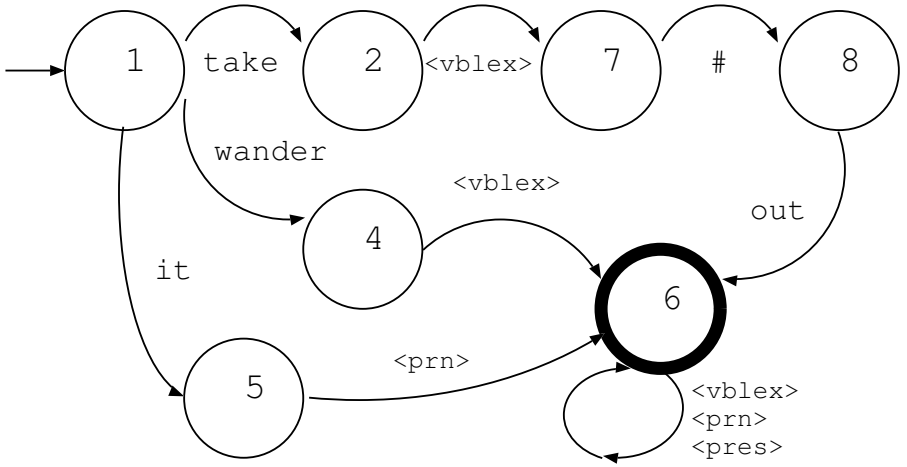
Intersection



Input analyser



Preprocessed bilingual FST

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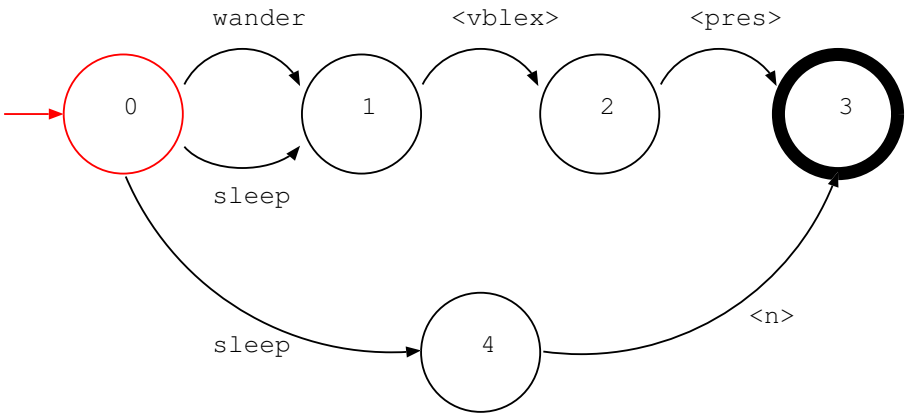

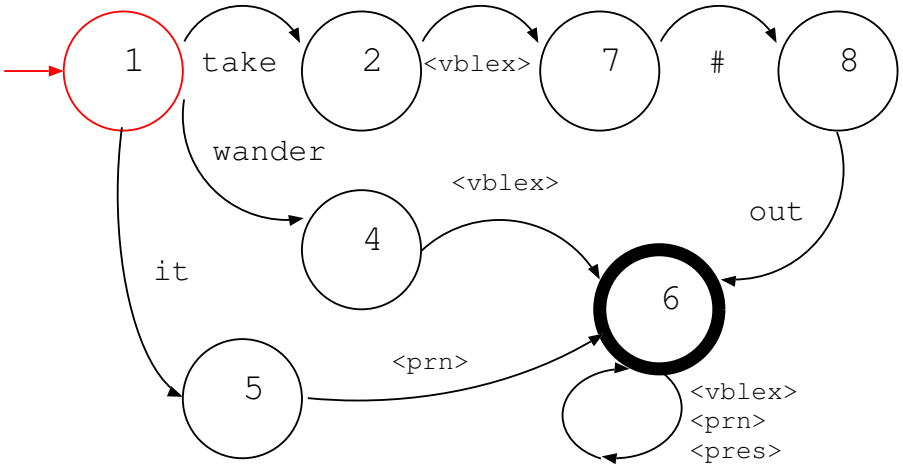

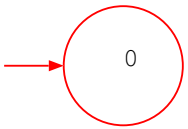

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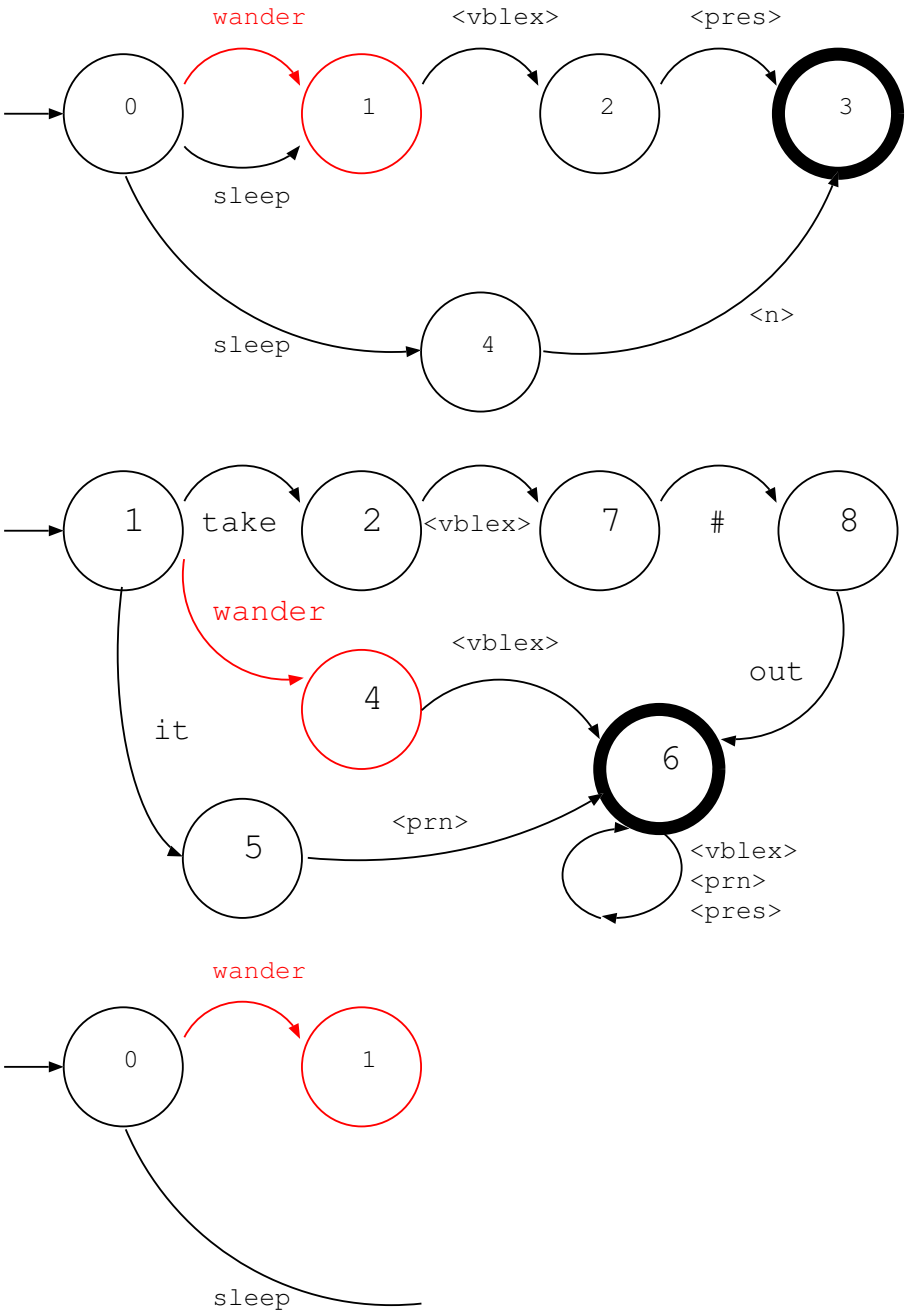
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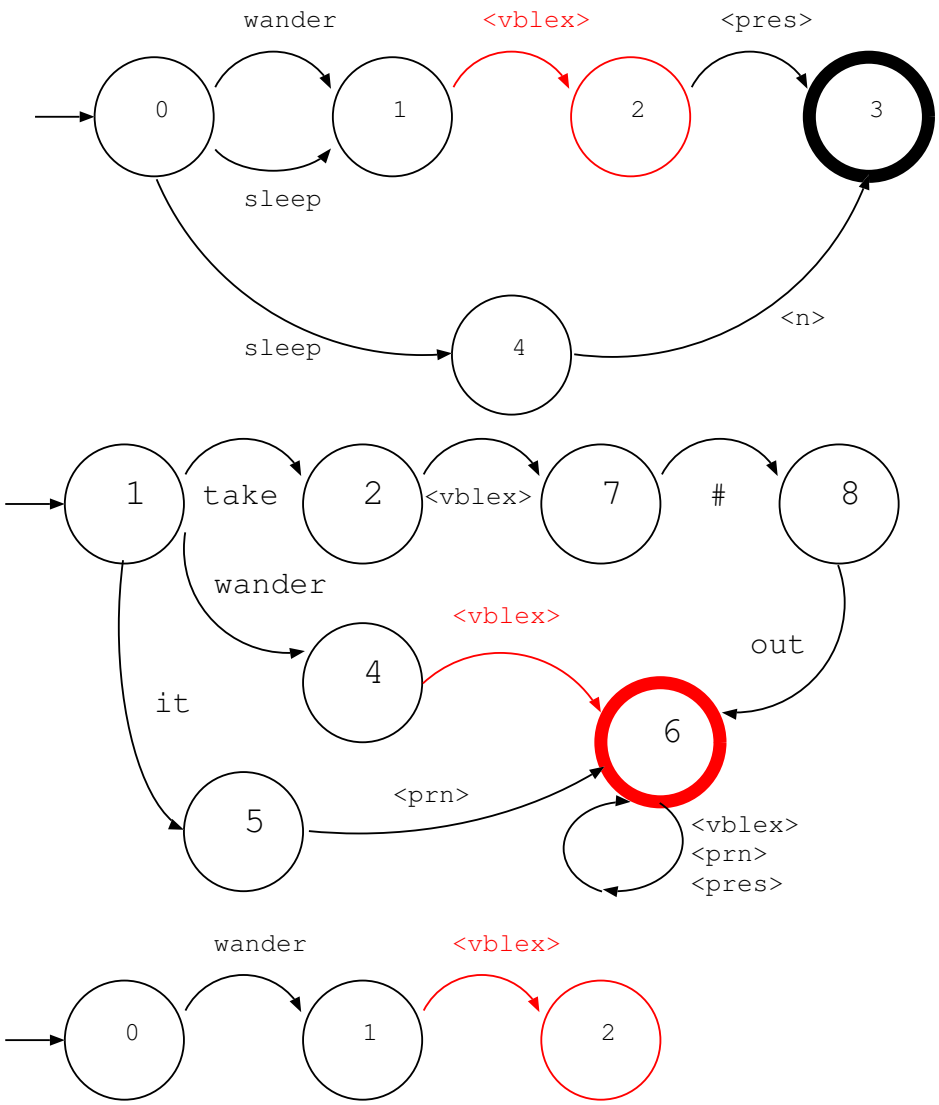
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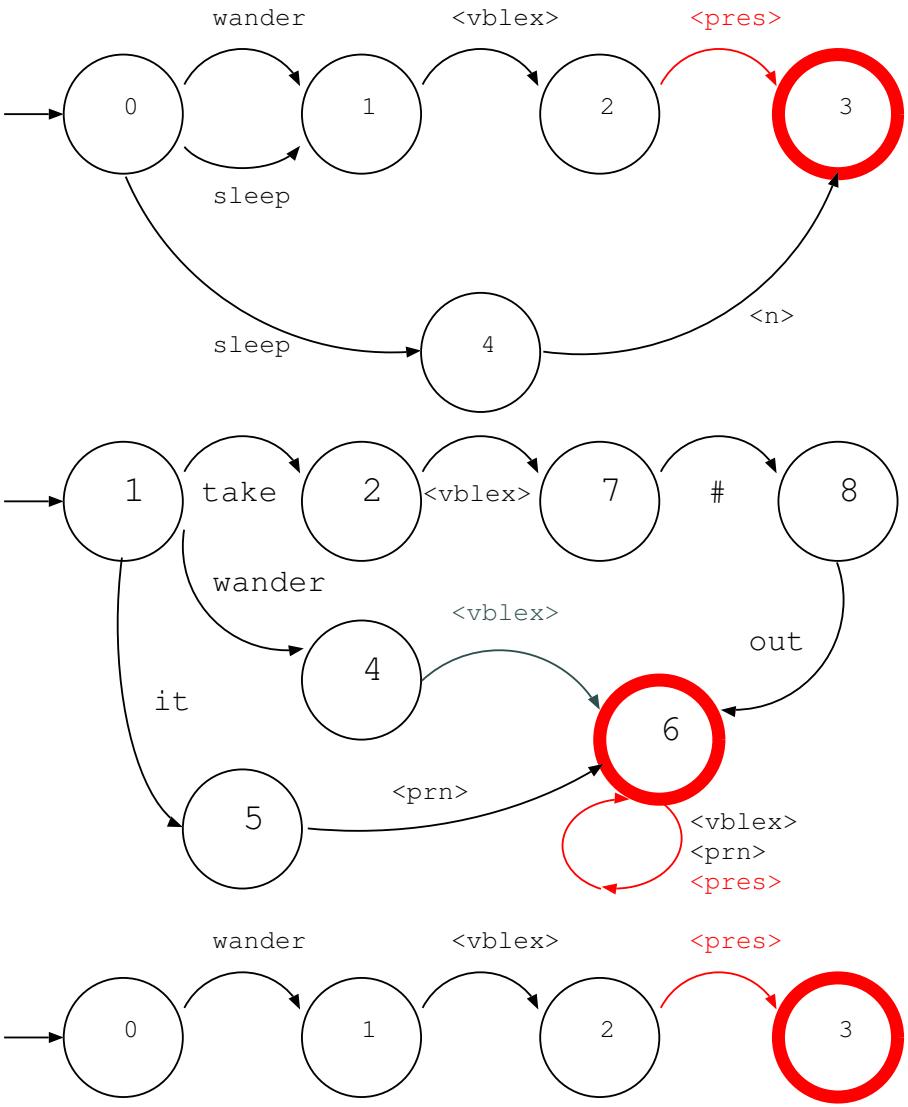
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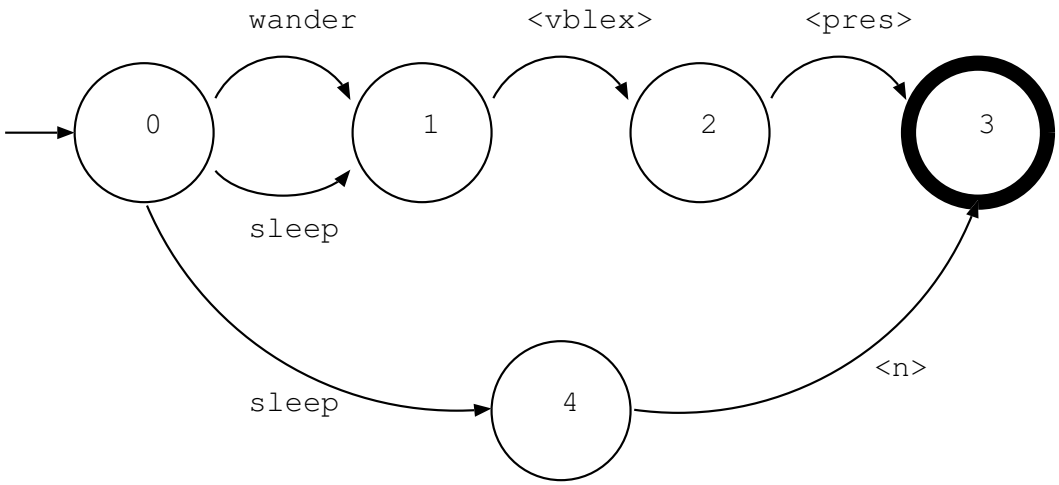
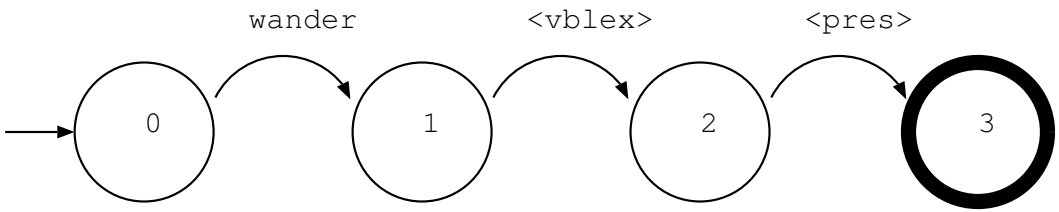
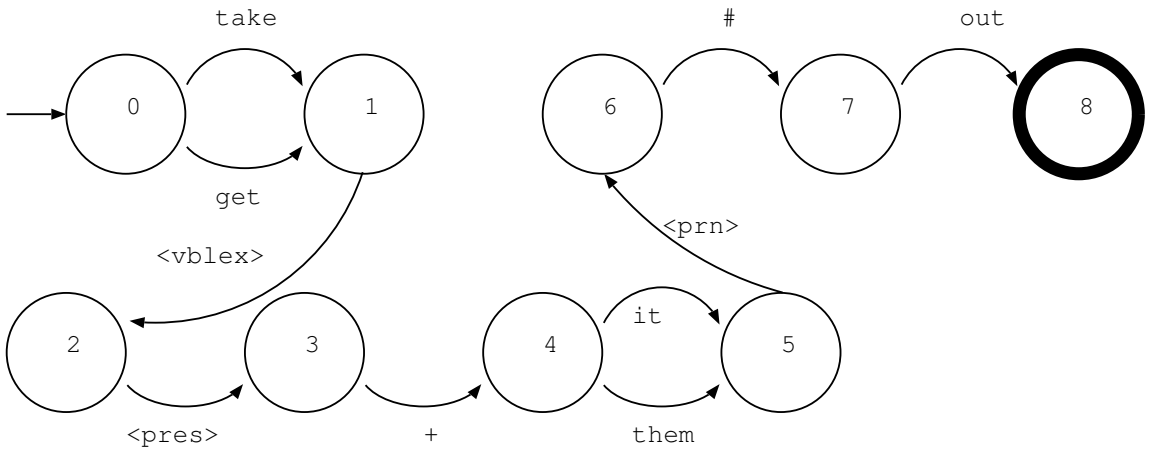


Input analyser



Fully trimmed analyser

Intersection with multiwords



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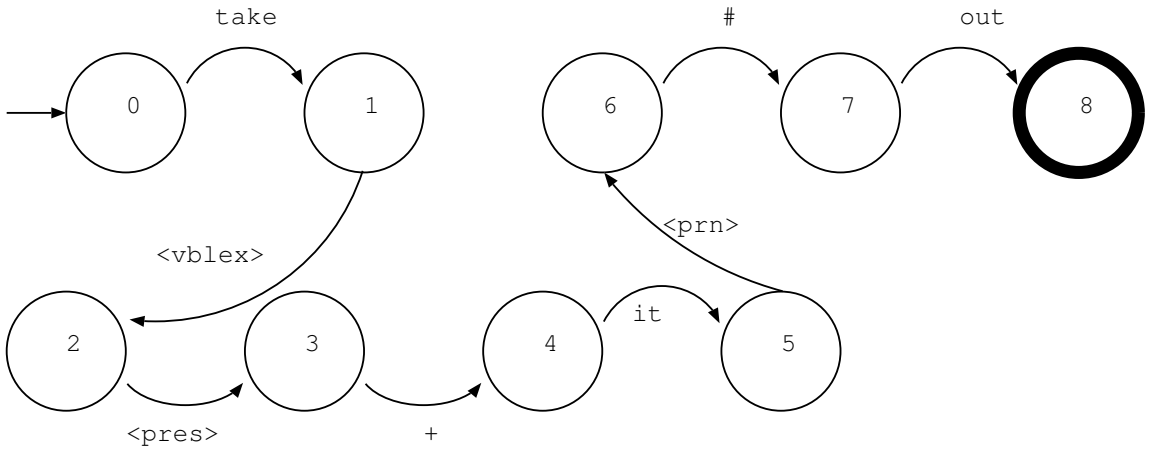

Trimmed analyser

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`lt-trim` in use

```
$ lt-trim full-ana.bin bi.bin trimmed-ana.bin
```

(But language pair developers typically just type “make”.)

Speed and memory usage is comparable to regular lttoolbox (`lt-comp`) compiling.

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Ending Dictionary Redundancy

- New Autotools rules let us formally depend on monolingual data packages
- All new languages added to Apertium use this system – no monolingual data redundancy
- But: Implementing trimming in old/well-developed language pairs means manual merging – divergent dictionaries problematic
  - Merging Norwegian Bokmål between sme-nob and nno-nob: about 3 hrs work
  - dan-nob added further 3 hrs

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Conclusion

- `lt-trim` works
- Monolingual data now in a single /languages/ SVN module, easier for other projects to find and use our data
- Next up: special-purpose HFST trimming tool to get around compounding problem?
- Still much manual merge work to be done

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