TectoMT:
Machine Translation System

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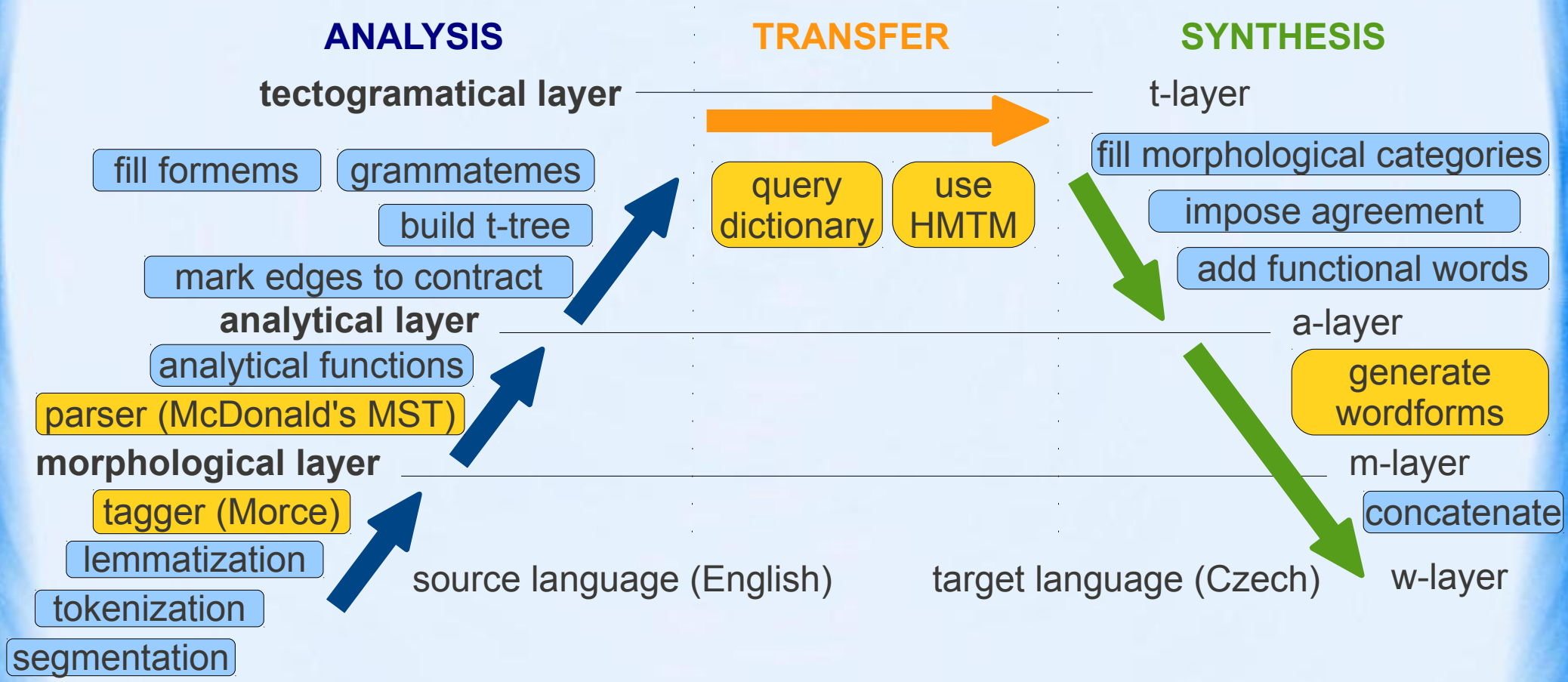
Translation scheme

TectoMT

rule based & statistical blocks



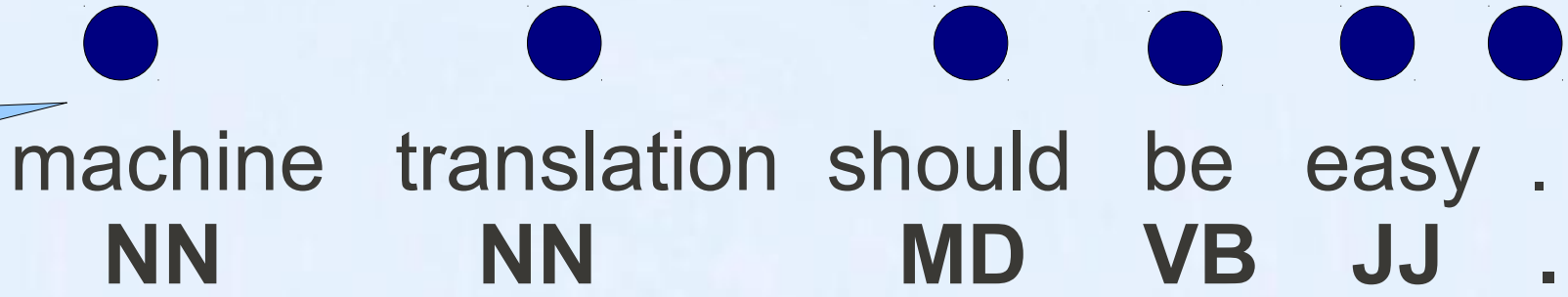
Demo Translation – Analysis

TectoMT

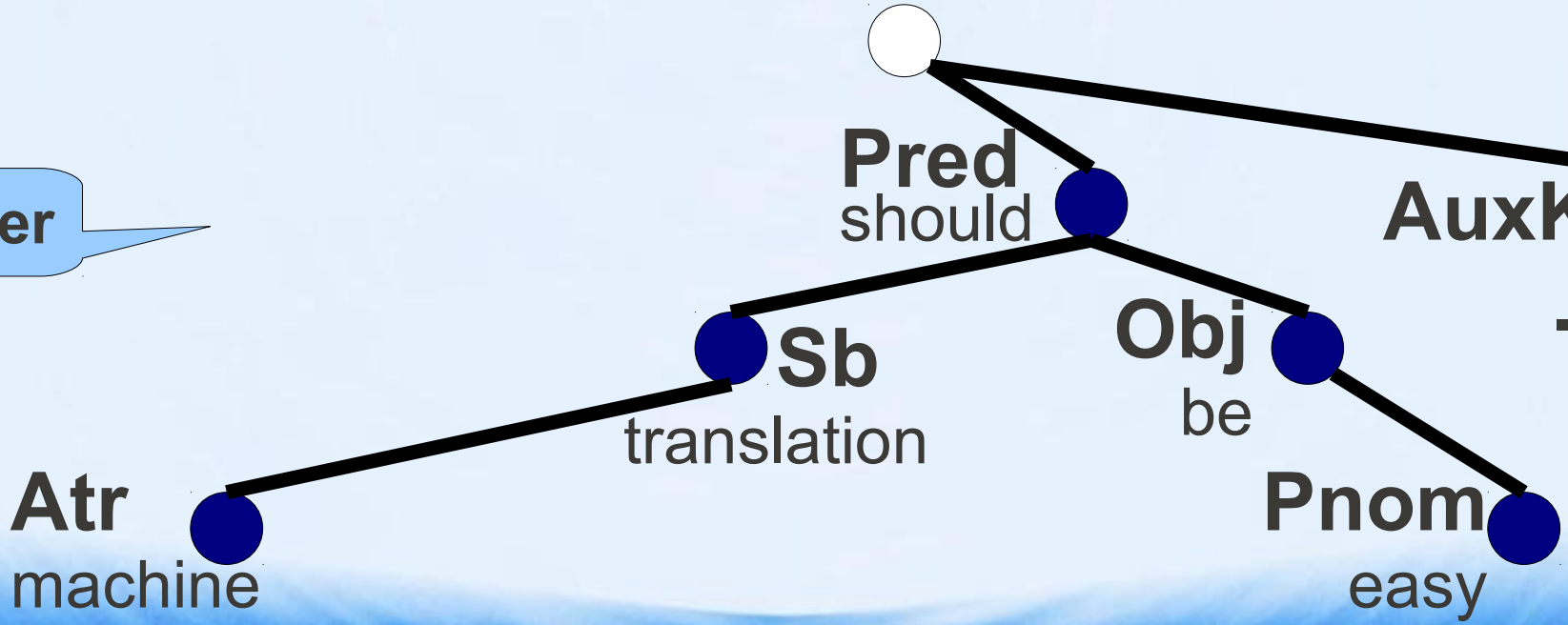
raw text

Machine translation should be easy.

m-layer



a-layer



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TectoMT

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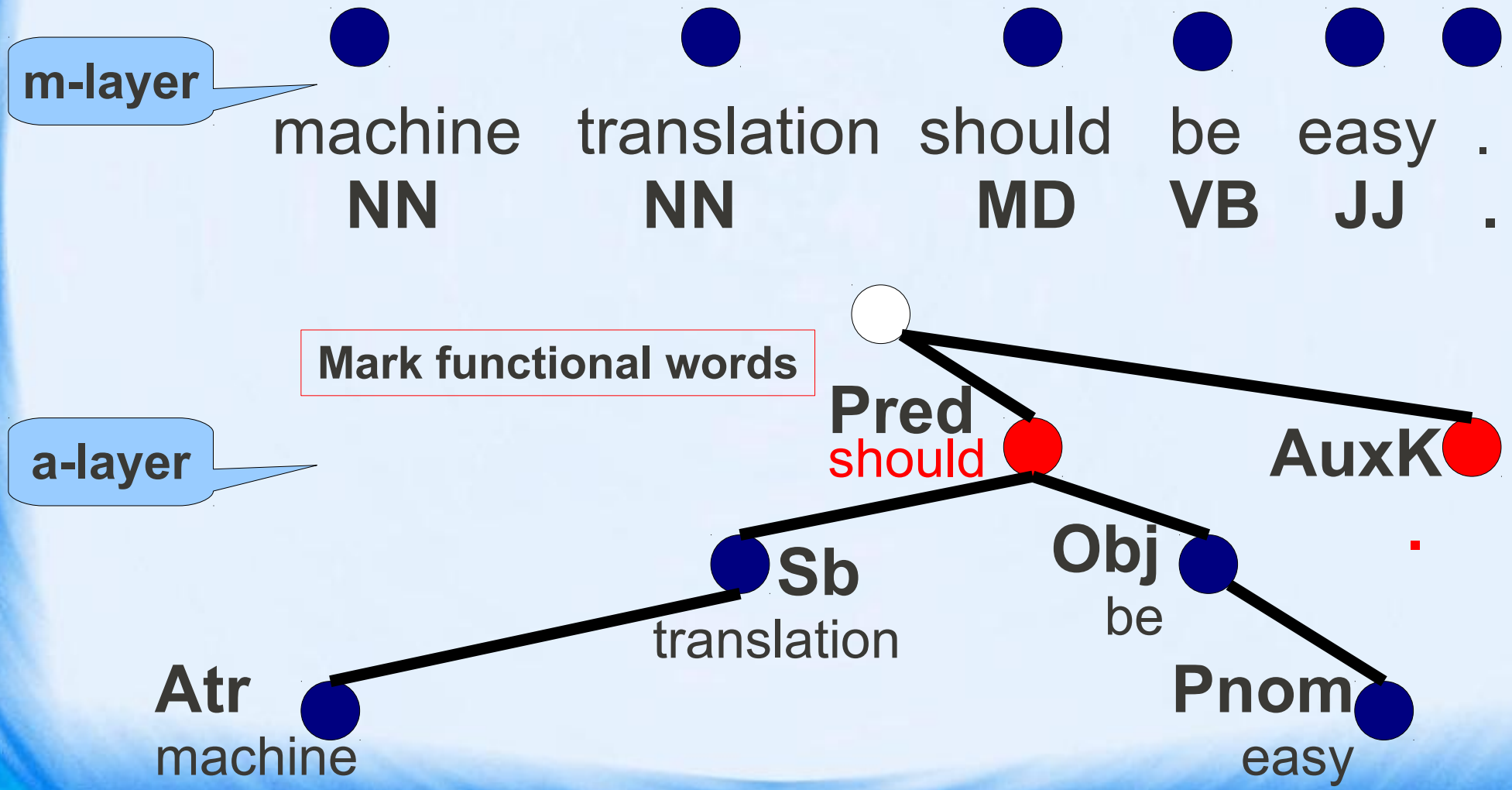

Demo Translation – Analysis

TectoMT

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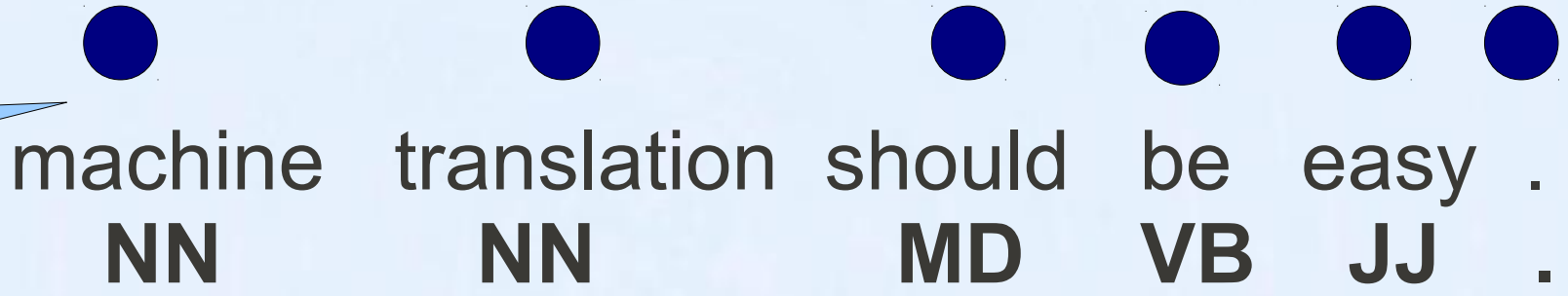
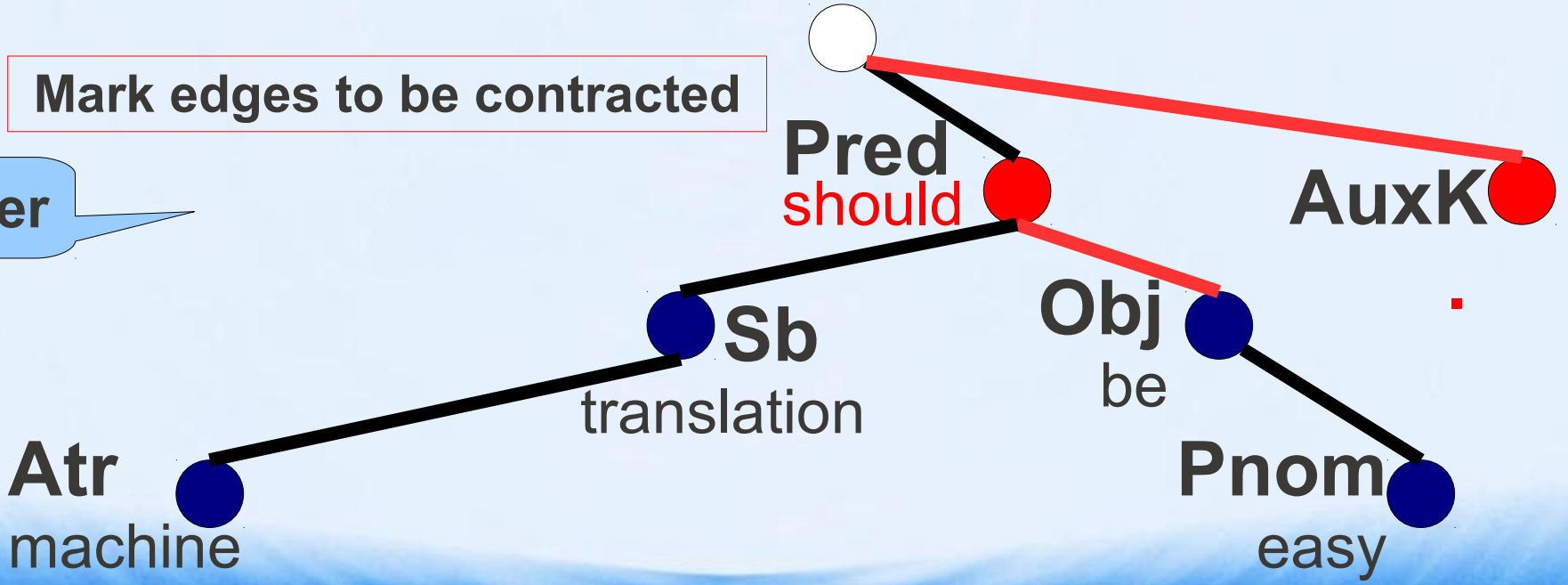
m-layer



Mark edges to be contracted

a-layer



Demo Translation – Analysis

TectoMT

raw text

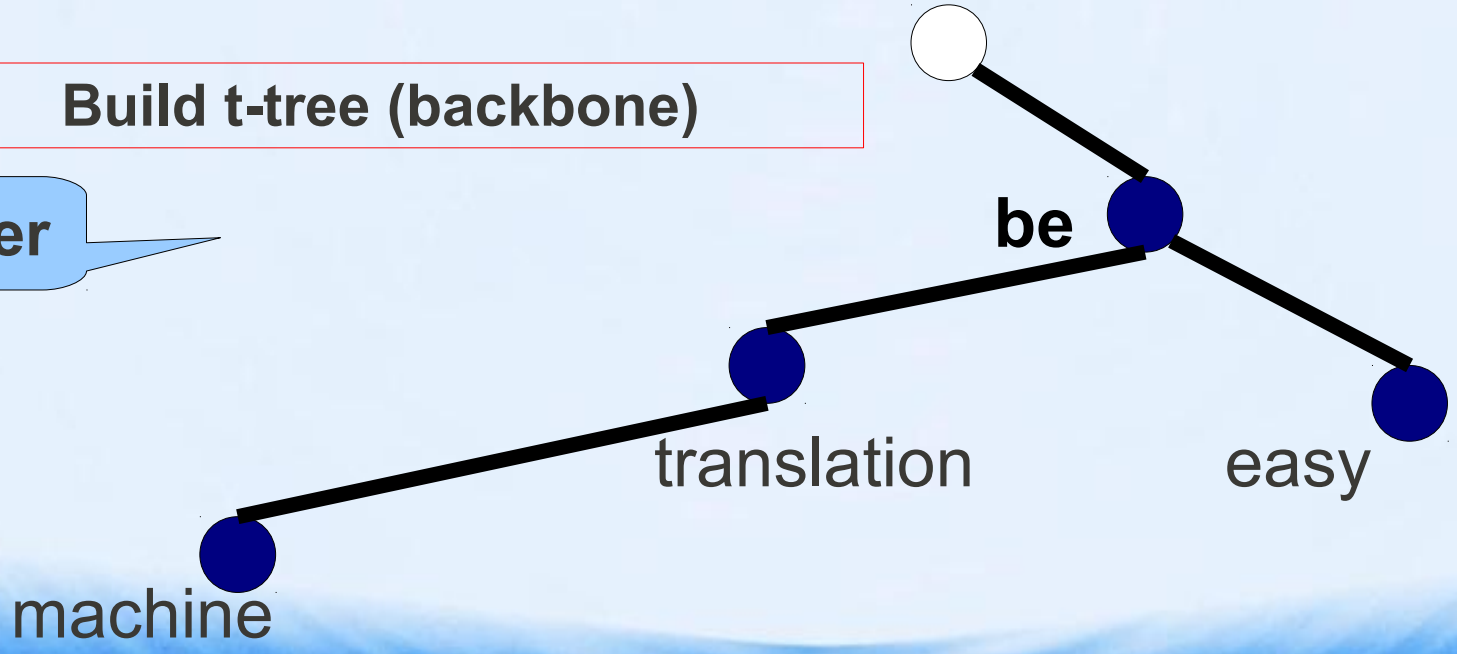
Machine translation should be easy.

m-layer

machine	translation	should	be	easy	.
NN	**NN**	**MD**	**VB**	**JJ**	**.**

Build t-tree (backbone)

t-layer



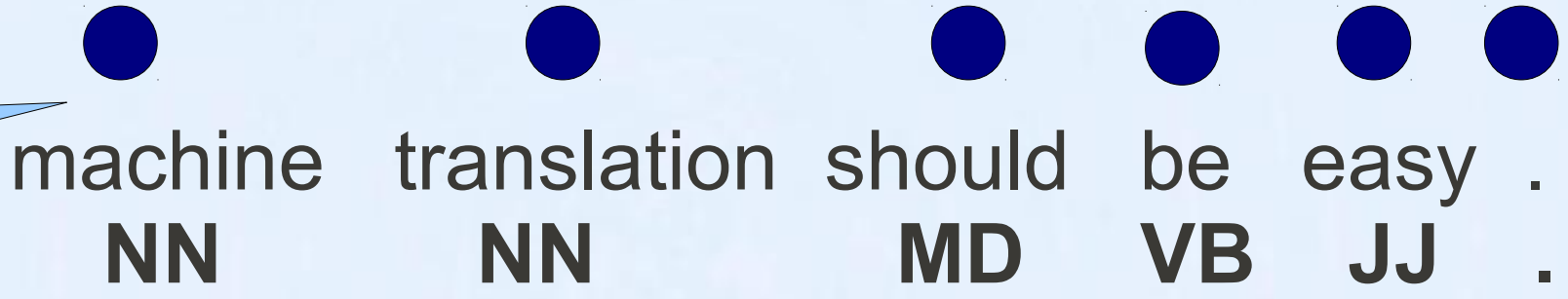
Demo Translation – Analysis

TectoMT

raw text

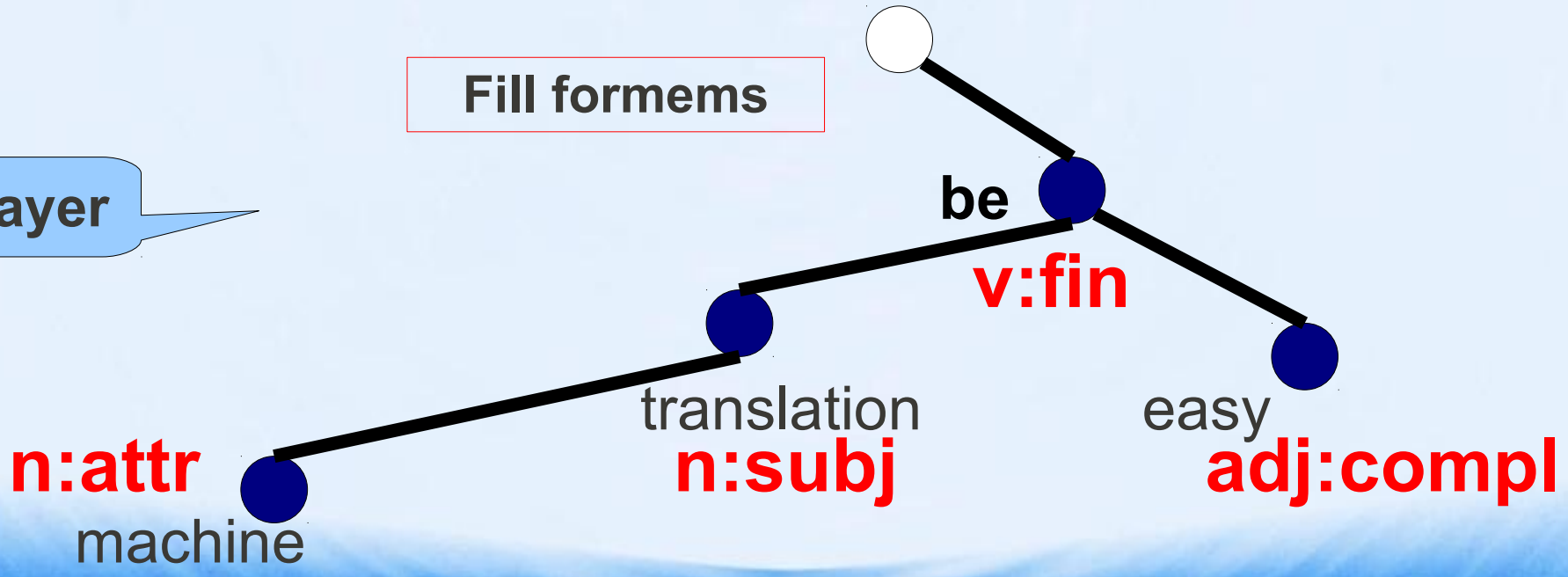
Machine translation should be easy.

m-layer



t-layer

Fill formems

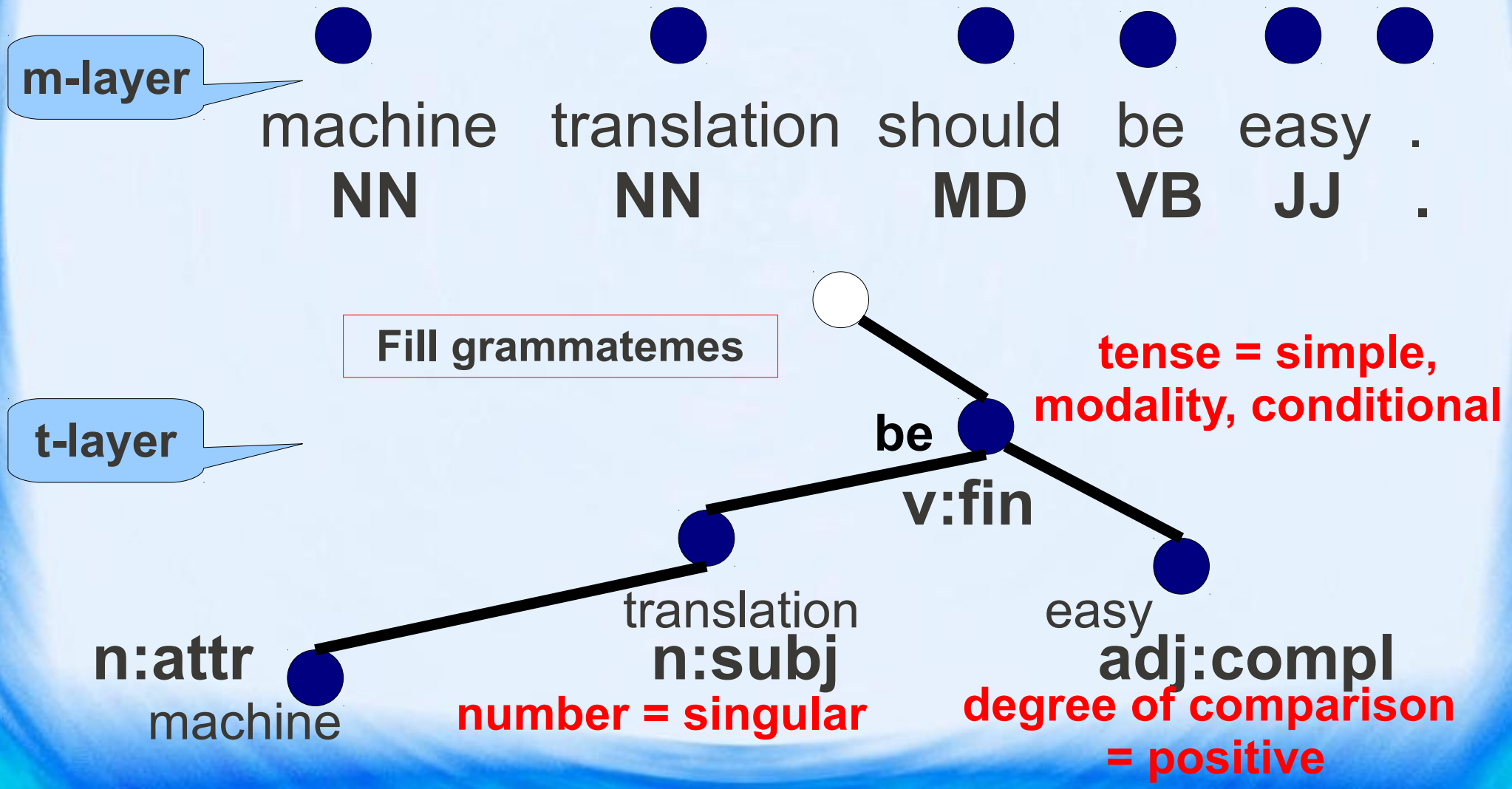


Demo Translation – Analysis

TectoMT

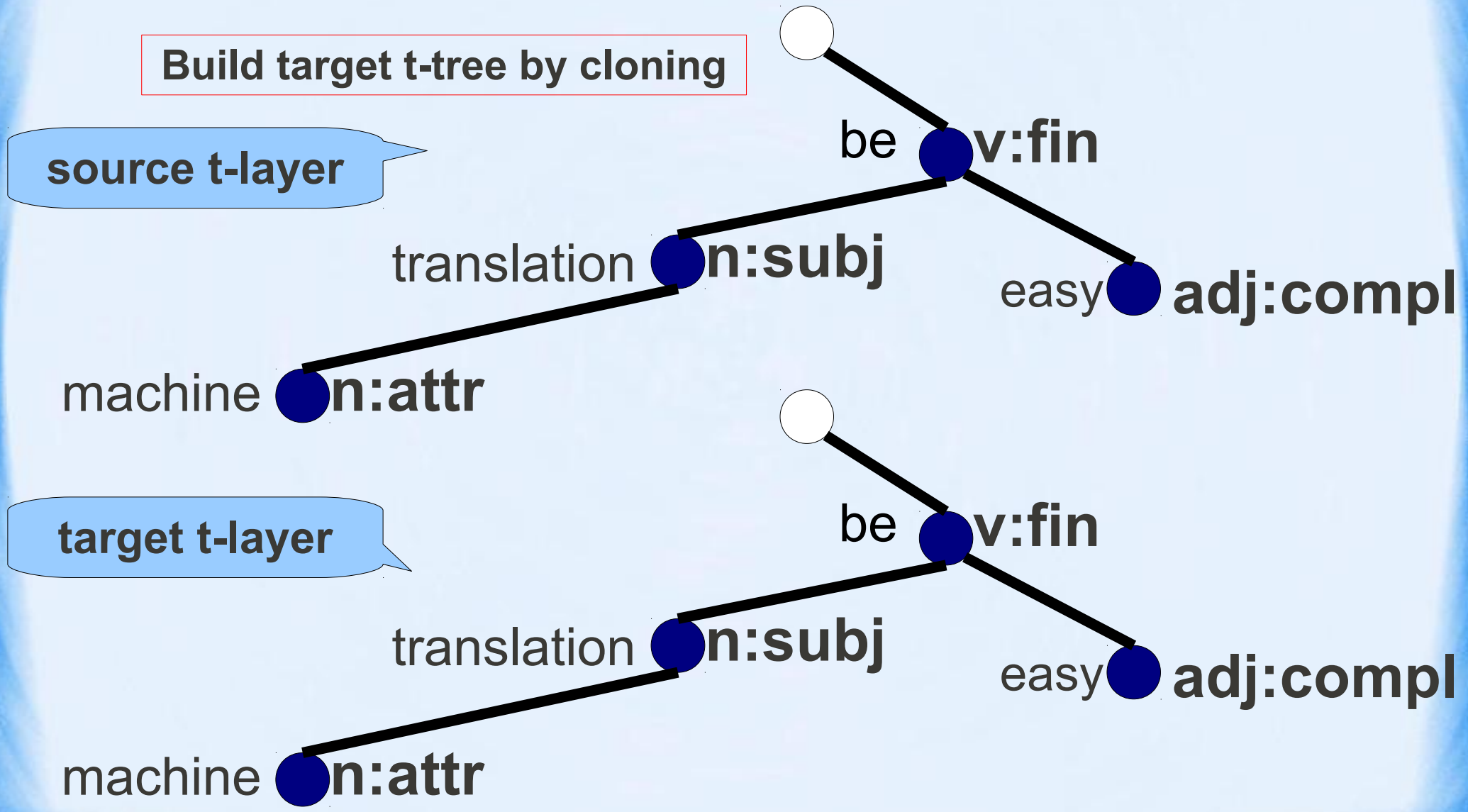
raw text

Machine translation should be easy.



Demo Translation – Transfer

TectoMT

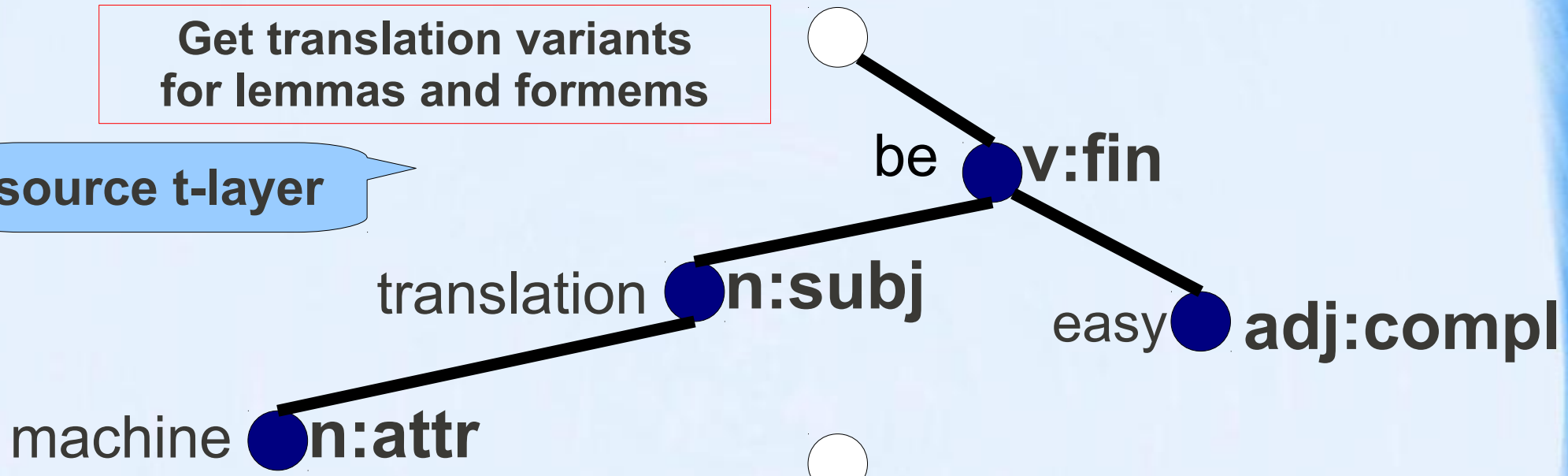


Demo Translation – Transfer

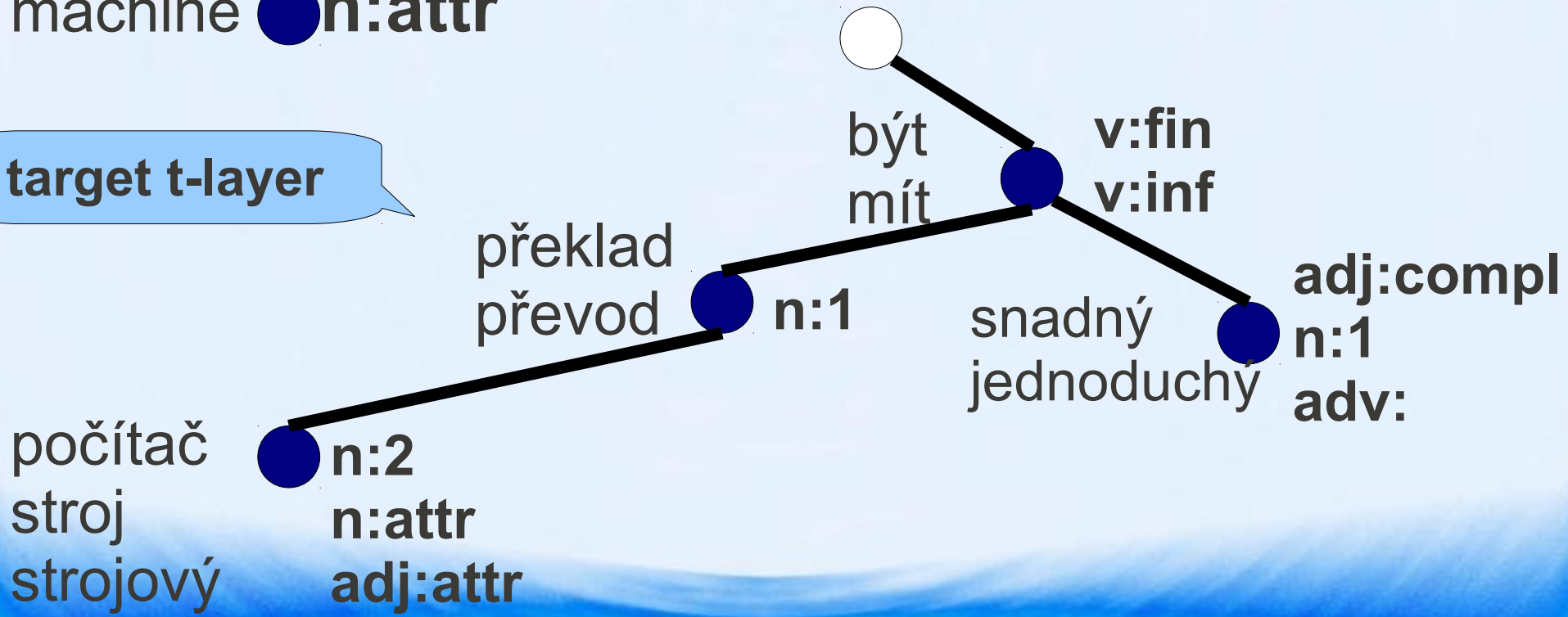
TectoMT

Get translation variants for lemmas and formems

source t-layer



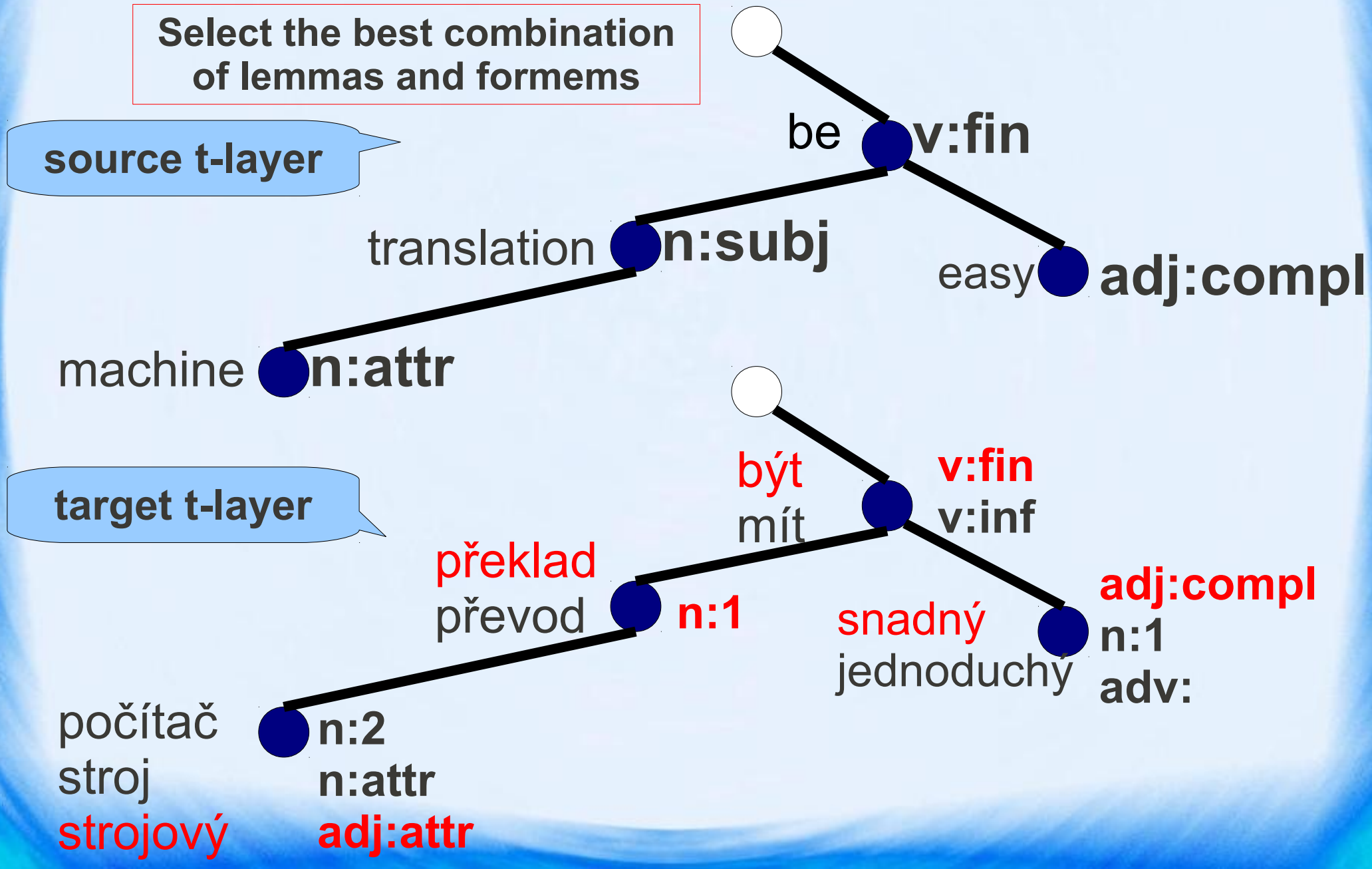
target t-layer



Demo Translation – Transfer

TectoMT

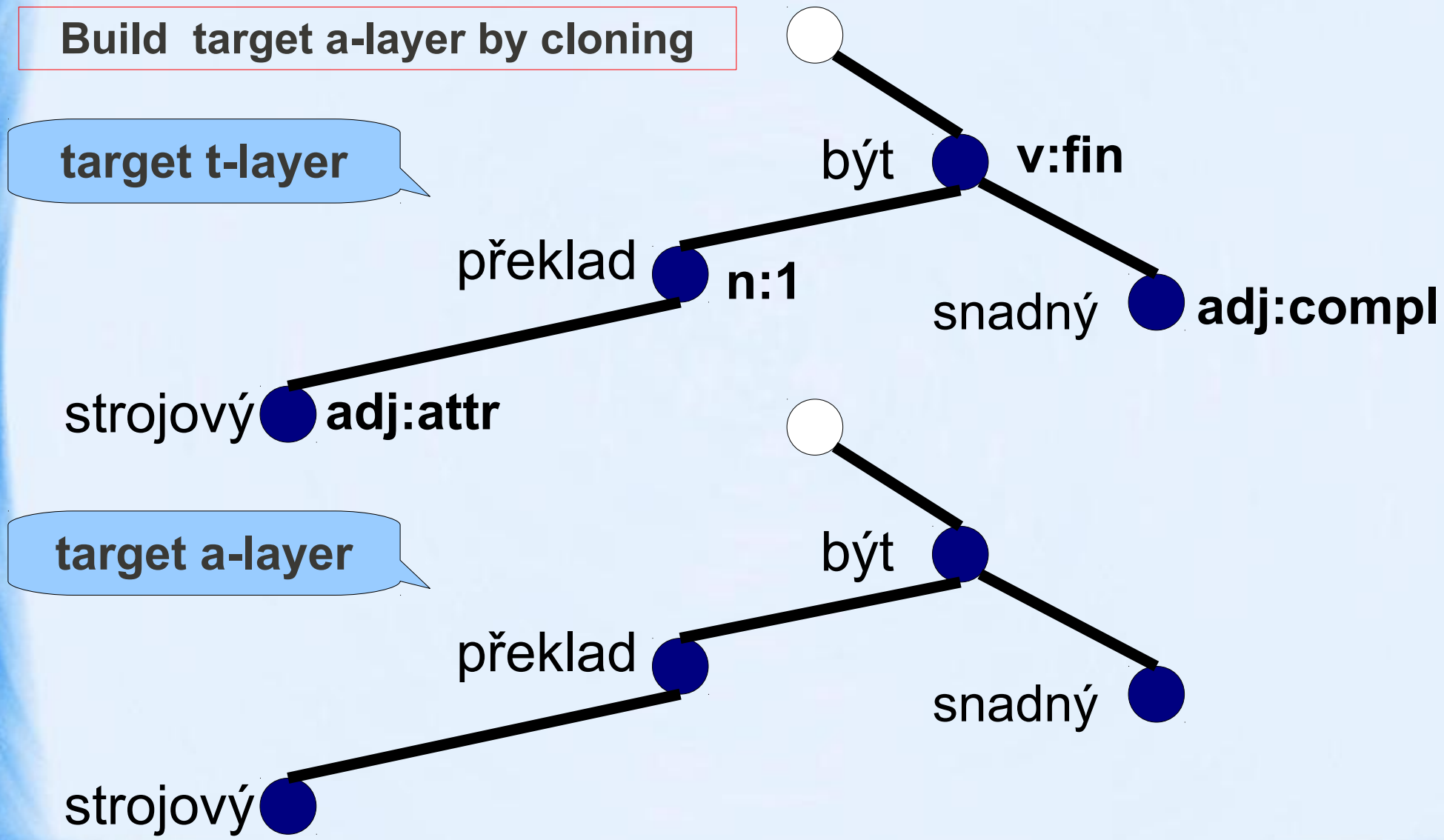
Select the best combination of lemmas and formems



Demo Translation – Synthesis

TectoMT

Build target a-layer by cloning

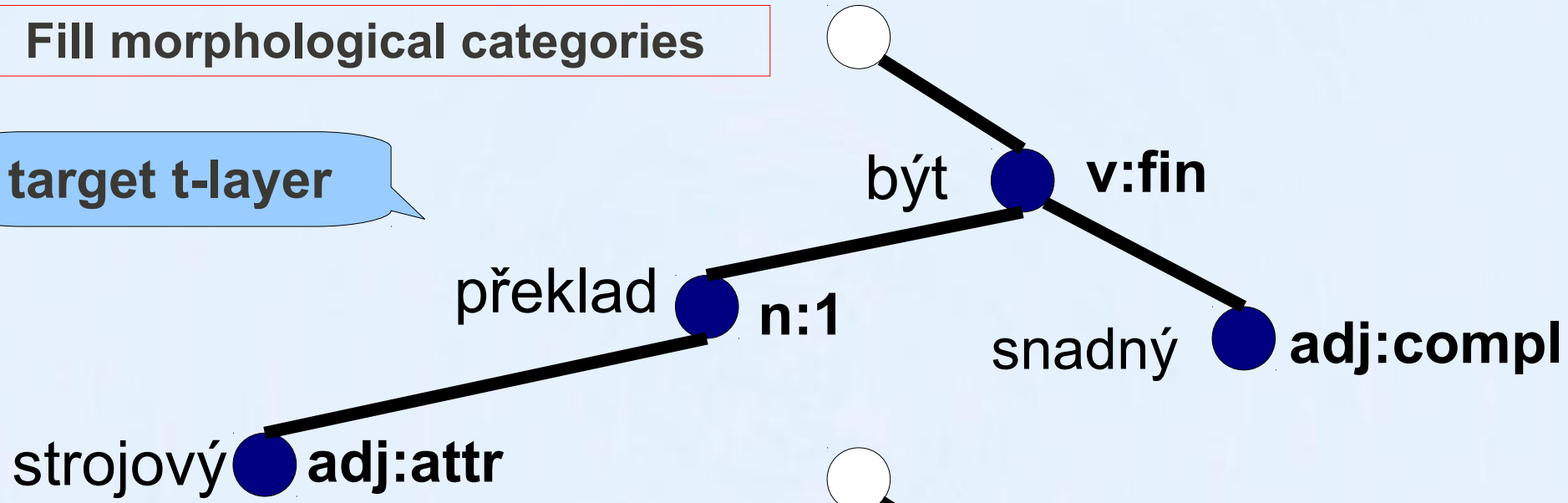


Demo Translation – Synthesis

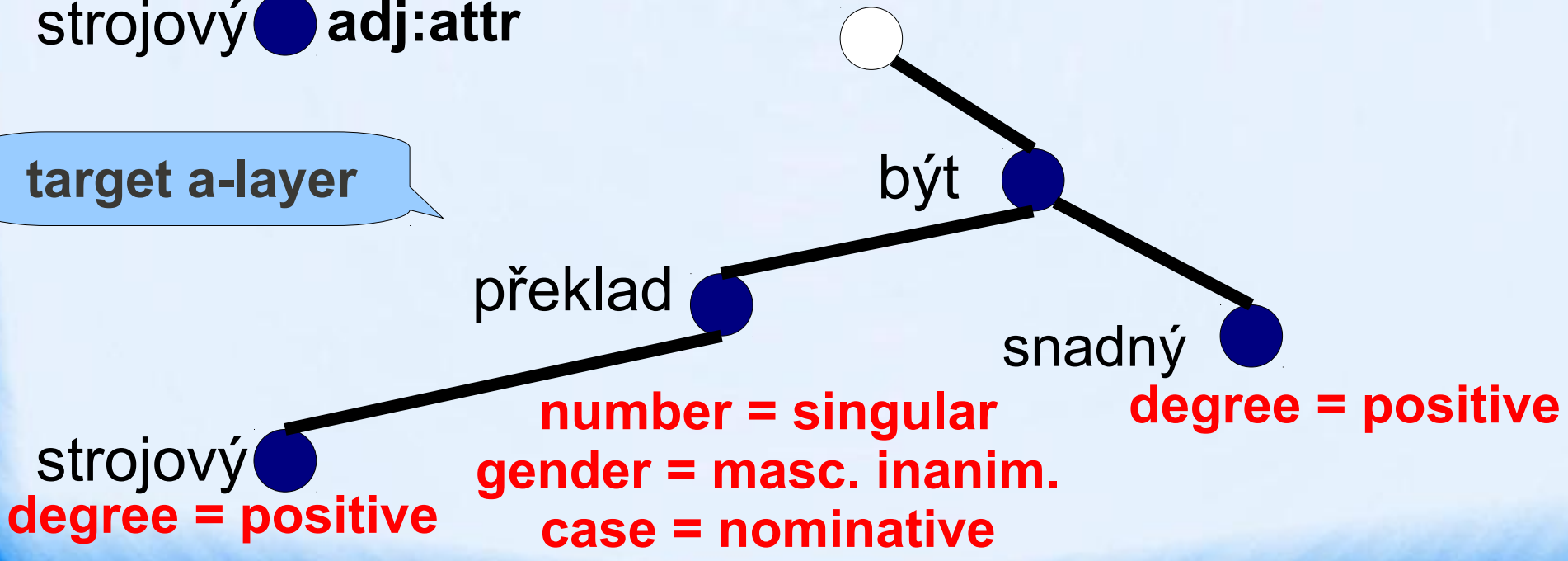
TectoMT

Fill morphological categories

target t-layer



target a-layer

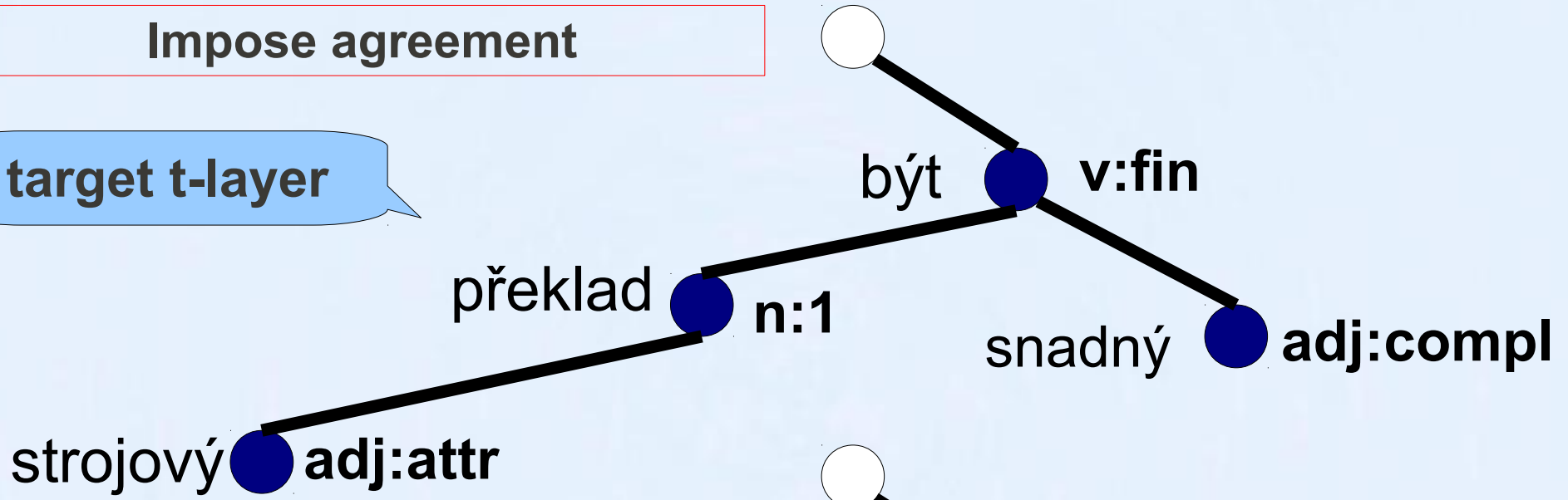


Demo Translation – Synthesis

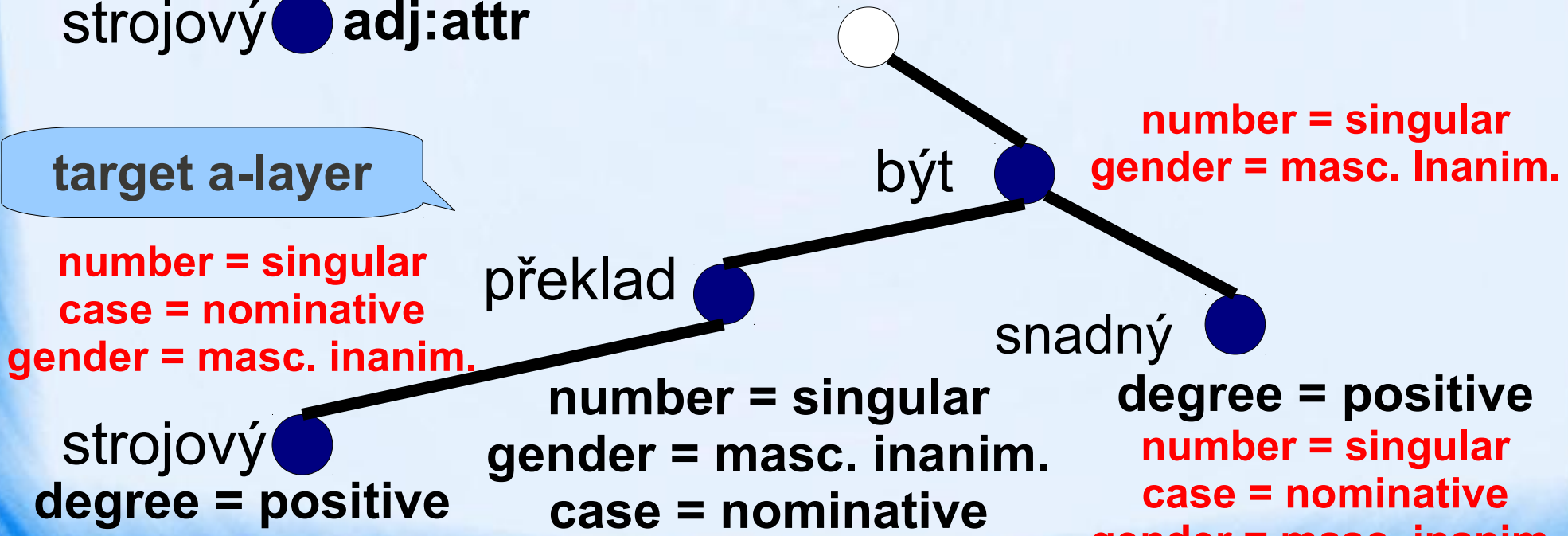
TectoMT

Impose agreement

target t-layer



target a-layer

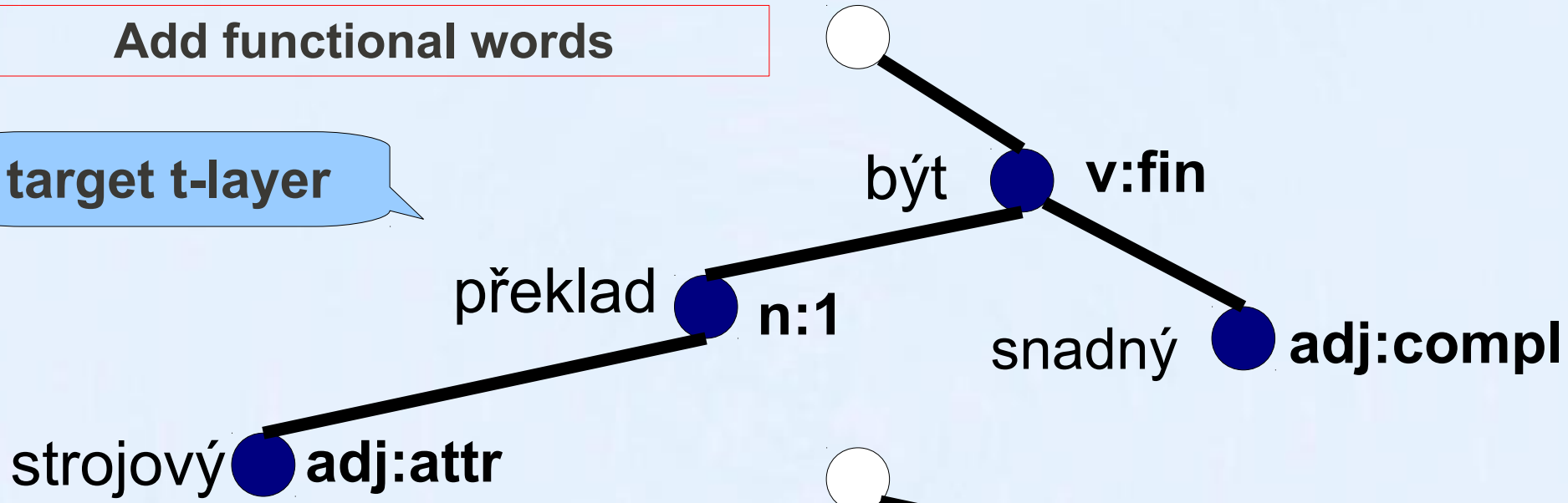


Demo Translation – Synthesis

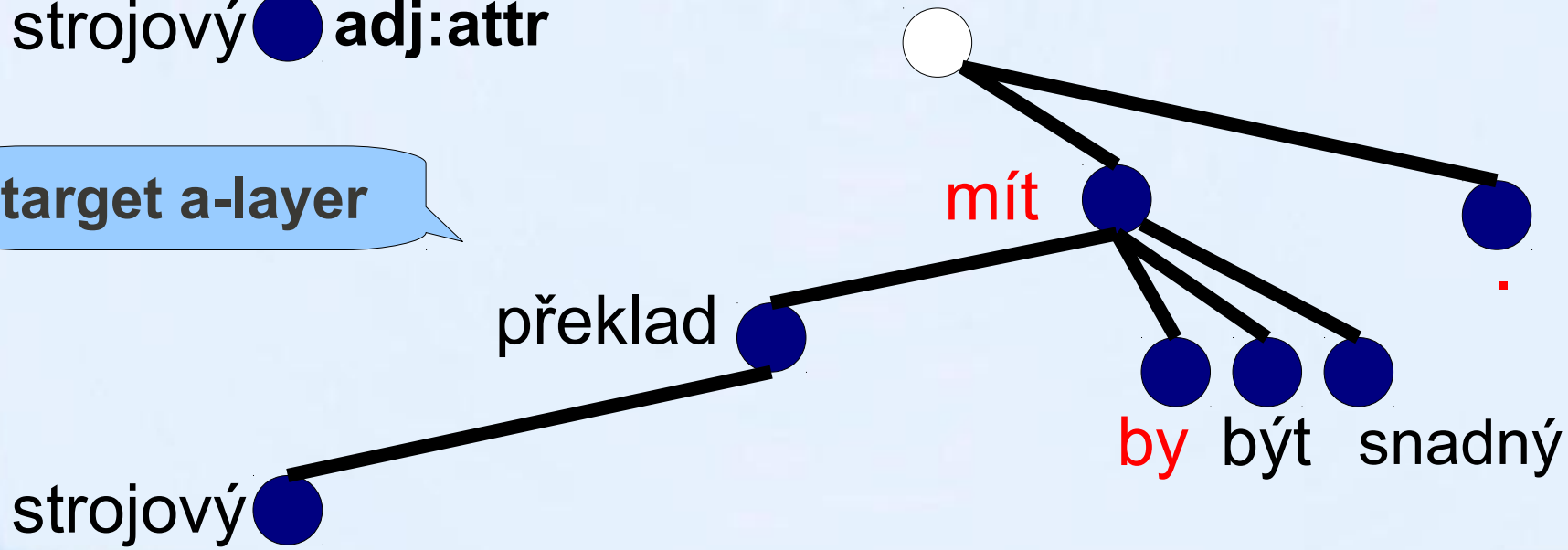
TectoMT

Add functional words

target t-layer



target a-layer

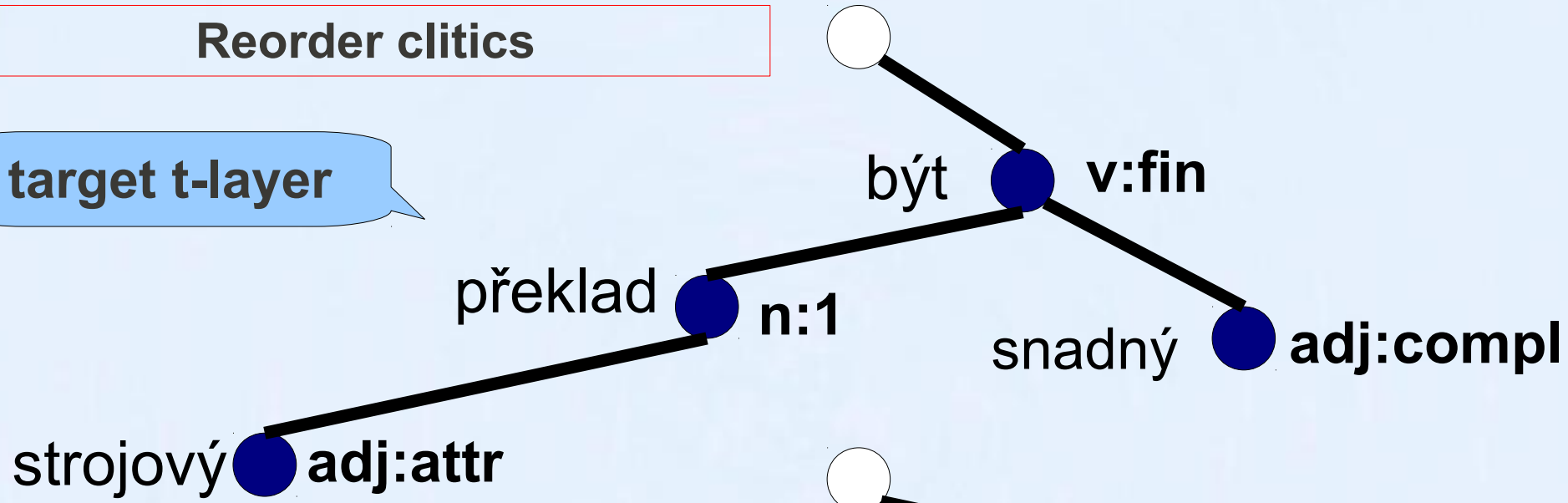


Demo Translation – Synthesis

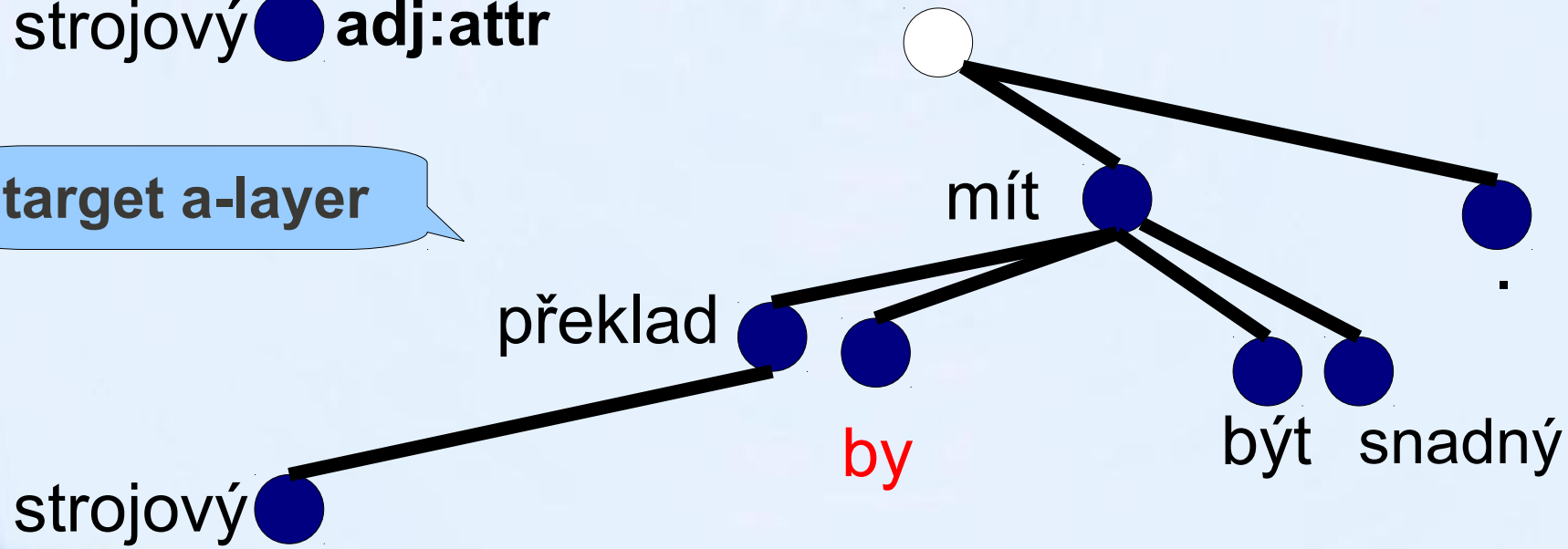
TectoMT

Reorder clitics

target t-layer

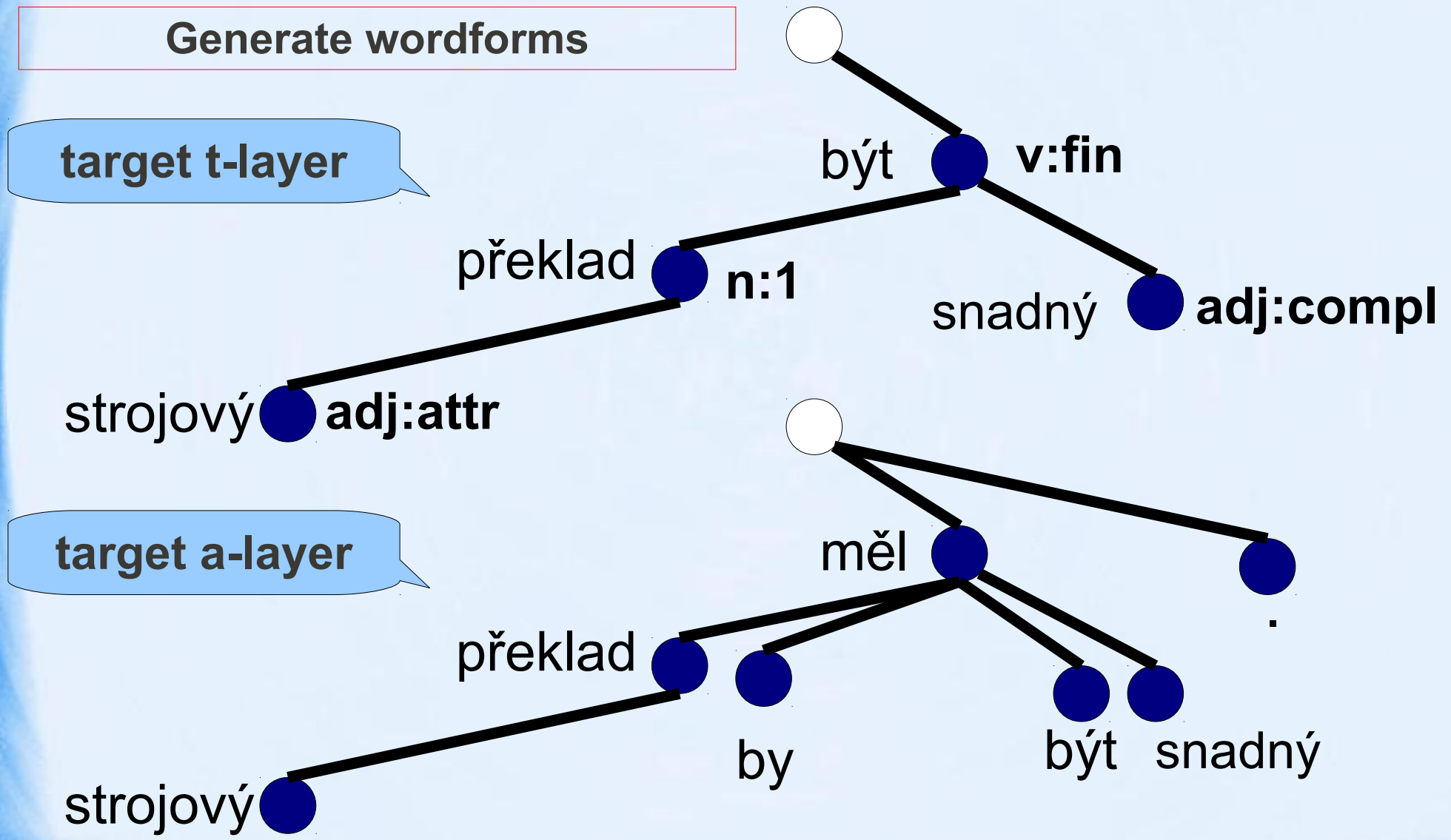


target a-layer



Demo Translation – Synthesis

TectoMT

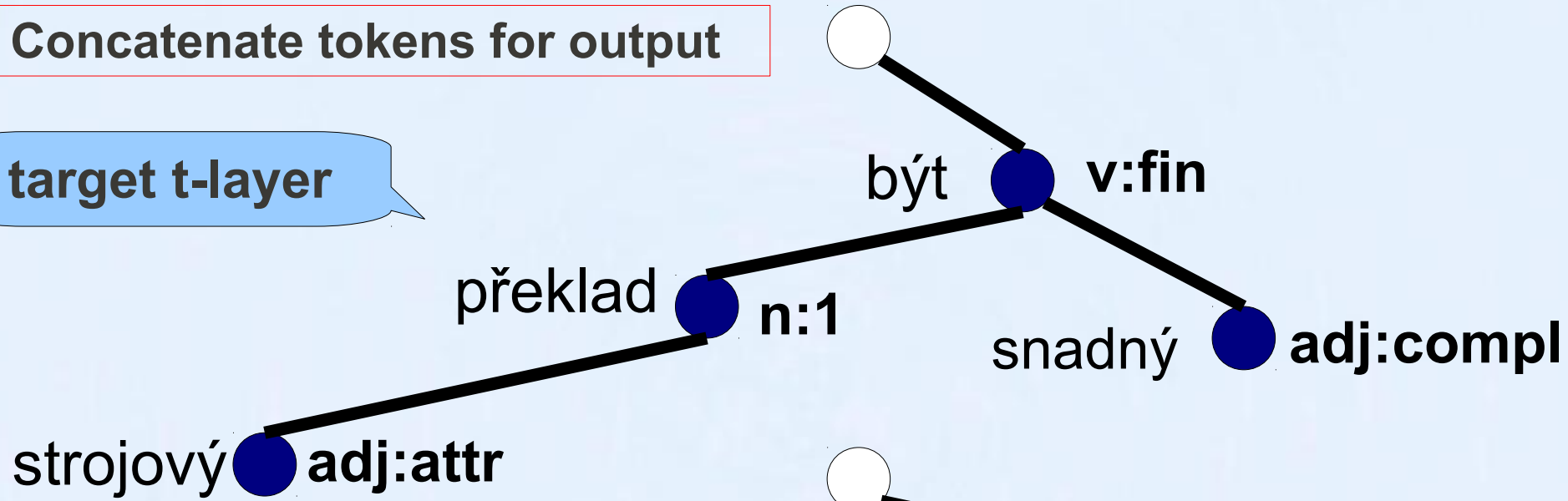


Demo Translation – Synthesis

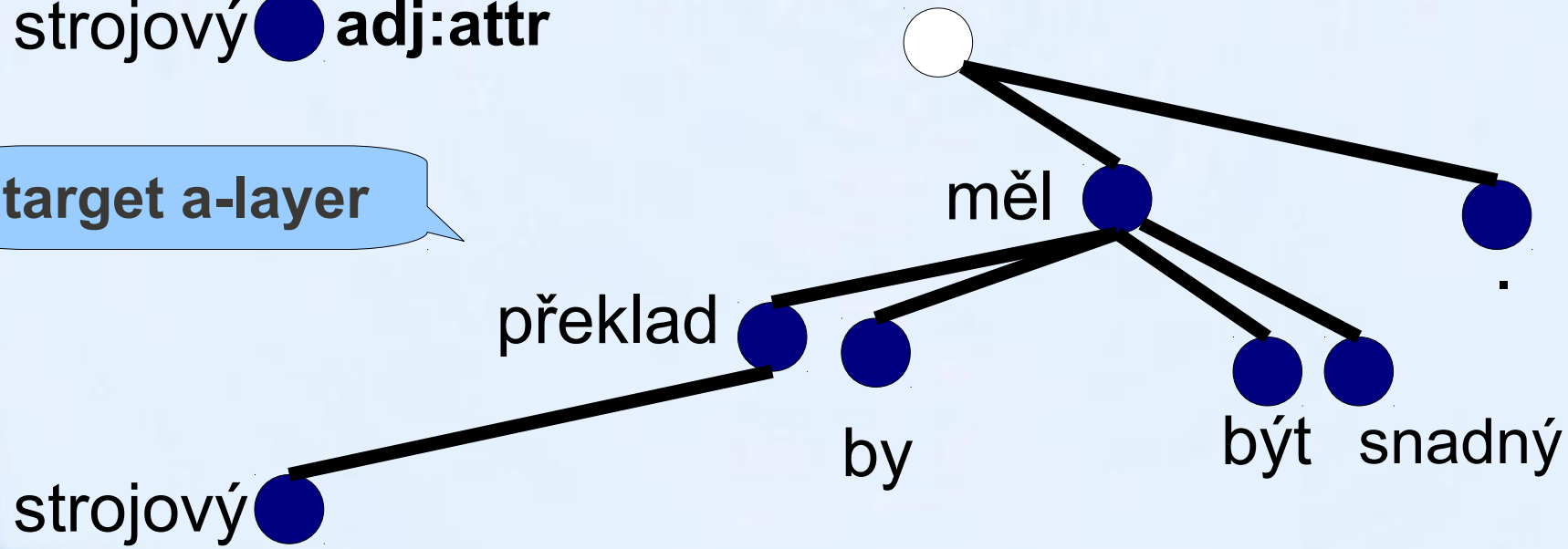
TectoMT

Concatenate tokens for output

target t-layer



target a-layer



Strojový překlad by měl být snadný.

Demo Translation – Real Scenario

TectoMT

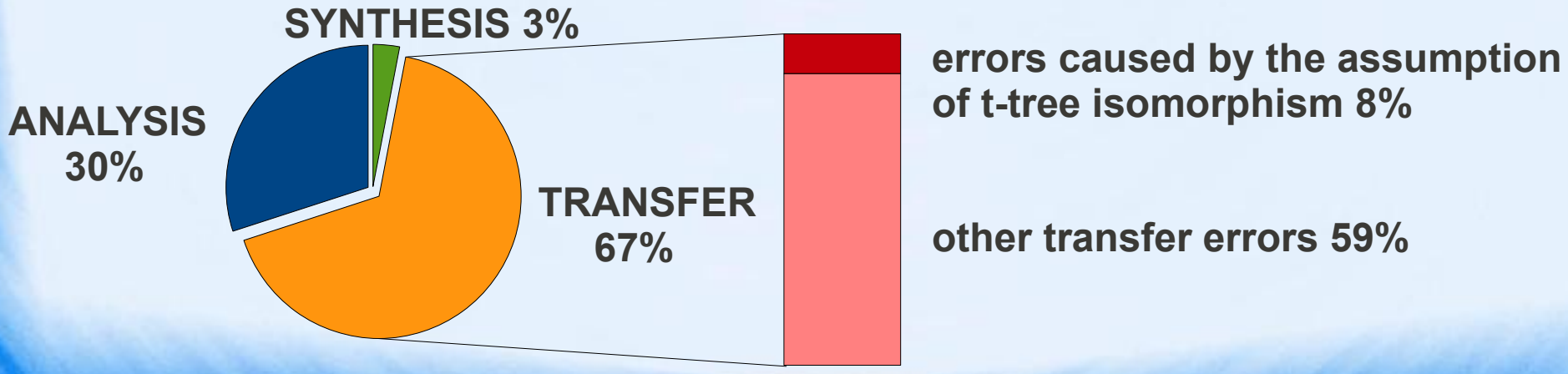
SEnglishW_to_SEnglishM::
Tokenization
Normalize_forms
Fix_tokenization
TagMorce
Fix_mtags
Lemmatize_mtree
SEnglishM_to_SEnglishN::
Stanford_named_entities
Distinguish_personal_names
SEnglishM_to_SEnglishA::
McD_parser
Fill_is_member_from_deprel
Fix_tags_after_parse
McD_parser REPARSE=1
Fill_is_member_from_deprel
Fix_McD_topology
Fix_nominal_groups
Fix_is_member
Fix_atree
Fix_multiword_prep_and_conj
Fix_dicendi_verbs
Fill_afun_AuxCP_Coord
Fill_afun
SEnglishA_to_SEnglishT::
Mark_edges_to_collapse
Mark_edges_to_collapse_neg
Build_ttree
Fill_is_member
Move_aux_from_coord-
_to_members
Fix_tlemmas
Assign_coap_functors
Fix_either_or
Fix_is_member
Mark_clause_heads
Mark_passives
Assign_functors
Mark_infin
Mark_relclause_heads
Mark_relclause_coref
Mark_dsp_root
Mark_parentheses
Recompute_deepord
Assign_nodetype
Assign_grammatemes
Detect_formeme
Rehang_shared_attr
Detect_voice
Fix_imperatives
Fill_is_name_of_person
Fill_gender_of_person
Add_cor_act
Find_text_coref
SEnglishT_to_TCzechT::
Clone_ttree
Translate_LF_phrases
Translate_LF_joint_static
Delete_superfluous_tnodes
Translate_F_try_rules
Translate_F_add_variants
Translate_F_rerank
Translate_L_try_rules
Translate_L_add_variants
Translate_LF_numerals_by_rules
Translate_L_filter_aspect
Transform_passive_constructions
Prune_personal_name_variants
Remove_unpassivizable_variants
Translate_LF_compounds
Cut_variants
Rehang_to_eff_parents
Translate_LF_tree_Viterbi
Rehang_to_orig_parents
Fix_transfer_choices
Translate_L_female_surnames
Add_noun_gender
Add_relpron_below_rc
Change_Cor_to_PersPron
Add_PersPron_below_vfin
Add_verb_aspect
Fix_date_time
Fix_grammatemes_after_transfer
Fix_negation
Move_adjectives_before_nouns
Move_genitives_to_postposit
Move_relclause_to_postposit
Move_dicendi_closer_to_dsp
Move_PersPron_next_to_verb
Move_enough_before_adj
Fix_money
Recompute_deepord
Find_gram_coref_for_refl_pron
Neut_PersPron_gender_from_antec
Override_pp_with_phrase_translation
Valency_related_rules
Fill_clause_number
Turn_text_coref_to_gram_coref
TCzechT_to_TCzechA::
Clone_atree
Distinguish_homonymous_mlemmas
Reverse_number_noun_dependency
Init_morphcat
Fix_possessive_adjectives
Mark_subject
Impose_pron_z_agr
Impose_rel_pron_agr
Impose_subjpred_agr
Impose_attr_agr
Impose_compl_agr
Drop_subj_pers_prons
Add_prepositions
Add_subconjs
Add_reflex_particles
Add_auxverb_compound_passive
Add_auxverb_modal
Add_auxverb_compound_future
Add_auxverb_conditional
Add_auxverb_compound_past
Add_clausal_expletive_pronouns
Resolve_verbs
Project_clause_number
Add_parentheses
Add_sent_final_punct
Add_subord_clause_punct
Add_coord_punct
Add_apposition_punct
Choose_mlemma_for_PersPron
Generate_wordforms
Move_clitics_to_wackernagel
Recompute_ordering
Delete_superfluous_prepos
Delete_empty_nouns
Vocalize_prepositions
Capitalize_sent_start
Capitalize_named_entities
TCzechA_to_TCzechW::
Concatenate_tokens
Ascii_quotes
Remove_repeated_tokens

Annotation of Translation Errors

TectoMT

sample of 250 sentences, 1463 errors in total

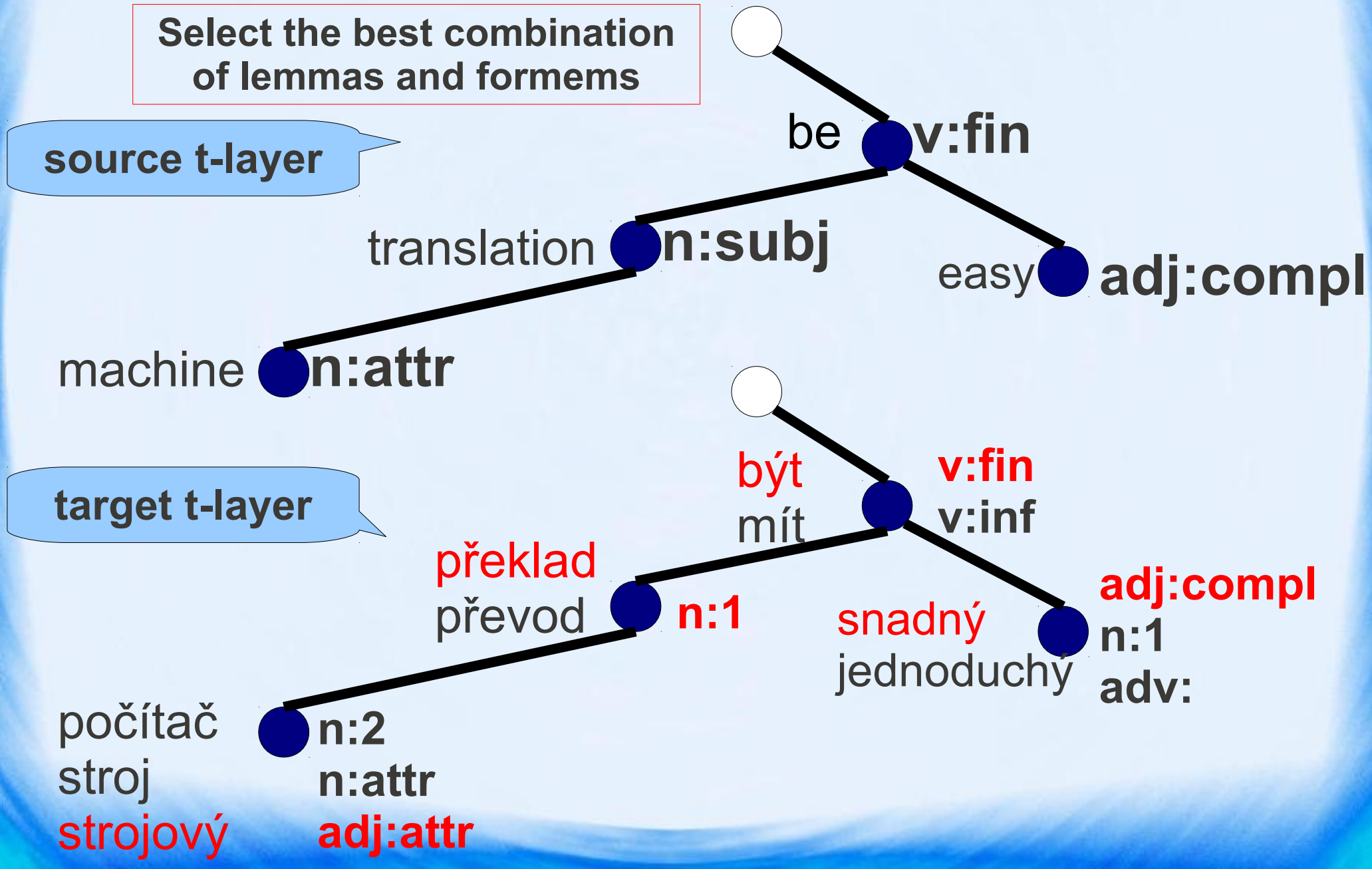
Type	lemma, formeme, gram., w. order,...
Subtype	gram: gender, person, tense,...
Seriousness	serious, minor
Circumstances	coordination, named entity, numbers
Source	tok, lem, tagger, parser, tecto, trans, x, syn, ?



HMTM – Motivation

TectoMT

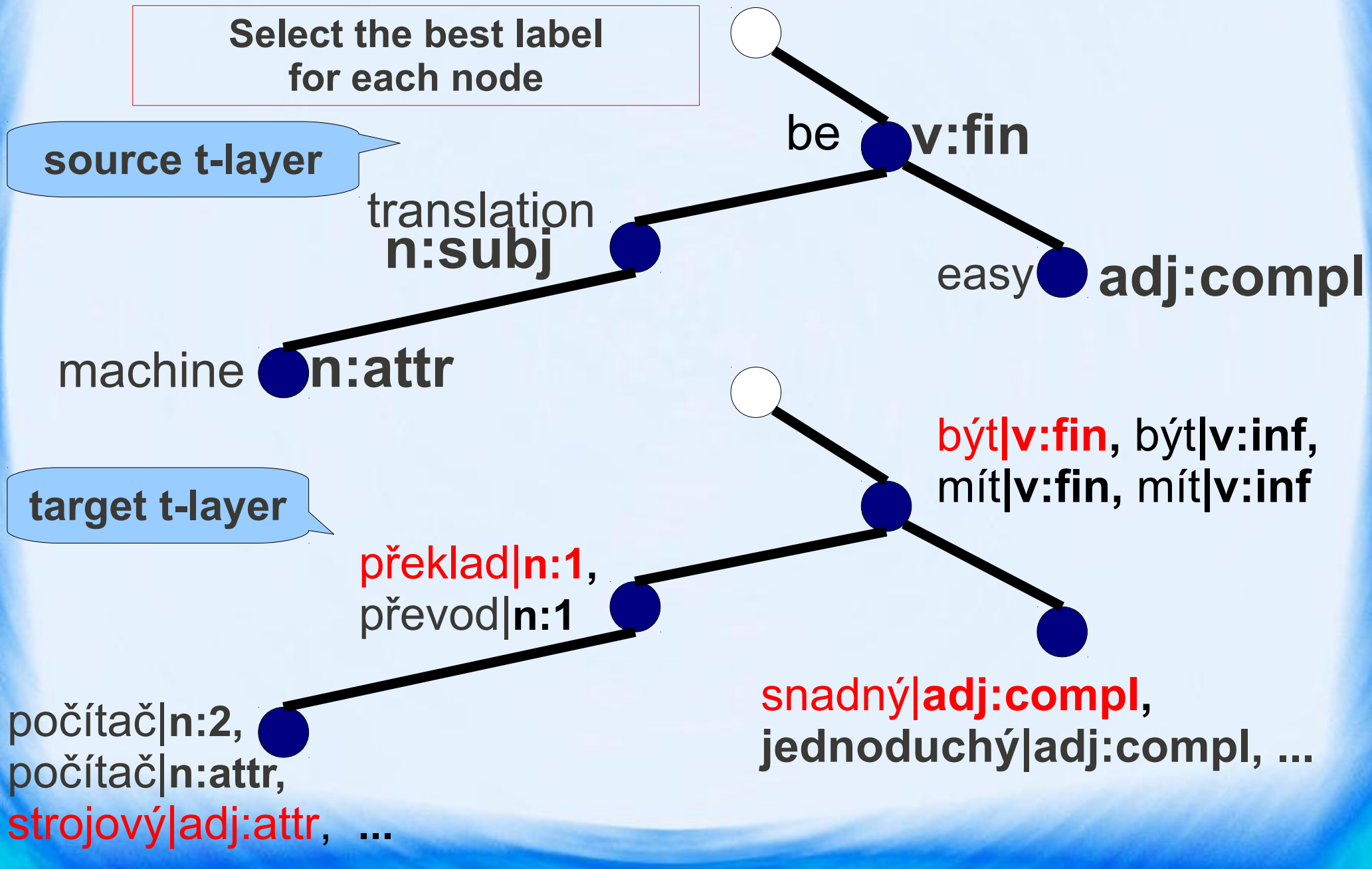
Select the best combination of lemmas and formems



HMTM – Motivation

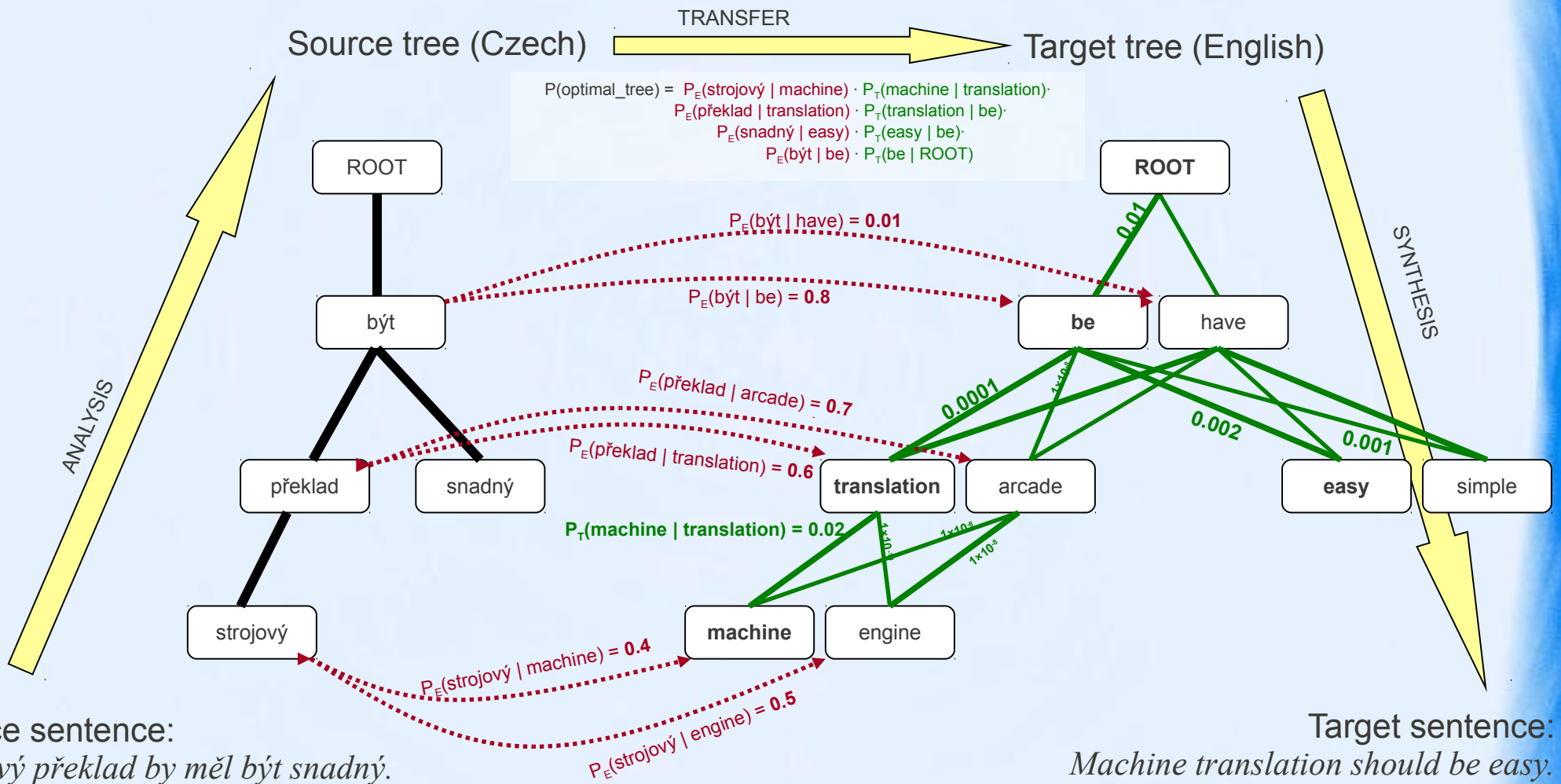
TectoMT

Select the best label for each node



HMTM in MT

TectoMT



P_E(source | target) … emission probabilities … **translation model**

P_T(dependent | governing) … transition probabilities … **target-language tree model**

Combining Dictionaries

TectoMT

- new general interface (for lemmas and formems)

```
$dict->get_translations($input_label, $features)
```

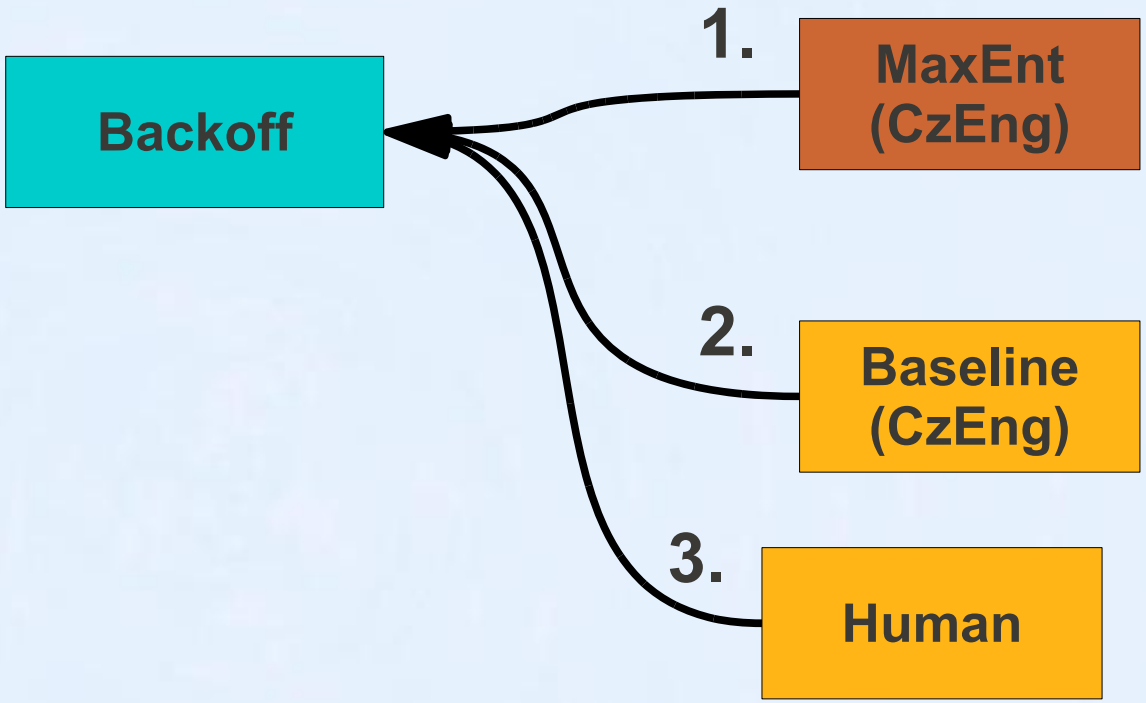
returns a list of translation variants including probabilities

- OOP style, dictionary constructor can take another dictionary (or more) as a parameter → hierachy
- Four basic types of dictionaries:

Static plain	loaded from a file „lemma → lemma“
Context	loaded from a file „lemma,features → lemma“
Derivational	translations derived dynamicaly, input dictionary
Combinaional	combination of more input dictionaries

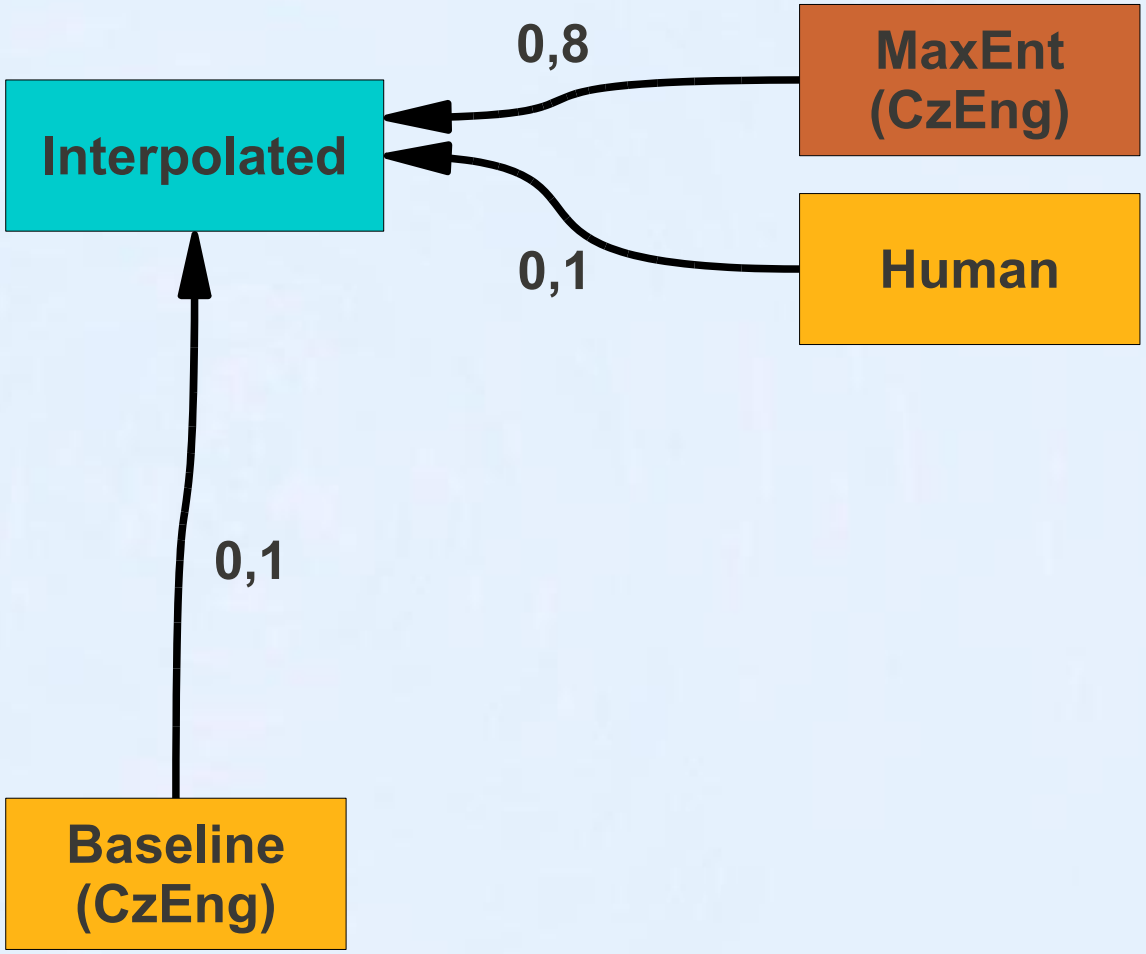
Hierarchy of lemma dictionaries

TectoMT



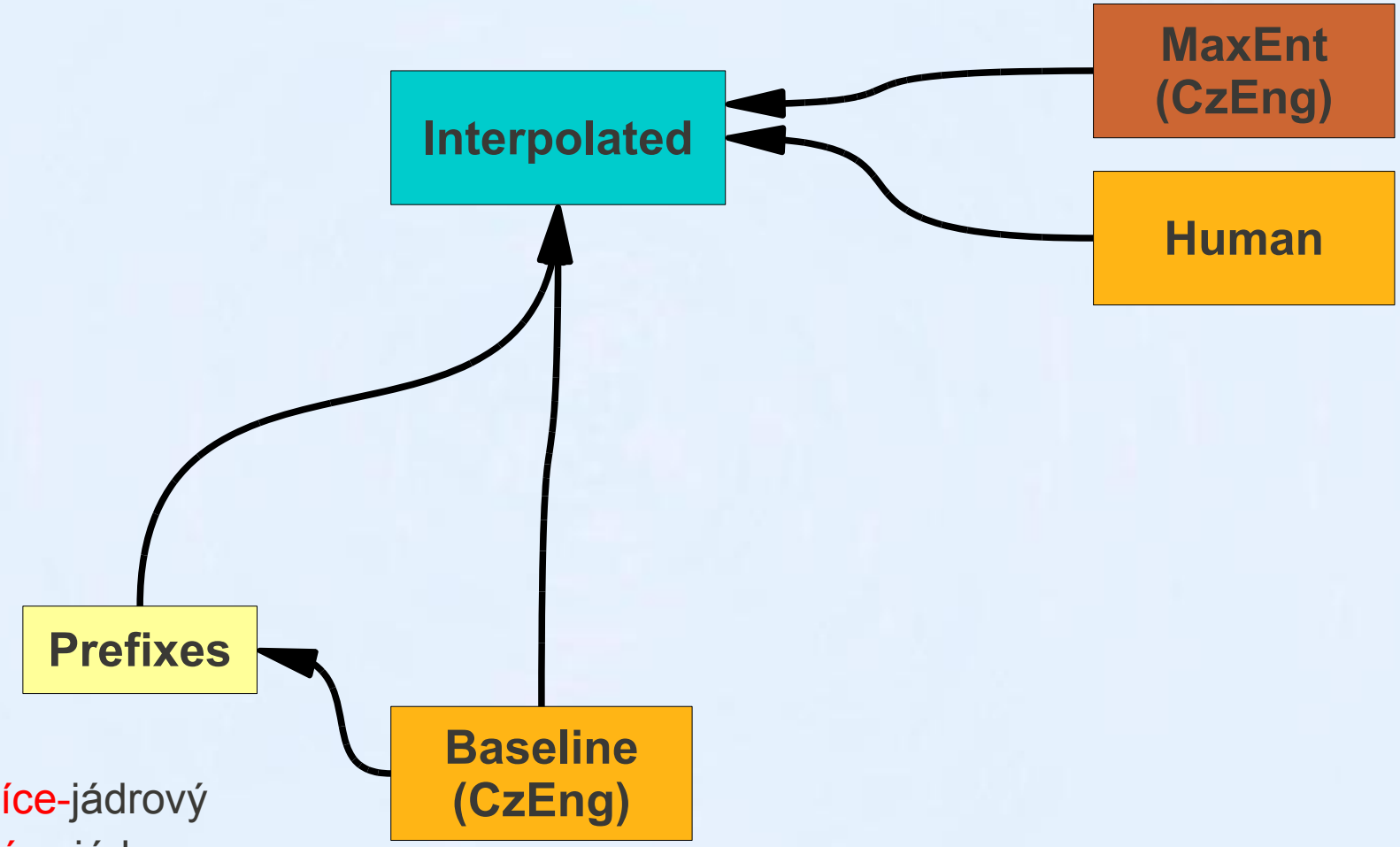
Hierarchy of lemma dictionaries

TectoMT



Hierarchy of lemma dictionaries

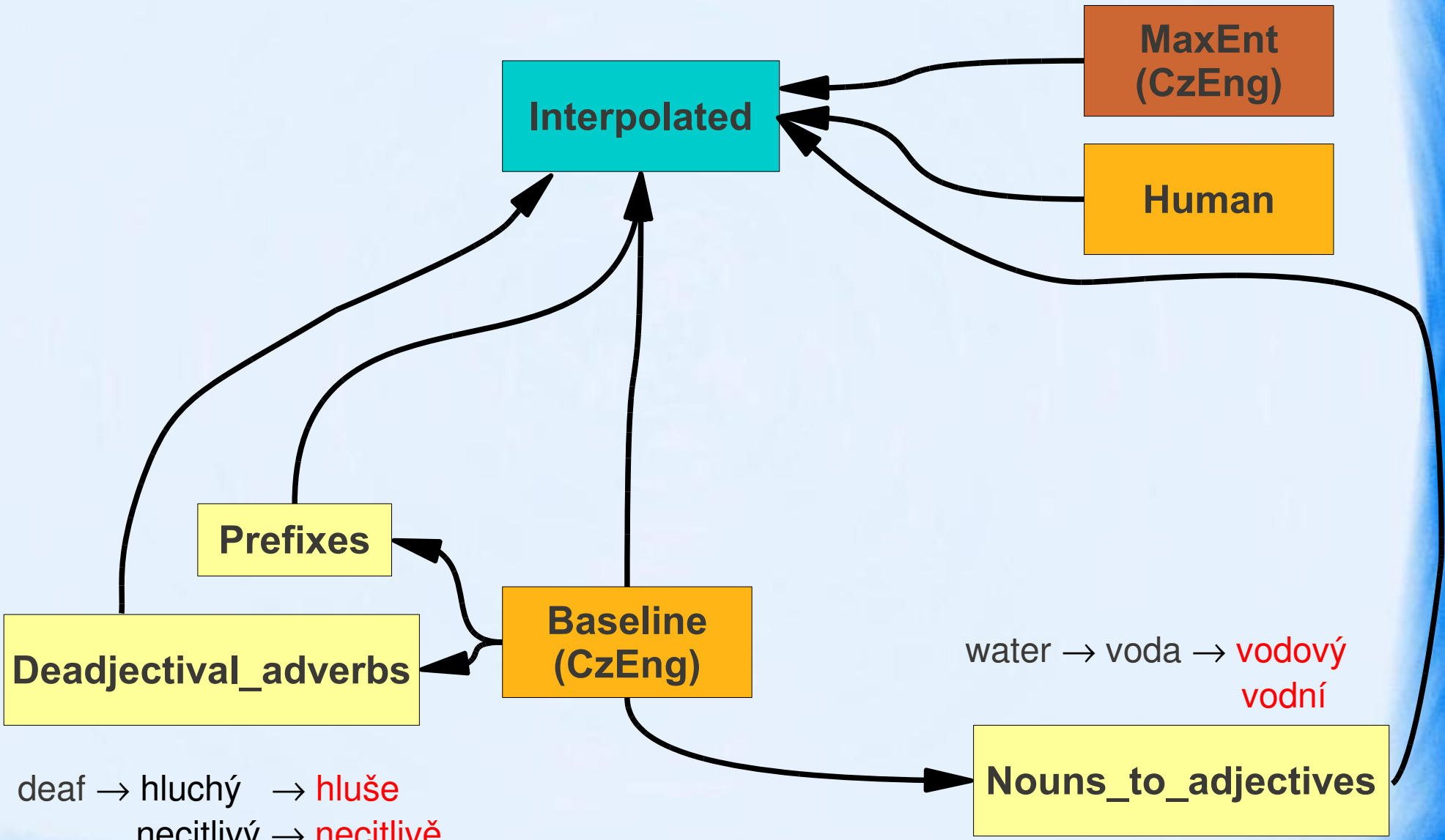
TectoMT



multi-core → více-jádrový
více-jádro
multi-jádrový
multi-jádro

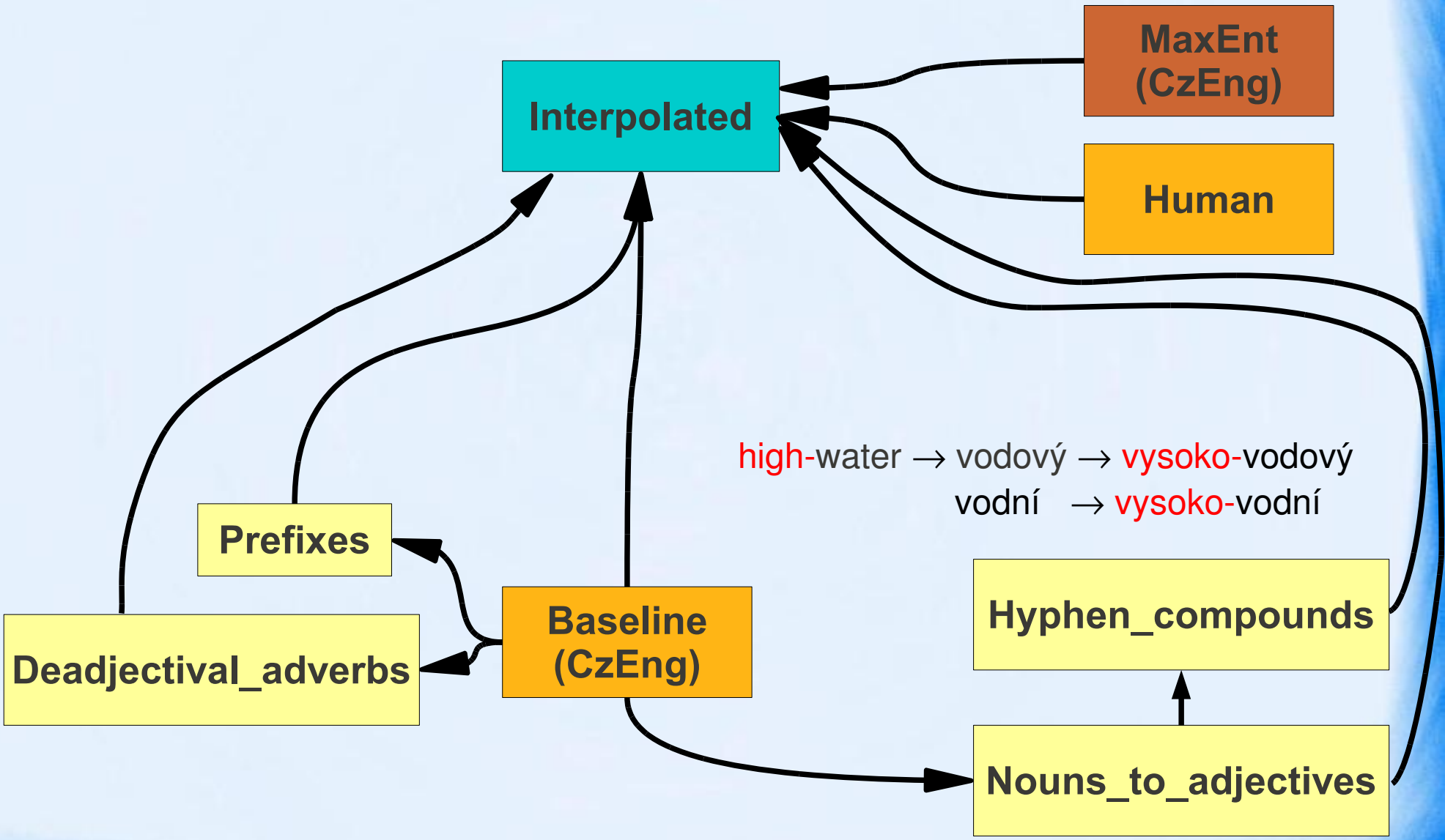
Hierarchy of lemma dictionaries

TectoMT



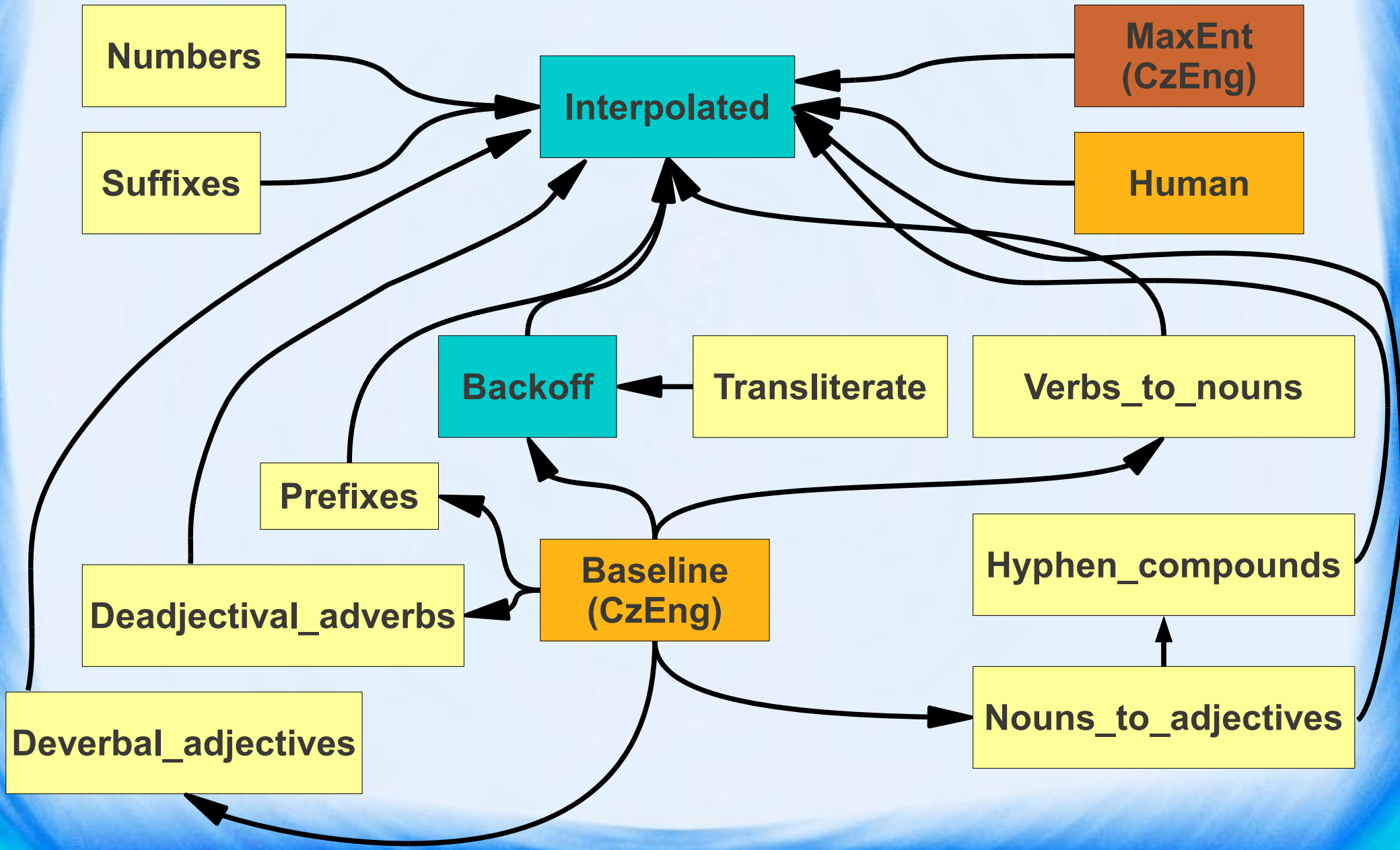
Hierarchy of lemma dictionaries

TectoMT



Hierarchy of lemma dictionaries

TectoMT



Maximum Entropy Dictionary

TectoMT

Baseline Dictionary

$$p(y|x) = \frac{count(x, y)}{count(x)}$$

- Maximum likelihood estimates (from the training sections of CzEng 0.9)
- Pruned by thresholds on *p(x|y)* and *p(y|x)*
- No context used
  x = source lemma
  y = target lemma

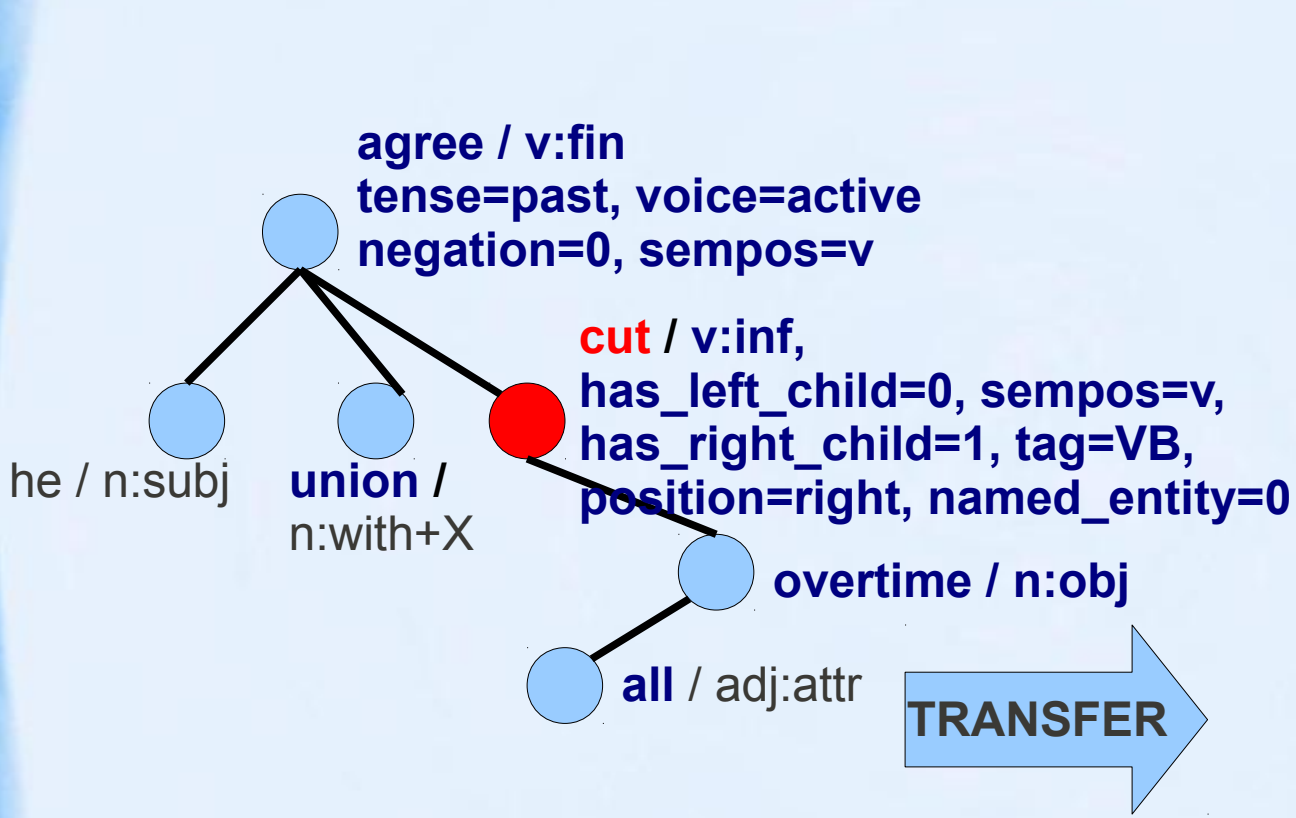
MaxEnt Dictionary

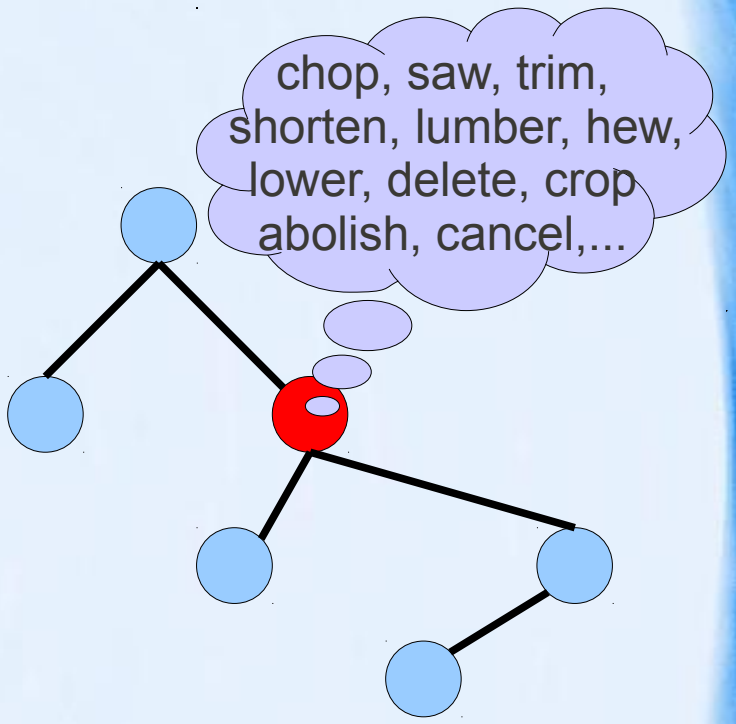
$$p(y|x) = \frac{1}{Z(x)} \exp \sum_i \lambda_i f_i(x, y)$$

- One MaxEnt model for each source lemma (same training data as for the Baseline Dict.)
- Interpolated with Baseline Dict. (due to pruning)
- Context features used (x = source context)
  - local tree context
  - local linear context
  - morphological & syntactic categories
  - ...

Maximum Entropy Dictionary

TectoMT





ANALYSIS

SYNTHESIS

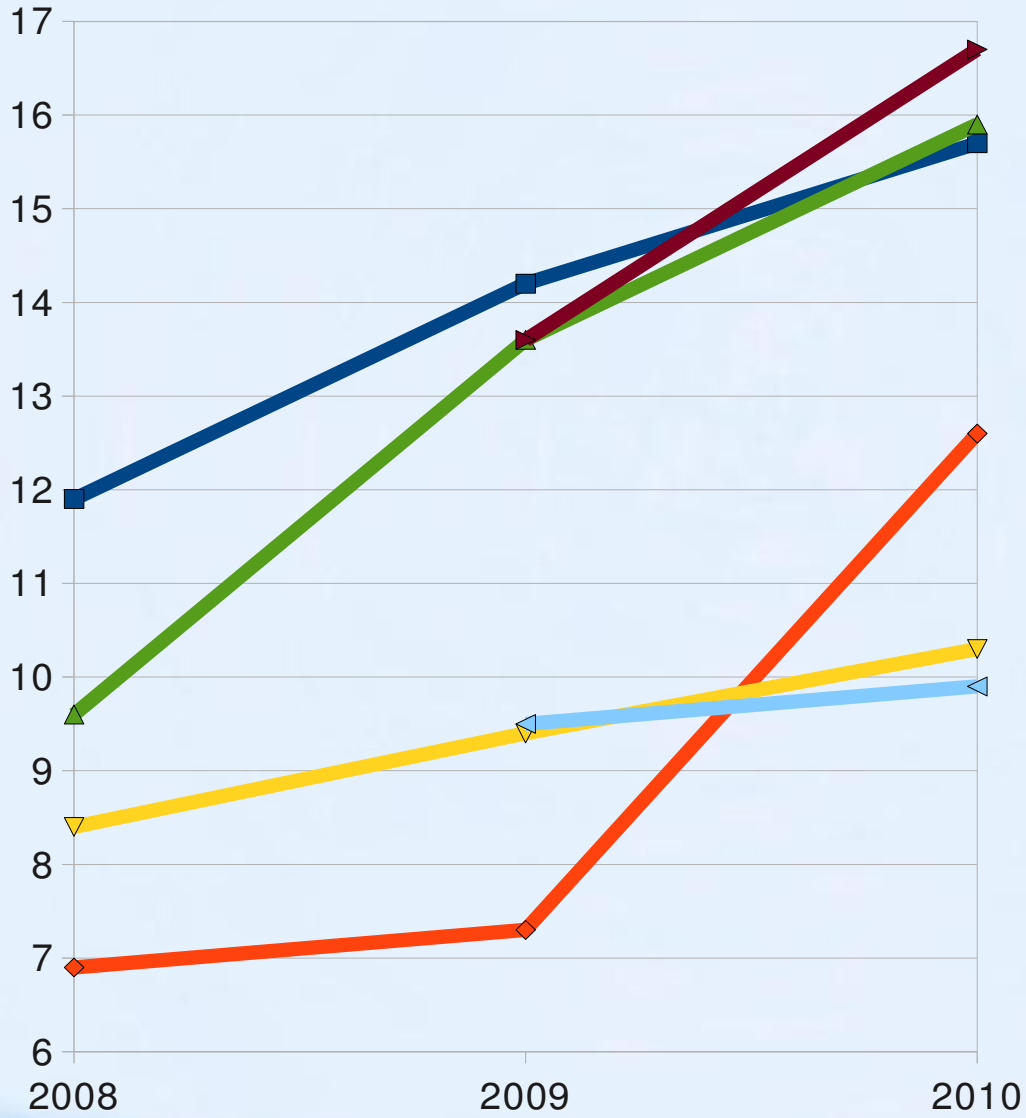
He agreed with the unions to cut all overtime.

Dohodl se s odbory na zrušení všech přesčasů.

Results – BLEU

TectoMT

WMT = Workshop on Statistical Machine Translation

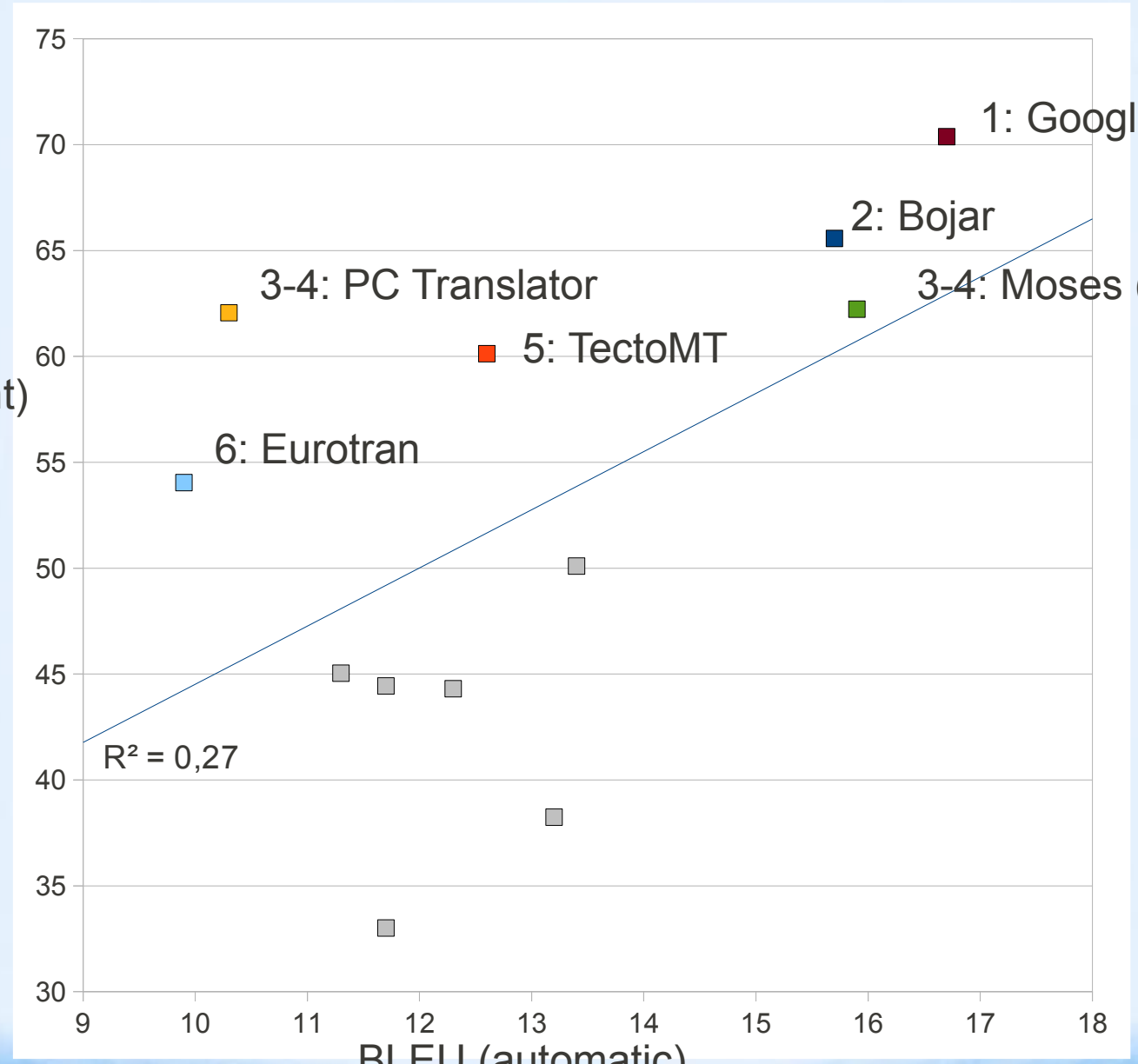


TectoMT:

Year		BLEU
2008	WMT	6,9
2009	WMT	7,3
2009/09		10,2
2010/01		10,4
2010/02		11,3
2010/03	WMT	12,6

WMT results: http://matrix.statmt.org

Results – BLEU vs. Ranks



Examples of Translation (2009)

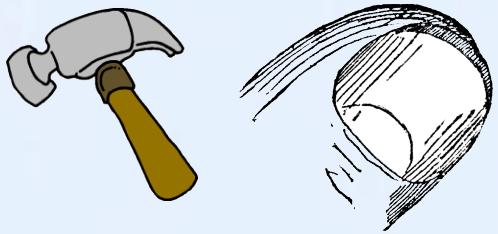
TectoMT

A miss by an inch
is a miss by a mile.

Slečna palec je slečna miliónu.

I'd rather be a hammer
than a nail.

Spíše bych byl kladivo než nehet.

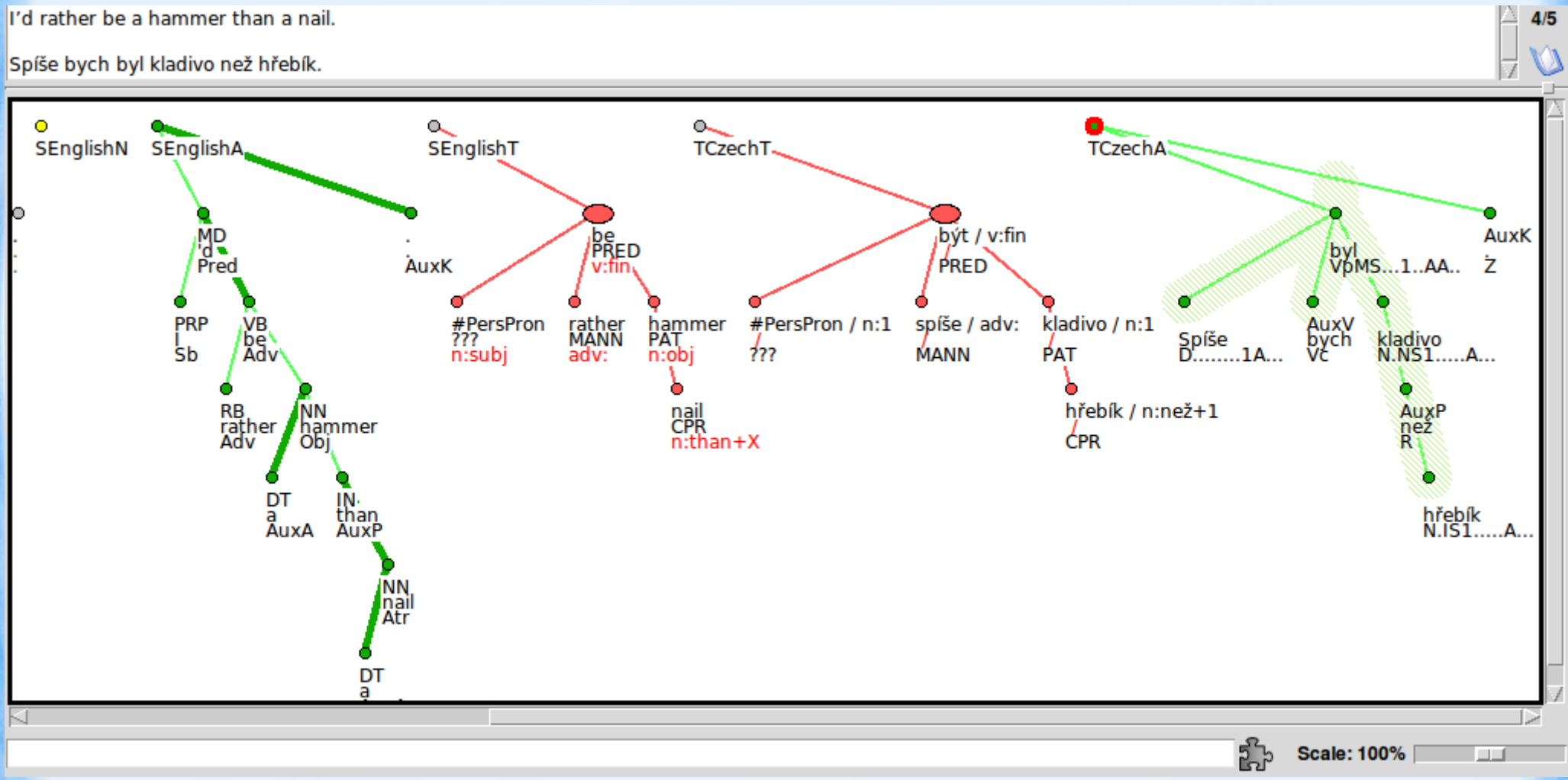


A bird in the hand is worth
two in the bush.

Pták v ruce je cenný
dvakrát v Bushovi.

Example of Translation (2010)

TectoMT



Sample of MaxEnt Features

TectoMT

input_label=nail

output_label=hřebík#N (metal nail)

child_formeme_n:in+X=1	1.64483855116042
is_member=1	1.30042900630692
child_formeme_v:fin=1	1.04422203176176
next_node_tlemma=down	0.838961007712912
is_capitalized=1	0.792130821958927
position=right	0.747785245407306
tense_g=post	0.744919903760696
voice_g=active	0.659489975893991
prev_node_tlemma=drive	0.655357850937254
parent_capitalized=1	0.622953832124697
formeme=n:from+X	0.599348506643414
prev_node_tlemma=hammer	0.592276691427986
child_tlemma_few=1	0.553464629114697
child_tlemma_remove=1	0.546698831608057
sempos=n.denot	0.504719359514573
next_node_tlemma=and	0.502529618088752
formeme_g=v:until+fin	0.491064112122981
child_tlemma_rusty=1	0.428884558837039
tag_g=VBP	0.422967377093101
next_node_tlemma=screw	0.344701934524519
...	

output_label=nehet#N (fingernail or toenail)

child_formeme_n:poss=1	1.32717038827268
child_tlemma_finger=1	1.07509772743853
child_formeme_n:of+X=1	0.982021327950337
position=left	0.886912864256063
prev_node_tlemma=black	0.770671304450658
child_tlemma_broken=1	0.761077744287099
child_formeme_v:attr=1	0.700099311992958
formeme=n:at+X	0.674547829214778
formeme_g=n:attr	0.673367412957367
child_tlemma_long=1	0.673158400394094
next_node_tlemma=file	0.600496248030202
child_tlemma_false=1	0.584236638145312
prev_node_tlemma=false	0.584236638145312
number=sg	0.563056142428995
formeme=n:obj	0.533943098032196
formeme=n:by+X	0.528852315800188
...	