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Depfix:

Automatic post-editing of phrase-based machine translation outputs

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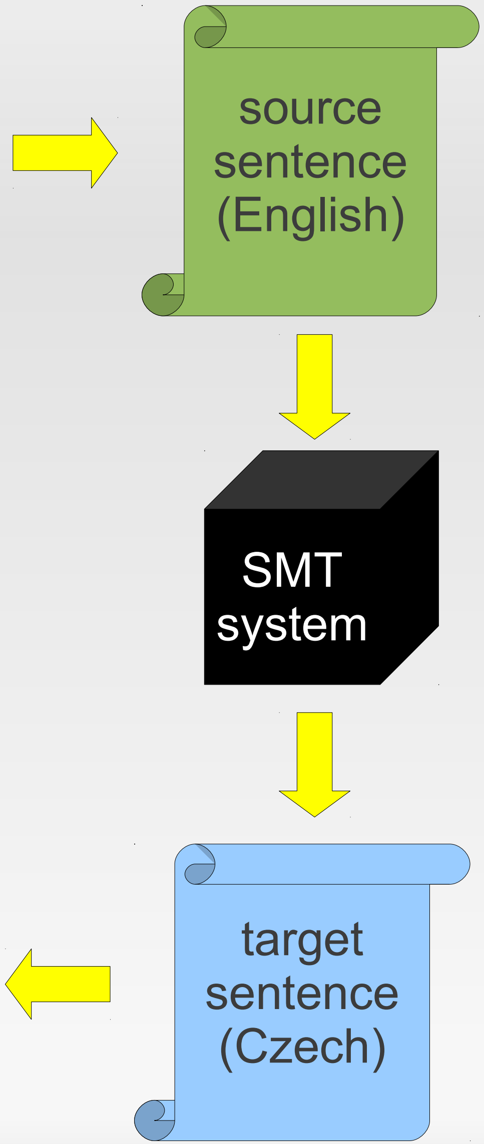
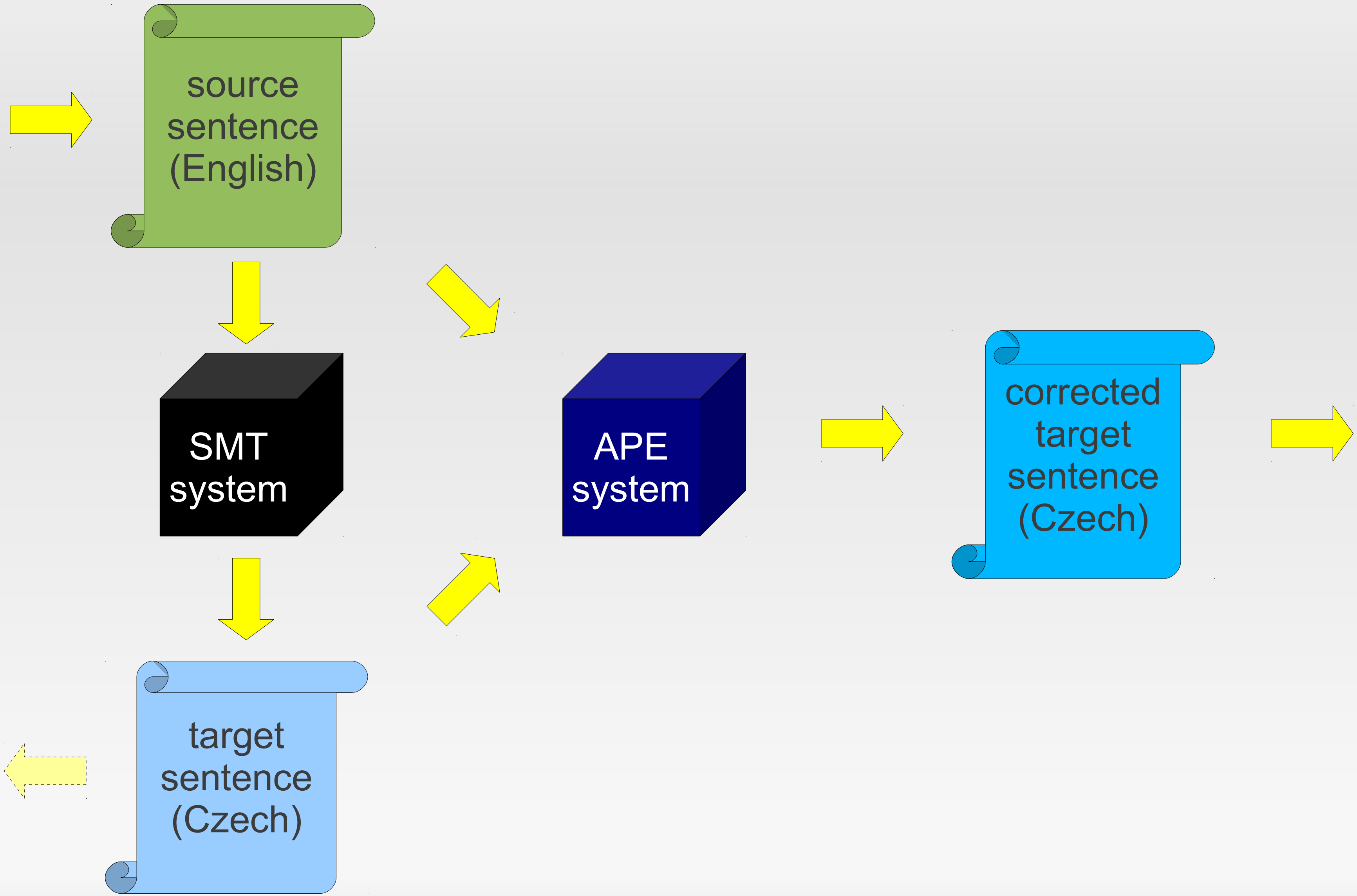
Edinburgh SMT group meeting, 29th January 2014

Statistical Machine Translation



Automatic Post-editing of SMT



Depfix

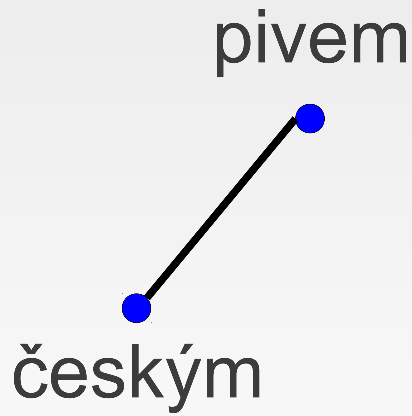
- input: target sentence (+ source sentence)

1. analysis
   - tokenization, lemmatization, tagging, word-alignment, parsing, deep-syntax induction
2. correction
   - a set of rules, e.g. noun-adjective agreement
3. generation
   - morphological generator

- output: corrected target sentence

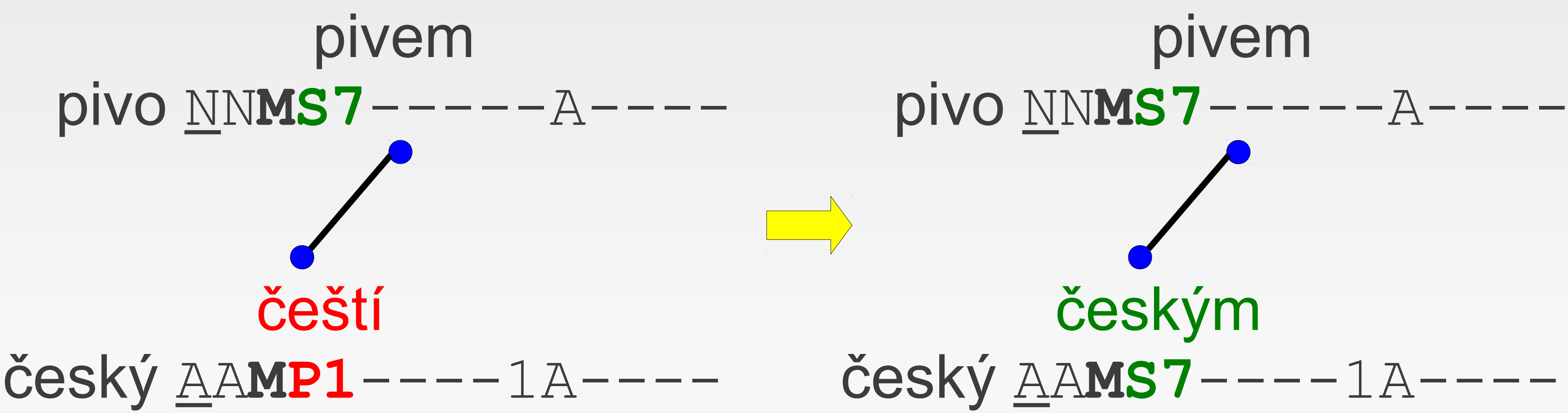
Analysis

- most important:
  - **lemma** + Czech fine-grained morphological **tag**
    - gender, number, case, person, tense, negation...
    - e.g. *pivem* (*beer* in instrumentative case)
    - → *pivo* `NNNS7-----A----`
  - dependency **tree**
    - tells us e.g. that the modifier *českým* (Czech) belongs to *pivem* (beer)
    - we use **MST parser adapted for parsing SMT outputs**



Correction

- usually edge-local
- morphological agreement of noun and adjective:
  - set **gender**, **number** and **case** of the adjective to **gender**, **number** and **case** of the noun



Generation

- morphological generator
  - lemma & tag → word form
  - e.g. *český* `AAMS7----1A----` → *českým*
- Czech morphology is far from trivial
  - 2 numbers, 4 genders, 7 cases, various paradigms...
  - homonymous forms
    - *piva* = sg gen / pl nom / pl acc / pl voc
  - variants
    - sg loc = *pivu / pivě*

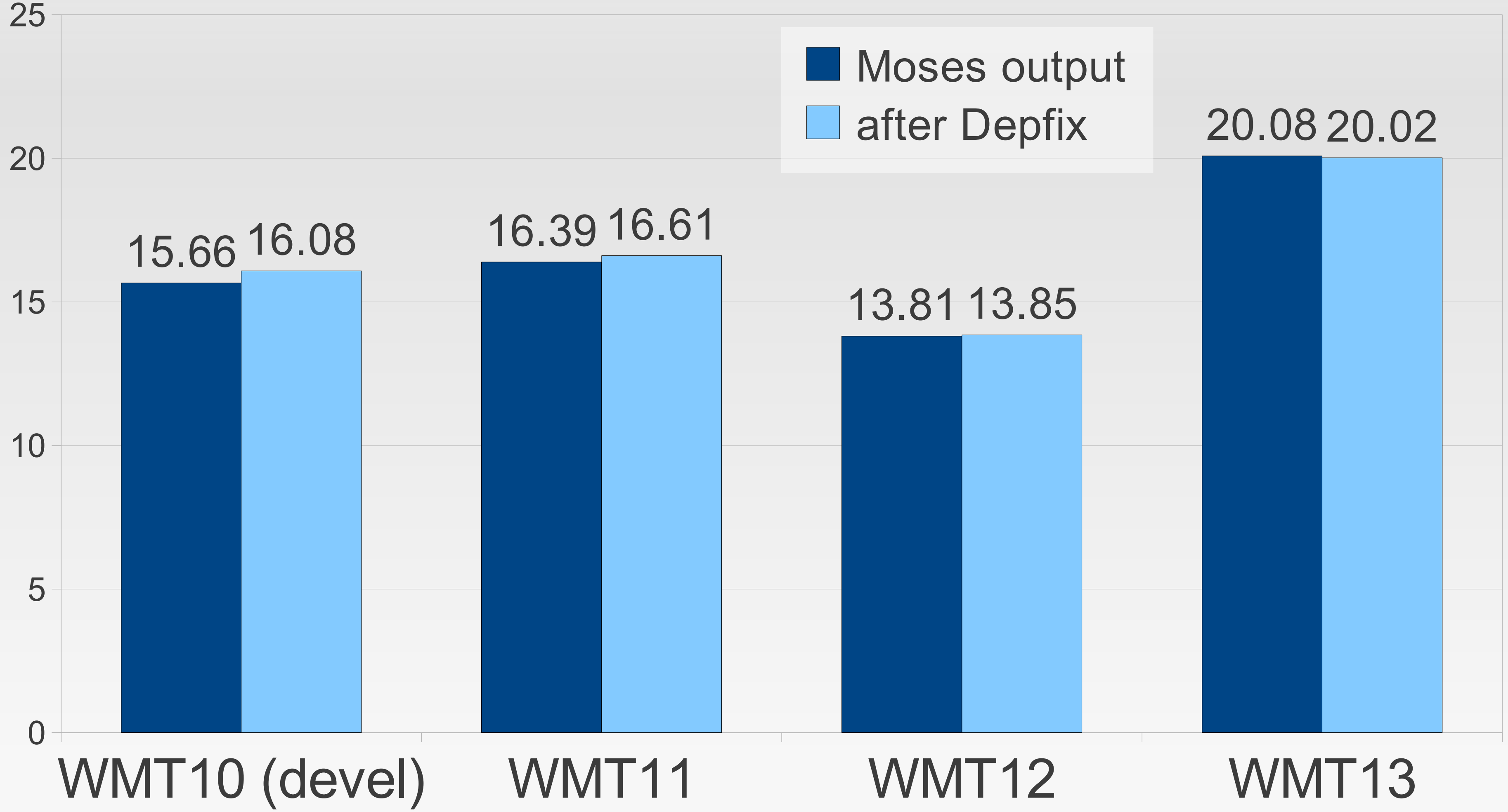
Correction types (I)

- agreement
  - preposition – noun (case)
  - noun – adjective (gender, number, case)
  - subject – predicate (gender, number, person)
  - antecedent – relative pronoun (gender, number, case)
- minor errors
  - projection of tokenization
  - source-aware truecasing
  - vocalization of prepositions

Correction types (II)

- transfer of meaning to morphology
  - translation of possessives and “of” (genitive)
  - translation of passive voice and “by” (instrumentative)
  - subject (nominative)
  - verb tense
  - negation
- coarse translation of missing items
  - missing reflexive verbs
- analysis corrections (alignment, tags, trees)

Automatic evaluation (BLEU)



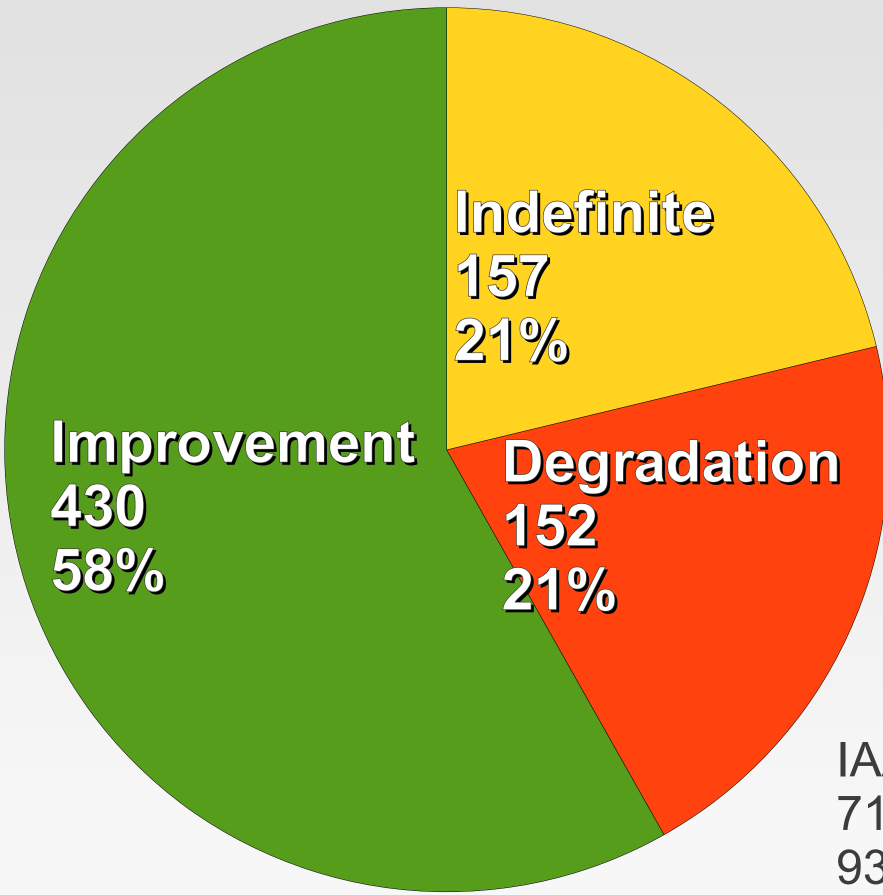
Automatic evaluation (Δ BLEU)

data/system	CU Bojar	CU TectoMT	CU Zeman	UEdin
WMT10 (dev)	+0.33	-0.07	+0.61	+0.78
WMT11	+0.47	-0.10	+0.73	+0.64
WMT12	+0.07	-0.02	+0.34	+0.23

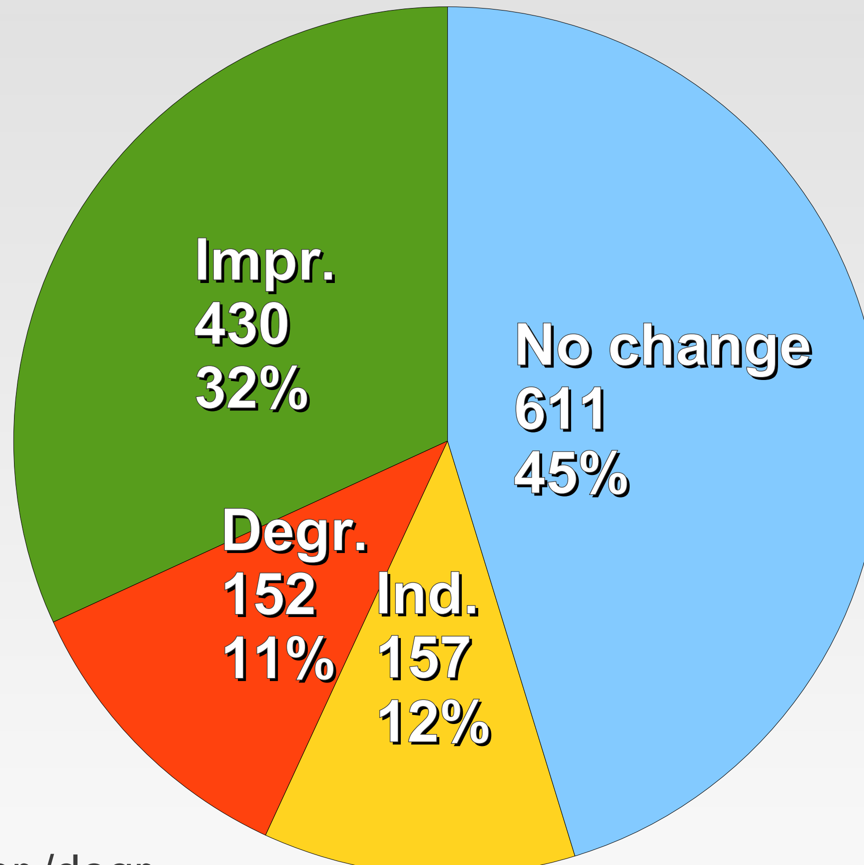
data/system	SFU	EuroTrans	Bing	Google Tr.
WMT10 (dev)	**+1.05**	+0.35	+0.78	+0.59
WMT11	–	+0.21	–	+0.23
WMT12	+0.41	+0.15	+0.37	0.00

Manual evaluation (WMT12)

- changed sentences



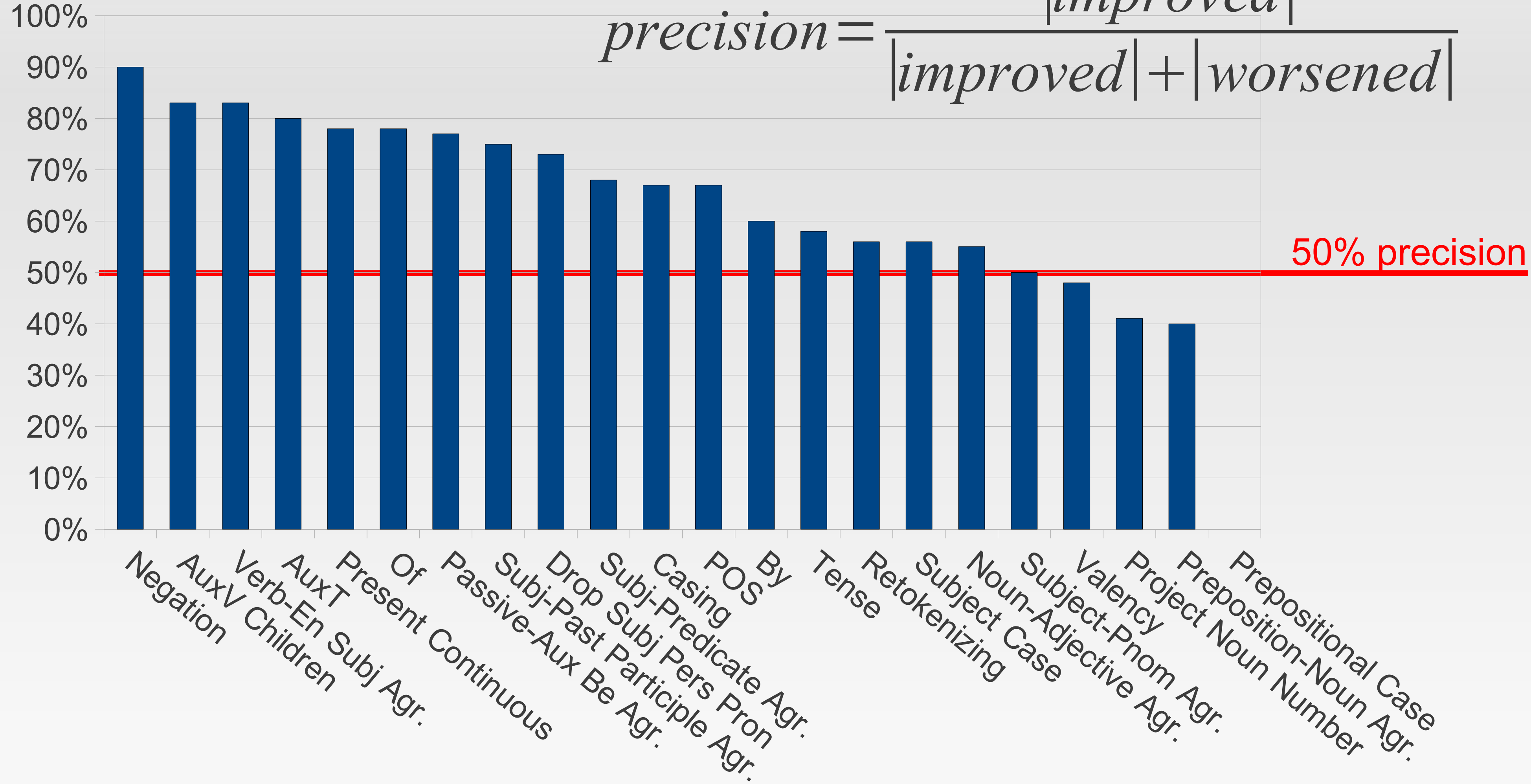
- all sentences



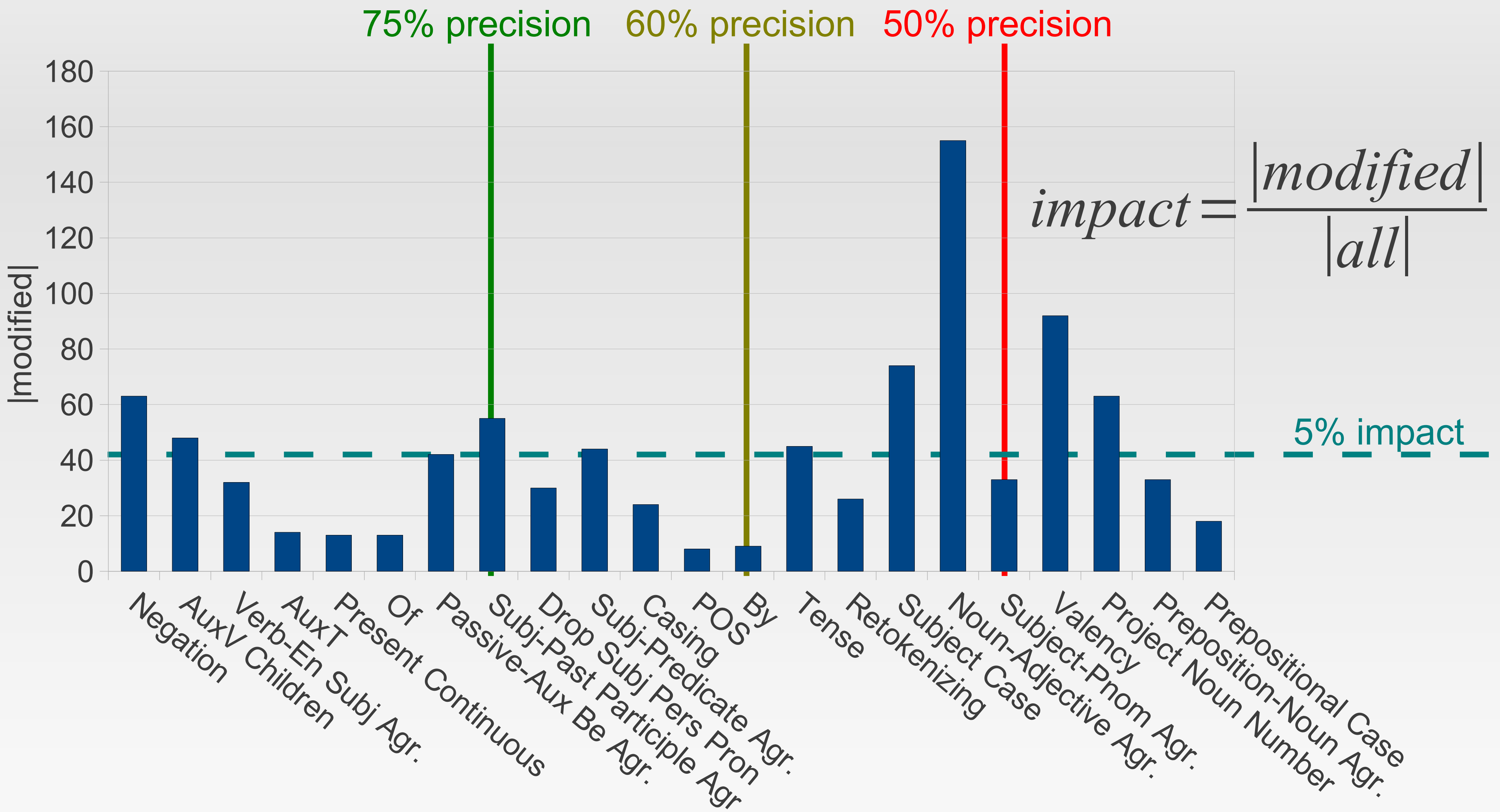
IAA:
71% all
93% impr./degr.

Precision of rules (part of WMT12)

$$precision = \frac{|improved|}{|improved| + |worsened|}$$



Impact of rules (part of WMT12)



$$impact = \frac{|modified|}{|all|}$$

Current & future work

- if we can write the rules manually...
  - …can we also machine-learn them?
- currently running experiments
  - predict: gender, number, case (of modifier)
  - data: parallel corpus & its translation by Moses
  - decision trees / maximum entropy classifier
  - features (modifier, head & their source counterparts)
    - tag (split by category), dependency relation label, edge direction, number of modifiers, lemma
  - preliminary positive results

Delving deeper...

- more corrections
  - an example of a cascade of corrections
  - correction of negation
  - correction of verb tense translation
- MSTperl parser
  - reimplementation of MST parser
  - adapted for parsing SMT outputs

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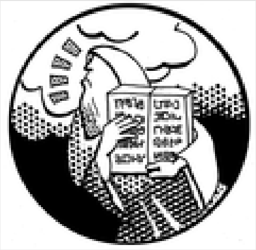
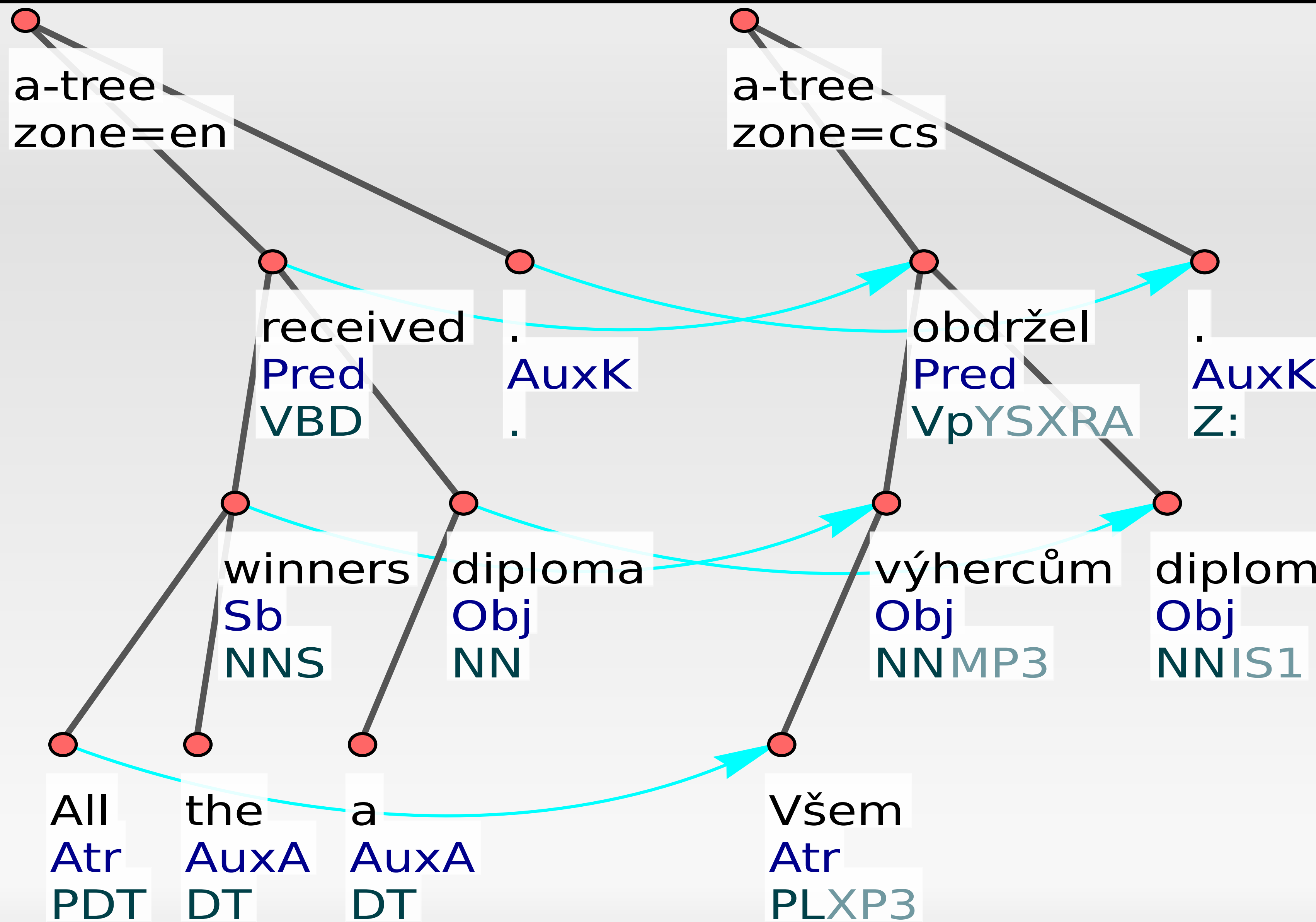
A cascade of corrections

- Source:
  - *All the winners received a diploma.*
- Moses:
  - *Všem výhercům obdržel diplom.*
  - *To all the winners he received a diploma.*

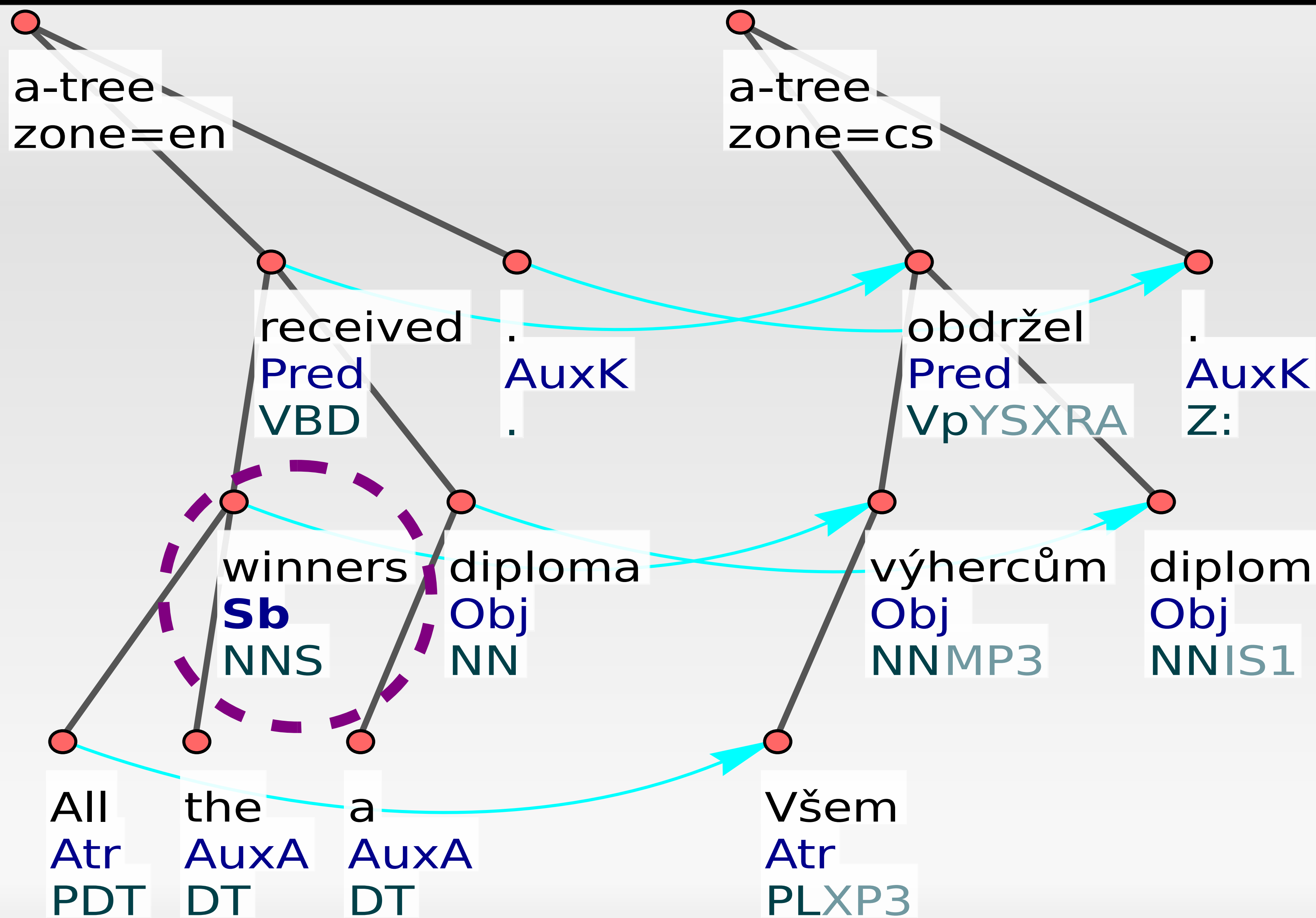


- Depfix:
  - *Všichni výherci obdrželi diplom.*
  - *All the winners received a diploma.*

Všem výhercům obdržel diplom.



Transfer of meaning: subject



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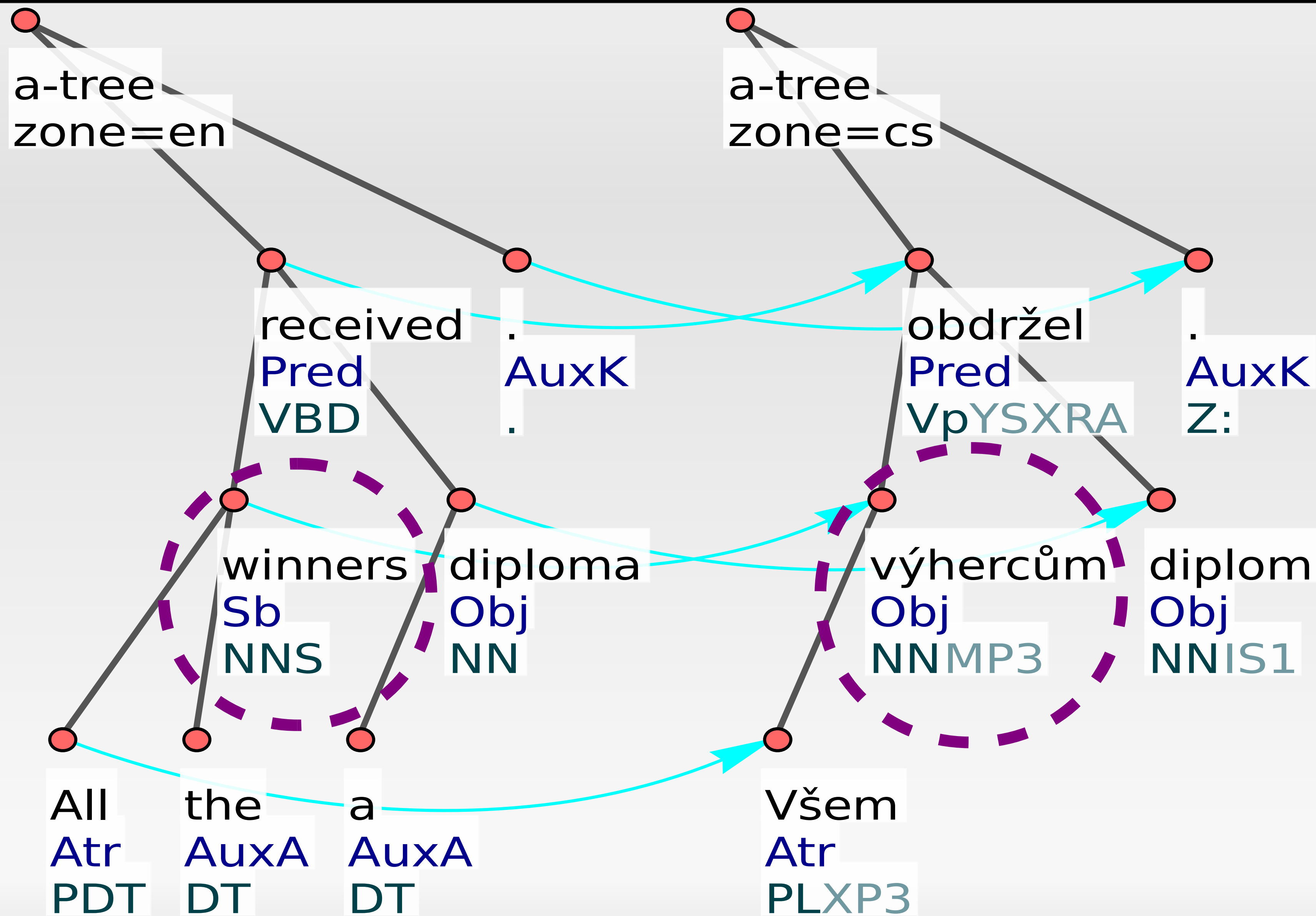
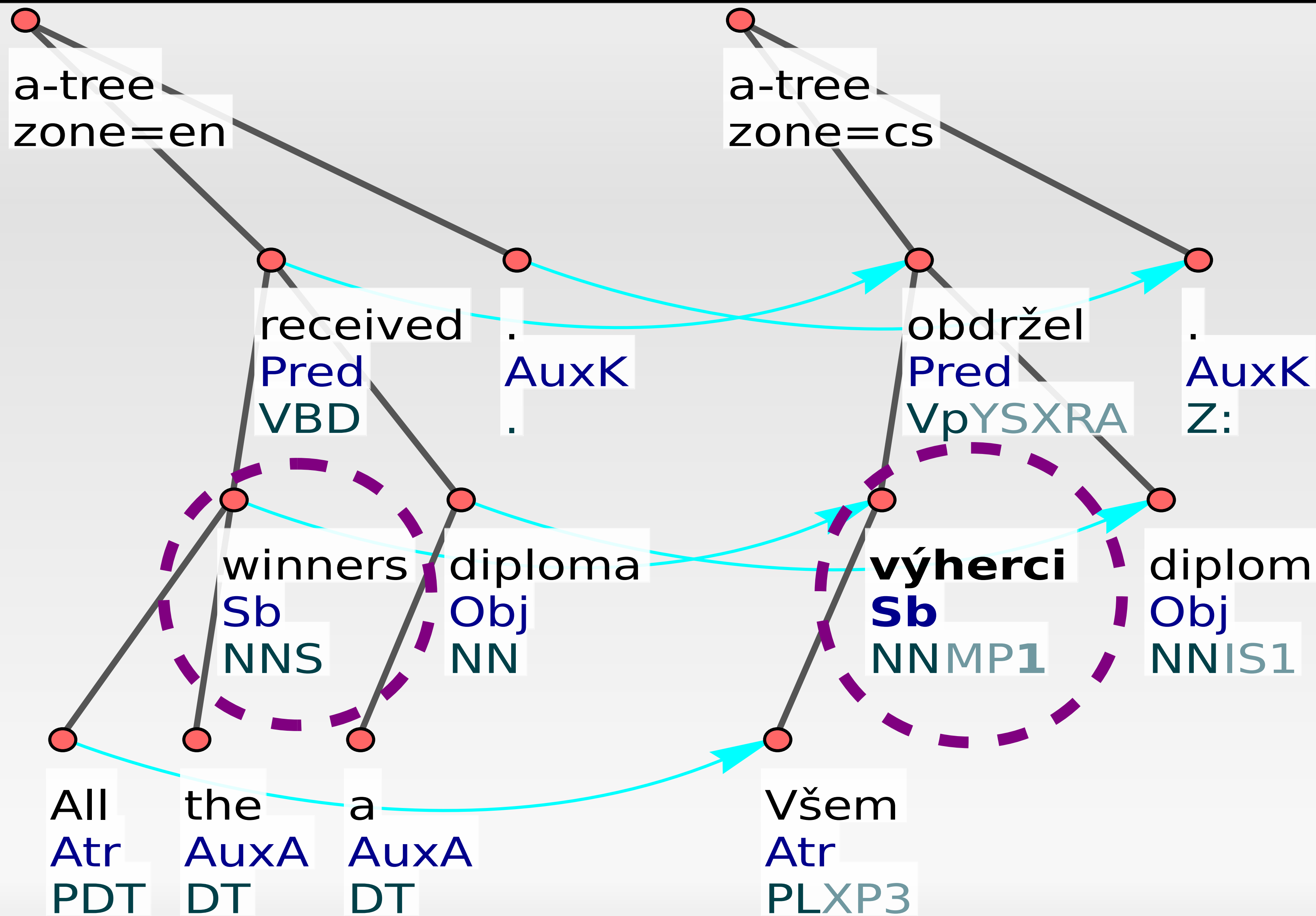
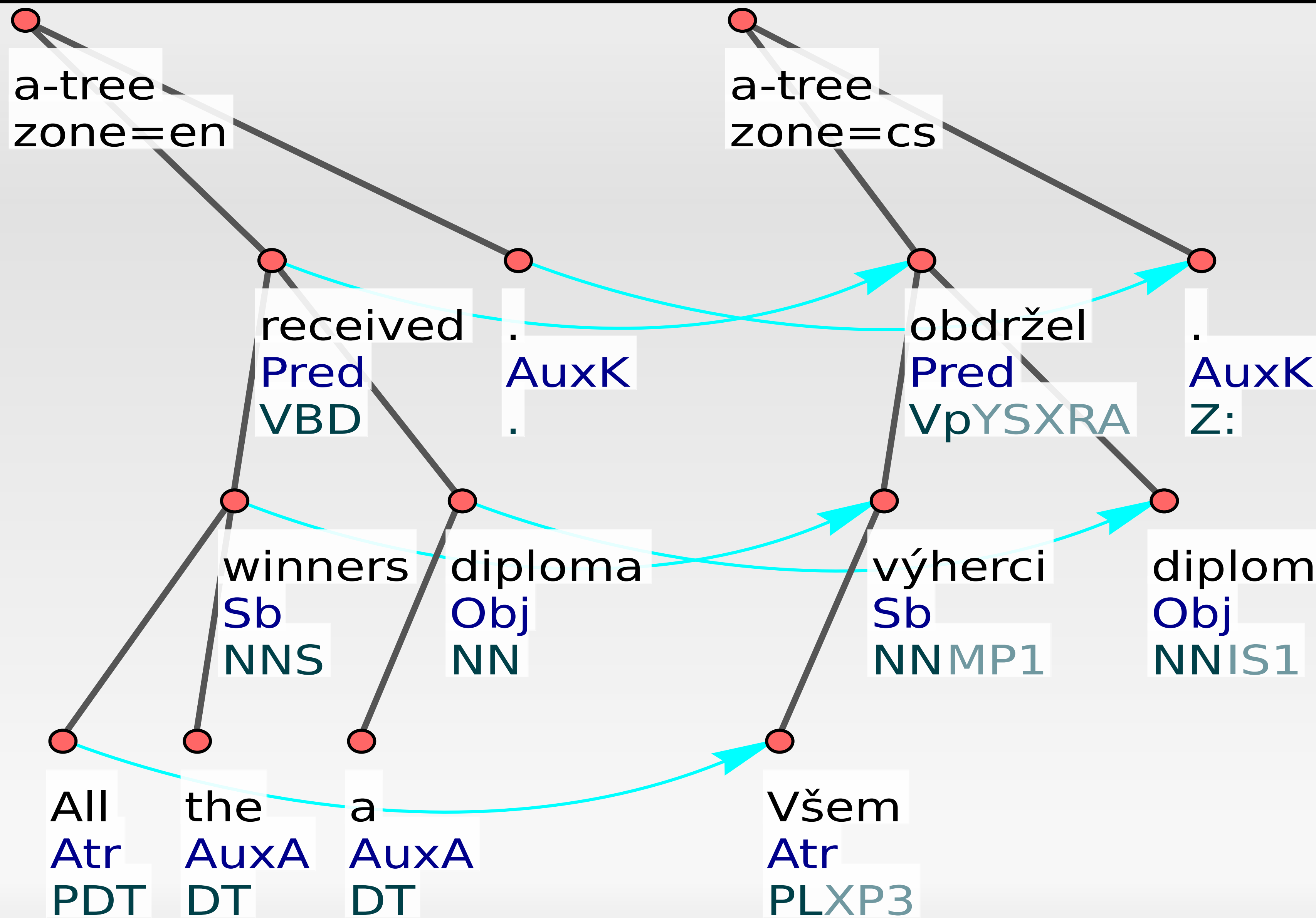


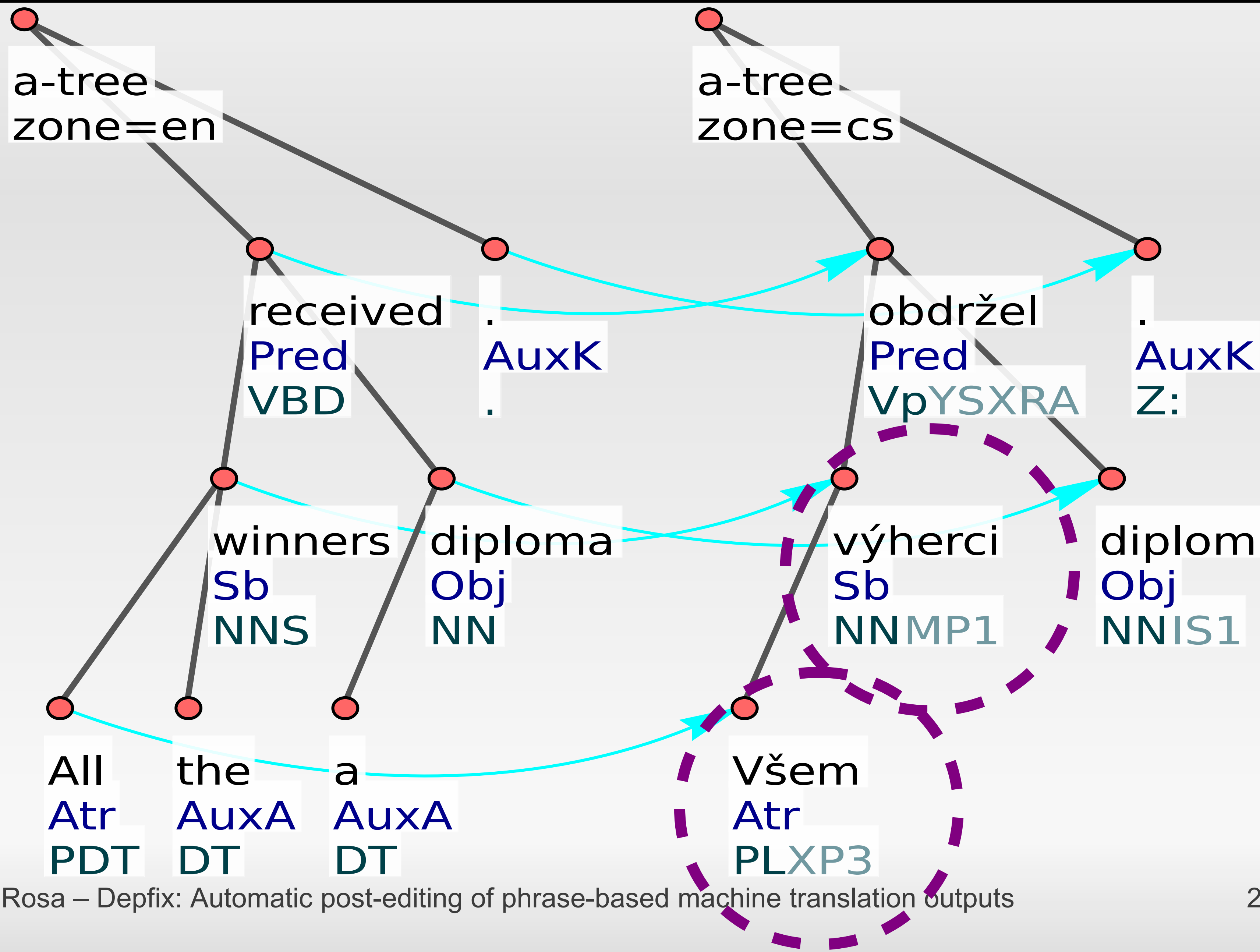
Subject → nominative



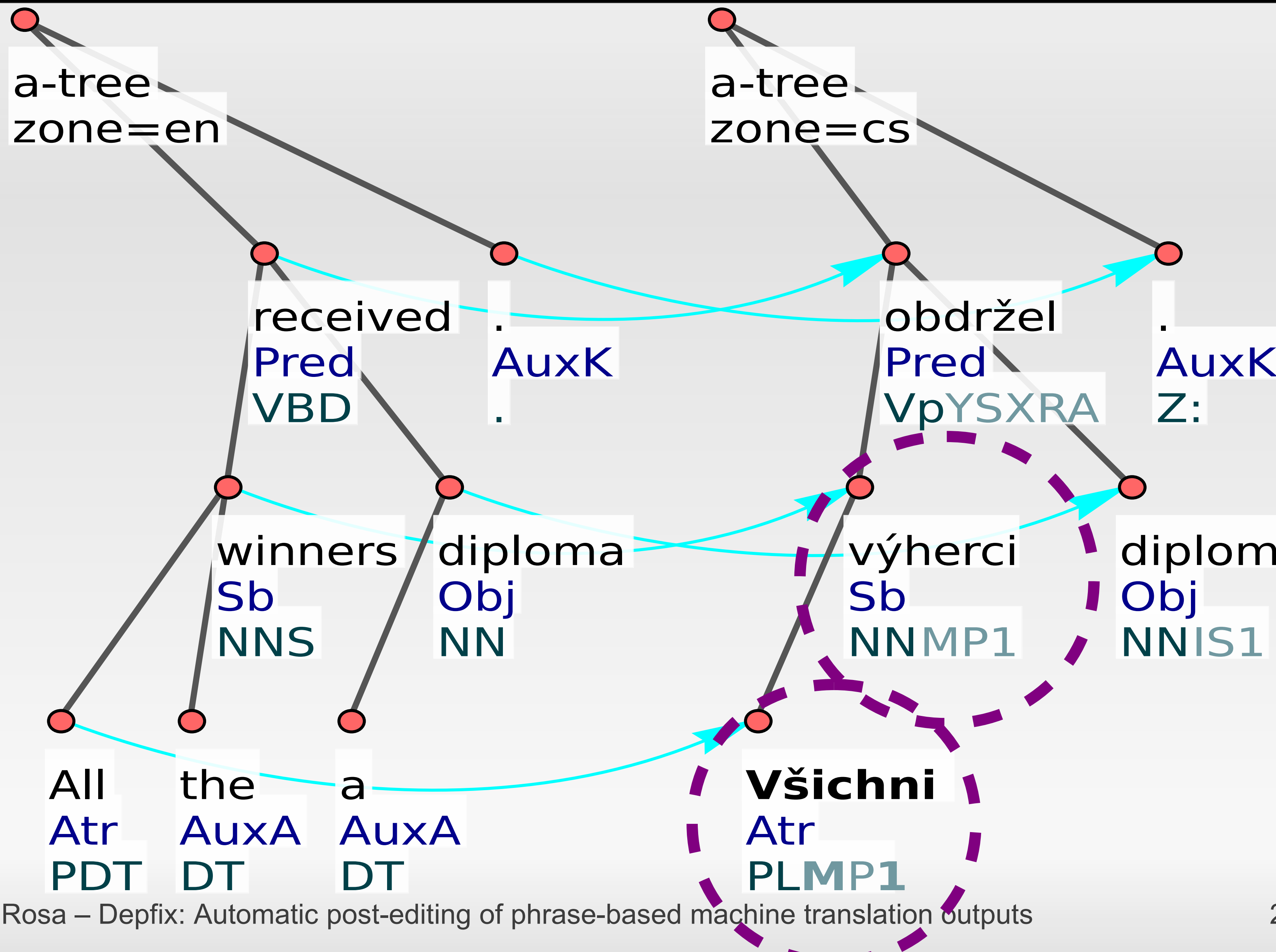
Všem výherci obdržel diplom.



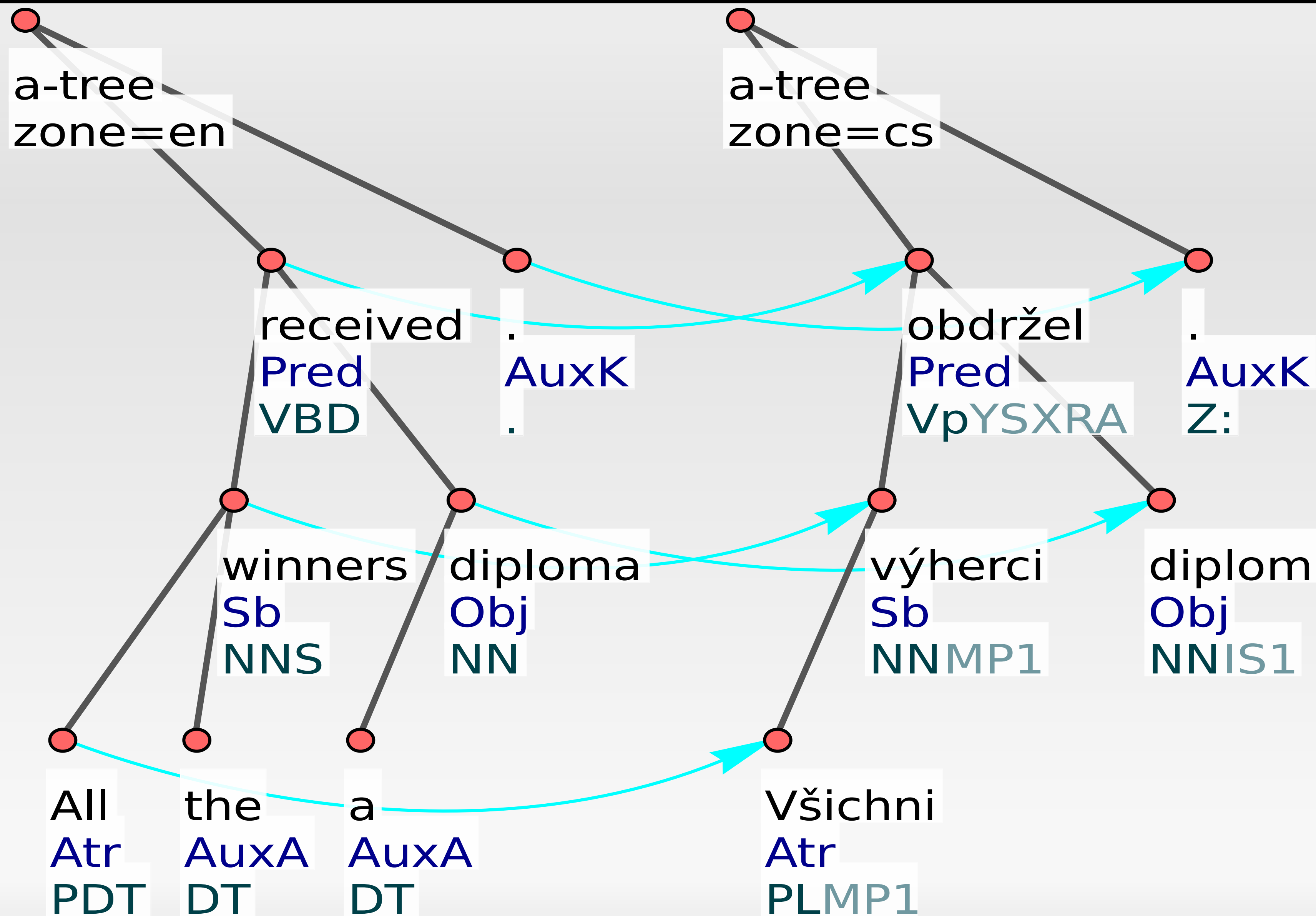
Noun-adjective agreement



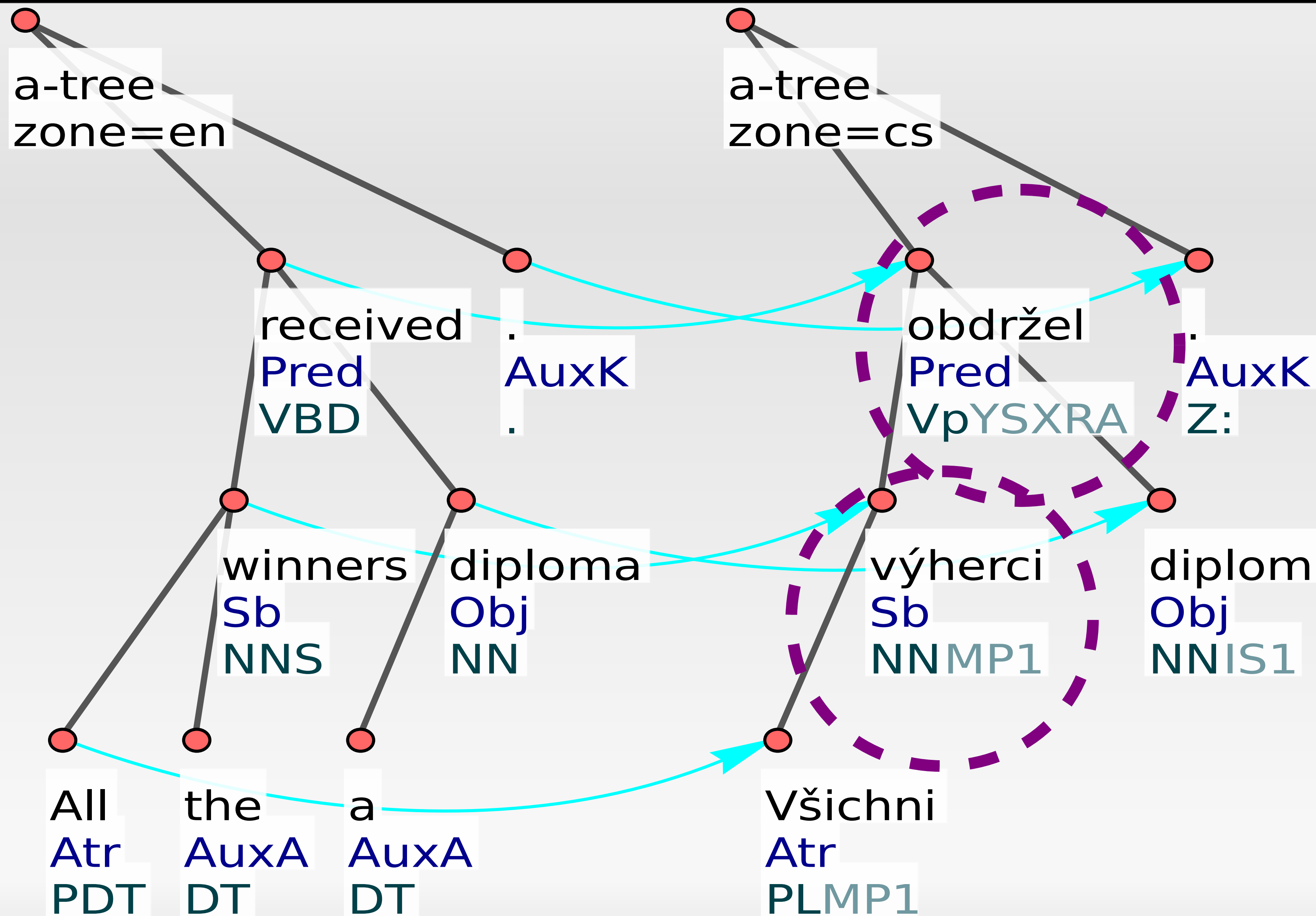
Agreement: gender, case (number)



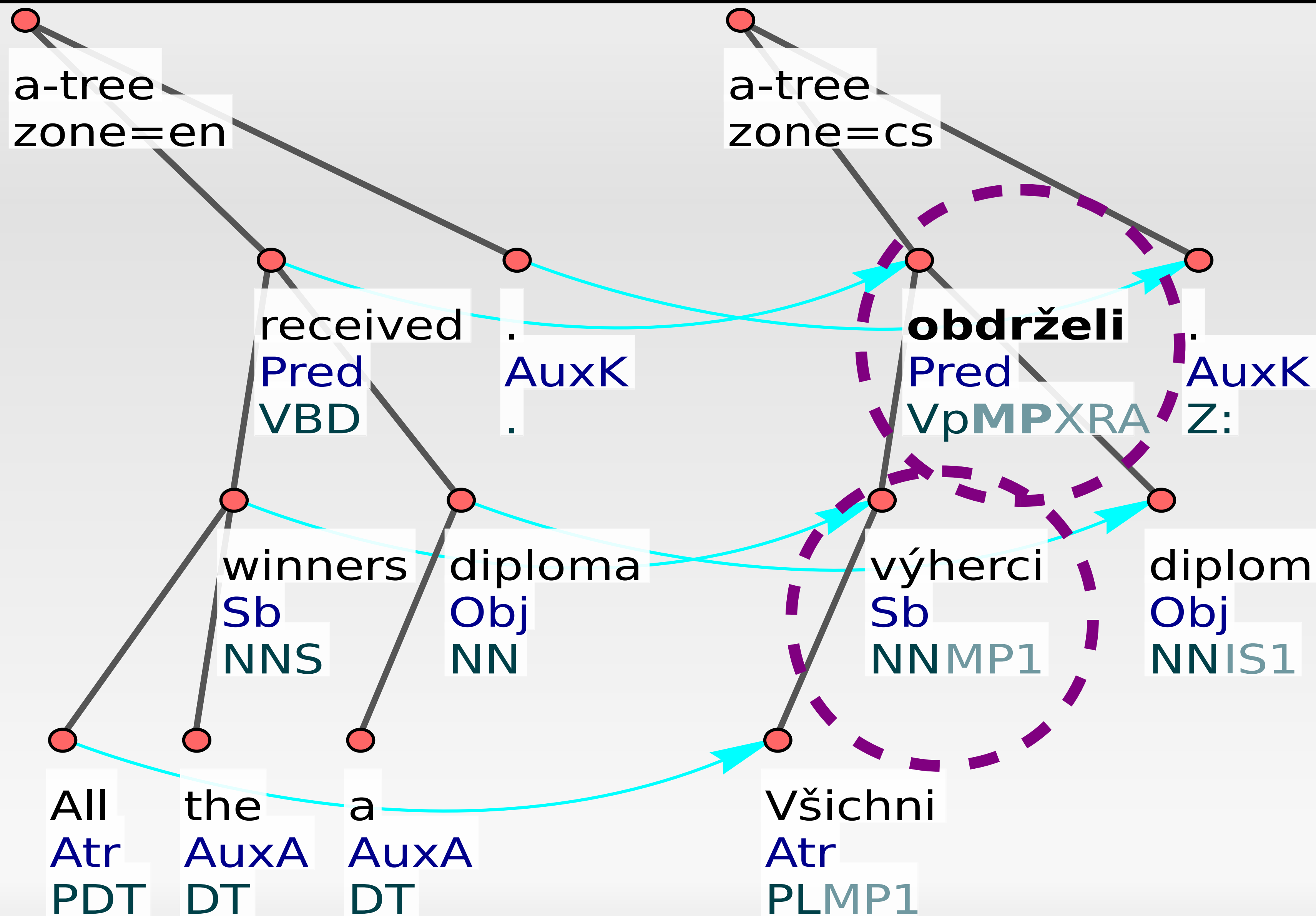
Všichni výherci obdržel diplom.



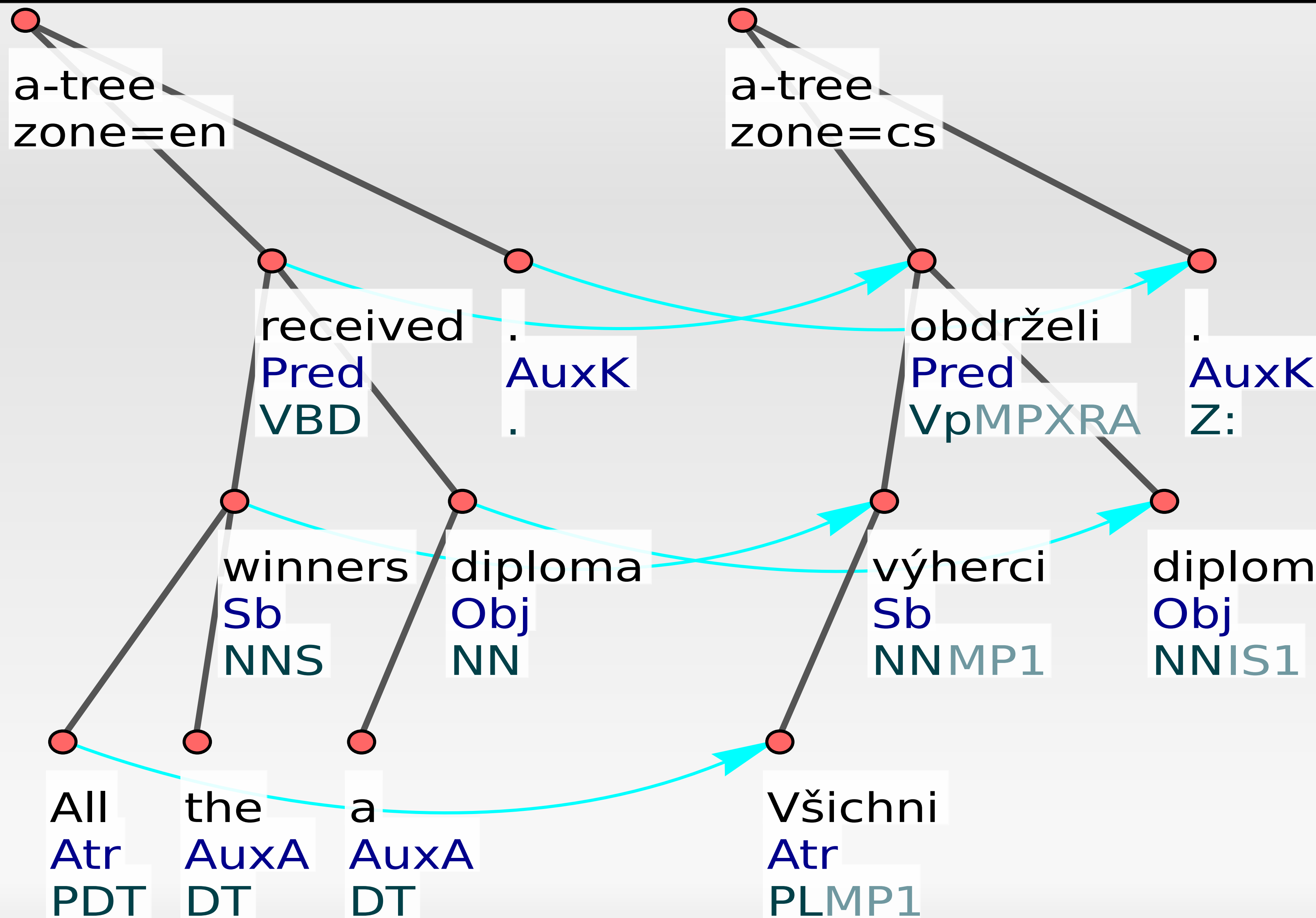
Subject-predicate agreement



Agreement: gender, num (person)



Všichni výherci obdrželi diplom.



Delving deeper...

- more corrections
  - an example of a cascade of corrections
  - **<u>translation of negation</u>**
  - correction of verb tense translation
- MSTperl parser
  - reimplementation of MST parser
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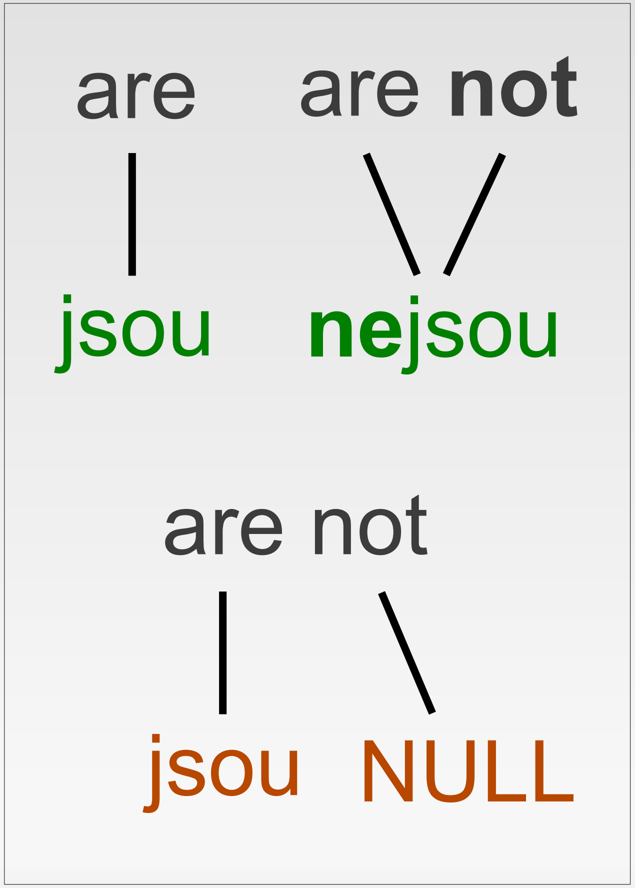
http://thedrivenclass.com/blog-detail/32876

Motivation

- *These **are not** actually errors.*
  - Moses: ***Jsou** to vlastně chyby.*
  - Gloss: *These **are** actually errors.*
  - Reference: ***Nejsou** to vlastně chyby.*
- *I **would not** cheat on you.*
  - Moses: *Já bych tě **podváděl**.*
  - Gloss: *I **would** cheat on you.*
  - Reference: *Já bych tě **nepodváděl**.*

Expressing negation

- default way in English: ***not* token**
  - *These are **not** actually errors.*
- default way in Czech: ***ne-* prefix**
  - ***Ne**jsou to vlastně chyby.*
- hard for word-alignment
- hard for PB SMT

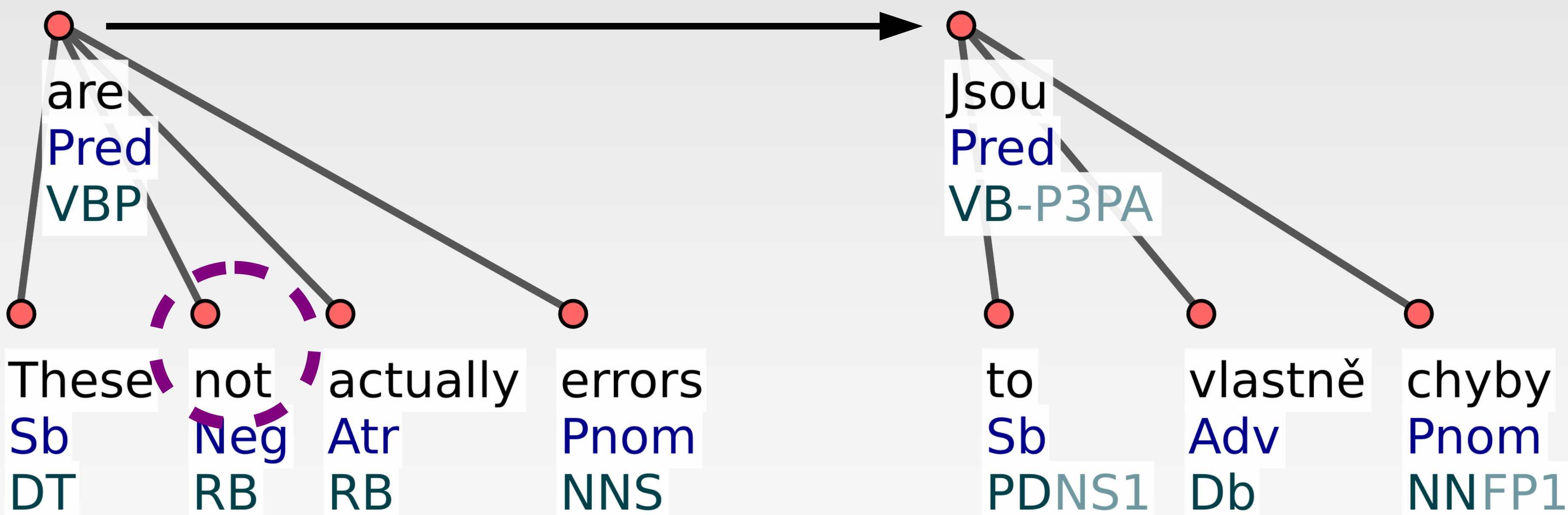


Actually, much more complex

- many ways to express negation (CS, EN)
  - negative particle (*not*), negative affix (*mis-*, *-less*), negative preposition (*without*)...
  - lexical means (*not happy ~ sad*)
  - differences between Czech and English
    - techniques based on word-alignment do badly
- the negation can be placed differently
  - usually it is the predicate heading the clause
    - but which part of it if it is multiword?
  - but not always

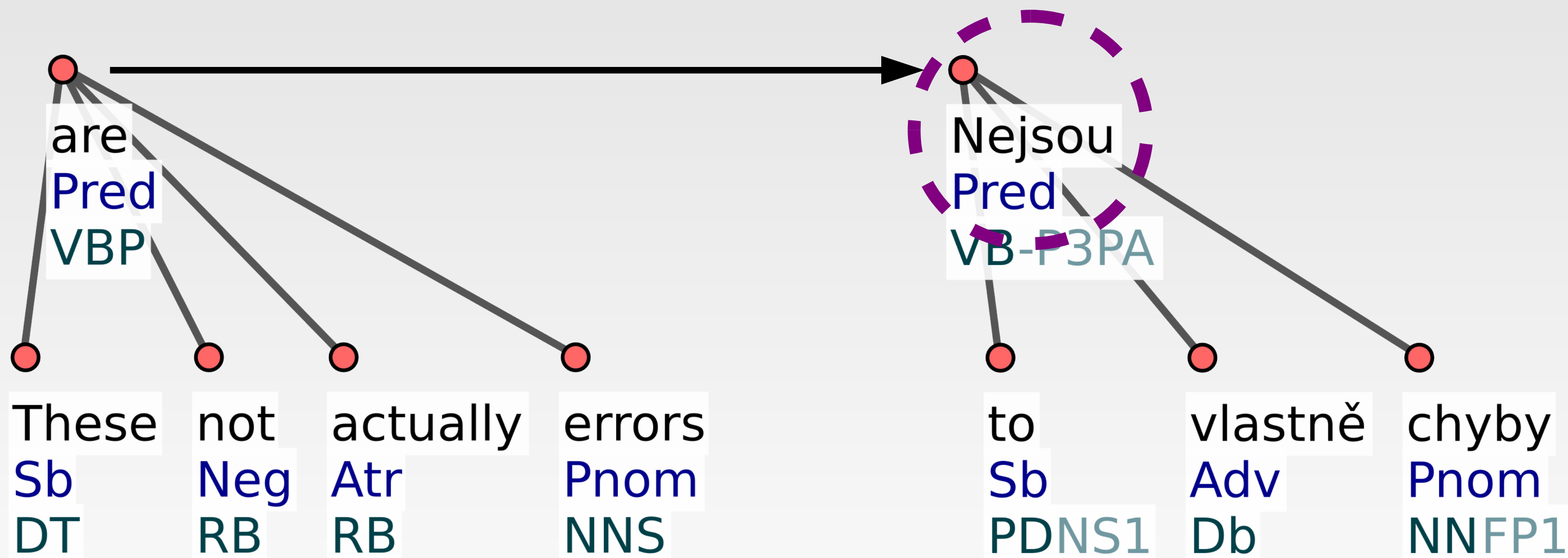
Detecting the problem

- English clause seems to be negative
- Czech clause seems to be positive



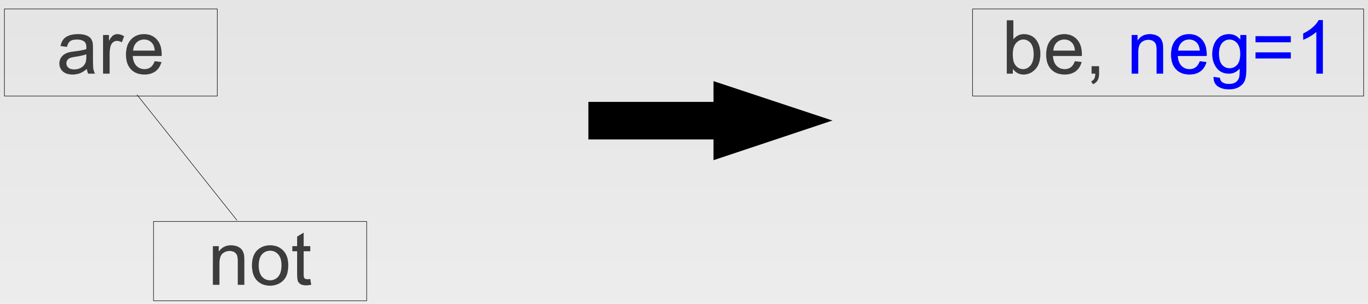
Fixing the problem

- find a place to put the negation (clause head)
- negate it (using tag & morpho generator)

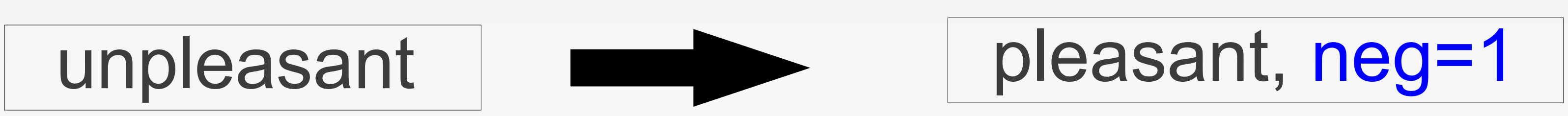


Deep syntactic analysis

- auxiliary nodes collapsed into values of attributes on parent nodes



- abstract from various ways of expressing negation (not, no, un-, in-,...)



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Verb tense translation

- analyze the source (English) verb
- analyze the target (Czech) verb
- if they do not seem to match, change CS tense:
  - EN future * → CS future
  - EN past *; present perfect → CS past
  - EN present * → CS present
- avoid hard cases
  - conditionals, reported speech...

English verbs analysis

- parsing the verb form
  - all VB* and MD modifiers of the main verb
  - occasionally checking other modifiers (*to*)
- normalize to forms of *have*, *be* and *love*
- other words mark something
  - modality (modals, *have to, be (**un**)able to...*)
  - future (*will, going to* – careful: *was going to*)
  - conditionality (*would, should*)
  - past (*did*)

English verbs analysis

(present is the default – can be overidden by markers such as *did* or *will*)

- 'love' => [ ],
- 'loved' => ['past'],
- 'have loved' => ['perf'],
- 'be loving' => ['cont'],
- 'be loved' => ['pass'],
- 'had loved' => ['past', 'perf'],
- 'were loving' => ['past', 'cont'],
- 'were loved' => ['past', 'pass'],
- 'have been loving' => ['perf', 'cont'],
- 'have been loved' => ['perf', 'pass'],
- 'be being loved' => ['cont', 'pass'],
- 'had been loving' => ['past', 'perf', 'cont'],
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MST parser

- Maximum Spanning Tree parser
- McDonald, Crammer, Pereira (2005)
  - Online large-margin training of dependency parsers
- McDonald, Pereira, Ribarov, Hajič (2006)
  - **Non-projective** dependency parsing using spanning tree algorithms
- discriminative, edge-local features
- MIRA learning algorithm

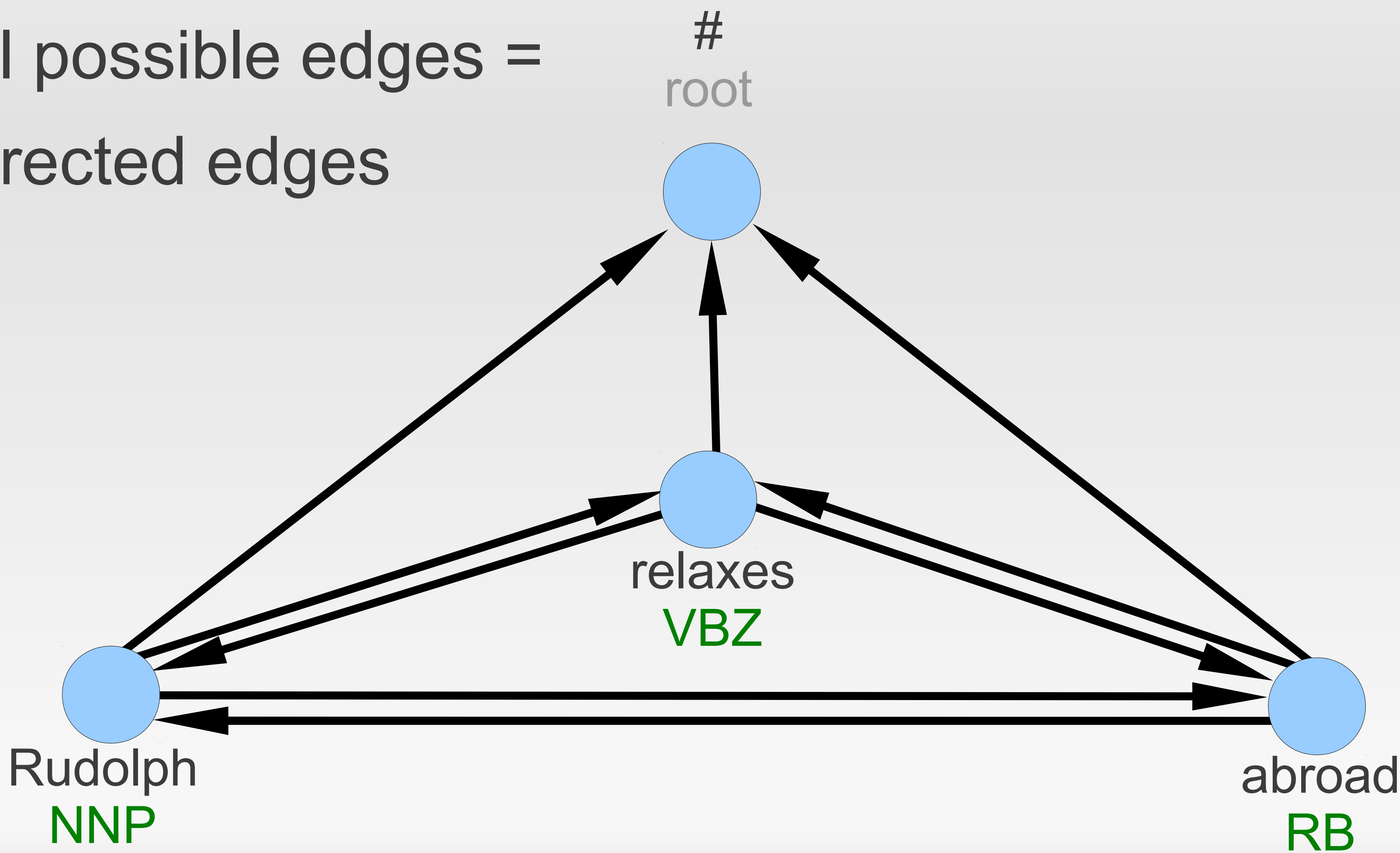
(1) Words and Tags

words = nodes

(2) (Nearly) Complete Graph

all possible edges =

directed edges

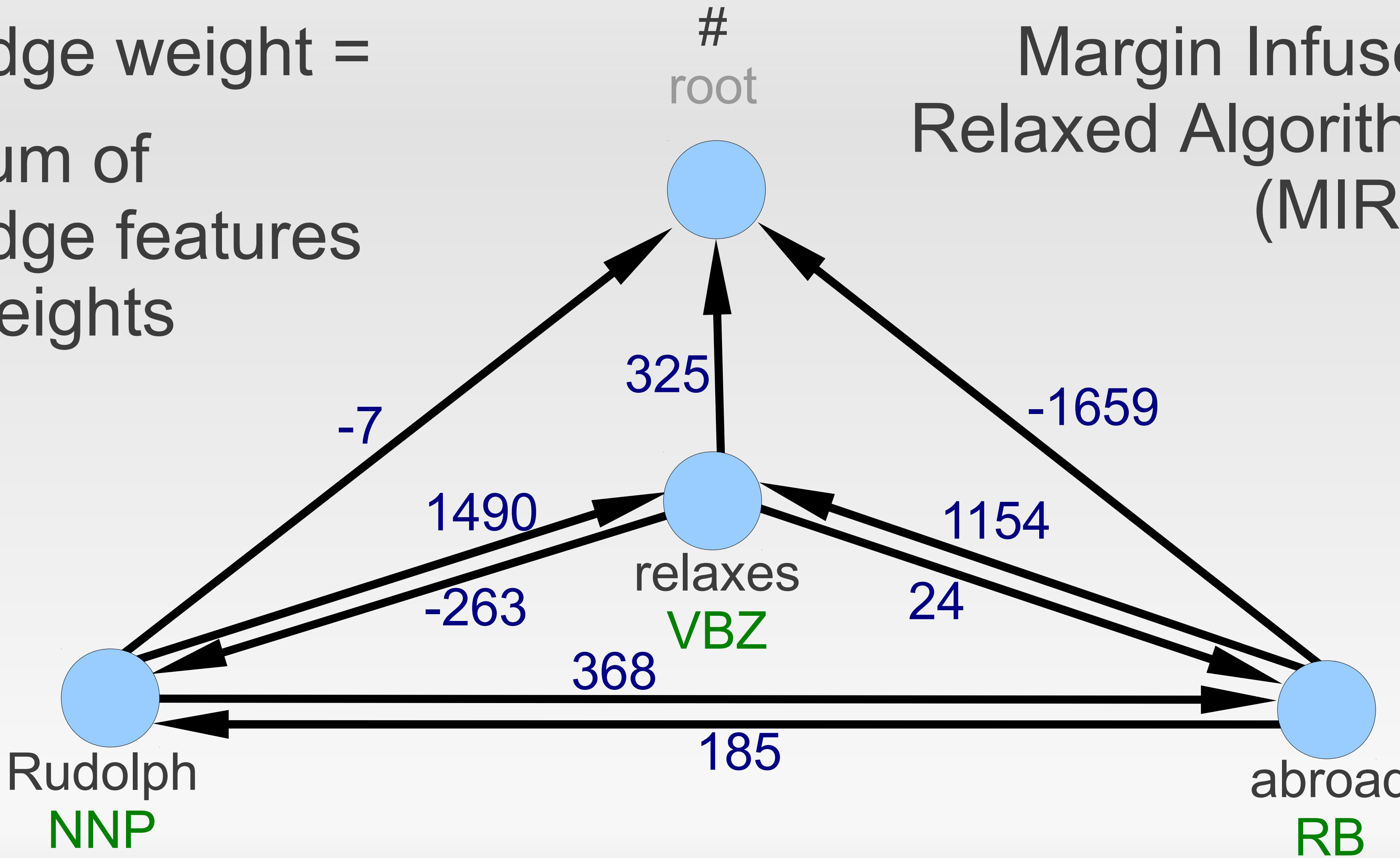


(3) Assign Edge Weights

edge weight =

sum of
edge features
weights

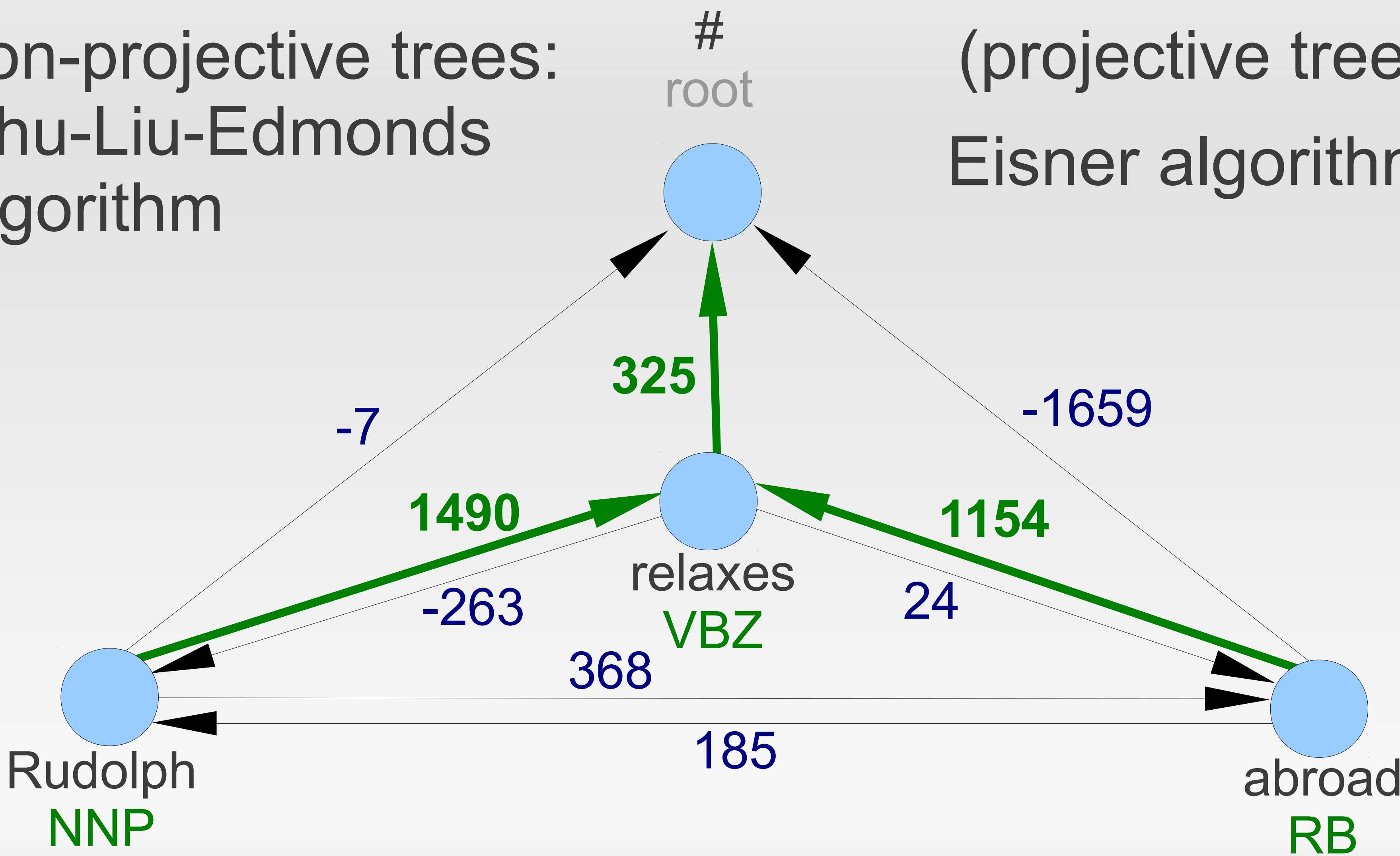
Margin Infused
Relaxed Algorithm
(MIRA)



(4) Maximum Spanning Tree

non-projective trees: Chu-Liu-Edmonds algorithm

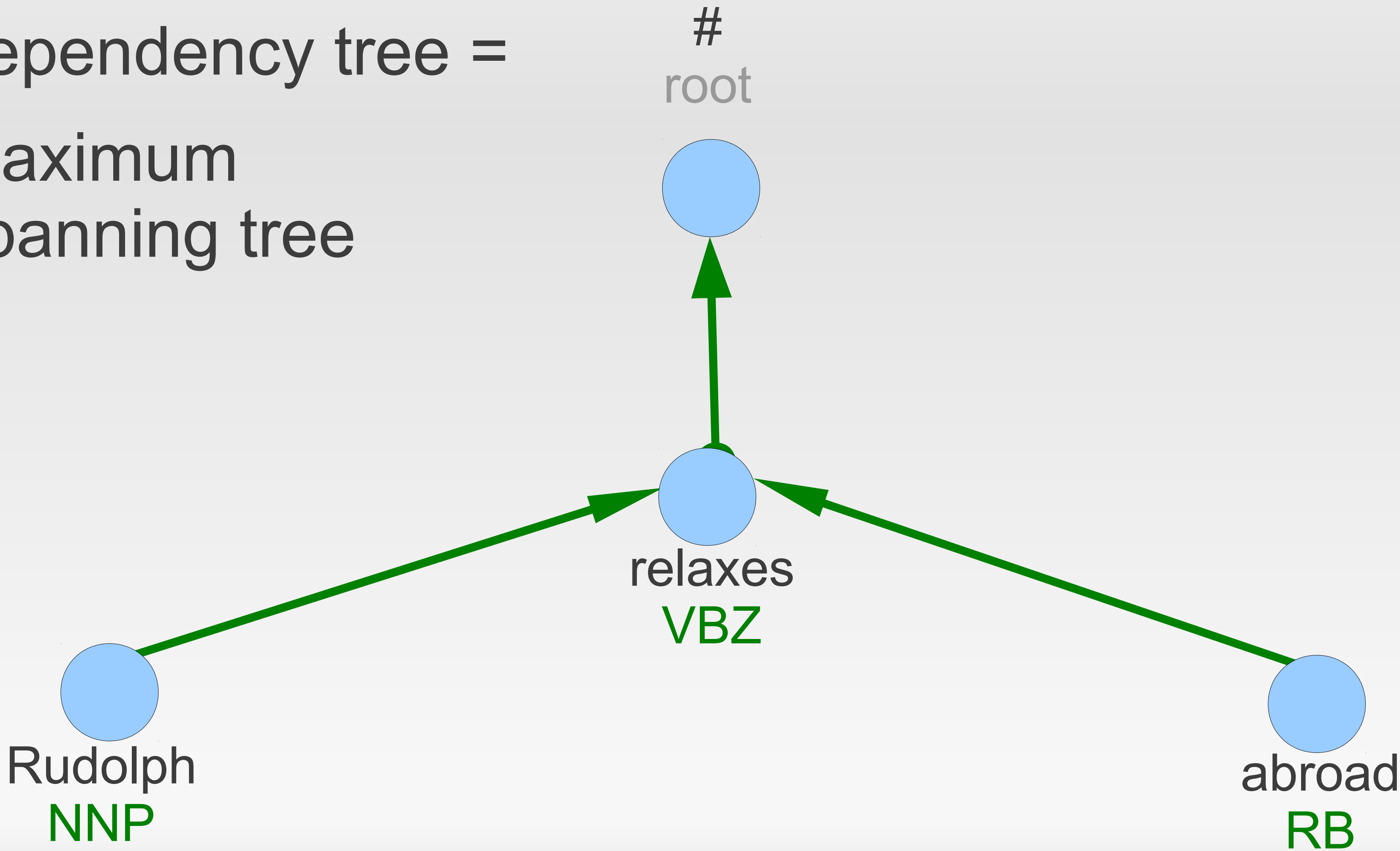
(projective trees: Eisner algorithm)



(5) Unlabeled Dependency Tree

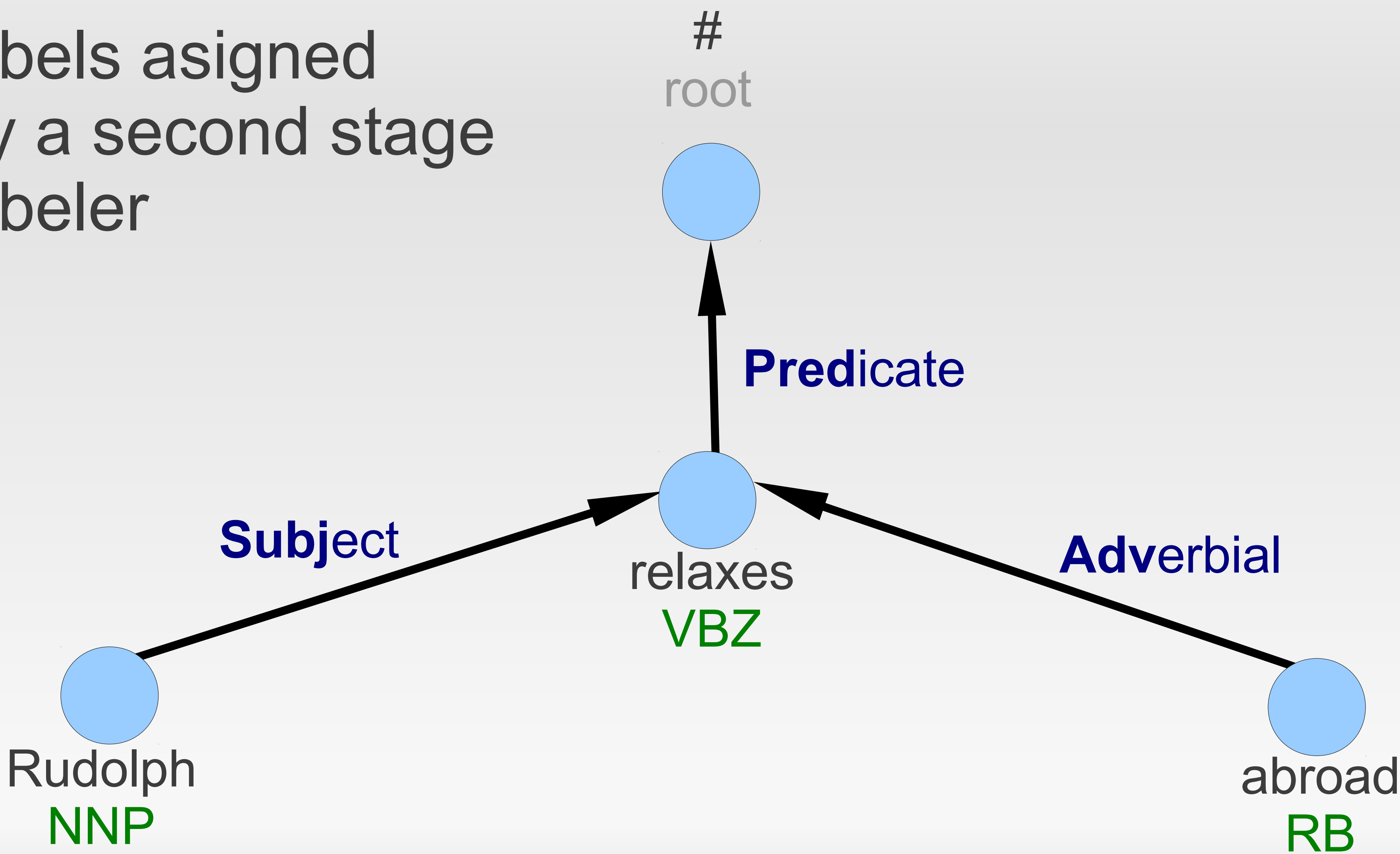
dependency tree =

maximum
spanning tree



(6) Labeled Dependency Tree

labels asigned
by a second stage
labeler



Parsing of SMT Outputs

- can be useful in many applications
  - automatic classification of translation errors
  - **automatic correction of translation errors (Depfix)**
  - multilingual question answering...
- ✔ we have the source sentence available
  - Can we use it to help parsing?
- ✗ SMT outputs noisy (errors in fluency, grammar...)
  - parsers trained on gold standard treebanks
  - Can we adapt parser to noisy sentences?

MSTperl

- reimplementation of MST Parser in Perl
  - http://ufal.mff.cuni.cz/tools/mstperl-parser
  - first-order, non-projective
- adapted for SMT outputs parsing
  - worsening the training data
  - adding parallel information
  - manually boosting feature weights
  - exploiting large-scale data

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  - **worsening the training data**
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  - manually boosting feature weights
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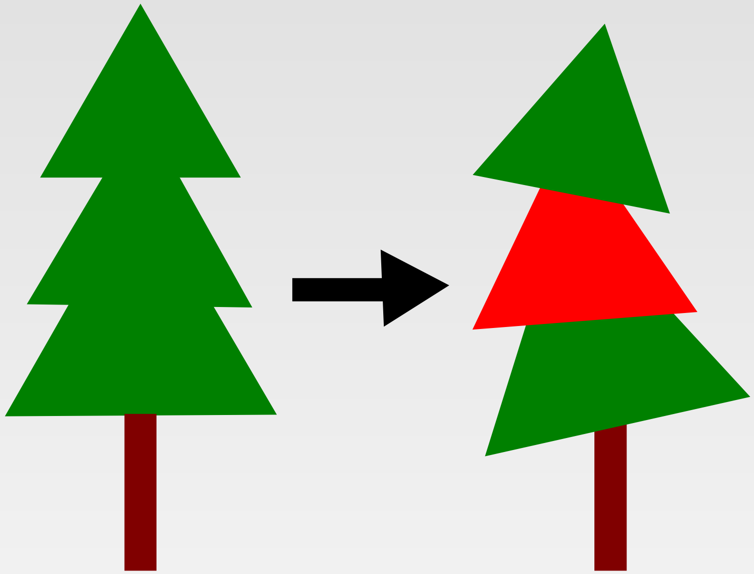
Parser Training Data

- Prague Czech-English Dependency Treebank
  - parallel treebank
  - 50k sentences, 1.2M words
  - morphological tags, surface syntax, deep syntax
  - word alignment

Worsening the Treebank

- treebank used for training contains correct sentences
- SMT output is noisy
  - grammatical errors
  - incorrect word order
  - missing/superfluous words
  - ...
- let's introduce similar errors into the treebank!
  - so far, we have only tried inflection errors



Worsen (1): Apply SMT

- translate English side of PCEDT to Czech
  - by an SMT system (we used Moses)
- now we have e.g.:
  - Gold English
    - Rudolph's car is black.
  - Gold Czech
    - $\text{Rudolfovo}_{\text{NEUT}}$ $\text{auto}_{\text{NEUT}}$ je $\text{černé}_{\text{NEUT}}$.
  - SMT Czech
    - $\text{Rudolfova}_{\text{FEM}}$ $\text{auto}_{\text{NEUT}}$ je $\text{černý}_{\text{MASC}}$.

Worsen (2): Align SMT to Gold

- align SMT Czech to Gold Czech
- Monolingual Greedy Aligner
  - alignment link score = linear combination of:
    - similarity of word forms (or lemmas)
    - similarity of morphological tags (fine-grained)
    - similarity of positions in the sentence
    - indication whether preceding/following words aligned
  - repeat: align best scoring pair until below threshold
  - no training: weights and threshold set manually

Worsen (3): Create Error Model

- for each tag:
  - estimate probabilities of SMT system using an incorrect tag instead of the correct tag (Maximum Likelihood Estimate)
- Czech tagset: fine-grained morphological tags
  - part-of-speech, gender, number, case, person, tense, voice...
  - 1500 different tags in training data

Worsen (3): Error Model

- Adjective, Masculine, Plural, Instrumental case (`AAMP7`), e.g. *lingvistickými* (linguistic)
  - **0.2** Adjective, Masculine, Singular, Nominative case
    - e.g. *lingvistický*
  - **0.1** Adjective, Masculine, Plural, Nominative case
    - e.g. *lingvističtí*
  - **0.1** Adjective, Neuter, Singular, Accusative case
    - e.g. *lingvistické*
- … altogether 2000 such change rules

Worsen (4): Apply Error Model

- take Gold Czech
- for each word:
  - assign a new tag randomly sampled according to Tag Error Model
  - generate a new word form
    - rule-based generator, generates even unseen forms
    - new_form = generate_form(lemma, tag) || old_form
- → get Worsened Czech
- use resulting *Gold English-Worsened Czech* parallel treebank to train the parser

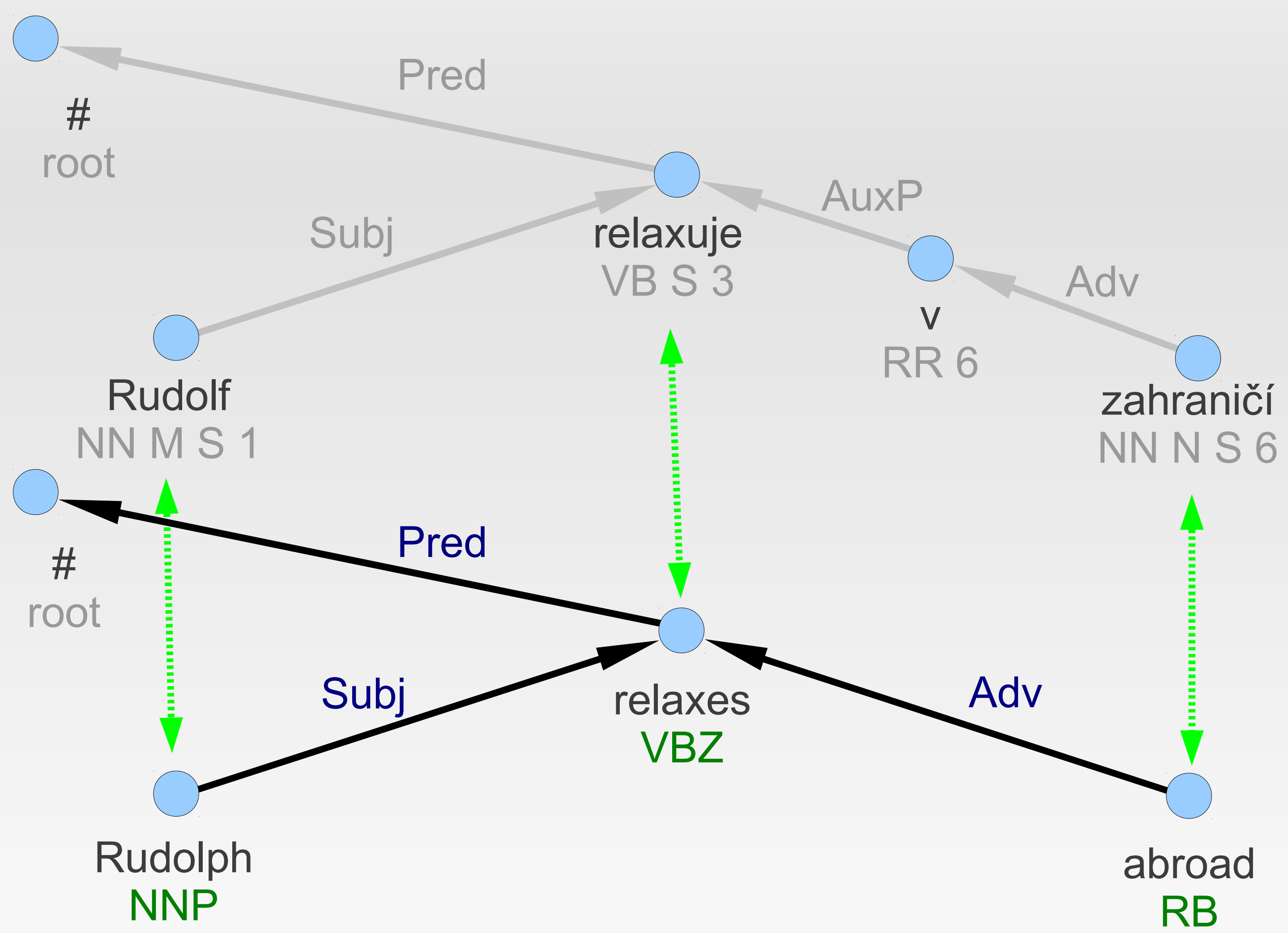
MSTperl

- reimplementation of MST Parser in Perl
  - http://ufal.mff.cuni.cz/tools/mstperl-parser
  - first-order, non-projective
- adapted for SMT outputs parsing
  - worsening the training data
  - **adding parallel information**
  - manually boosting feature weights
  - exploiting large-scale data

Parallel Features

- word alignment (using GIZA++)
- additional features (if aligned node exists):
  - aligned tag (NNS, VBD...)
  - aligned dependency label (Subject, Attribute...)
  - aligned edge existence (0/1)

Parallel Features Example



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  - **manually boosting feature weights**
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Manually boosting feature weights

- **aligned edge existence** is the key feature here
- observation: since the worsening is probably too mild, its weight is too low
  - edge exists: -0.57
  - edge does not exist: -0.83
  - missing aligned node(s): -0.67

Manually boosting feature weights

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- observation: since the worsening is probably too mild, its weight is too low
  - edge exists: **-0.57**
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- experiment: manually increase its weight
  - edge exists: **-0.25**

Manually boosting feature weights

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- experiment: manually increase its weight
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- success – manual changing of weights feasible

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  - manually boosting feature weights
  - **exploiting large-scale data**

Exploiting large-scale data

- exploiting large-scale parsed data (CzEng) to provide additional lexical features
- lexical features are important for the parser
- CzEng has 10 times more word types (lemmas) than PCEDT (400k vs. 40k)
- training the parser on whole CzEng infeasible
- new feature: pointwise mutual information

$$PMI'(parent, child) = \log \frac{count([parent, child])}{count([parent, *]) \cdot count([*, child])}$$

Direct Evaluation: by Inspection

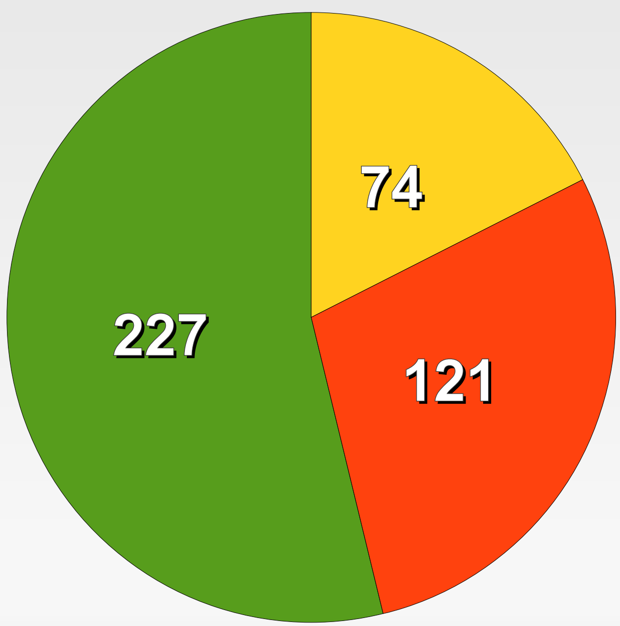
- manual inspection of several parse trees
  - comparing baseline and adapted parser ouputs
- examples of improvements:
  - subject identification even if not in nominative case
  - adjective-noun dependence identification even if agreement violated (gender, number, case)
- hard to do reliably
  - trying to find a correct parse tree for an (often) incorrect sentence – not well defined

Indirect Evaluation: in Depfix

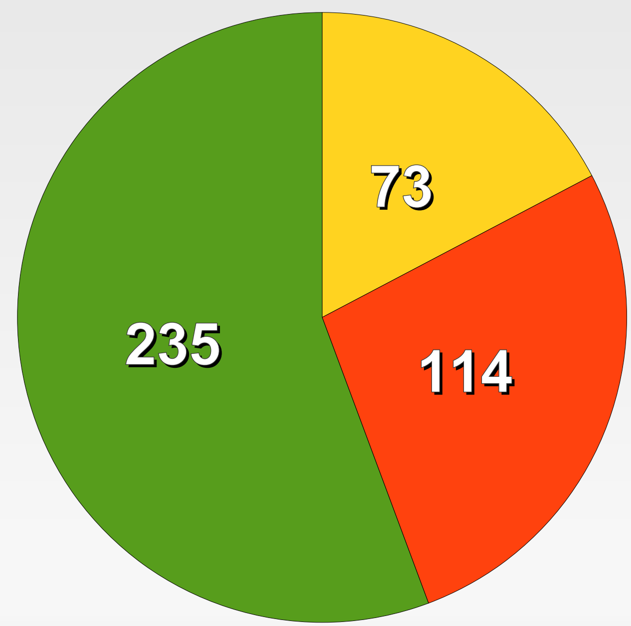
- run Depfix with
  - baseline 1: the original McDonald's MST parser
  - baseline 2: basic MSTperl (without the adaptations)
  - adapted MSTperl
- manual evaluation of adapted MSTperl versus the two baseline parsers
  - how many sentences come out better from Depfix using adapted MSTperl than from Depfix using a baseline parser

Indirect Evaluation: in Depfix

- improvements and deteriorations in Depfix:
  - adapted MSTperl vs original McDonald's MST Parser i'm parsin' it



  - adapted MSTperl vs basic MSTperl



Conclusion

- automatic post-editing of SMT is possible
  - “easy” with using linguistic analysis and generation
  - adapting the parser for SMT outputs also helps
- rule-based system for English→Czech
  - achieves improvements across SMT systems
- machine-learned system (**now** English→Czech)
  - could learn more fine-grained rules
  - could be easily extended to other languages
    (if we have analysis and generation)

Thank you for your attention

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Depfix:

Automatic post-editing of phrase-based machine translation outputs

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