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Depfix:

Automatic post-editing of phrase-based machine translation outputs

Charles University in Prague
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Monday seminar, 14th October 2013

Outline

- translation of negation (and its correction)
  - motivation
  - the fixing pipeline
- analysis and corrections
  - m-layer (lemmas, tags, word-alignment)
  - a-layer (dependency trees, analytical functions)
  - t-layer (“tecto-trees”, formemes, grammatemes)
- evaluation
- parsing of SMT outputs (MSTperl parser)

Motivation: Translation of negation

http://thedrivenclass.com/blog-detail/32876

Motivation: Errors in negation

- These **are not** actually errors.

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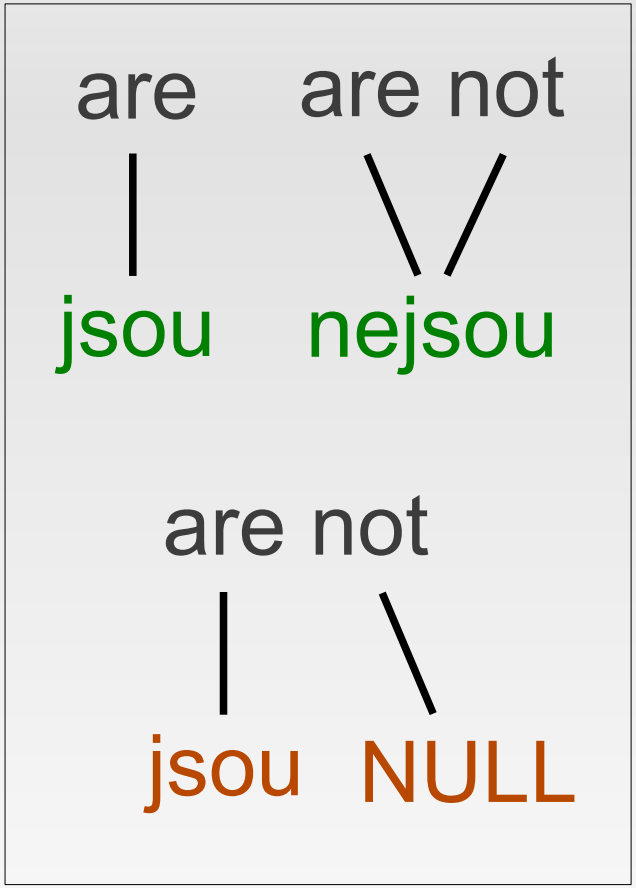

- some phenomena hard to get right with PBSMT

Simple to fix?

- there is a negation in the source
  - These are **not** actually errors

Simple to fix?

- there is a negation in the source
  - These are **not** actually errors
- there is no negation in the target
  - Jsou to vlastně chyby

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Simple to fix?

- there is a negation in the source
  - These are **not** actually errors
- there is no negation in the target
  - Jsou to vlastně chyby
- add the negative prefix (ne-) into the target
  - **Ne**jsou to vlastně chyby

Simple to fix?

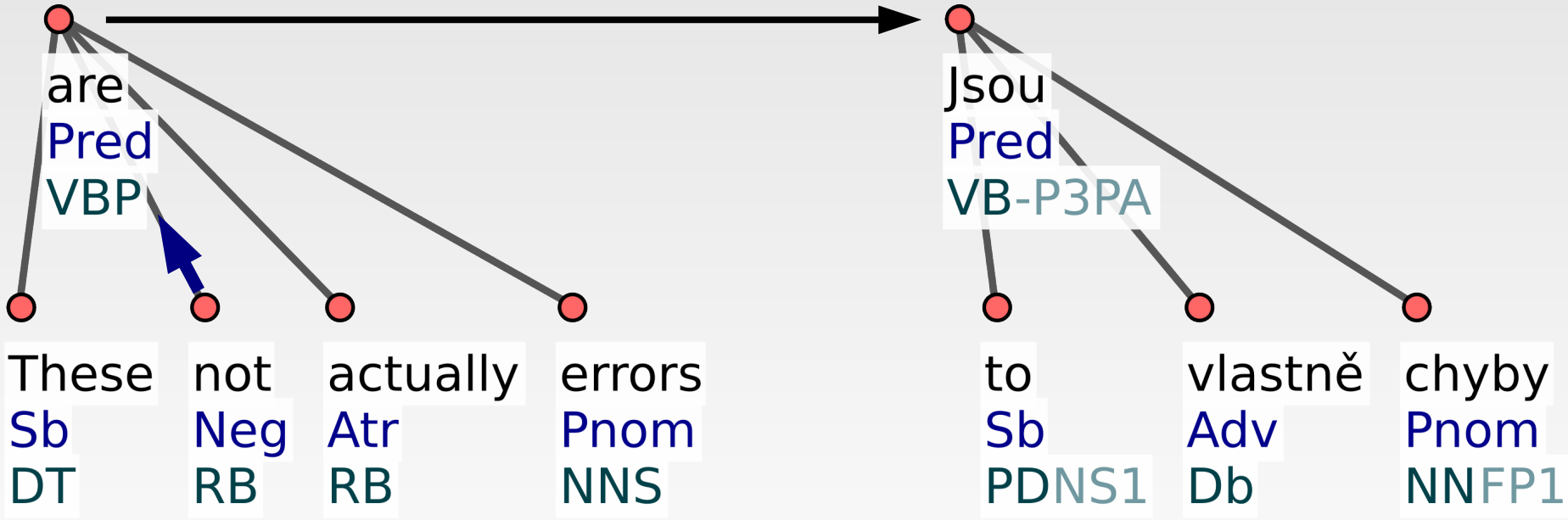
- there is a negation in the source
  - These are **not** actually errors
- there is no negation in the target
  - Jsou to vlastně chyby
- add the negative prefix (ne-) into the target
  - **Ne**jsou to vlastně chyby
- such a simple approach might be sufficient
- but usually useful to use some more NLP tools

Part-of-speech tagger

- run a POS tagger on the target sentence
  - Jsou to vlastně chyby
  - verb pronoun adverb noun
- a good heuristic: negate the (finite) verb!
  - **Ne**jsou to vlastně chyby
  - verb pronoun adverb noun
- fine-grained tags may even mark the negation
  - jsou VB-P---3P-**A**A---
  - nejsou VB-P---3P-**N**A---

Dependency parser

- parse both source and target
- project negation through word alignment



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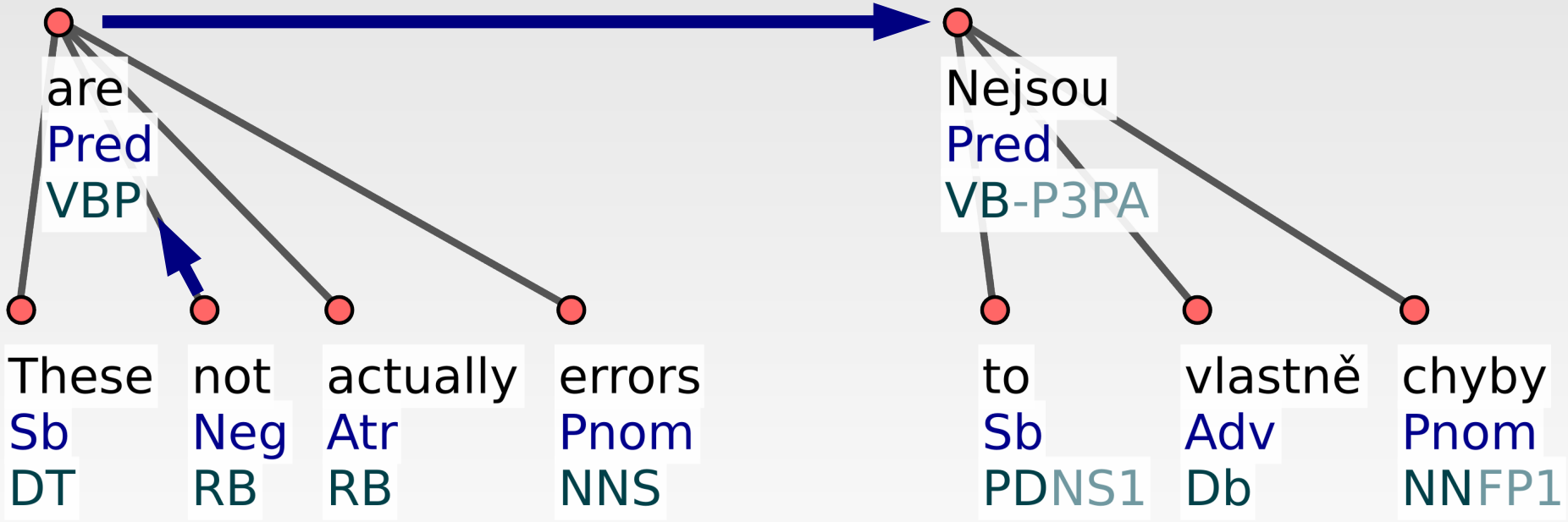
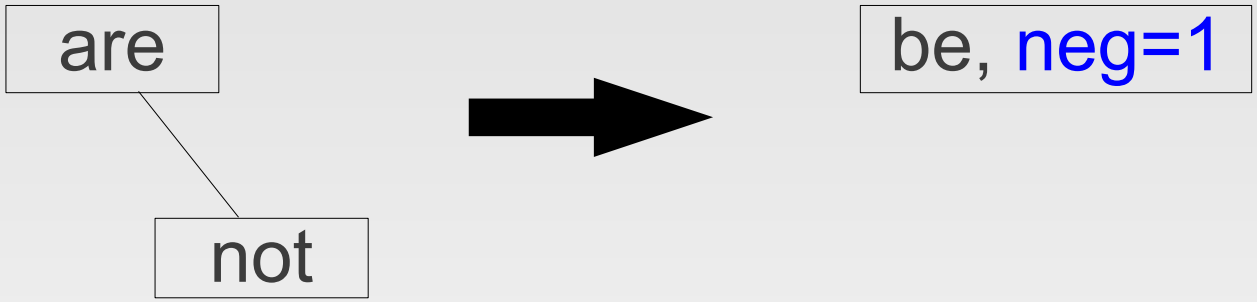


Deep syntactic analysis

- auxiliary nodes collapsed into values of attributes on parent nodes



- abstract from various ways of expressing negation (not, no, un-, in-,...)
  - all marked by `neg=1` on the lexical node

Morphological generator

- `form = generate(word, morphological features)`

Morphological generator

- `form = generate(lemma, tag)`

Morphological generator

- `form = generate(lemma, tag)`
- instead of: `new_form = 'ne' + form`
  - `'nejsou' = 'ne' + 'jsou'`

Morphological generator

- `form = generate(lemma, tag)`
- instead of: `new_form = 'ne' + form`
  - `'nejsou' = 'ne' + 'jsou'`
- use the more sophisticated: `new_form = generate(lemma(form), negate(tag))`
  - `'nejsou' = generate(lemma('jsou'), negate('VB-P---3P-AA---'))`

Morphological generator

- `form = generate(lemma, tag)`
- instead of: `new_form = 'ne' + form`
  - `'nejsou' = 'ne' + 'jsou'`
- use the more sophisticated: `new_form = generate(lemma(form), negate(tag))`
  - `'nejsou' = generate(lemma('jsou'), negate('VB-P---3P-AA---'))`
  - `'nejsou' = generate( 'být' , 'VB-P---3P-NA---' )`

Depfix pipeline

- input
  - English sentence
  - its Czech translation, provided by an SMT system
- m-layer analysis and fixes (tagger, word-aligner)
- a-layer analysis and fixes (dependency parser)
- t-layer analysis and fixes (t-tree analyzer)
- output (morphological generator)
  - the Czech translation, corrected

Outline

- ✔ translation of negation (and its correction)
  - ✔ motivation
  - ✔ the fixing pipeline
- ➔ **analysis and corrections**
  - m-layer (lemmas, tags, word-alignment)
  - a-layer (dependency trees, analytical functions)
  - t-layer (“tecto-trees”, formemes, grammatemes)
- evaluation
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M-layer

- analysis: lemmas, tags, word-alignment
  - +adding missing alignment links by string similarity
- corrections:
  - tokenization projection
  - morphological number projection
  - source-aware truecasing
  - vocalisation of prepositions

Tokenization projection

Source	Michèle **Alliot-Marie** had sent a communication
Moses	Michèle **Alliot - Marie** poslal sdělení
Gloss	Michèle Alliot - Marie sent$_{masc}$ a communication
Depfix	Michèle **Alliot-Marie** poslala sdělení
Gloss	Michèle Alliot-Marie sent$_{fem}$ a communication

Source-aware truecasing

Source	the director of the best hotel in **Pec**, Karel **Rada**.
Moses	ředitel nejlepší hotel v **peci**, Karel **rada**.
Gloss	the director of the best hotel in the **oven**, Karel **advice**.
Depfix	ředitel nejlepšího hotelu v **Peci**, Karel **Rada**.
Gloss	the director of the best hotel in **Pec**$_{\textbf{town}}$, Karel **Rada**$_{\textbf{surname}}$.

Vocalisation of prepositions

Source	The work being done by experts from three institutions
Moses	Práce odborníků **z** tří institucí
Gloss	Work by experts from three institutions
Depfix	Práce odborníků **ze** tří institucí
Gloss	Work by experts from three institutions

Outline

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  - **a-layer** (dependency trees, analytical functions)
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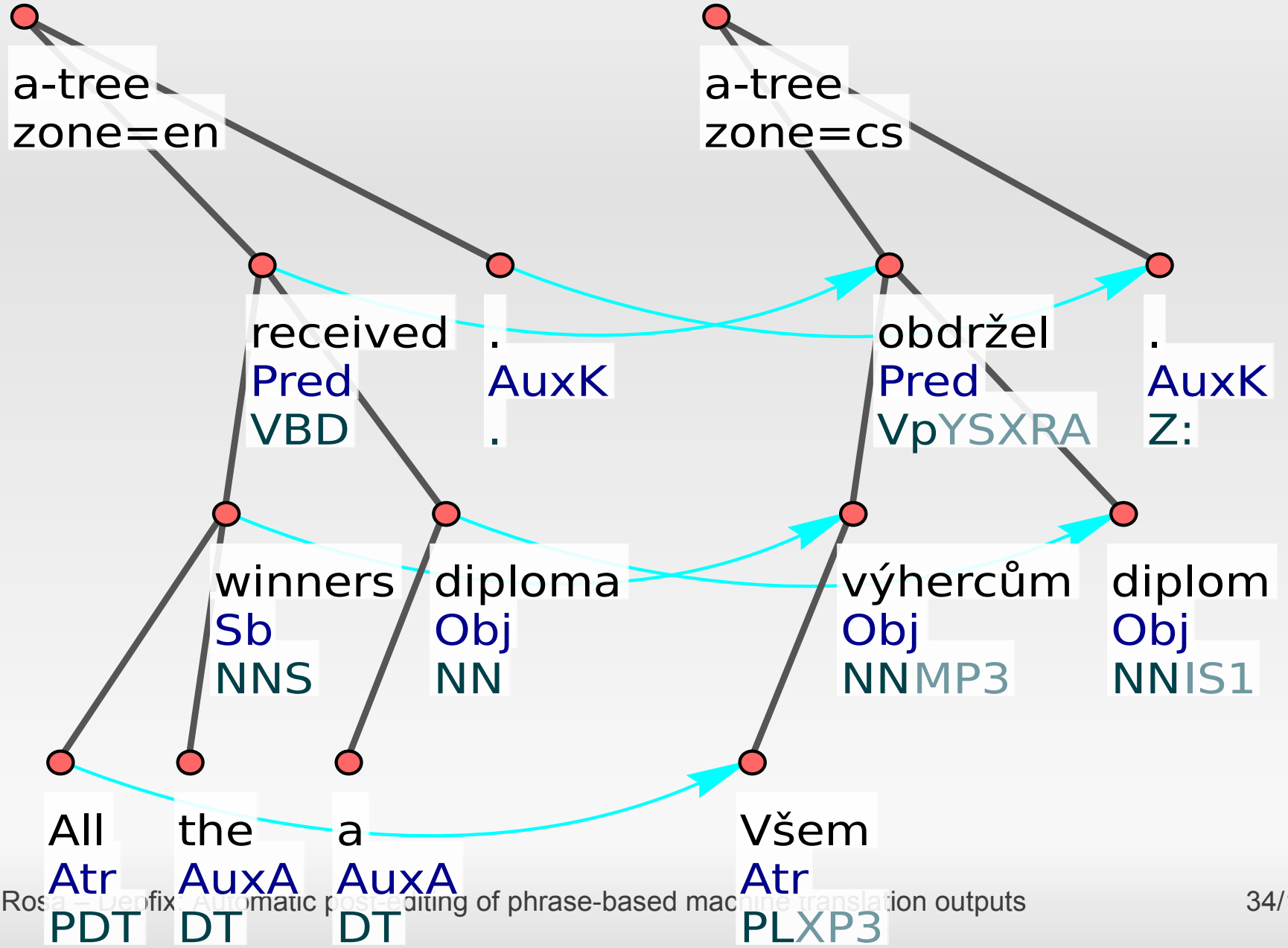
A-layer

- analysis: dependency trees, analytical functions
  - for Czech: MSTperl (adapted MST parser)
  - + fixing prepositions without children, auxiliary verbs with children, AuxT/AuxR...
- morphological agreement fixes:
  - preposition-noun, noun-adjective, subject-predicate...
- fixes of transfer of meaning to morphology
  - possessives, passives, subject...

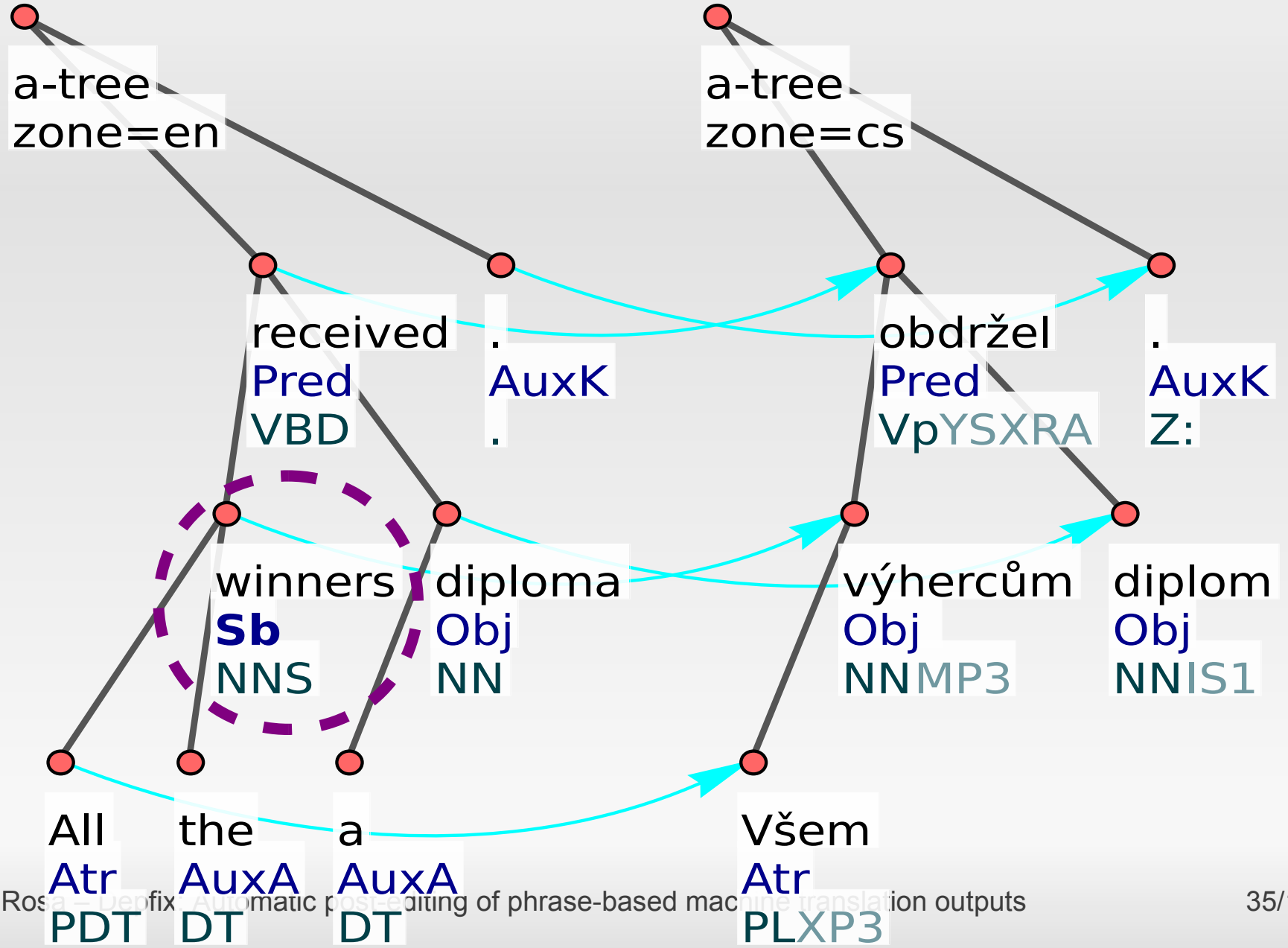
A-layer motivation

- 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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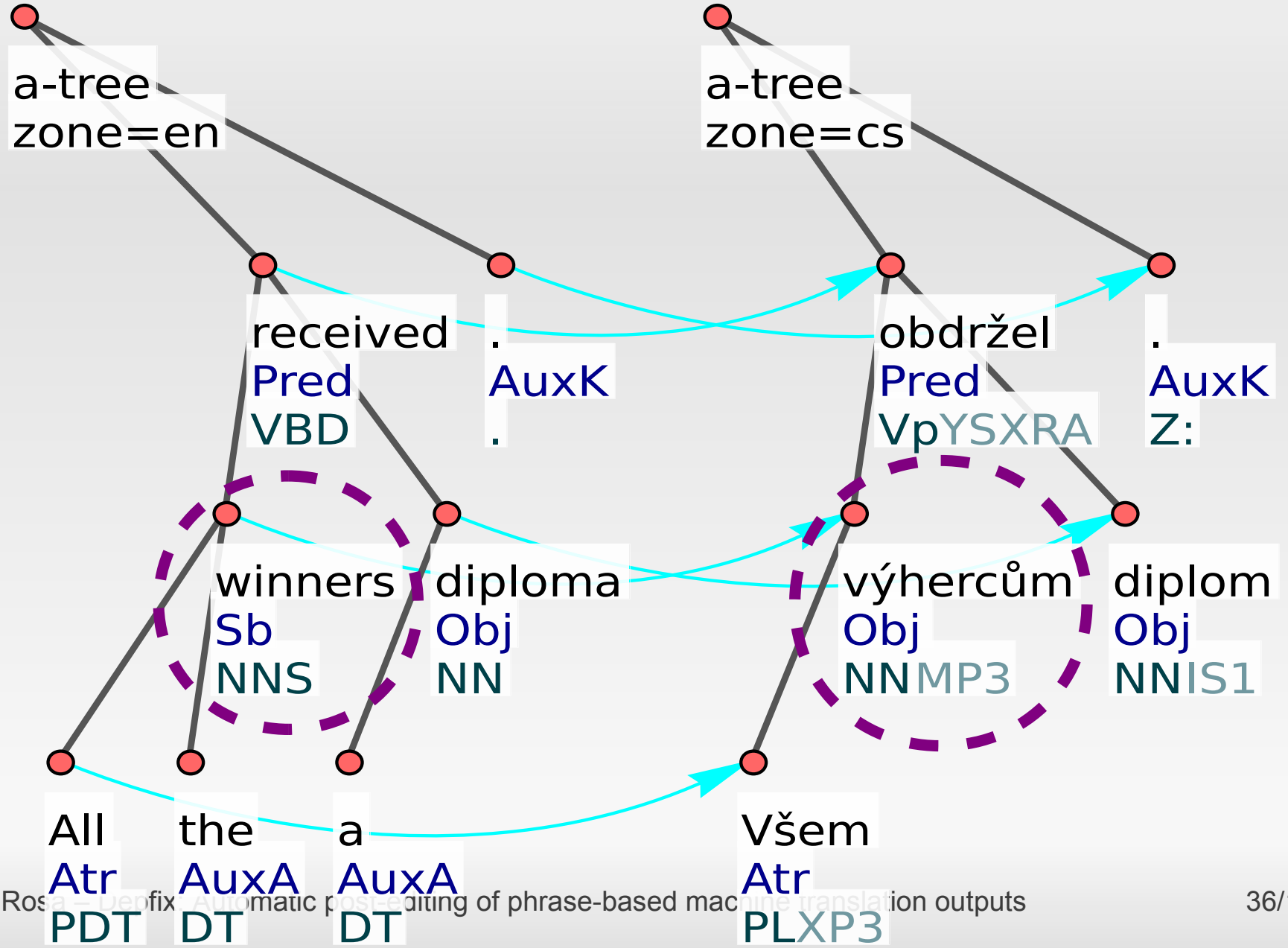
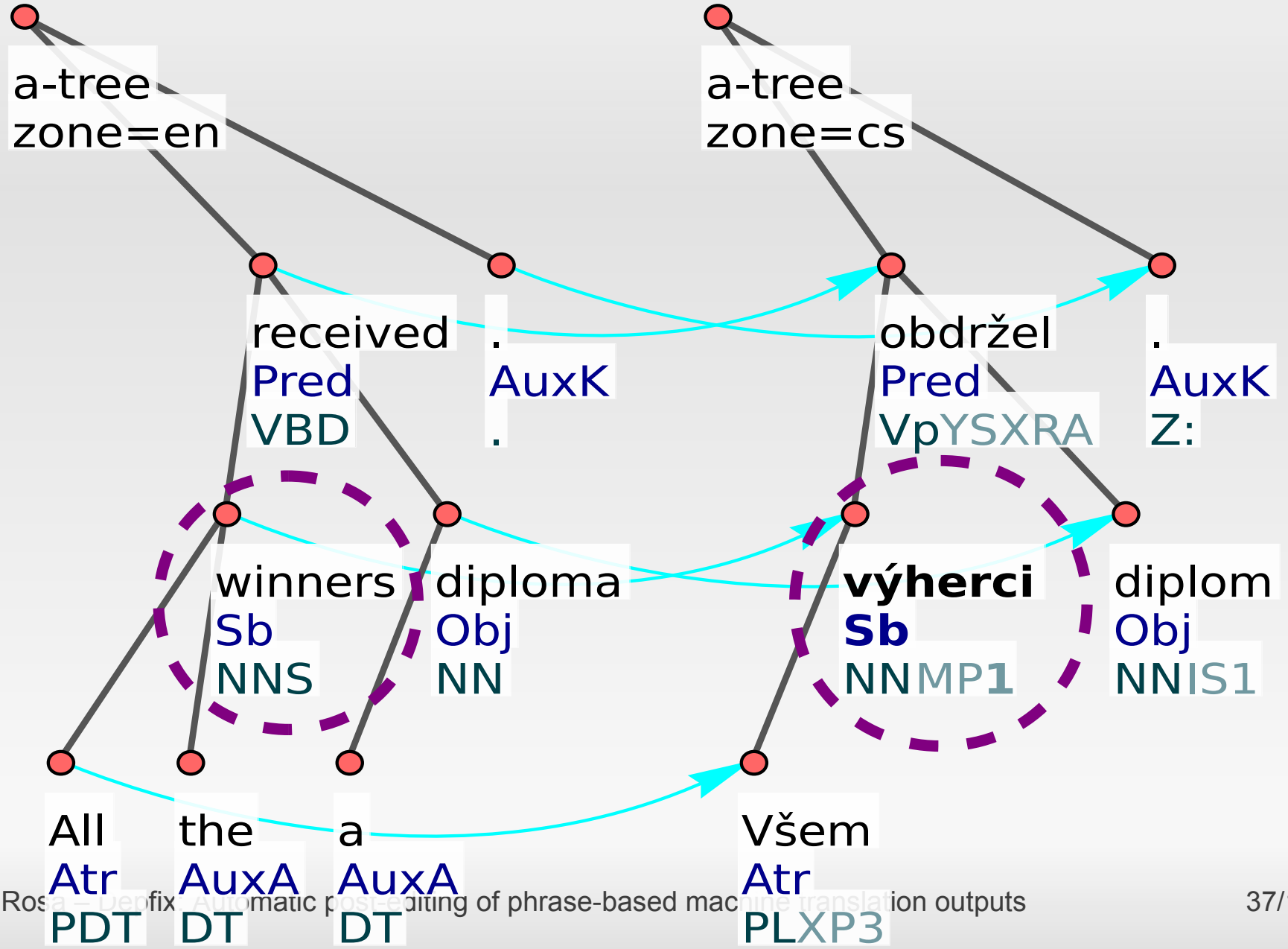
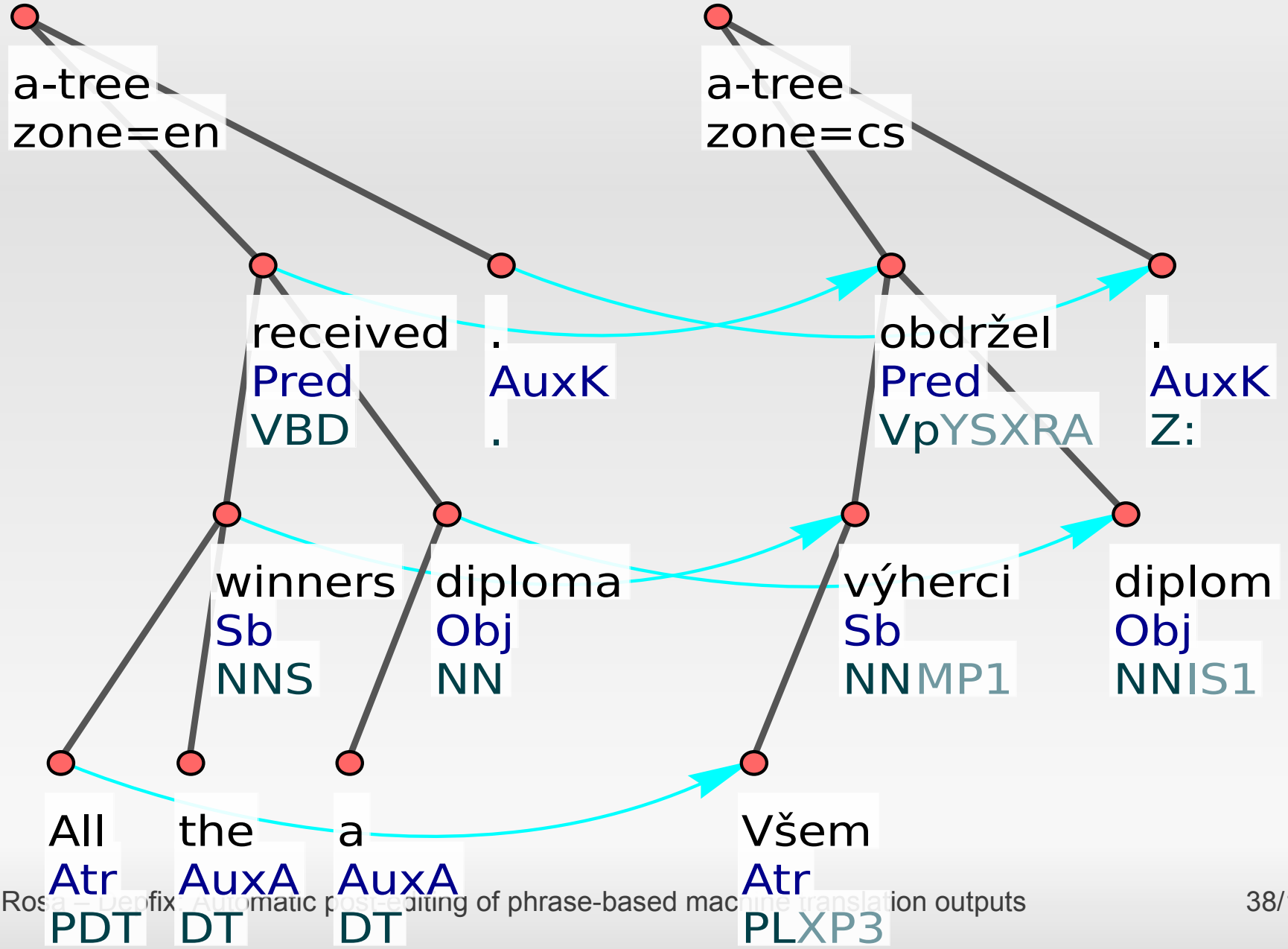


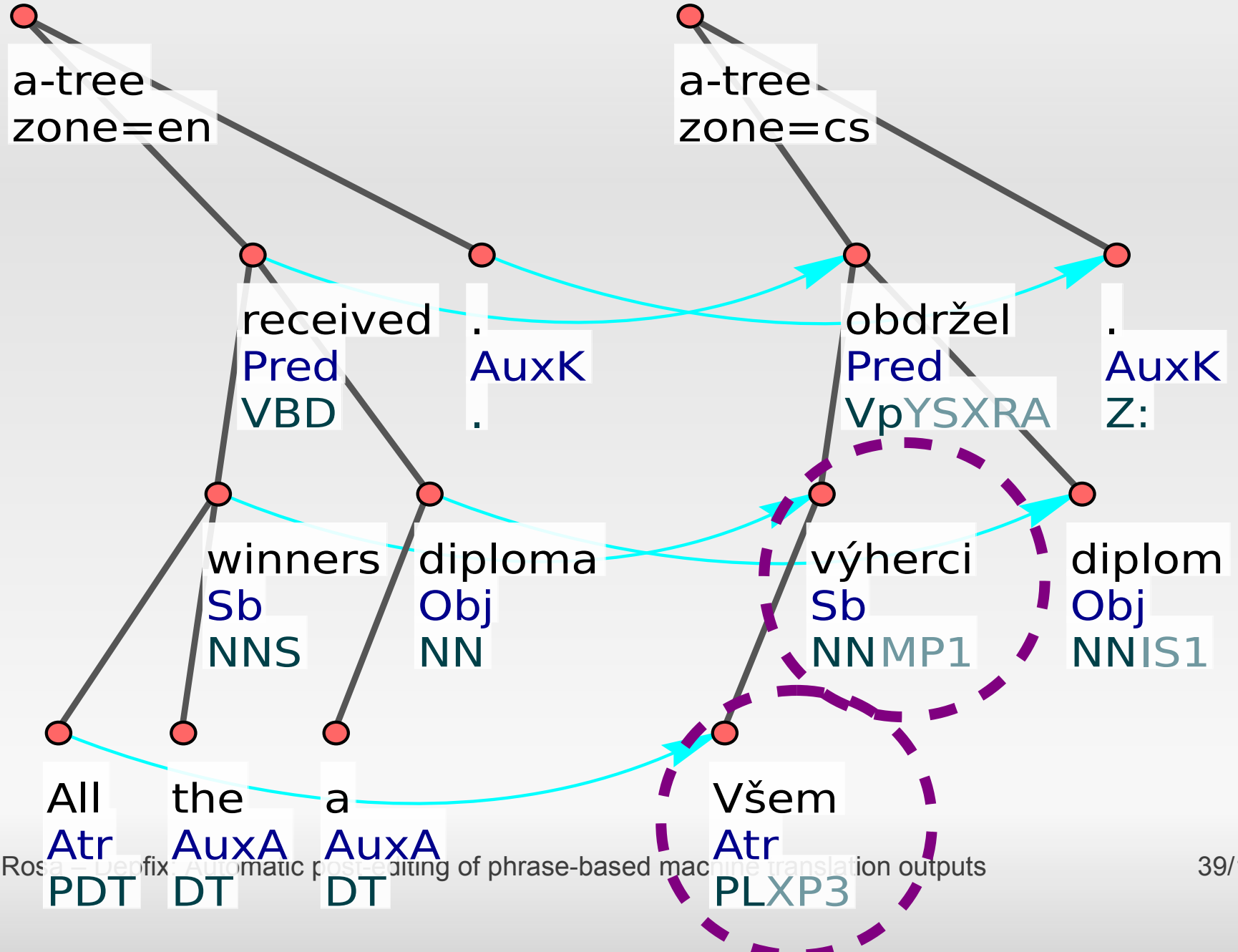
Subject → nominative



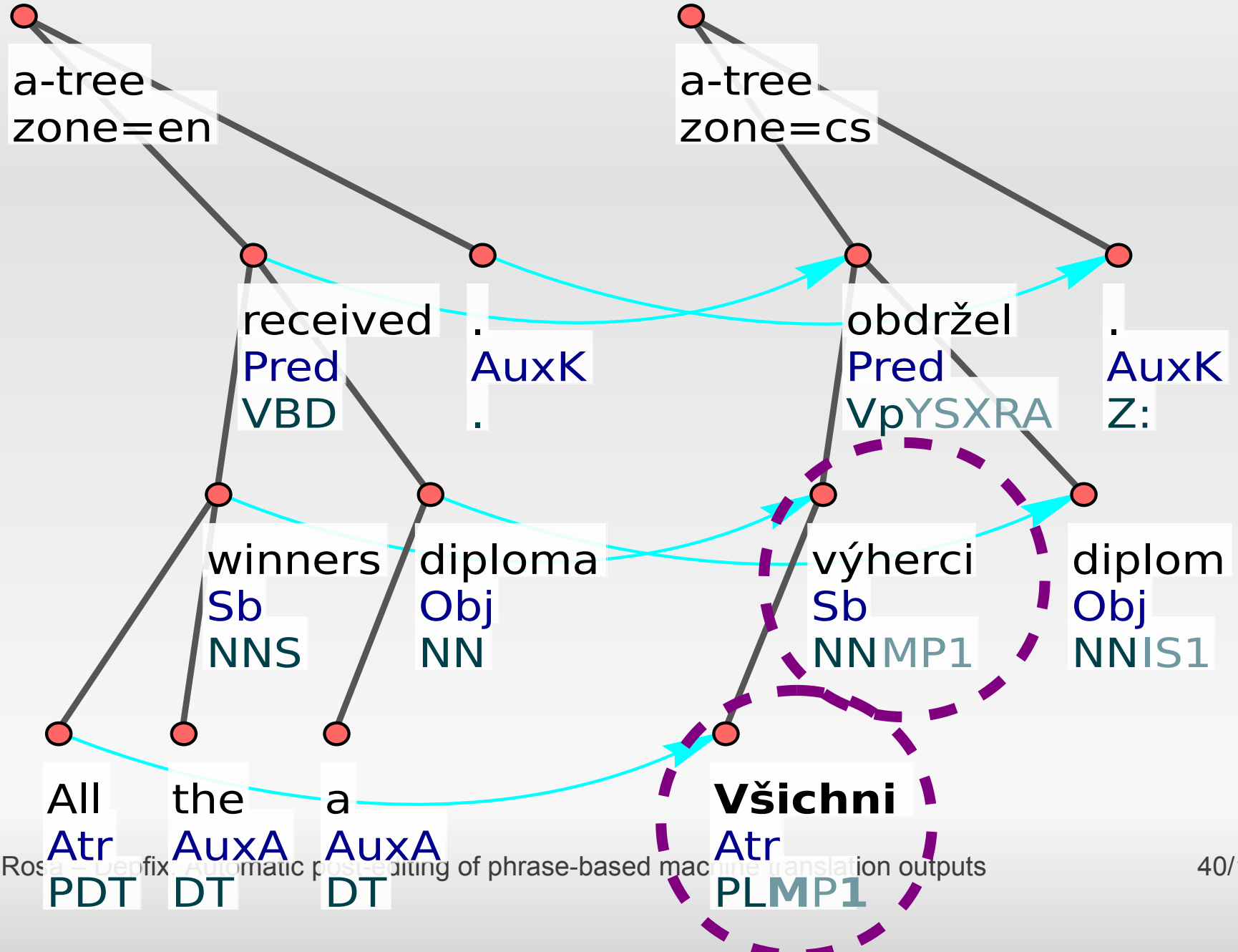
Všem výherci obdržel diplom.



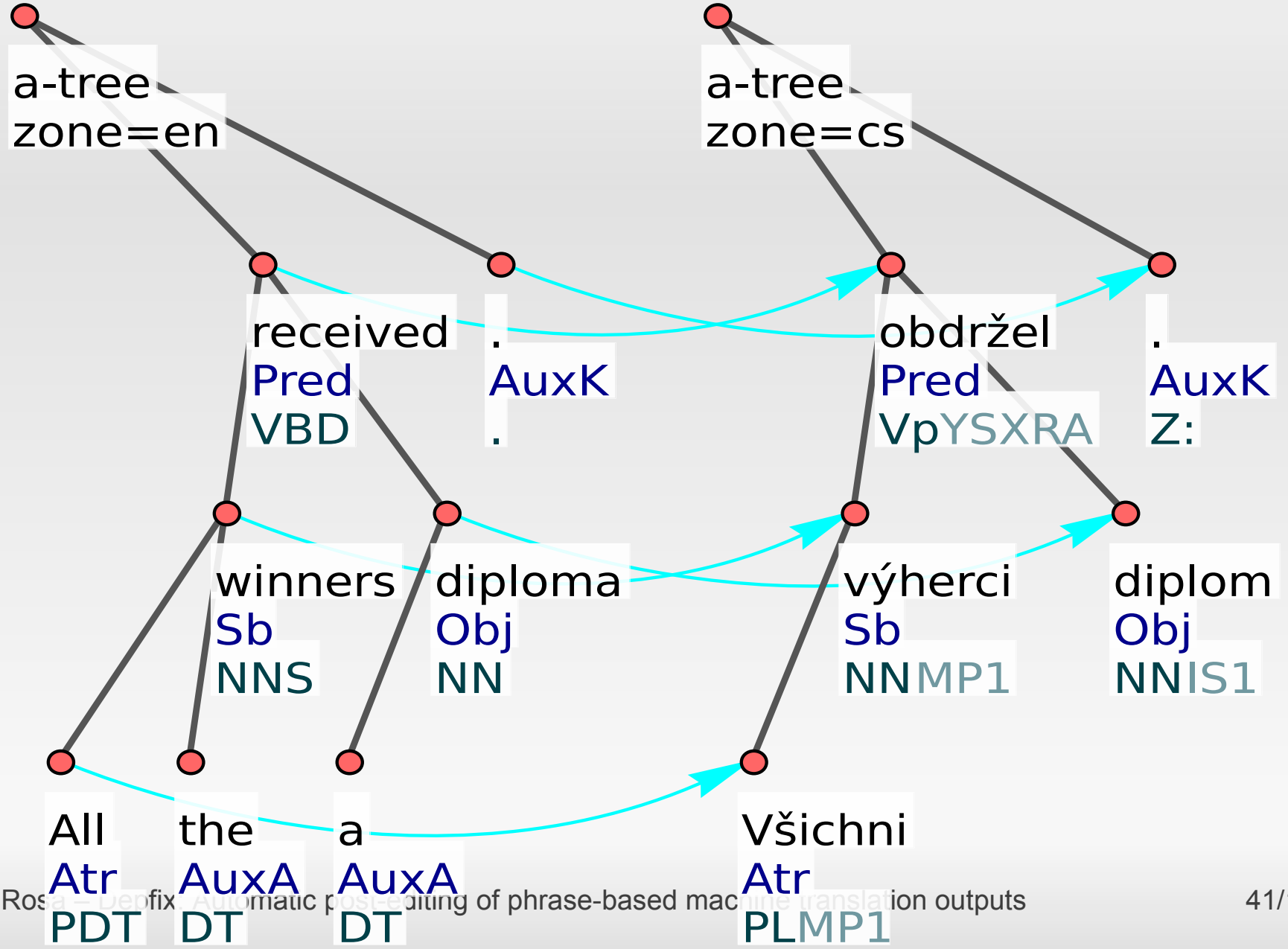
Noun-adjective agreement



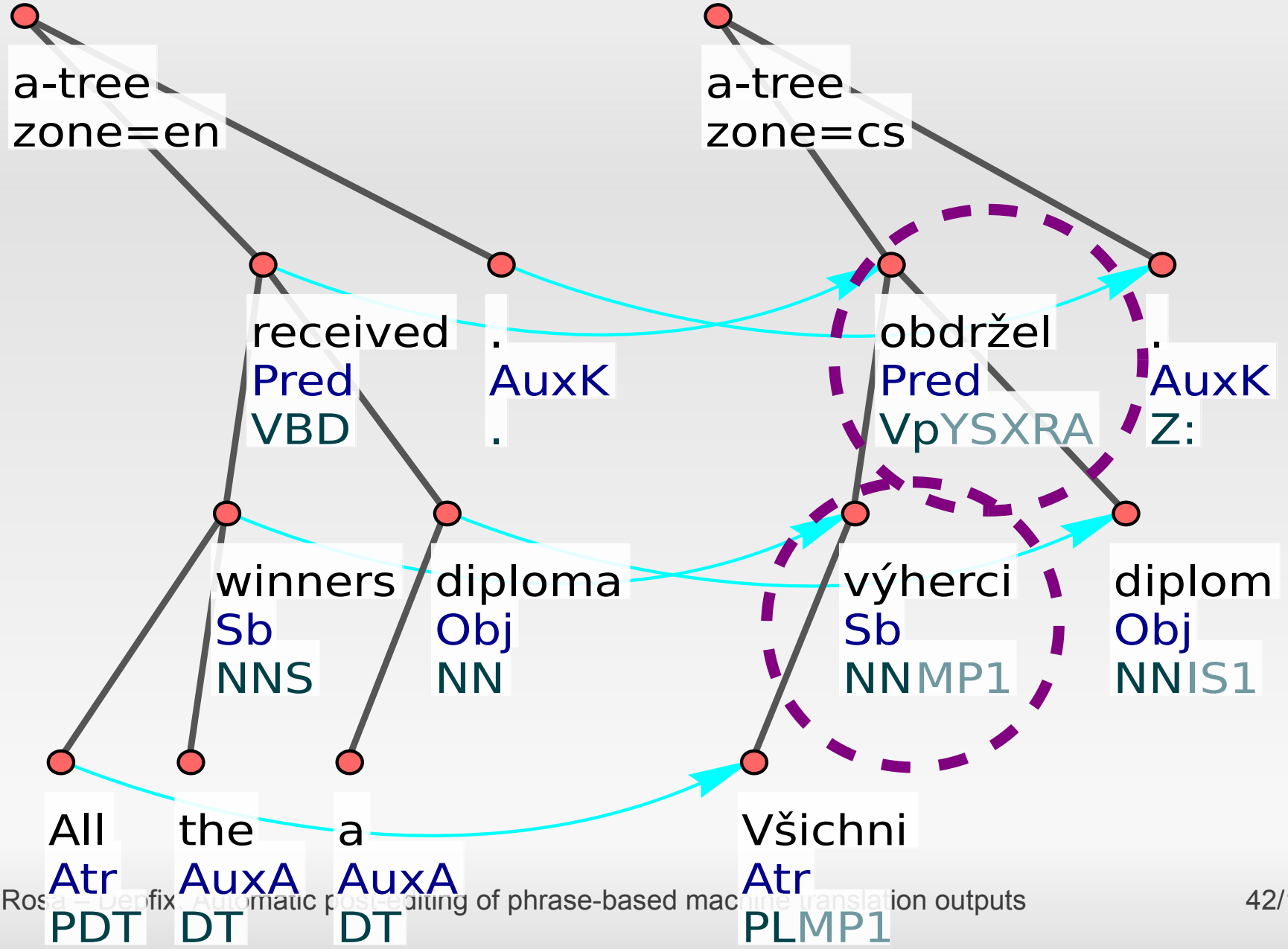
Agreement: gender, case (number)



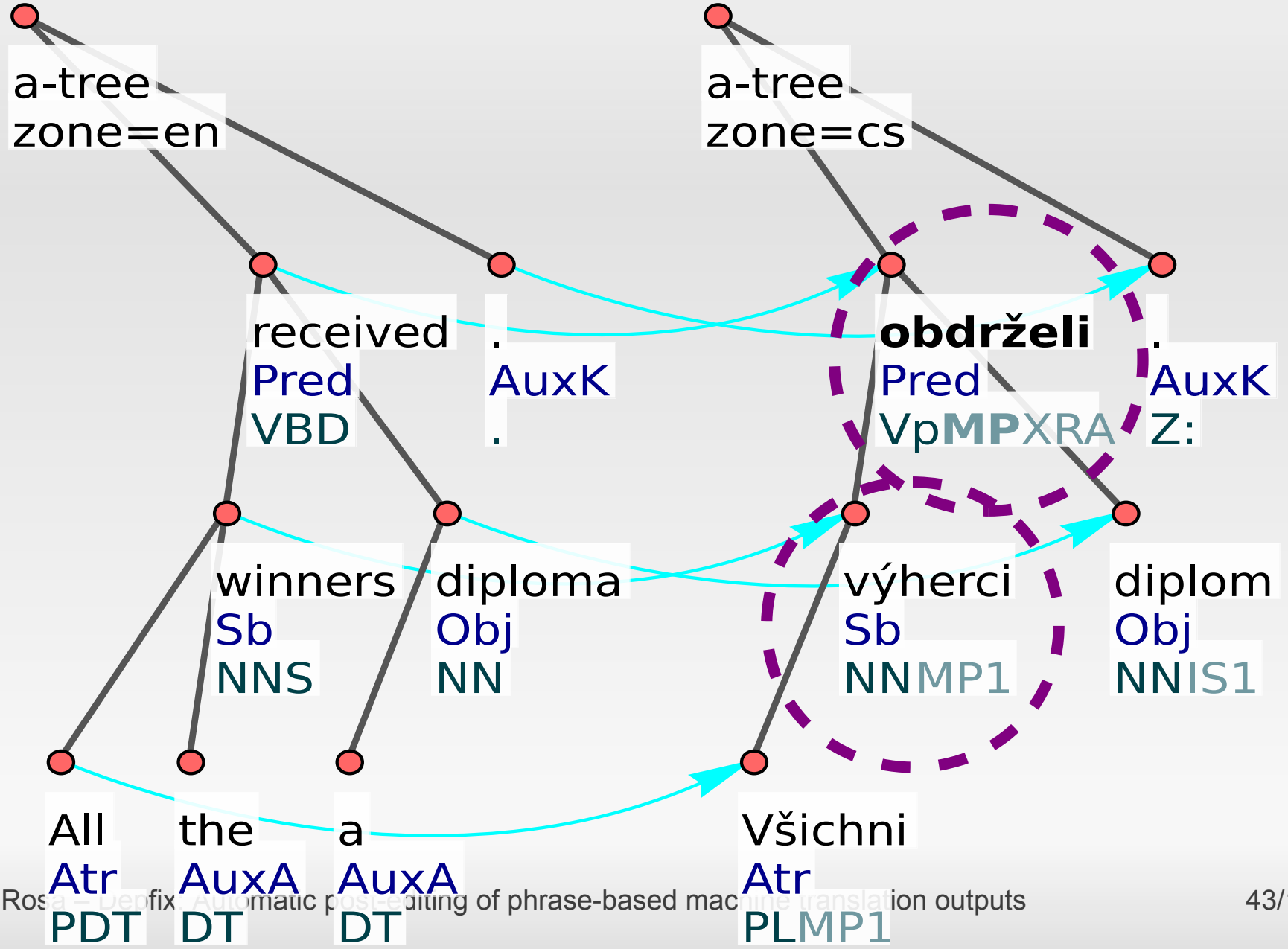
Všichni výherci obdržel diplom.



Subject-predicate agreement



Agreement: gender, num (person)



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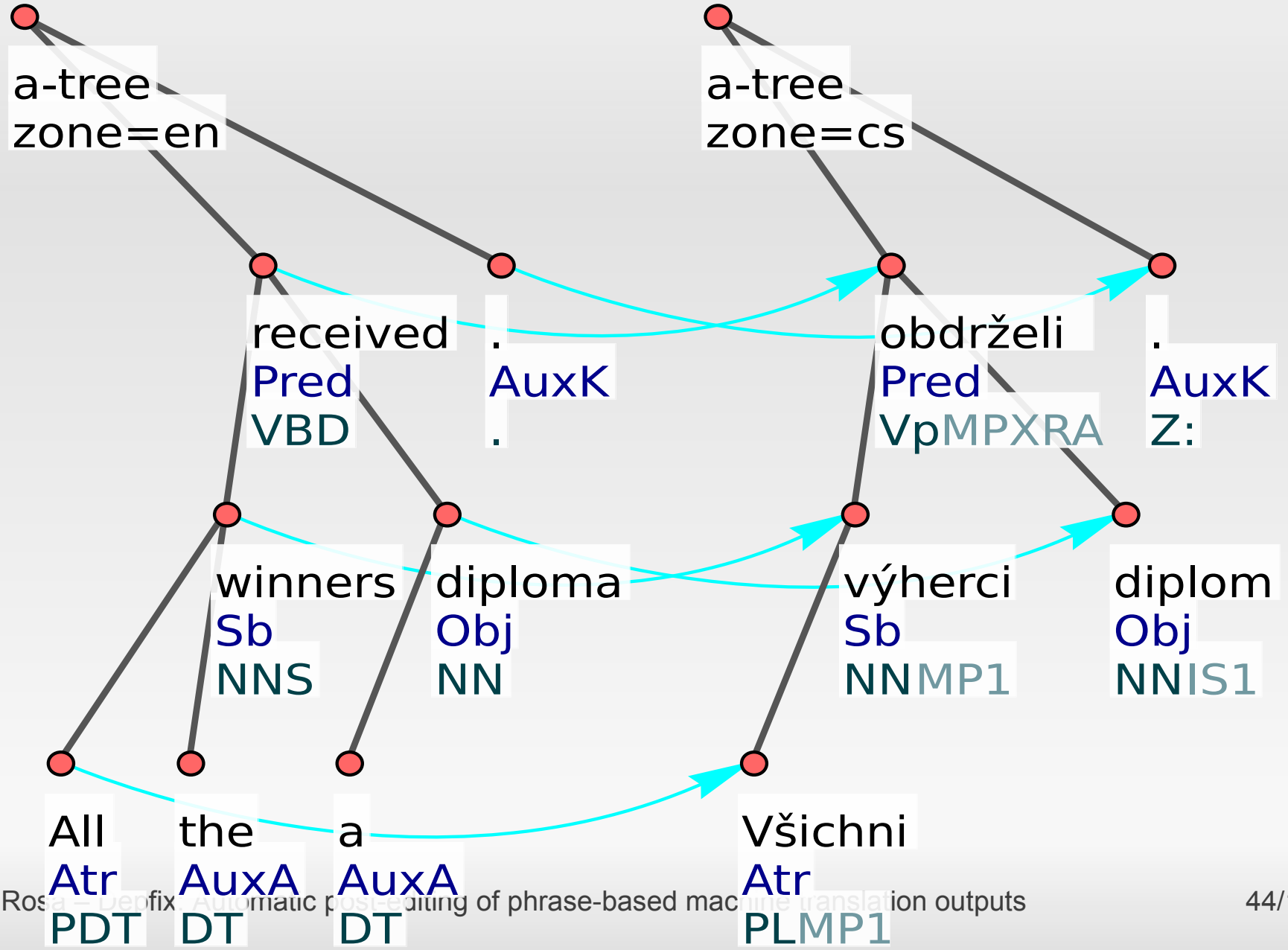

Preposition-noun agreement

Source	It is a story about sport, race relations, and Nelson Mandela.
Moses	Je to příběh **o sportu**, rasových **vztahů**, a Nelson **Mandela**.
Gloss	It is a story **about**$_{\textbf{loc}}$ **sport**$_{\textbf{loc}}$, race **relations**$_{\textbf{gen}}$, and Nelson$_{\text{nom}}$ **Mandela**$_{\textbf{nom}}$.
Depfix	Je to příběh **o sportu**, rasových **vztazích**, a Nelson **Mandelovi**.
Gloss	It is a story **about**$_{\textbf{loc}}$ **sport**$_{\textbf{loc}}$, race **relations**$_{\textbf{loc}}$, and Nelson$_{\text{nom}}$ **Mandela**$_{\textbf{loc}}$.

Noun-adjective agreement

Source	this half-hearted increase will bear the same fruit
Moses	**tato polovičatá nárůst** bude nést stejné ovoce
Gloss	**this**$_{\text{fem}}$ **half-hearted**$_{\text{fem}}$ **increase**$_{\text{masc}}$ will bear the same fruit
Depfix	**tento polovičatý nárůst** bude nést stejné ovoce
Gloss	**this**$_{\text{masc}}$ **half-hearted**$_{\text{masc}}$ **increase**$_{\text{masc}}$ will bear the same fruit

Translation of 'of'

Source	unsustainable deficit level **of public finances**.
Moses	neudržitelná úroveň schodku **veřejné finance**.
Gloss	unsustainable deficit level **public finances**.
Depfix	neudržitelná úroveň schodku **veřejných financí**.
Gloss	unsustainable deficit level **of public finances**.

Translation of 's

Source	**Janota's** possible **continuation** in office will be the topic of Friday's meeting.
Moses	**Janota je** možné **pokračování** ve funkci bude tématem páteční schůze.
Gloss	**Janota is** possible **continuation** in office will be the topic of Friday's meeting.
Depfix	možné **pokračování Janoty** ve funkci bude tématem páteční schůze.
Gloss	possible **continuation of Janota** in office will be the topic of Friday's meeting.

Translation of Subject

Source	At a time when **Swiss voters**$_{\text{subj}}$ have called for a ban on the construction of minarets
Moses	V době, kdy **švýcarské voliče**$_{\text{acc}}$ vyzvali k zákazu výstavby minaretů
Gloss	At a time, when **Swiss voters were called** for a ban on the construction of minarets
Depfix	V době, kdy **švýcarští voliči**$_{\text{nom}}$ vyzvali k zákazu výstavby minaretů
Gloss	At a time, when **Swiss voters called** for a ban on the construction of minarets

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T-layer

- analysis: t-trees, formemes, grammatemes
  - + systematic analysis of English verb tenses
- rule-based fixes:
  - ✔ negation
  - verb tenses
  - subject pronoun dropping
- statistical fixes:
  - valency

Translation of verb tenses

Source	This **will bring** problems for whoever is in office
Moses	To **přináší** problémy pro každého, kdo je v kanceláři
Gloss	This **brings** problems for anyone who is in office
Depfix	To **bude přinášet** problémy pro každého, kdo je v kanceláři
Gloss	This **will bring** problems for anyone who is in office

Subject pronoun dropping

Source	I don't blame them.
Moses	**Já** se jim nedivím.
Gloss	I myself them don't-blame$_{\text{1st person sg}}$.
Depfix	Nedivím se jim.
Gloss	Don't-blame$_{\text{1st person sg}}$ myself them.

Correction of valency errors

- Source text in English:

  EU criticizes not only the Greek government

- Google Translate to Czech (6th Aug 2013):

  *EU kritizuje nejen **řecká vláda*** **nominative (subject)**

  - *Not only **the Greek government** criticizes EU*

- Post-editation by Deepfix:

  *EU kritizuje nejen **řeckou vládu*** **accusative (object)**

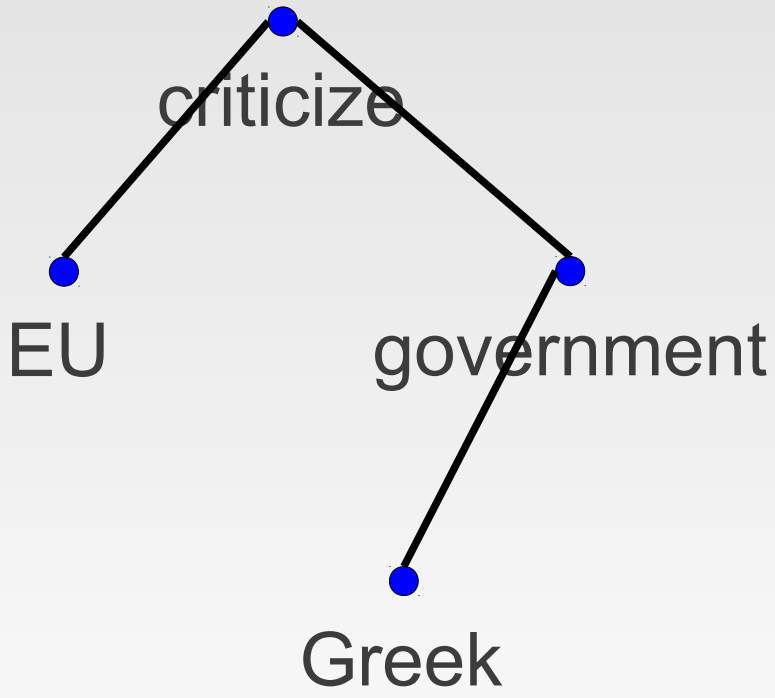
  - *EU criticizes not only **the Greek government***

Valency of *criticize* (*kritizovat*)

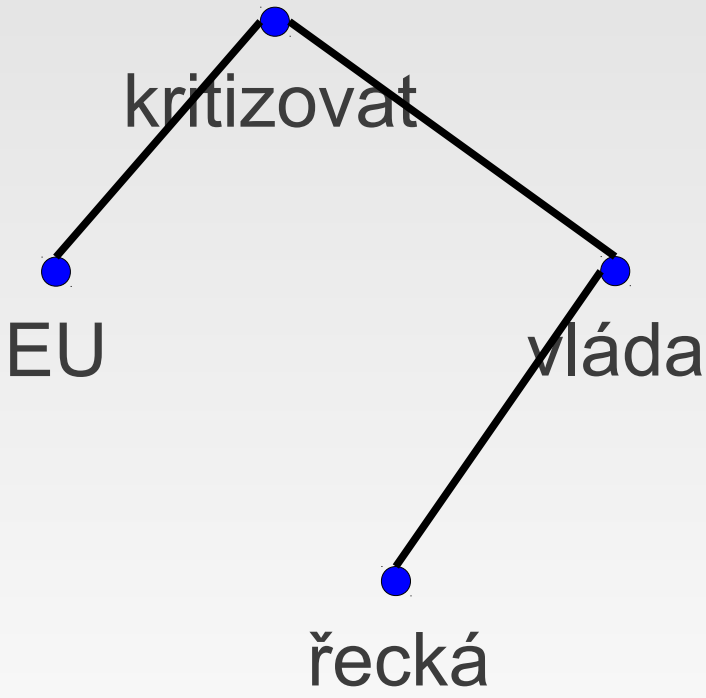
- *EU*$_{\text{subject}}$ *criticizes the Greek government*$_{\text{object}}$
- *EU*$_{\text{nominative}}$ *kritizuje řeckou vládu*$_{\text{accusative}}$
- a valency frame of a verb
  - subject *criticize* object (position)
  - nominative *kritizovat* accusative (cases)
- decomposition into head-argument pairs
  - (*to criticize, government*) ~ (*kritizovat, vládu*)
  - (*to criticize,* Object) ~ (*kritizovat,* accusative)

Deep syntactic dependency trees

EU criticizes
the Greek government



EU kritizuje
řecká vláda



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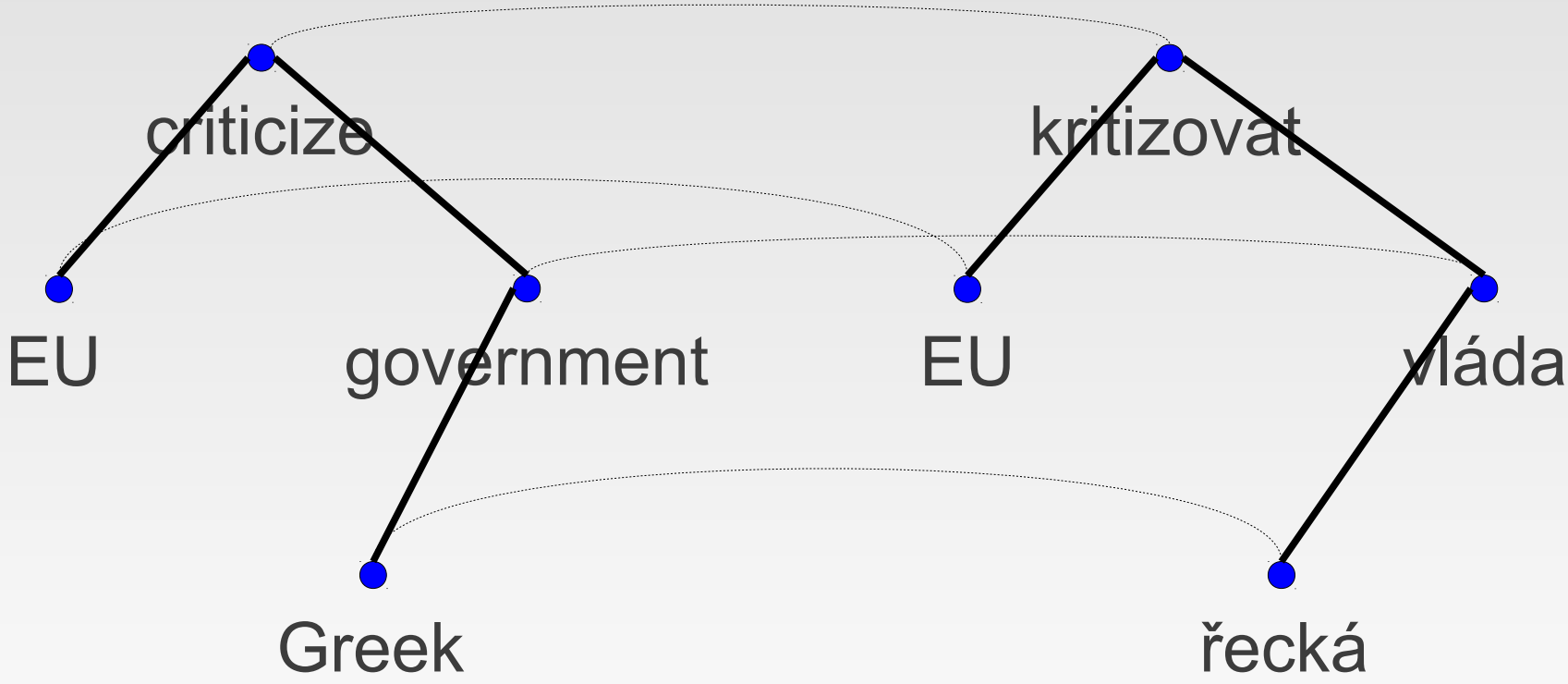

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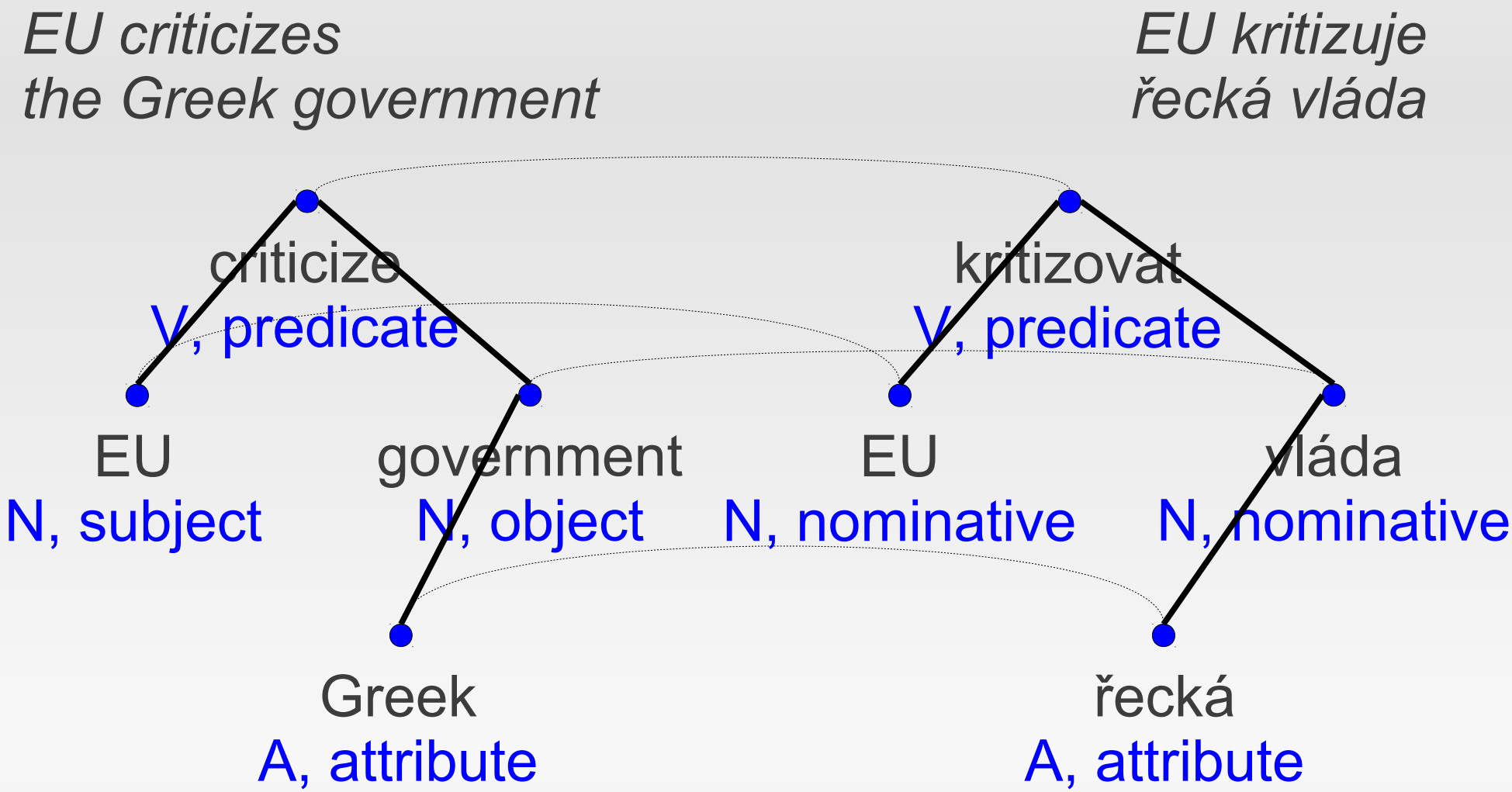
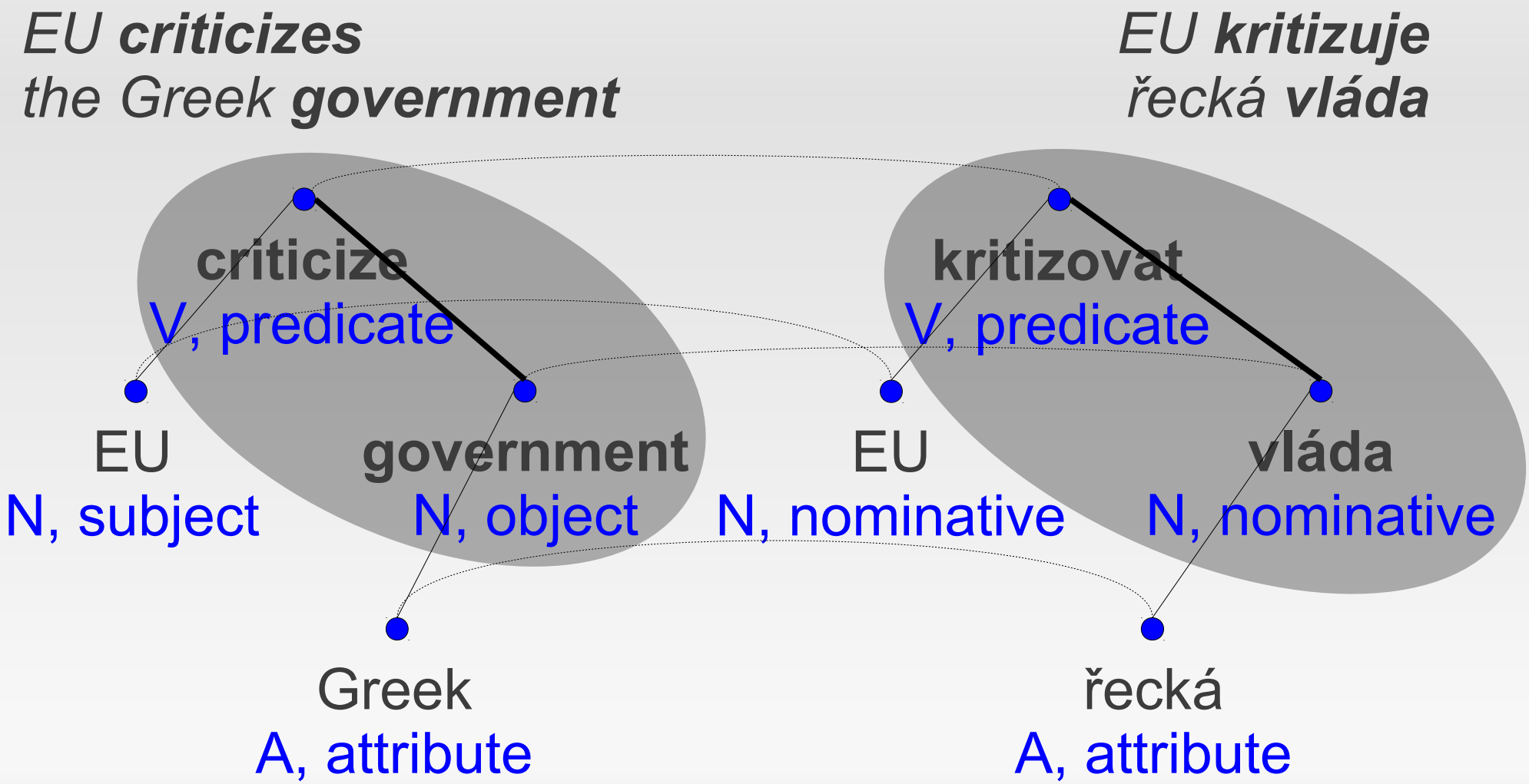
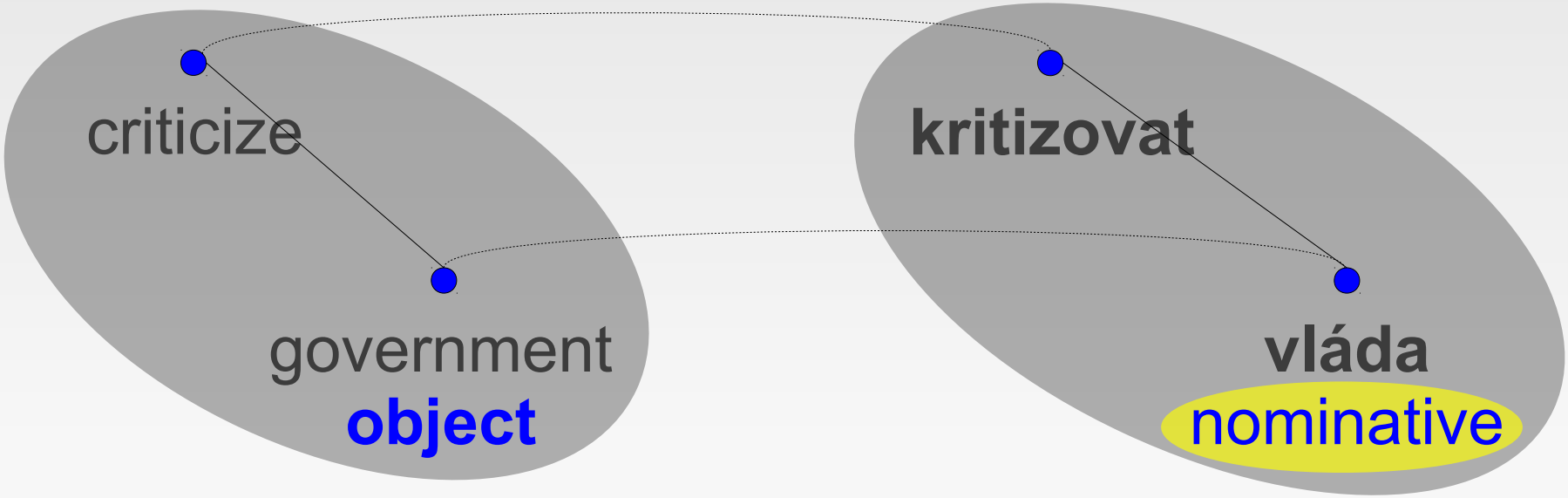


(head, arg) pair identification



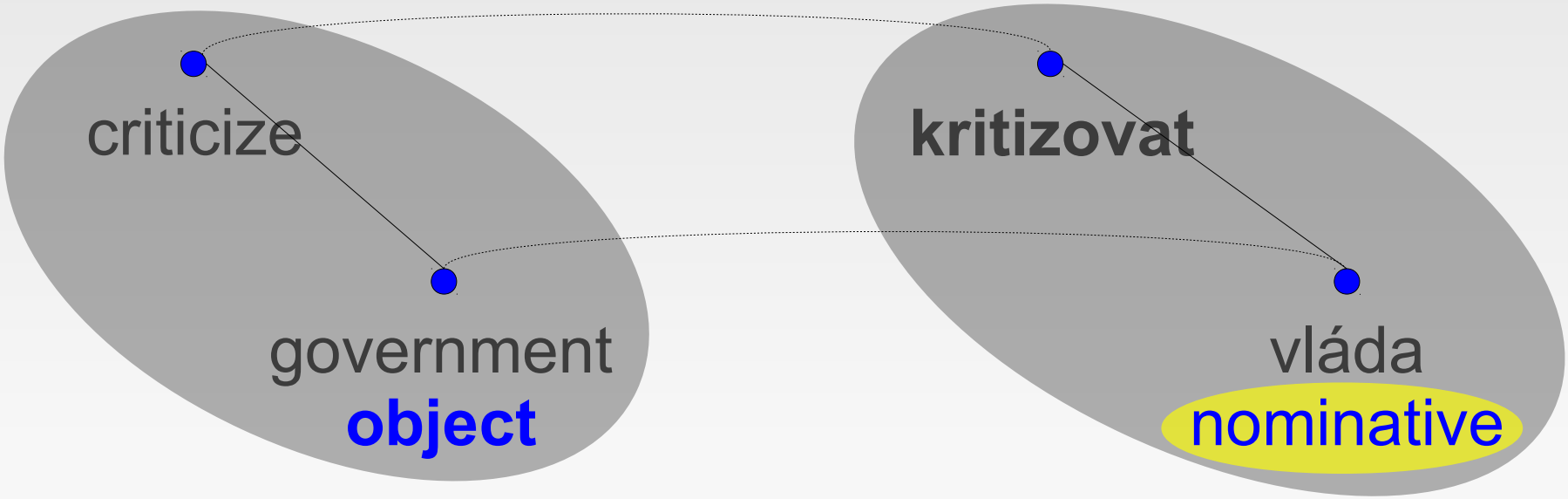
Valency models (FIX)

- $P(arg_{case} \mid head_{lemma}, English\_arg_{function})$
- $P(arg_{case} \mid head_{lemma}, English\_arg_{function}, arg_{lemma})$
- estimated from CzEng 1.0 (15M parallel stcs)



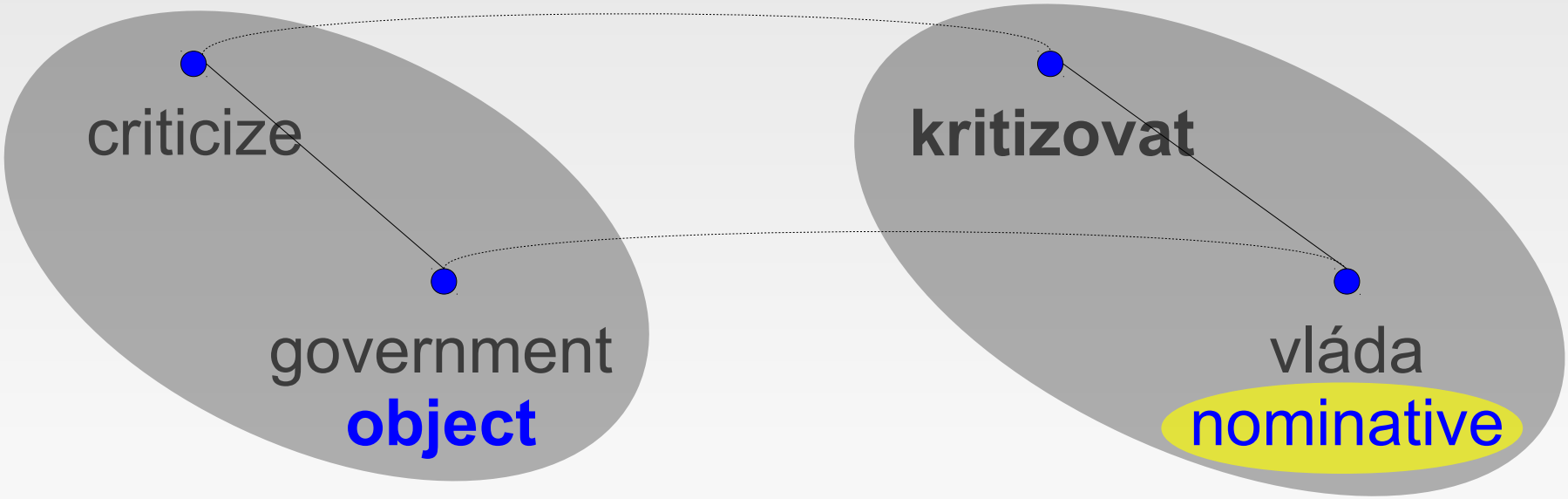
Argument case probabilities

- P(nominative | *kritizovat*, object) = 0.03
- P(accusative | *kritizovat*, object) = 0.80



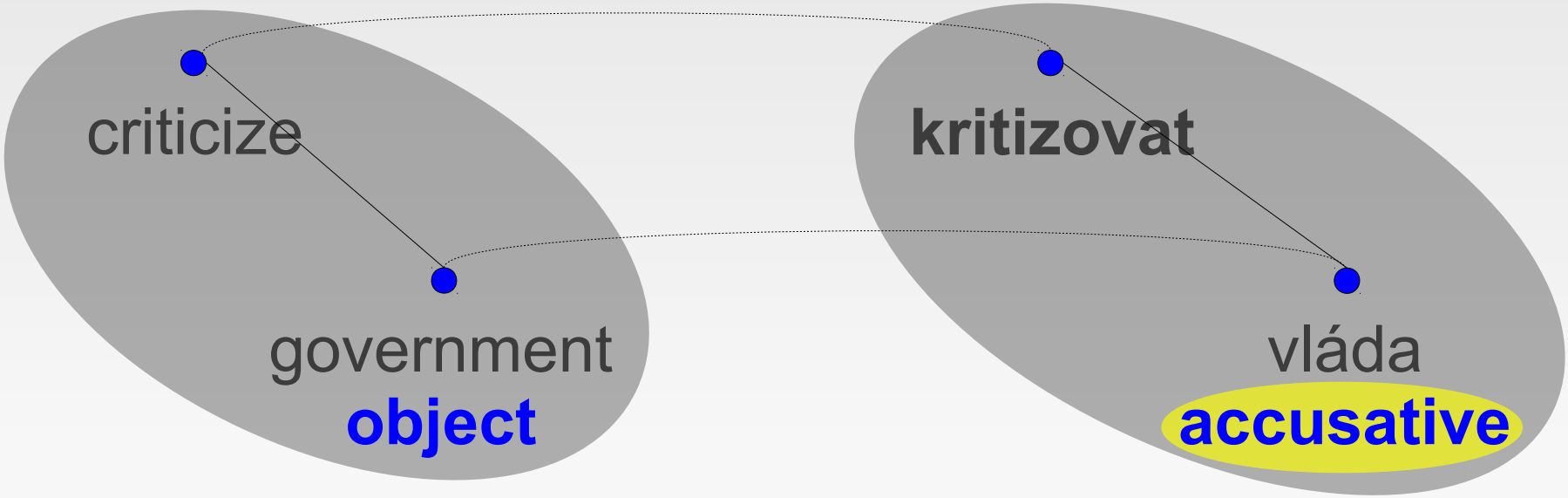
Argument case probabilities

- P(nominative | *kritizovat*, object) = 0.03
- P(accusative | *kritizovat*, object) = 0.80
- threshold: 0.55



Argument case correction

- P(nominative | *kritizovat*, object) = 0.03
- P(**accusative** | *kritizovat*, object) = **0.80**
- threshold: **0.55**



Sentence correction

- Statitical machine translation output:

  EU kritizuje nejen ***řecká***$_{\text{nominative}}$ ***vláda***$_{\text{nominative}}$

  - *Not only* ***the Greek government*** *criticizes EU*
- Valency model correction:

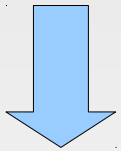
  EU kritizuje nejen ***řecká***$_{\text{nominative}}$ ***vládu***$_{\text{accusative}}$
- Agreement enforcement:

  EU kritizuje nejen ***řeckou***$_{\text{accusative}}$ ***vládu***$_{\text{accusative}}$

  - *EU criticizes not only* ***the Greek government***

Some interesting details

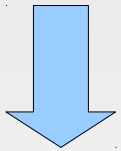
- the model actually works on formemes
  - functions (EN), cases (CS), **prepositions** (EN, CS)
  - in: *The government spends on the middle schools.*
  - SMT: *Vládá utrácí střední školy.*



    - (spend, on+X) → (utrácet, 4) P = 0.07
    - *The government destroys the middle schools.*
  - out: *Vládá utrácí za střední školy.*
    - (spend, on+X) → (utrácet, za+4) P = 0.89
    - *The government spends on the middle schools.*

Some interesting details

- the model actually works on formemes
  - functions (EN), cases (CS), **prepositions** (EN, CS)
  - in: *The government spends on the middle schools.*
  - SMT: *Vládá utrácí střední školy.*



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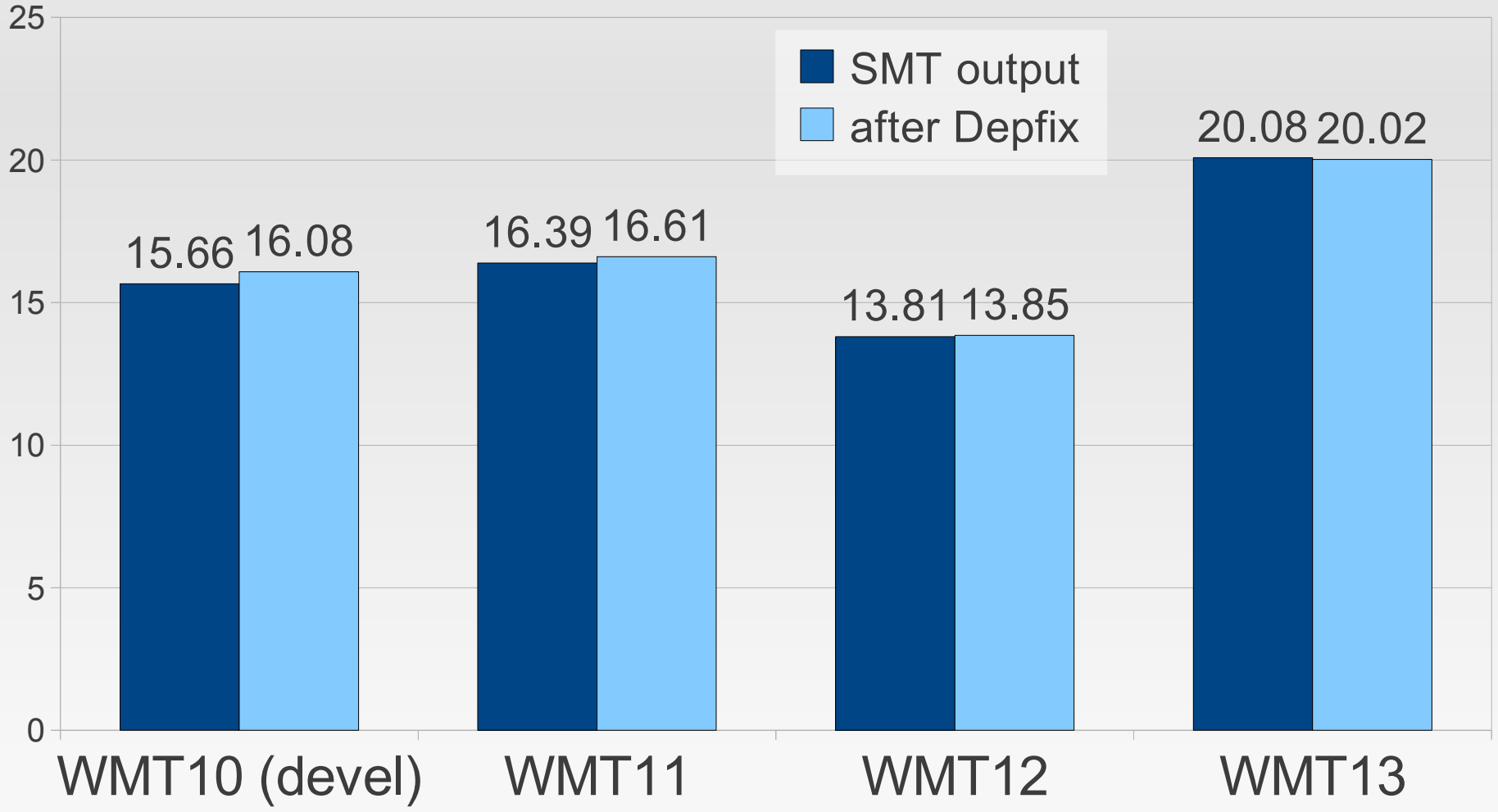
    - *The government spends on the middle schools.*
- we model both verb valency and noun valency

Outline

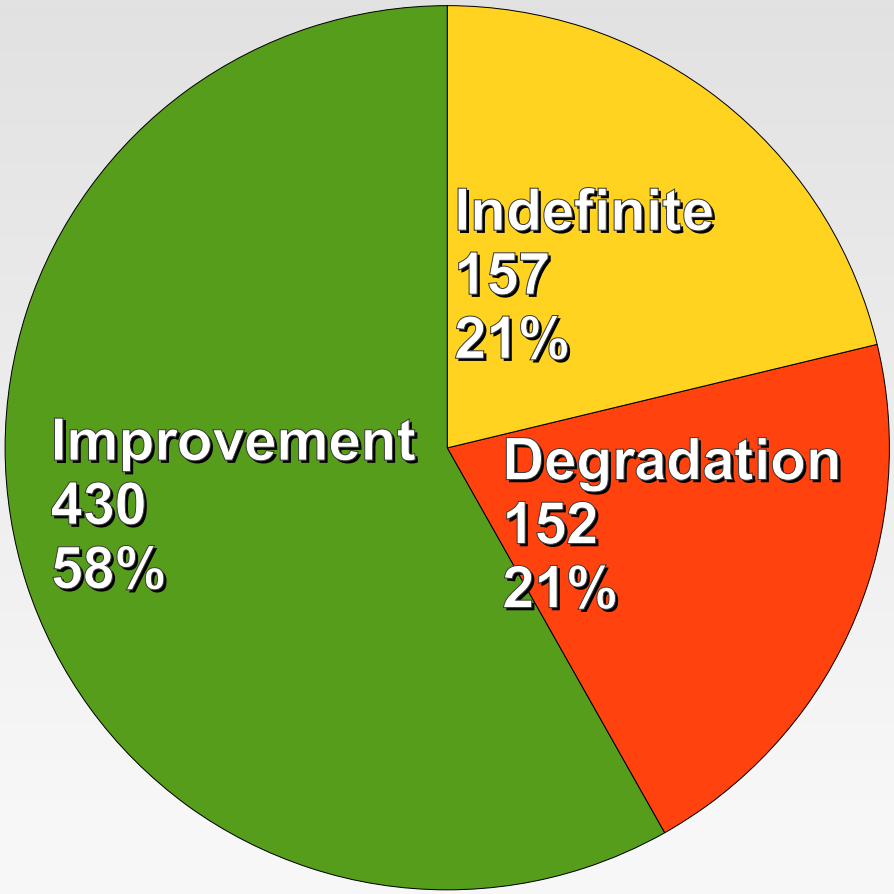
- translation of negation (and its correction)
  - motivation
  - the fixing pipeline
- analysis and corrections
  - m-layer (lemmas, tags, word-alignment)
  - a-layer (dependency trees, analytical functions)
  - t-layer (“tecto-trees”, formemes, grammatemes)
- **evaluation**
- parsing of SMT outputs (MSTperl parser)

Automatic evaluation (BLEU)

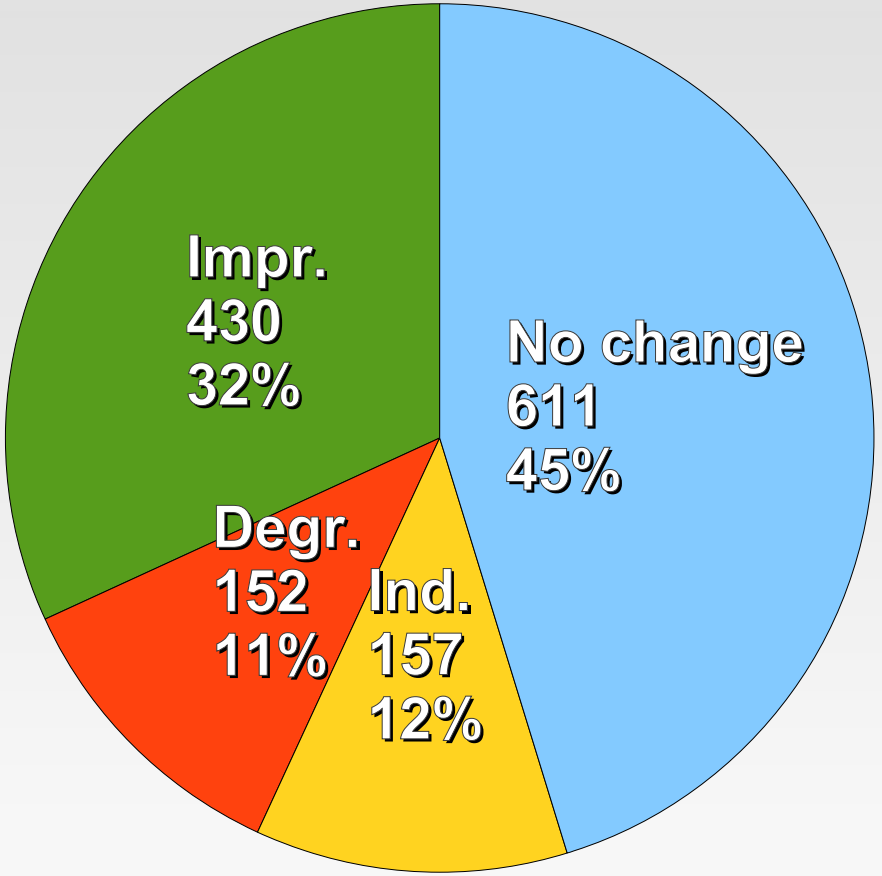


Manual evaluation

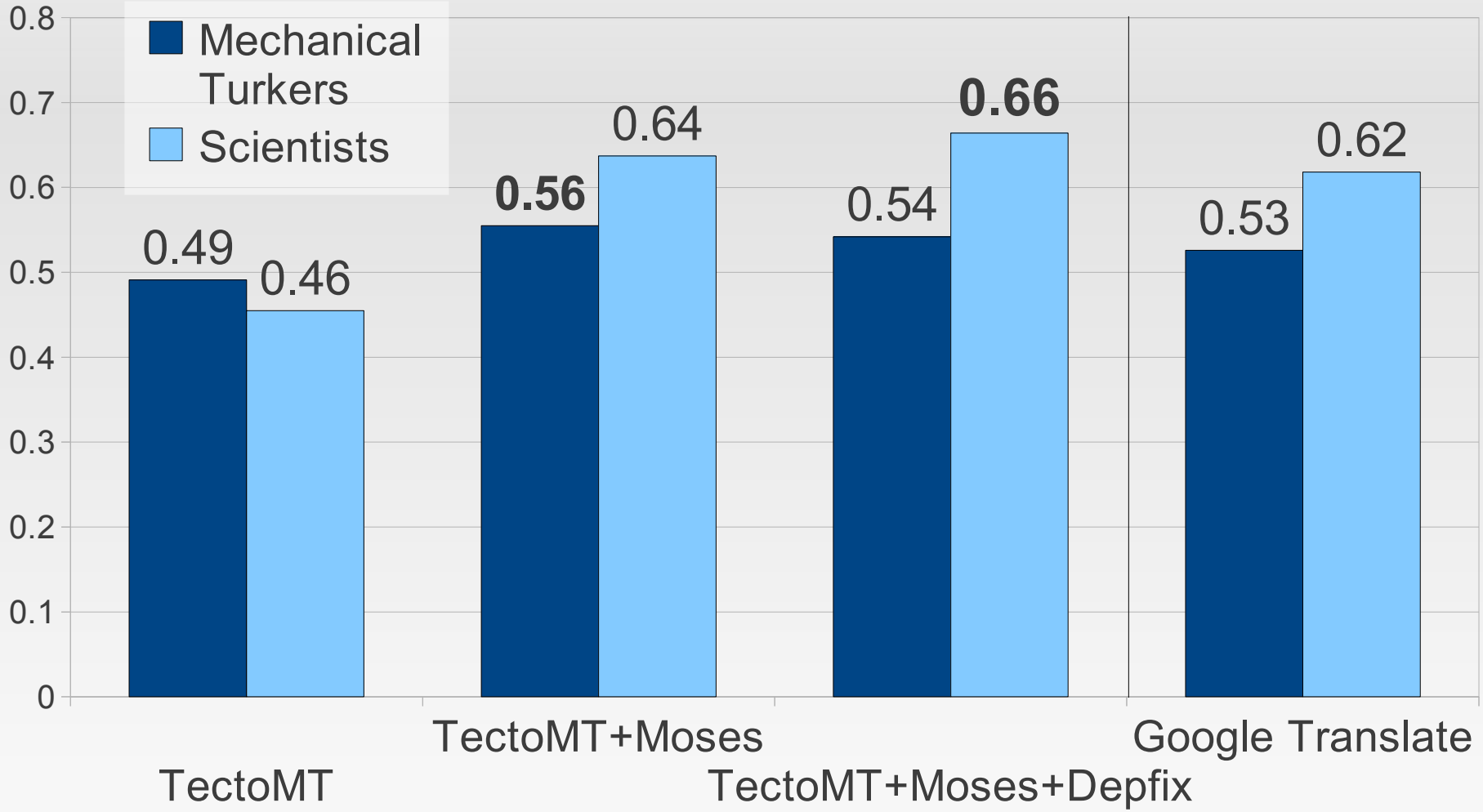
- changed sentences



- all sentences



Manual evaluation (WMT13)



iHNed.cz evaluation (M. Kalina)

Jak překladač z Matfyzu porazil Google

(...)

Pomohl odstraňovač chyb

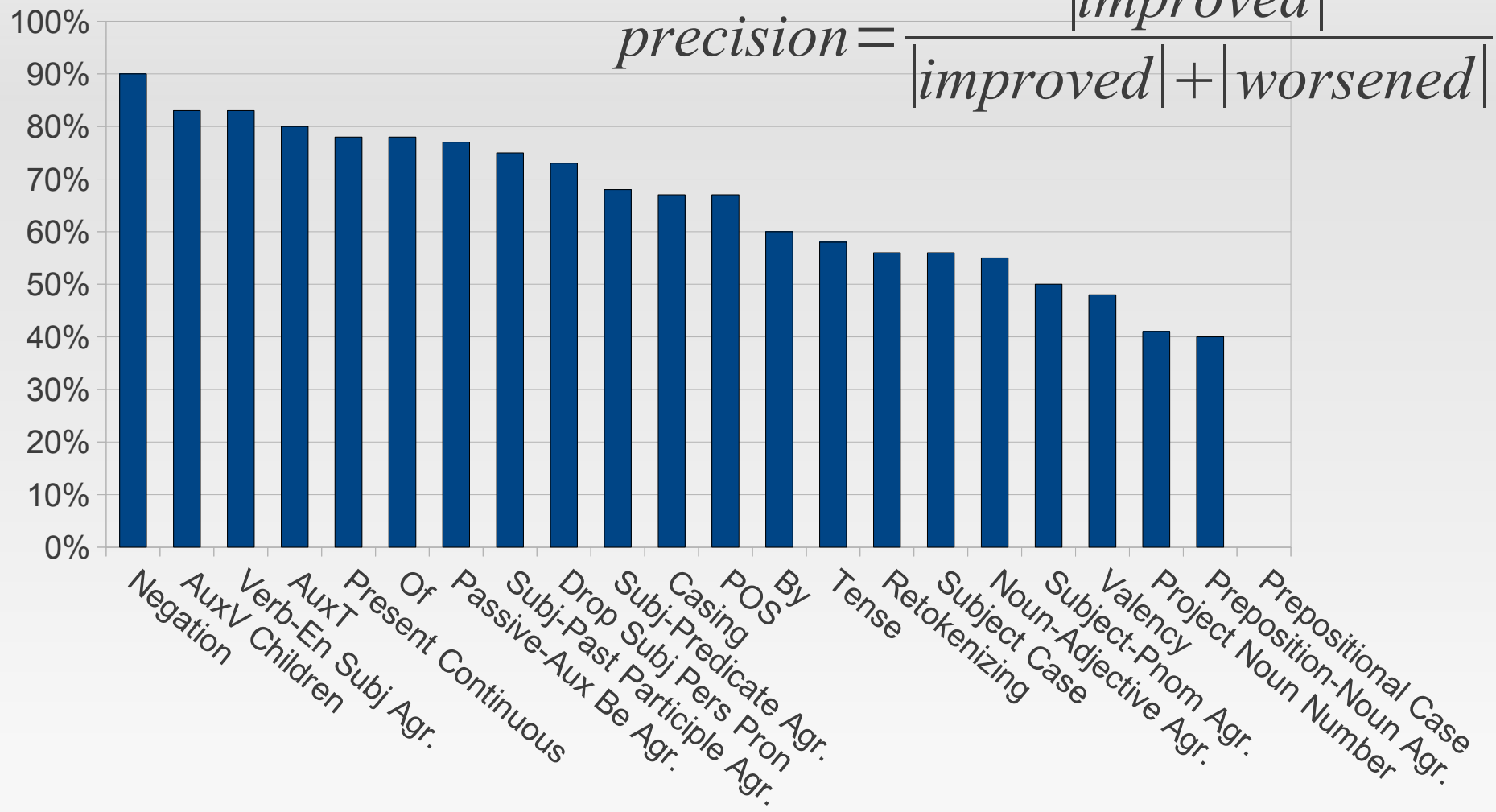
(...)

Aby byl výsledek ještě lepší, prošel výsledný text ještě automatickou korekturou pomocí českého systému **Depfix**, odstraňovače chyb, jenž opravil například špatně přeložené negativní věty a pády.

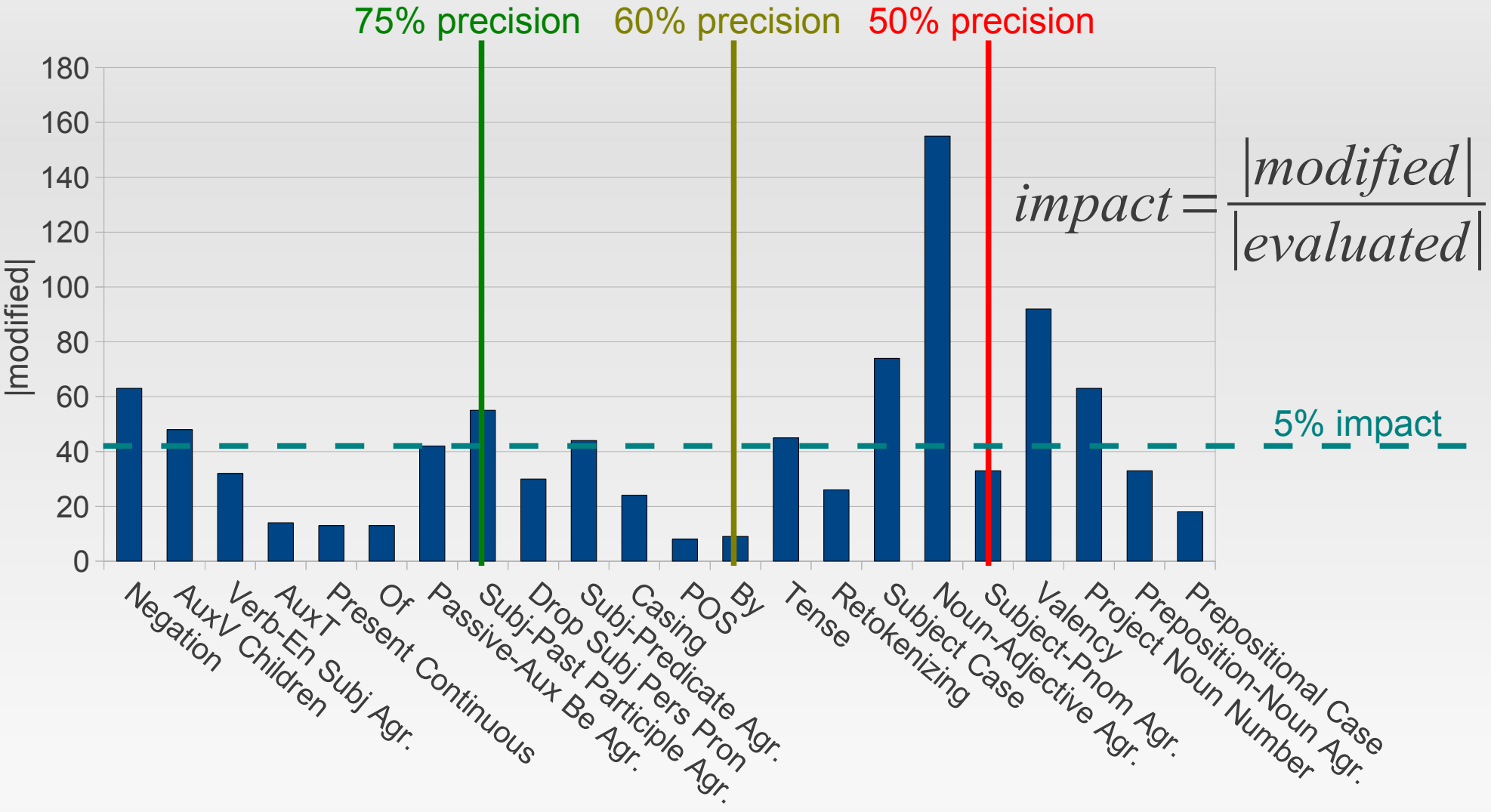
http://tech.ihned.cz/hnfuture/c1-60978500-prekladac-google-maffyz-system

Precision of rules

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



Impact of rules



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- evaluation
- → **parsing of SMT outputs** (MSTperl parser)

Parsing of SMT Outputs

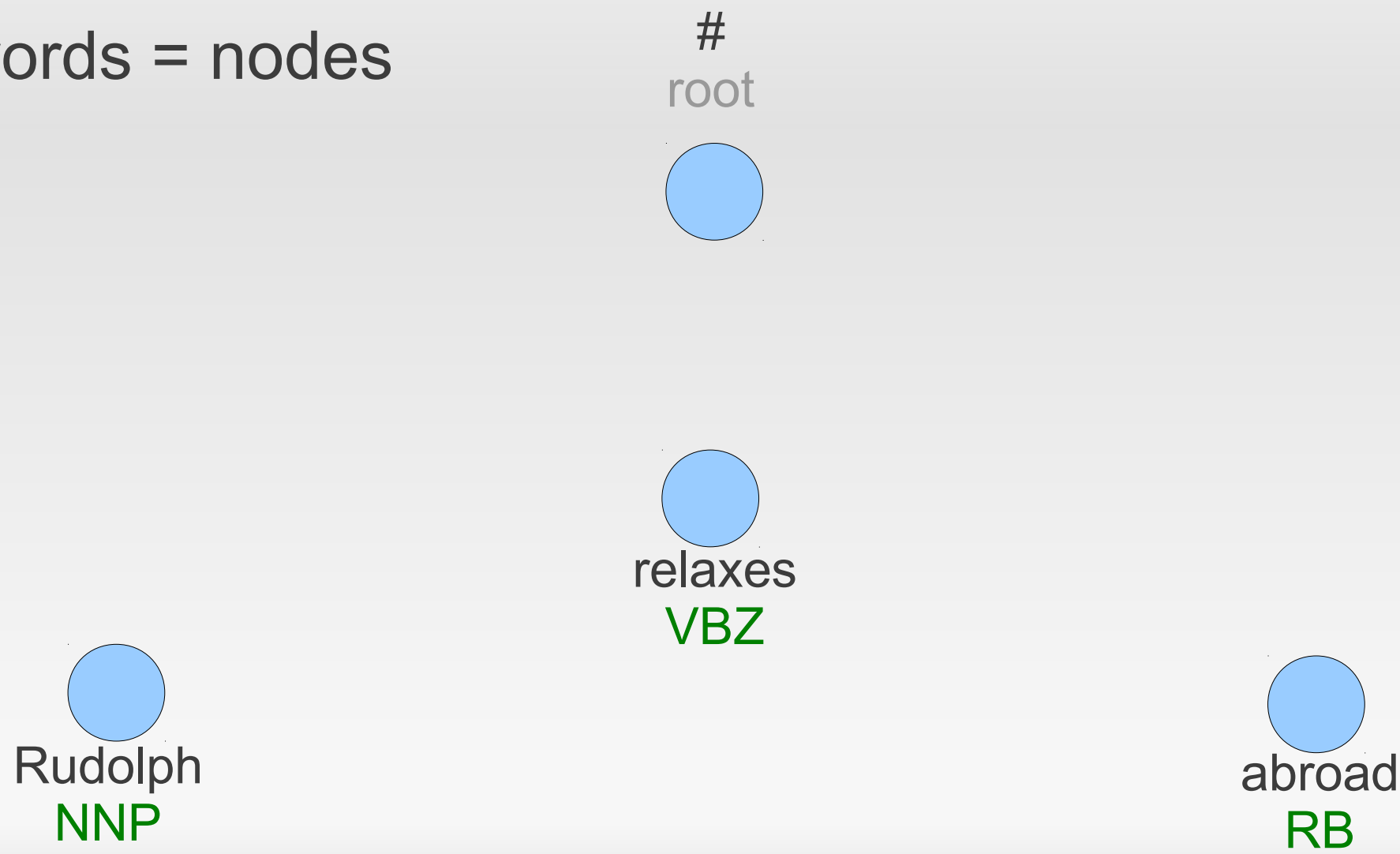
- can be useful in many applications
  - automatic classification of translation errors
  - **automatic correction of translation errors (Depfix)**
  - multilingual question answering...
- ✔ we have the source sentence available
  - Can we use it to help parsing?
- ✗ SMT outputs noisy (errors in fluency,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

MST parser

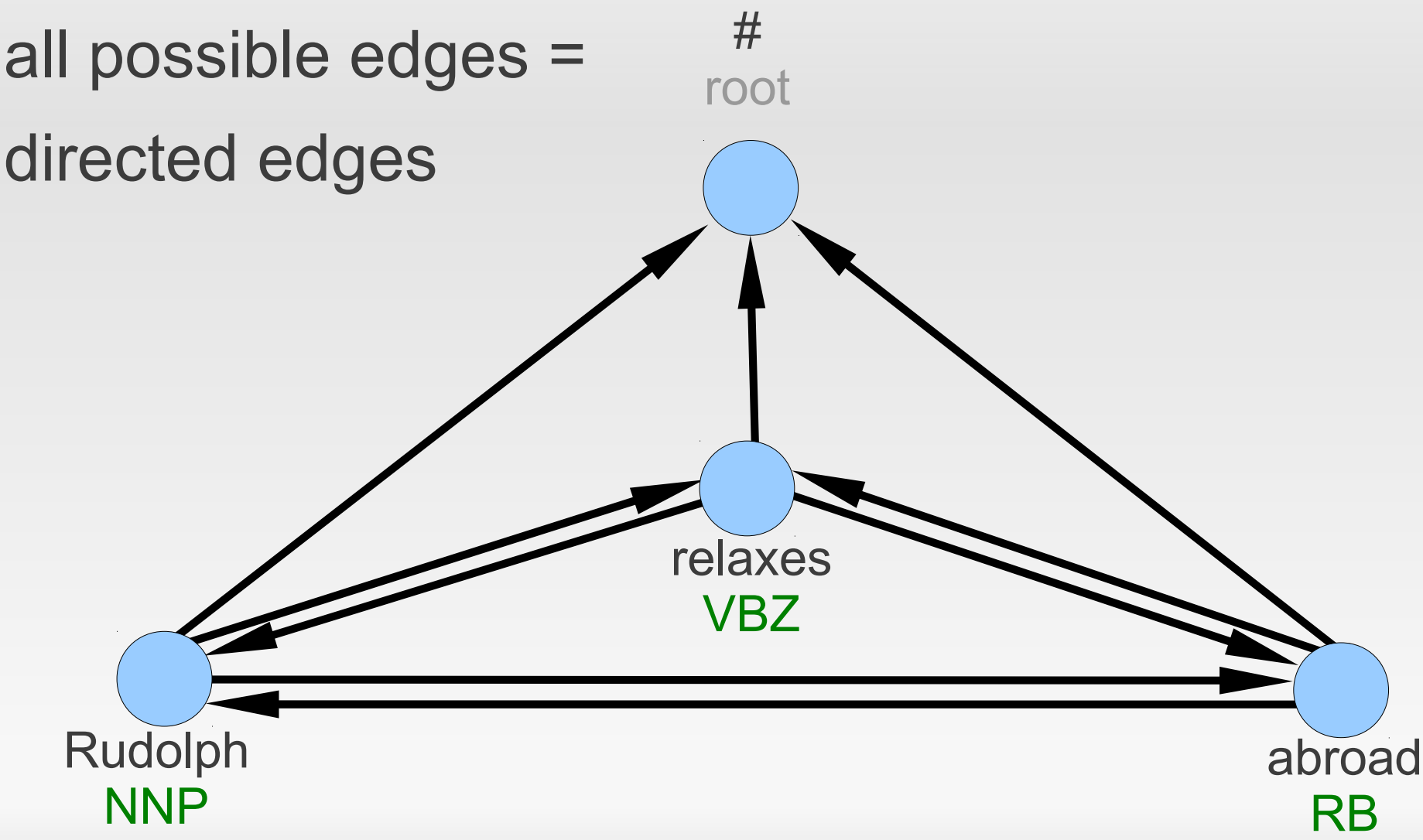
- Maximum Spanning Tree parser
- McDonald, Crammer, Pereira (2005)
  - Online large-margin training of dependency parsers
- McDonald, Pereira, Ribarov, Hajič (2006)
  - **Non-projective** dependency parsing using spanning tree algorithms

(1) Words and Tags

words = nodes



(2) (Nearly) Complete Graph

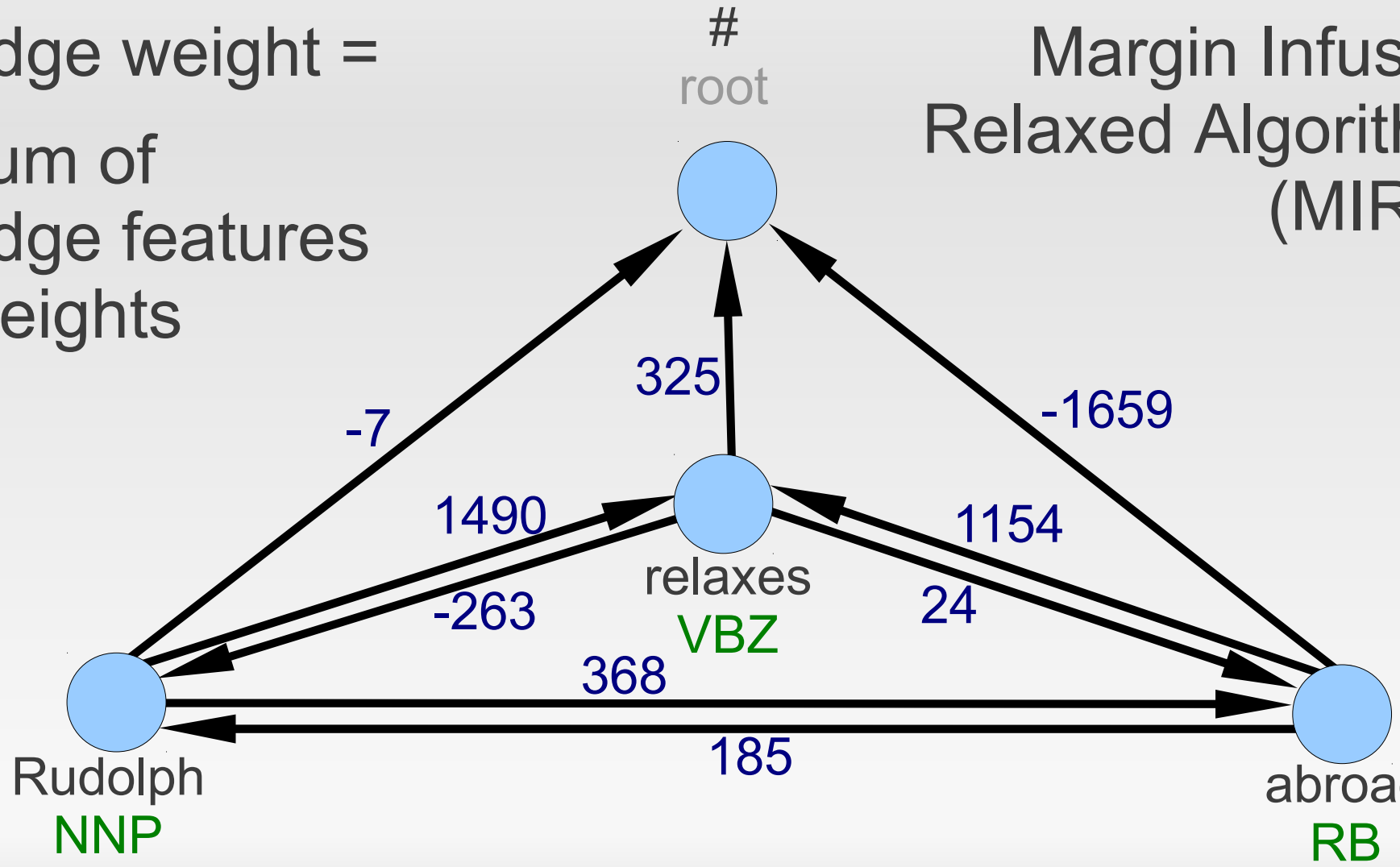


(3) Assign Edge Weights

edge weight =

sum of
edge features
weights

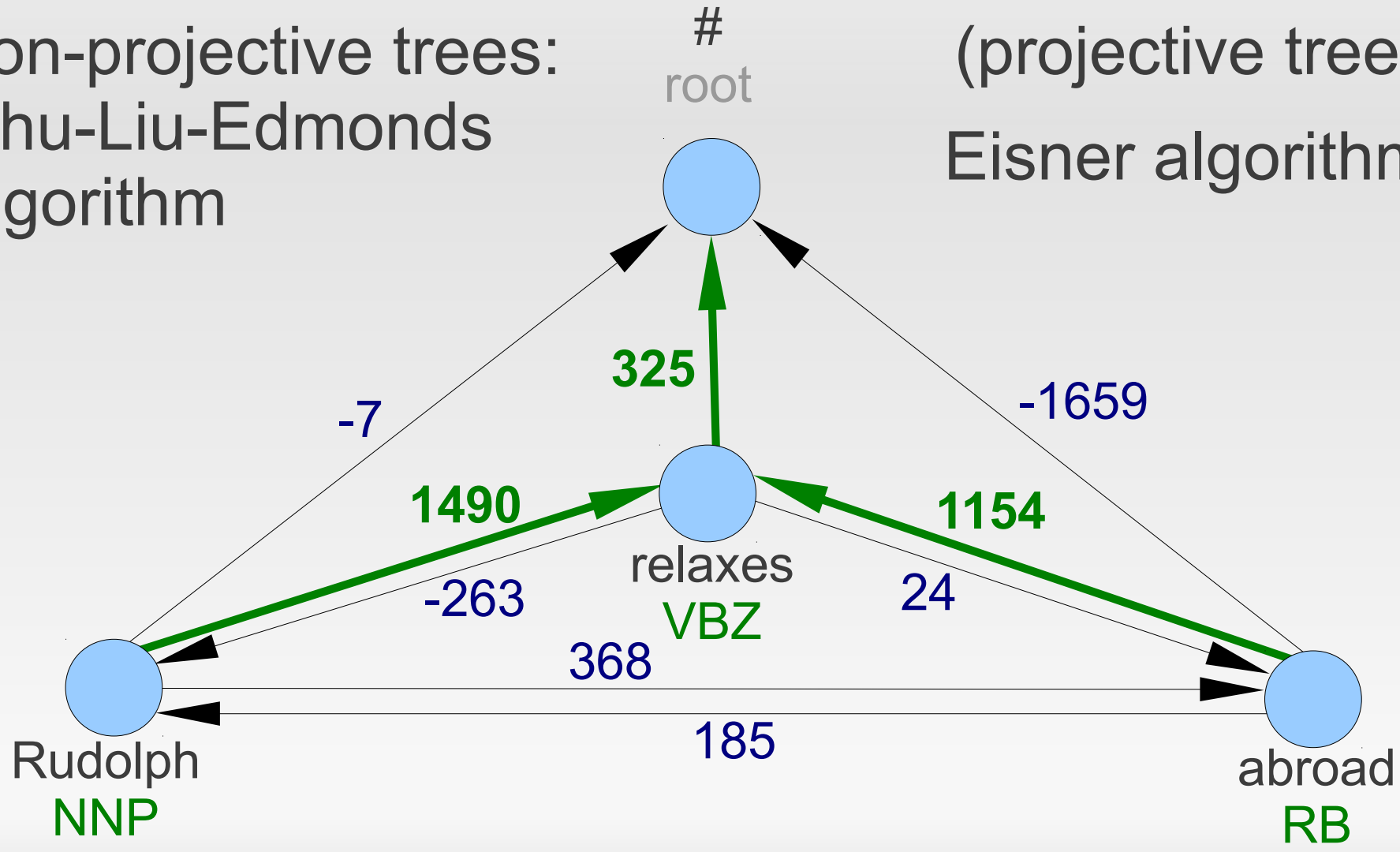
Margin Infused
Relaxed Algorithm
(MIRA)



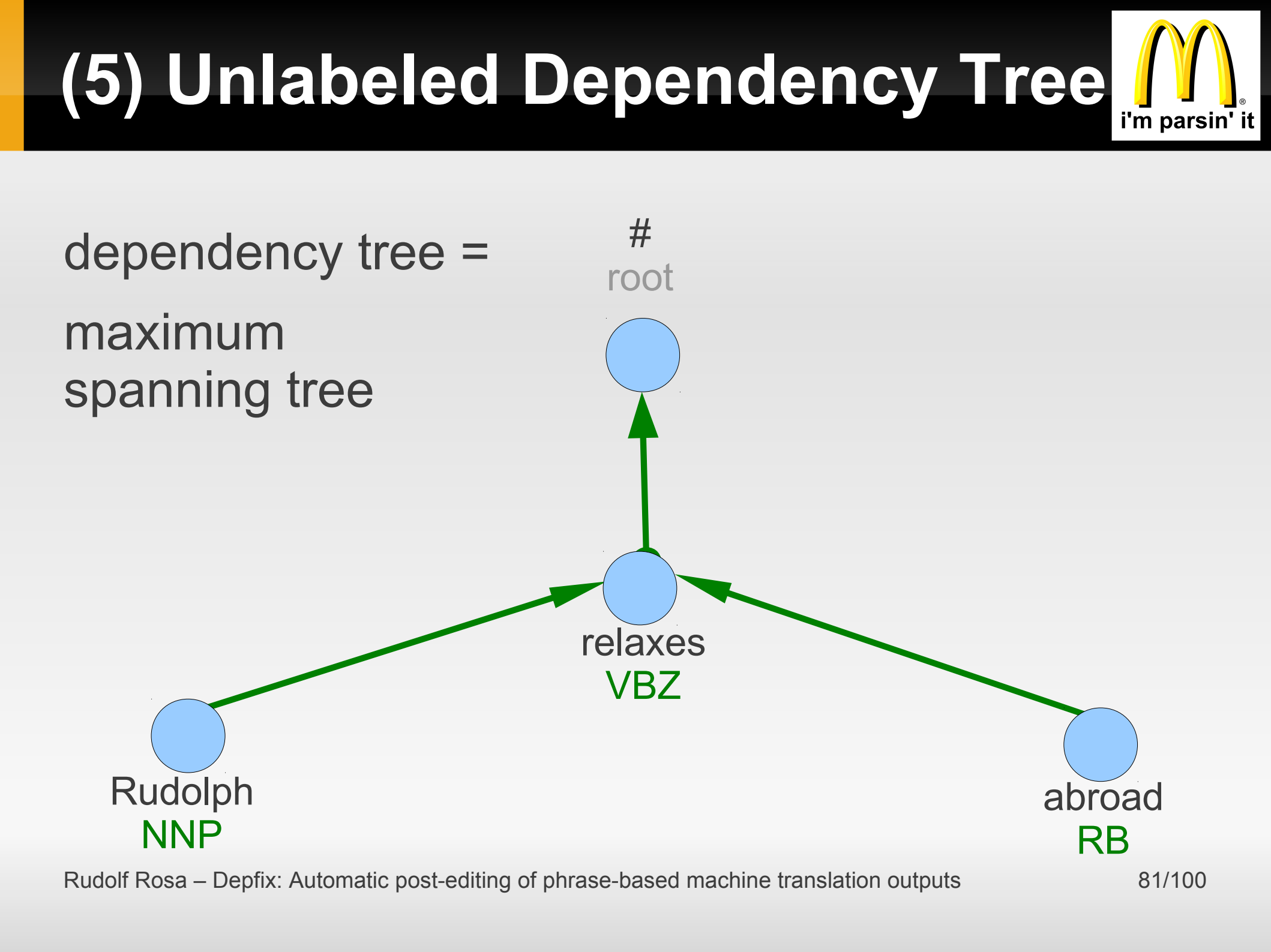
(4) Maximum Spanning Tree

non-projective trees:
Chu-Liu-Edmonds
algorithm

(projective trees:
Eisner algorithm)



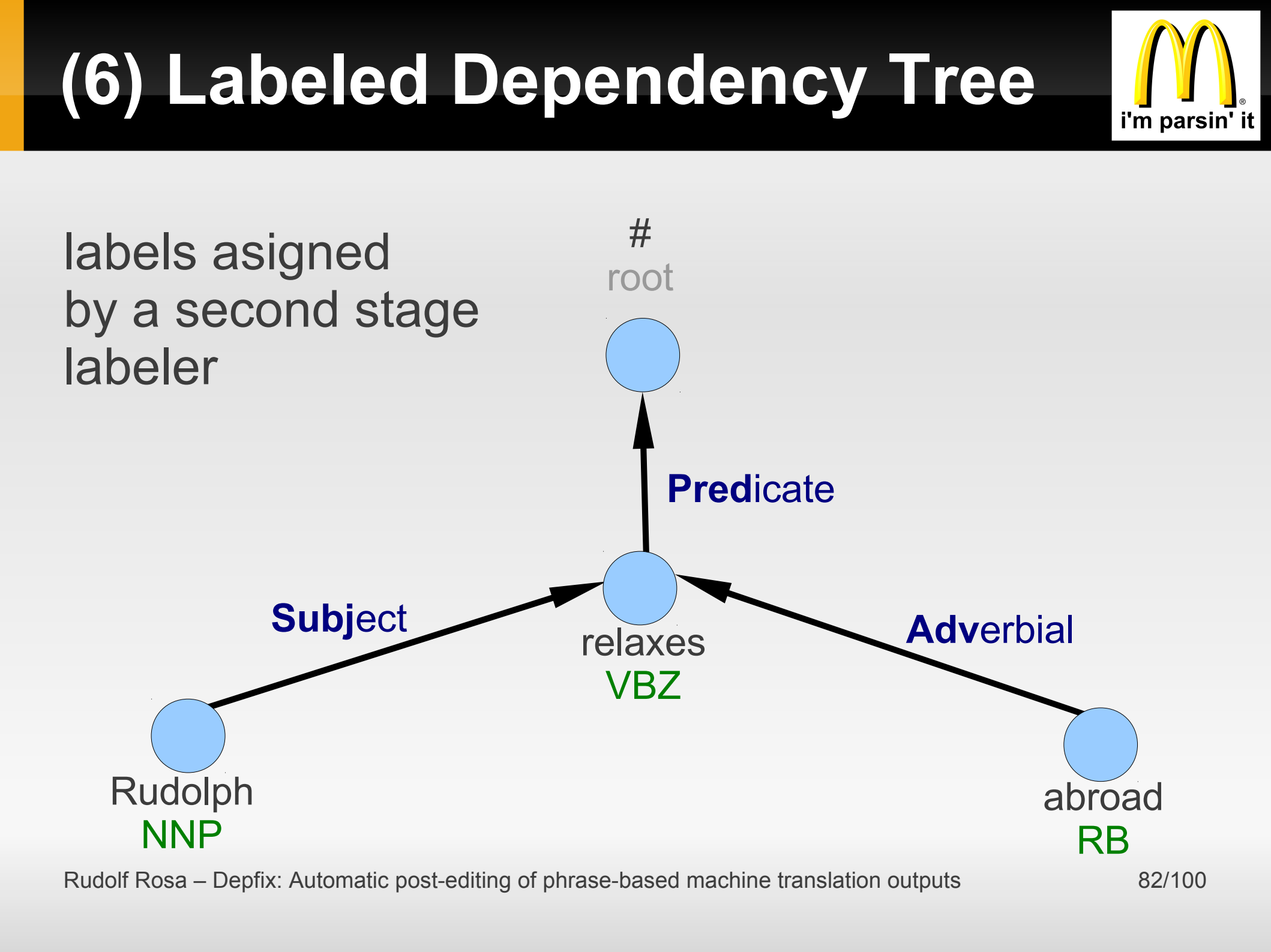
(5) Unlabeled Dependency Tree



dependency tree =

maximum spanning tree

(6) Labeled Dependency Tree



labels asigned
by a second stage
labeler

#
root

Predicate

Subject

relaxes
VBZ

Adverbial

Rudolph
NNP

abroad
RB

Tool::Parser::MSTperl

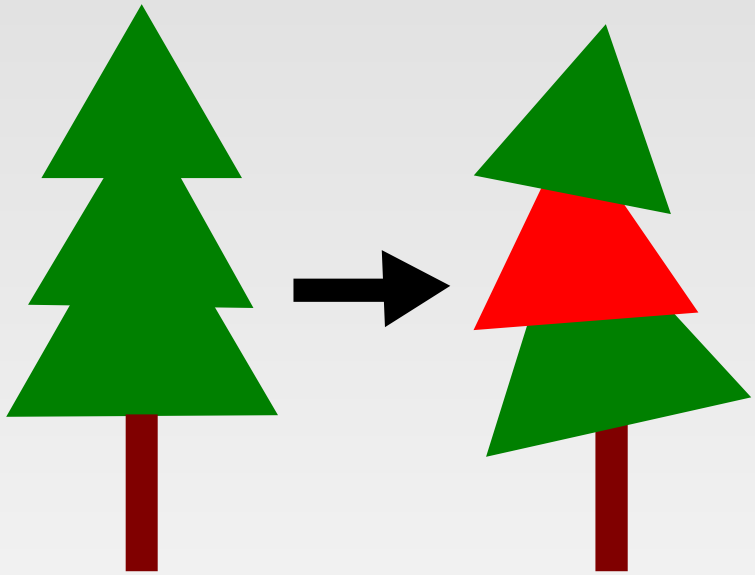
- reimplementation of MST Parser in Perl
  - Treex::Block::W2A::CS::ParseMSTperl
  - (so far only) first-order, non-projective
- adapted for SMT outputs parsing
  - worsening the training data (David Mareček)
  - adding parallel information
  - manually boosting feature weights
  - exploiting large-scale data

Parser Training Data

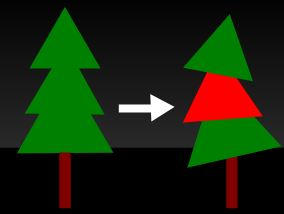
- Prague Czech-English Dependency Treebank
  - parallel treebank
  - 50k sentences, 1.2M words
  - morphological tags, surface syntax, deep syntax
  - word alignment

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

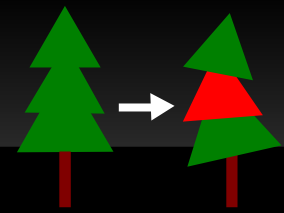


Worsen (1): Apply SMT



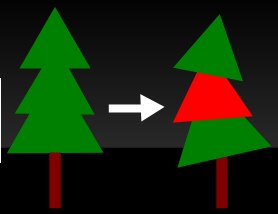
- translate English side of PCEDT to Czech
  - by an SMT system (we used Moses)
- now we have e.g.:
  - Gold English
    - Rudolph's car is black.
  - Gold Czech
    - Rudolfovo$_{NEUT}$ auto$_{NEUT}$ je černé$_{NEUT}$.
  - SMT Czech
    - Rudolfova$_{FEM}$ auto$_{NEUT}$ je černý$_{MASC}$.

Worsen (2): Align SMT to Gold



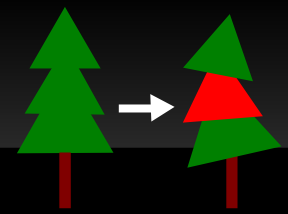
- align SMT Czech to Gold Czech
- Monolingual Greedy Aligner (Martin Popel)
  - alignment link score = linear combination of:
    - similarity of word forms (or lemmas)
    - similarity of morphological tags (fine-grained)
    - similarity of positions in the sentence
    - indication whether preceding/following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

Worsen (3): Create Error Model



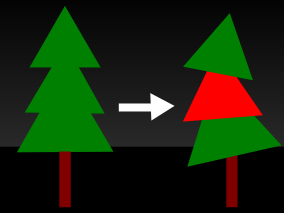
- for each tag:
  - estimate probabilities of SMT system using an incorrect tag instead of the correct tag (Maximum Likelihood Estimate)
- Czech tagset: fine-grained morphological tags
  - part-of-speech, gender, number, case, person, tense, voice...
  - 1500 different tags in training data

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

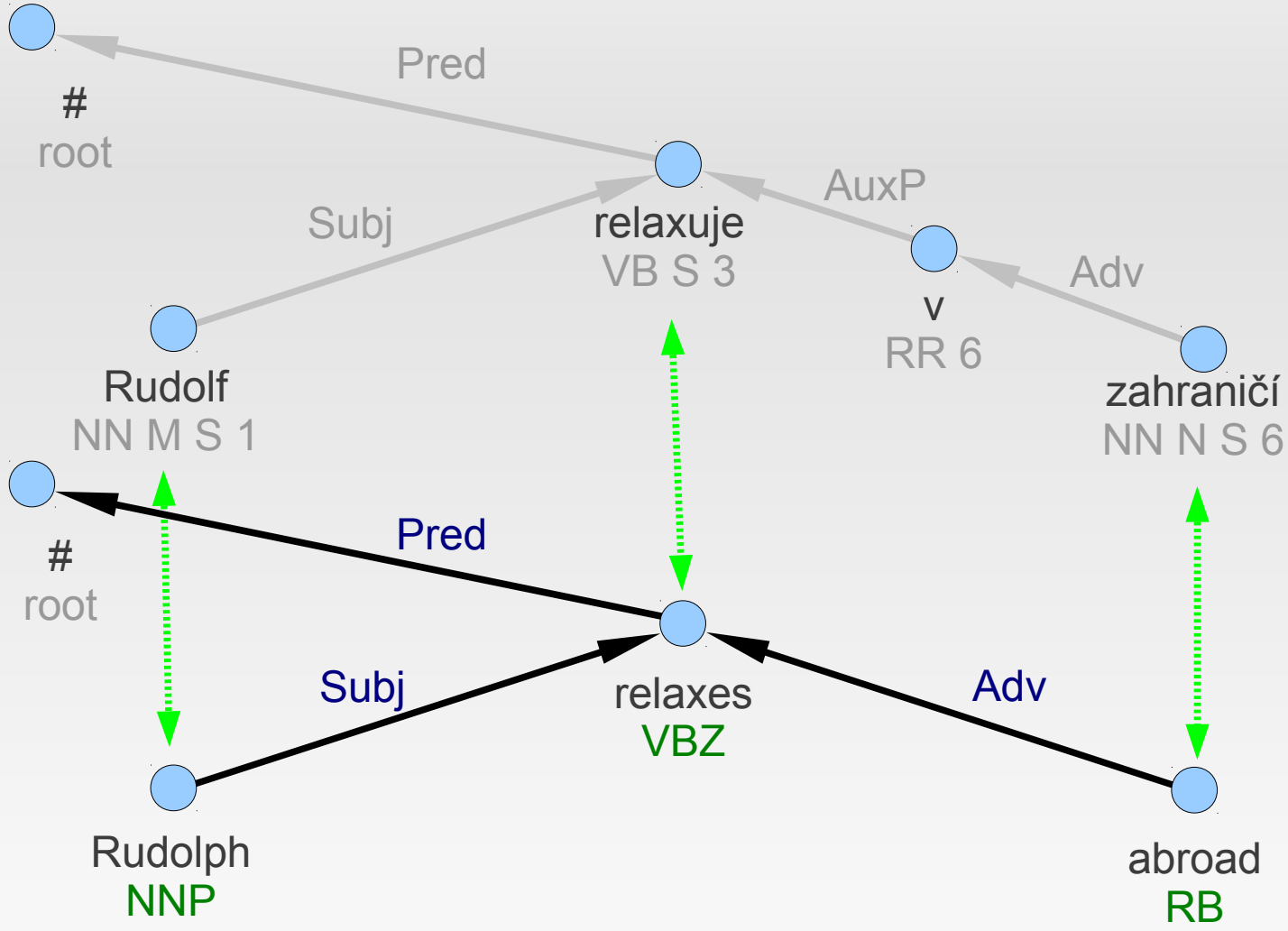


- take Gold Czech
- for each word:
  - assign a new tag randomly sampled according to Tag Error Model
  - generate a new word form
    - rule-based generator, generates even unseen forms
    - new_form = generate_form(lemma, tag) || old_form
- → get Worsened Czech
- use resulting *Gold English-Worsened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

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



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

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- experiment: manually increase its weight
  - edge exists: **-0.25**
- success – manual changing of weights feasible

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

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

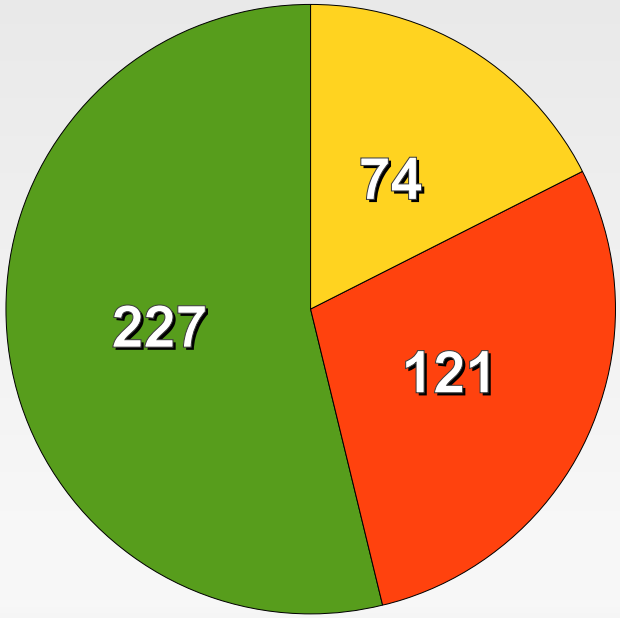
Direct Evaluation: by Inspection

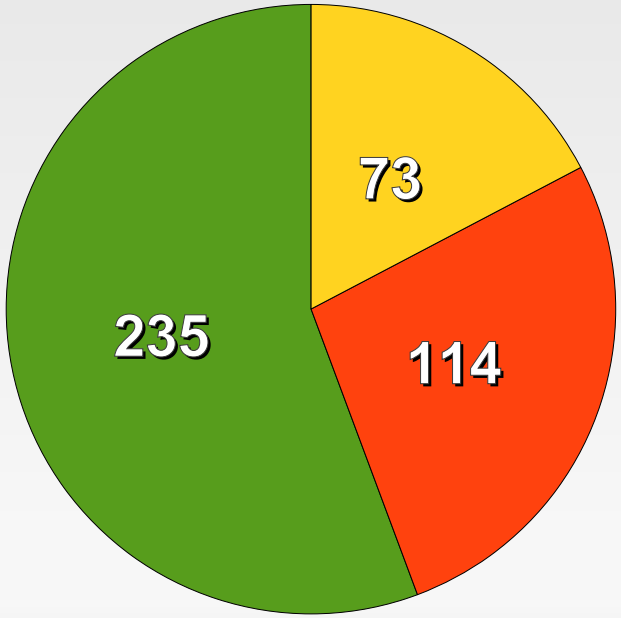
- manual inspection of several parse trees
  - comparing baseline and adapted parser ouputs
- examples of improvements:
  - subject identification even if not in nominative case
  - adjective-noun dependence identification even if agreement violated (gender, number, case)
- hard to do reliably
  - trying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

Indirect Evaluation: in Depfix

- improvements and deteriorations in comparison to Depfix employing a baseline parser:
  - original McDonald's MST Parser 

  - our baseline setup, without adaptations





Outline – all done!

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- evaluation
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Thank you for your attention

Rudolf Rosa
rosa@ufal.mff.cuni.cz

Depfix:

**Automatic post-editing
of phrase-based machine translation outputs**

Charles University in Prague
Faculty of Mathematics and Physics
Institute of Formal and Applied Linguistics

For this presentation and other information, please visit:

http://ufal.mff.cuni.cz/~rosa/