The Prague Dependency Treebanks

Morphology, Syntax, Semantics

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The Prague Dependency Treebank

- The idea
  - Apply the “old” Prague theory to real-word texts
  - Provide enough data for ML experiments
- ?“Old” Prague theory
  - Prague structuralism (1930s)
  - Stratificational approach
  - Centered on “deep syntax”
    - Separated from “surface form”
    - Dependency based (how else ☺)

PDT: The Methodology

- Manual annotation is PRIMARY
  - Some help from existing tools possible
- "No information loss, no redundancy"
  - Much formalization, but…
  - … original form always retrievable
- Dictionaries
  - In theory: "secondary", side effect of annotation
  - In reality: help consistency
  - Links: data → dictionary(-ies)
- Extensive support for Machine Learning
- Ergonomy of annotation
  - Graphical ("linguistic") presentation & editing

The Prague Dependency Treebank Project: Czech Treebank

- 1995 (Dublin) 1996-2006-2010-…
  - 1998 PDT v. 0.5 released (JHU workshop)
    - 400k words manually annotated, unchecked
  - 2001 PDT 1.0 released (LDC):
    - 1.3MW annotated, morphology & surface syntax
  - 2006 PDT 2.0 release
    - 0.8MW annotated (50k sentences) + PDT 1.0 corrected
    - the “tectogrammatical layer”
      - underlying (deep) syntax

Related Projects (Treebanks)

- Prague Czech-English Dependency Treebank
  - WSJ portion of PTB, translated to Czech (1.2 mil. words)
  - automatically analyzed
    - English side (PTB), too
    - Manual annotation started
- Prague Arabic Dependency Treebank
  - apply same representation to annotation of Arabic
  - surface syntax so far
- Both published (partial version) in 2004 (LDC)
  - PCEDT version 2.0 being prepared (2011)

PDT Annotation Layers

PDT 1.0 (2001)
PDT 2.0 (2006)
PDT 2.5 (2011)

- L0 (w) Words (tokens)
  - automatic segmentation and markup only
- L1 (m) Morphology
  - Tag (full morphology, 13 categories), lemma
- L2 (a) Analytical layer (surface syntax)
  - Dependency, analytical dependency function
- L3 (t) Tectogrammatical layer (“deep” syntax)
  - Dependency, functor (detailed), grammatemes, ellipsis solution, coreference, topic/focus (deep word order), valency lexicon

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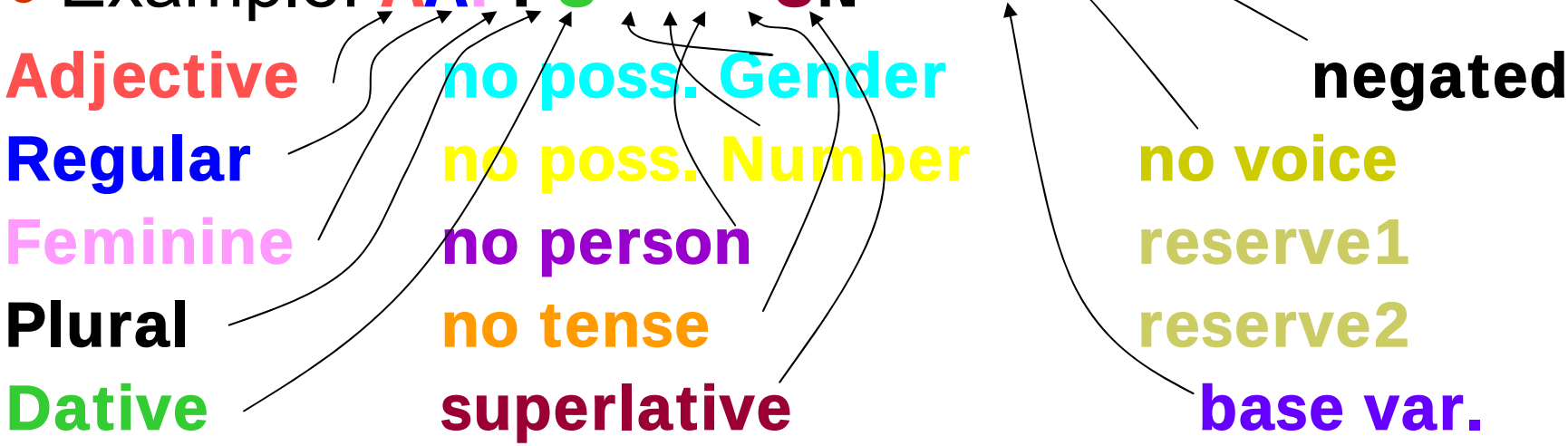
Morphological Attributes

Ex.: nejnezajímavějším
"(to) the most uninteresting"

- Tag: 13 categories
  - Example: AAFP3----3N----



- Lemma: POS-unique identifier

  Books/verb -> book-1, went -> go, to/prep. -> to-1

Morphological Disambiguation

- Full morphological disambiguation
  - more complex than (e.g. English) POS tagging
- Several full morphological taggers:
  - (Pure) HMM
  - Feature-based (MaxEnt-like)
    - used in the PDT distribution
  - Averaged Perceptron (M. Collins, EMNLP'02)
- All: ~ 94-96% accuracy (perceptron is best)
  - "COMPOST" (available for several languages)
    - EACL 2009 paper, http://ufal.mff.cuni.cz/compost

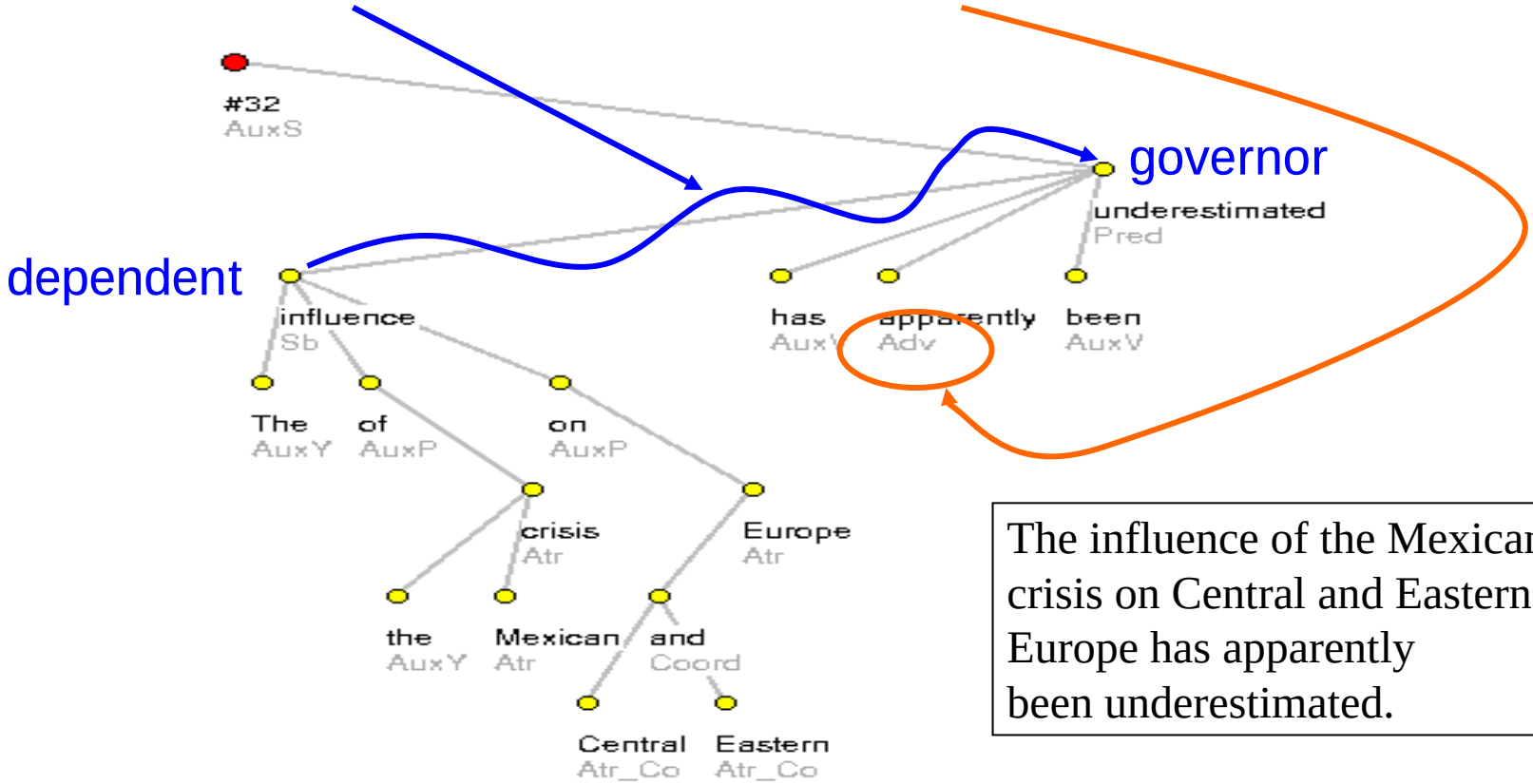
The Segmentation Problem: Arabic

- Tokenization / segmentation not always trivial

String ···· Token	Token Tag	Buckwalter Morph Tags	Token Form	Token Gloss
	F---------	FUT	sa-	will
سيخبرهم	VIIA-3MS--	IV3MS+IV+IVSUFF_MOOD:I	yu-ḫbir-u	he-notify
	S----3MP4-	IVSUFF_DO:3MP	-hum	them
	P---------	PREP	bi-	about/by
بذلك	SD----MS--	DEM_PRON_MS	ḏālika	that
عن ·····	P---------	PREP	ʿan	by/about
طريق ·····	N-------2R	NOUN+CASE_DEF_GEN	ṭarīq-i	way-of
الرسائل ·····	N-------2D	DET+NOUN+CASE_DEF_GEN	ar-rasāʾil-i	the-messages
القصيرة ·····	A-----FS2D	DET+ADJ+NSUFF_FEM_SG+ +CASE_DEF_GEN	al-qaṣīr-at-i	the-short
	C---------	CONJ	wa-	and
والإنترنت	Z-------2D	DET+NOUN_PROP+ +CASE_DEF_GEN	al-ʾinternet-i	the-internet
	C---------	CONJ	wa-	and
وغيرها	FN------2R	NEG_PART+CASE_DEF_GEN	ġayr-i	other/not-of
	S----3FS2-	POSS_PRON_3FS	-hā	them

Layer 2 (a-layer): Analytical Syntax

- Dependency + Analytical Function



The influence of the Mexican crisis on Central and Eastern Europe has apparently been underestimated.

Analytical Syntax: Functions

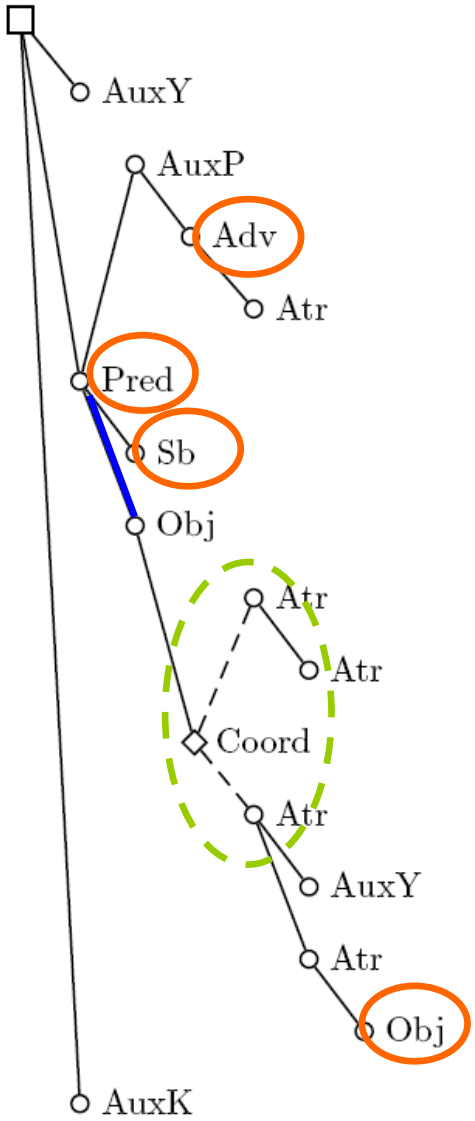
- Main (for [main] semantic lexemes):
  - Pred, Sb, Obj, Adv, Atr, Atv(V), AuxV, Pnom
  - “Double” dependency: AtrAdv, AtrObj, AtrAtr
- Special (function words, punctuation,...):
  - Reflefives, particles: AuxT, AuxR, AuxO, AuxZ, AuxY
  - Prepositions/Conjunctions: AuxP, AuxC
  - Punctuation, Graphics: AuxX, AuxS, AuxG, AuxK
- Structural
  - Elipsis: ExD, Coordination etc.: Coord, Apos

PDT-style Arabic Surface Syntax

- Only several differences
  - (Sometimes) Separate nodes for individual segments (cf. tagging/segmentation)
  - Copula treatment (Czech: rare → treated as ellispsis; Arabic: systematic solution), Pred
  - (Added) analytic functions:
    - AuxM لَمْ *lam* (did-not)
    - Ante مَا *mā* (what)
- Work by Faculty of Arts (Arabic language) students

Arabic Surface Syntax Example

- In the section on literature, the magazine presented the issue of the Arabic language and the dangers that threaten it.



وَ *wa-*	and	C---------
فِي *fī*	in	P---------
مِلَفِّ *milaffi*	collection/file-of	N-------2R
اَلأَدَبِ *al-ʾadabi*	the-literature	N-------2D
طَرَحَت *ṭaraḥat*	it-presented	VP-A-3FS--
اَلمَجَلَّةُ *al-mağallatu*	the-magazine	N-----FS1D
قَضِيَّةَ *qaḍīyata*	issue-of	N-----FS4R
اَللُّغَةِ *al-luġati*	the-language	N-----FS2D
اَلعَرَبِيَّةِ *al-ʿarabīyati*	the-Arabic	A-----FS2D
وَ *wa-*	and	C---------
اَلأَخطَارِ *al-ʾaḫṭāri*	the-dangers	N-------2D
اَلَّتِي *allatī*	that	SR----FS--
تُهَدِّدُ *tuhaddidu*	they-threaten	VIIA-3FS--
هَا *-hā*	it	S----3FS4-
. .	.	G---------

English Analytic Layer

- By conversion from PTB
  - Extended analytic functions
- Head rules
  - Jason Eisner's, added more for full conversion
    - Coordination, traces, etc.
- Coordination handling
  - Same as in Czech/Arabic PDT

Penn Treebank

- University of Pennsylvania, 1993
  - Linguistic Data Consortium
- Wall Street Journal texts, ca. 50,000 sentences
  - 1989-1991
  - Financial (most), news, arts, sports
  - 2499 (2312) documents in 25 sections
- Annotation
  - POS (Part-of-speech tags)
  - Syntactic “bracketing” + bracket (syntactic) labels
  - (Syntactic) Function tags, traces, co-indexing

Penn Treebank Example

```
( (S
    (NP-SBJ
      (NP (NNP Pierre) (NNP Vinken) )
      (, ,)
      (ADJP
        (NP (CD 61) (NNS years) )
        (JJ old) )
      (, ,) )
    (VP (MD will)
      (VP (VB join)
        (NP (DT the) (NN board) )
        (PP-CLR (IN as)
          (NP (DT a) (JJ nonexecutive) (NN director) ))
        (NP-TMP (NNP Nov.) (CD 29) )))
    (. .) ))
```

"Preterminal" POS tag (NNS) (noun, plural)

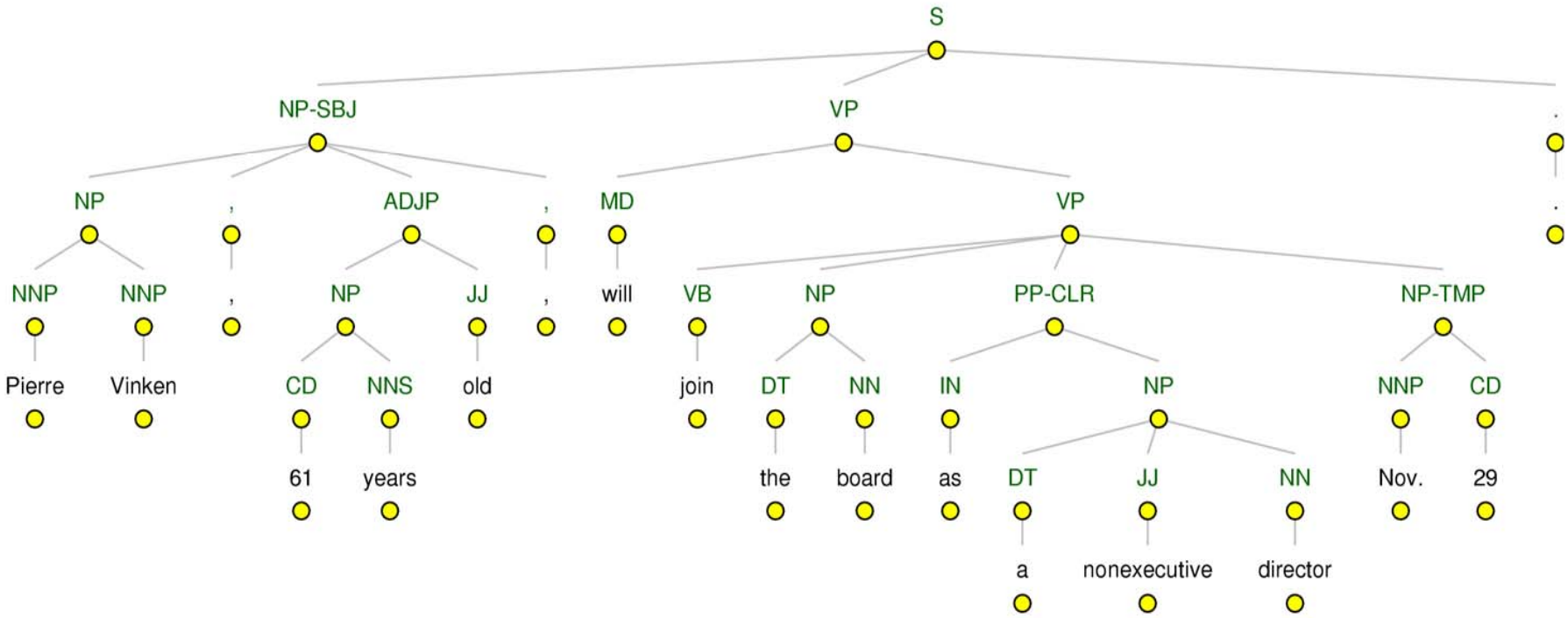
Noun Phrase

Phrase label (NP)

Pierre Vinken, 61 years old, will join the board as a nonexecutive director Nov. 29.

Penn Treebank Example: Sentence Tree

- Phrase-based tree representation:



Parallel Czech-English Annotation

- English text -> Czech text (human translation)
- Czech side (goal): all layers manual annotation
- English side (goal):
  - Morphology and surface syntax: technical conversion
    - Penn Treebank style -> PDT Analytic layer
  - Tectogrammatical annotation: manual annotation
    - (Slightly) different rules needed for English
- Alignment
  - Natural, sentence level only (now)

Human Translation of WSJ Texts

- Hired translators / FCE level
- Specific rules for translation
  - Sentence per sentence only
    - …to get simple 1:1 alignment
  - Fluent Czech at the target side
  - If a choice, prefer “literal” translation
- The numbers:
  - English tokens: 1,173,766
  - Translated to Czech:
    - Revised/PCEDT 1.0: 487,929
    - Now finished (all 2312 documents)

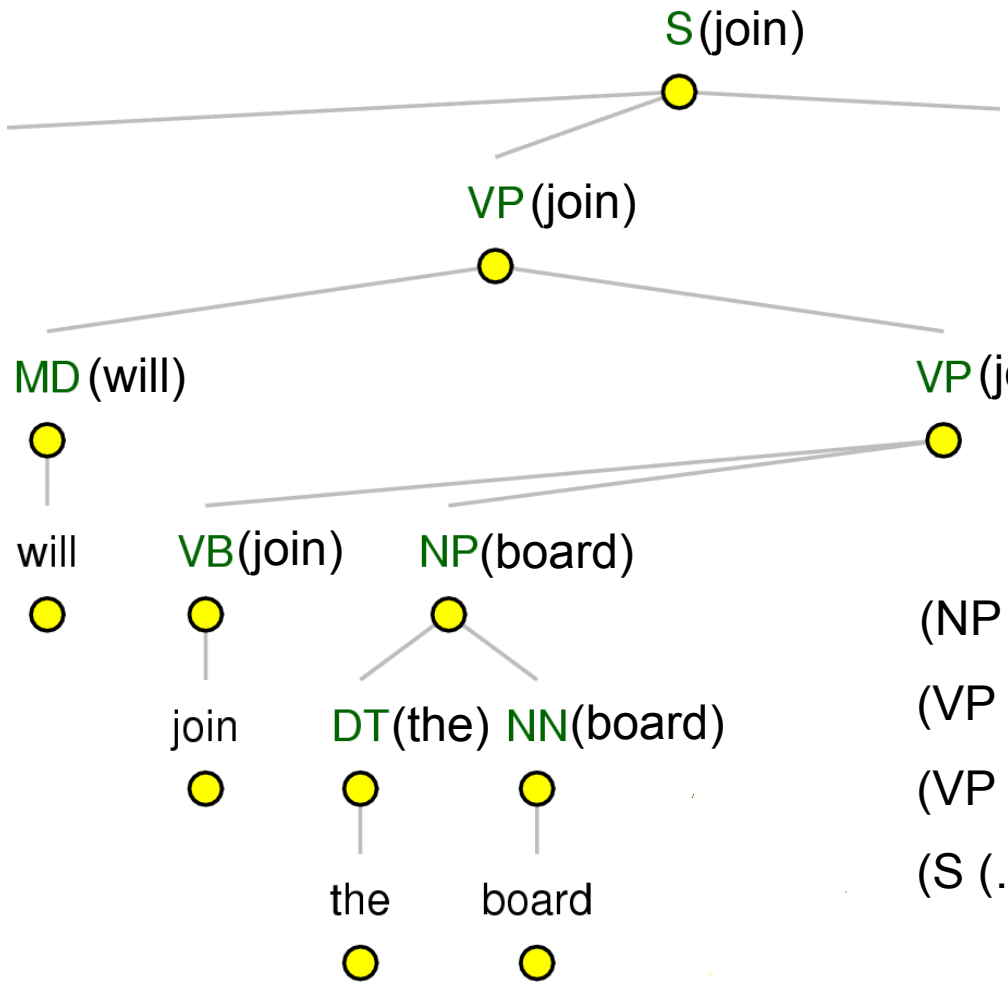
English Annotation POS and Syntax

- Automatic conversion from Penn Treebank
  - PDT morphological layer
    - From POS tags
  - PDT analytic layer
    - From:
      - Penn Treebank Syntactic Structure
      - Non-terminal labels
      - Function tags (non-terminal “suffixes”)
    - 2-step process
      - Head determination rules
      - Conversion to dependency + analytic function

Head Determination Rules

- Exhaustive set of rules
  - By J. Eisner + M. Cmejrek/J. Curin
  - 4000 rules (non-terminal based)
    - Ex.: (S (NP-SBJ VP .)) → VP
  - Additional rules
    - Coordination, Apposition
    - Punctuation (end-of-sentence, internal)
- Original idea (possibility of conversion)
  - J. Robinson (1960s)

Example: Head Determination Rules (J.E.)



Rules:

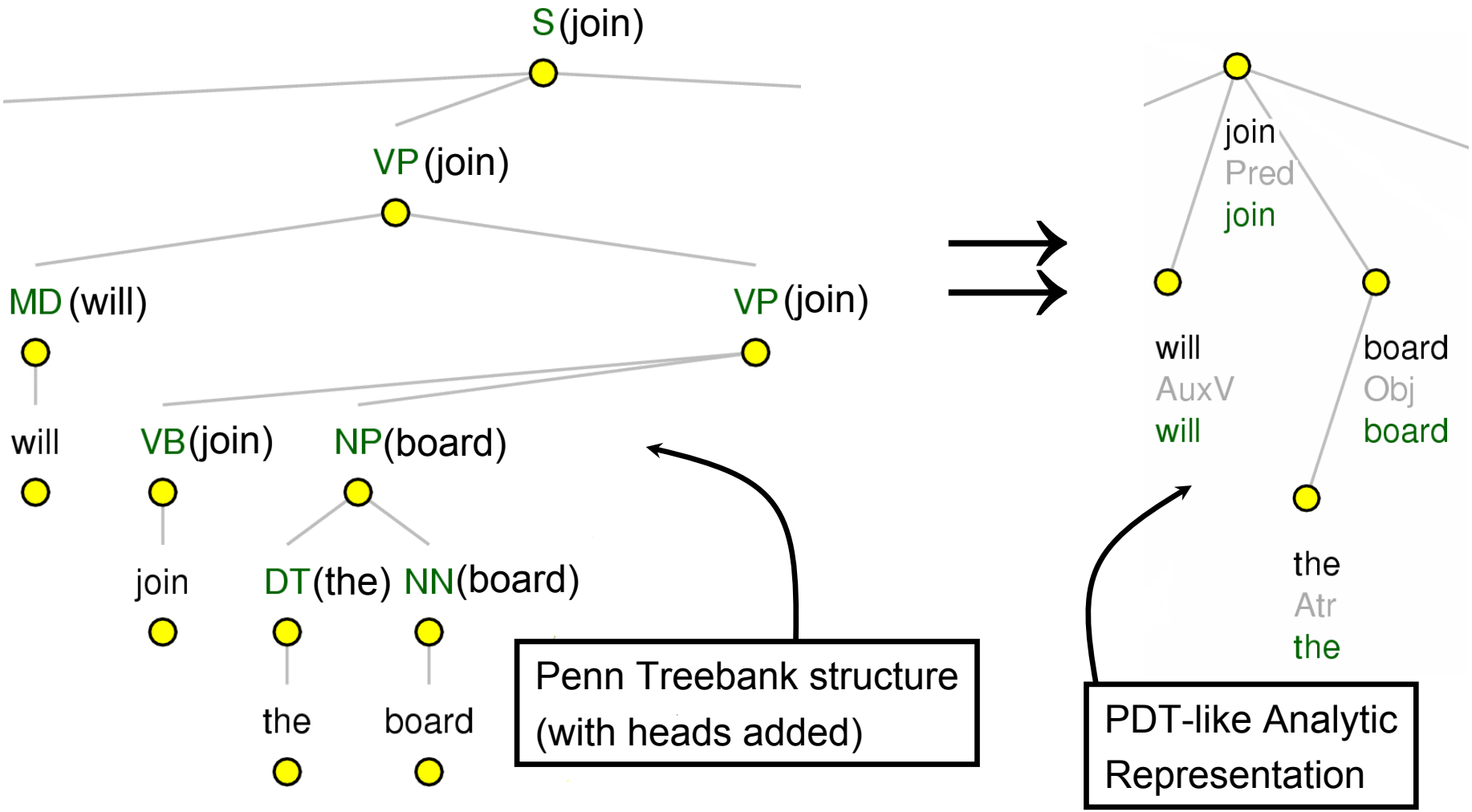
(NP (DT NN)) → NN

(VP (VB NP)) → VB

(VP (MD VP)) → VP

(S (… VP …)) → VP

Example: Analytical Structure, Functions



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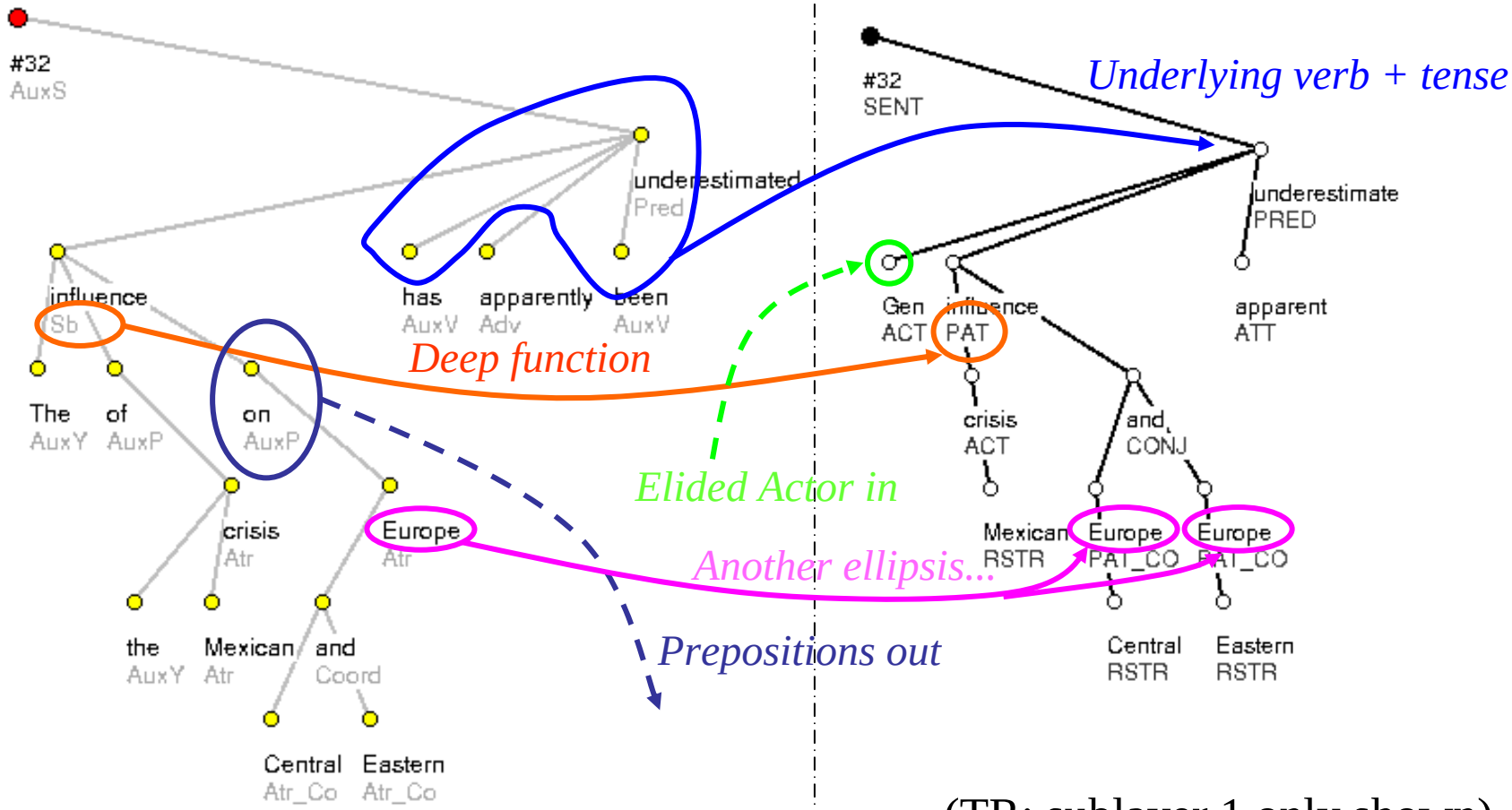
Layer 3 (t-layer): Tectogrammatical

- Underlying (deep) syntax
- 4 sublayers (integrated):
  - dependency structure, (detailed) functors
    - valency annotation
  - topic/focus and deep word order
  - coreference (mostly grammatical only)
  - all the rest (grammatemes):
    - detailed functors
    - underlying gender, number, ...
- Total
  - 39 attributes (vs. 5 at m-layer, 2 at a-layer)

Analytical vs. Tectogrammatical



(TR: sublayer 1 only shown)

Layer 3: Tectogrammatical

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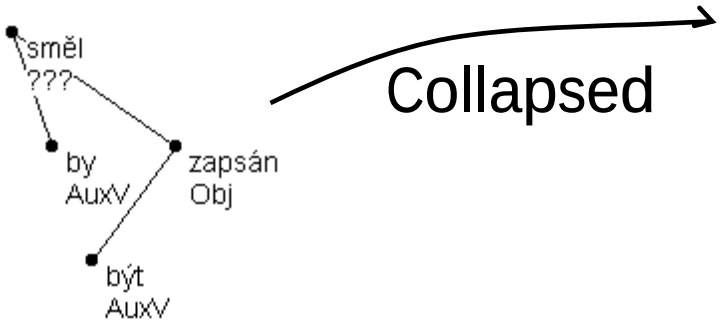
  - topic/focus and deep word order
  - coreference
  - all the rest (grammatemes):
    - detailed functors
    - underlying gender, number, ...

Tectogrammatical Functors

- "Actants": syntactic ACT, PAT, semantic EFF, ADDR, ORIG
  - modify: verbs, nouns, adjectives
  - cannot repeat in a clause, usually obligatory
- Free modifications (~ 50), semantically defined
  - can repeat; optional, sometimes obligatory
  - Ex.: LOC, DIR1, ...; TWHEN, TTILL,...; RSTR; BEN, ATT, ACMP, INTT, MANN; MAT, APP; ID, DPHR, ...
- Special
  - Coordination, Rhematizers, Foreign phrases,...

Tectogrammatical Example

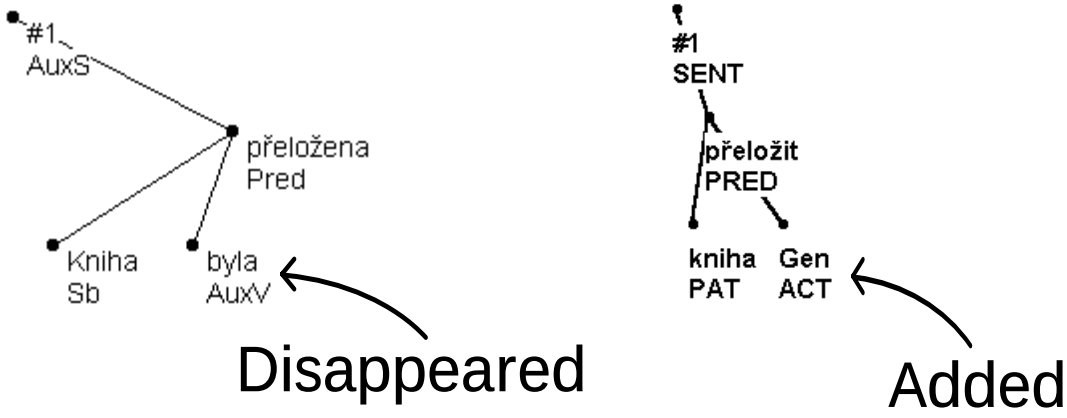
- Analytical verb form:
  - (he) allowed would-be to-be enrolled
  - směl by být zapsán



Additional attributes (grammatemes): conditional + “allow”

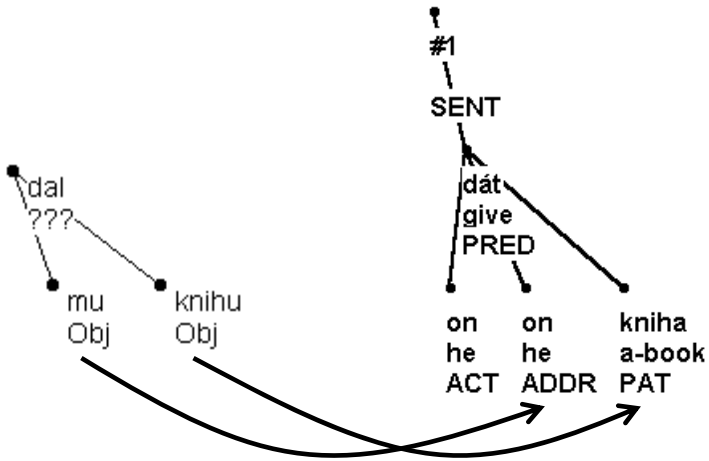
Tectogrammatical Example

- Passive construction (action)
  - (The) book has-been translated [by Mr. X]
  - Kniha byla přeložena



Tectogrammatical Example

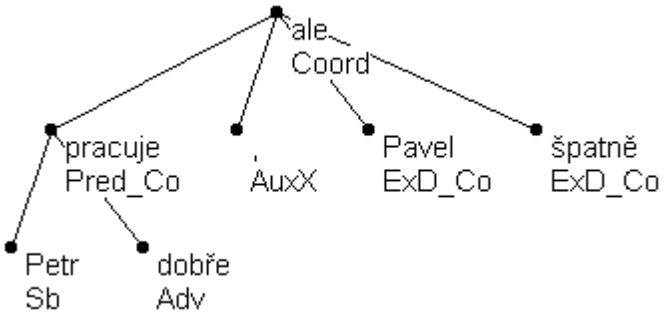
- Object
  - (he) gave him a-book
  - dal mu knihu

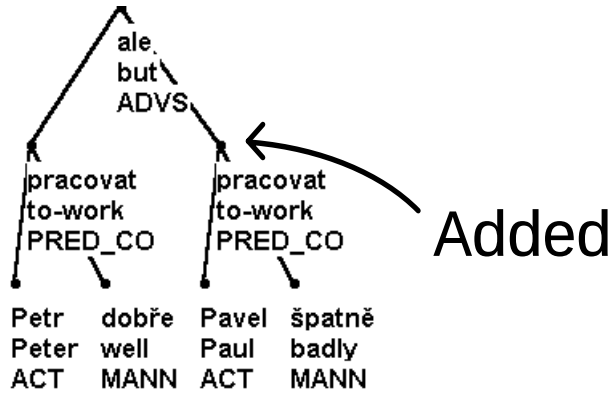


Obj goes into ACT, PAT, ADDR, EFF or ORIG based on governor's valency frame

Tectogrammatical Example

- Incomplete phrases
  - Peter works well , but Paul badly
  - Petr pracuje dobře, ale Pavel špatně





Layer 3: Tectogrammatical

- Underlying (deep) syntax
- 4 sublayers:
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  - coreference
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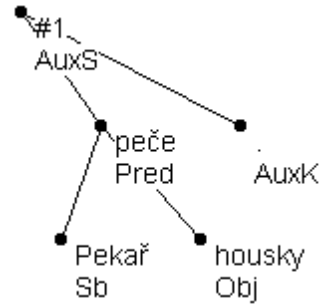
    - underlying gender, number, ...

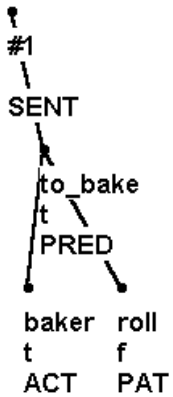
Deep Word Order Topic/Focus

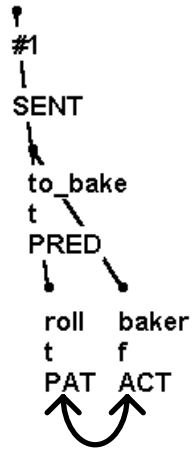
- Example:

Analytical dep. tree:



- Baker bakes rolls. vs. *Baker*^{IC} bakes rolls.





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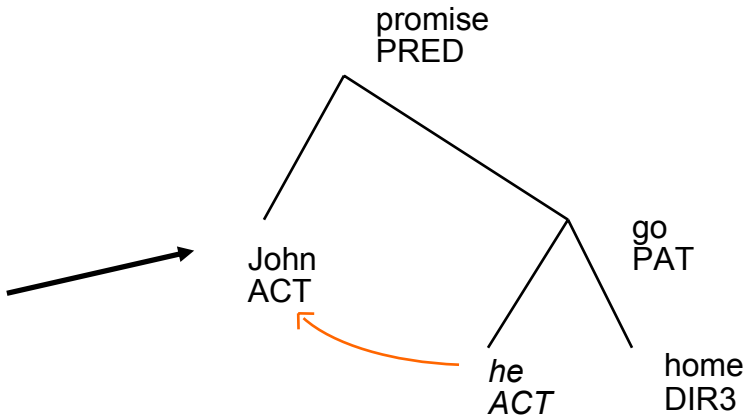
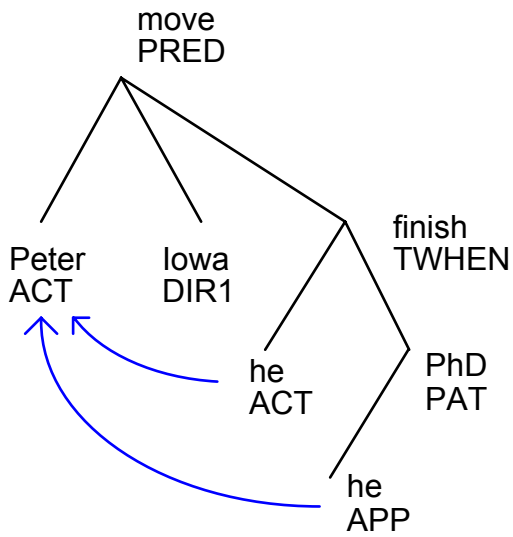
Coreference

- Grammatical (easy)
  - relative clauses
    - which, who
      - Peter and Paul, who ...
  - control
    - infinitival constructions
      - John promised to go ...
  - reflexive pronouns
    - {him,her,thme}self(-ves)
      - Mary saw herself in ...



Coreference

- Textual
  - Ex.: Peter moved to Iowa after he finished his PhD.



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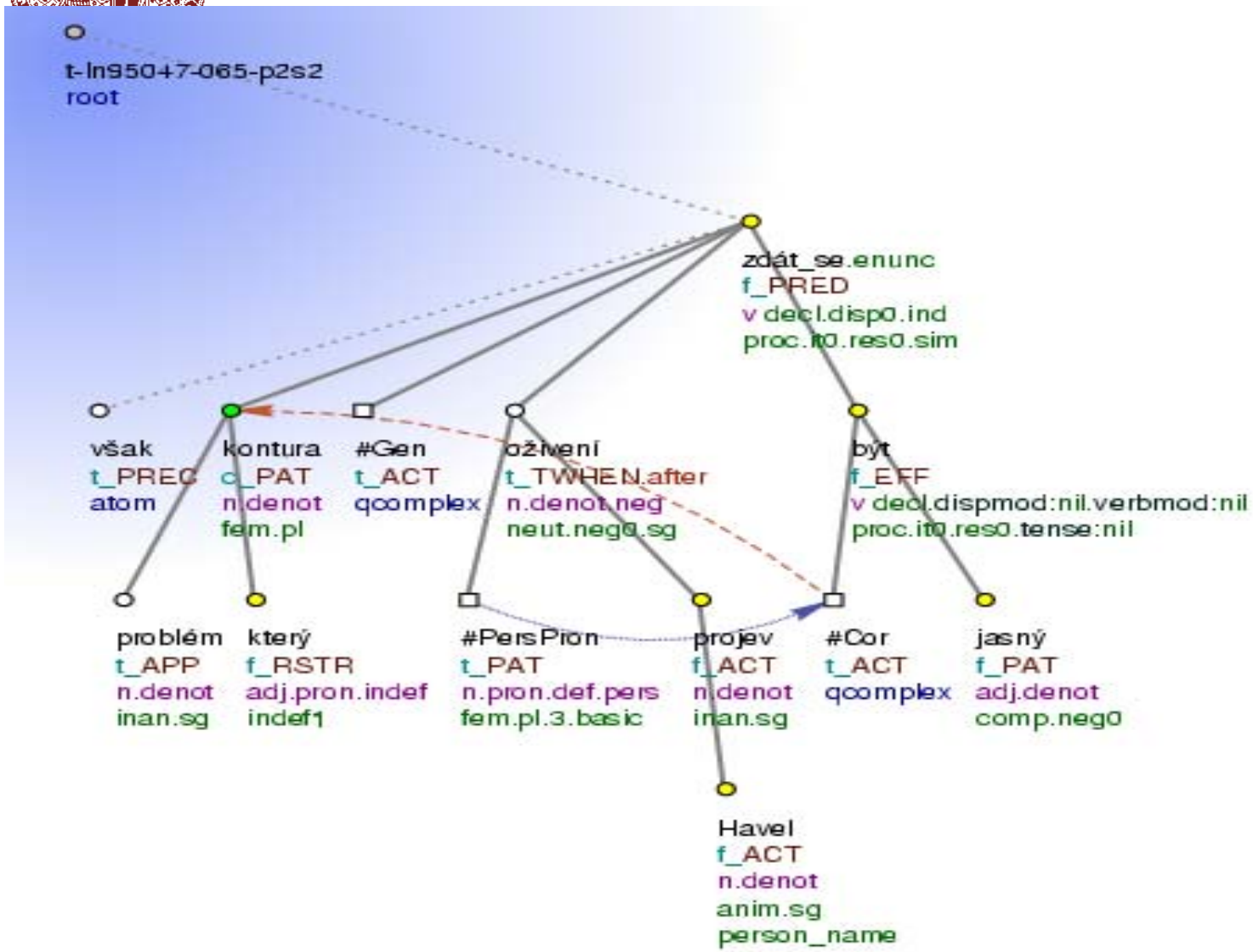
Grammatemes

- Detailed functors (subfunctors)
  - only for some functors:
    - TWHEN: before/after
    - LOC: next-to, behind, in-front-of, ...
    - also: ACMP, BEN, CPR, DIR1, DIR2, DIR3, EXT
- Lexical (underlying)
  - number (SG/PL), tense, modality, degree of comparison, ...
  - strictly only where necessary (agreement!)

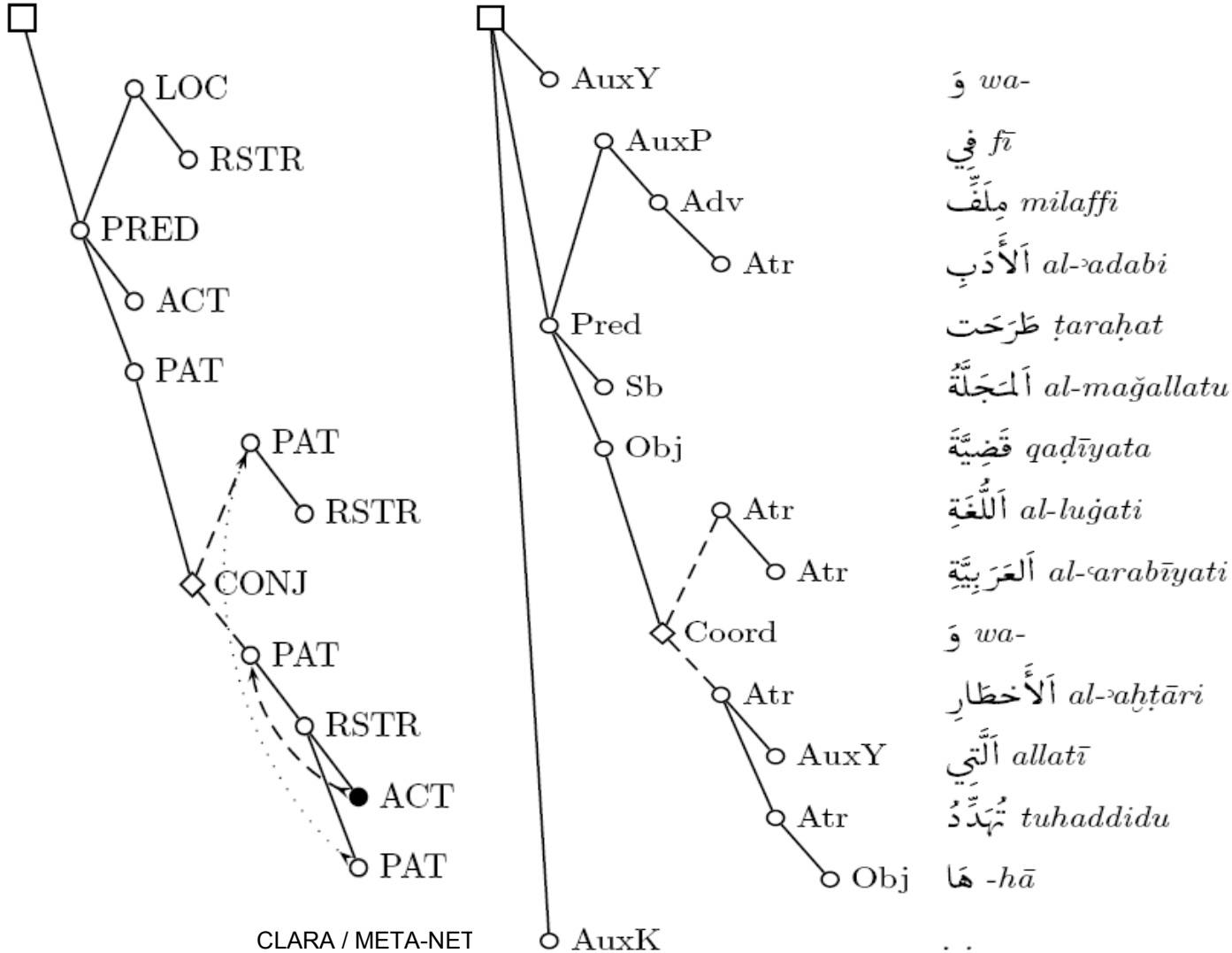
Fully Annotated Sentence



The boundaries of some problems seem to be clearer after they were revived by Havel's speech.

Arabic Example: Tectogrammatics

- In the section on literature, the magazine presented the issue of the Arabic language and the dangers that threaten it.

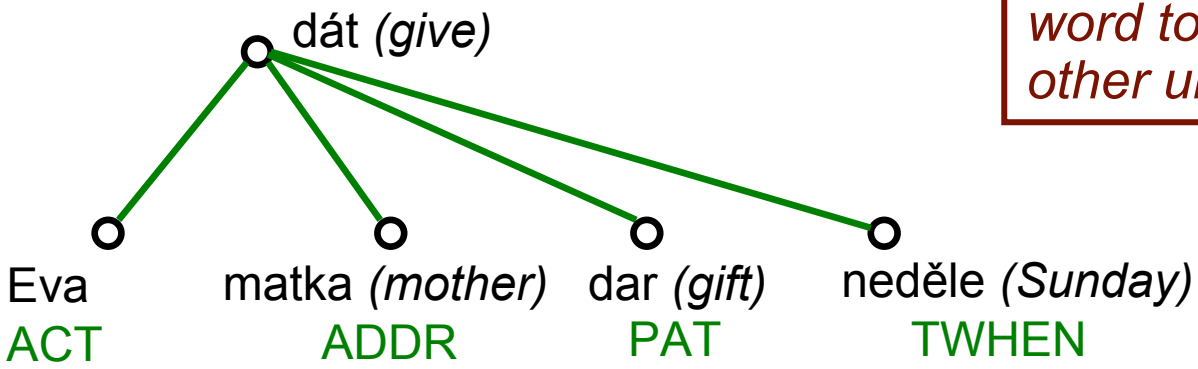


English PDT-style Annotation

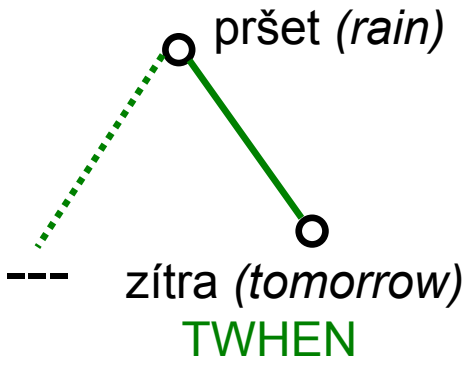
- Morphology and Syntax
  - By conversion
- Tectogrammatical annotation
  - Manual (English TR: by S. Cinková)
  - Pre-annotation
    - Transformation from Penn Treebank & Propbank (Palmer, Kingsbury) by Z. Žabokrtský et al.
  - Valency
    - From Propbank Frame Files (Cinková, Šindlerová, Nedolužko, Semecký)
  - The annotation is finished now (Nov. 2010; 1 mil. words)

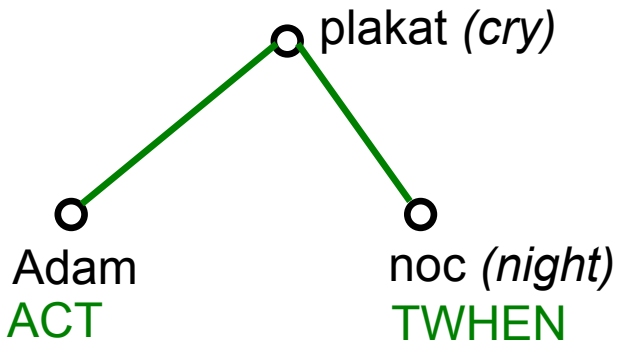
Valency in the PDT

Valency: *specific ability of a word to combine itself with other units of meaning*



Specifies actor





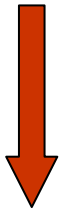
Valency - Basic Principles

inner participants vs. free modifications
(arguments vs. adjuncts)

obligatory vs. optional modifications
(the dialogue test)

Inner Participant …

… Free Modification



ACT(or), PAT(ient)
ADDR(essee), EFF(ect),
ORIG(in) (5)

- each occurs just with particular verbs
- each modifies the verb only once (in a clause)

Location (LOC, DIR1,…)
Time (TWHEN, TTILL, …),
Manner, Intention,… (70)

- can modify in principle any verb
- can be repeated (within the same clause)

Obligatory … Optional

The Dialogue Test

Answering a question about a semantically obligatory modification, the speaker cannot say: *I don't know*.

A: *John left.*
B: *From where?*
A: **I don't know.*

A: *John left.*
B: *To where?*
A: *I don't know.*

„from where“
➔ obligatory modification

„to where“
➔ optional modification

Valency frame

Structure:

	obligatory	optional
argument		
adjunct		

Contents:

- functor
- obligatoriness
- surface form

one meaning of the word ➔ one valency frame

word: *leave*
meaning 1: *sb left sth* → frame1: ACT PAT
meaning 2: *sb left from somewhere* → frame2: ACT DIR1

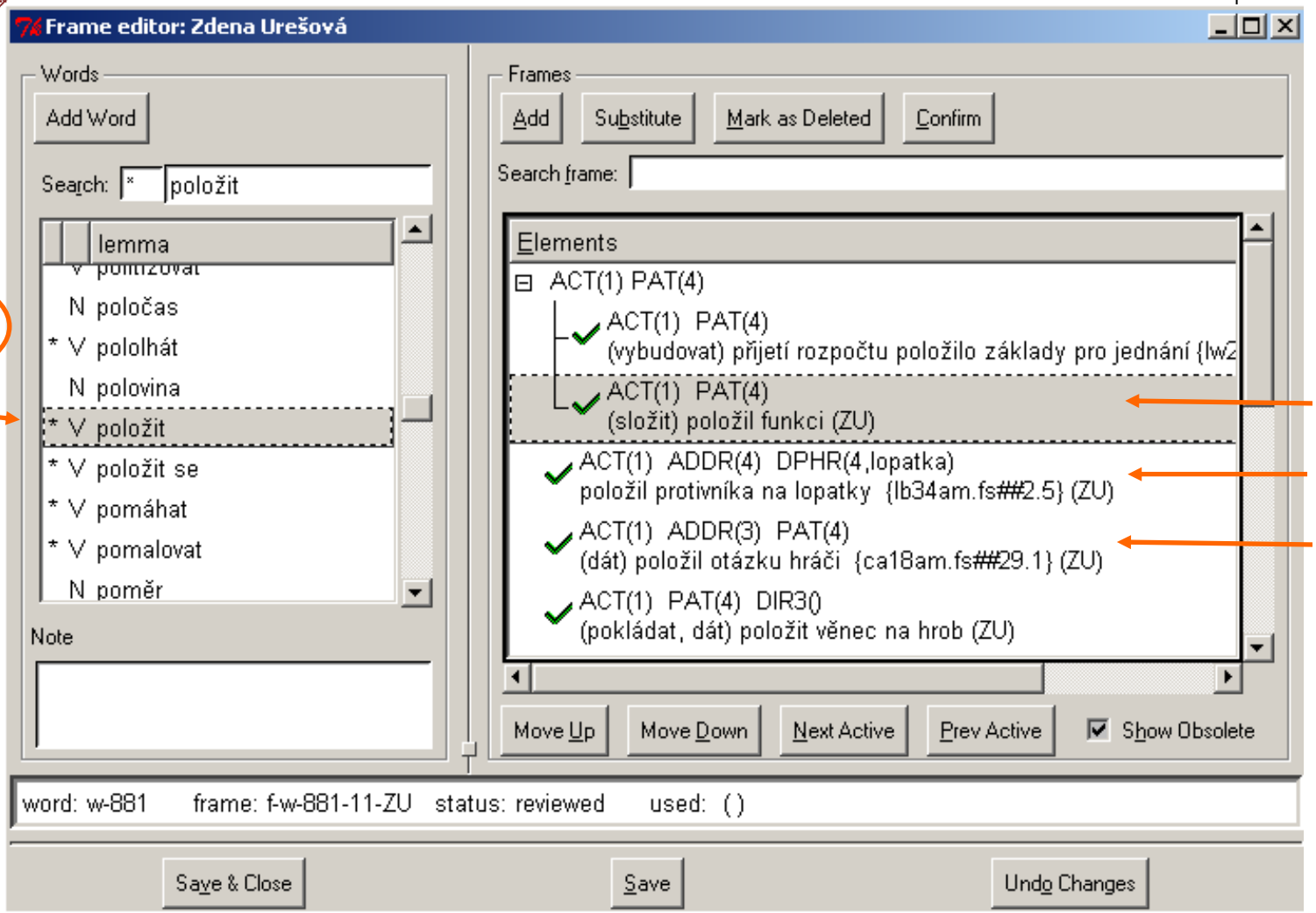
Valency lexicon: PDT-VALLEX

- 8500 verb senses / valency frames
- 9000 noun sense / valency frames
- some adjectives and adverbs

PDT-VALLEX Entry
verb: *dosáhnout*
meaning 1: *to reach sth*
meaning 2: *to get sb to do sth*
meaning 3: …
meaning 4: …

*** dosáhnout**
ACT(.1) PAT(.2,.4) v-w714f1 **Used:** 272×
dosáhnout určité úrovně
mzda d. v tomto oboru 80 tisíc
d. pokročilého věku
ACT(.1) PAT(.2,*aby*[.v]) ?ORIG(*na-1*[.6],*od-1*[.2]) v-w714f2 **Used:** 7×
dosáhl na něm slibu
dosáhli na sobě slibu
ACT(.1) DPHR(*svůj-1*.2) v-w714f3 **Used:** 2×
dosáhl svého
ACT(.1) DIR3(*) v-w714f4 **Used:** 2×
dosáhl na strop
rukou.MEANS

The PDT-VALLEX editor



'lay down'

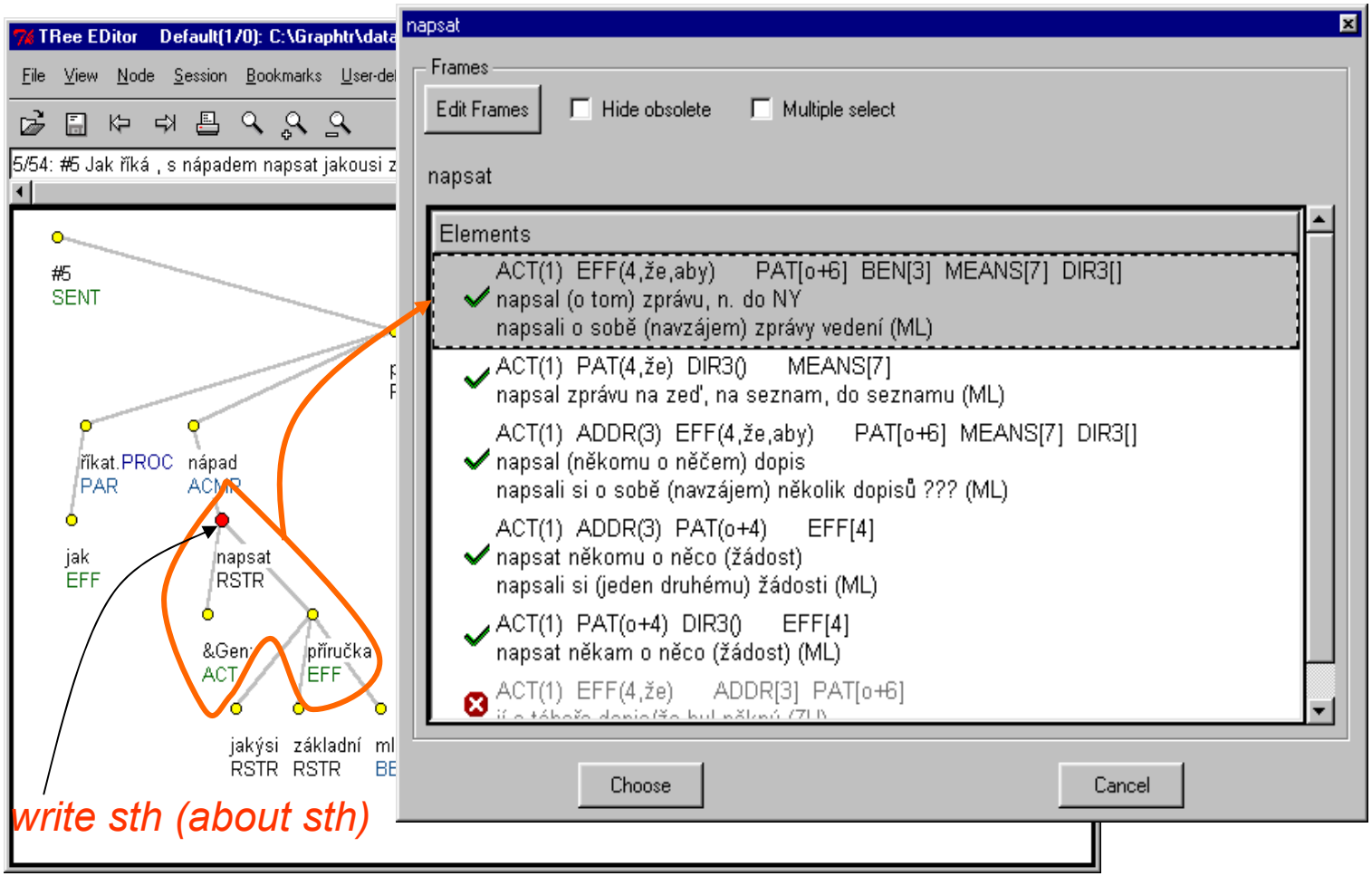
senses:

resign

win

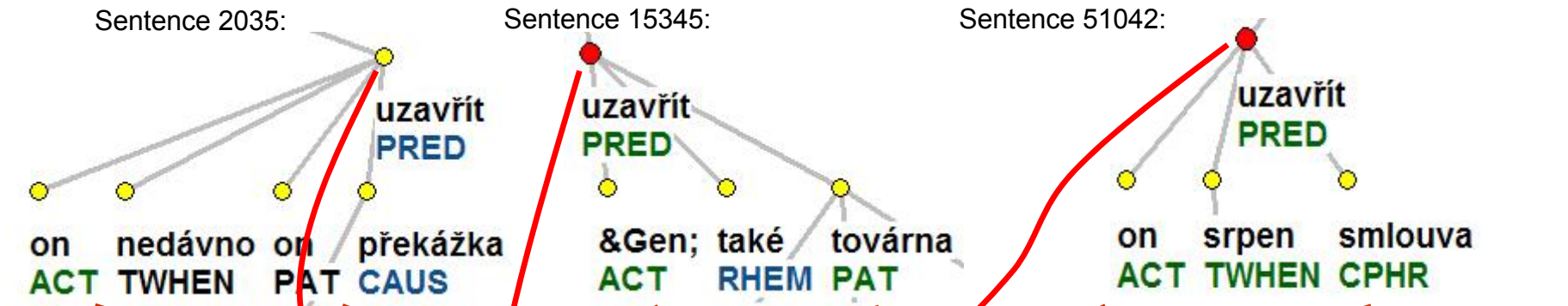
ask

Valency Lexicon and TrEd



Corpus <-> Valency Lexicon

- **Corpus** – occurrences of „uzavřít“ (*to close*) :



- **Lexicon**:

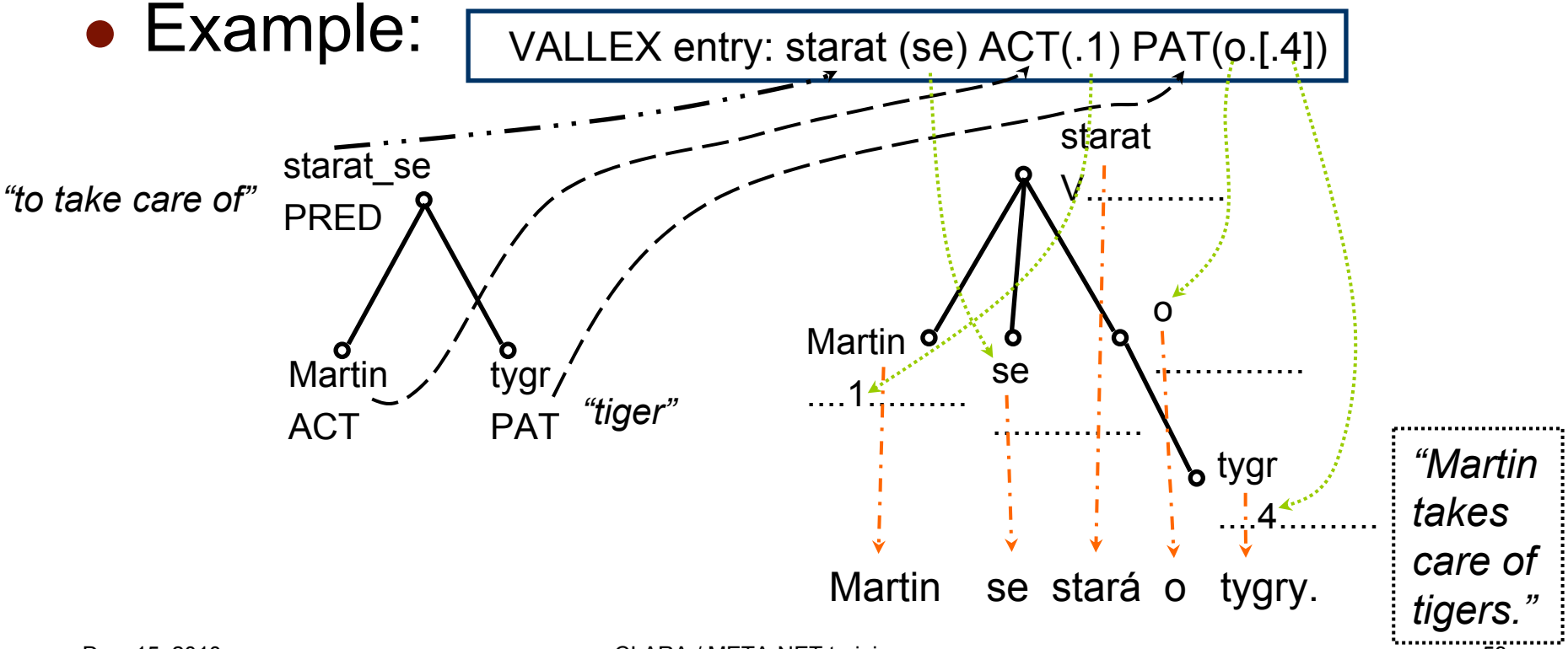
ENTRY: uzavřít

vf$_1$: ACT(.1) CPHR({smlouva}.4)
ex: u. dohodu *(close a contract)*

vf$_2$: ACT(.1) PAT(.4)
ex.: u. pokoj *(close a room, house)*

Valency and Text Generation

- Using valency for...
  - ...getting the correct (lemma, tag) of verb arguments
- Example:



The Annotation Process

- 4 sublayers
  - work on structure first, rest in parallel
- Structure
  - automatic preprocessing - programmed conversion from analytical layer annotation
- Grammatemes
  - mostly automatically (based on lower layers' annotation), manual checking, corrections
- Cross-sublayer/cross-layer checking
  - partly automatic, then manual

The Annotation Scheme

- XML + principles of linear- and tree-based standoff annotation

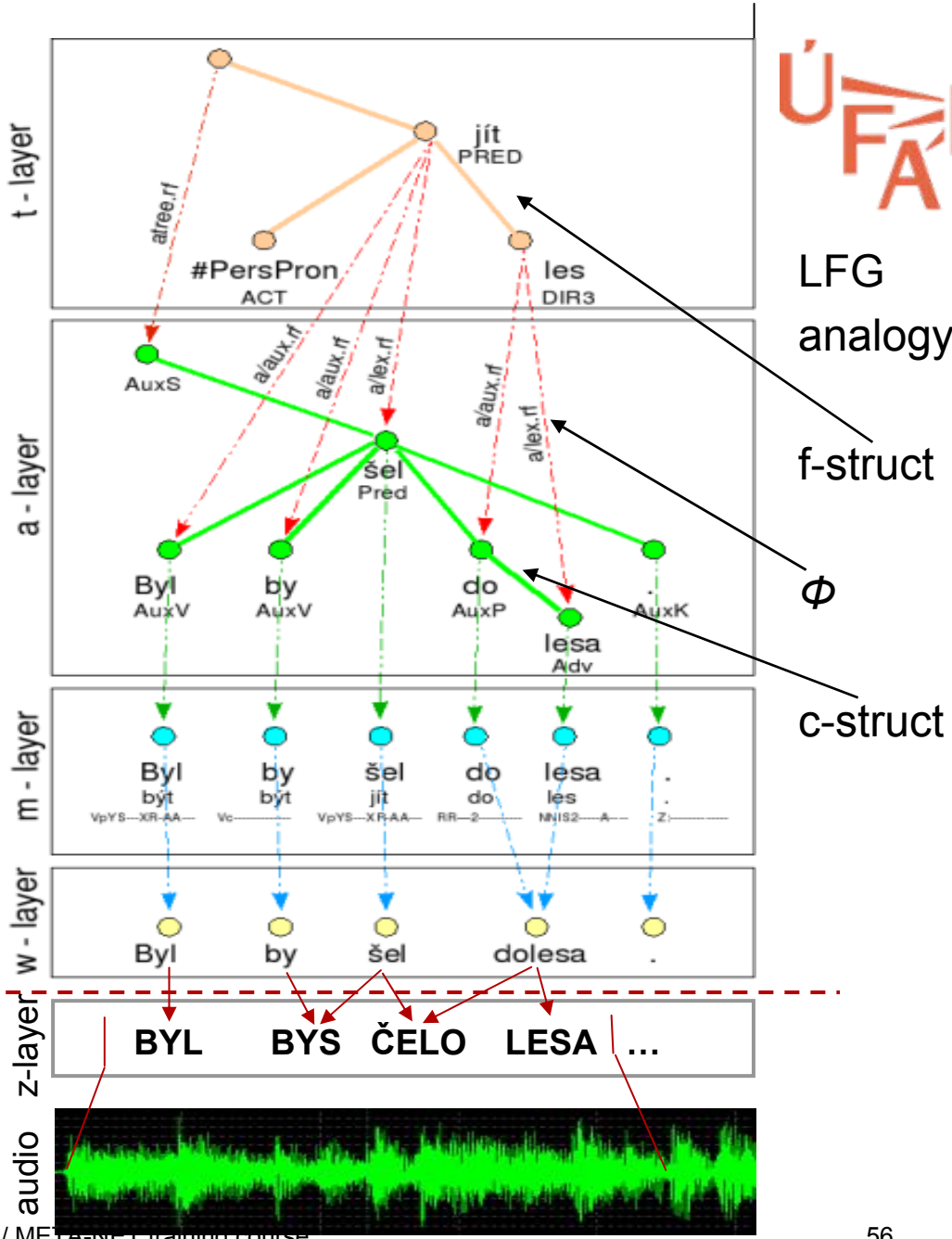
$\Rightarrow$ **PML**

(Prague Markup Language)

- Layer schemes (Relax NG)
  - PDT/PADT: t(ecto), a(nalytic), m(orphology), …
  - English: + phrase-based (p-layer)

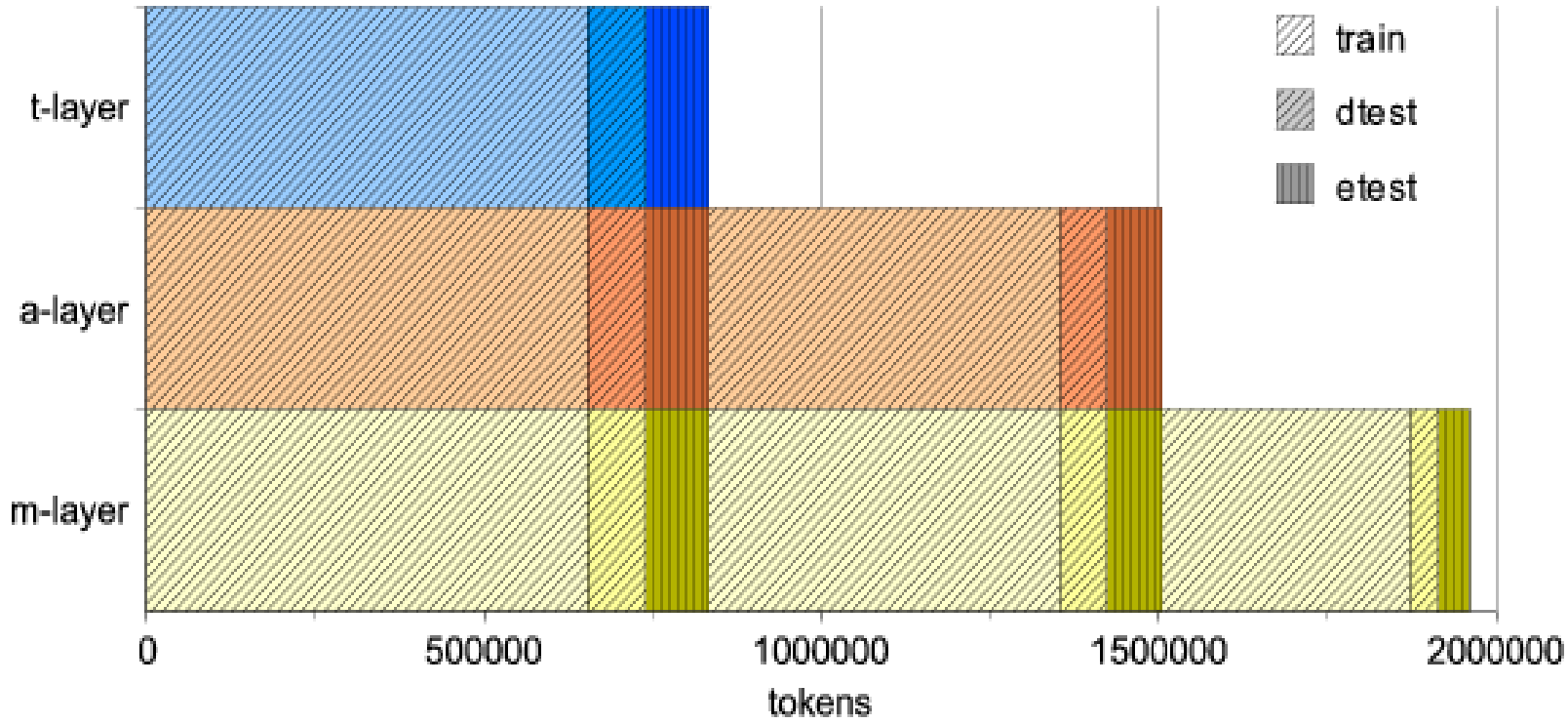
PML/XML Annotation Layers

- Strictly top-down links
- w+m+a can be easily "knitted"
- API for cross-layer access (programming)
- PML Schema / Relax NG
- [z and audio layers: used for spoken data (audio as layer "-1")]



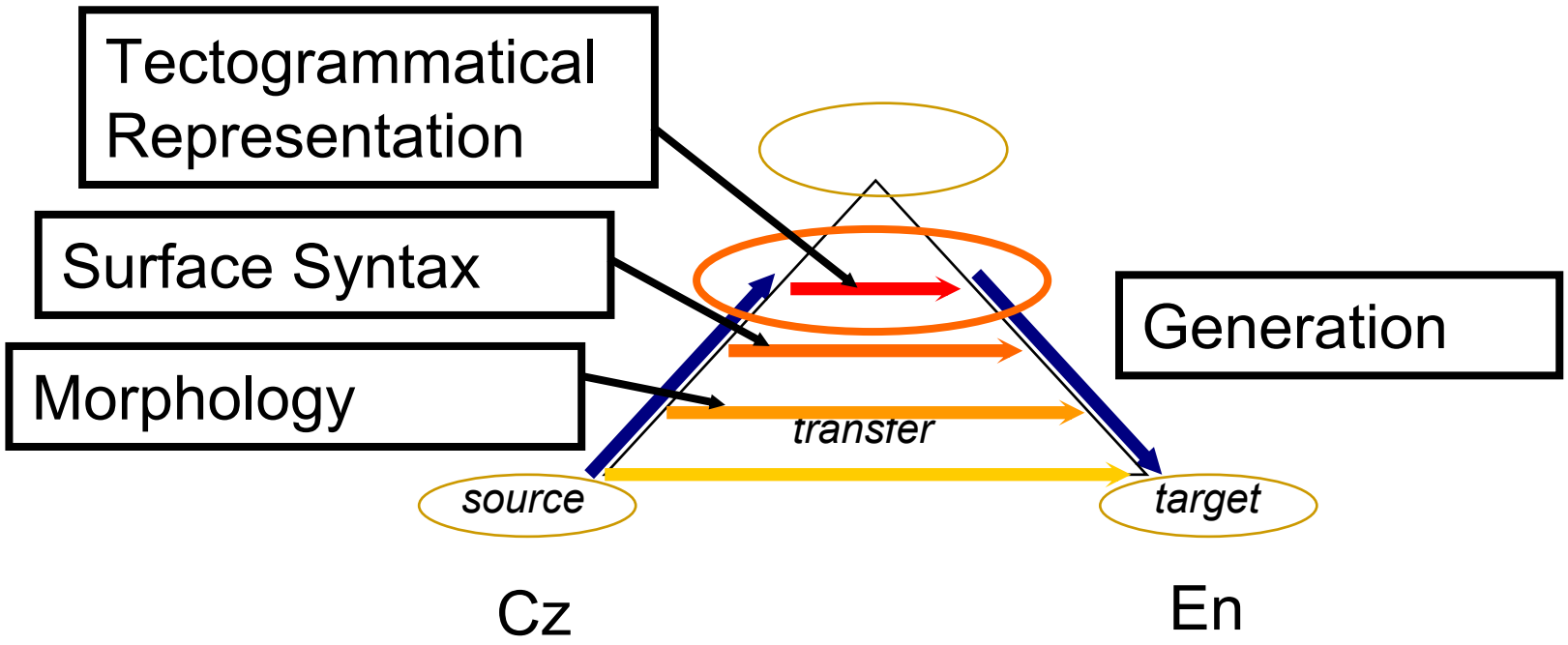
PDT 2.0: The Data

- Data sizes

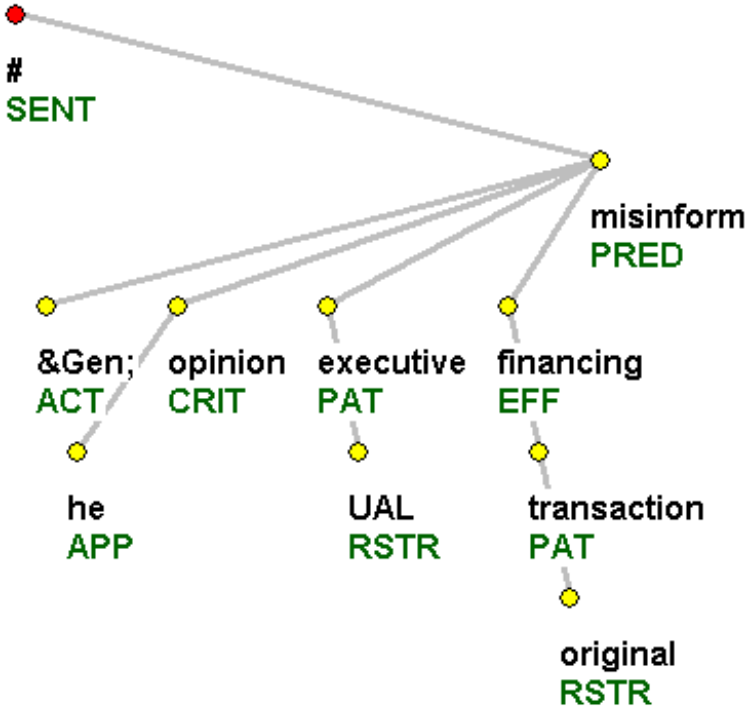


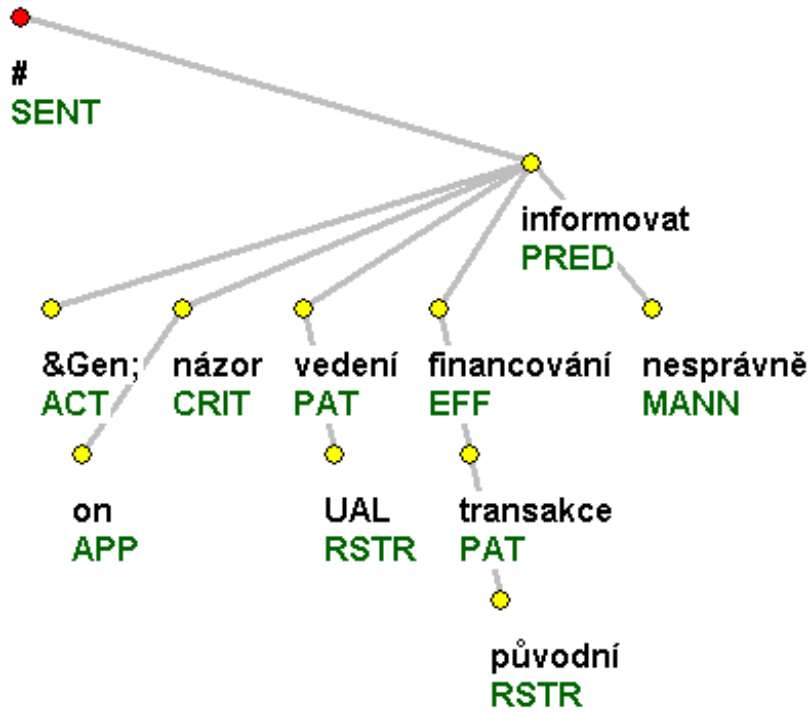
Tectogrammatical Layer in Machine Translation

- The Translation ("Vauquois") triangle



Dependency trees in MT



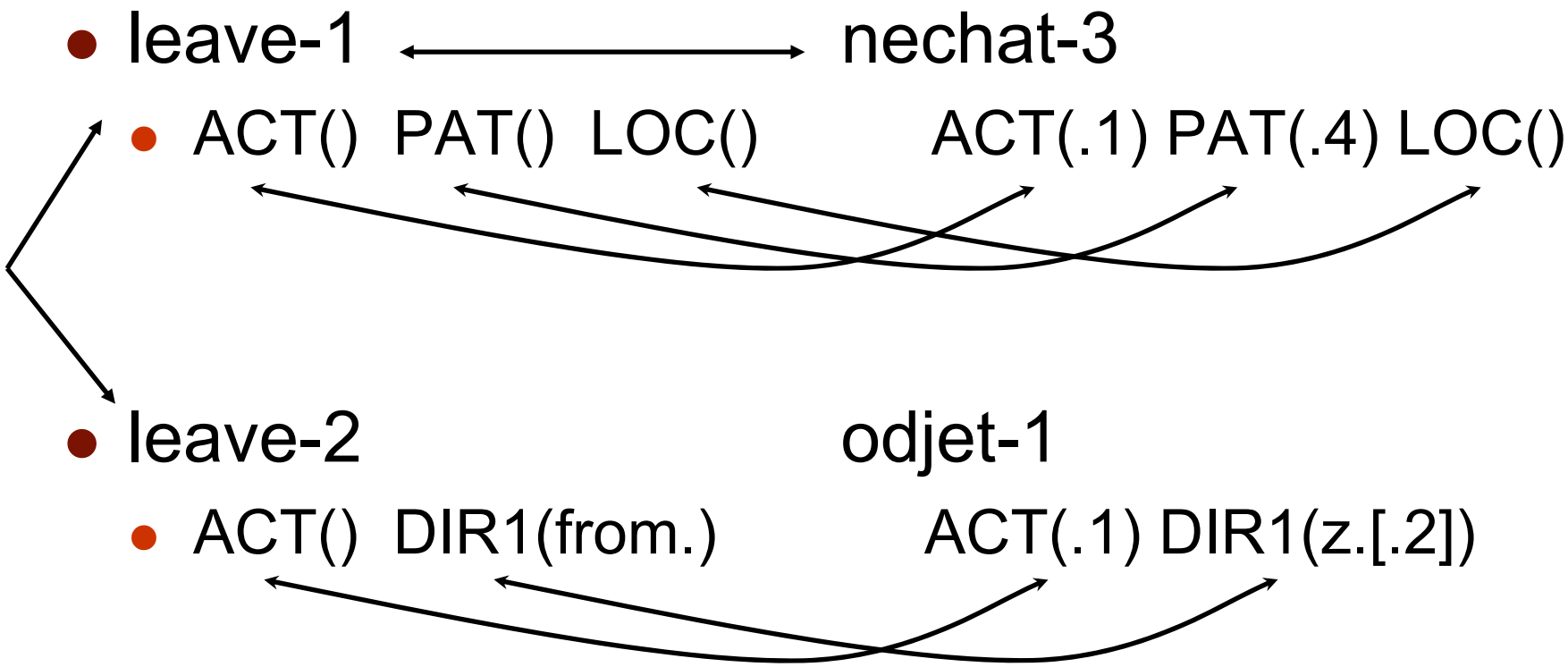


According to his opinion UAL's executives were misinformed about the financing of the original transaction.

Podle jeho názoru bylo vedení UAL o financování původní transakce nesprávně informováno.

Transfer:
- structure (~0)
- lexical
- functions
- grammatical

Valency and Translation



To summarize…

- PDT is/has (a)…
  - Dependency-based treebanking project
    - Czech (other languages in the works – Eng, Ar)
  - ~ 1mil. words
    - sufficient size for ML experiments
  - 4 layers of annotation
    - token, morphology, syntax, **deep syntax/semantics++**)
    - independent and full information at all levels, but...
    - interlinked (for the development of parsers/generators)
  - Valency dictionary integrated (links from data)

Some pointers

- Current version of PDT: v2.0, LDC2006T01
  - all three levels, 1.9/1.5/0.8 Mwords
  - http://ufal.mff.cuni.cz/pdt2.0
- http://ufal.mff.cuni.cz
  - Research -> Corpora (Treebank(s))
- http://ufal.mff.cuni.cz/pedt
  - Deep syntax (TR) of Penn Treebank texts
- http://www.ldc.upenn.edu
  - LDC2001T10 (PDT v1.0), LDC2004T23 (PADT 1.0), LDC2004T25 (PCEDT 1.0), LDC2006T01 (PDT 2.0)
- http://www.clsp.jhu.edu: Workshop 2002
  - Using TL for MT Generation