Tree-based Machine Translation

using syntax and semantics

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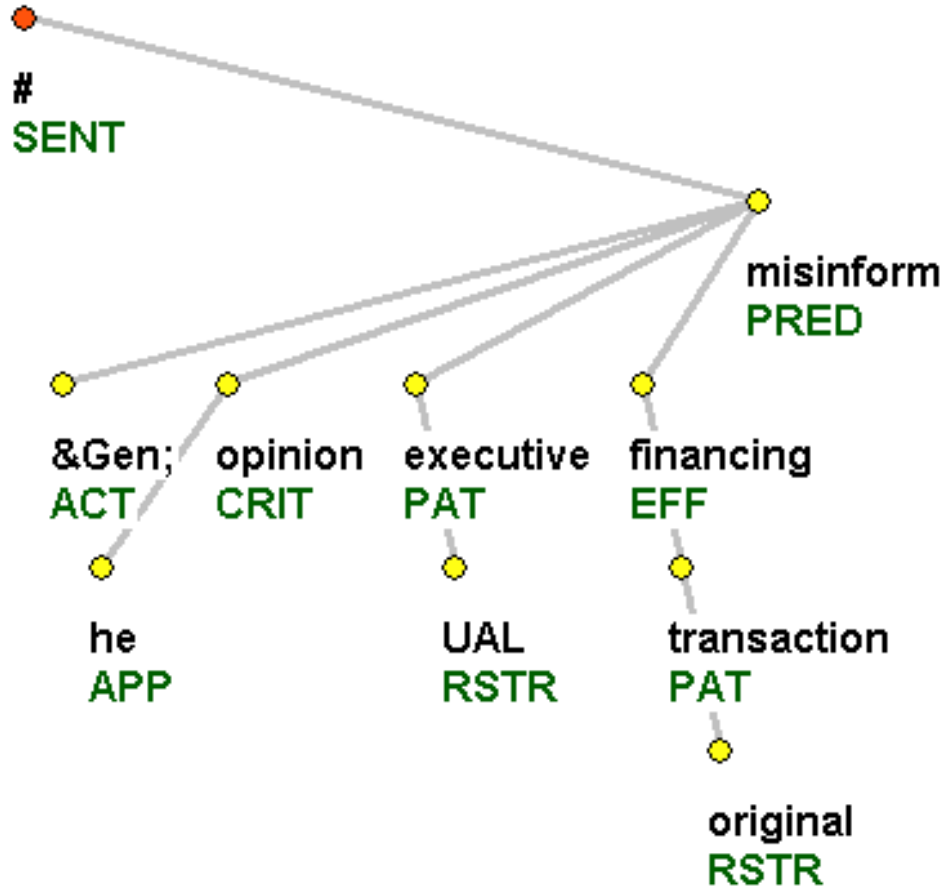
The Kinds of Trees We Grow

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



Meaning Representation

- Language-dependent:
  - Unit: lexical unit with lexical “meaning” (executive)
- Almost language-independent: PAT →
  - Dependency relations (executive misinform)
  - Semantic features (executive$_{PL}$, …)
    - Number, Tense, Modality, Mood, (In)definitness, ...
- Language-independent:
  - Dependency tree (as a formal object)
  - Information structure (topic,focus) (executive^{t}, misinform^{f})
  - Co-reference (anaphora resolution) (PERSON-NAME←he)

The Prague Dependency Treebank (PDT)

- Meaning ("tectogrammatical") representation
  - Layered approach
  - Language specific (...but specificity is "minimal")
  - Highest unit: sentence (utterance)
  - Syntax: dependency based
    - Combined syntactic and semantic representation
- Languages
  - Czech, English, Arabic, (German)
  - Slovak, Slovene, Greek, Latin, ... (other teams)

PDT annotation layers

- L0 (w) Words (tokens)
  - automatic segmentation and markup only
- L1 (m) Morphology
  - Tag (full morphology), lemma
- L2 (a) Analytical layer (surface syntax)
  - Dependency, analytical dependency function
- L3 (t) Tectogrammatical layer (“deep” syntax)
  - Dependency (labeled), sem. features, ellipsis resolution, co-reference, topic/focus, valency

The Annotation Layers

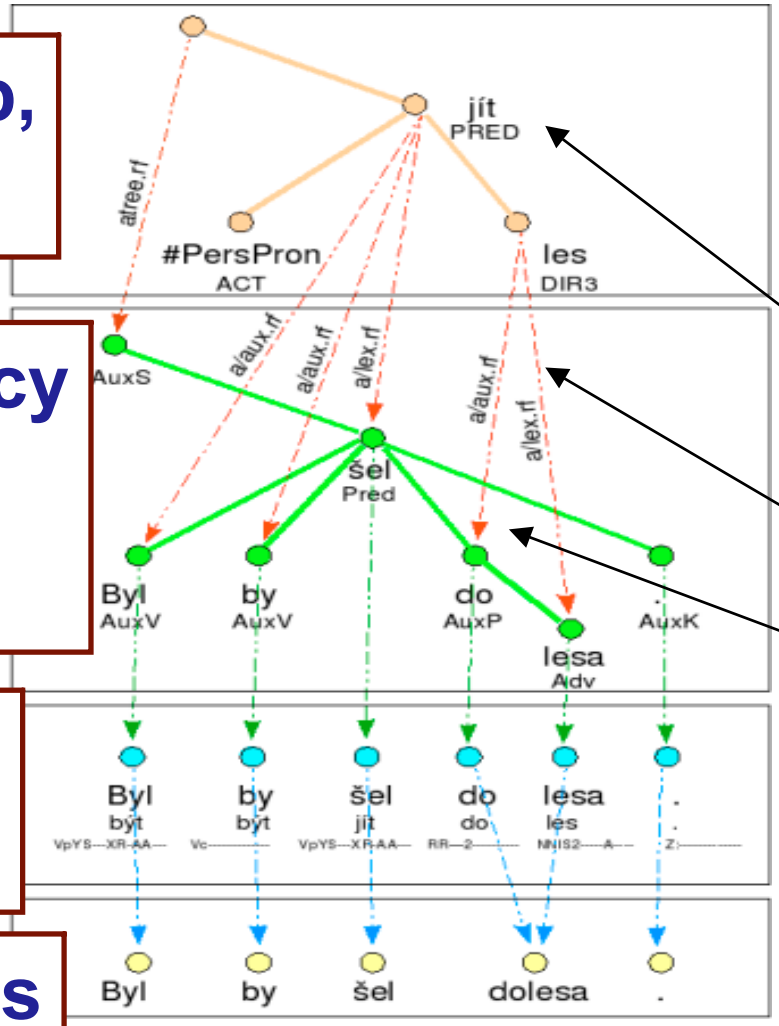
- Interlin
  top-down links
- API for cros
  access
  (programmi
- XML
- PML Schema /
  Relax

Meaning (deep, "rich" syntax)

Dependency Surface Syntax

Morphology, Lemmatization

Words



LFG analogy:

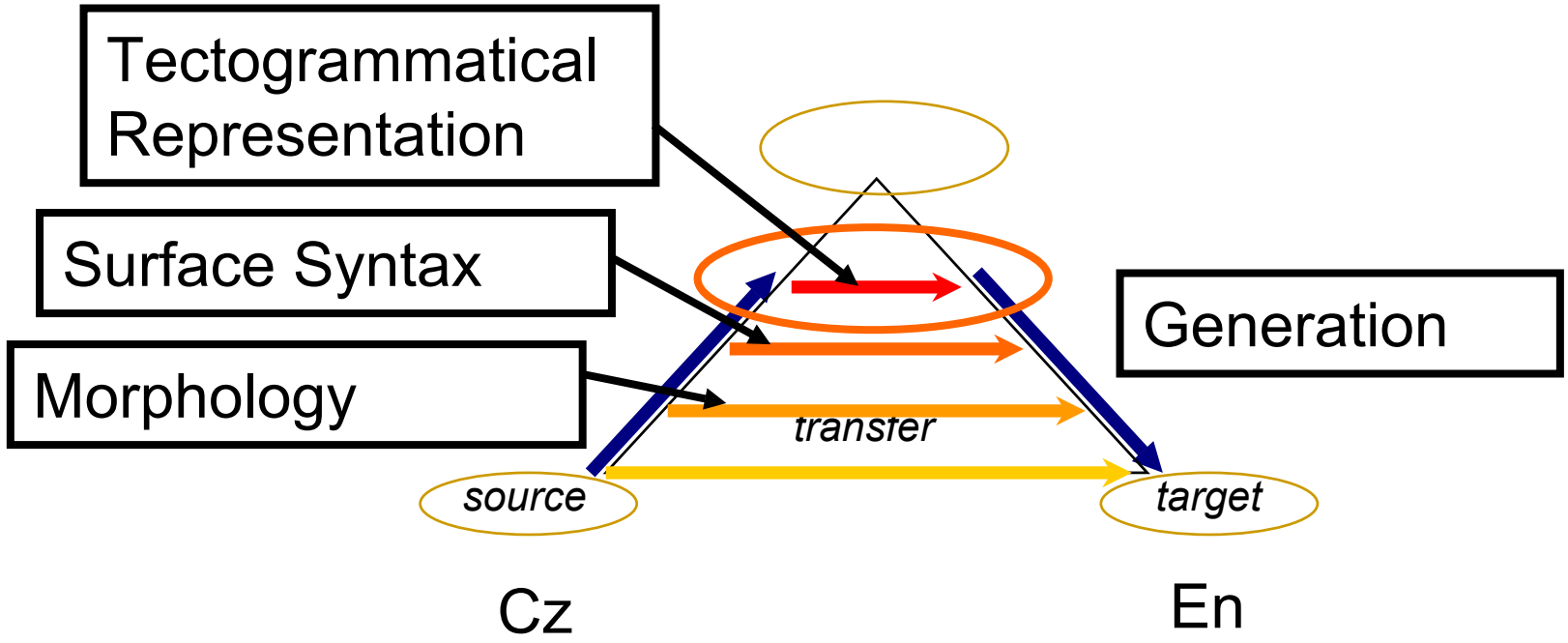
f-struct

ϕ

c-struct

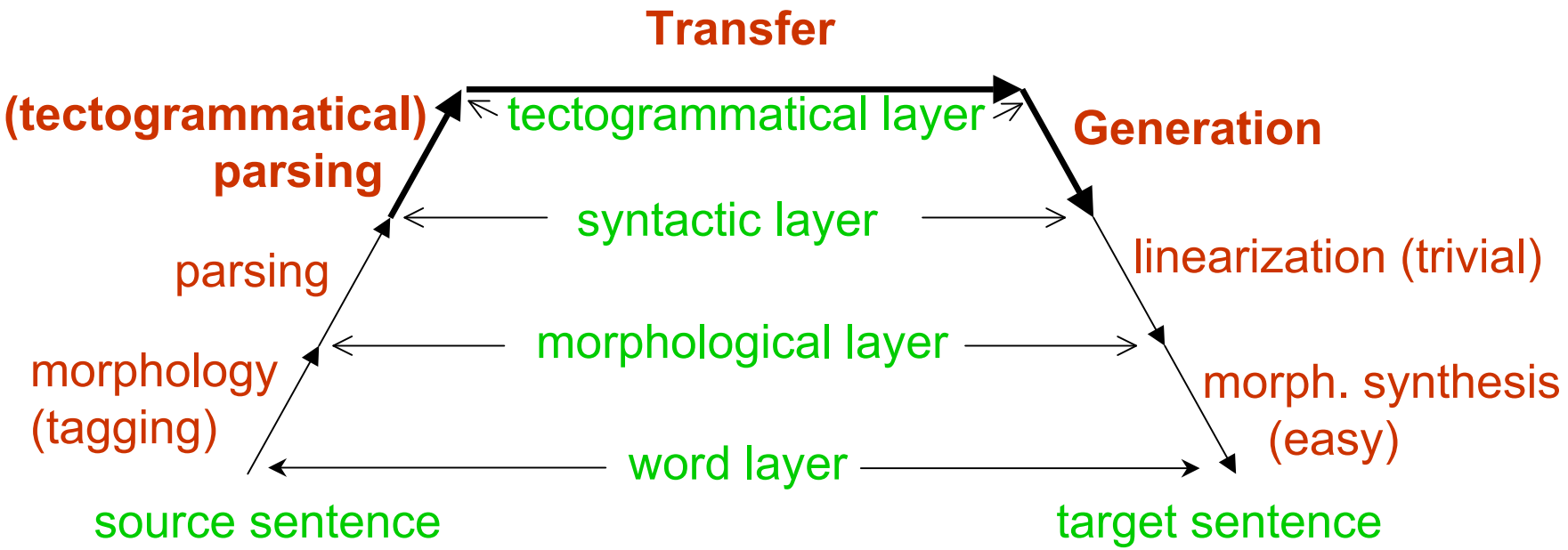
Machine Translation Scheme

- The Translation ("Vauquois") triangle



Tectogrammatical Layer in Machine Translation

- The additional three steps:

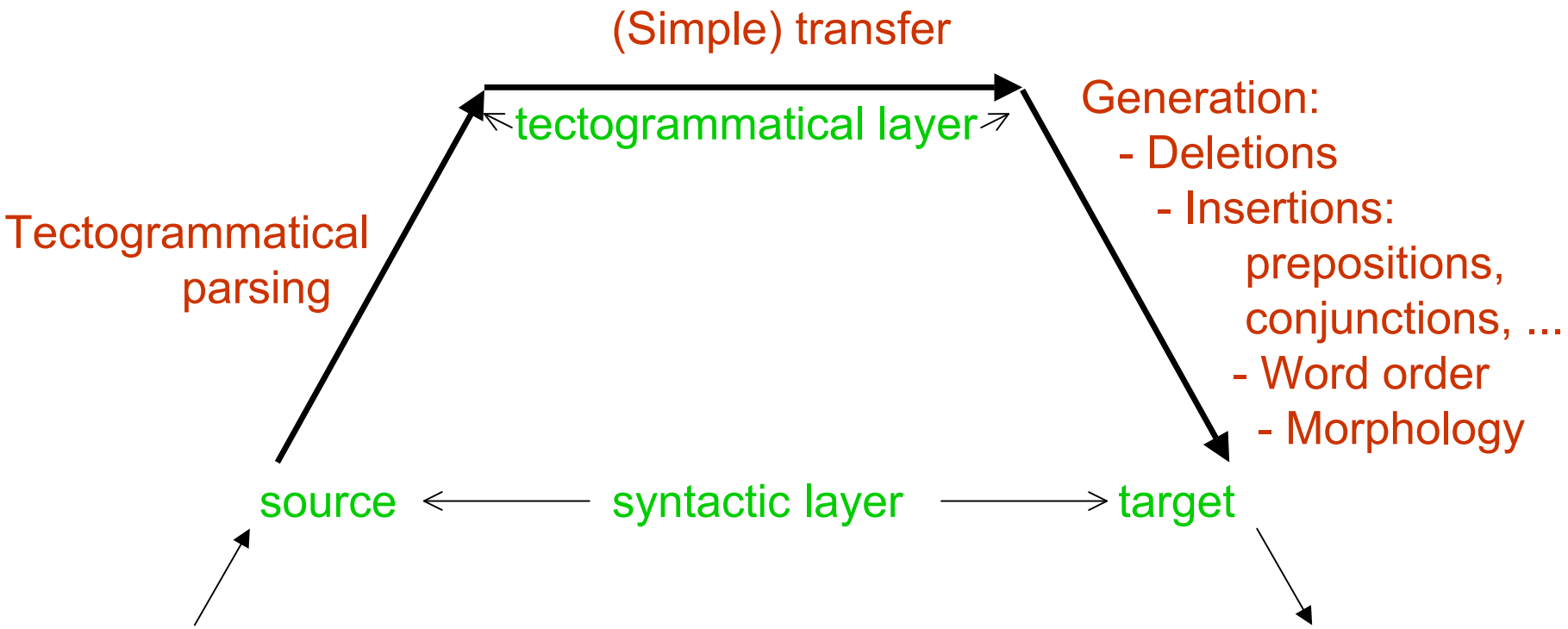


The Additional Steps

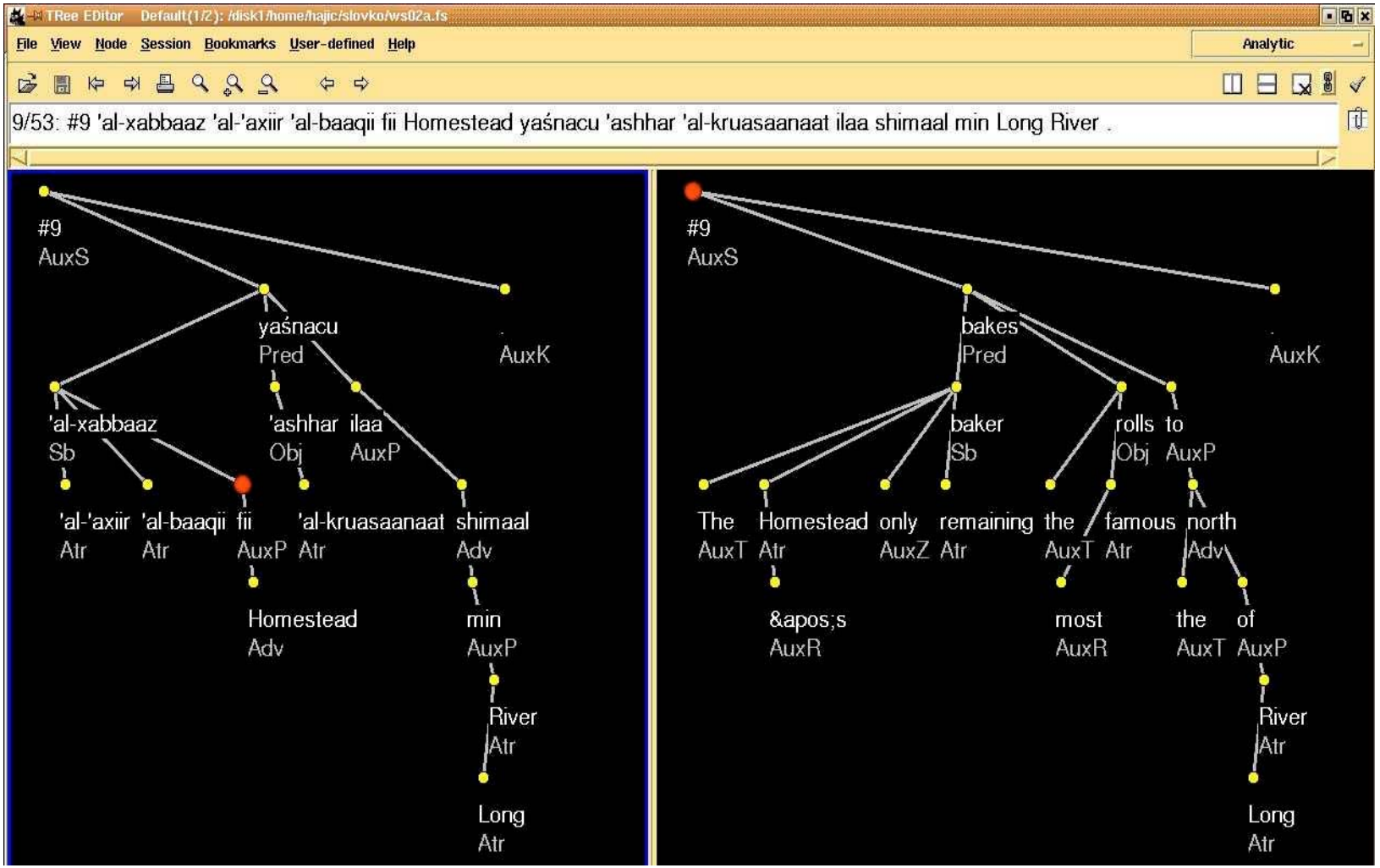
- Analytical (surface) → Tectogrammatical
  - additional parsing required
- Transfer
  - minimal effort: only “true”, non-1:1 transformations (*like swimming* ~ *schwimmen gern*)
- Generation
  - back from Tectogrammatical representation to Analytical (surface syntax)

Zooming In ...

- The additional three steps:



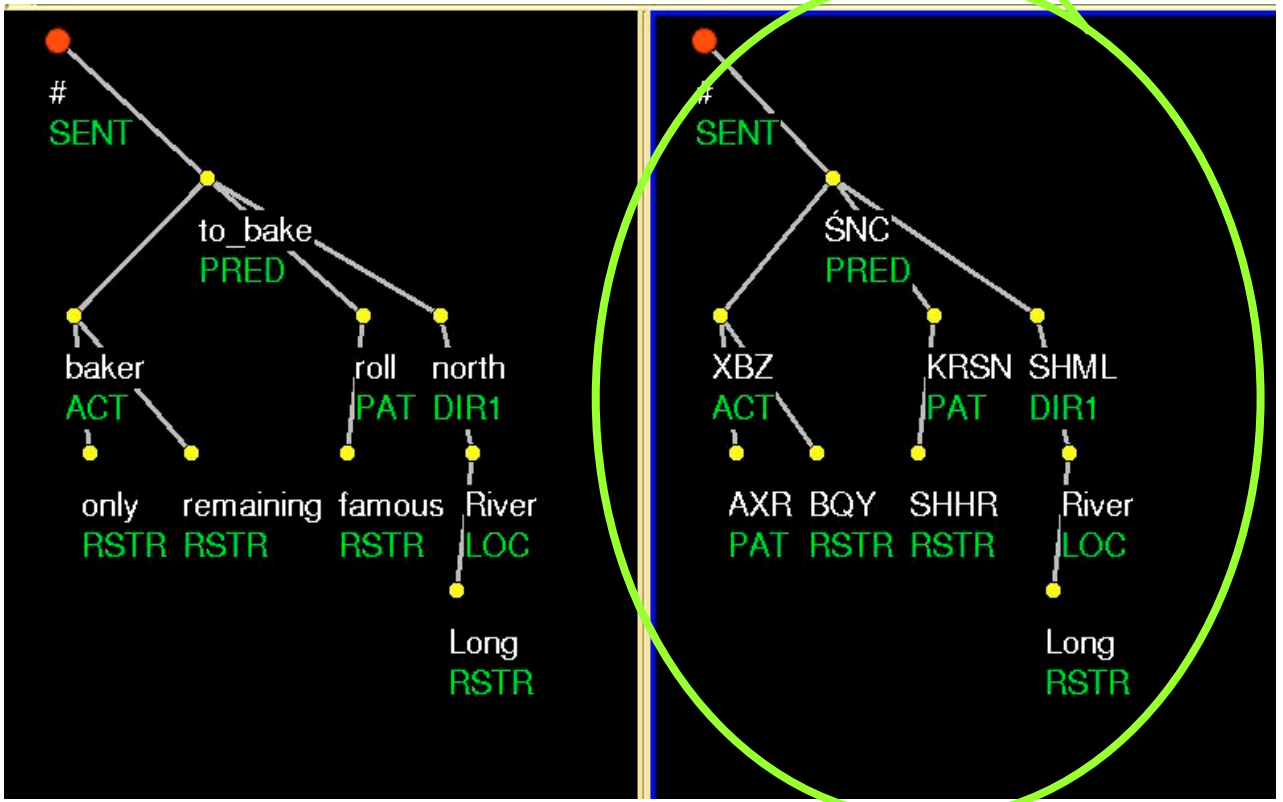
Analytical Layer Correspondence (Ar-En)



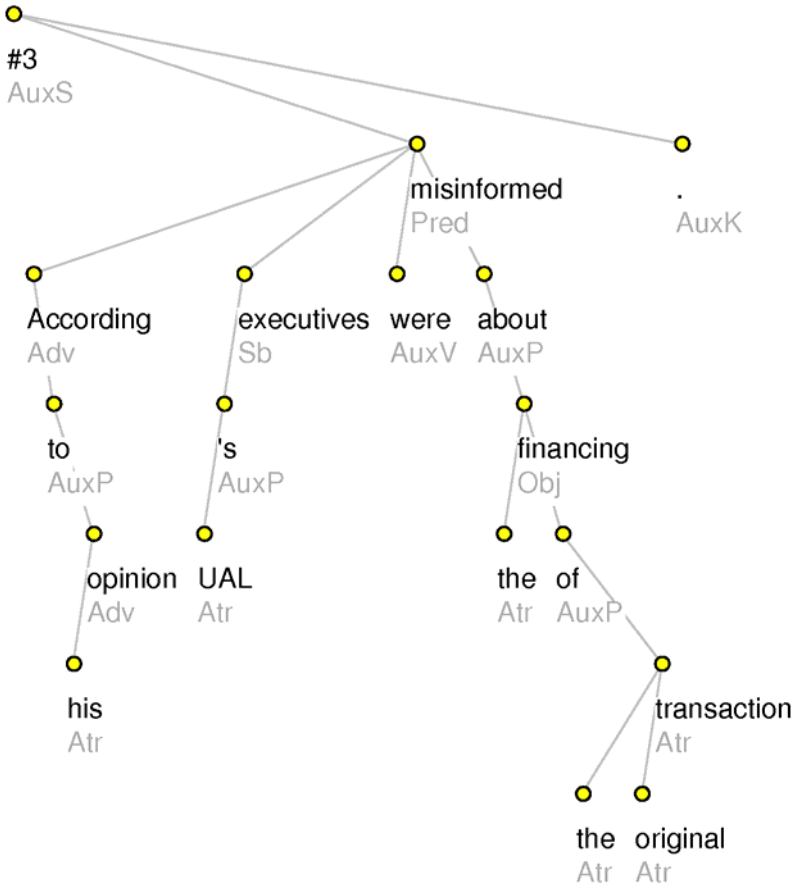
Tectogrammatical Correspondence (En-Ar)

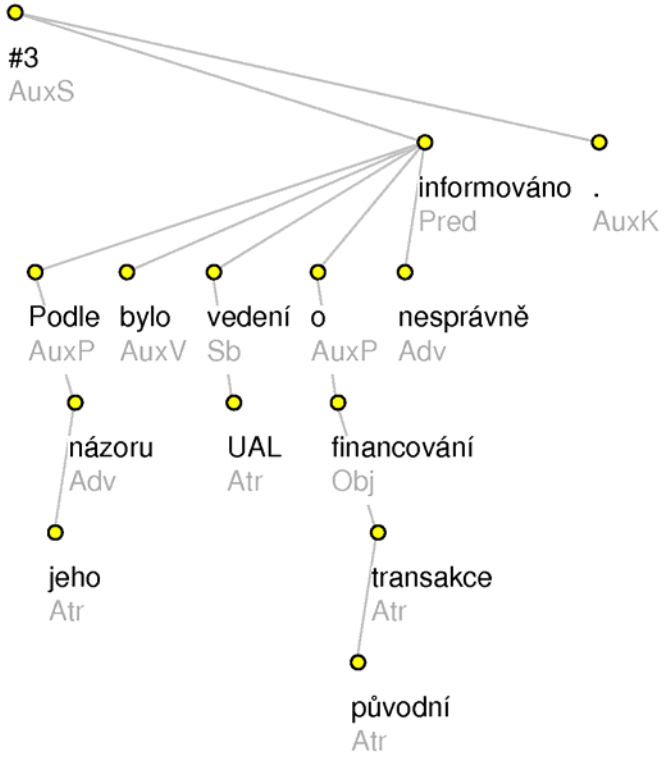
The [Homestead's] only remaining baker bakes the most famous rolls to the north of Long River.

'al-xabaaz 'al-'axiir 'al-baaqii [fii Homestead] yaśmacu 'ashhar 'al-kruasaanaat ilaa shimaal min Long River.



Depedency Syntax En-Cz





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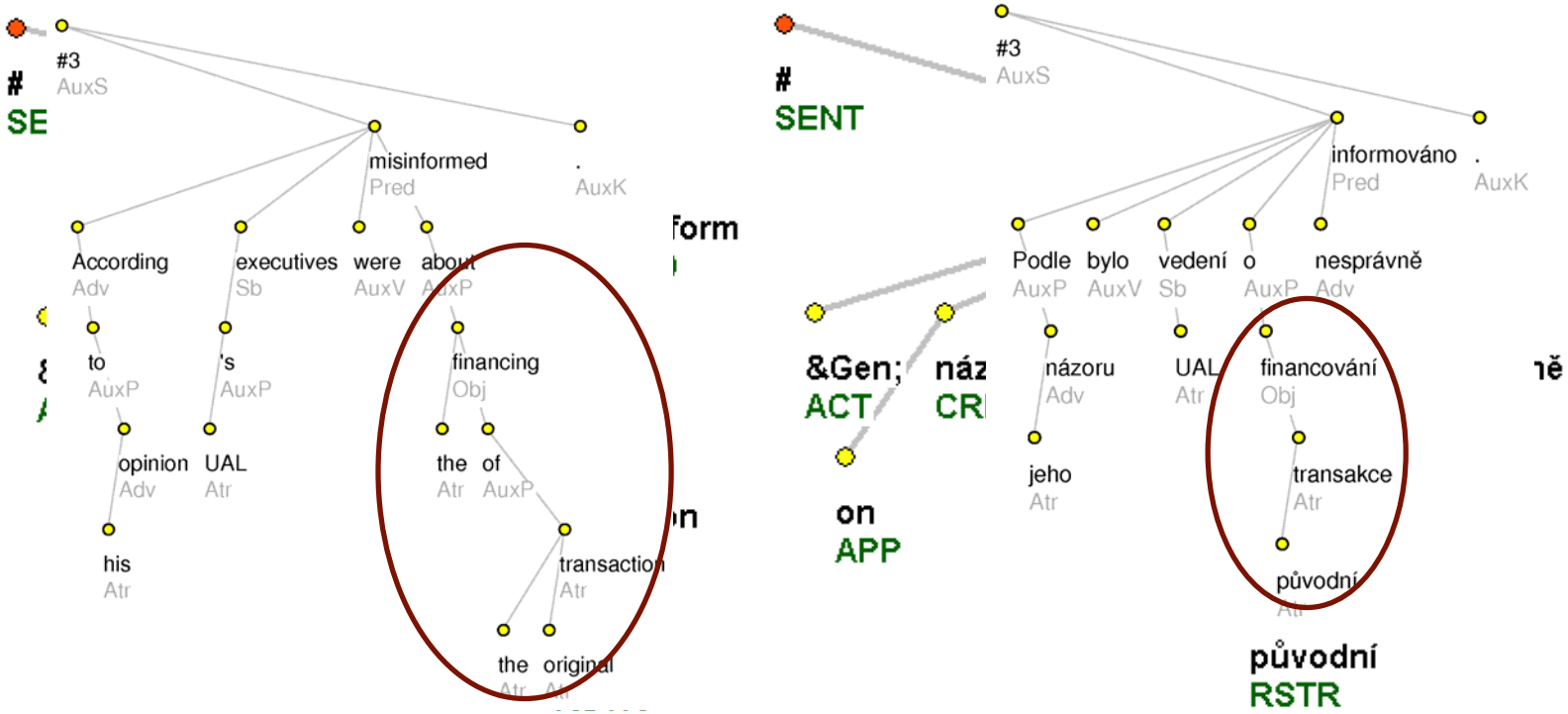
Meaning Level
En-Cz Correspondence



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

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

Parallel Czech-English Annotation: Penn Treebank

- English text -> Czech text (human translation)
- Czech side: all layers manual annotation
- English side:
  - Morphology and surface syntax: technical conversion
    - Penn Treebank style -> PDT surface dep. syntax layer
  - Tectogrammatical annotation: manual annotation
    - Auto pre-annotation
    - Many other resources merged in:
      - NP structure, BBN corpus (coreference, NE), Prop- &NomBank
- Alignment: natural, sentence level

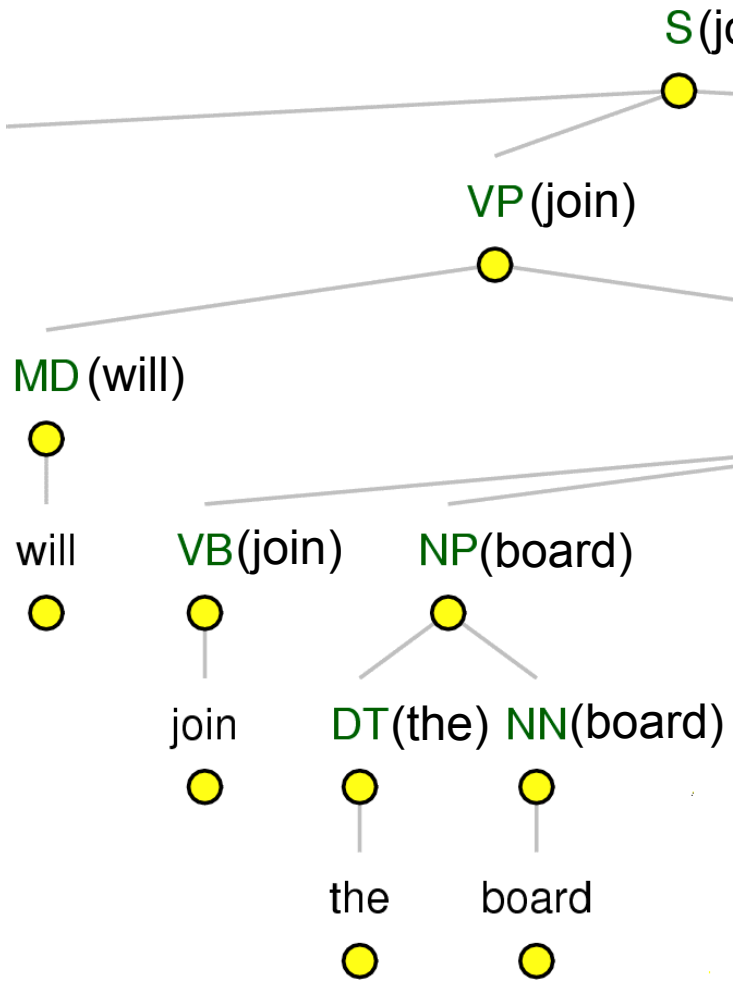
Human Translation of WSJ Texts

- 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 - “literal” translation preferred
- The numbers:
  - English tokens: 1173766
  - Documents (all of WSJ): 2312

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



- Rules:

(NP (DT NN)) → NN

(VP (VB NP)) → VB

(VP (MD VP)) → VP

(S (… VP …)) → VP

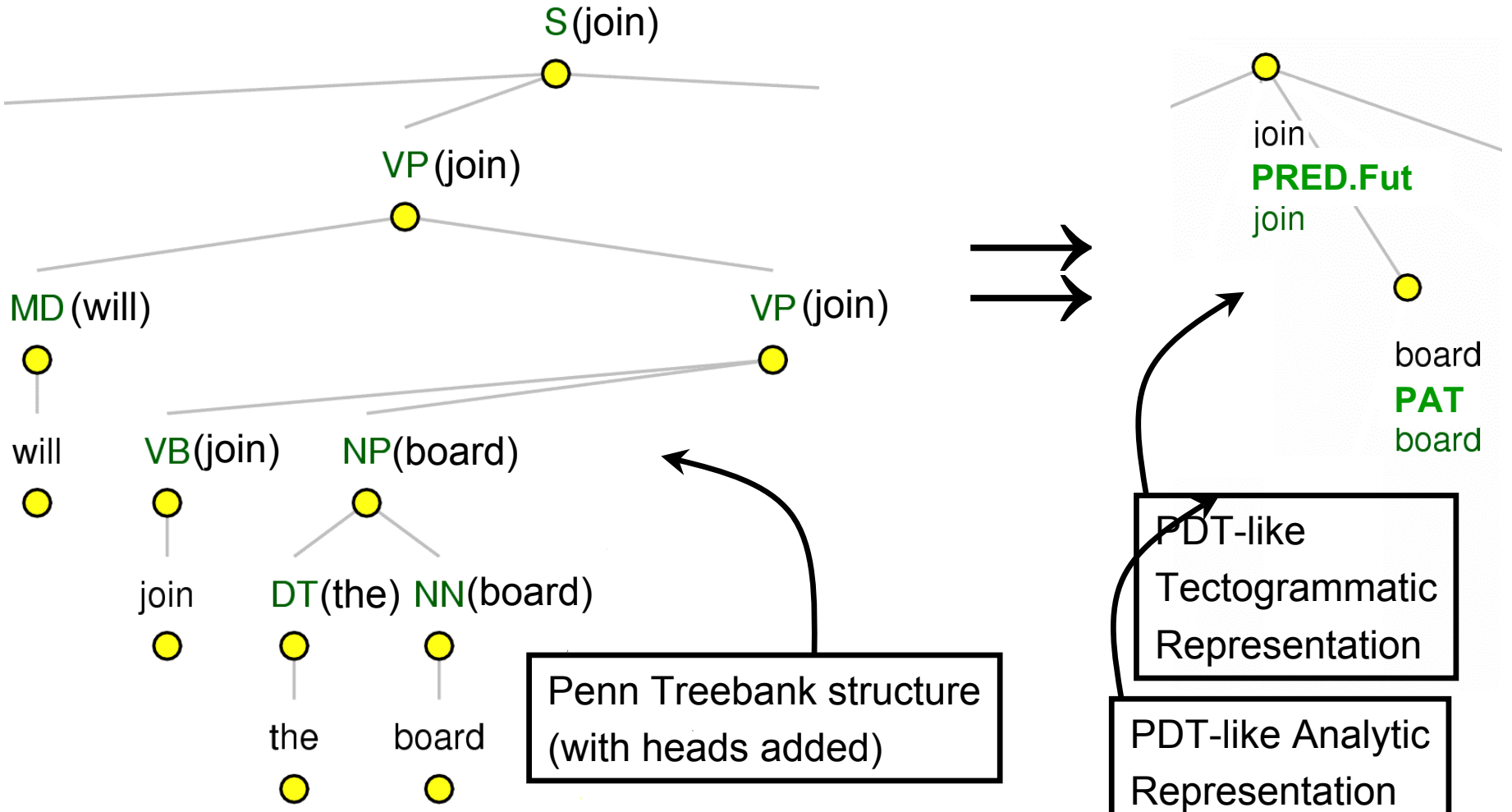
Conversion: Analytic Structure, Functions

- Syntactic Function assignment (conversion)
- Rules
  - based on functional tags:

-SBJ Sb	-PRD Pnom	-BNF Obj	-DTV Obj
-LGS Obj	-ADV Adv	-DIR Adv	-EXT Adv
-LOC Adv	-MNR Adv	-PRP Adv	-PUT Adv
-TMP Adv			

  - Ad-hoc rules (if functional tags missing)
  - Lemmatization (years → year)

Syntactic Structure, Functions: PTB to PDT



Czech PDT-style Annotation

- All layers
  - (morphology, analytic, tectogrammatical)
- So far…
  - Automatic (many tools by many authors)
- Manual annotation
  - In progress
  - Top-down
    - Tectogrammatical first (lower layers automatically)
    - … then syntactic structure and morphology

To summarize:

- PDT is/has (a)…
  - (Family of) dependency-based treebanking project(s)
    - Czech (English, Arabic, ...)
  - ~ 1mil. words
    - sufficient size for ML experiments
  - 4 interlinked layers of annotation
    - token, morphology, syntax, **deep syntax/semantics++**)
    - independent and “full” information at all levels
    - interlinked (for the development of parsers/generators)
  - Parallel corpus Cze <-> Eng -> *Machine Translation*

Some pointers

- Current version of PDT: v2.0, LDC2006T01
  - http://ufal.mff.cuni.cz/pdt2.0
- http://ufal.mff.cuni.cz
  - Research -> Corpora (Treebanks)
- http://www.ldc.upenn.edu
  - LDC2001T10 (PDT v1.0), LDC2004T23 (PADT 1.0), LDC2004T25 (PCEDT 1.0), LDC2006T01 (PDT 2.0)
- http://ufal.mff.cuni.cz/pedt
  - Penn Treebank in PDT style annotation (1/3)