

The Universe of Dependencies: Past and Future



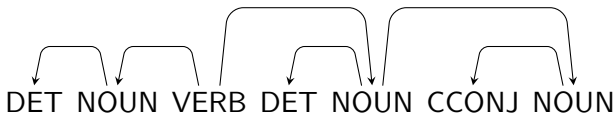
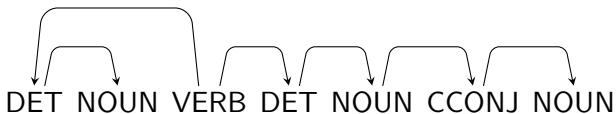
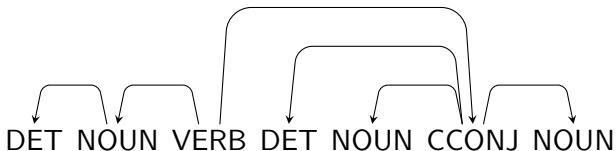
FACULTY
OF MATHEMATICS
AND PHYSICS
Charles University

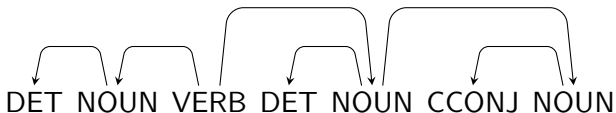
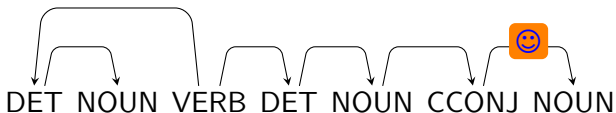
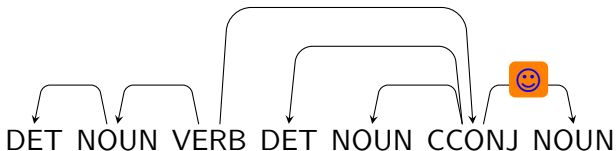


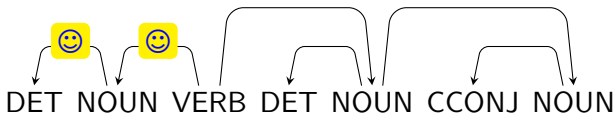
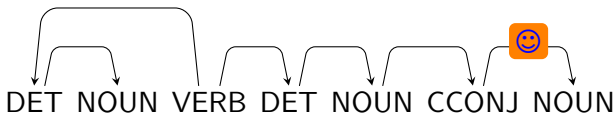
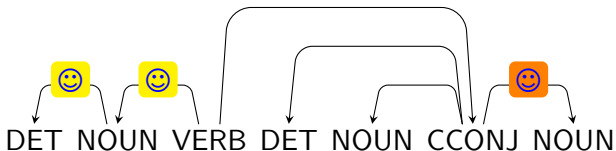
Daniel Zeman

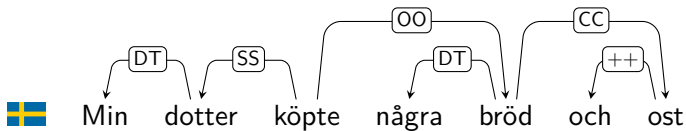
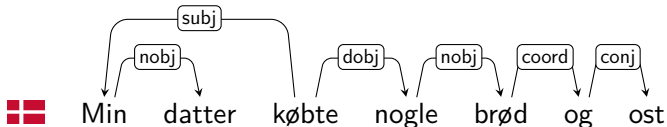
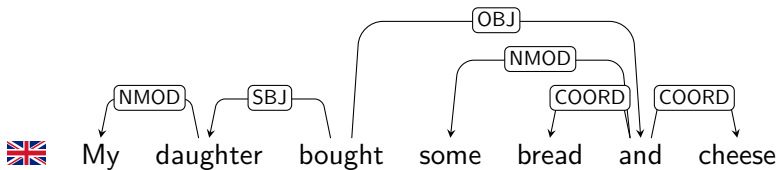
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<http://universaldependencies.org/>









Universal Dependencies

<http://universaldependencies.org/>

Milestones:

- 2008-05 Intersect (morphological features)
- 2012-05 Google Universal POS tags
- 2012-05 HamleDT (harmonized Prague-style treebanks)
- 2013-08 Google Universal Dependency Treebank
- 2014-05 Universal Stanford Dependencies
- 2014-04 EACL Göteborg, **kick-off meeting of UD**
- 2014-10 UD guidelines version 1
- 2015-01 released first 10 treebanks
- every ~6 months new release
- 2016-12 **UD guidelines version 2**

Goals and Requirements

- Cross-linguistically consistent grammatical annotation

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- Caveats:
 - ▶ Not a new linguistic theory – but linguistically informed and relevant
 - ▶ Not an ideal parsing representation – but useful for comparative evaluation
 - ▶ Not the ultimate annotation scheme – but a lightweight **lingua franca**



Not
"Universal"
in the strictly
typological
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Design Principles

- Dependency
 - ▶ Widely used in practical NLP systems
 - ▶ Available in treebanks for many languages

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- Recoverability
 - ▶ Transparent mapping from input text to word segmentation

Golden Rules

- Maximize parallelism
 - ▶ Don't annotate the same thing in different ways
 - ▶ Don't make different things look the same

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- Maximize parallelism
 - ▶ Don't annotate the same thing in different ways
 - ▶ Don't make different things look the same
- But don't overdo it
 - ▶ Balance: is it still the same thing?
 - ▶ Don't annotate things that are not there
 - ▶ Allow **language-specific** extensions

Morphology

Některé	dívky	si	nicméně	pochvalovaly	zmrzlinu	.
<i>Some</i>	<i>girls</i>		<i>nevertheless</i>	<i>praised</i>	<i>ice-cream</i>	.

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- Lemma representing the semantic content of the word

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DET	NOUN	PRON	CCONJ	VERB	NOUN	PUNCT

- Lemma representing the semantic content of the word
- Part-of-speech tag representing the abstract lexical category associated with the word

Morphology

Některé <i>Some</i>	dívky <i>girls</i>	si	nicméně <i>nevertheless</i>	pochvalovaly <i>praised</i>	zmrzlinu <i>ice-cream</i>	.
některý DET	dívka NOUN	se PRON	nicméně CCONJ	pochvalovat VERB	zmrzlina NOUN	.
PronType=Ind Gender=Fem Number=Plur Case=Nom	Gender=Fem Number=Plur Case=Nom	PronType=Prs Reflex=Yes Case=Dat		VerbForm=Part Tense=Past Voice=Act Aspect=Imp Gender=Fem Number=Plur	Gender=Fem Number=Sing Case=Acc	

- Lemma representing the semantic content of the word
- Part-of-speech tag representing the abstract lexical category associated with the word
- Features representing lexical and grammatical properties associated with the lemma or the particular word form

Part-of-Speech Tags

Open

ADJ

ADV

INTJ

NOUN

PROPN

VERB

Closed

ADP

AUX

CCONJ

DET

NUM

PART

PRON

SCONJ

Other

PUNCT

SYM

X

- Taxonomy of 17 universal part-of-speech tags, based on the Google Universal Tagset (Petrov et al., 2012)
- All languages use the same inventory, but not all tags have to be used by all languages

Features v1

Lexical

PronType

NumType

Poss

Reflect

Inflectional (Nominal)

Gender

Animacy

Number

Case

Definite

Degree

Inflectional (Verbal)

VerbForm

Mood

Tense

Aspect

Voice

Person

Negative

- Standardized inventory of morphological features, based on Intersect (Zeman, 2008)
- Languages select relevant features and can add language-specific features or values with documentation

Features v2

Lexical

PronType

NumType

Poss

Reflect

Foreign

Abbr

Inflectional (Nominal)

Gender

Animacy

Number

Case

Definite

Degree

Inflectional (Verbal)

VerbForm

Mood

Tense

Aspect

Voice

Evident

Person

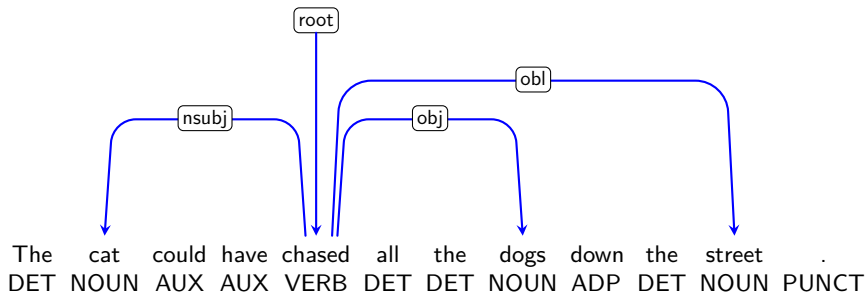
Polite

Polarity

Syntax

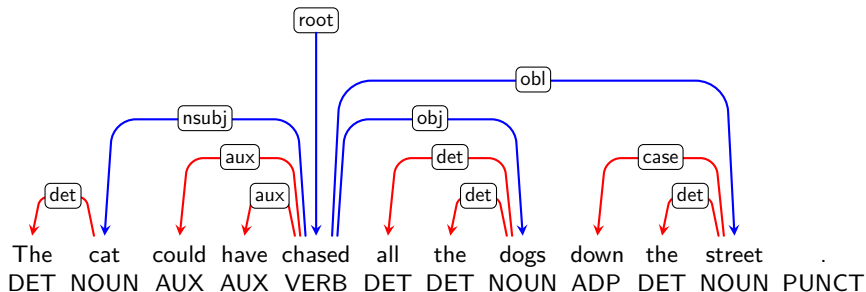
The cat could have chased all the dogs down the street .
DET NOUN AUX AUX VERB DET DET NOUN ADP DET NOUN PUNCT

Syntax

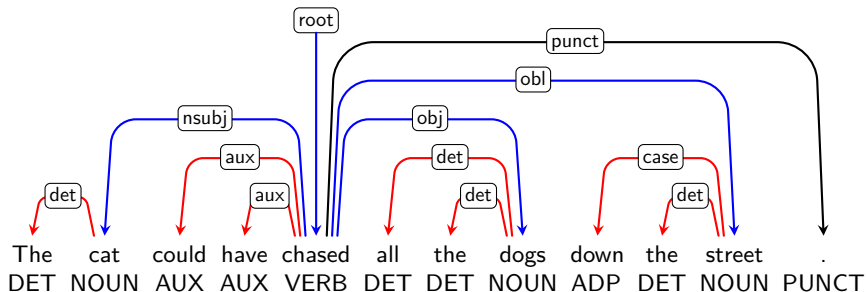


- Content words are related by dependency relations

Syntax

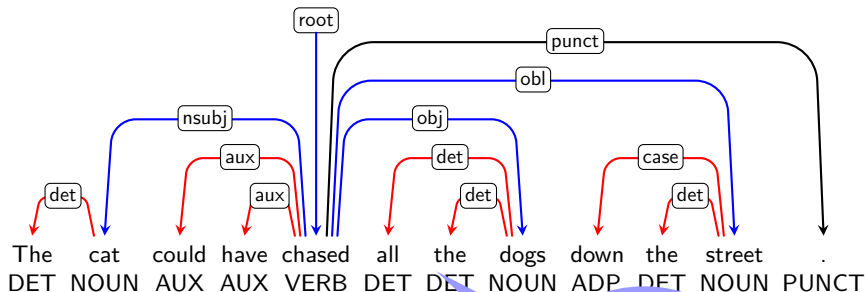


- Content words are related by dependency relations
- Function words attach to closest content words

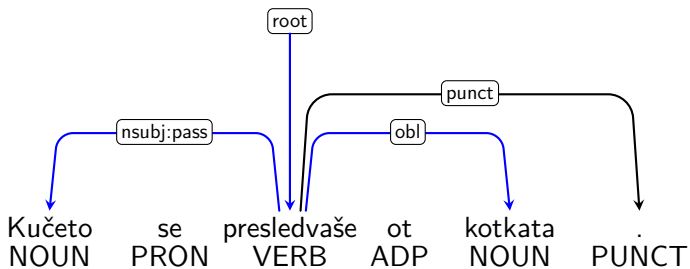
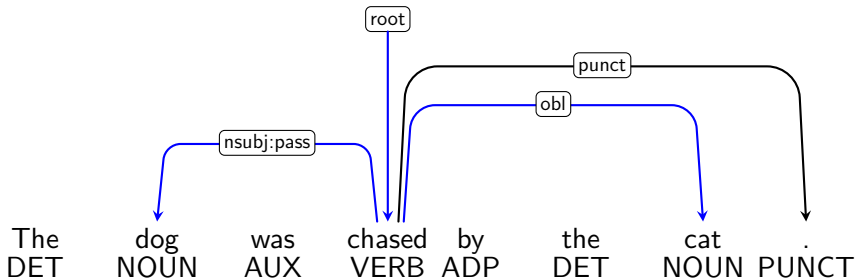


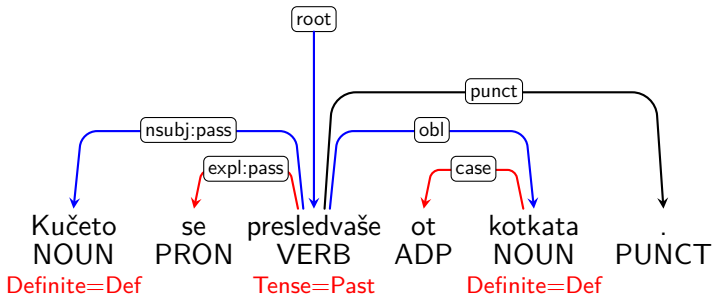
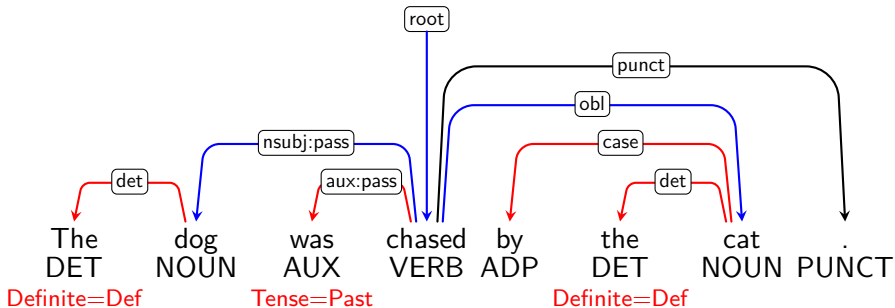
- Content words are related by dependency relations
- Function words attach to closest content words
- Punctuation attach to head of phrase or clause

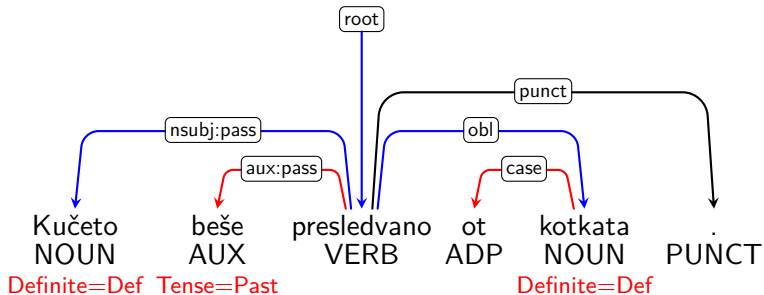
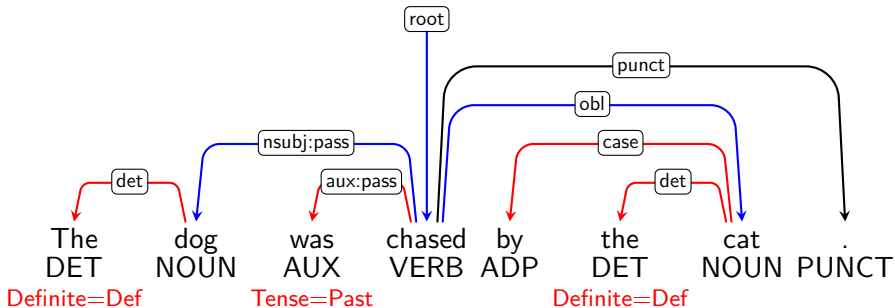
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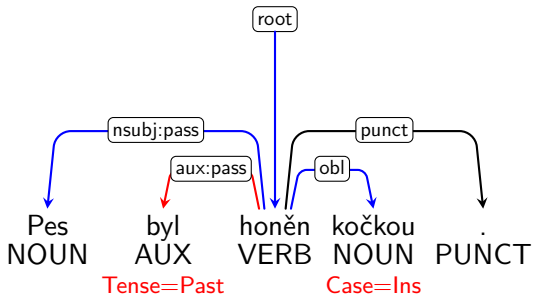
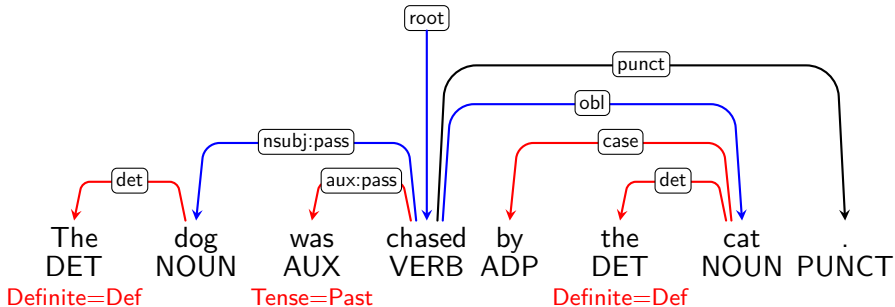


Not
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Dependency Relations

- Taxonomy of 38 (40) universal grammatical relations, broadly attested in language typology (de Marneffe et al., 2014)
 - ▶ Language-specific **subtypes** may be added

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- Taxonomy of 38 (40) universal grammatical relations, broadly attested in language typology (de Marneffe et al., 2014)
 - ▶ Language-specific **subtypes** may be added
- Organizing principles
 - ▶ Three types of structures: nominals, clauses, modifiers
 - ▶ **Core** arguments vs. other dependents (**not** arguments vs. adjuncts)

Dependents of Clausal Predicates

	Nominal	Clausal	Other
Core	<i>nsubj</i> <i>(nsubj:pass)</i> <i>(d)obj</i> <i>iobj</i>	<i>csubj</i> <i>(csubj:pass)</i> <i>ccomp</i> <i>xcomp</i>	
Non-Core	<i>obl (nmod)</i> <i>vocative</i> <i>discourse</i> <i>expl</i>	<i>advcl</i>	<i>advmod</i> <i>(neg)</i> <i>aux</i> <i>(aux:pass)</i> <i>cop</i> <i>mark</i> <i>punct</i>

Dependents of Nominals

Nominal

nmod

appos

nummod

clf (classif?)

Clausal

acl

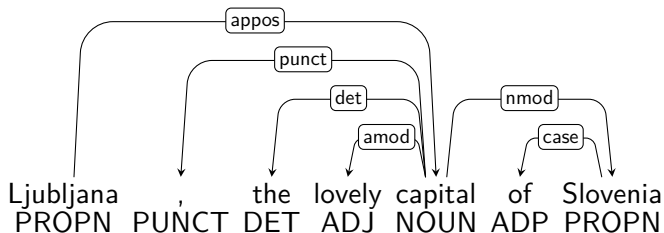
Other

amod

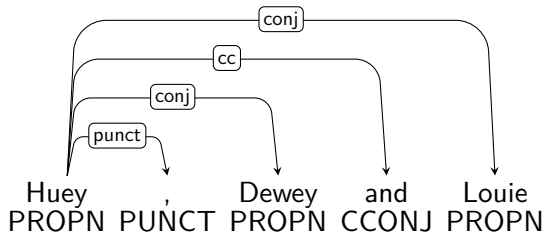
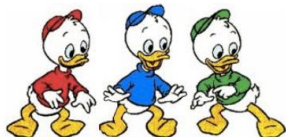
det

(neg)

case

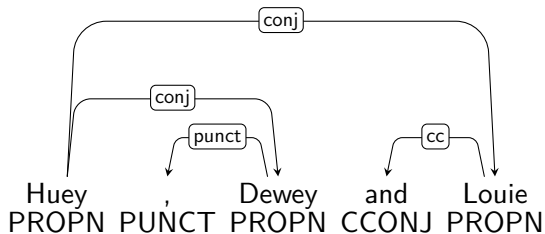
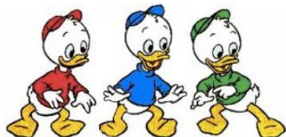


“Stanford-style” Coordination in V1 ...



- Coordinate structures are headed by the first conjunct
 - ▶ Subsequent conjuncts depend on it via the **conj** relation
 - ▶ Conjunctions depend on it via the **cc** relation
 - ▶ Punctuation marks depend on it via the **punct** relation

... slightly modified in V2



- Coordinate structures are headed by the first conjunct
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Multiword Expressions

Relation	Examples
<i>fixed</i> (mwe)	<i>in spite of, as well as, ad hoc</i>
<i>flat</i> (name)	<i>president Havel, New York, four thousand</i>
<i>compound</i>	<i>phone book, dress up</i>
<i>goeswith</i>	<i>notwith standing, with out</i>

- UD annotation **almost** does not permit “words with spaces”
 - ▶ Multiword expressions are analyzed using special relations
 - ▶ The **fixed**, **flat** and **goeswith** relations are always head-initial
 - ▶ The **compound** relation reflects the internal structure
- Words with spaces may be allowed in v2:
 - ▶ Vietnamese (spaces delimit syllables, not words)
 - ▶ Numbers (“1 000 000”)
 - ▶ Possibly other approved cases, e.g. multi-word abbreviations

Other Relations

Relation	Explanation
<i>parataxis</i>	<i>Loosely linked clauses of same rank</i>
<i>list</i>	<i>Lists without syntactic structure</i>
<i>orphan</i>	<i>Orphans in ellipsis linked together</i>
<i>(remnant)</i>	<i>Orphans in ellipsis linked to parallel elements</i>
<i>reparandum</i>	<i>Disfluency linked to (speech) repair</i>
<i>foreign</i>	<i>Elements within opaque stretches of code switching</i>
<i>dep</i>	<i>Unspecified dependency</i>
<i>root</i>	<i>Syntactically independent element of clause/phrase</i>

Language-Specific Relations

- Language-specific relations are **subtypes** of universal relations added to capture important phenomena
- Subtyping permits us to “back off” to universal relations

Language-Specific Relations

Relation	Explanation
<i>acl:relcl</i>	<i>Relative clause</i>
<i>compound:prt</i>	<i>Verb particle (dress up)</i>
<i>nmod:poss</i>	<i>Possessive nominal (Mary 's book)</i>
<i>obl:agent</i>	<i>Agent in passive (saved by the bell)</i>
<i>cc:preconj</i>	<i>Preconjunction (both ... and)</i>
<i>det:predet</i>	<i>Predeterminer (all those ...)</i>

Word Segmentation

- Must be **reproducible** on new data
- Surface tokens vs. syntactic words
- Chinese, Vietnamese etc.: no clues, non-trivial algorithm
- Arabic, Tamil etc.: part of morphological analysis
- Spanish, German etc.: rather limited cases of contractions
- Others: only punctuation (low-level tokenization)

Word Segmentation

Vamos nos a el mar .
VERB PRON ADP DET NOUN PUNCT

Vámonos al mar .
VERB+PRON ADP+DET NOUN PUNCT

Word Segmentation

- Fusions

- ▶ $al = a + el$
- ▶ $naň = na + něj$

- Clitics

- ▶ $vámonos = vamos + nos$
- ▶ $izmenjat'sja = izmenjat' + sja$
- ▶ $potrafilibyšmy = potrafilo + by + jestešmy$

UD Version 2

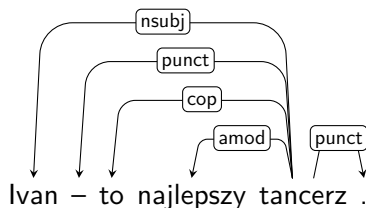
- Words with spaces
- POS tags (CONJ → CCONJ, redefined AUX, PART, PRON/DET)
- Morphological features (new features, new values, some renamed)
- Predicate dependents: dobj/obj, nmod/obl
 - ▶ nsubj:pass, csubj:pass, aux:pass made subtypes
- **Nonverbal predicates (copula)**
- Coordination and ellipsis
- Functional relations
 - ▶ New relation clf (classifier)
 - ▶ aux not only for verbs
 - ▶ Removed relation neg (use features instead)
- Multiword expressions
 - ▶ mwe renamed fixed, name removed, flat added instead (covers more)
 - ▶ compound extended to complex predicates (light verbs, serial verbs)

Nonverbal Predicate and Copula

- Some languages use a copula verb:



- Some languages use a copula **pronoun**:

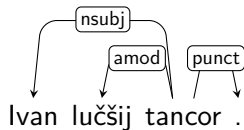


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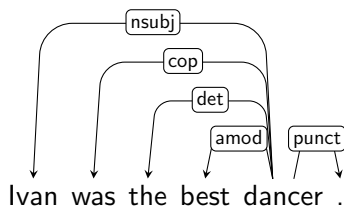


- Some languages **omit the copula**:

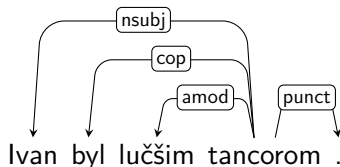


Nonverbal Predicate and Copula

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- Some languages use it **only in some tenses**:

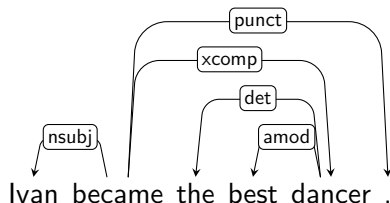


Copula Verbs: We Are Restrictive!

- *To be* is copula:



- *To become* is not copula:

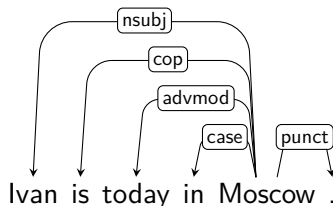


Once Copula, Always Copula!

- This is parallel with Russian:

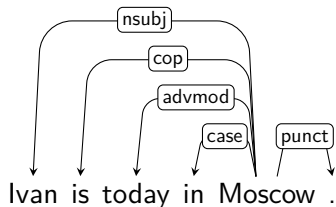


- This is also parallel with Russian:

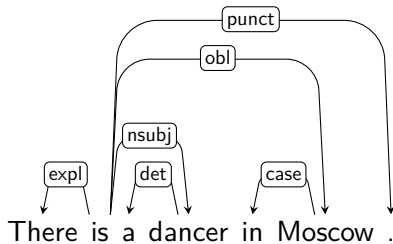


Well, Almost...

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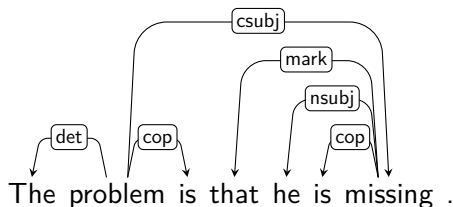


- But not with this in English:

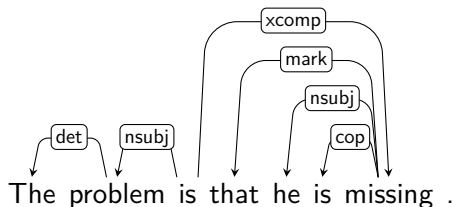


Clauses and Copula

- A clause can be the subject:



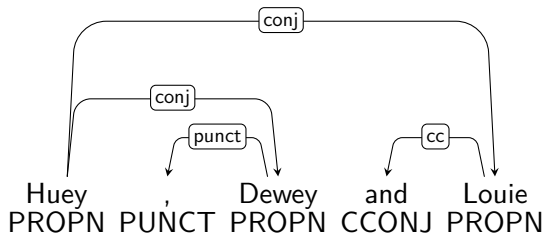
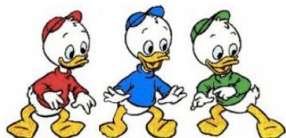
- But it cannot be annotated as the nonverbal predicate:



UD Version 2

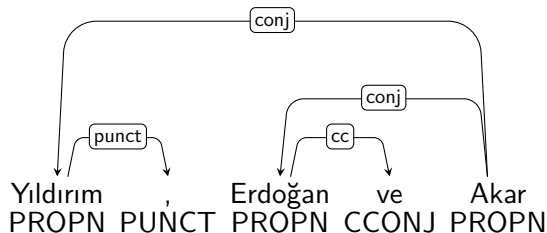
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V2 Coordination Is Still Left-Headed



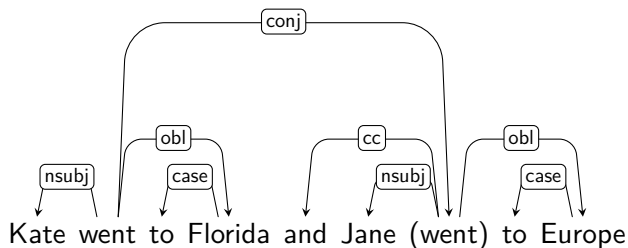
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But Some Languages Might Prefer the Opposite



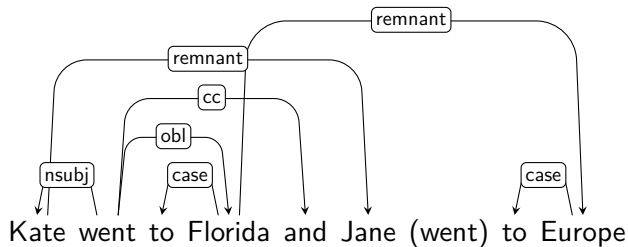
- Coordinate structures would be headed by the last conjunct
 - ▶ Preceding conjuncts would depend on it via the **conj** relation
 - ▶ Conjunctions would depend on the preceding conjunct
 - ▶ Punctuation marks would depend on the preceding conjunct

Deleted Predicates in Coordination

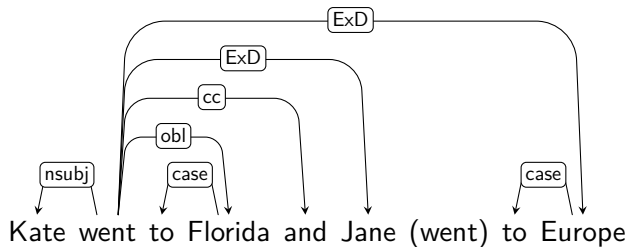


- Some treebanks would use an **empty node** to represent the second *went*.
- UD **enhanced representation** now allows empty nodes!
- But the basic representation sticks with the overt words.

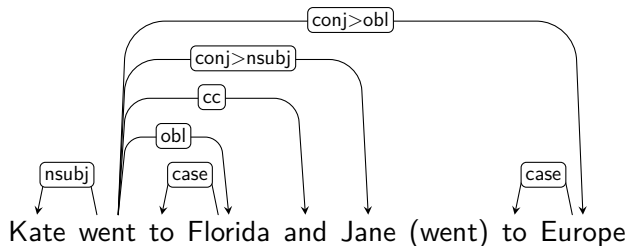
UD V1: The remnant Relation



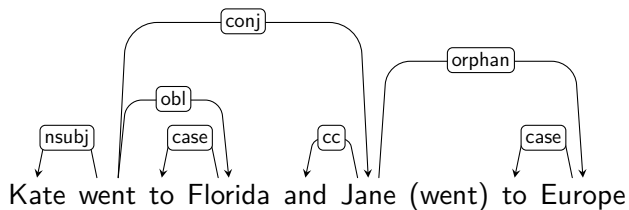
PDT: The ExD Relation



Perseus Treebanks: Chained Relations



UD V2: The orphan Relation



Where Are We Now?



Where Are We Now?

- Two years of UD version 1
- 5 treebank releases (every 6 months)
- 64 treebanks
- 47 languages (over 50% world's population)
- Over 12M tokens; treebanks range from <1K to 1.5M
- Over 140 contributors
 - ▶ language group consistency SIGs
- Version 2 guidelines to be **launched this week**
- CoNLL Shared Task in parsing UD coming next year

47 Languages and Growing

▶		Ancient Greek-PROIEL	206K	LF	-	☰	▶		Irish	23K	LF	📄	☰
▶		Arabic	242K	LF	-	☰	▶		Italian	252K	LF	📄	☰
▶		Basque	121K	LF	📄	☰	▶		Japanese-KTC	267K	L	📄	☰
▶		Bulgarian	156K	LF	📄	☰	▶		Kazakh	4K	L	📄	👤
▶		Buryat	5K	L	-	👤	▶		Korean	-	-	-	-
▶		Catalan	530K	LF	📄	☰	▶		Latin	47K	LF	-	☰
▶		Chinese	123K	F	📄	☰	▶		Latin-ITTB	291K	LF	-	☰
▶		Coptic	4K	L	📄	👤	▶		Latin-PROIEL	165K	LF	-	☰
▶		Croatian	87K	LF	-	☰	▶		Latvian	20K	LF	-	☰
▶		Czech	1,503K	LF	📄	☰	▶		Norwegian	311K	LF	📄	☰
▶		Czech-CAC	493K	LF	📄	☰	▶		Old Church Slavonic	57K	LF	-	☰
▶		Czech-CLTT	35K	LF	📄	☰	▶		Persian	151K	F	📄	☰
▶		Danish	100K	LF	📄	☰	▶		Polish	83K	LF	-	☰
▶		Dutch	209K	LF	-	☰	▶		Portuguese	209K	LF	-	☰
▶		Dutch-LassySmall	98K	LF	-	☰	▶		Portuguese-BR	298K	F	-	☰
▶		English	254K	LF	📄	👤	▶		Romanian	145K	LF	📄	☰
▶		English-ESL	97K	L	📄	👤	▶		Russian	99K	F	📄	☰
▶		English-LinES	82K	-	📄	☰	▶		Russian-SynTagRus	1,032K	LF	📄	☰
▶		Estonian	234K	LF	-	☰	▶		Sanskrit	1K	LF	-	☰
▶		Faroese	119K	F	-	☰	▶		Slovenian	140K	LF	📄	☰
▶		Finnish	181K	LF	📄	☰	▶		Slovenian-SST	29K	LF	📄	👤
▶		Finnish-FTB	159K	LF	-	☰	▶		Spanish	423K	LF	📄	☰
▶		French	390K	LF	📄	☰	▶		Spanish-AnCora	547K	LF	📄	☰
▶		Galician	138K	L	📄	☰	▶		Swedish	96K	LF	📄	☰
▶		German	293K	LF	-	☰	▶		Swedish-LinES	79K	-	📄	☰
▶		Gothic	56K	LF	-	☰	▶		Tamil	8K	LF	-	☰
▶		Greek	59K	LF	📄	☰	▶		Turkish	56K	LF	📄	☰
▶		Hebrew	115K	F	-	☰	▶		Ukrainian	-	-	-	☰
▶		Hindi	351K	LF	-	☰	▶		Urdu	-	-	-	☰
▶		Hungarian	42K	LF	📄	👤	▶		Uyghur	45K	F	-	☰
▶		Indonesian	121K	-	-	☰	▶		Vietnamese	43K	L	-	☰

Where Are We Going?

- Launching UD version 2
- Treebanks v2 release in February/March (CoNLL Shared Task!)
- CoNLL Shared Task in parsing UD coming next year
- Consistency checking

- Common vocabulary is great ...

- Common vocabulary is great ...
- ... because we finally understand each other ...



... almost














*Childs of you be
vary acute!*



Consistency Checking

- Automatic tests catch only a fraction
- Focus groups on
 - ▶ Romance, Germanic, **Slavic**, Uralic, Turkic languages

Existing Slavic Treebanks

Language	Code	Treebank	Sent	Tok
Bulgarian 	[bg]	BulTreeBank	13,221	196K
Church Slavonic	[cu]	PROIEL	7,818	72K
Croatian 	[hr]	SETimes.HR	6,289	139K
Croatian 	[hr]	HOBS	4,626	117K
Czech 	[cs]	PDT	87,913	1504K
Czech 	[cs]	CAC	24,709	494K
Czech 	[cs]	CLTT	1,125	35K
Polish 	[pl]	IPI PAN	8,227	84K
Russian 	[ru]	SynTagRus	60,551	1068K
Russian 	[ru]	Google	5,030	99K
Slovak 	[sk]	SNK	63,238	994K
Slovenian 	[sl]	SSJ500K	27,829	500K
Slovenian 	[sl]	SST	3,188	29K
Ukrainian 	[uk]	UDT	255	2K

Pronouns and Determiners

- English + Romance languages: **DET** = article or pronominal adjective
this, which, every

Pronouns and Determiners

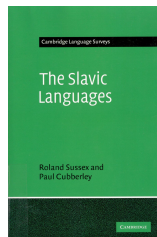
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this, which, every
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Pronouns and Determiners

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Pronouns and Determiners

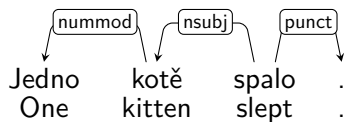
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- Some authors do recognize determiners in Slavic!



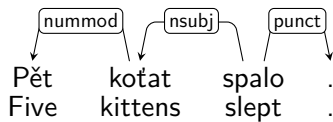
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- We have the words (except for articles).
- Some authors do recognize determiners in Slavic!
- UD v1: functional borderline (but ellipsis?)
 - ▶ *This.DET car is expensive.*
 - ▶ *This.PRON is expensive.*
- Less strict in UD v2.

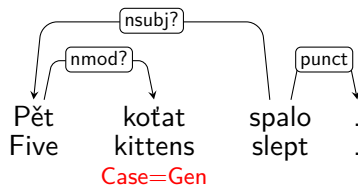
Quantified Noun Phrase



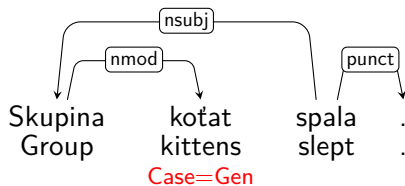
Quantified Noun Phrase



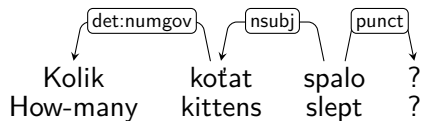
Quantified Noun Phrase



Quantified Noun Phrase



Quantified Noun Phrase



Language-Specific Labels

	Numeric	Pronominal
Noun governs	nummod	det:nummod
Numeral governs	nummod:gov	det:numgov

Verb Forms

- Conflicting terminologies in traditional grammars
- Participle ... verb or adjective?
- Converb ... verb or adverb?

- Tags and features apply to **individual words!**

Verb Forms

- POS tags and features apply to individual words!
- A *ko so se leta 1942 vračali, ...*
 - ▶ past tense

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Verb Forms

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- *A ko **so se** leta 1942 **vračali**, ...*
 - ▶ past tense
- *... da ne **bi** v Atene **prišli** ...*
 - ▶ conditional mood
- *... v prihodnje ne **bodo vozili** zgolj les ...*
 - ▶ future tense

Verb Forms

- *vračali, prišli, vozili*

cs “active participle” / “past tense”

ru “past tense” / “finite!”

- ▶ Active participle is something else: *narušivšij*

bg “participle + past (aorist) / imperfect” (two subtypes)

cu “participle + resultative aspect” (lang-spec)

- “l-participle”

- ▶ But that would be a language-specific verb form.

Core Arguments

- Easier cross-linguistically than argument-adjunct?
- **S**ubject of intransitive verb
- **A**gent of transitive verb
- **P**atient (direct object) of transitive verb

- Indirect object? Dative only?

Core vs. Oblique Dependents

- **Core arguments:** what exactly is it?
- English:
 - ▶ *He gave **John** the book.* (iobj)
 - ▶ *He gave the book **to John**.* (obl)
- Spanish:
 - ▶ *Dio el libro **a John**.* (iobj)
- Czech:
 - ▶ Currently every Obj is translated to (d)obj, regardless the case and the presence of preposition

Direct and Indirect Object

- Not as easy as accusative vs. dative.
- Default: obj
- Heuristics for iobj
 - ▶ *Cením si vaší pomoci.* (Gen)
I appreciate your help.
 - ▶ *Čelíme velkým problémům.* (Dat)
We are facing big problems.
 - ▶ *Nedisponuje takovým rozpočtem.* (Ins)
He does not have such budget.
 - ▶ *Učí mou dceru fyziku.* (2 × Acc)
He teaches my daughter physics.

All Slavic Treebanks Have Non-Accusative (D)Objects

- *podrobit se* *testu*; odpovídají *smlouvě*; jednat *s někým*
- *mówi o niej*; używa *wielkich słów*
- *ot kotorix* zavisit; otnositsja *k programmam*
- *potrebuje informacij*; slediti *evropskim smernicam*; ukvarjal se bom *orožjem*
- *odriče se imuniteta*; priključiti se *naporima*
- *se harakterizira s razvitie*; molja *za vnimanie*

Reflexive Pronouns

- Direct or indirect object (obj, iobj):
Řízl se do prstu / Řízl ho do prstu.
 - ▶ Including reciprocal usage:
Políbili se. / They kissed each other.

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 - ▶ **expl:pv** (pronominal verb; previously compound)

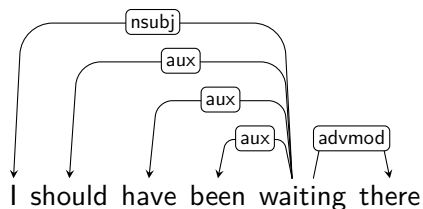
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To se snadněji řekne než udělá. / That is easier said than done.
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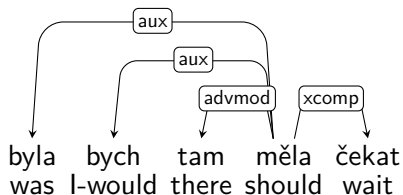
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To se snadněji řekne než udělá. / That is easier said than done.
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- Impersonal construction (~ passive?):
Zde se mluví německy. / German is spoken here.
 - ▶ **expl:impers**

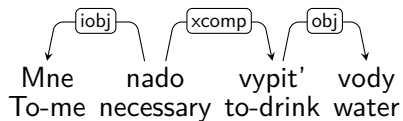
Modal Auxiliary in English



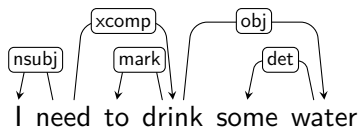
Modal Verb in Czech



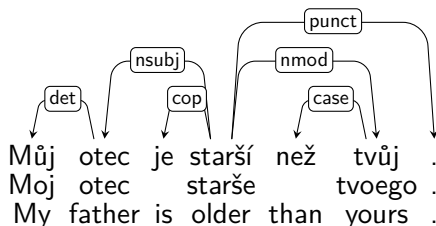
Modal Predicative in Russian



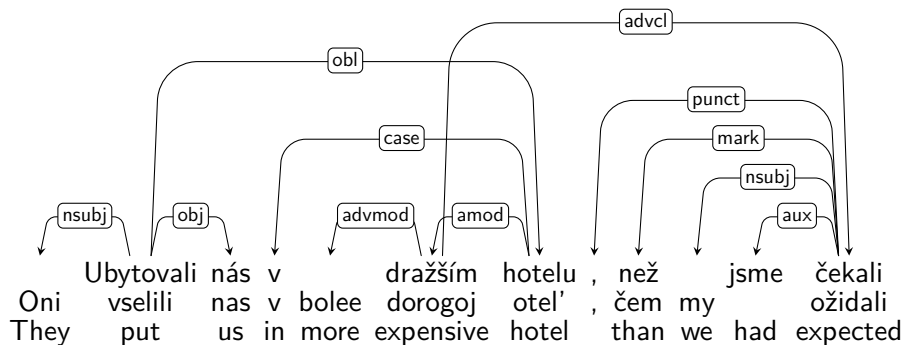
Modal / Control Verb in English



Comparative Constructions



Comparative Constructions



Wrapping Up



Wrapping Up

- UD has had a great start

Wrapping Up

- UD has had a great start
- Still a long way to go
- Consistency matters!

Wrapping Up

- UD has had a great start
- Still a long way to go
- Consistency matters!
- Get involved. It's fun!

Thank You!
Questions?