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Universal Dependencies

A Framework for Cross-Linguistically Consistent Grammatical Annotation

Joakim Nivre

Introduction

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- Computational linguistics use it for machine learning and evaluation
- Corpus linguistics use it for studying complex linguistic phenomena

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- Empirically grounded linguistic typology and comparative linguistics

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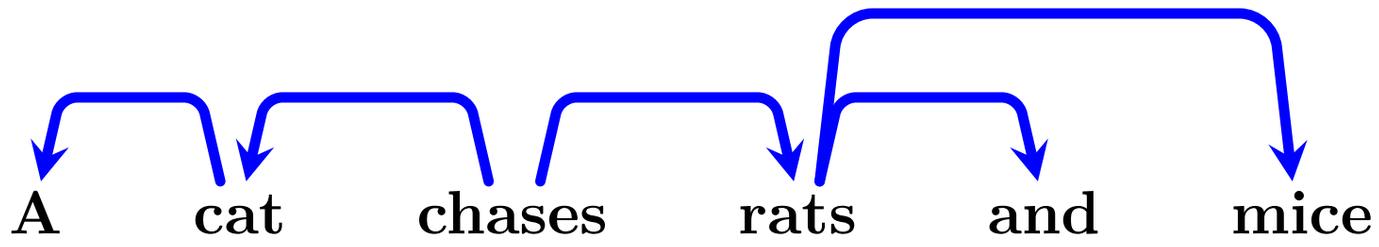
Linguistic annotation guidelines vary across languages 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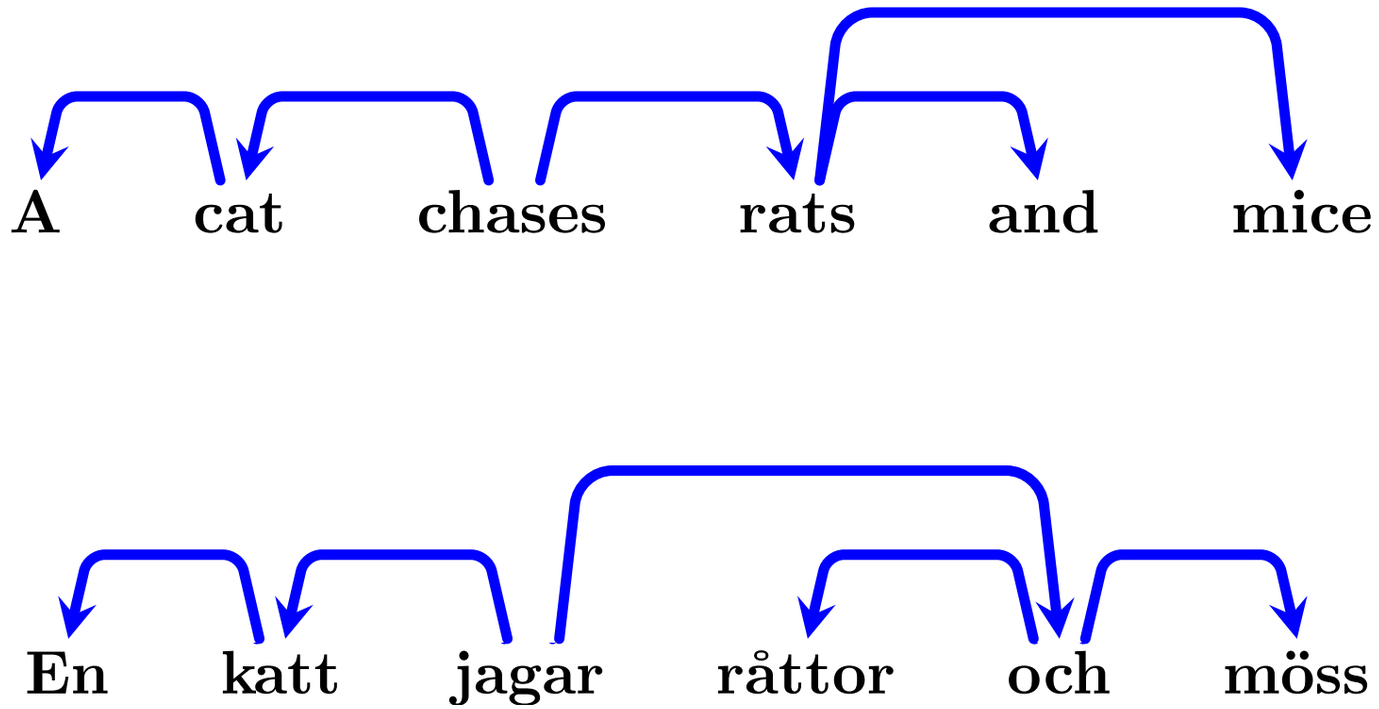
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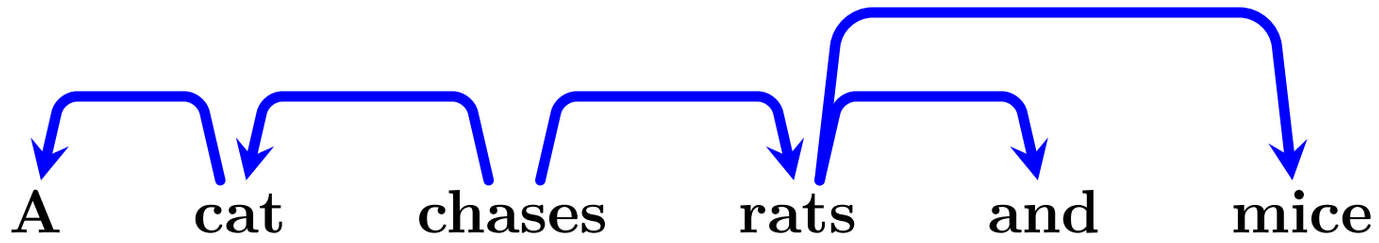
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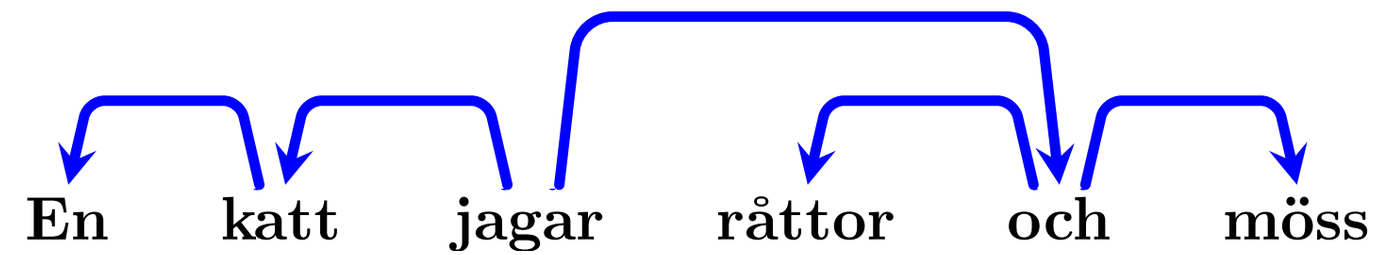
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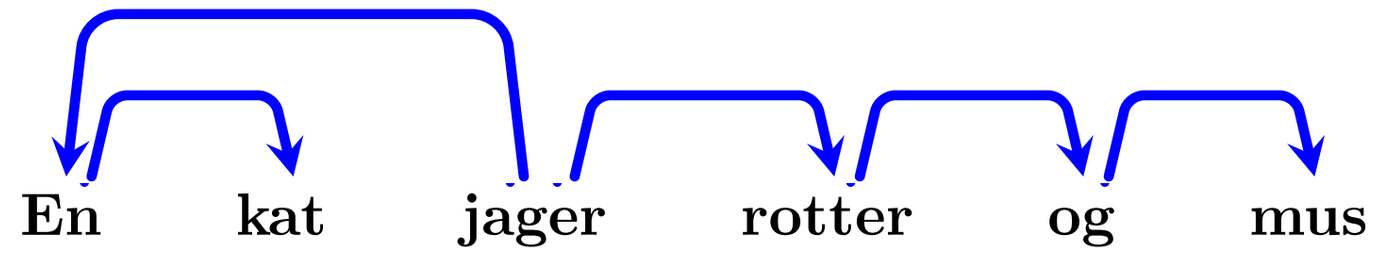
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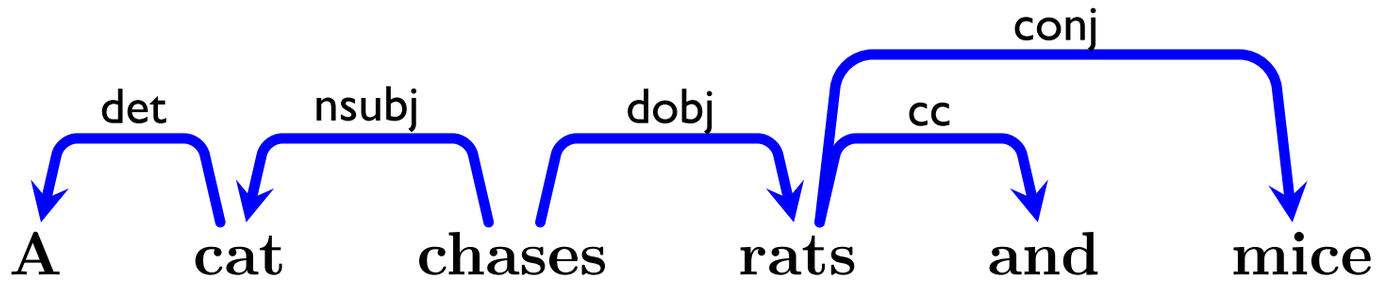
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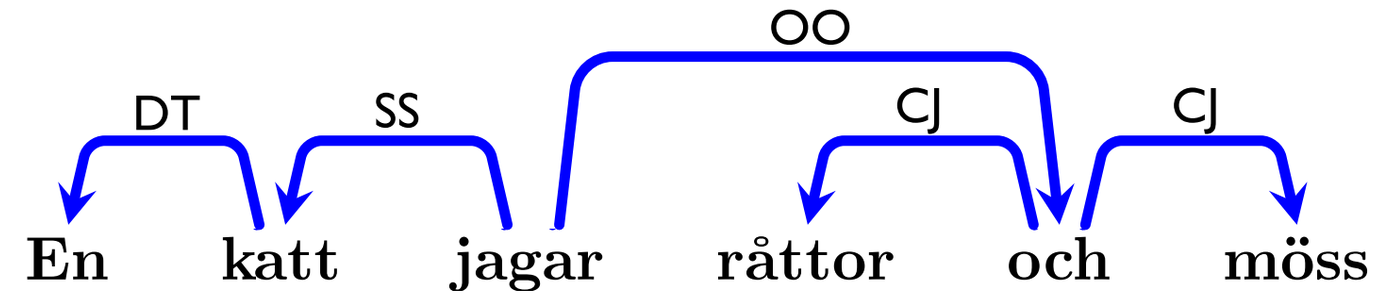
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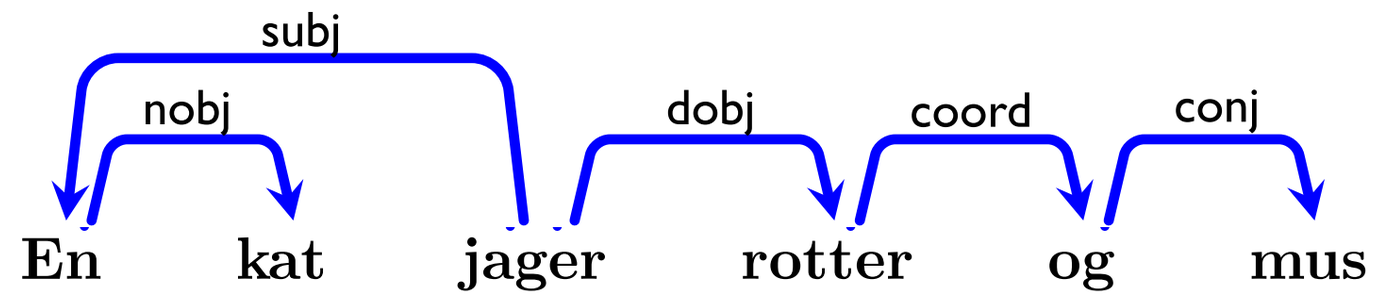
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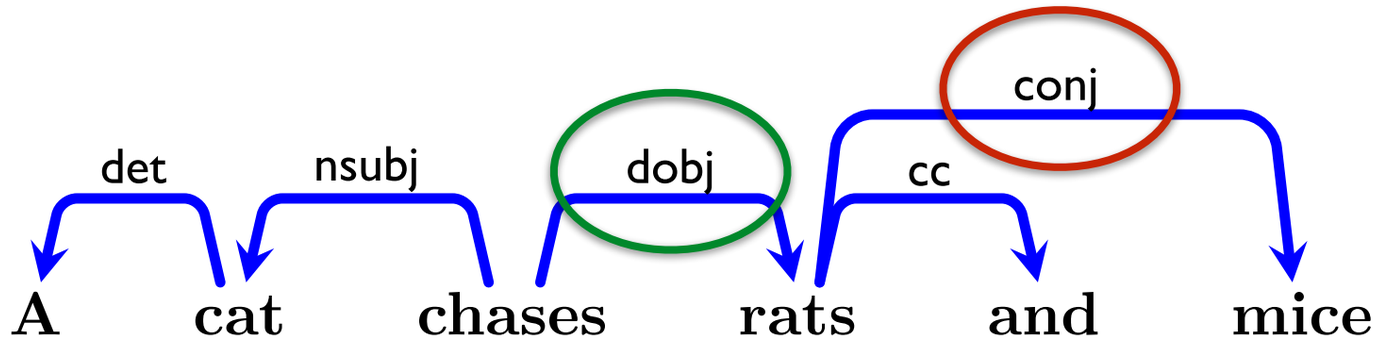
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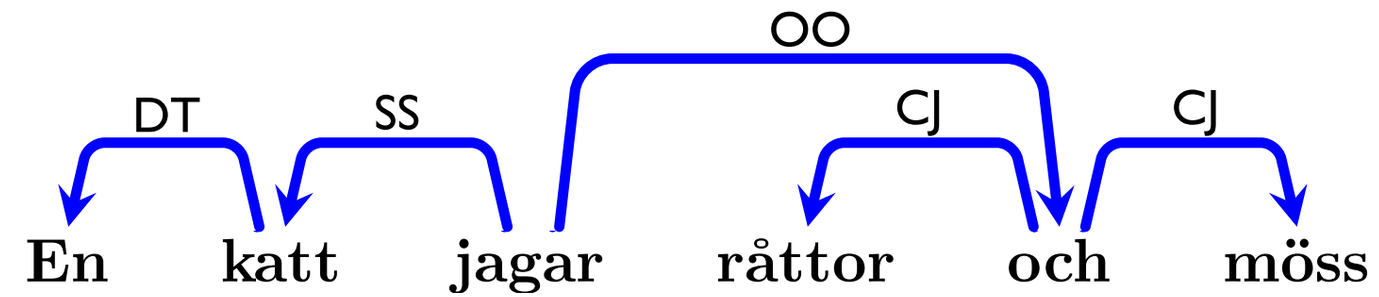
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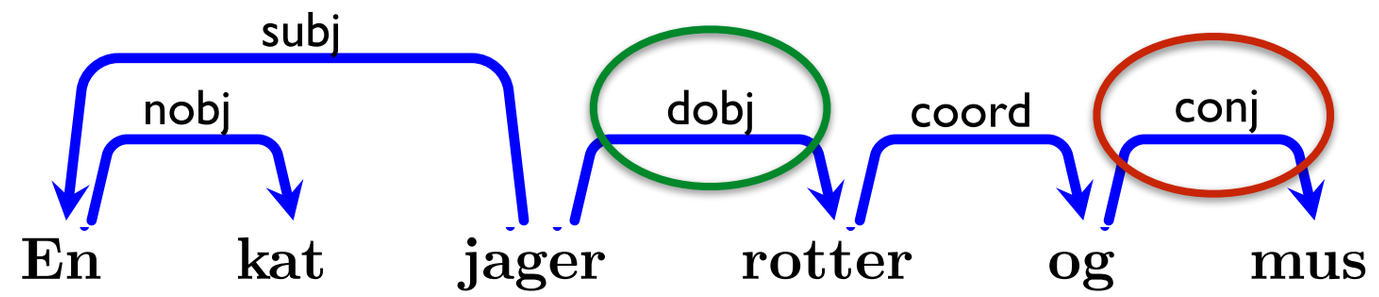
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- Hard to make progress towards a universal parser

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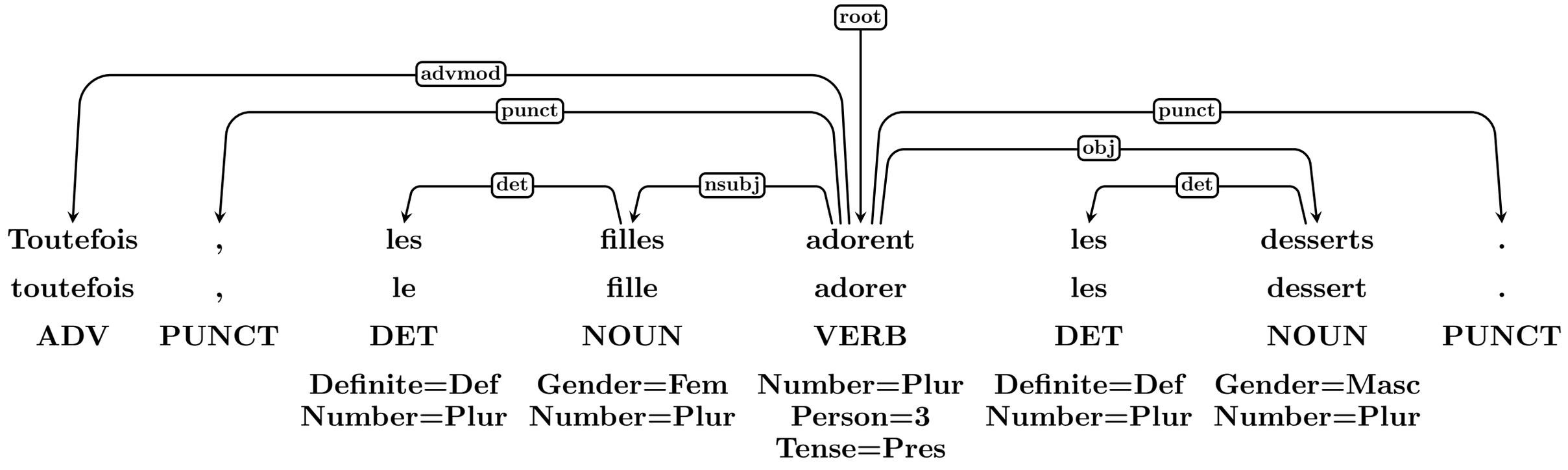

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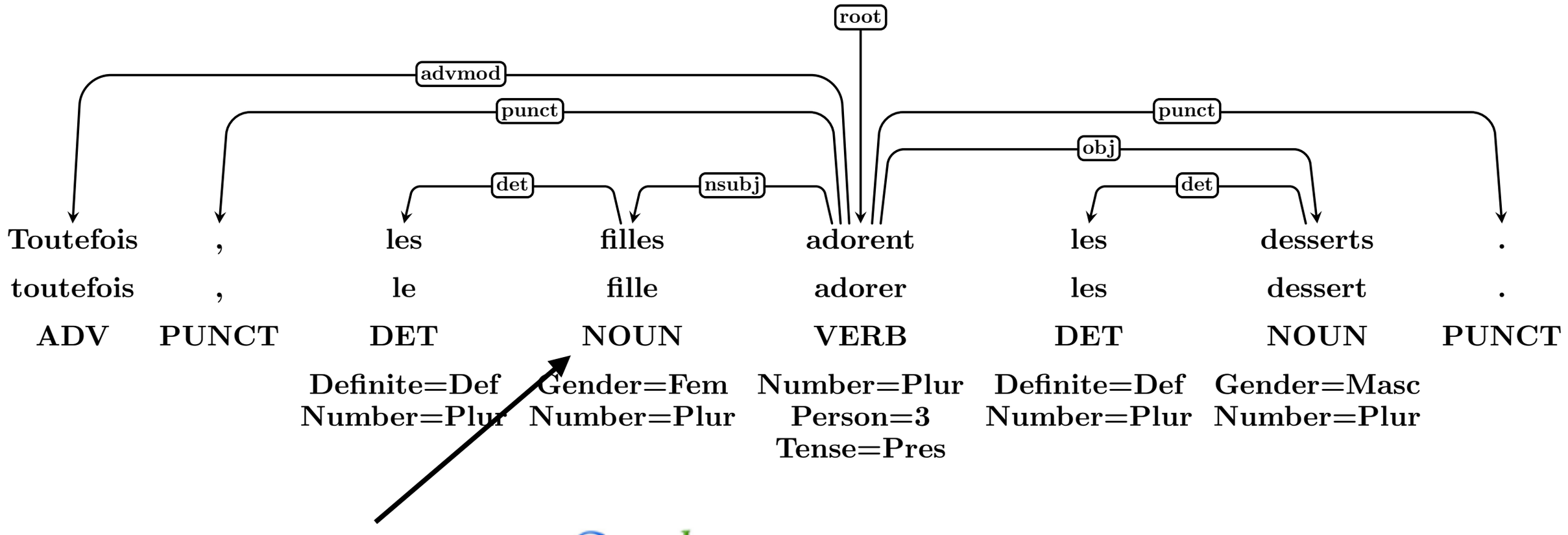

Part-of-speech tags Google

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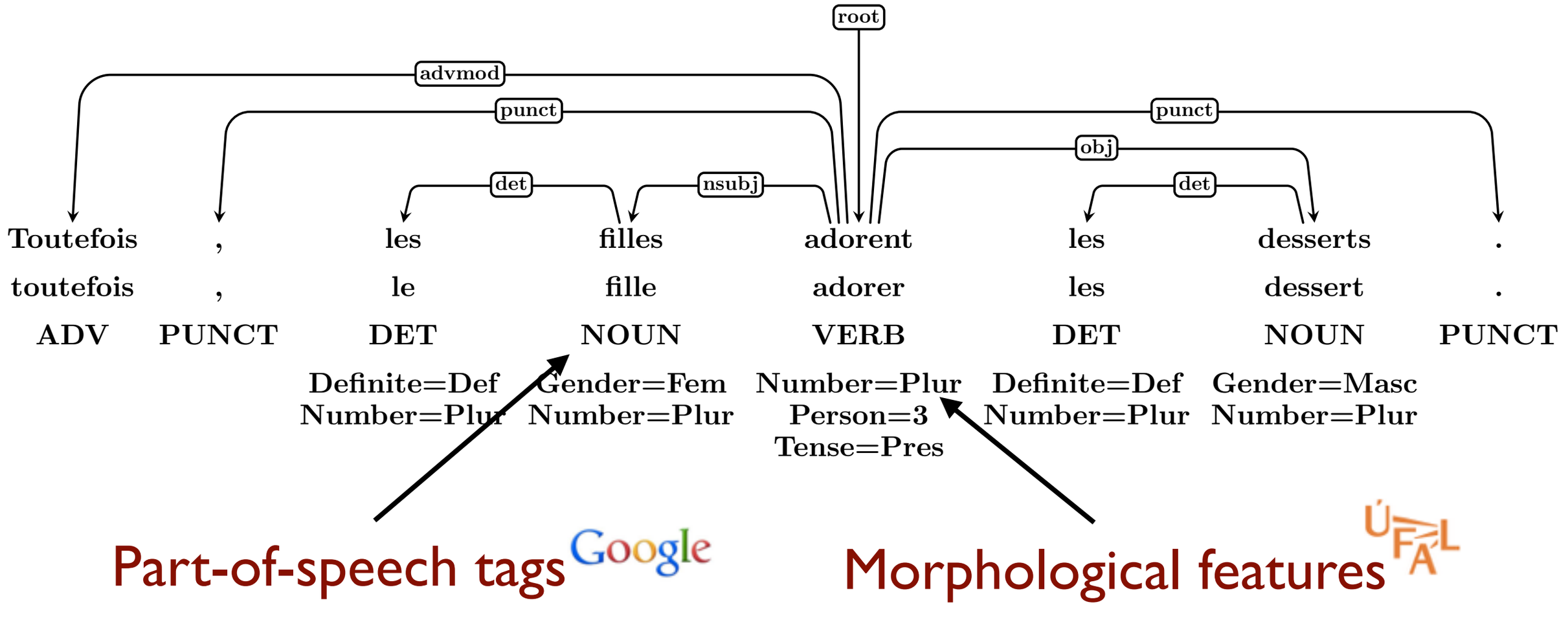

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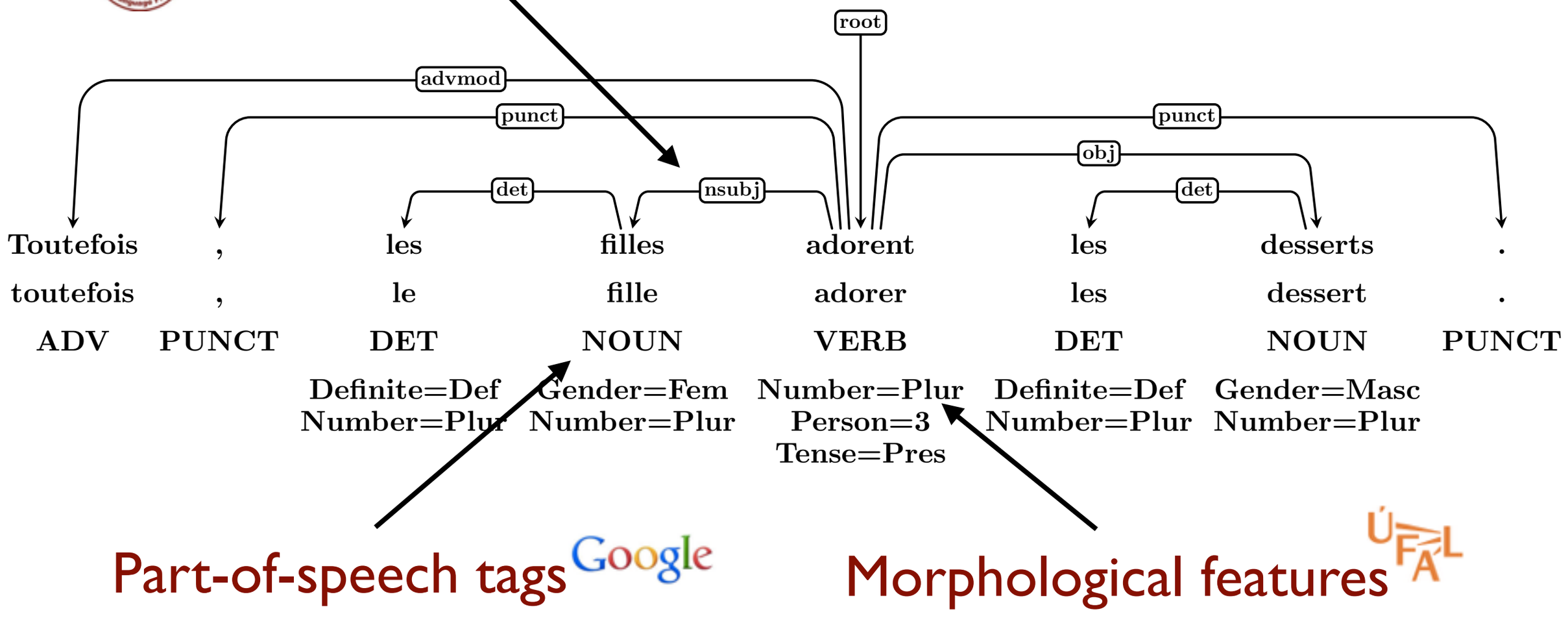
Dependency relations



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Morphological features ÚFAL

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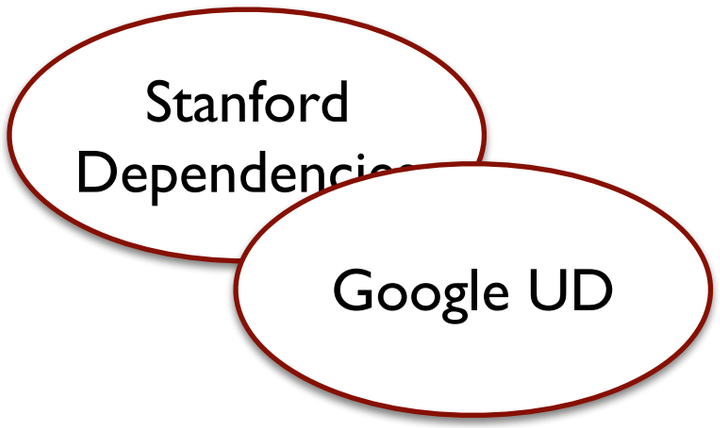

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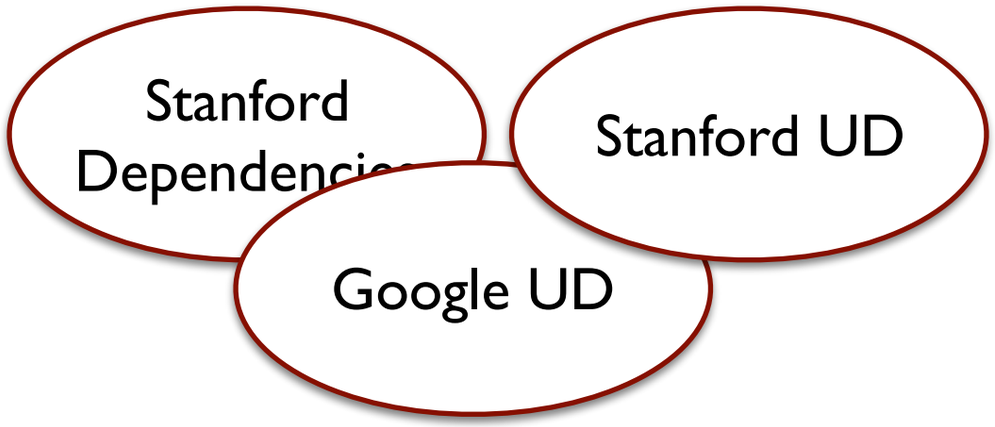

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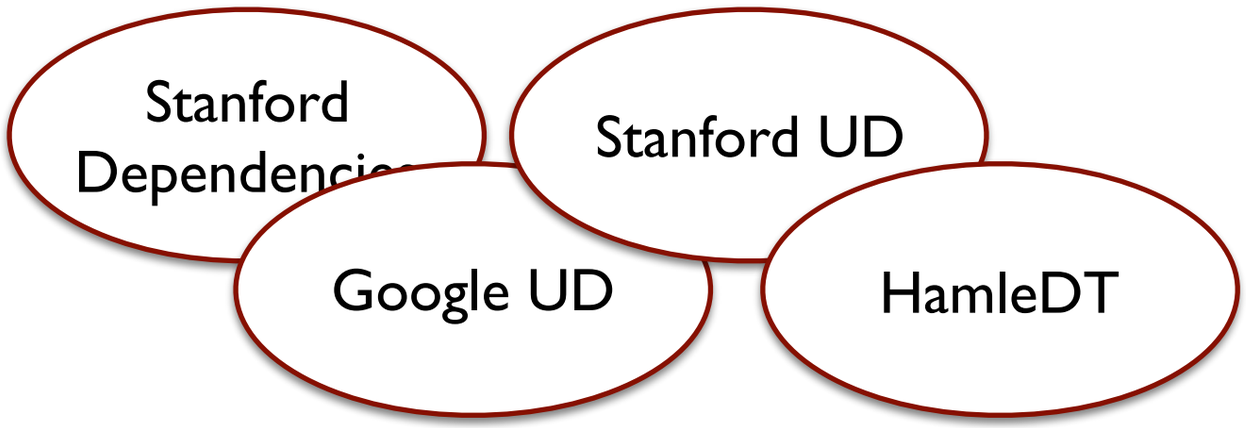

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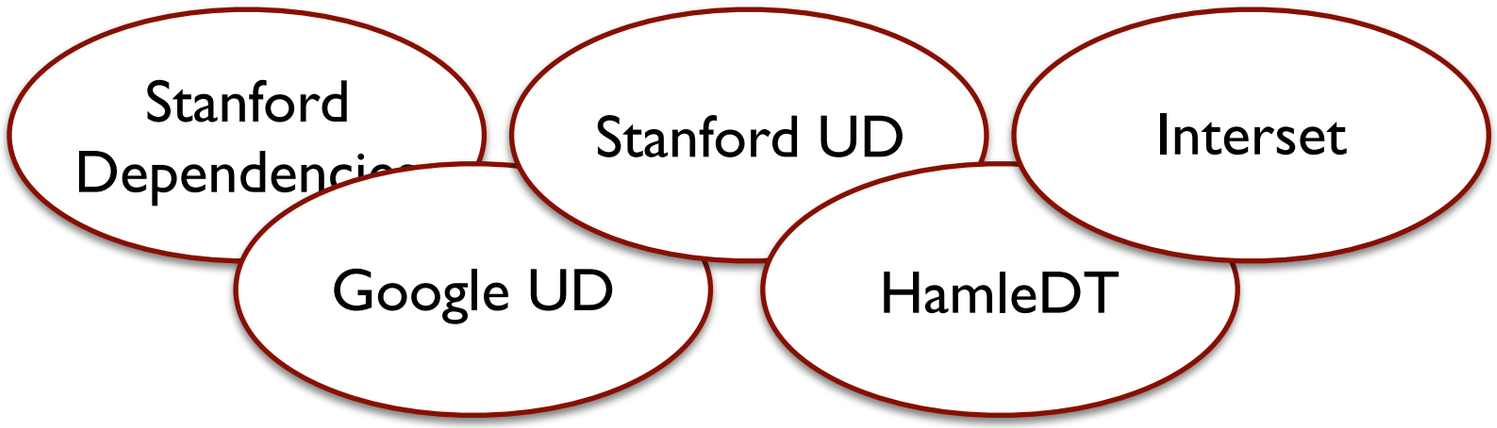

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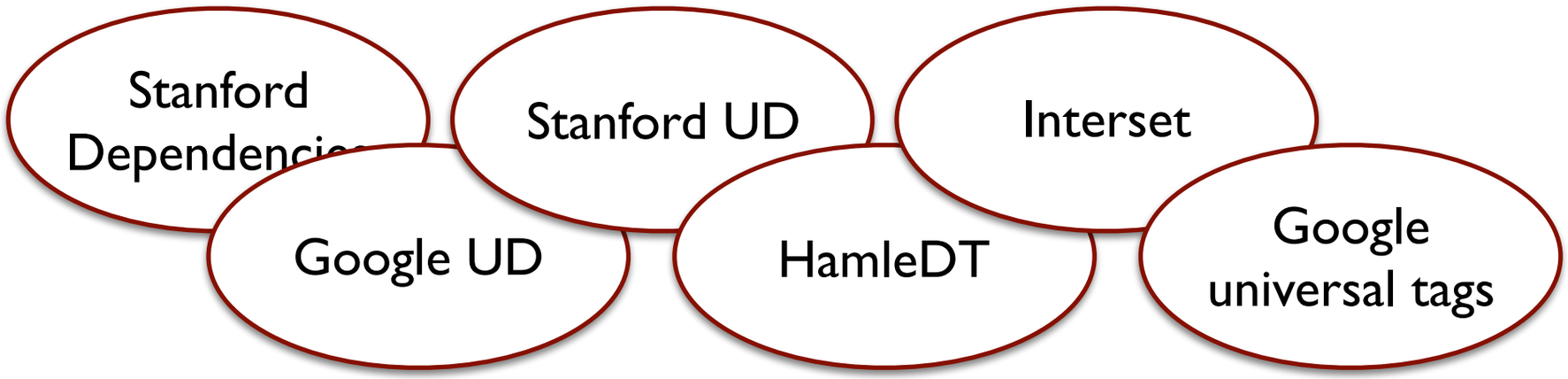

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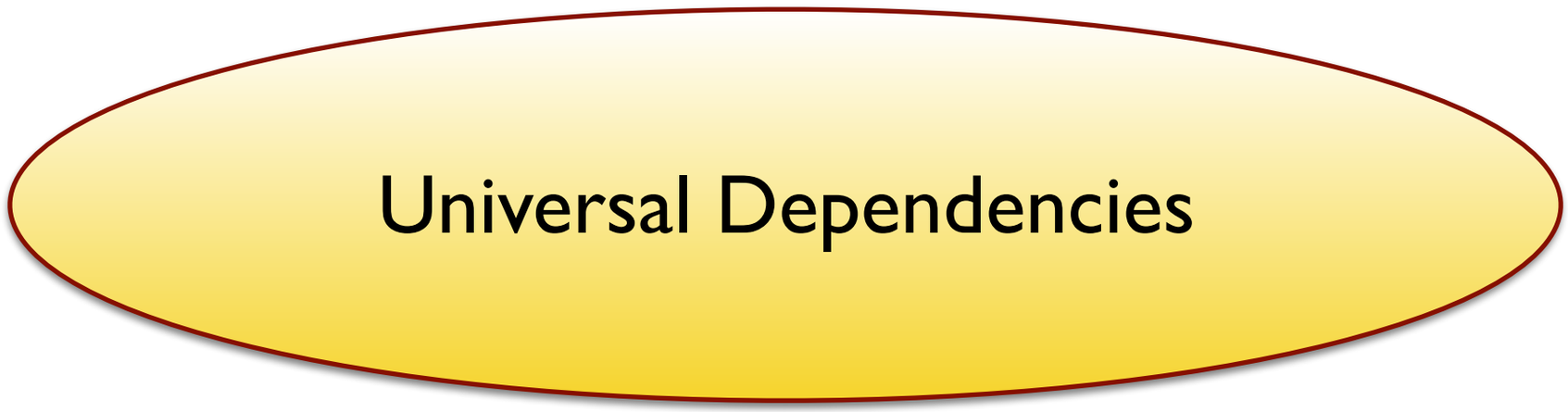

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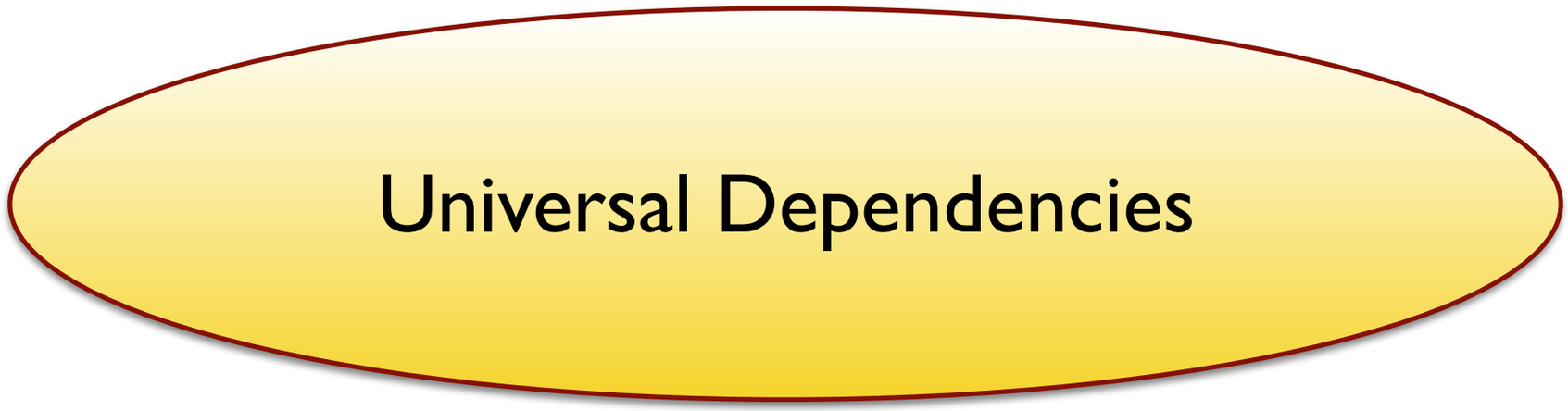

Milestones:

- Kick-off meeting at EACL in Gothenburg, April 2014
- Guidelines v1, October 2014
- Treebank releases every 6 months (v1.0–v1.4)
- Guidelines v2, December 2016
- Treebank release v2.0, March 2017 New!

Open community effort – anyone can contribute!

UD Treebanks

Ancient Greek	182K	UFB					
Ancient Greek-PROIEL	198K	UFB	-		✓		
Arabic	217K	UFB	-		✓		
Arabic-NYUAD	629K	UFB	-				
Basque	97K	UFB			✓		
Belarusian	6K	UFB	-				
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Catalan	472K	UFB			✓		
Chinese	111K	UFB			✓		W
Coptic	3K	UFB			✓		
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Kazakh	<1K	UFB			✓		W
Korean	63K	F					
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Norwegian-Bokmaal	280K	UFB			✓		
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Old Church Slavonic	47K	UFB	-		✓		
Persian	135K	UFB			✓		
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Portuguese	201K	UFB			✓		
Portuguese-BR	268K	F	-		✓		
Romanian	202K	UFB			✓		W
Russian	87K	UFB			✓		W
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Swedish-LinES	64K				✓		
Swedish Sign Language	<1K		-		✓		
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Urdu	123K	UFB	-				
Uyghur	1K		-		✓		
Vietnamese	31K	UFB	-		✓		

March 1, 2017:

- 50 languages
- 70 treebanks
- 162 contributors
- 8000+ downloads

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Galician-TreeGal	14K	UFP			✓		
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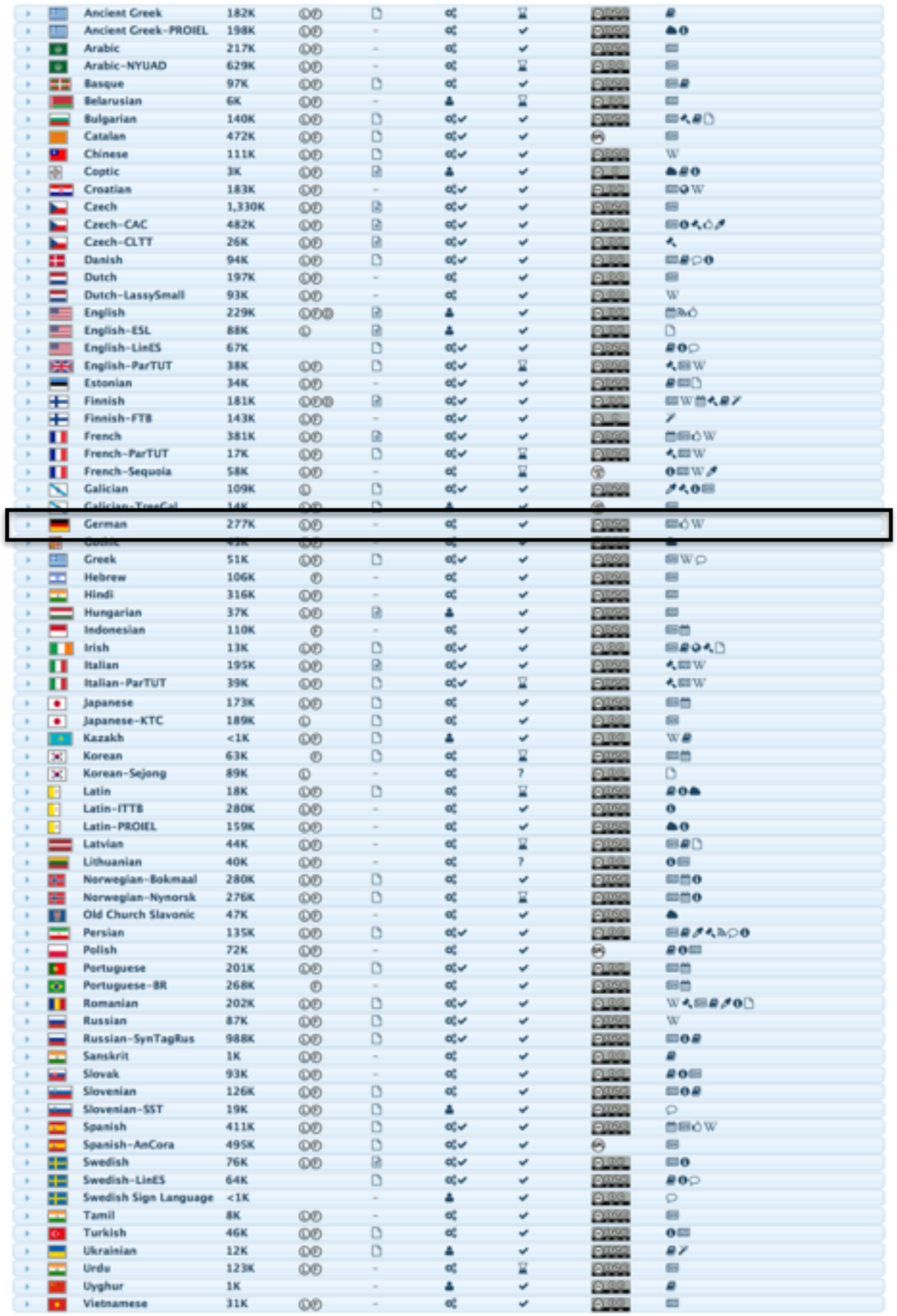

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Czech	1,330K	UFP			✓		
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Arabic	217K	UFP	-		✓		
Arabic-NYUAD	629K	UFP	-				
Basque	97K	UFP			✓		
Belarusian	6K	UFP	-				
Bulgarian	140K	UFP			✓		
Catalan	472K	UFP			✓		
Chinese	111K	UFP			✓		W
Coptic	3K	UFP			✓		
Croatian	183K	UFP	-		✓		W
Czech	1,330K	UFP			✓		
Czech-CAC	482K	UFP			✓		
Czech-CLTT	26K	UFP			✓		
Danish	94K	UFP			✓		
Dutch	197K	UFP	-		✓		
Dutch-LassySmall	93K	UFP	-		✓		W
English	229K	UFPB			✓		
English-ESL	88K	U			✓		
English-LinES	67K				✓		
English-ParTUT	38K	UFP			✓		W
Estonian	34K	UFP	-		✓		
Finnish	181K	UFPB			✓		W
Finnish-FTB	143K	UFP	-		✓		
French	381K	UFP			✓		W
French-ParTUT	17K	UFP			✓		W
French-Sequoia	58K	UFP	-				W
Galician	109K	U			✓		
Galician-TreeGal	14K	UFP			✓		
German	277K	UFP	-		✓		W
Gothic	45K	UFP	-		✓		
Greek	51K	UFP			✓		W
Hebrew	106K	F	-		✓		
Hindi	316K	UFP	-		✓		
Hungarian	37K	UFP			✓		
Indonesian	110K	F	-		✓		
Irish	13K	UFP			✓		
Italian	195K	UFP			✓		W
Italian-ParTUT	39K	UFP			✓		W
Japanese	175K	UFP			✓		
Japanese-KTC	189K	U			✓		
Kazakh	<1K	UFP			✓		W
Korean	63K	F					
Korean-Sejong	89K	U	-		?		
Latin	18K	UFP					
Latin-ITTB	280K	UFP	-		✓		
Latin-PROIEL	159K	UFP	-		✓		
Latvian	44K	UFP	-				
Lithuanian	40K	UFP	-		?		
Norwegian-Bokmaal	280K	UFP			✓		
Norwegian-Nynorsk	276K	UFP					
Old Church Slavonic	47K	UFP	-		✓		
Persian	135K	UFP			✓		
Polish	72K	UFP	-		✓		
Portuguese	201K	UFP			✓		
Portuguese-BR	268K	F	-		✓		
Romanian	202K	UFP			✓		W
Russian	87K	UFP			✓		W
Russian-SynTagRus	988K	UFP			✓		
Sanskrit	1K	UFP	-		✓		
Slovak	93K	UFP	-		✓		
Slovenian	126K	UFP			✓		
Slovenian-SST	19K	UFP			✓		
Spanish	411K	UFP			✓		W
Spanish-AnCora	495K	UFP			✓		
Swedish	76K	UFP			✓		
Swedish-LinES	64K				✓		
Swedish Sign Language	<1K		-		✓		
Tamil	8K	UFP	-		✓		
Turkish	46K	UFP			✓		
Ukrainian	12K	UFP			✓		
Urdu	123K	UFP	-				
Uyghur	1K		-		✓		
Vietnamese	31K	UFP	-		✓		

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- 162 contributors
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Chief Cat Herder

Release and Documentation Task Force

Universal Guidelines Group

Goals and Requirements

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Cross-linguistically consistent grammatical annotation

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Cross-linguistically consistent grammatical annotation

Support multilingual research in NLP and linguistics

- Meaningful linguistic analysis within and across languages
- Syntactic parsing in monolingual and cross-lingual settings
- Useful information for downstream language understanding tasks

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Build on common usage and existing de facto standards

Complement – not replace – language-specific schemes

The UD Philosophy

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Maximize parallelism – but don't overdo it

- Don't annotate the same thing in different ways
- Don't make different things look the same
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Universal taxonomy with language-specific elaboration

- Languages select from a universal pool of categories
- Allow language-specific extensions

Design Principles

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Dependency

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

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- Basic annotation units are words – syntactic words
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Recoverability

- Transparent mapping from input text to word segmentation

Word Segmentation

What is a word?

- Single part-of-speech tag
- Real syntactic relation

Two-level segmentation

- Represent orthographic tokens in addition to syntactic words

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大阪国際会議場	大阪 国際 会議場

Morphology

Le **chat** **chasse** **les** **chiens** **.**

Morphology

Le	**chat**	**chasse**	**les**	**chiens**	**.**
le	**chat**	**chasser**	**le**	**chien**	**.**

- Lemma representing the semantic content of the word

Morphology

Le	**chat**	**chasse**	**les**	**chiens**	**.**
le	**chat**	**chasser**	**le**	**chien**	**.**
DET	**NOUN**	**VERB**	**DET**	**NOUN**	**PUNCT**

- Lemma representing the semantic content of the word
- Part-of-speech tag representing its grammatical class

Morphology

Le … hiens .
le … hien .
DET … OUN PUNCT

Open	Closed	Other
ADJ	ADP	PUNCT
ADV	AUX	SYM
INTJ	CCONJ	X
NOUN	DET	
PROPN	NUM	
VERB	PART	
	PRON	
	SCONJ	

- Lemma rep … of the word
- Part-of-speech tag representing its grammatical class

Morphology

Le	chat	chasse	les	chiens	.
le	chat	chasser	le	chien	.
DET	NOUN	VERB	DET	NOUN	PUNCT
Definite=Def Gender=Masc Number=Sing	Gender=Masc Number=Sing	Mood=Ind Number=Sing Person=3 Tense=Pres VerbForm=Fin	Definite=Def Gender=Masc Number=Plur	Gender=Masc Number=Plur	

- Lemma representing the semantic content of the word
- Part-of-speech tag representing its grammatical class
- Features representing lexical and grammatical properties of the lemma or the particular word form

Morphology

Le			hiens	.
le			hien	.
DET	N		OUN	PUNCT
Definite=Def Gender=Masc Number=Sing	Gend Num		er=Masc er=Plur	

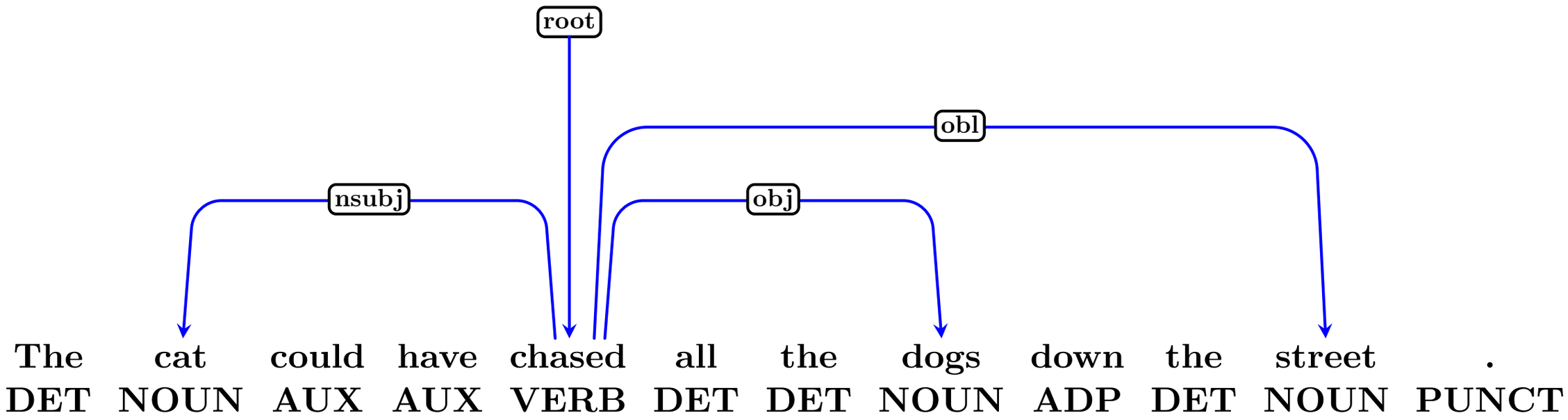
Lexical	Inflectional Nominal	Inflectional Verbal
PronType	Gender	VerbForm
NumType	Animacy	Mood
Poss	Number	Tense
Reflex	Case	Aspect
Foreign	Definite	Voice
Abbr	Degree	Evident
		Polarity
		Person
		Polite

- Lemma rep of the word
- Part-of-spe tical class
- Features representing lexical and grammatical properties of the lemma or the particular word form

Syntax

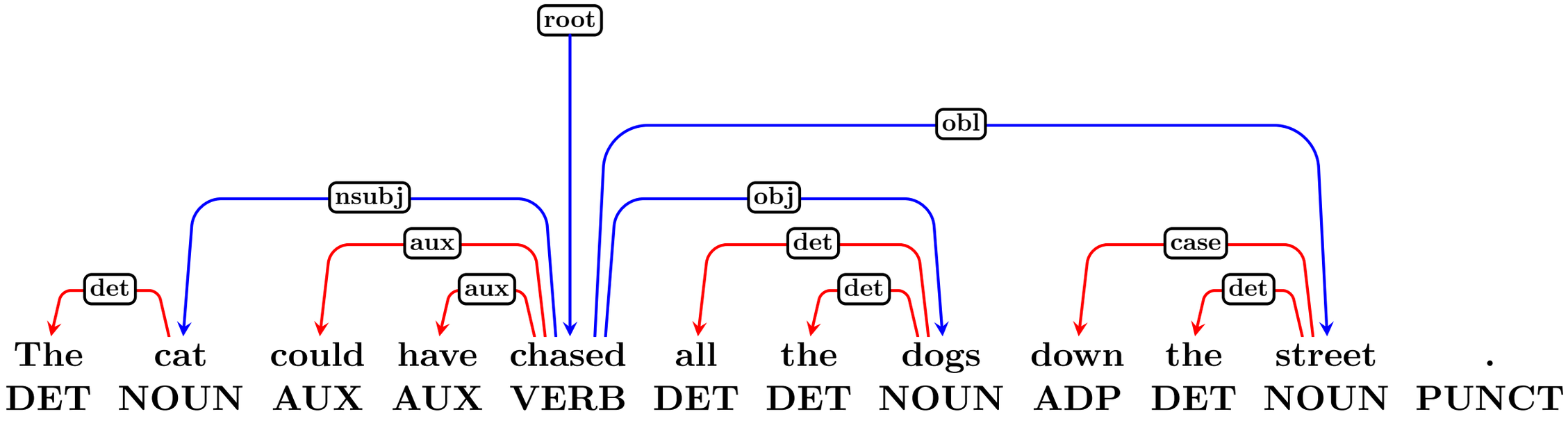
The	cat	could	have	chased	all	the	dogs	down	the	street	.
DET	NOUN	AUX	AUX	VERB	DET	DET	NOUN	ADP	DET	NOUN	PUNCT

Syntax



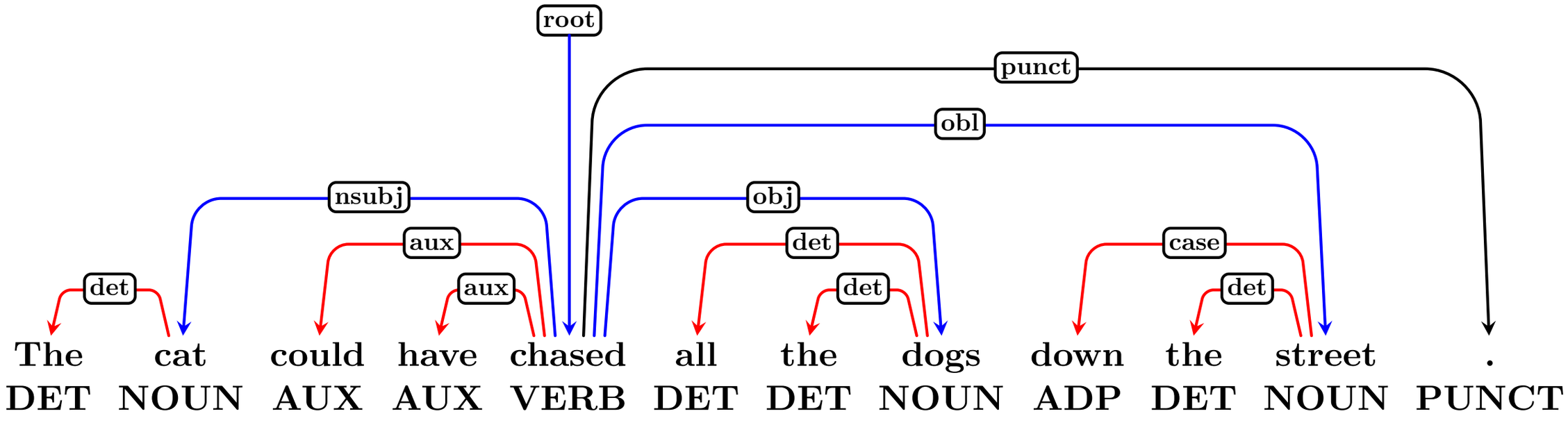
- Content words are related by dependency relations

Syntax

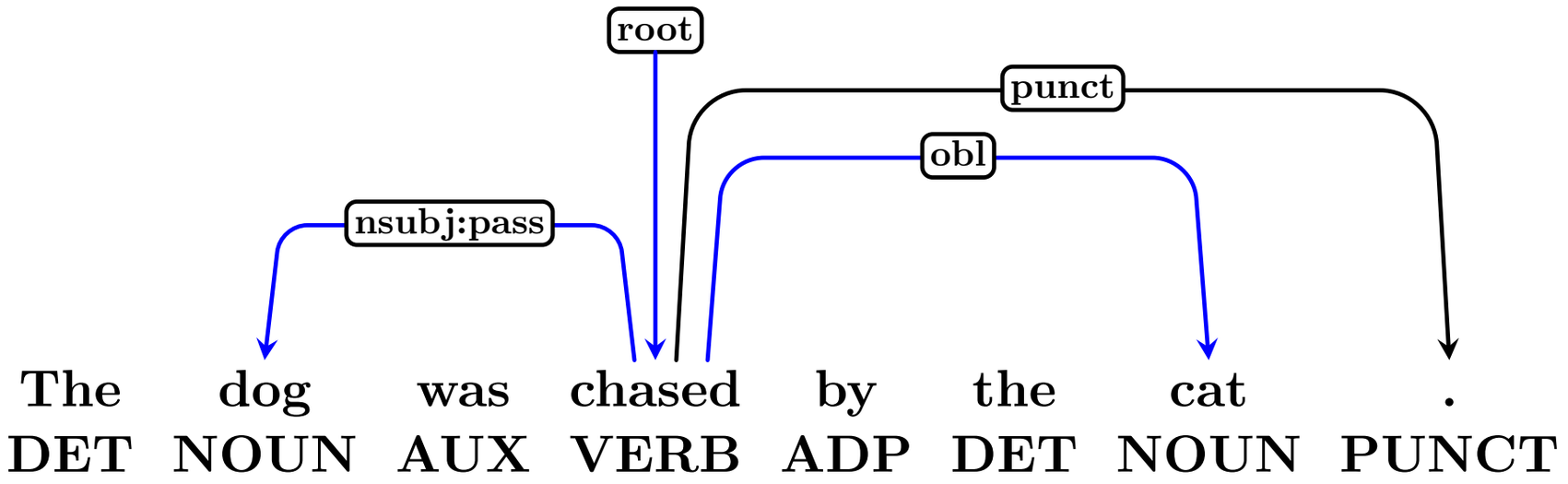


- Content words are related by dependency relations
- Function words attach to the content word they modify

Syntax



- Content words are related by dependency relations
- Function words attach to the content word they modify
- Punctuation attach to head of phrase or clause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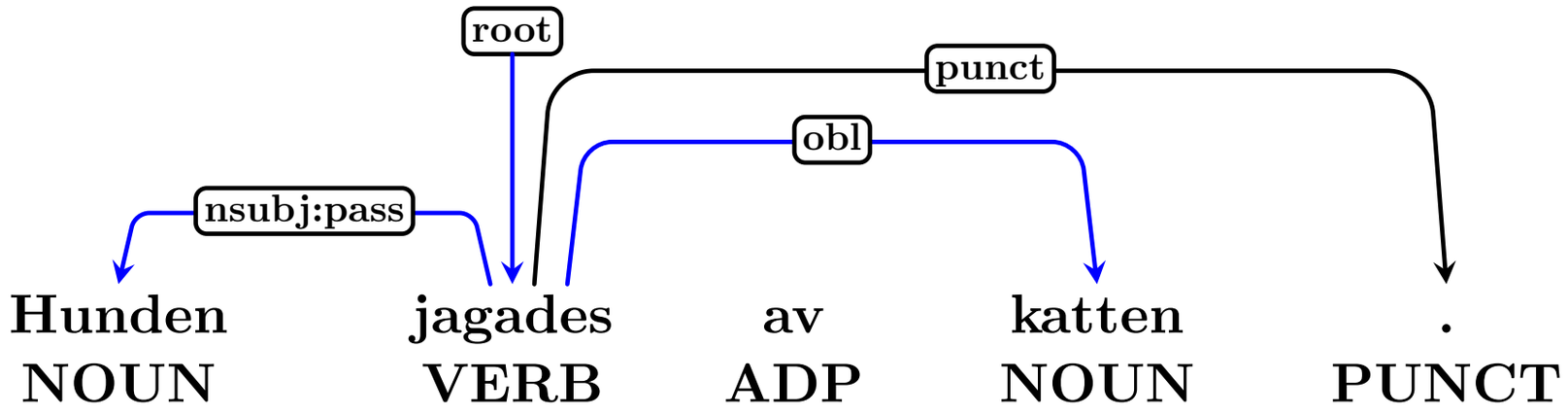
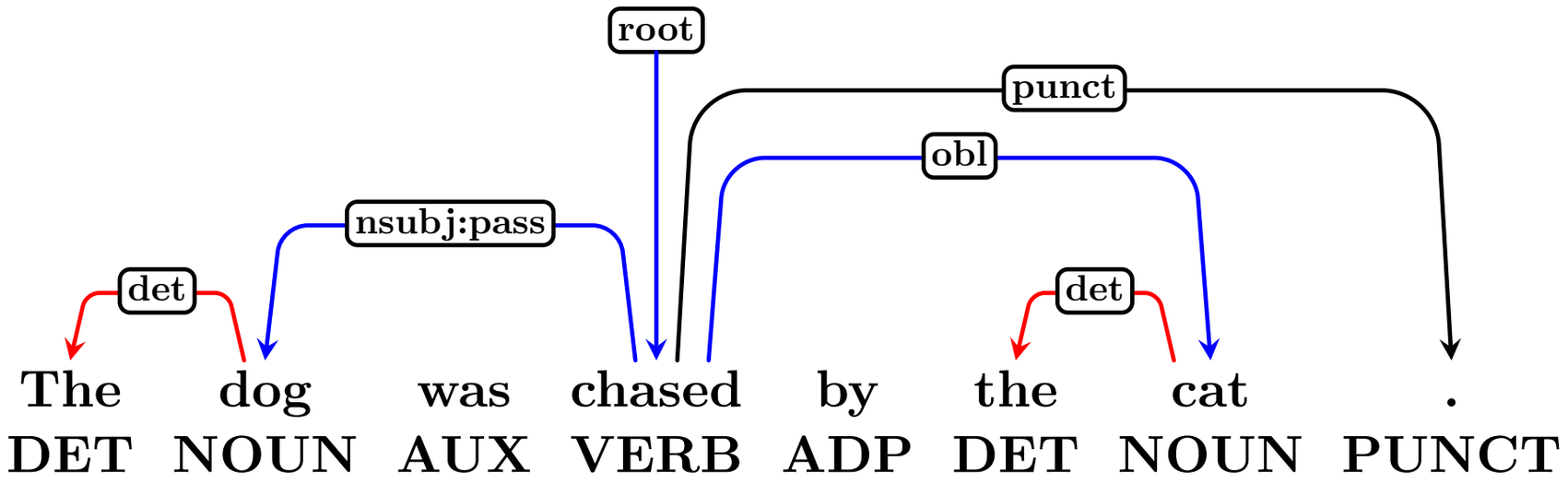
punct
obl
nsubj:pass
The dog was chased by the cat .
DET NOUN AUX VERB ADP DET NOUN PUNCT


root
punct
obl
nsubj:pass
Hunden jagades av katten .
NOUN VERB ADP NOUN PUNCT


root
punct
obl
nsubj:pass
det
det
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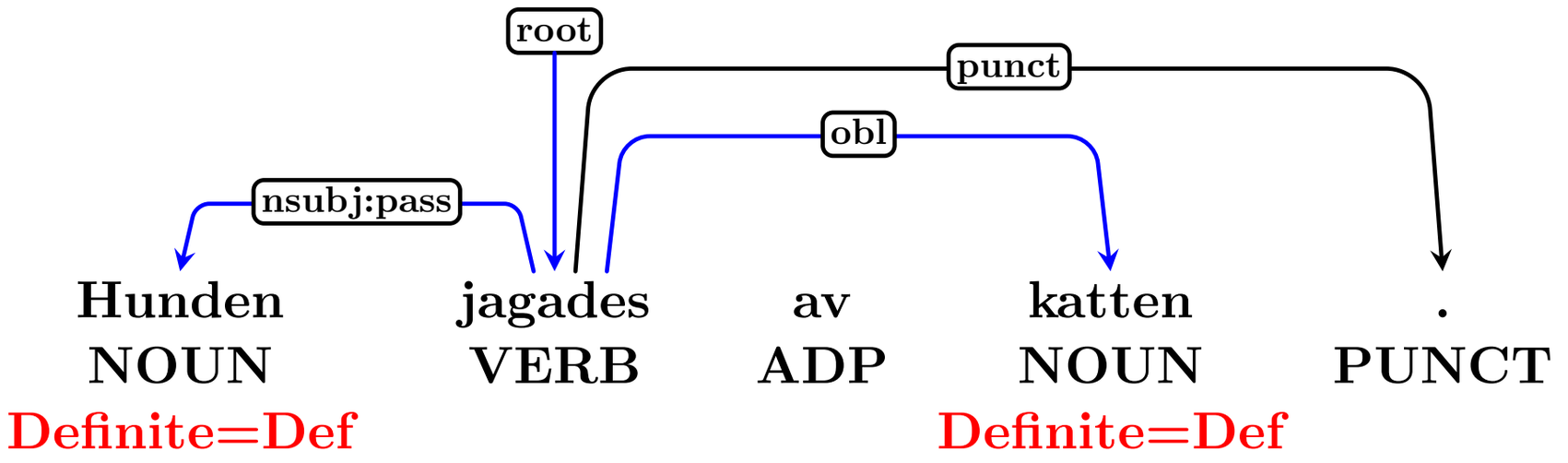
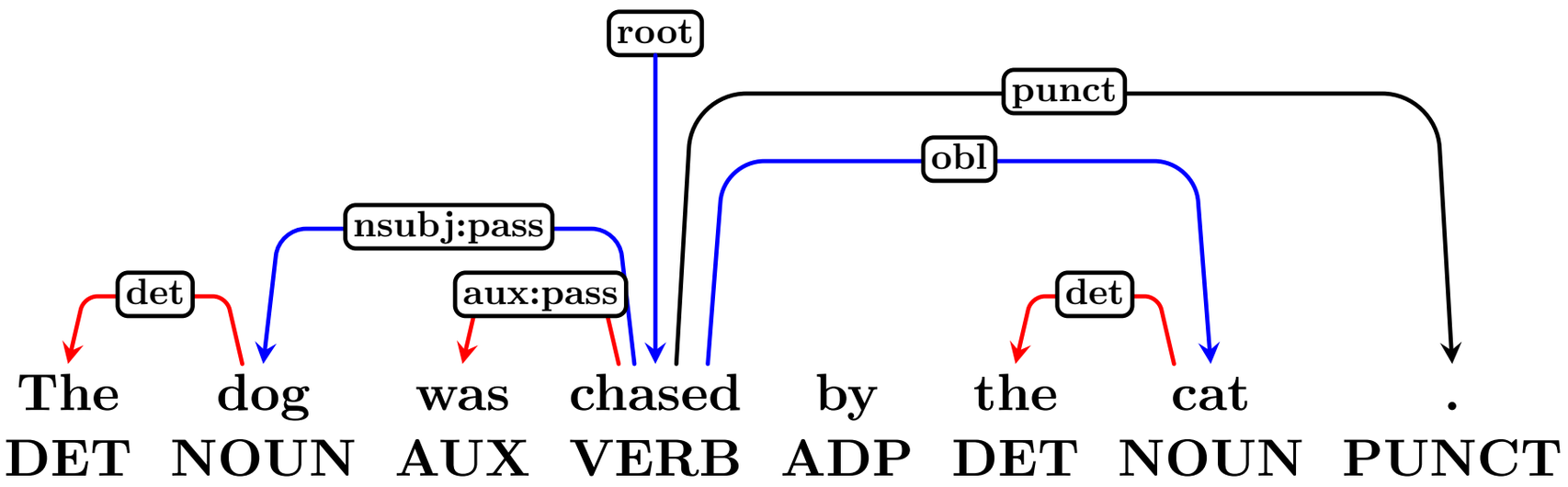
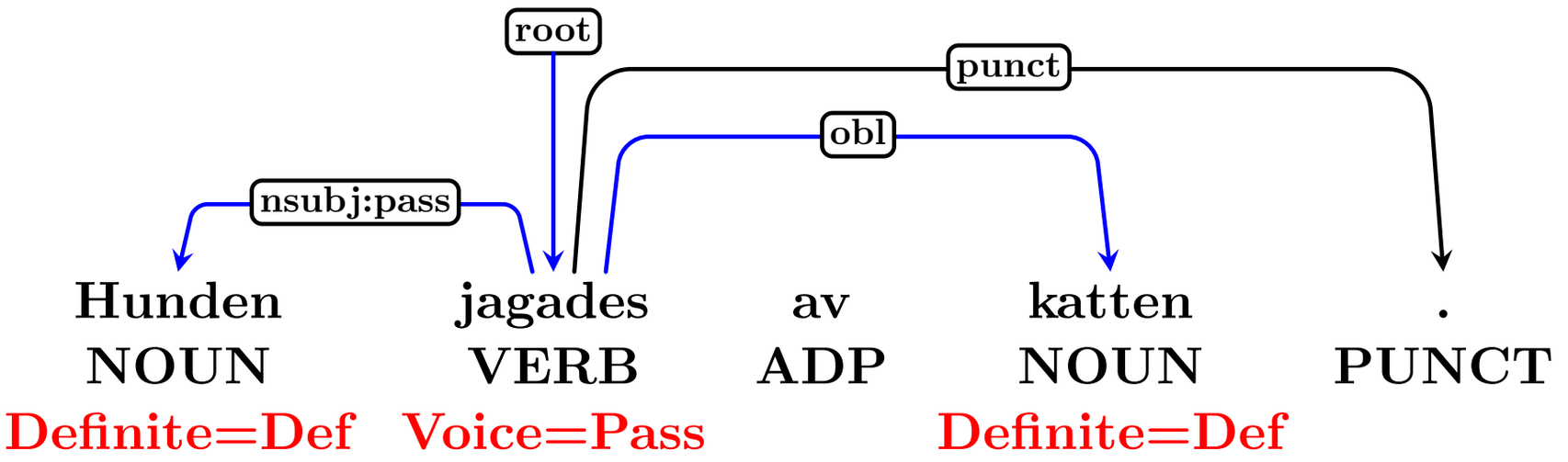
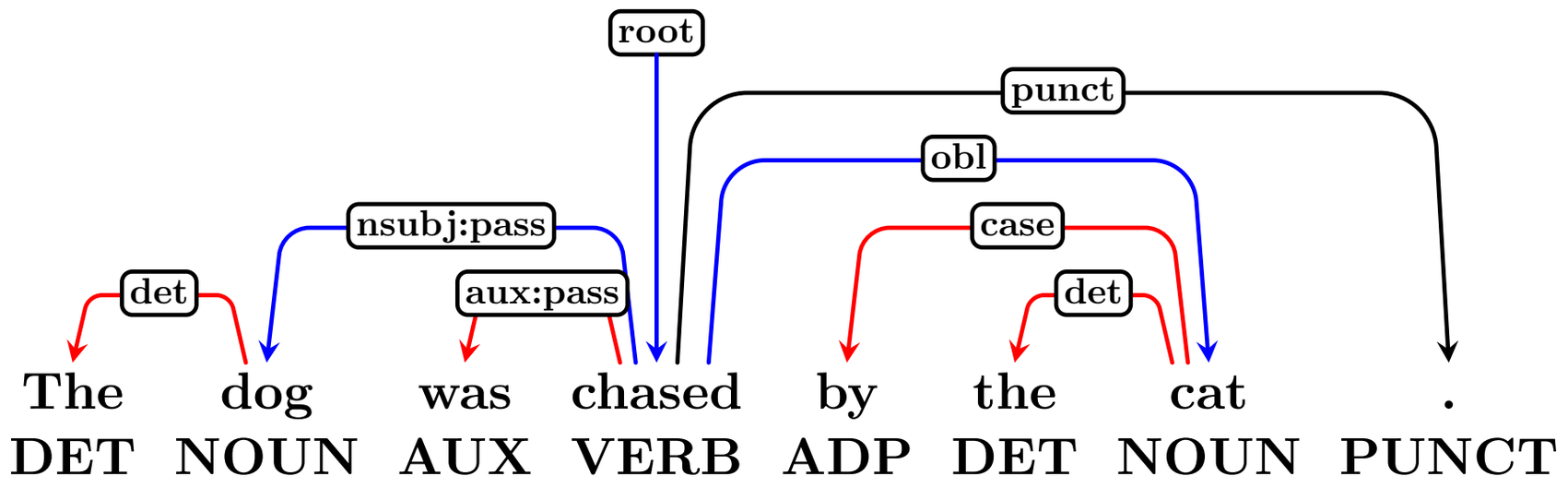

root
punct
obl
nsubj:pass
Hunden jagades av katten .
NOUN VERB ADP NOUN PUNCT
Definite=Def
Definite=Def


root
punct
obl
nsubj:pass
det
aux:pass
det
The dog was chased by the cat .
DET NOUN AUX VERB ADP DET NOUN PUNCT


root
punct
obl
nsubj:pass
Hunden jagades av katten .
NOUN VERB ADP NOUN PUNCT
Definite=Def Voice=Pass Definite=Def


root
punct
obl
nsubj:pass
case
det
aux:pass
det
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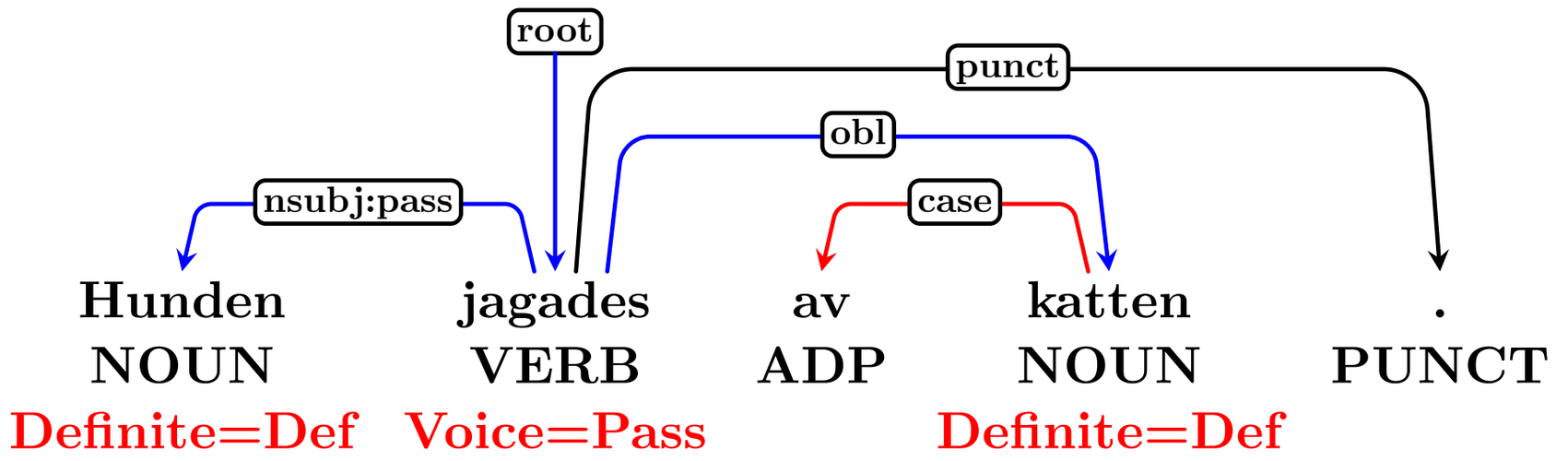
DET NOUN AUX VERB ADP DET NOUN PUNCT


root
punct
obl
nsubj:pass
case
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Definite=Def Voice=Pass Definite=Def

Syntactic Relations

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Taxonomy of 37 universal syntactic relations

- Three types of structures: nominals, clauses, modifiers
- Core arguments vs. other dependents (not arguments vs. adjuncts)
- Language-specific subtypes

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Basic and enhanced representations

- Basic dependencies form a (possibly non-projective) tree
- Additional dependencies in the enhanced representation

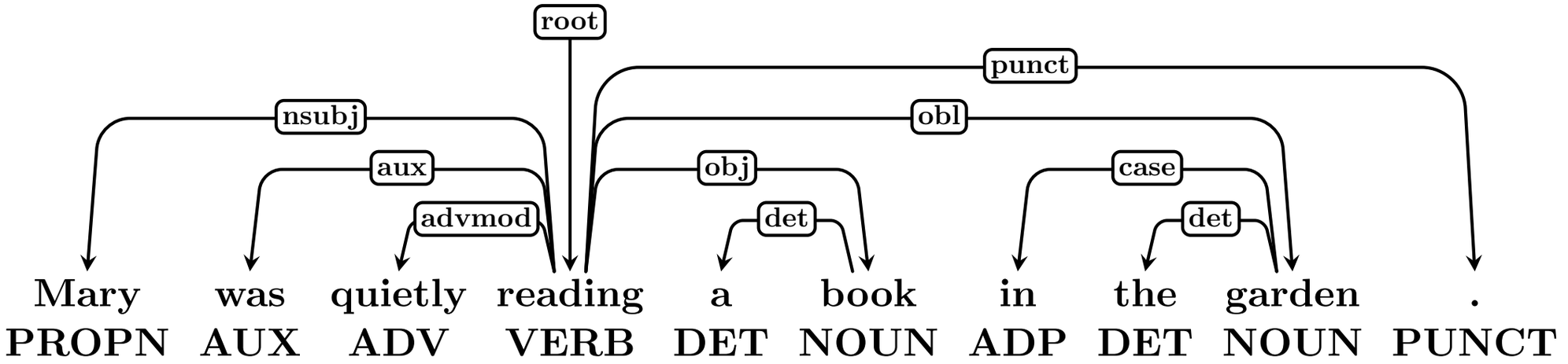
Syntactic Relations

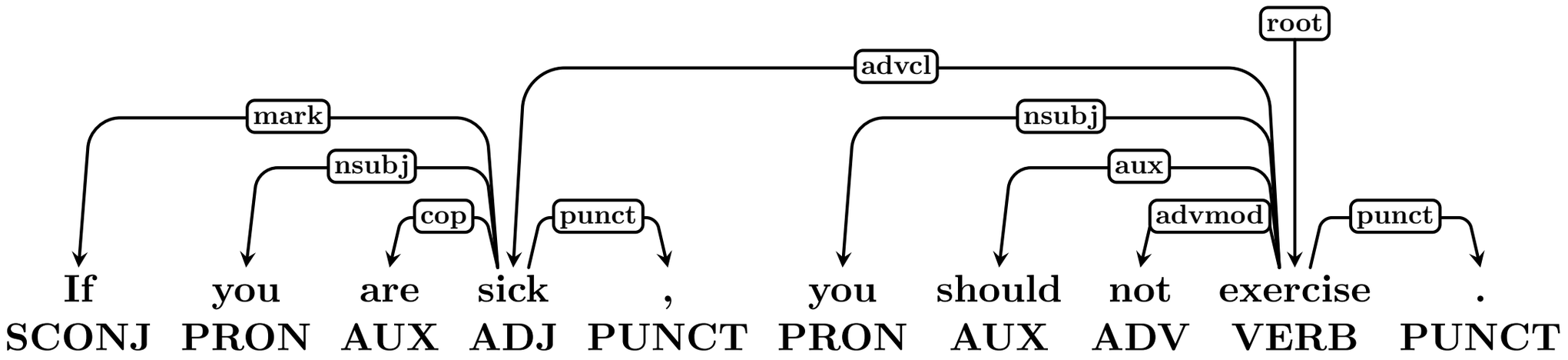
	Nominal	Clause	Modifier Word	Function Word
Core Predicate Dep	nsubj obj iobj	csubj ccomp xcomp		
Non-Core Predicate Dep	obl vocative expl dislocated	advcl	advmod* discourse	aux cop mark
Nominal Dep	nmod appos nummod	acl	amod	det clf case
Coordination	**MWE**	**Loose**	**Special**	**Other**
conj cc	fixed flat compound	parataxis list	orphan goeswith reparandum	punct root dep

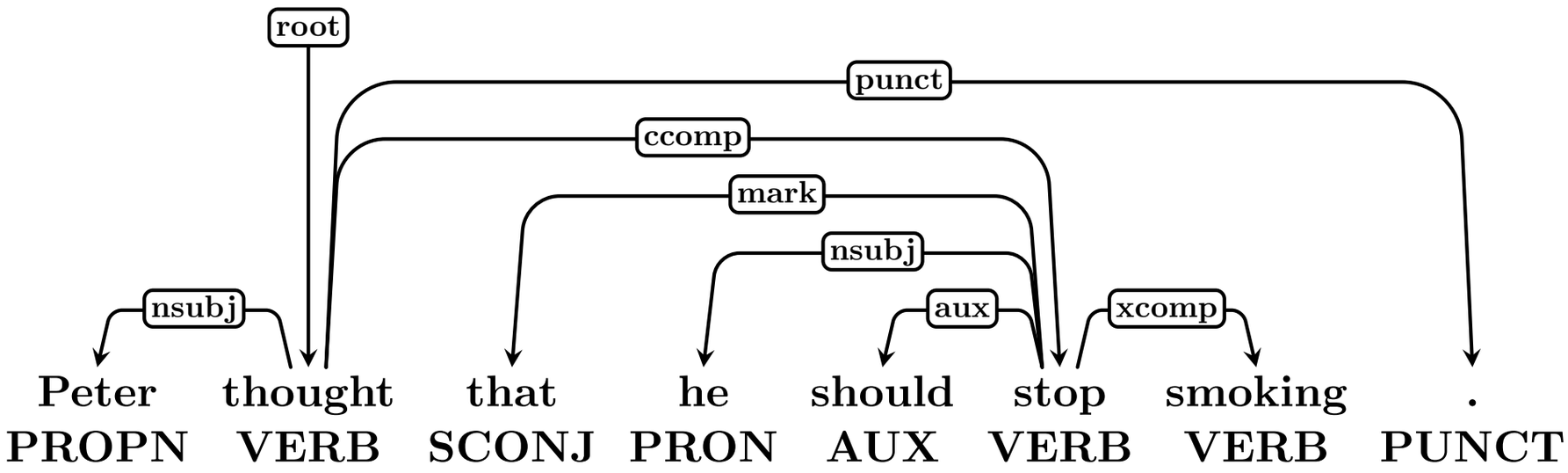
* Generalized modifier of predicates and (non-nominal) modifiers

Dependents of Clausal Predicates

	Nominal	Clause	Modifier Word	Function Word
Core	nsubj obj iobj	csubj ccomp xcomp		
Non-Core	obl vocative expl dislocated	advcl	advmod discourse	aux cop mark


root
punct
nsubj
obl
aux
obj
case
advmod
det
det
Mary was quietly reading a book in the garden .
PROPN AUX ADV VERB DET NOUN ADP DET NOUN PUNCT


root
advcl
mark
nsubj
nsubj
aux
cop
punct
advmod
punct
If you are sick , you should not exercise .
SCONJ PRON AUX ADJ PUNCT PRON AUX ADV VERB PUNCT


root
punct
ccomp
mark
nsubj
nsubj
aux
xcomp
Peter thought that he should stop smoking .
PROPN VERB SCONJ PRON AUX VERB VERB PUNCT

Core Arguments

Core Arguments

Arguments of basic intransitive and transitive verbs

- Verbs usually only agree with core arguments
- Core arguments normally appear as bare nominals without adpositions
- Certain cases, traditionally called nominative, accusative, and absolutive are typically reserved core arguments
- Core arguments often occupy special positions in the clause
- Syntactic phenomena like control, relativization and passivization can be restricted to core arguments

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- Core arguments vs. oblique dependents – encoding of grammatical function
- Arguments vs. adjuncts – valency or subcategorization

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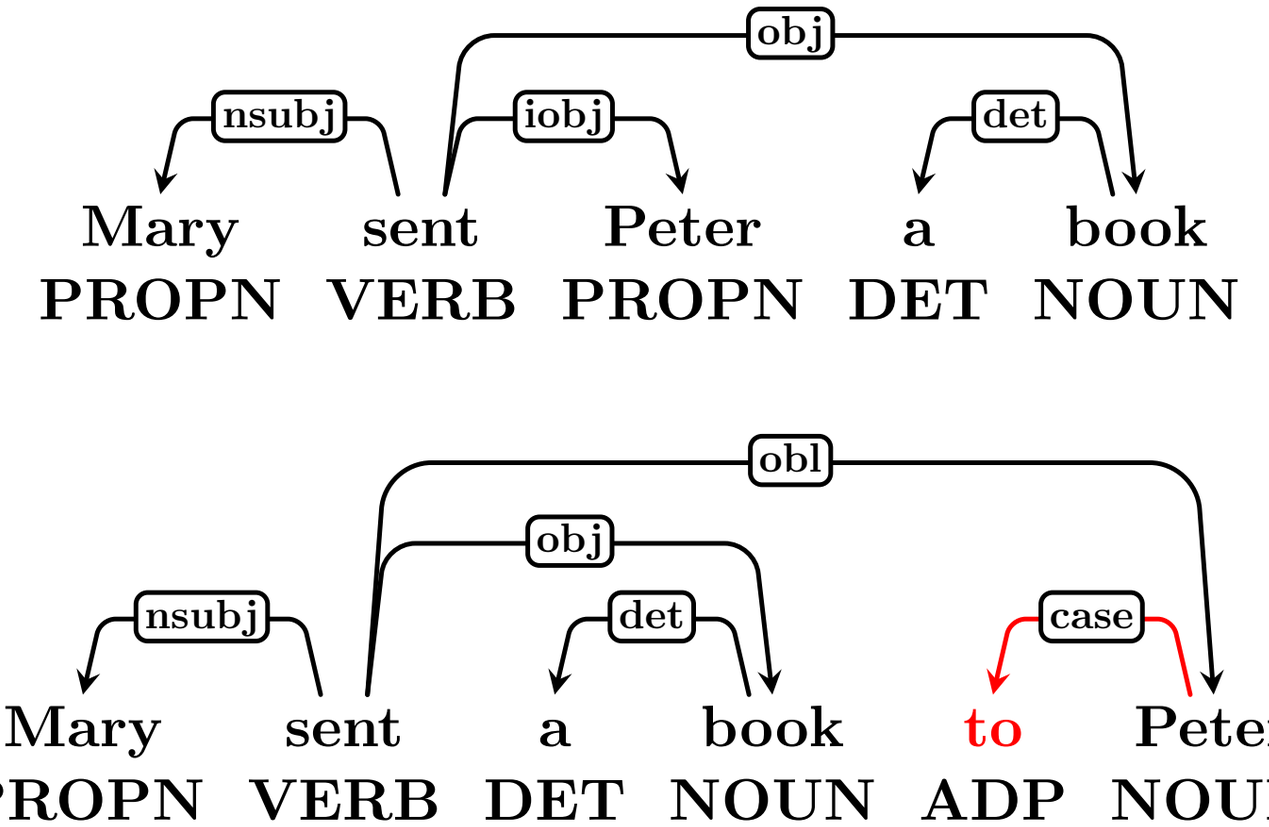
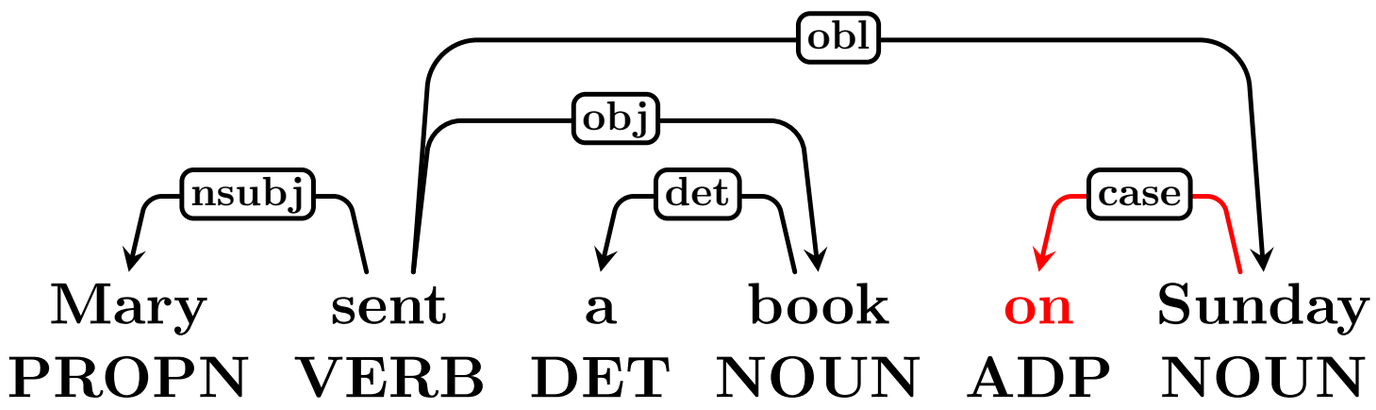
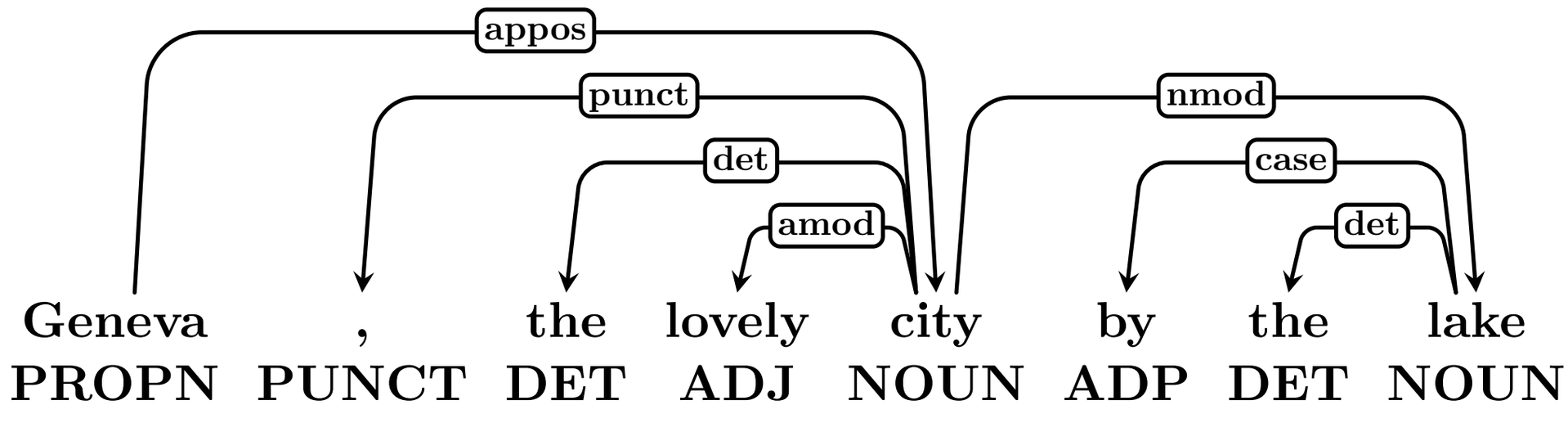

obj
nsubj
iobj
det
Mary sent Peter a book
PROPN VERB PROPN DET NOUN
obl
obj
nsubj
det
case
Mary sent a book to Peter
PROPN VERB DET NOUN ADP NOUN

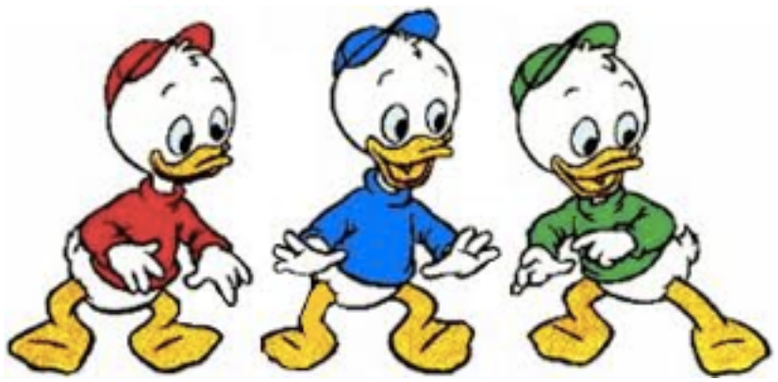

obl
obj
nsubj
det
case
Mary sent a book on Sunday
PROPN VERB DET NOUN ADP NOUN

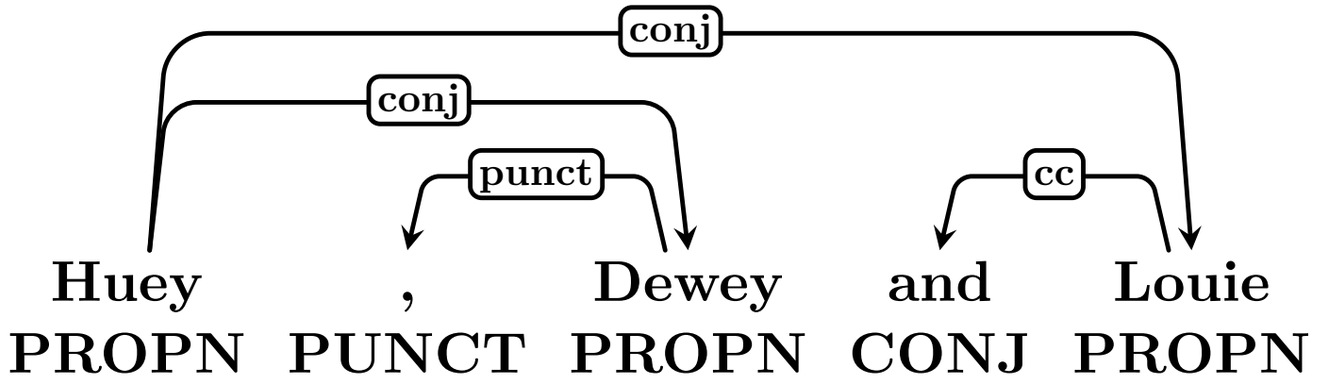
Dependents of Nominals

Nominal	Clause	Modifier Word	Function Word
nmod appos nummod	acl	amod	det clf case



Coordination

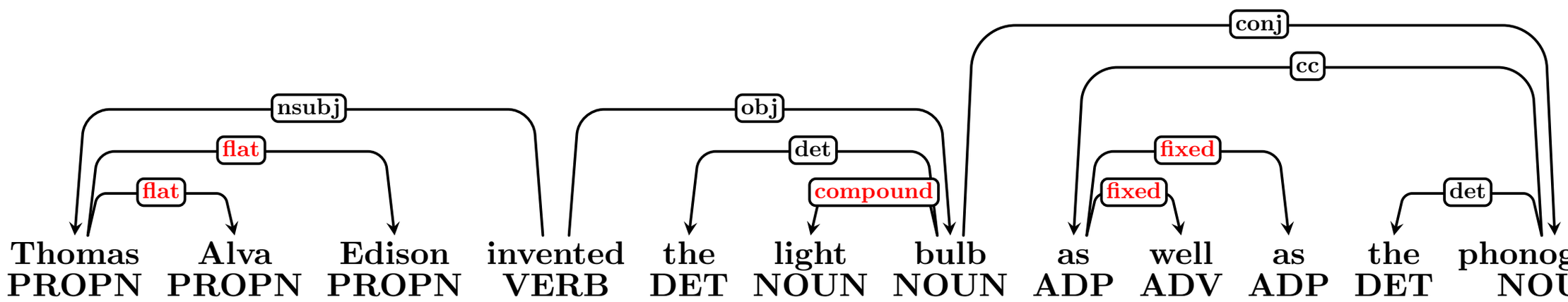




Coordinate structures are headed by the first conjunct

- Subsequent conjuncts depend on it via the conj relation
- Conjunction depends on following conjunct via the cc relation
- Punctuation depends on following conjunct via the punct relation

Multiword Expressions



Only restricted classes of MWEs get special treatment:

- Fixed grammaticized expressions (fixed)
- Semi-fixed expressions with no clear head (flat)
- Lexical compounds – normally headed (compound)

Loose Joining Relations

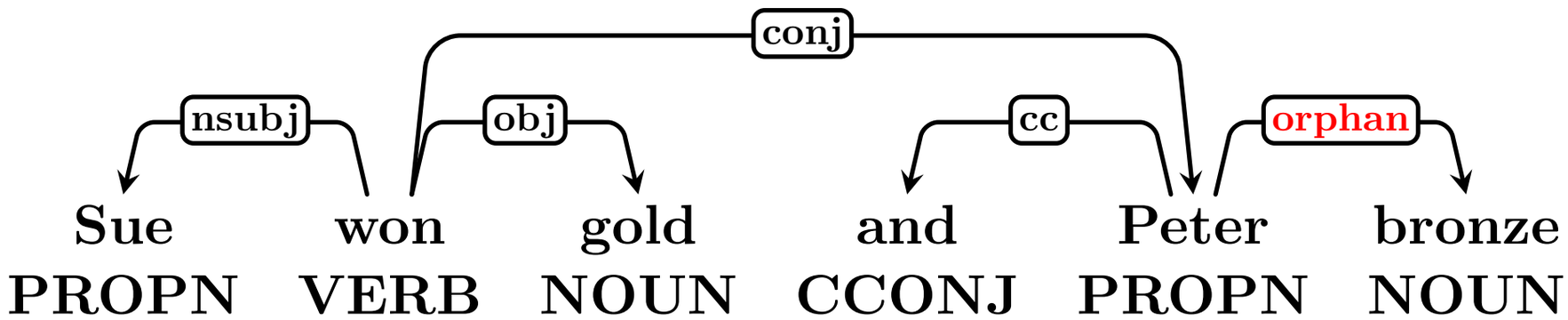
The parataxis relation:

- Side-by-side sentences ("run-on sentences")
  Bearded dragons are sight hunters, they need to see the food to move.
- Injective clauses (parentheticals)
  Calafia has great fries (they are to die for!) and decent burgers.
- Certain types of reported speech
  That guy, he said, left early this morning.
- Tag questions
  It's not me, is it?

The list relation:

- Chains of comparable items
  Steve Jones Phone: 555-9814 Email: jones@abc.edf

Ellipsis

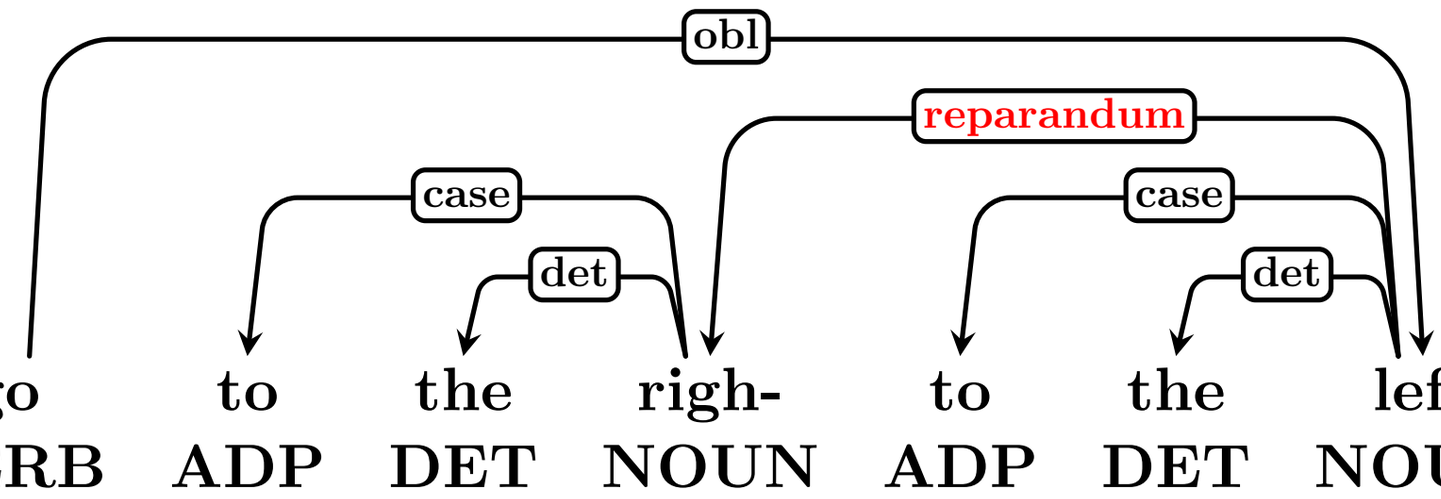


The UD approach to ellipsis (from v2):

1. If the elided word has no children, do nothing.
2. If the elided word has children, promote one of them to be the head.
3. If the elided word is a predicate and the new head a core argument, attach other non-functional elements with the orphan relation.

Implicit relations are recovered in enhanced dependencies

Disfluencies



The reparandum relation:

- Disfluencies that are overridden in a speech repair

The goeswith relation:

- Parts of words resulting from orthographic or editing mistakes

Punctuation

- A punctuation mark separating coordinated units is attached to the following conjunct.
- A punctuation mark preceding or following a subordinated unit is attached to this unit.
- Within the relevant unit, a punctuation mark is attach at the highest possible node that preserves projectivity.
- Paired punctuation marks should be attached to the same word unless that would create non-projectivity.

Special Relations

The root relation:

- The word at the root of the dependency tree
- Normally the predicate of the main clause
- Exactly one word in each tree

The dep relation:

- Unspecified syntactic relation (when all else fails)

A Two-Level Architecture

- Universal relations to allow cross-linguistic comparison
- Subtypes to capture language-specific phenomena

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Universal	Subtype

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acl	acl:relcl

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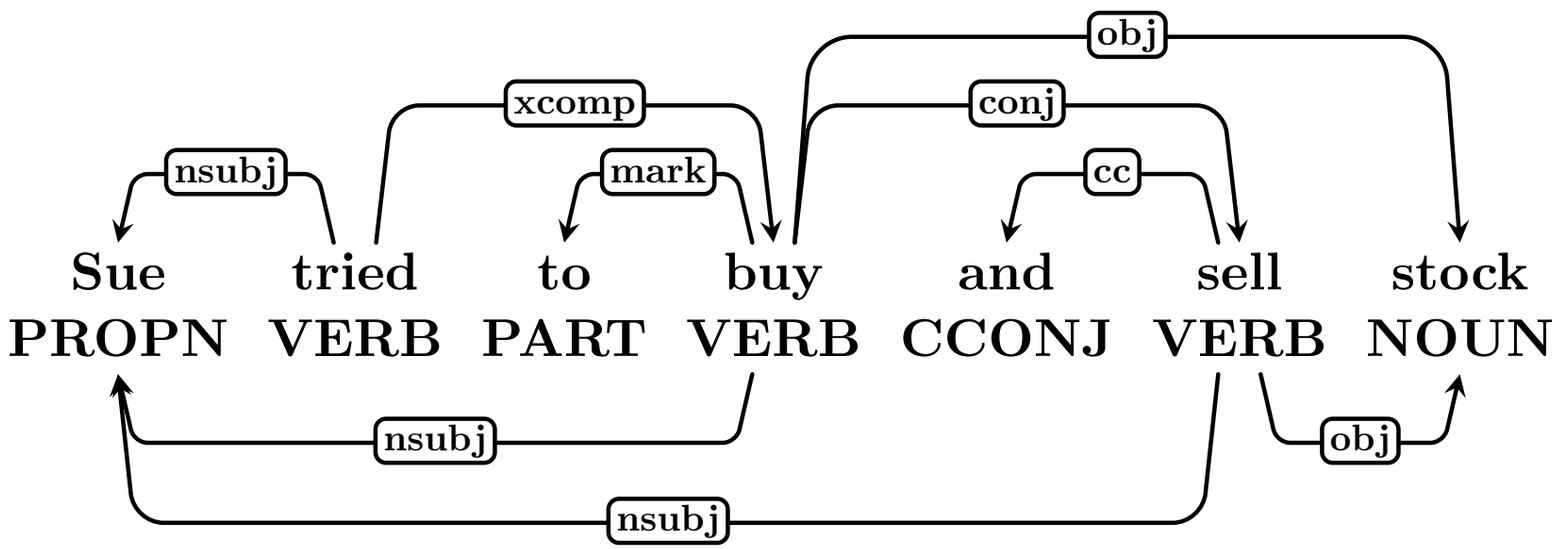
Universal	Subtype
acl	acl:relcl
compound	compound:prt
nmod	nmod:poss
flat	flat:name

Enhanced Dependencies



An extended dependency graph containing

- Null nodes for elided predicates
- Additional subject relations for control and raising constructions
- Propagation of dependents over coordination
- Coreference in relative clause constructions
- Labels augmented with function word information

CoNLL-U Format

- Revised version of the CoNLL-X format
- Two-level segmentation and enhanced dependencies

CoNLL-U Format

ID
1–2
1
2
3–4
3
4
5
6

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CoNLL-U Format

ID	FORM
1-2	Vámonos
1	Vamos
2	nos
3-4	al
3	a
4	el
5	mar
6	.

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CoNLL-U Format

ID	FORM	LEMMA
1-2	Vámonos	_
1	Vamos	ir
2	nos	nosotros
3-4	al	_
3	a	a
4	el	el
5	mar	mar
6	.	.

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CoNLL-U Format

ID	FORM	LEMMA	UPOSTAG
1-2	Vámonos	_	_
1	Vamos	ir	VERB
2	nos	nosotros	PRON
3-4	al	_	_
3	a	a	ADP
4	el	el	DET
5	mar	mar	NOUN
6	.	.	.

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ID	FORM	LEMMA	UPOSTAG	XPOSTAG
1-2	Vámonos	_	_	_
1	Vamos	ir	VERB	_
2	nos	nosotros	PRON	_
3-4	al	_	_	_
3	a	a	ADP	_
4	el	el	DET	_
5	mar	mar	NOUN	_
6	.	.	.	_

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CoNLL-U Format

ID	FORM	LEMMA	UPOSTAG	XPOSTAG	FEATS
1-2	Vámonos	_	_	_	_
1	Vamos	ir	VERB	_	Mood=Imp|Number=Plur|Person=1
2	nos	nosotros	PRON	_	PronType=Per|Number=Plur|Person=1
3-4	al	_	_	_	_
3	a	a	ADP	_	_
4	el	el	DET	_	Definite=Def|Number=Sing|
5	mar	mar	NOUN	_	Number=Sing|Gender=Masc
6	.	.	.	_	_

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CoNLL-U Format

ID	FORM	LEMMA	UPOSTAG	XPOSTAG	FEATS	HEAD
1-2	Vámonos	_	_	_	_	_
1	Vamos	ir	VERB	_	Mood=Imp|Number=Plur|Person=1	0
2	nos	nosotros	PRON	_	PronType=Per|Number=Plur|Person=1	1
3-4	al	_	_	_	_	_
3	a	a	ADP	_	_	5
4	el	el	DET	_	Definite=Def|Number=Sing|	5
5	mar	mar	NOUN	_	Number=Sing|Gender=Masc	1
6	.	.	.	_	_	1

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CoNLL-U Format

ID	FORM	LEMMA	UPOSTAG	XPOSTAG	FEATS	HEAD	DEPREL
1-2	Vámonos	_	_	_	_	_	_
1	Vamos	ir	VERB	_	Mood=Imp|Number=Plur|Person=1	0	root
2	nos	nosotros	PRON	_	PronType=Per|Number=Plur|Person=1	1	expl
3-4	al	_	_	_	_	_	_
3	a	a	ADP	_	_	5	case
4	el	el	DET	_	Definite=Def|Number=Sing|	5	det
5	mar	mar	NOUN	_	Number=Sing|Gender=Masc	1	obl
6	.	.	.	_	_	1	punct

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CoNLL-U Format

ID	FORM	LEMMA	UPOSTAG	XPOSTAG	FEATS	HEAD	DEPREL	DEPS
1-2	Vámonos	_	_	_	_	_	_	_
1	Vamos	ir	VERB	_	Mood=Imp|Number=Plur|Person=1	0	root	_
2	nos	nosotros	PRON	_	PronType=Per|Number=Plur|Person=1	1	expl	_
3-4	al	_	_	_	_	_	_	_
3	a	a	ADP	_	_	5	case	_
4	el	el	DET	_	Definite=Def|Number=Sing|	5	det	_
5	mar	mar	NOUN	_	Number=Sing|Gender=Masc	1	obl	_
6	.	.	.	_	_	1	punct	_

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CoNLL-U Format

ID	FORM	LEMMA	UPOSTAG	XPOSTAG	FEATS	HEAD	DEPREL	DEPS	MISC
1-2	Vámonos	_	_	_	_	_	_	_	_
1	Vamos	ir	VERB	_	Mood=Imp|Number=Plur|Person=1	0	root	_	_
2	nos	nosotros	PRON	_	PronType=Per|Number=Plur|Person=1	1	expl	_	_
3-4	al	_	_	_	_	_	_	_	_
3	a	a	ADP	_	_	5	case	_	_
4	el	el	DET	_	Definite=Def|Number=Sing|	5	det	_	_
5	mar	mar	NOUN	_	Number=Sing|Gender=Masc	1	obl	_	_
6	.	.	.	_	_	1	punct	_	_

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http://universaldependencies.org

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A universal grammar?

- Not in any strong sense, but hopefully in the sense of providing comparable concepts for meaningful cross-linguistic comparison

Manning's Law

The secret to understanding the design of UD is to realize that it is a very subtle compromise between approximately 6 things:

1. **UD needs to be satisfactory on linguistic analysis grounds for individual languages.**
2. **UD needs to be good for linguistic typology, i.e., providing a suitable basis for bringing out cross-linguistic parallelism across languages and language families.**
3. **UD must be suitable for rapid, consistent annotation by a human annotator.**
4. **UD must be suitable for computer parsing with high accuracy.**
5. **UD must be easily comprehended and used by a non-linguist, whether a language learner or an engineer with prosaic needs for language processing.**
6. **UD must support well downstream language understanding tasks (relation extraction, reading comprehension, machine translation, …).**

It's easy to come up with a proposal that improves UD on one of these dimensions. The interesting and difficult part is to improve UD while remaining sensitive to all these dimensions.

UD Events in 2017

Tutorial on Universal Dependencies

- Tutorial at EACL, April 4, 2017, Valencia, Spain

CoNLL-2017 Shared Task

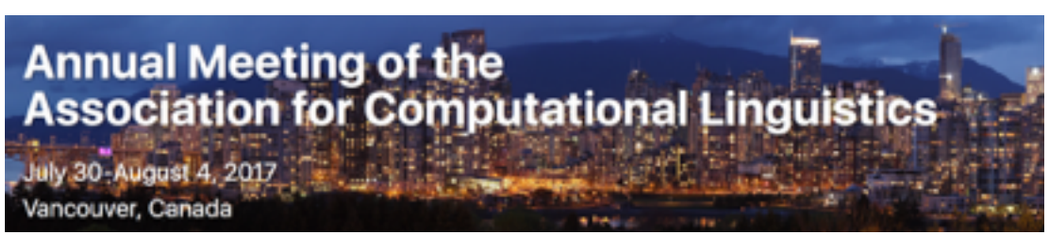
http://universaldependencies.org/conll17/

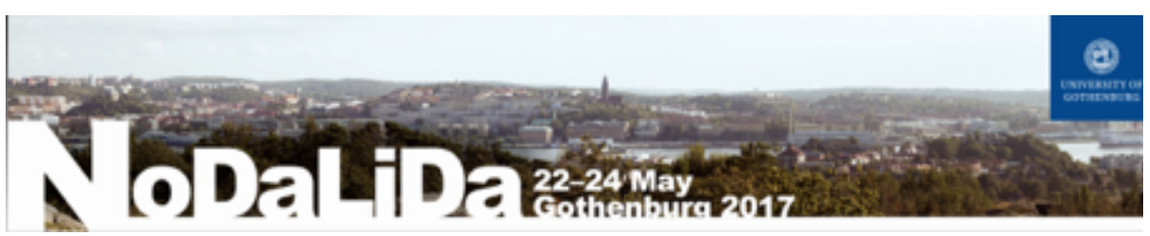
- Multilingual parsing from raw text to universal dependencies
- Collocated with ACL, August 3–4, 2017, Vancouver, Canada

First Workshop on Universal Dependencies

http://universaldependencies.org/udw17/

- Collocated with NoDaLiDa, May 20, 2017, Gothenburg, Sweden





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