



Dependency Grammars: Dependency and Non-Dependency Relations; Free Word Order

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Phrase structure vs. dependency tree

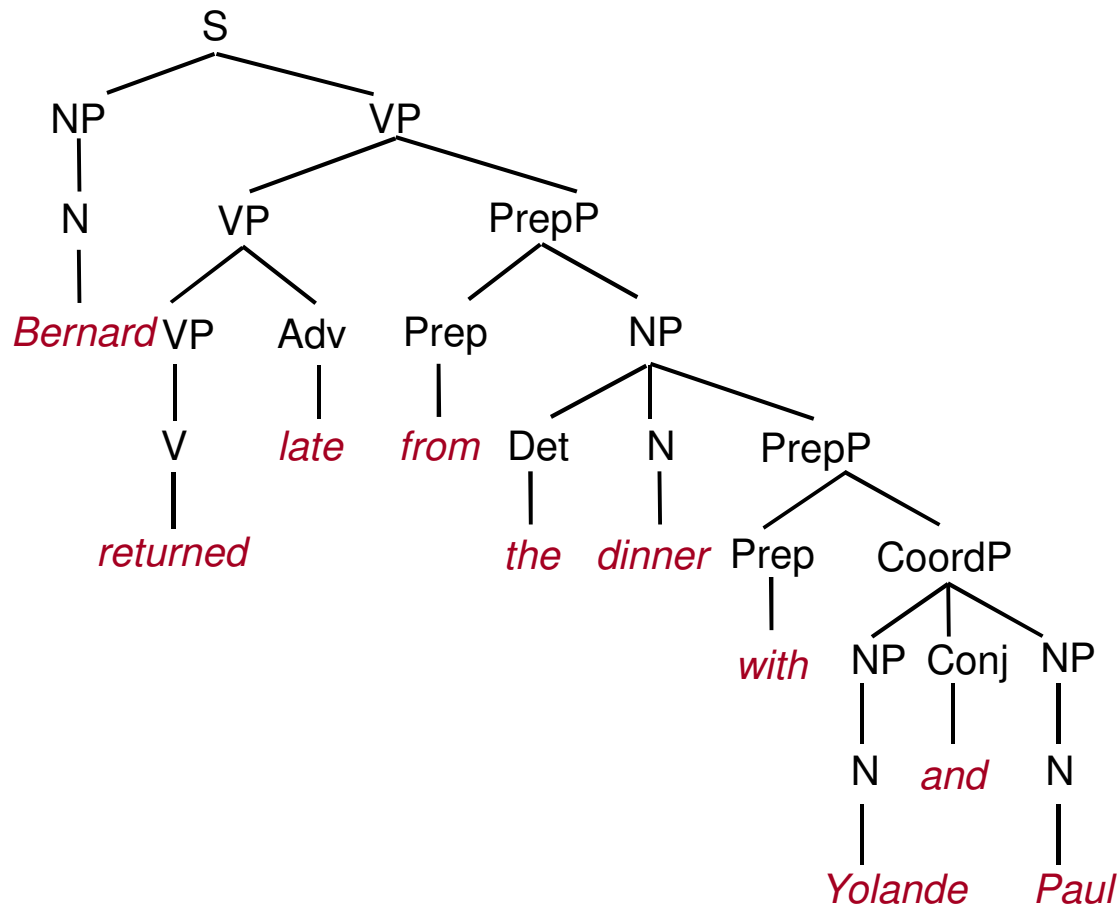
Bernard returned late from the dinner with Yolande and Paul.



Phrase structure vs. dependency tree



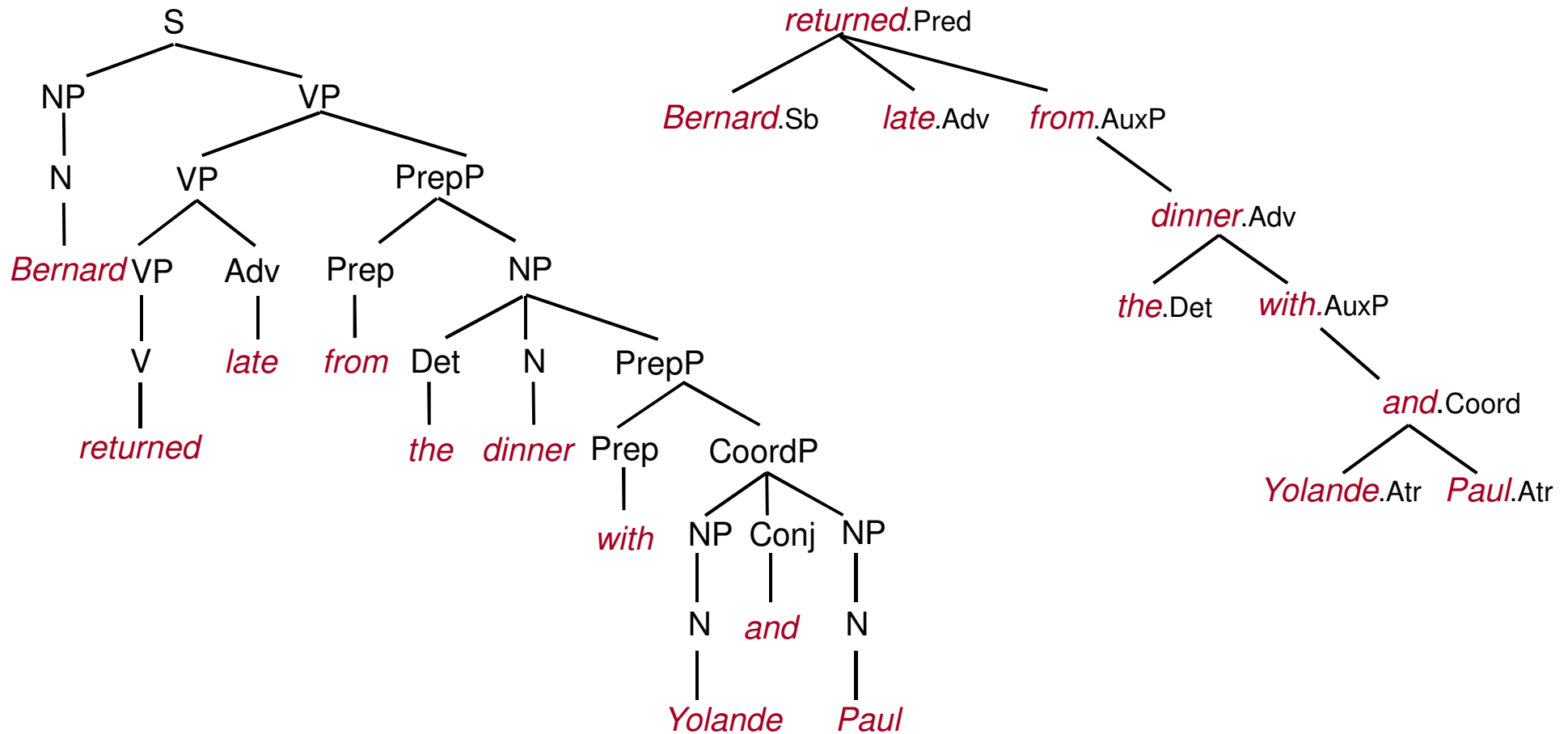
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Phrase structure vs. dependency tree



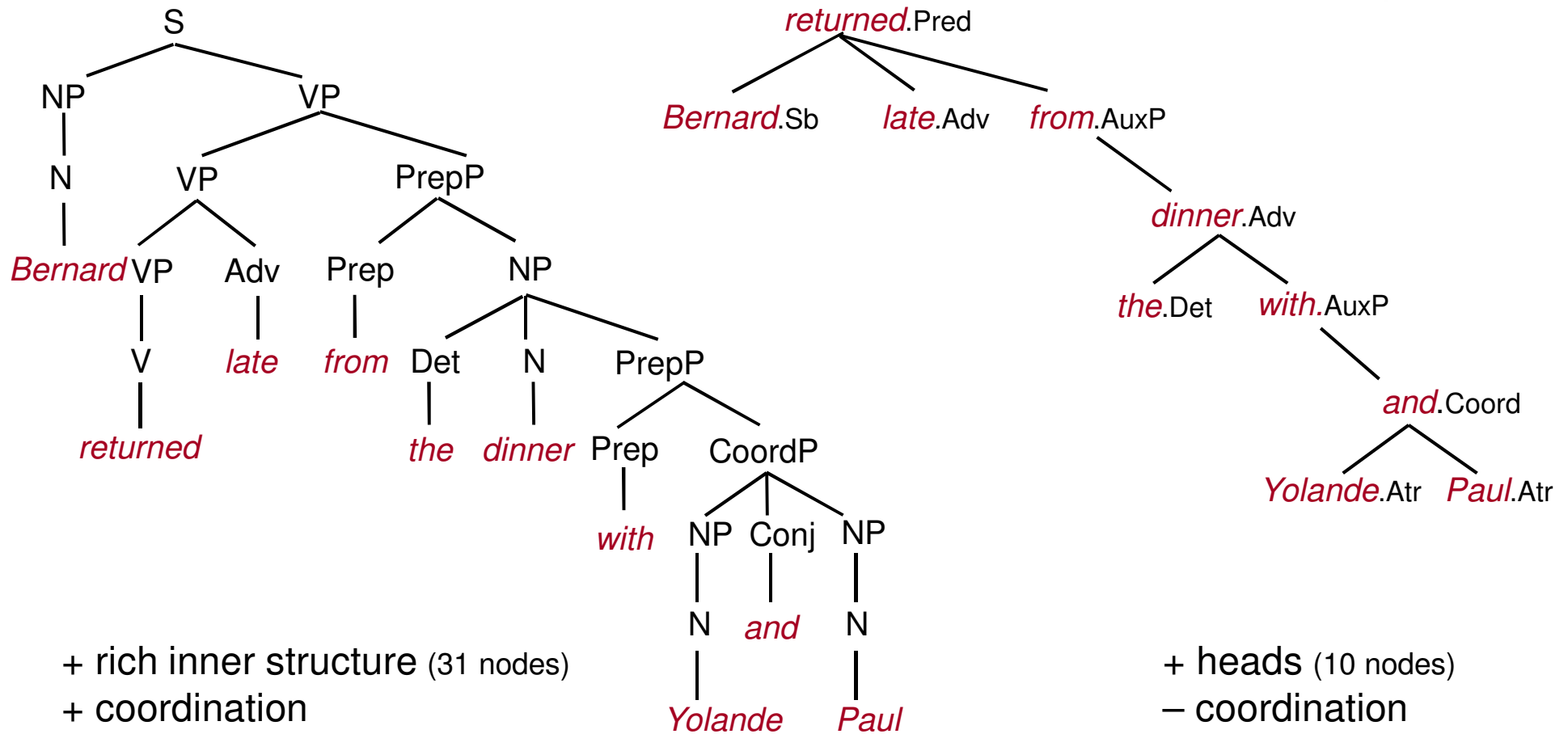
Bernard returned late from the dinner with Yolande and Paul.



Phrase structure vs. dependency tree



Bernard returned late from the dinner with Yolande and Paul.



- + rich inner structure (31 nodes)
- + coordination
- free word order

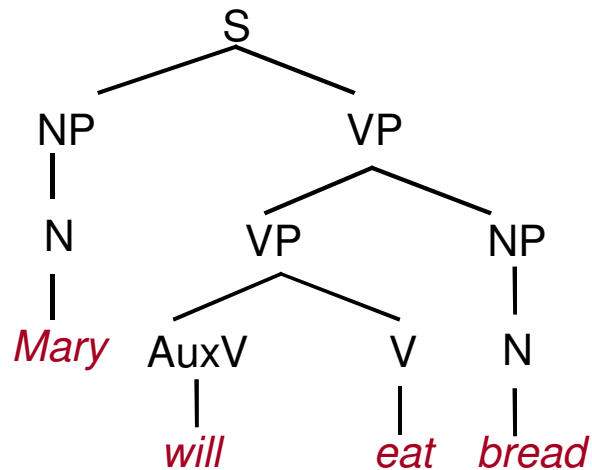
- + heads (10 nodes)
- coordination
- + free word order

Phrase structure vs. dependency tree

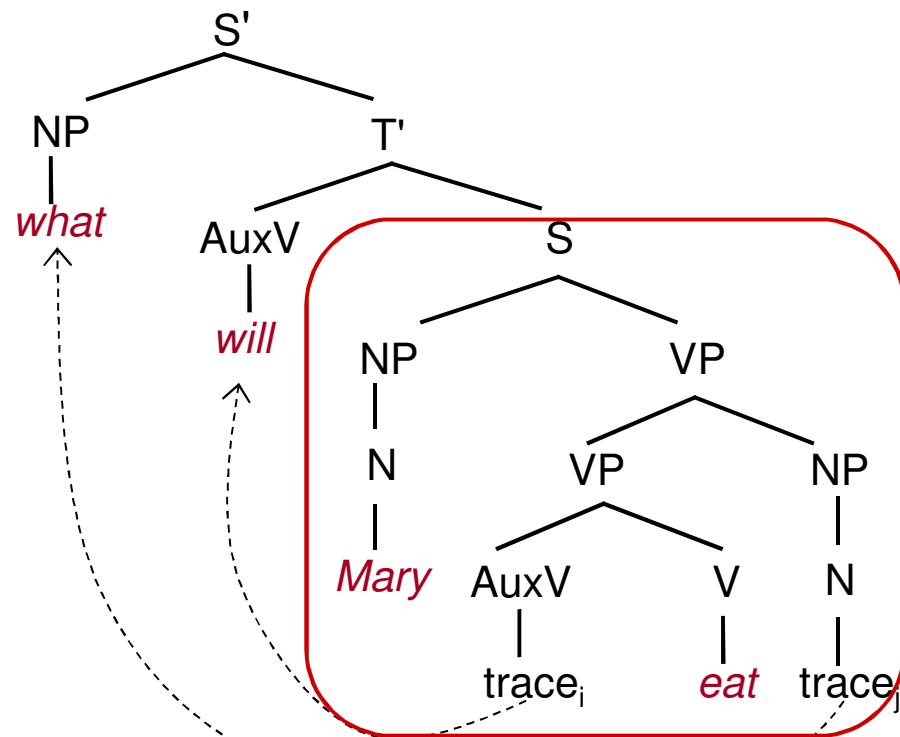


discontinuous 'phrases': solution for English

Mary will eat bread.



What will Mary eat?



Syntactic Dependencies



- principle of **lexicalization**
- based on dependencies as an asymmetric binary relations between language units
 - detecting heads: not commonly agreed criteria
 - possible reduction criterion
 - constituent-based criterion
 - criterion of maximal parallelism between languages
 - (finite) verb as the structural center of clause structure
 - a single "position" in a tree for a single syntactic function
(subject, direct object, indirect object, ...)
 - problem with **coordination** and other **non-dependency relations**

Non-Dependency Relations



coordination ... "multiplication" of a single syntactic position

- different referents
- coordination of sentence members / sentences

My sister Mary and John came late.

Mary came in time but John was late.

I can't leave since it hasn't stopped raining yet.

Nemohu odejít, neboť ještě nepřestalo pršet.

- coordination may be embedded

nice and romantic towers and castles

krásné a romantické hrady a zámky

Non-Dependency Relations



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apposition ... "multiplication" of a single syntactic position

- identical referent

Charles IV, Holy Roman Emperor

The Hobbit, or There and Back Again

George Washington, the first president of the United States

Non-Dependency Relations



coordination ... "multiplication" of a single syntactic position

- different referents
- coordination of sentence members / sentences
- coordination may be embedded

apposition ... "multiplication" of a single syntactic position

- identical referent

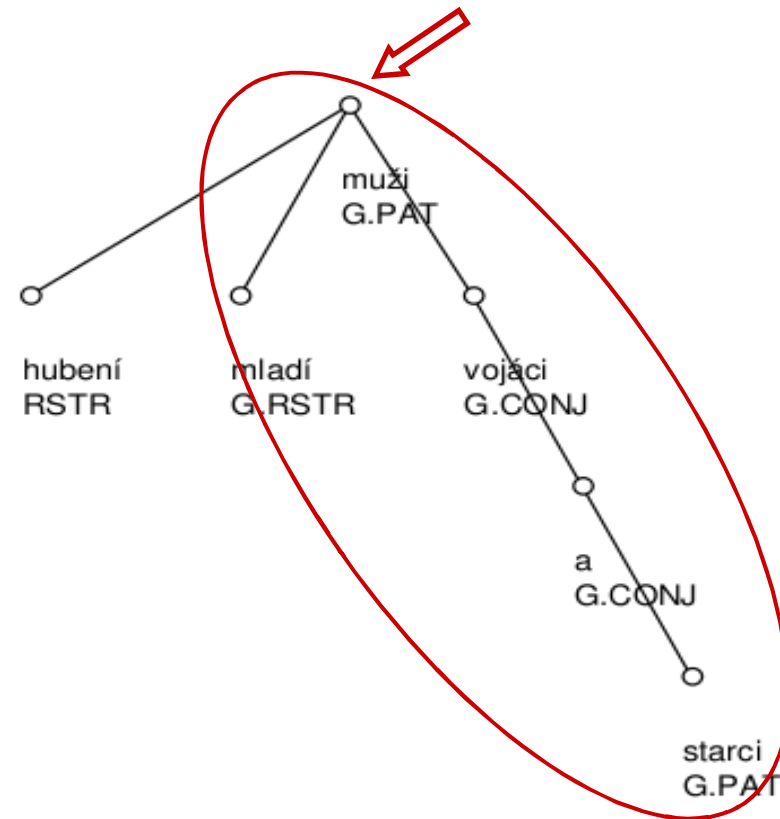
⇒ cannot be represented by dependency edges
necessary to enrich the data structure

Coordination in Dependency Trees I



Mel'čuk (1988):

- ‘grouping’ (G) ... treating the first conjunct as the head
- problem:
shared modification
vs. modification of a single member



Hubení ((mladí muži) , vojáci a starci)
[Thin young men, soldiers and old-men]

Coordination in Dependency Trees II

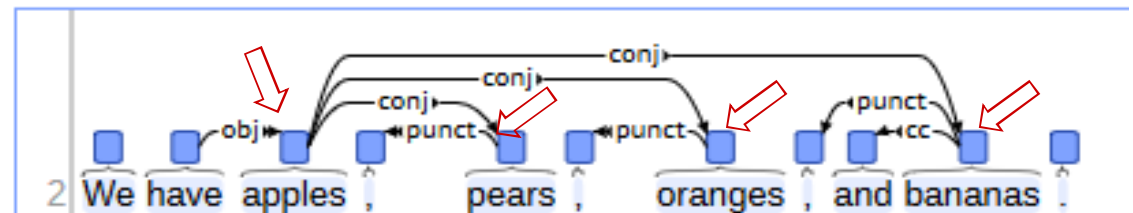
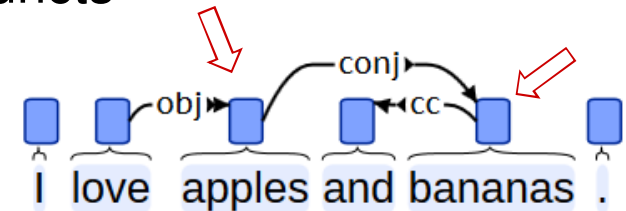


Universal Dependencies:

version 2 (2016):

- the *first conjunct* ~ the head of all following conjuncts

i.e., "left-headed" principle



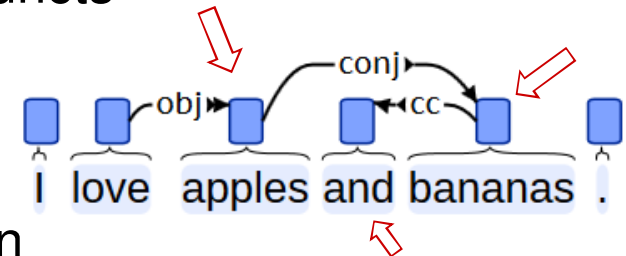
Coordination in Dependency Trees II



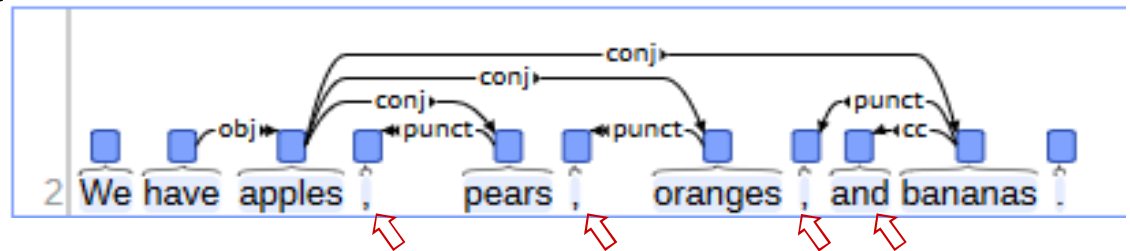
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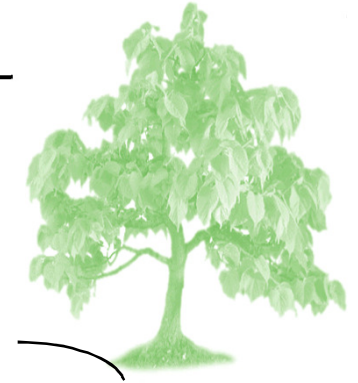
- the *first conjunct* ~ the head of all following conjuncts



- attach coordinating conjunctions and punctuation to the immediately succeeding conjunct



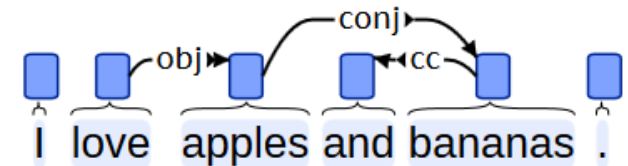
Coordination in Dependency Trees II



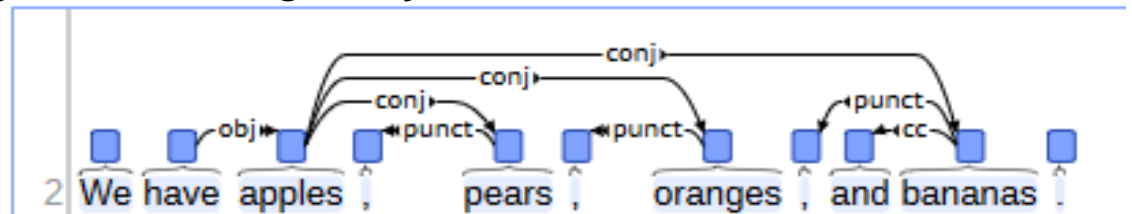
Universal Dependencies:

version 2 (2016):

- the *first conjunct* ~ the head of all following conjuncts



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- BUT: right-headed constructions

e.g., *one green and two red cars*

green as a (promoted) head (and *cars* as dependent)

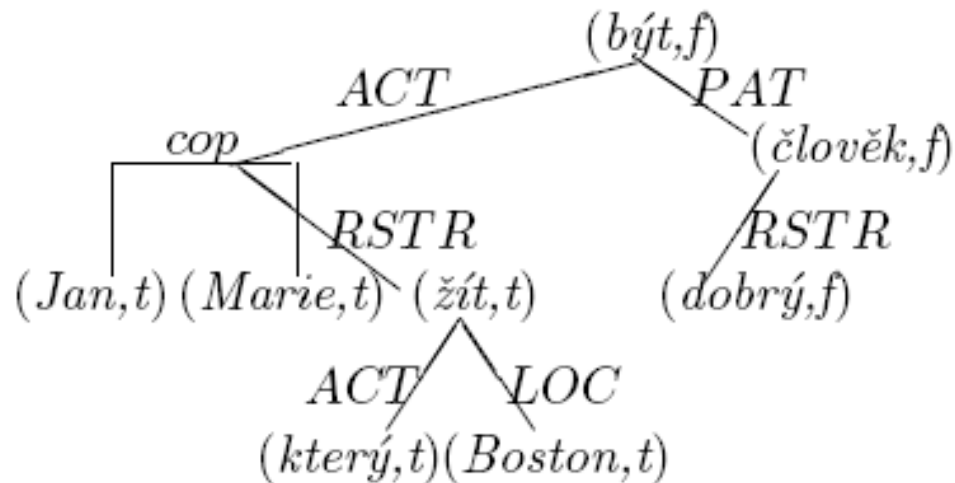


Coordination in Dependency Trees III



Petkevič (1995) ... formal representation of FGD
two types of brackets for tree linearization:

- $\langle \rangle$ for dependencies
- $[]$ for coordination



$\langle [(Jan, t); (Marie, t)]_{cop} RSTR \langle \langle (který, t) \rangle_{ACT} (žít, t) LOC \langle (Boston, t) \rangle \rangle_{ACT} (být, f) PAT \langle \langle (dobrý, f) \rangle_{RSTR} (člověk, f) \rangle$

John and Mary, who live in Boston, are good people.

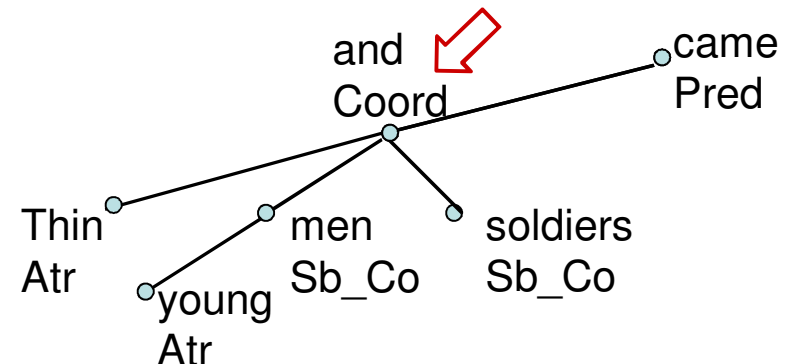
Coordination in Dependency Trees IV



PDT 2.0:

'connecting' constructions ~ coordination, apposition (, OPER)
specific types of nodes and edges:

- *connecting node* = node for coordinating / apposing conjunction



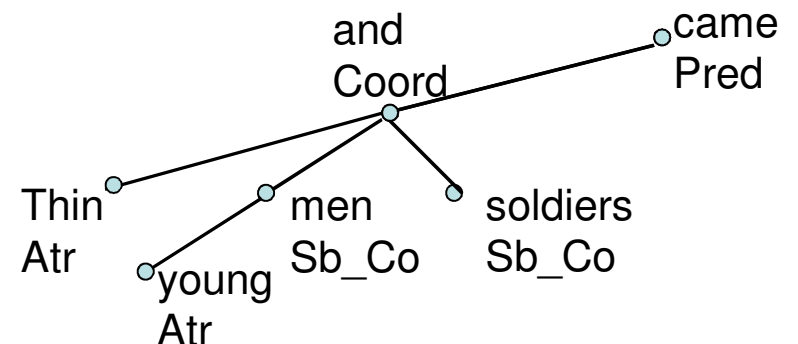
Coordination in Dependency Trees IV



PDT 2.0:

'connecting' constructions ~ coordination, apposition (, OPER)
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- *connecting node* = node for coordinating / apposing conjunction
- *members of a connecting construction* = nodes that are coordinated / are in apposition
 - `is_member`
- *effective parent* = node for governing node, i.e. node modified by the whole construction, 'linguistic parent'
- *effective child(ren)* ... modification(s) of the individual member of the connecting construction + common/shared modifier(s)



Coordination in Dependency Trees IV

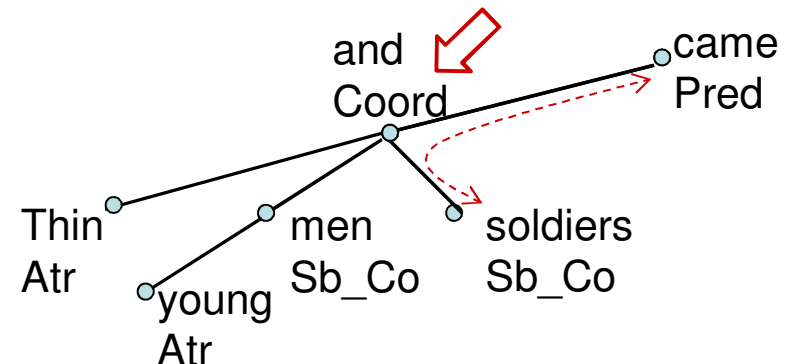


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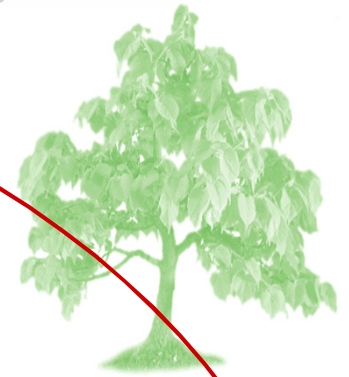
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- *"pass-through" nodes*



a-ln94200-33-p3s1
AuxS



AuxK

Centrum Sb
bude AuxV
shromažďovat Pred_Co
distribuovat Pred_Co
informace Obj

AuxP

tendrech Atr_Co
zakázkách Atr_Co
i Coord

státních Atr
doma Atr_Co
v AuxP

zahraničí Atr_Co

Centrum bude shromažďovat a distribuovat informace o tendrech a státních zakázkách doma i v zahraničí.

The center will gather and distribute the information on tenders and state commissions in this country as well as in abroad.

Coordination in Dependency Trees IV



PDT 2.0:

- embedded connecting constructions  recursivity

- *TrEd* (Tree Editor, Pajas):

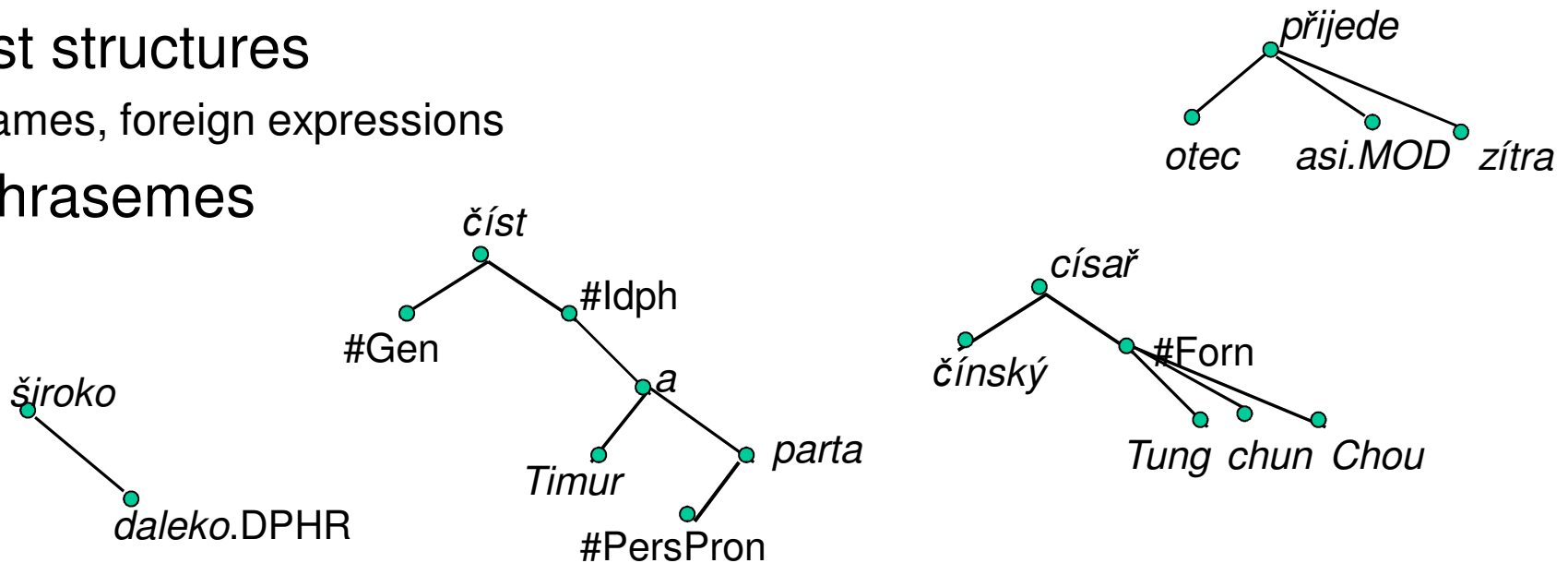
functions `GetEChildren`, `GetEParents`

Dependency and non-dependency relations



other non-dependency relations in PDT:

- technical root – effective root of a sentence
- syntactically unclear expressions
rhematizers; sentence, linking and modal adverbial expressions, conjunction modifiers
- list structures
names, foreign expressions
- phrasemes



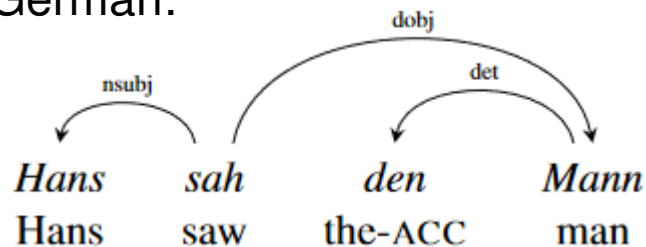
Problem with Free Word Order



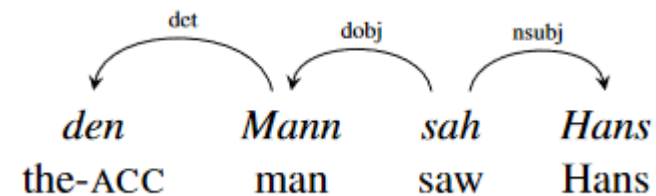
free word order:

- freedom of word order of dependents within a continuous ‘head domain’ (i.e., substring of head + its dependents)

German:



examples stolen from (Futrell et al., 2015)



Czech:

Hans.nom *viděl* *toho*.acc *člověka*.acc

toho.acc *člověka*.acc *viděl* *Hans*.nom

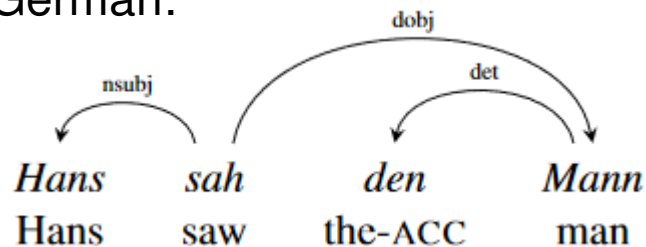


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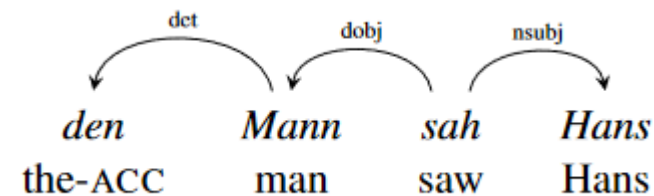
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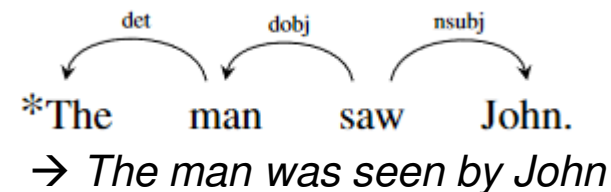
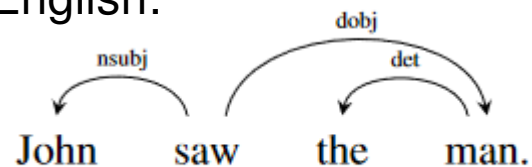


Czech:

Hans.nom *viděl* *toho*.acc *člověka*.acc

toho.acc *člověka*.acc *viděl* *Hans*.nom

English:



Problem with Free Word Order



free word order:

- relaxation of continuity of a head domain

English: long-distance unbounded dependency

John, Peter thought that Sue said that Mary loves.

A dependency arcs diagram for the sentence "John, Peter thought that Sue said that Mary loves." The diagram shows a long-distance dependency between "John" and "loves" highlighted in red. Other dependencies are shown in black: "Peter" is connected to "thought", "Sue" to "said", and "Mary" to "loves". The arcs are represented by horizontal lines with vertical lines connecting them to the words they span.

Problem with Free Word Order



free word order:

- relaxation of continuity of a head domain

English: long-distance unbounded dependency

John, Peter thought that Sue said that Mary loves.

A dependency parse tree for the English sentence "John, Peter thought that Sue said that Mary loves." The root node is "loves", which dominates "Mary" and "loves". "loves" also dominates "said", which dominates "Sue", which dominates "thought", which dominates "Peter", which dominates "John". The word "that" is shown as a filler word between "Sue" and "said".

Czech:

Marii se Petr tu knihu rozhodl nekoupit.
to-Mary PART Peter that book decided not-buy
'Peter decided not to buy that book to Mary.'

A dependency parse tree for the Czech sentence "Marii se Petr tu knihu rozhodl nekoupit." The root node is "rozhodl", which dominates "Petr" and "rozhodl". "rozhodl" also dominates "nekoupit", which dominates "knihu". "rozhodl" also dominates "se", which dominates "Marii". "rozhodl" also dominates "tu", which dominates "Petr". The word "that" is shown as a filler word between "Petr" and "knihu".



Problem with Free Word Order

free word order:

- relaxation of continuity of a head domain

English: long-distance unbounded dependency

John, Peter thought that Sue said that Mary loves.

A dependency parse tree for the English sentence "John, Peter thought that Sue said that Mary loves." The root node is "loves" (Mary loves). It branches to "said" (Sue said) and "thought" (Peter thought). "said" branches to "that" (Sue said that) and "loves" (Mary loves). "thought" branches to "John" and "said" (Peter thought that). "that" branches to "that" (Sue said that) and "loves" (Mary loves). "loves" branches to "Mary" and "loves" (Mary loves).

Czech:

Marii se Petr tu knihu rozhodl nekoupit.
to-Mary PART Peter that book decided not-buy
'Peter decided not to buy that book to Mary.'

A dependency parse tree for the Czech sentence "Marii se Petr tu knihu rozhodl nekoupit." The root node is "rozhodl" (Peter decided). It branches to "nekoupit" (not-buy) and "se" (PART). "nekoupit" branches to "knihu" (book) and "rozhodl" (Peter decided). "se" branches to "Marii" (to-Mary) and "rozhodl" (Peter decided). "rozhodl" branches to "Petr" and "rozhodl" (Peter decided). "knihu" branches to "knihu" (book) and "rozhodl" (Peter decided). "rozhodl" branches to "rozhodl" (Peter decided) and "rozhodl" (Peter decided).

German:

Maria hat einen Mann kennengelernt der Schmetterlinge sammelt.
Mary has a man met the butterflies collects
'Mary has met a man who collects butterflies.'

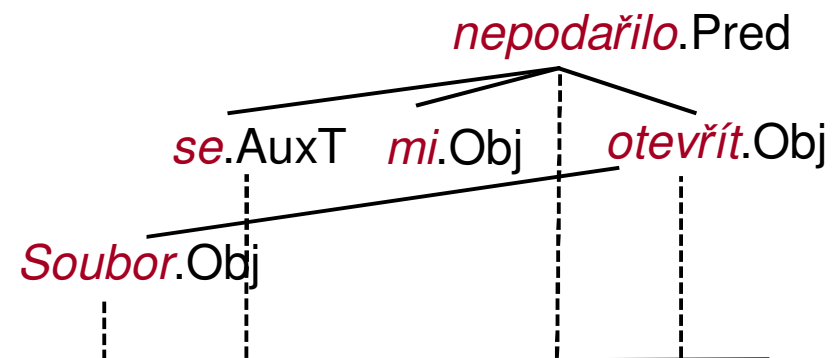
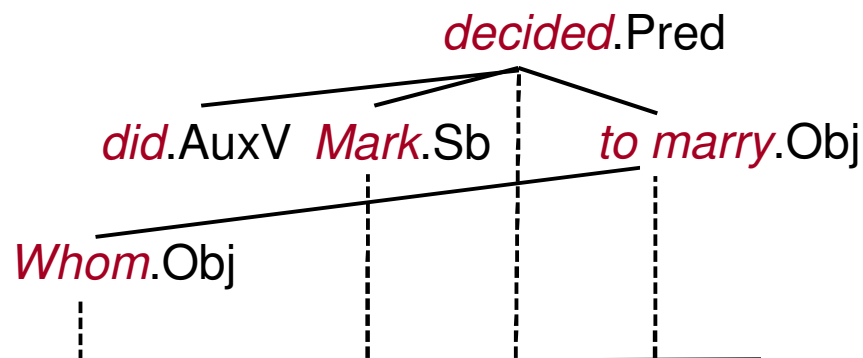
A dependency parse tree for the German sentence "Maria hat einen Mann kennengelernt der Schmetterlinge sammelt." The root node is "sammelt" (collects). It branches to "kennengelernt" (met) and "der" (the). "kennengelernt" branches to "einen" (a) and "kennengelernt" (met). "der" branches to "Mann" (man) and "kennengelernt" (met). "sammelt" branches to "Schmetterlinge" (butterflies) and "sammelt" (collects). "sammelt" branches to "sammelt" (collects) and "sammelt" (collects).

Projectivity and non-projectivity (definition)



Whom did Mark decide to marry?

Soubor se mi nepodařilo otevřít. (Oliva)



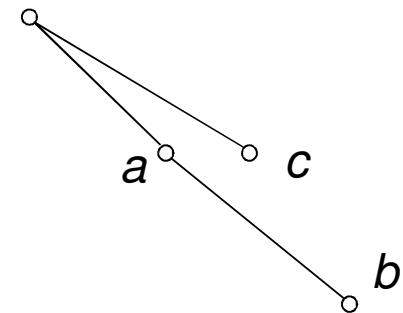
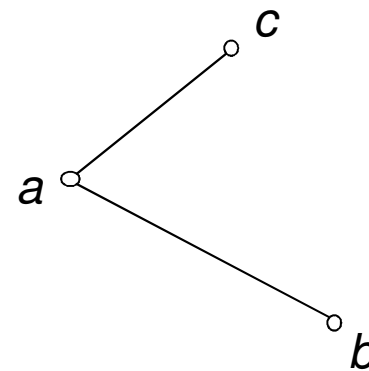
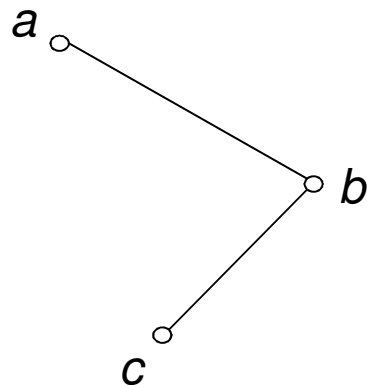
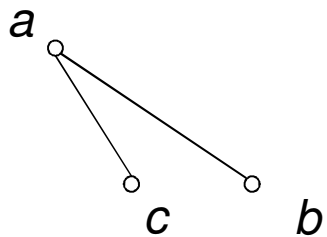
Projectivity and non-projectivity (definition)



(Marcus, 1965), (Harper & Hays)

A subtree S of a rooted dependency tree T is *projective* iff for all nodes a , b and c of the subtree S the condition holds:

$$(a \leq_D b) \wedge [(a <_{WO} c <_{WO} b) \vee (b <_{WO} c <_{WO} a)] \\ \Rightarrow (a <_D^* c)$$

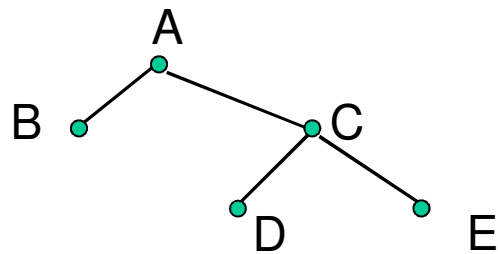


Projectivity and non-projectivity



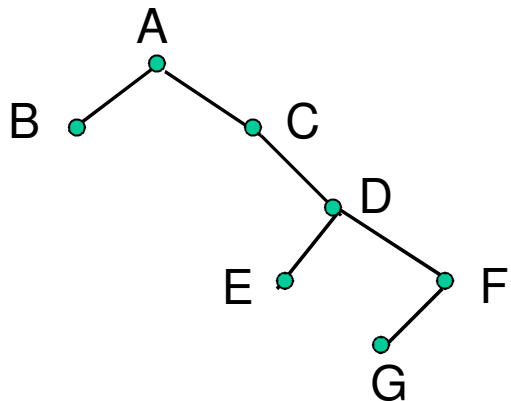
Projective dependency trees can be encoded by *linearization*:

- string of nodes, edges ~ brackets



A (B C (D E)) without WO ordering

(B) A ((D) C (E)) with WO

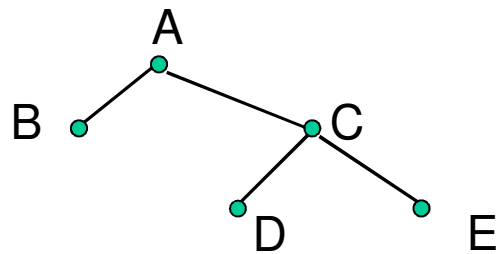


Projectivity and non-projectivity

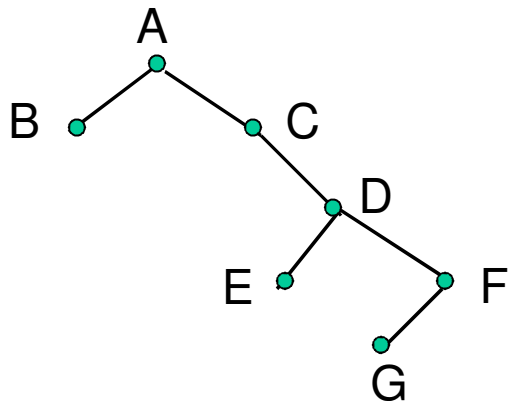


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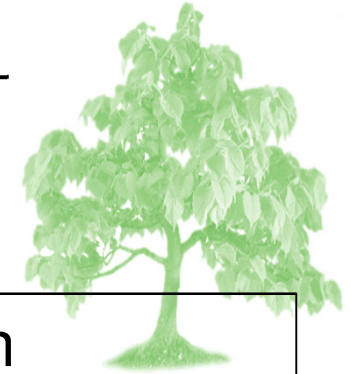


A (B C (D E)) without WO ordering
(B) A ((D) C (E)) with WO



A (B C (D (E F (G)))) without WO
(B) A (C ((E) D ((G) F))) with WO

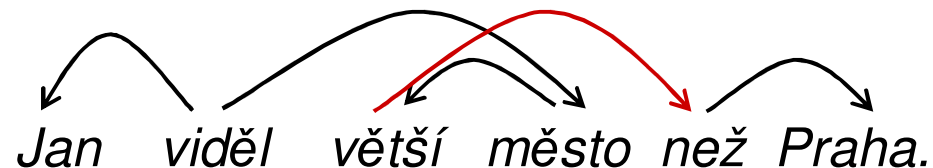
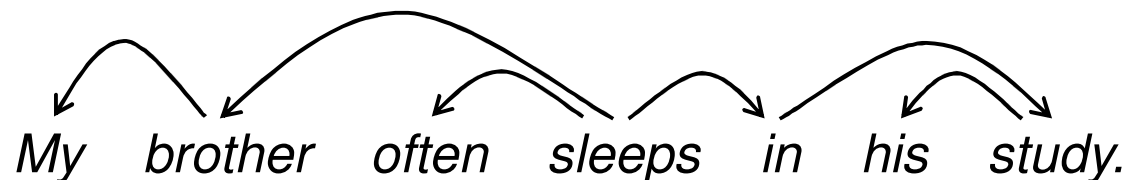
Planarity



A dependency graph T is *planar*, if it does *not* contain nodes a, b, c, d such that:

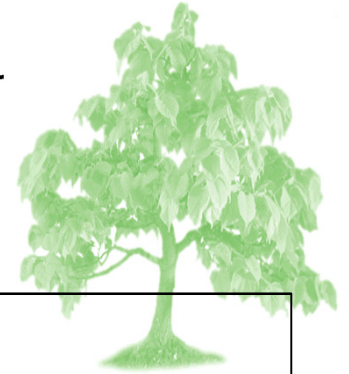
$$\textit{linked}(a,c) \ \& \ \textit{linked}(b,d) \ \& \ a <_{\text{WO}} b <_{\text{WO}} c <_{\text{WO}} d$$

linked(i,j) ... ‘there is an edge in T from i to j , or vice versa’



Informally, a dependency graph is planar, if its edges can be drawn above the sentence without crossing.

Planarity vs. projectivity

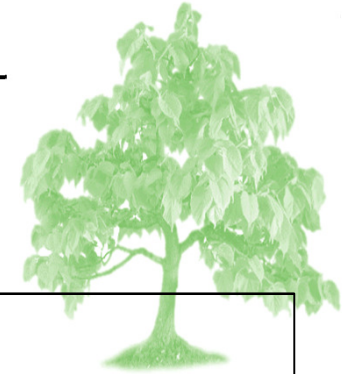


projectivity \Rightarrow planarity

projectivity $\stackrel{?}{\Leftarrow}$ planarity

(Kuhlmann, M., Nivre, J., 2006)

Planarity vs. projectivity



projectivity \Rightarrow planarity

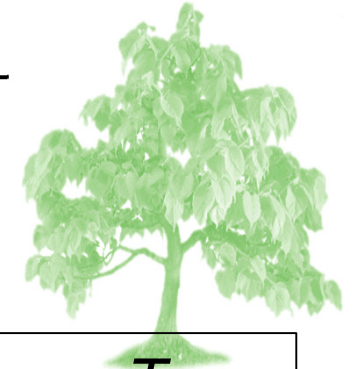
projectivity \nLeftarrow planarity

(Kuhlmann, M., Nivre, J., 2006)

Soubor se mi nepodařilo otevřít.

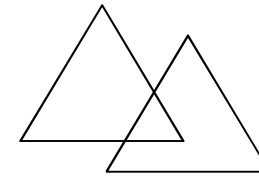
The sentence "Soubor se mi nepodařilo otevřít." is shown with dependency arcs. A red arc connects "Soubor" and "otevřít". Black arcs connect "se" to "nepodařilo", "mi" to "nepodařilo", and "nepodařilo" to "otevřít".

‘Well-Nestedness’

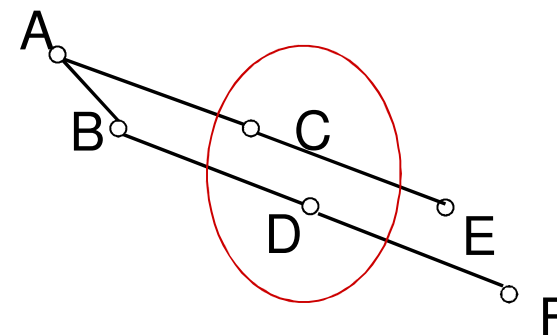
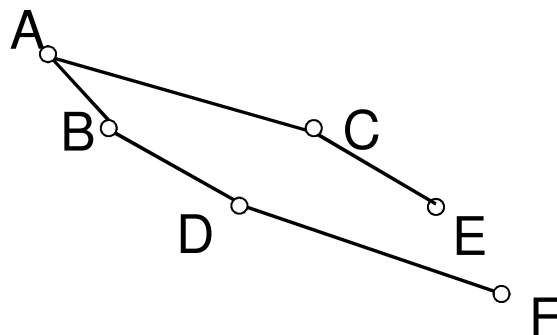


Two subtrees T_1, T_2 *interleave*, if there are nodes $l_1, r_1 \in T_1$ and $l_2, r_2 \in T_2$ such that

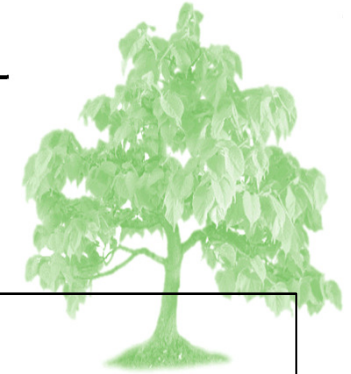
$$l_1 <_{WO} l_2 <_{WO} r_1 <_{WO} r_2$$



A dependency graph is *well-nested*, if no two of its disjoint subtrees interleave.’



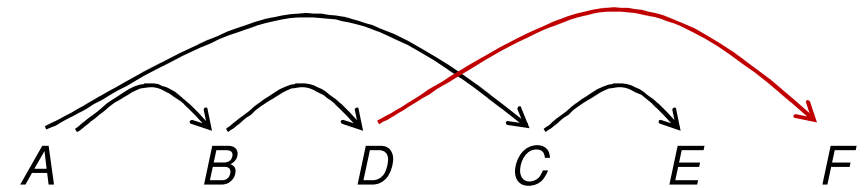
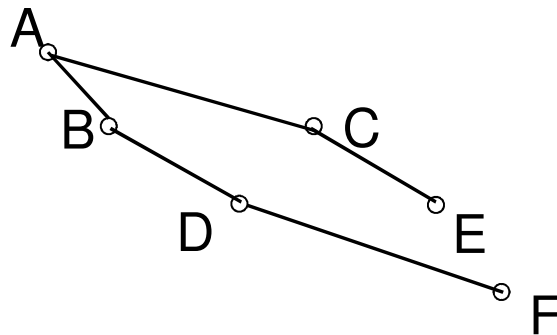
Planarity vs. projectivity



projectivity \Rightarrow planarity \Rightarrow well-nestedness

projectivity $\not\Leftarrow$ planarity $\not\Leftarrow$ well-nestedness

(Kuhlmann, M., Nivre, J., 2006)

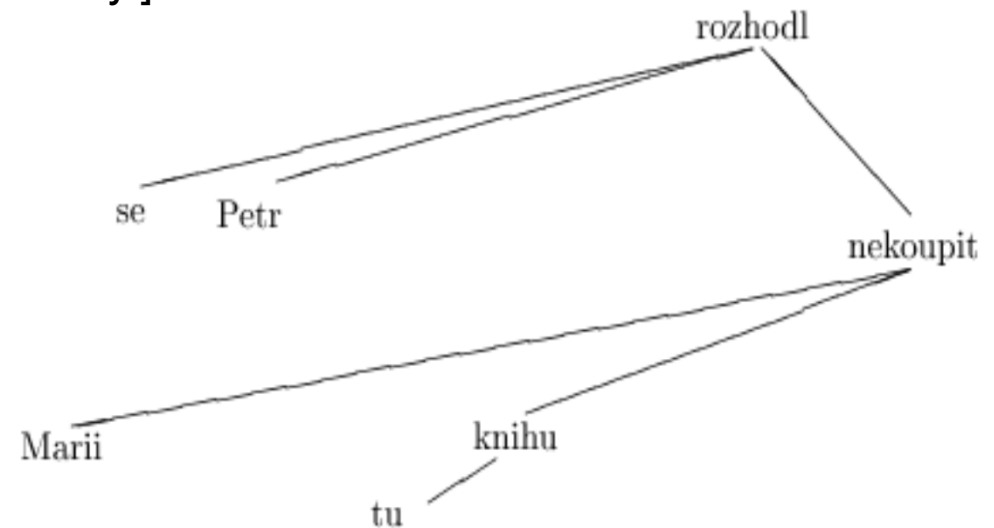


Projectivity and free word order

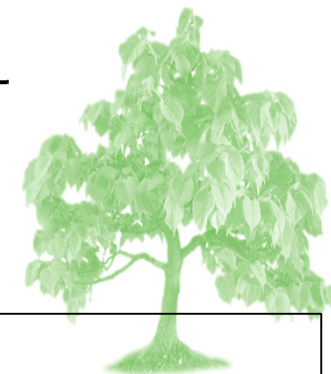


Czech:

Marii se Petr tu knihu rozhodl nekoupit.
to-Mary PART Peter that book decided not-buy
[Peter decided not to buy that book to Mary.]



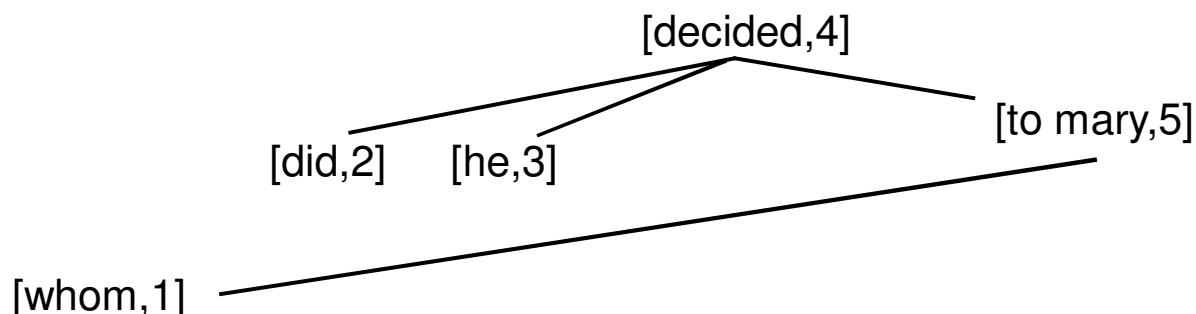
Gap Degree $gd(T)$



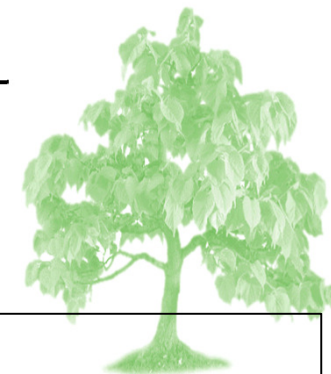
Coverage of a node $u \in T$

$Cov(u, T) = \{ i \mid i \text{ - word order position of } v \in T \text{ such that, } u \leq_D v \}$

$Cov(u_1, T) = \{ 1 \}$; $Cov(u_2, T) = \{ 2 \}$; $Cov(u_3, T) = \{ 3 \}$; $Cov(u_4, T) = \{ 1, 2, 3, 4, 5 \}$; $Cov(u_5, T) = \{ 1, 5 \}$



Gap Degree $gd(T)$



Coverage of a node $u \in T$

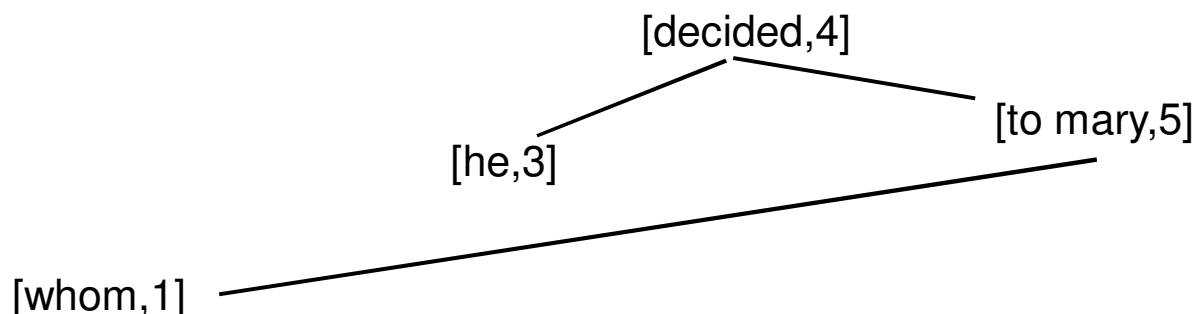
$Cov(u, T) = \{ i \mid i \text{ - word order position of } v \in T \text{ such that, } u \leq_D v \}$

Gap in Coverage of a node $u \in T \iff_{\text{def}} Cov(u, T)$ is not an interval

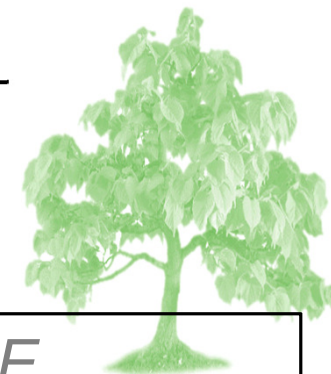
$gd(u, T)$... **number of Gaps** in $Cov(u, T)$

Tree Gap Degree $gd(T) = \max \{gd(u, T) \mid u \in T\}$

$Cov(u_1, T) = \{1\}$; $Cov(u_2, T) = \{2\}$; $Cov(u_3, T) = \{3\}$; $Cov(u_4, T) = \{1, 2, 3, 4, 5\}$; $Cov(u_5, T) = \{1, 5\}$



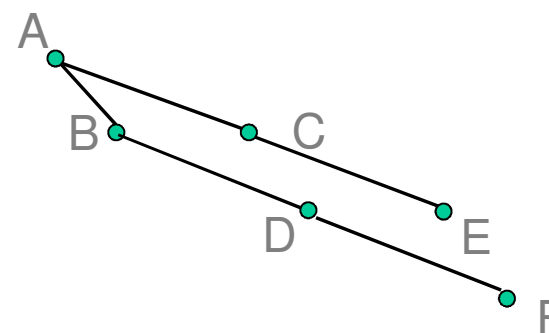
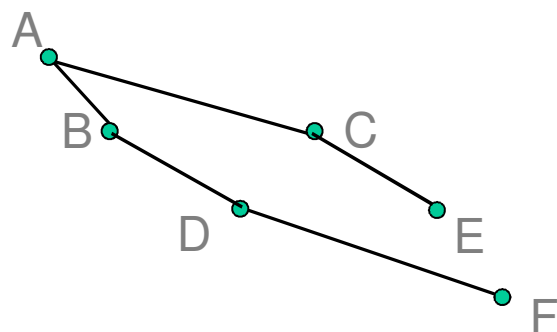
Edge Degree $ed(T)$



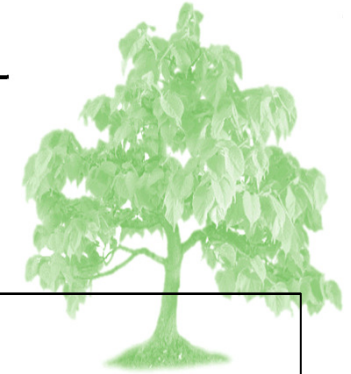
Let $T = (N, E)$ dependency tree, $e = [i, j]$ an edge in E , T_e the subgraph of T induced by the nodes contained in the span of e .

Degree of an edge $ed \in E$, $ed(e)$, is the number of connected components c in T_e such that the root of c is not dominated by the head of e .

Edge degree of T , $ed(T) \dots \max \{ed(e) \mid e \in T\}$



Planarity vs. projectivity



projectivity \Rightarrow planarity \Rightarrow well-nestedness

projectivity $\not\Leftarrow$ planarity $\not\Leftarrow$ well-nestedness

$gd(T) = 0 \Leftrightarrow ed(T) = 0 \Leftrightarrow$ projectivity

well-nestedness ... independent from gap/edge degree

$\forall d > 0$: there exist well-nested and non-well-nested trees such that $gd(T) = d$ and $ed(T) = d$

(Kuhlmann, M., Nivre, J., 2006)



property	DDT		PDT	
<i>all structures</i>	<i>n</i> = 4393		<i>n</i> = 73088	
gap degree 0	3732	84.95%	56168	76.85%
gap degree 1	654	14.89%	16608	22.72%
gap degree 2	7	0.16%	307	0.42%
gap degree 3	–	–	4	0.01%
gap degree 4	–	–	1	< 0.01%
edge degree 0	3732	84.95%	56168	76.85%
edge degree 1	584	13.29%	16585	22.69%
edge degree 2	58	1.32%	259	0.35%
edge degree 3	17	0.39%	63	0.09%
edge degree 4	2	0.05%	10	0.01%
edge degree 5	–	–	2	< 0.01%
edge degree 6	–	–	1	< 0.01%
projective	3732	84.95%	56168	76.85%
planar	3796	86.41%	60048	82.16%
well-nested	4388	99.89%	73010	99.89%
<i>non-projective structures only</i>	<i>n</i> = 661		<i>n</i> = 16920	
planar	64	9.68%	3880	22.93%
well-nested	656	99.24%	16842	99.54%

Kuhlmann, M., Nivre, J.
(2006)

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- Prague Dependency Treebank <http://ufal.mff.cuni.cz/pdt3.5>