Prague Dependency Treebank:

Introduction – (Non-)Projectivity

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Dependency tree (definition)

$T = \langle N, D, Q, WO, L \rangle$

⟨N, D⟩ … ***rooted tree***

Q ... lexical and grammatical categories

L … labeling function N → Q

D … oriented edges ~ relation on lex. and gram. categories

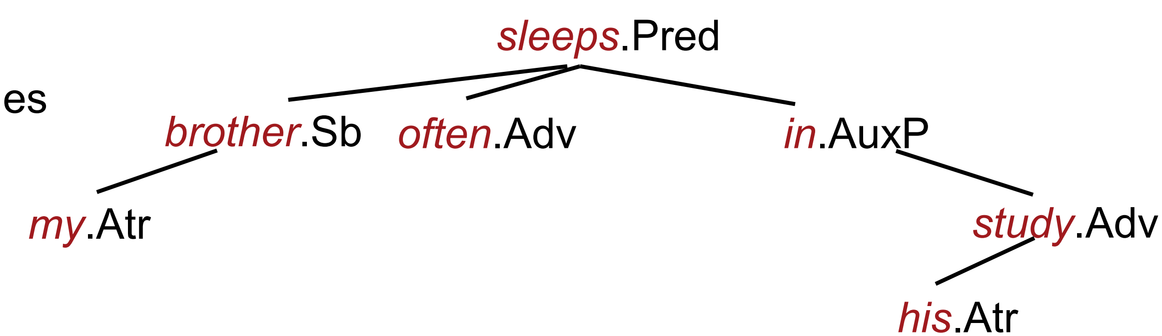
'dependency' relation

WO ... relation on N ~ (strong total ordering on N) …

word order

rooted tree

- finite graph
- no cycles, no loops
- max 1 edge between 2 diff. nodes
- root



Projectivity and non-projectivity (definition)

Whom Mark decided to marry?

Soubor se nepodařilo otevřít. (Oliva)

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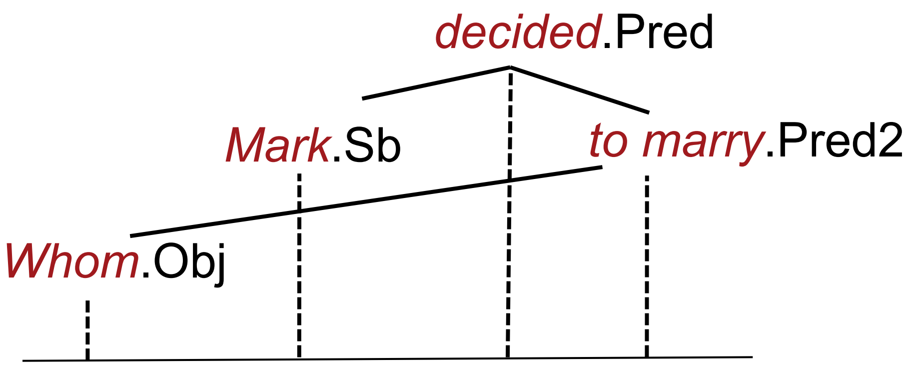

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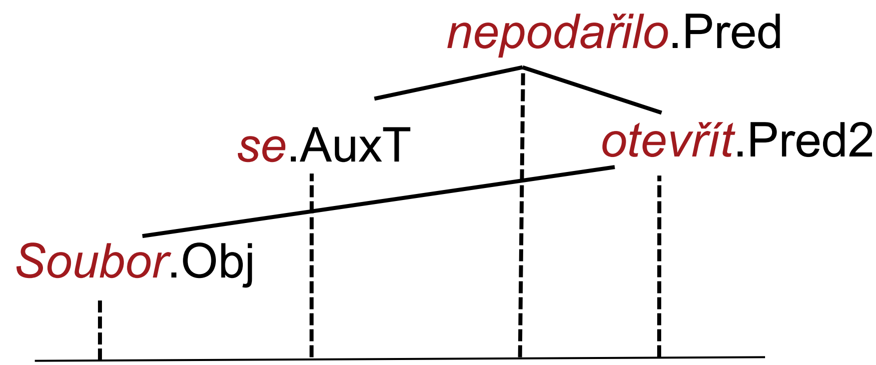


Projectivity and non-projectivity (definition)

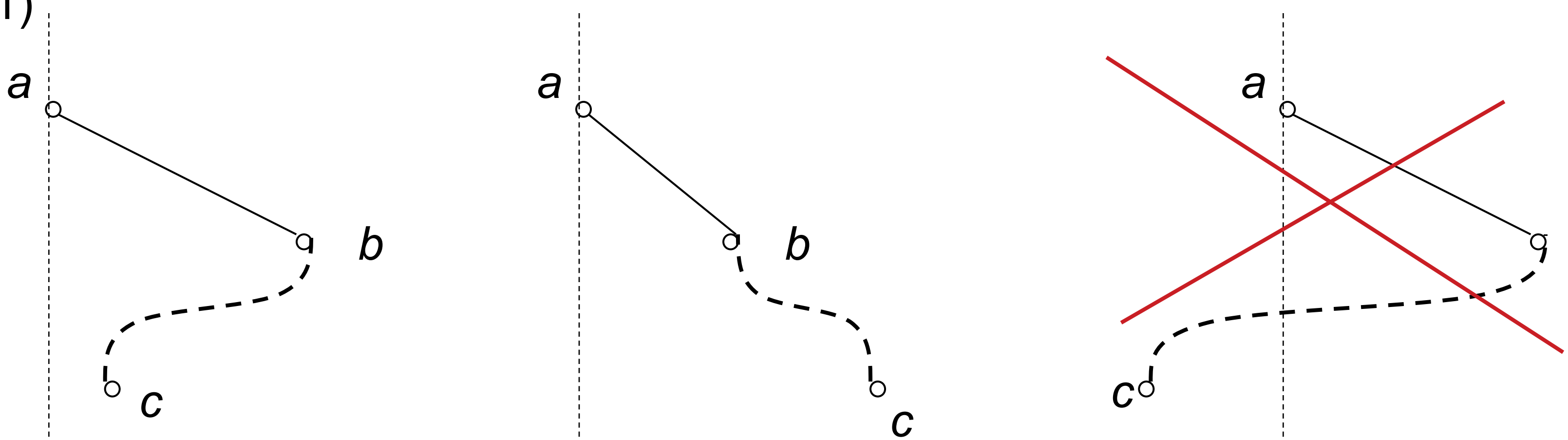
A subtree *S* of a rooted dependency tree *T* is *projective* iff for all nodes *a*, *b* and *c* of the subtree *S* the condition holds:

$$(1)\quad (a \leq_D b) \;\&\; (a <_{WO} b) \;\&\; (b \leq_D^{*} c) \;\Rightarrow\; (a <_{WO} c)$$

<u>and</u>

$$(2)\quad (a \leq_D b) \;\&\; (b <_{WO} a) \;\&\; (b \leq_D^{*} c) \;\Rightarrow\; (c <_{WO} a)$$

(1)



Projectivity and free word order

free word order:

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

Projectivity and free word order

free word order:

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

German:
Maria hat einen Mann kennengelernt der Schmetterlinge sammelt.
Mary - has - a man - met - the butteries - collects
Mary has met a man who collects butteries

Projectivity and free word order

English: long-distance unbounded dependency
John, Peter thought that Sue said that Mary loves.

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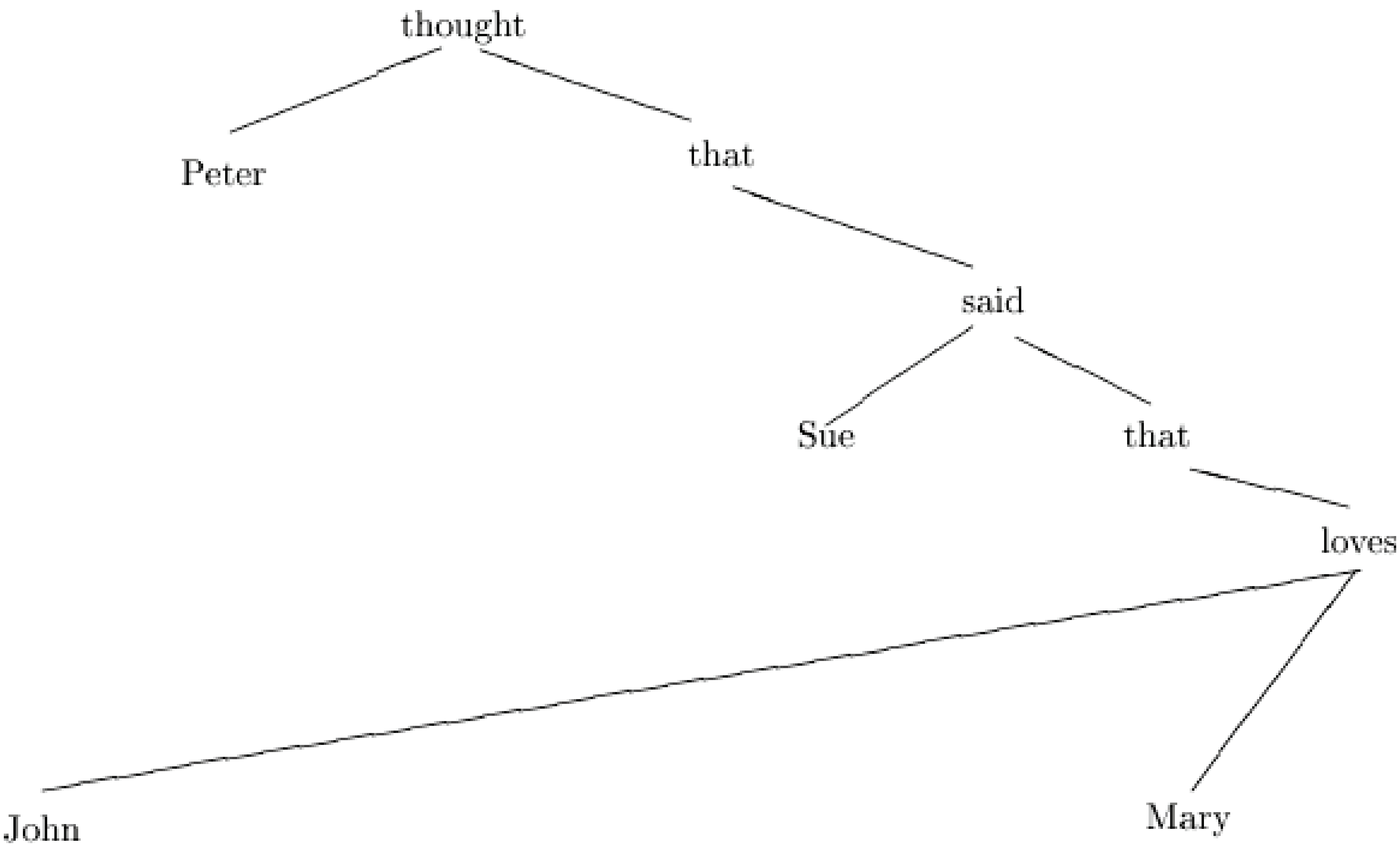
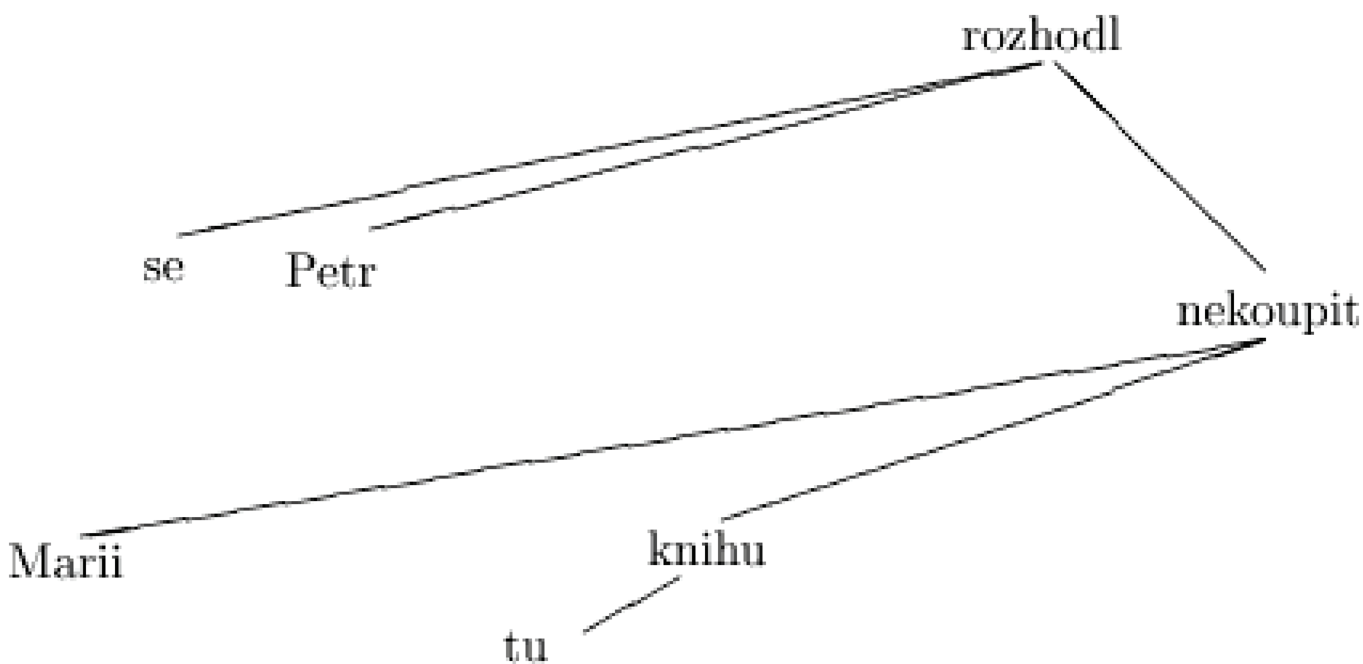


Projectivity and free word order

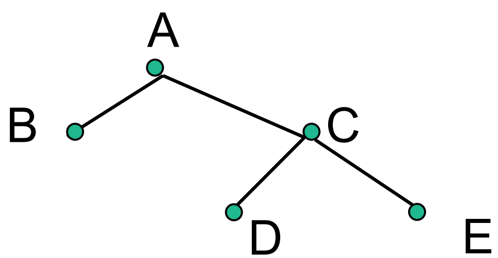
Czech:
Marii se Petr tu knihu rozhodl nekoupit.
to-Mary PART Peter that book decided not-buy
[Peter decided not to buy that book to Mary.]



Projectivity and non-projectivity

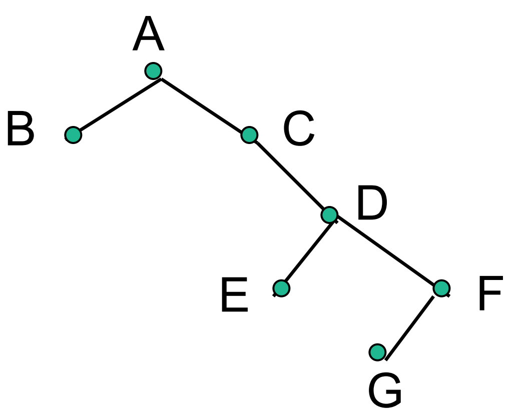
Projective dependency trees can be encoded by *linearization*:

- string of nodes, edges ~ brackets



A (B C (D))   without WO ordering

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



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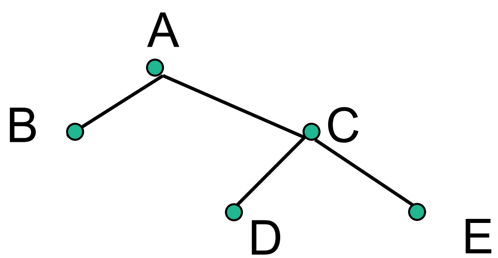

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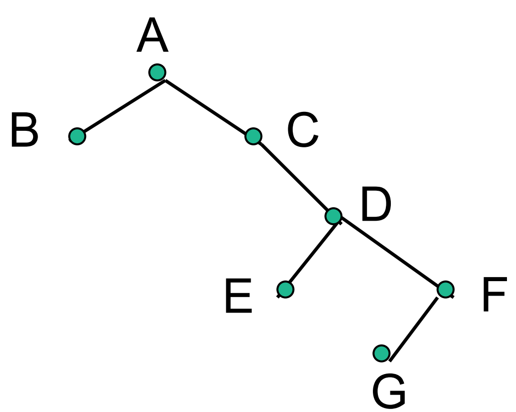


A (B C (D (E F (G))))   without WO

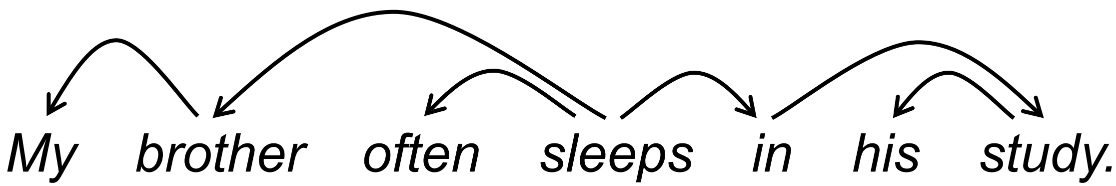
(B) A (C ((E) D ((G) F)))   with WO

Planarity

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

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

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



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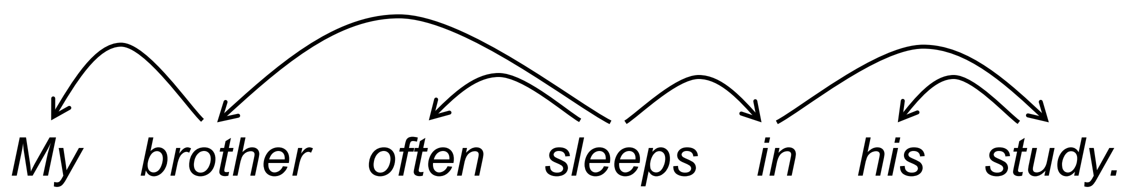

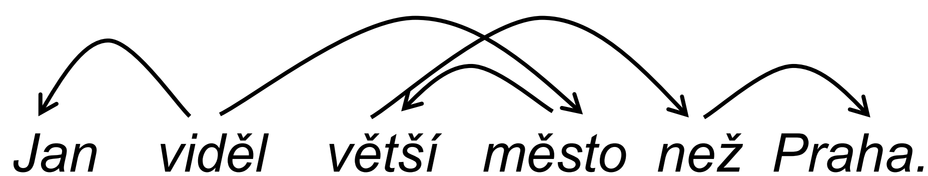

Jan - saw - bigger - city - than – Prague

Jan saw a city bigger than Prague.

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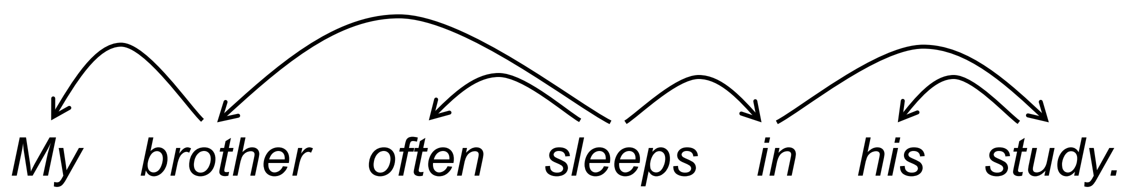
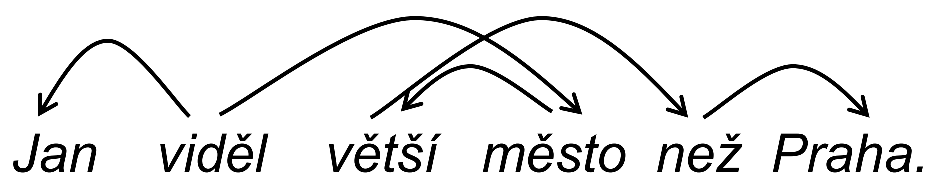




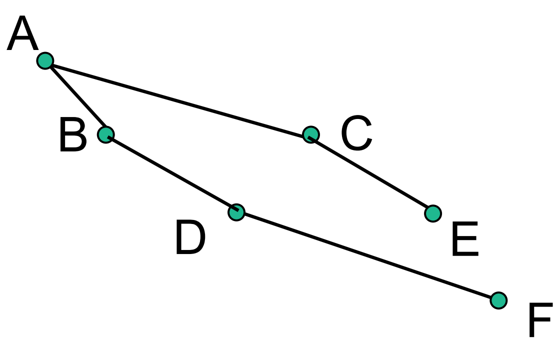
Informally, a dependency graph is planar, if its edges can be drawn above the sentence without crossing.

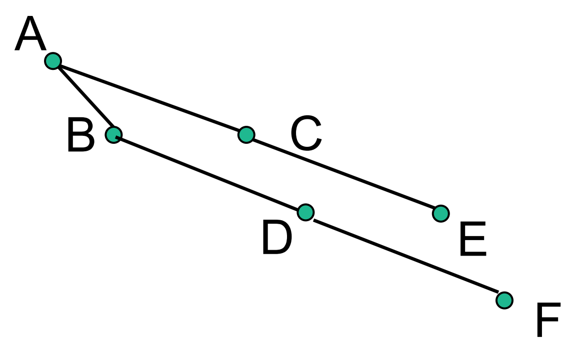
‘Well-Nestedness’

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.’





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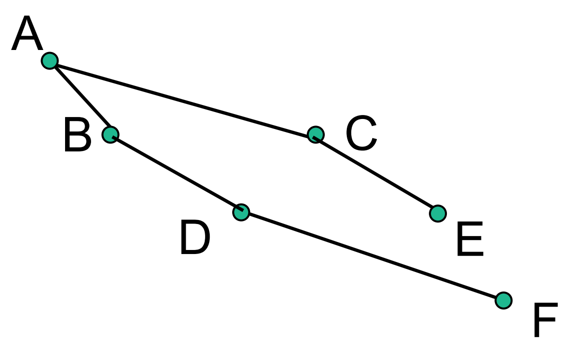
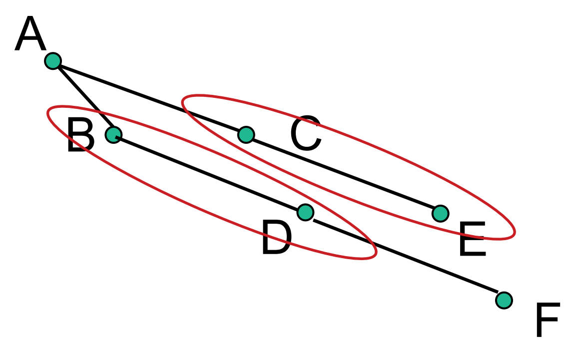


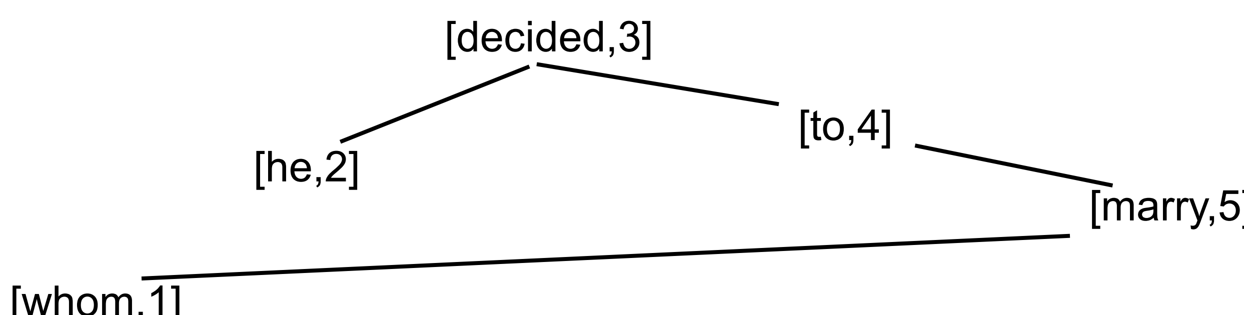


Gap Degree *dNh(T)*

Coverage of a node $u \in T$

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

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



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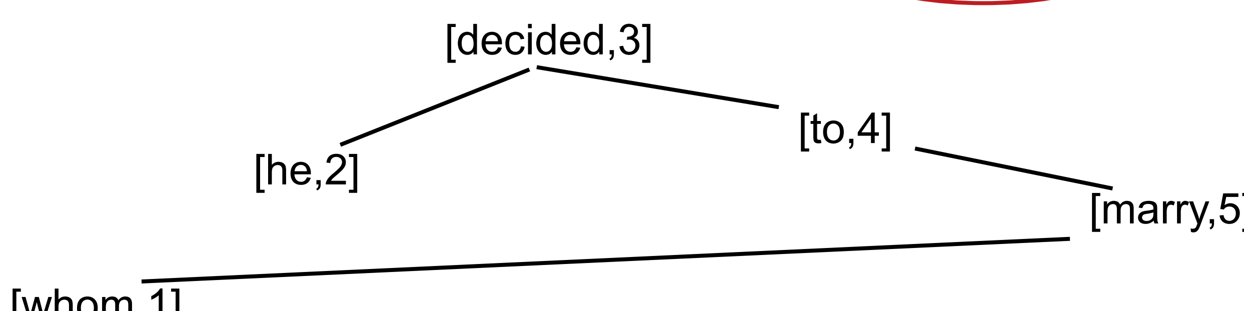

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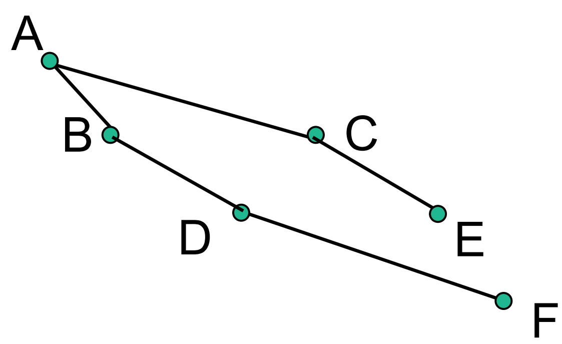

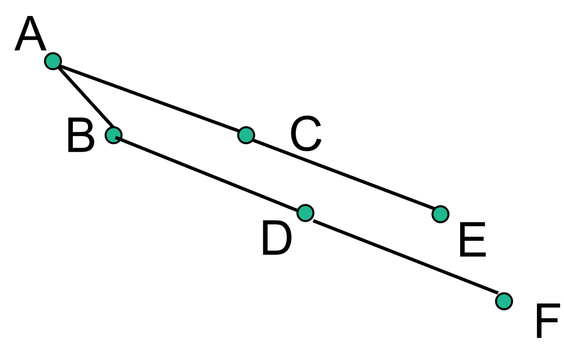

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$dNh(u,T)$ … *number of Gaps* in $Cov(u,T)$

Tree Gegree Degree $dNh(T)$ = max {$dNh(u,T)$| $u \in T$ }

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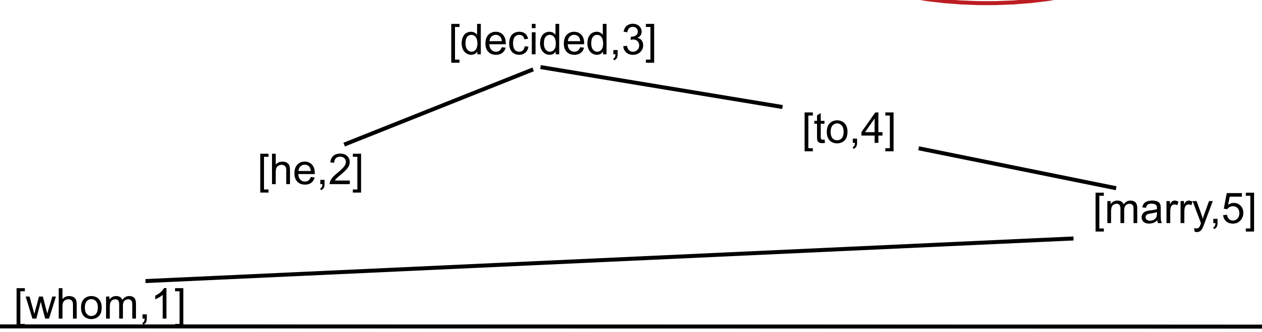

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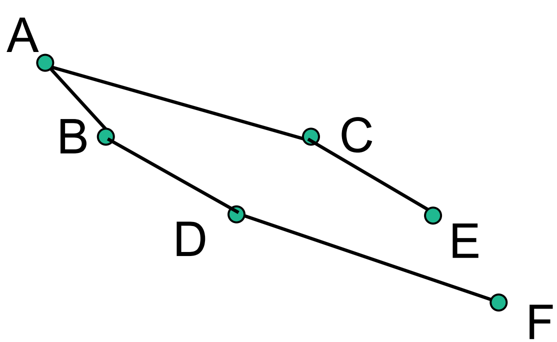
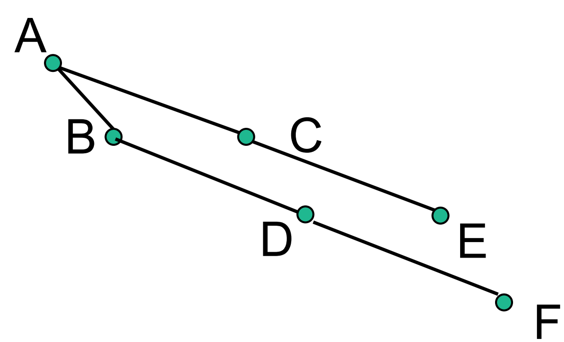
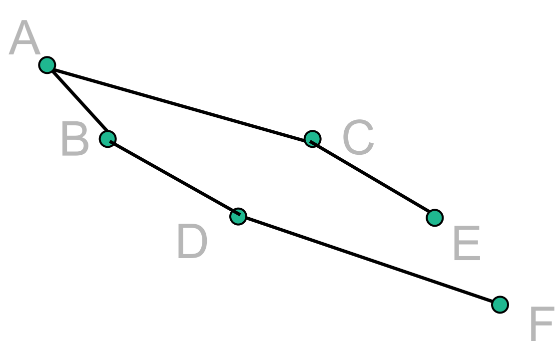
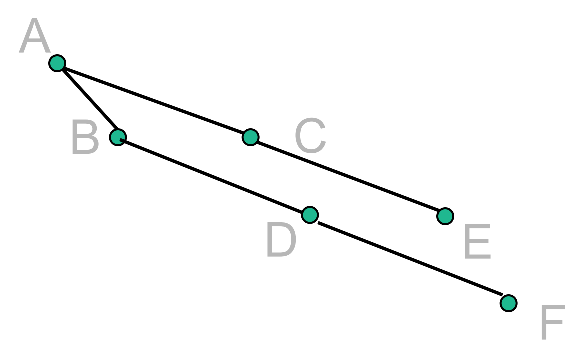




Edge Degree

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 $e \in E$, ***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) … max $\{ed(e) \mid e \in T\}$





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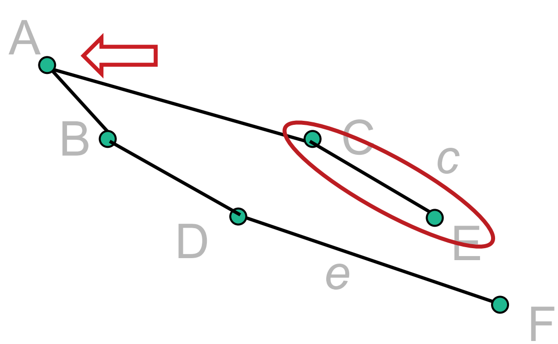

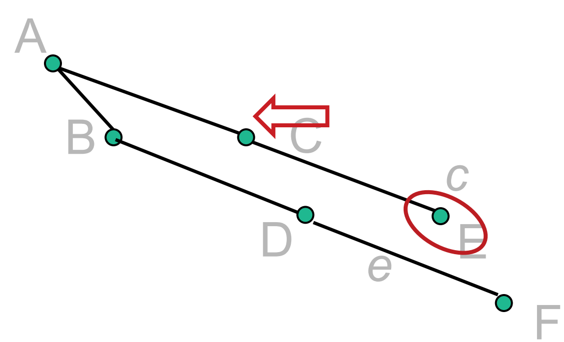

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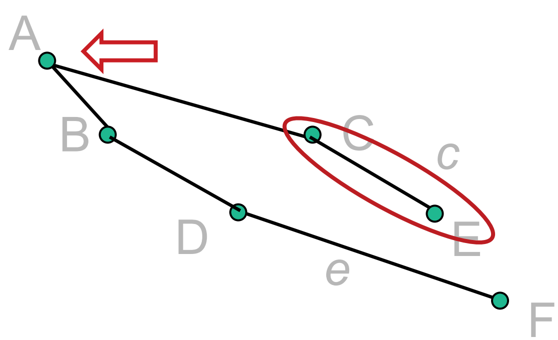

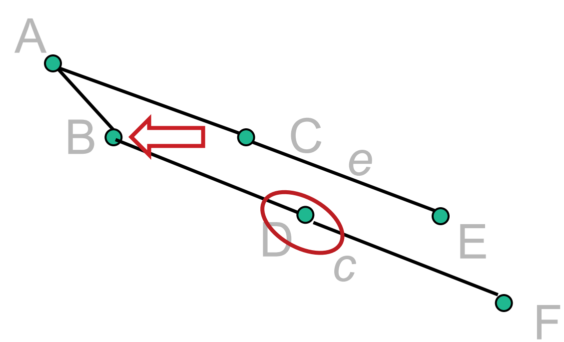

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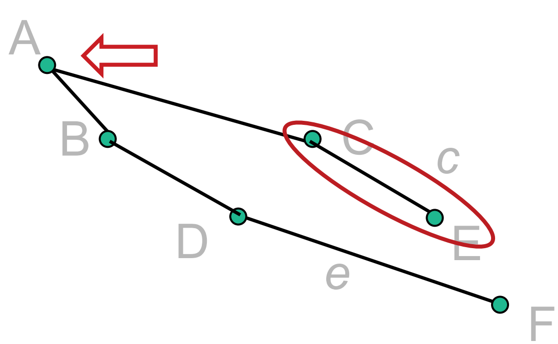

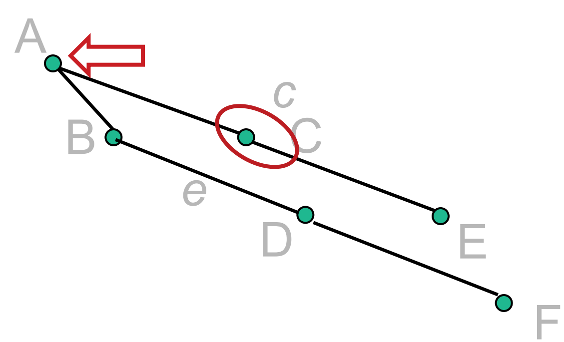

property	DDT		PDT	
all structures	$n = 4393$		$n = 73088$	
gap degree 0	3732	84.95%	56168	76.85%
gap degree 1	654	14.89%	16608	22.72%
gap degree 2	7	0.16%	307	0.42%
gap degree 3	–	–	4	0.01%
gap degree 4	–	–	1	< 0.01%
edge degree 0	3732	84.95%	56168	76.85%
edge degree 1	584	13.29%	16585	22.69%
edge degree 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%
non-projective structures only	$n = 661$		$n = 16920$	
planar	64	9.68%	3880	22.93%
well-nested	656	99.24%	16842	99.54%

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

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