



Natural Language Processing

Tutorial 5: Grammar and Parsing



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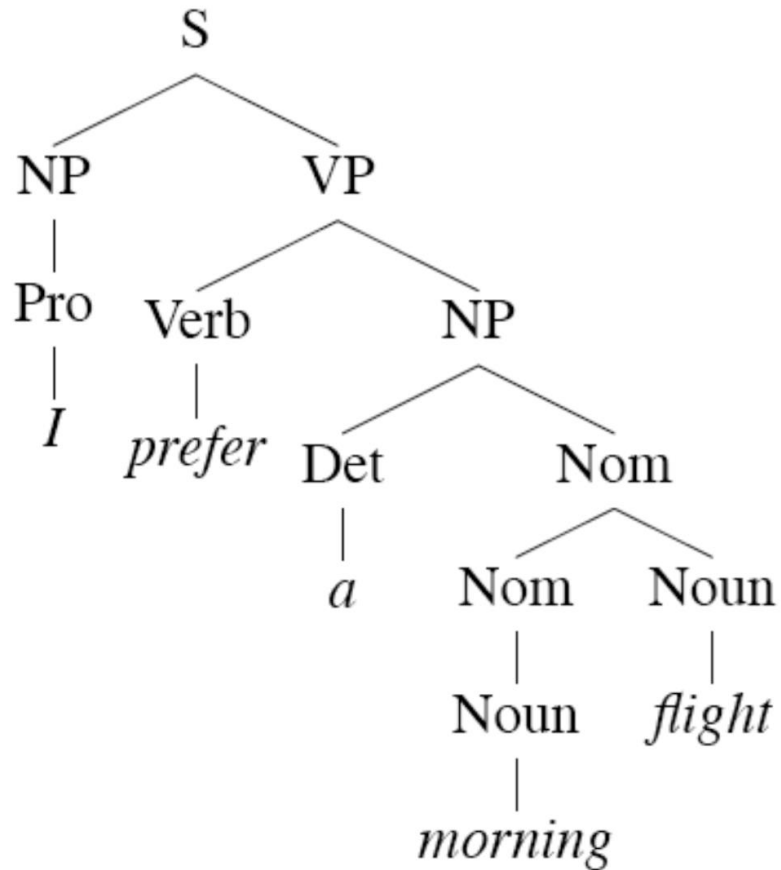


Q1. Draw phrase structures of the sentences.

- a) Does American airlines have a flight between five a.m. and six a.m.?
- b) I would like to fly on American airlines.
- c) Please repeat that.
- d) I need to fly between Philadelphia and Atlanta.
- e) What is the fare from Atlanta to Denver?



- Organizes words into nested constituents



Example constituents

- S
- NP
- Nom
- VP
- PP

POSTag Set

➤ Nouns

- Noun
- ProperNoun

➤ Pronouns

- Pro

➤ Modifiers

- Det
- Card (cardinal number e.g., five)
- Adj
- Adv

➤ Verbs

- Verb
- Aux (e.g., may)

➤ Prepositions

- Prep

➤ Infinitives (to-Verb)

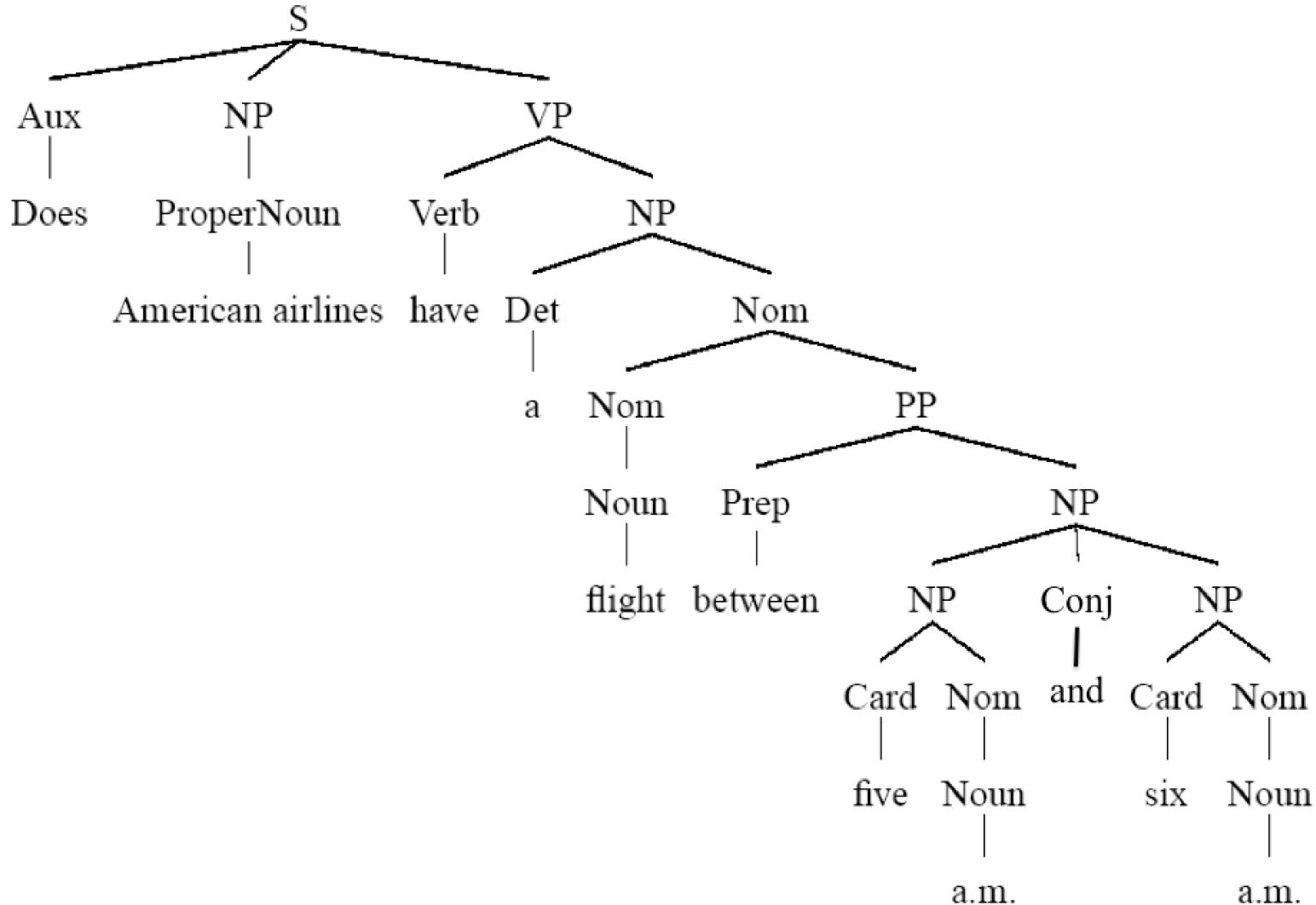
- Inf (i.e., to)

➤ Conjunctive (e.g., and)

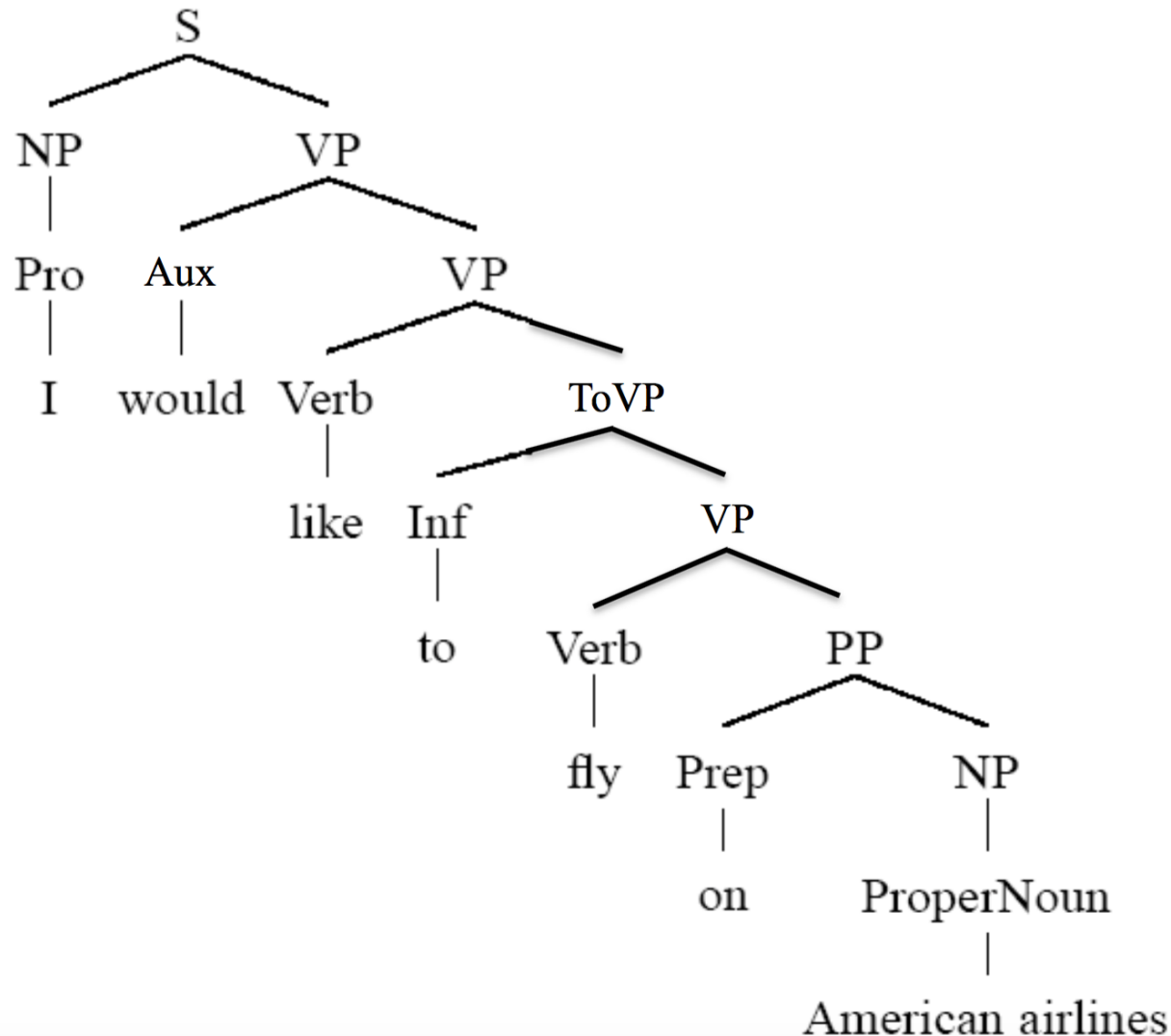
- Conj



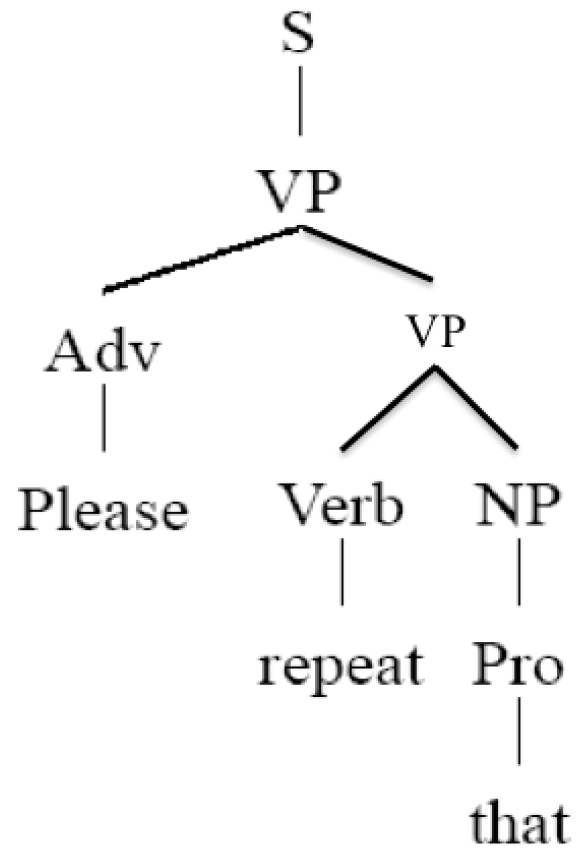
(a). Does American airlines have a flight between five a.m. and six a.m.?



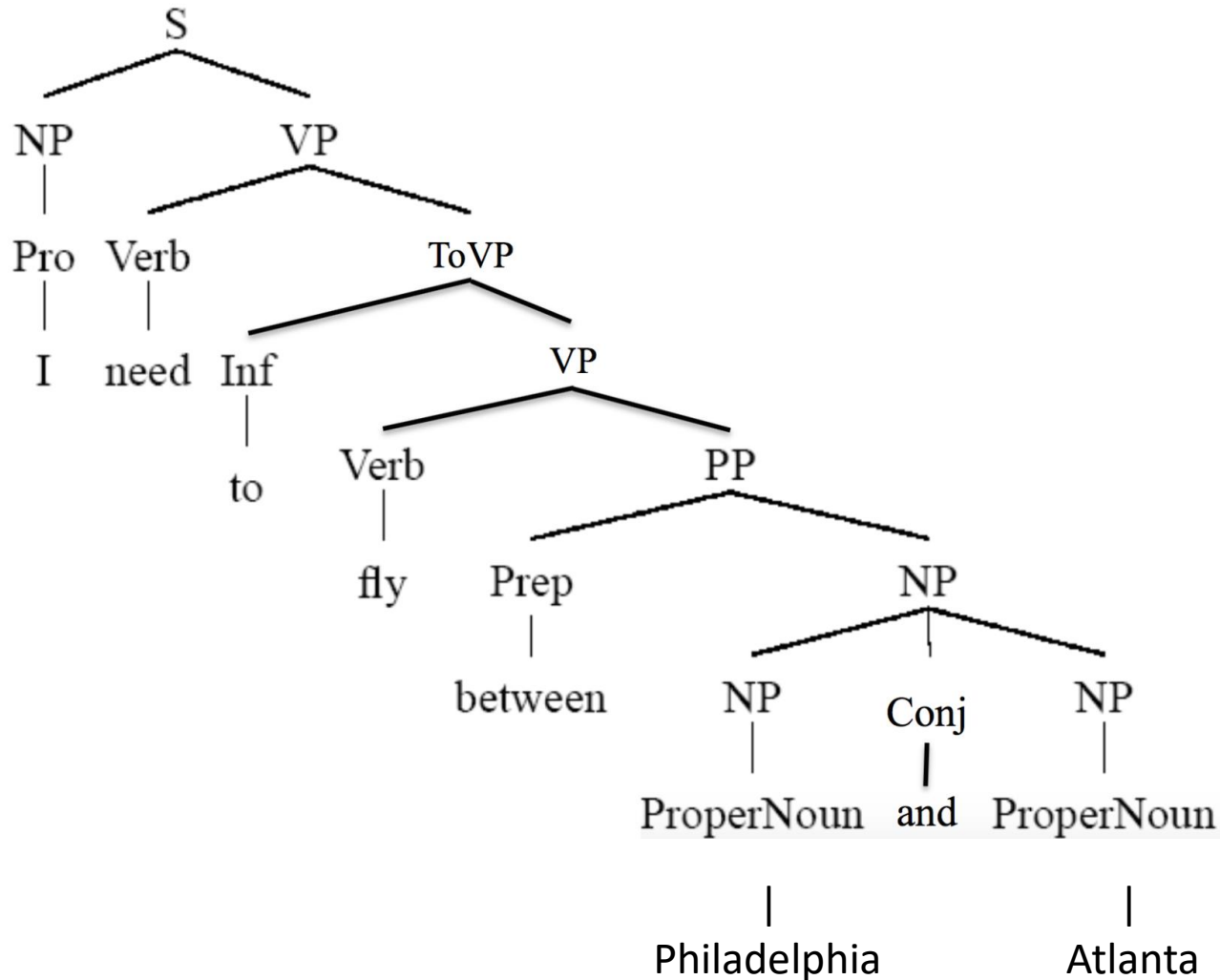
(b). I would like to fly on American airlines.



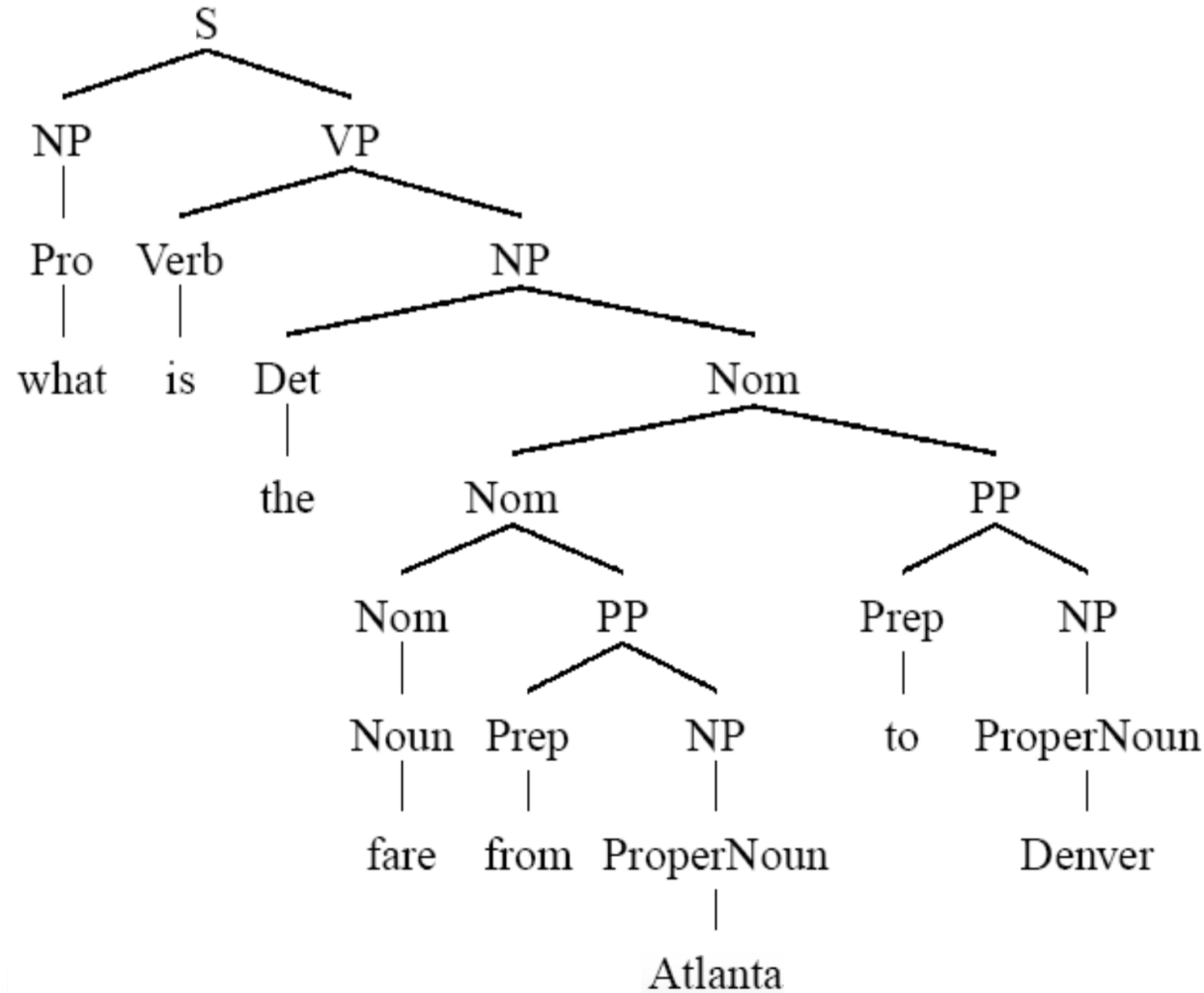
(c). Please repeat that.



(d). I need to fly between Philadelphia and Atlanta.



(e). What is the fare from Atlanta to Denver?



Q2. Consider the LI grammar used in our lectures.

$S \rightarrow NPVP$	$Nominal \rightarrow Noun$	$NP \rightarrow Verb PP$
$S \rightarrow Aux NPVP$	$Nominal \rightarrow Nominal Noun$	$VP \rightarrow VP PP$
$S \rightarrow VP$	$Nominal \rightarrow Nominal PP$	$PP \rightarrow Preposition NP$
$NP \rightarrow Pronoun$	$VP \rightarrow Verb$	
$NP \rightarrow Proper-Noun$	$VP \rightarrow Verb NP$	
$NP \rightarrow Det Nominal$	$VP \rightarrow Verb NP PP$	

➤ Draw the parse table for the following sentence using the LI grammar

- Reserve a room at MBS

➤ Parse table → CKY Parsing



- CKY algorithm requires grammars to be in Chomsky Normal Form (CNF).
 - CNF rules can only be in two forms: $A \rightarrow BC$ or $A \rightarrow w$.
 - That is, the right-hand side of each rule must expand either to **two non-terminals** or to **a single terminal**.

- Any CFG can be converted into a corresponding equivalent CNF grammar
 - Rules that mix terminals with non-terminals on the right-hand side
 - e.g., $INF-VP \rightarrow to VP$. Create a dummy non-terminal TO
 - $INF-VP \rightarrow to VP$ becomes $INF-VP \rightarrow TO VP$ and $TO \rightarrow to$
 - Rules that have a single non-terminal on the right-hand side
 - e.g., $S \rightarrow VP$. Rewrite the right-hand side and expand VP with all its corresponding rules. $S \rightarrow VP$ becomes $S \rightarrow Verb NP$, $S \rightarrow Verb NP PP$, and ...
 - Rules that the length of the right-hand side is greater than 2
 - e.g., $S \rightarrow Verb NP PP$. Create a dummy non-terminal $X1$. $S \rightarrow Verb NP PP$ becomes $S \rightarrow X1 NP$, $X1 \rightarrow Verb NP$

An example CFG grammar in its CNF form

Review

\mathcal{L}_1 Grammar	\mathcal{L}_1 in CNF
$S \rightarrow NP VP$	$S \rightarrow NP VP$
$S \rightarrow Aux NP VP$	$S \rightarrow XI VP$
	$XI \rightarrow Aux NP$
$S \rightarrow VP$	$S \rightarrow book \mid include \mid prefer$
	$S \rightarrow Verb NP$
	$S \rightarrow X2 PP$
	$S \rightarrow Verb PP$
	$S \rightarrow VP PP$
$NP \rightarrow Pronoun$	$NP \rightarrow I \mid she \mid me$
$NP \rightarrow Proper-Noun$	$NP \rightarrow TWA \mid Houston$
$NP \rightarrow Det Nominal$	$NP \rightarrow Det Nominal$
$Nominal \rightarrow Noun$	$Nominal \rightarrow book \mid flight \mid meal \mid money$
$Nominal \rightarrow Nominal Noun$	$Nominal \rightarrow Nominal Noun$
$Nominal \rightarrow Nominal PP$	$Nominal \rightarrow Nominal PP$
$VP \rightarrow Verb$	$VP \rightarrow book \mid include \mid prefer$
$VP \rightarrow Verb NP$	$VP \rightarrow Verb NP$
$VP \rightarrow Verb NP PP$	$VP \rightarrow X2 PP$
	$X2 \rightarrow Verb NP$
$VP \rightarrow Verb PP$	$VP \rightarrow Verb PP$
$VP \rightarrow VP PP$	$VP \rightarrow VP PP$
$PP \rightarrow Preposition NP$	$PP \rightarrow Preposition NP$

CNF rules can only be in two forms: $A \rightarrow BC$ or $A \rightarrow w$.

Each non-terminal node above the POS level in a parse tree will have **exactly two** daughters

That is: a non-terminal node can be derived from **exactly TWO constituents** (that can be derived earlier).



An example CFG grammar in its CNF form

\mathcal{L}_1 Grammar	\mathcal{L}_1 in CNF
$S \rightarrow NP VP$	$S \rightarrow NP VP$
$S \rightarrow Aux NP VP$	$S \rightarrow XI VP$
	$XI \rightarrow Aux NP$
$S \rightarrow VP$	$S \rightarrow book \mid include \mid prefer \mid reserve$
	$S \rightarrow Verb NP$
	$S \rightarrow X2 PP$
	$S \rightarrow Verb PP$
	$S \rightarrow VP PP$
$NP \rightarrow Pronoun$	$NP \rightarrow I \mid she \mid me$
$NP \rightarrow Proper-Noun$	$NP \rightarrow TWA \mid Houston \mid MBS$
$NP \rightarrow Det Nominal$	$NP \rightarrow Det Nominal$
$Nominal \rightarrow Noun$	$Nominal \rightarrow book \mid flight \mid meal \mid money$
$Nominal \rightarrow Nominal Noun$	$Nominal \rightarrow Nominal Noun$
$Nominal \rightarrow Nominal PP$	$Nominal \rightarrow Nominal PP$
$VP \rightarrow Verb$	$VP \rightarrow book \mid include \mid prefer \mid reserve$
$VP \rightarrow Verb NP$	$VP \rightarrow Verb NP$
$VP \rightarrow Verb NP PP$	$VP \rightarrow X2 PP$
	$X2 \rightarrow Verb NP$
$VP \rightarrow Verb PP$	$VP \rightarrow Verb PP$
$VP \rightarrow VP PP$	$VP \rightarrow VP PP$
$PP \rightarrow Preposition NP$	$PP \rightarrow Preposition NP$

Reserve a room at MBS

reserve | room

 reserve
/rɪˈzəv/

See definitions in:

All Ecclesiastical Finance Military Sport Amerindian Ecology Textiles

verb

1. retain for future use.

"roll out half the dough and reserve the other half"

Similar: put to one side put aside set aside lay aside keep back keep

2. arrange for (a room, seat, ticket, etc.) to be kept for the use of a particular person.

"a place was reserved for her in the front row"

Similar: book make a reservation for order arrange in advance arrange for

noun

1. a supply of a commodity not needed for immediate use but available if required.

"Australia has major coal, gas, and uranium reserves"

Similar: stock store supply stockpile reservoir pool fund bank

2. a body of troops withheld from action to reinforce or protect others, or additional to the regular

forces and available in an emergency.

"the men were stationed as a central reserve ready to be transported wherever necessary"



Q2(i)

\mathcal{L}_1 in CNF

$S \rightarrow NP VP$
 $S \rightarrow X1 VP$
 $X1 \rightarrow Aux NP$
 $S \rightarrow book \mid include \mid prefer$
 $S \rightarrow Verb NP$
 $S \rightarrow X2 PP$
 $S \rightarrow Verb PP$
 $S \rightarrow VP PP$
 $NP \rightarrow I \mid she \mid me$
 $NP \rightarrow TWA \mid Houston$
 $NP \rightarrow Det Nominal$
 $Nominal \rightarrow book \mid flight \mid meal \mid money$
 $Nominal \rightarrow Nominal Noun$
 $Nominal \rightarrow Nominal PP$
 $VP \rightarrow book \mid include \mid prefer$
 $VP \rightarrow Verb NP$
 $VP \rightarrow X2 PP$
 $X2 \rightarrow Verb NP$
 $VP \rightarrow Verb PP$
 $VP \rightarrow VP PP$
 $PP \rightarrow Preposition NP$

0	1	2	3	4	5
Reserve	a	room	at	MBS	
[0,1]	[0,2]	[0,3]	[0,4]	[0,5]	
	[1,2]	[1,3]	[1,4]	[1,5]	
		[2,3]	[2,4]	[2,5]	
			[3,4]	[3,5]	
				[4,5]	

“reserve” can be a noun or verb, similar to “book”



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 $VP \rightarrow Verb PP$
 $VP \rightarrow VP PP$
 $PP \rightarrow Preposition NP$

① Reserve	② a	③ room	④ at	⑤ MBS	⑥
[0,1]	[0,2]	[0,3]	[0,4]	[0,5]	
	[1,2]	[1,3]	[1,4]	[1,5]	
		[2,3]	[2,4]	[2,5]	
			[3,4]	[3,5]	
				[4,5]	



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 $X2 \rightarrow Verb NP$
 $VP \rightarrow Verb PP$
 $VP \rightarrow VP PP$
 $PP \rightarrow Preposition NP$

① Reserve	① a	② room	③ at	④ MBS	⑤
S, VP, Verb, Nominal, Noun [0,1]	[0,2]	[0,3]	[0,4]	[0,5]	
	[1,2]	[1,3]	[1,4]	[1,5]	
		[2,3]	[2,4]	[2,5]	
			[3,4]	[3,5]	
				[4,5]	



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0	1	2	3	4	5
S, VP, Verb, Nominal, Noun					
[0,1]	[0,2]	[0,3]	[0,4]	[0,5]	
	Det				
	[1,2]	[1,3]	[1,4]	[1,5]	
		[2,3]	[2,4]	[2,5]	
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 $X2 \rightarrow Verb NP$
 $VP \rightarrow Verb PP$
 $VP \rightarrow VP PP$
 $PP \rightarrow Preposition NP$

①	②	③	④	⑤
Reserve	a	room	at	MBS
S, VP, Verb, Nominal, Noun [0,1]	[0,2]	[0,3]	[0,4]	[0,5]
Det [1,2]	[1,3]	[1,4]	[1,5]	
	[2,3]	[2,4]	[2,5]	
		[3,4]	[3,5]	
			[4,5]	



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$XI \rightarrow Aux NP$

$S \rightarrow book \mid include \mid prefer$

$S \rightarrow Verb NP$

$S \rightarrow X2 PP$

$S \rightarrow Verb PP$

$S \rightarrow VP PP$

$NP \rightarrow I \mid she \mid me$

$NP \rightarrow TWA \mid Houston$

$NP \rightarrow Det Nominal$

$Nominal \rightarrow book \mid flight \mid meal \mid money \mid room$

$Nominal \rightarrow Nominal Noun$

$Nominal \rightarrow Nominal PP$

$VP \rightarrow book \mid include \mid prefer$

$VP \rightarrow Verb NP$

$VP \rightarrow X2 PP$

$X2 \rightarrow Verb NP$

$VP \rightarrow Verb PP$

$VP \rightarrow VP PP$

$PP \rightarrow Preposition NP$

① Reserve	② a	③ room	④ at	⑤ MBS
S, VP, Verb, Nominal, Noun [0,1]	[0,2]	[0,3]	[0,4]	[0,5]
Det [1,2]	[1,3]	[1,4]	[1,5]	
	Nominal, Noun [2,3]	[2,4]	[2,5]	
		[3,4]	[3,5]	
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①	②	③	④	⑤
Reserve	a	room	at	MBS
S, VP, Verb, Nominal, Noun [0,1]	[0,2]	[0,3]	[0,4]	[0,5]
Det [1,2]	NP [1,3]	[1,4]	[1,5]	
	Nominal, Noun [2,3]	[2,4]	[2,5]	
		[3,4]	[3,5]	
			[4,5]	



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 $X2 \rightarrow Verb NP$
 $VP \rightarrow Verb PP$
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0	Reserve	1	a	2	room	3	at	4	MBS	5
S, VP, Verb, Nominal, Noun				S, VP, X2						
[0,1]	[0,2]			[0,3]	[0,4]			[0,5]		
	Det			NP						
	[1,2]			[1,3]	[1,4]			[1,5]		
				Nominal, Noun						
				[2,3]	[2,4]			[2,5]		
							[3,4]	[3,5]		
									[4,5]	



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0	1	2	3	4	5
Reserve	a	room	at	MBS	
S, VP, Verb, Nominal, Noun [0,1]		S,VP,X2 [0,3]			
	Det [1,2]	NP [1,3]			
		Nominal, Noun [2,3]			
			Prep [3,4]		
					[4,5]



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① Reserve	② a	③ room	④ at	⑤ MBS
S, VP, Verb, Nominal, Noun [0,1]	[0,2]	S,VP,X2 [0,3]	[0,4]	[0,5]
	Det [1,2]	NP [1,3]	[1,4]	[1,5]
		Nominal, Noun [2,3]	[2,4]	[2,5]
			Prep [3,4]	[3,5]
				[4,5]



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0	Reserve	1	a	2	room	3	at	4	MBS	5
	S, VP, Verb, Nominal, Noun			S,VP,X2						
	[0,1]	[0,2]		[0,3]	[0,4]			[0,5]		
		Det		NP						
		[1,2]		[1,3]	[1,4]			[1,5]		
				Nominal, Noun						
				[2,3]	[2,4]			[2,5]		
					Prep					
					[3,4]			[3,5]		
								[4,5]		



Q2(i)

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S, VP, Verb, Nominal, Noun				S,VP,X2						
[0,1]	[0,2]			[0,3]	[0,4]			[0,5]		
	Det			NP						
	[1,2]			[1,3]	[1,4]			[1,5]		
				Nominal, Noun						
				[2,3]	[2,4]			[2,5]		
					Prep					
					[3,4]			[3,5]		
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Q2(i)

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① Reserve	① a	② room	③ at	④ MBS	⑤
S, VP, Verb, Nominal, Noun [0,1]	[0,2]	S,VP,X2 [0,3]	[0,4]	[0,5]	
	Det [1,2]	NP [1,3]	[1,4]	[1,5]	
		Nominal, Noun [2,3]	[2,4]	[2,5]	
			Prep [3,4]	[3,5]	
				NP, Proper- Noun [4,5]	



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① Reserve	① a	② room	③ at	④ MBS	⑤
S, VP, Verb, Nominal, Noun [0,1]	[0,2]	S,VP,X2 [0,3]	[0,4]	[0,5]	
	Det [1,2]	NP [1,3]	[1,4]	[1,5]	
		Nominal, Noun [2,3]	[2,4]	[2,5]	
			Prep [3,4]	PP [3,5]	
				NP, Proper- Noun [4,5]	



Q2(i)

\mathcal{L}_1 in CNF

$S \rightarrow NP VP$
 $S \rightarrow XI VP$
 $XI \rightarrow Aux NP$
 $S \rightarrow book \mid include \mid prefer$
 $S \rightarrow Verb NP$
 $S \rightarrow X2 PP$
 $S \rightarrow Verb PP$
 $S \rightarrow VP PP$
 $NP \rightarrow I \mid she \mid me$
 $NP \rightarrow TWA \mid Houston$
 $NP \rightarrow Det Nominal$
 $Nominal \rightarrow book \mid flight \mid meal \mid money$
 $Nominal \rightarrow Nominal Noun$
 $Nominal \rightarrow Nominal PP$
 $VP \rightarrow book \mid include \mid prefer$
 $VP \rightarrow Verb NP$
 $VP \rightarrow X2 PP$
 $X2 \rightarrow Verb NP$
 $VP \rightarrow Verb PP$
 $VP \rightarrow VP PP$
 $PP \rightarrow Preposition NP$

0	Reserve	1	a	2	room	3	at	4	MBS	5
S, VP, Verb, Nominal, Noun				S,VP,X2						
[0,1]	[0,2]			[0,3]	[0,4]			[0,5]		
	Det			NP						
	[1,2]			[1,3]	[1,4]			[1,5]		
				Nominal, Noun				Nominal		
				[2,3]	[2,4]			[2,5]		
					Prep			PP		
					[3,4]			[3,5]		
								NP, Proper- Noun		
								[4,5]		



Q2(i)

\mathcal{L}_1 in CNF

$S \rightarrow NP VP$
 $S \rightarrow X1 VP$
 $X1 \rightarrow Aux NP$
 $S \rightarrow book \mid include \mid prefer$
 $S \rightarrow Verb NP$
 $S \rightarrow X2 PP$
 $S \rightarrow Verb PP$
 $S \rightarrow VP PP$
 $NP \rightarrow I \mid she \mid me$
 $NP \rightarrow TWA \mid Houston$
 $NP \rightarrow Det Nominal$
 $Nominal \rightarrow book \mid flight \mid meal \mid money$
 $Nominal \rightarrow Nominal Noun$
 $Nominal \rightarrow Nominal PP$
 $VP \rightarrow book \mid include \mid prefer$
 $VP \rightarrow Verb NP$
 $VP \rightarrow X2 PP$
 $X2 \rightarrow Verb NP$
 $VP \rightarrow Verb PP$
 $VP \rightarrow VP PP$
 $PP \rightarrow Preposition NP$

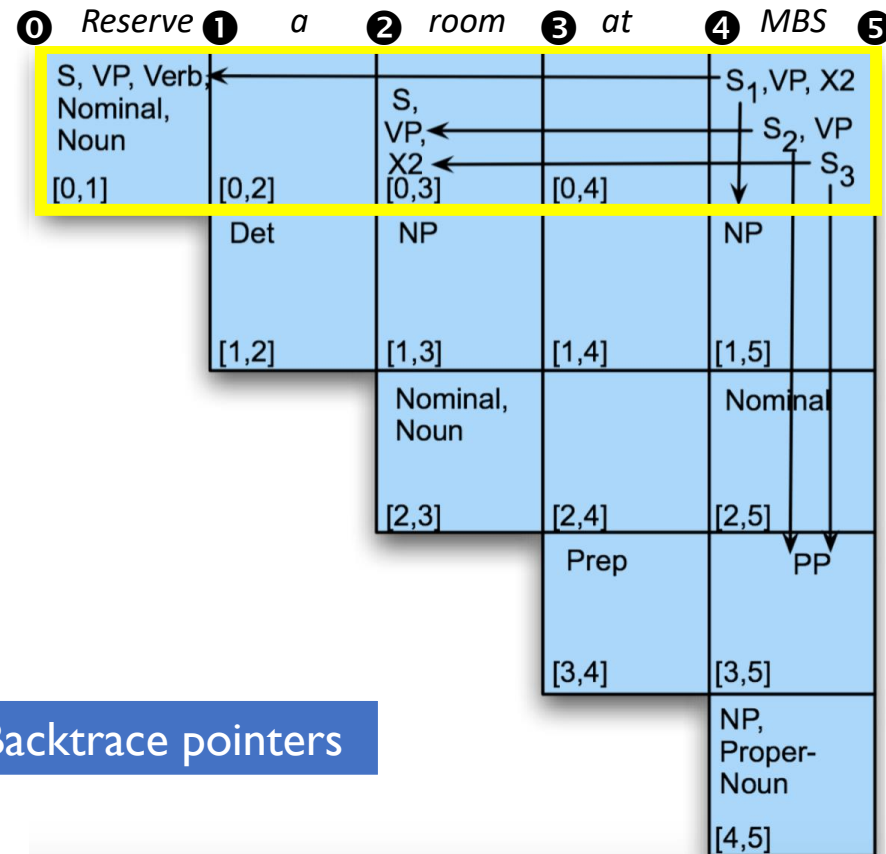
0	1	2	3	4	5
Reserve	a	room	at	MBS	
S, VP, Verb, Nominal, Noun [0,1]		S,VP,X2 [0,3]			
	Det [1,2]	NP [1,3]		NP [1,5]	
		Nominal, Noun [2,3]		Nominal [2,5]	
			Prep [3,4]	PP [3,5]	
				NP, Proper- Noun [4,5]	



Q2(i)

\mathcal{L}_1 in CNF

$S \rightarrow NP VP$
 $S \rightarrow X1 VP$
 $X1 \rightarrow Aux NP$
 $S \rightarrow book \mid include \mid prefer$
 $S \rightarrow Verb NP$
 $S \rightarrow X2 PP$
 $S \rightarrow Verb PP$
 $S \rightarrow VP PP$
 $NP \rightarrow I \mid she \mid me$
 $NP \rightarrow TWA \mid Houston$
 $NP \rightarrow Det Nominal$
 $Nominal \rightarrow book \mid flight \mid meal \mid money$
 $Nominal \rightarrow Nominal Noun$
 $Nominal \rightarrow Nominal PP$
 $VP \rightarrow book \mid include \mid prefer$
 $VP \rightarrow Verb NP$
 $VP \rightarrow X2 PP$
 $X2 \rightarrow Verb NP$
 $VP \rightarrow Verb PP$
 $VP \rightarrow VP PP$
 $PP \rightarrow Preposition NP$



Q2(ii) Revise the LI grammar

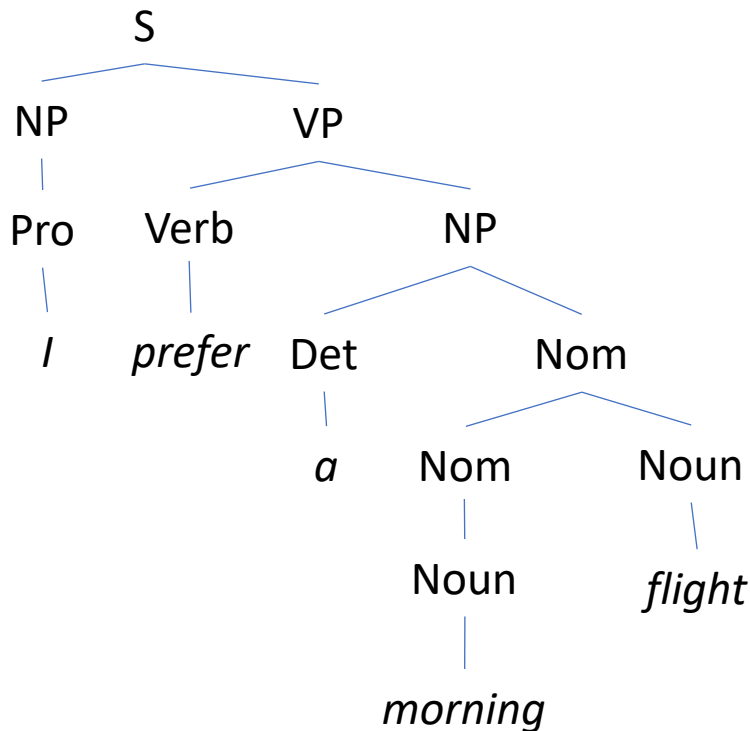
➤ In order to be able to parse the following sentences:

- I would like to fly on American airlines.
- Please repeat that.
- I need to fly between Philadelphia and Atlanta.
- What is the fare from Atlanta to Denver?

$S \rightarrow NP VP$	Nominal \rightarrow Noun	$NP \rightarrow$ Verb PP
$S \rightarrow$ Aux NP VP	Nominal \rightarrow Nominal Noun	$VP \rightarrow$ VP PP
$S \rightarrow$ VP	Nominal \rightarrow Nominal PP	$PP \rightarrow$ Preposition NP
$NP \rightarrow$ Pronoun	$VP \rightarrow$ Verb	
$NP \rightarrow$ Proper-Noun	$VP \rightarrow$ Verb NP	
$NP \rightarrow$ Det Nominal	$VP \rightarrow$ Verb NP PP	

Derivation

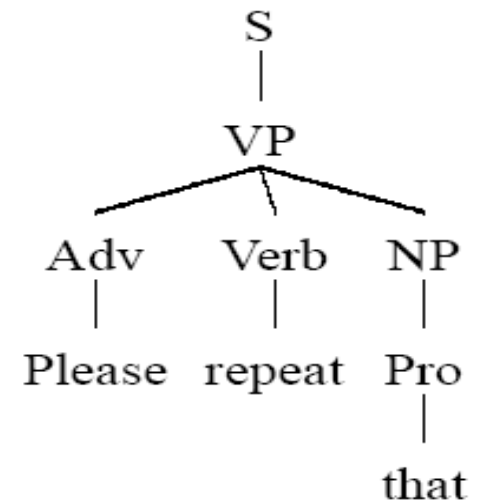
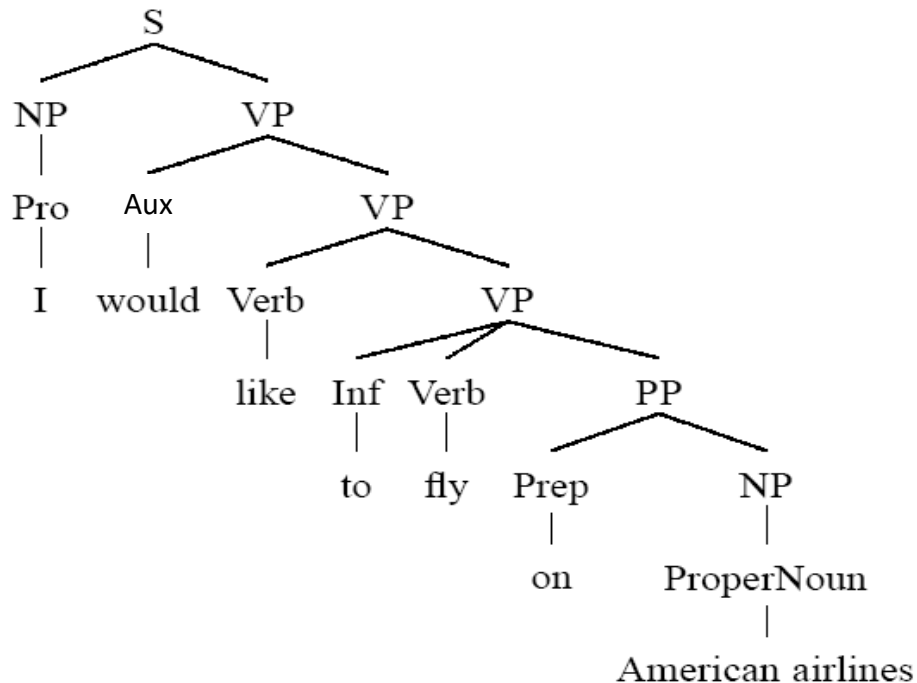
- A derivation (parse tree) consists of the bag of grammar rules that are in the tree



1. $S \rightarrow NP VP$
2. $NP \rightarrow Pro$
 $Pro \rightarrow I$
3. $VP \rightarrow Verb NP$
 $Verb \rightarrow prefer$
4. $NP \rightarrow Det Nom$
 $Det \rightarrow a$
5. $Nom \rightarrow Nom Noun$
 $Noun \rightarrow morning$
6. $Nom \rightarrow Noun$
 $Noun \rightarrow flight$

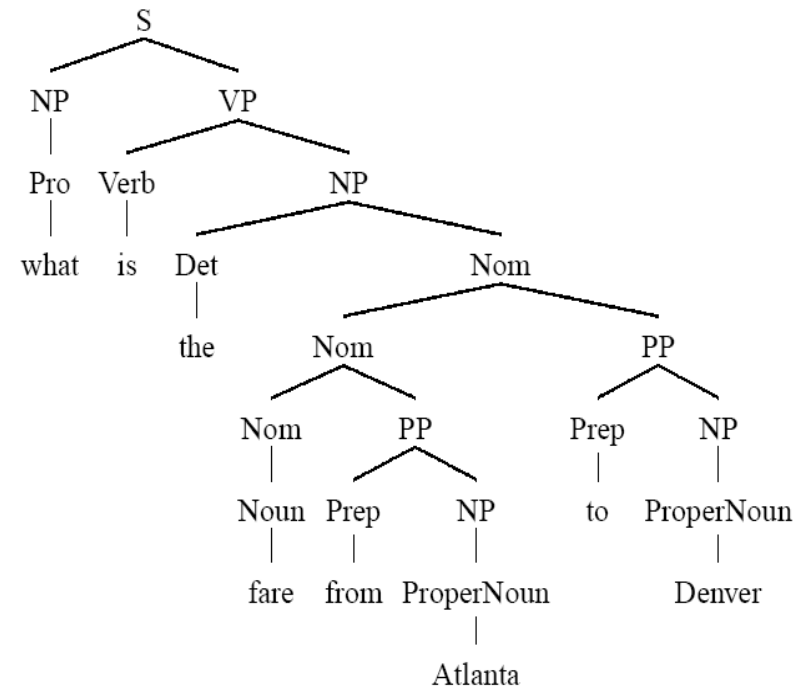
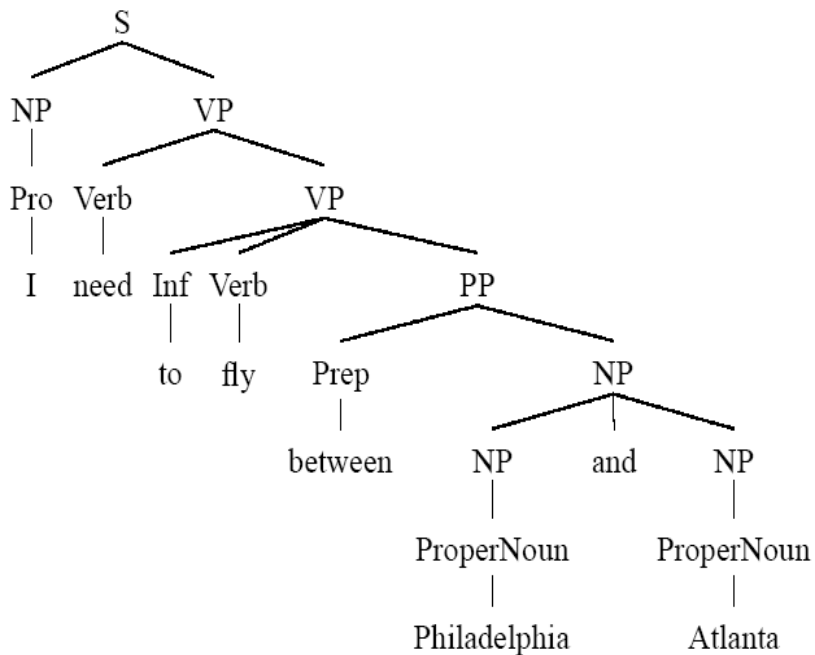
The first two sentences

- I would like to fly on American airlines.
- Please repeat that.



The next two sentences

- I need to fly between Philadelphia and Atlanta.
- What is the fare from Atlanta to Denver?



Q2(ii) Revise the *LI* grammar

➤ In order to be able to parse the following sentences:

- I would like to fly on American airlines.
- Please repeat that.
- I need to fly between Philadelphia and Atlanta.
- What is the fare from Atlanta to Denver?

$S \rightarrow NPVP$	Nominal \rightarrow Noun	$NP \rightarrow$ Verb PP
$S \rightarrow Aux\ NPVP$	Nominal \rightarrow Nominal Noun	$VP \rightarrow$ VP PP
$S \rightarrow VP$	Nominal \rightarrow Nominal PP	$PP \rightarrow$ Preposition NP
$NP \rightarrow$ Pronoun	$VP \rightarrow$ Verb	
$NP \rightarrow$ Proper-Noun	$VP \rightarrow$ Verb NP	
$NP \rightarrow$ Det Nominal	$VP \rightarrow$ Verb NP PP	



Q2(ii) Include the rules that are not listed in L1

- $S \rightarrow NP VP$
- $S \rightarrow Aux NP VP$
- $S \rightarrow VP$
- $NP \rightarrow Pronoun$
- $NP \rightarrow ProperNoun$
- $NP \rightarrow Det Nominal$
- $NP \rightarrow NP Conj NP$
- $Nominal \rightarrow Noun$
- $Nominal \rightarrow Nominal Noun$
- $Nominal \rightarrow Nominal PP$
- $VP \rightarrow Verb$
- $VP \rightarrow Verb NP$
- $VP \rightarrow Verb NP PP$
- $VP \rightarrow Verb PP$
- $VP \rightarrow VP PP$
- $VP \rightarrow Aux VP$
- $VP \rightarrow Verb VP$
- $VP \rightarrow InfVerb PP$
- $VP \rightarrow AdvVerb NP$
- $PP \rightarrow Preposition NP$
- -----
- $Det \rightarrow the$
- $Noun \rightarrow fare$
- $Verb \rightarrow like \mid fly \mid repeat \mid need \mid is$
- $Pronoun \rightarrow I \mid that \mid what$
- $ProperNoun \rightarrow American\ airlines \mid Philadelphia \mid Atlanta \mid Denver$
- $Aux \rightarrow would$
- $Preposition \rightarrow from \mid to \mid on \mid between$
- $Conj \rightarrow and$
- $Inf \rightarrow to$
- $Adv \rightarrow please$



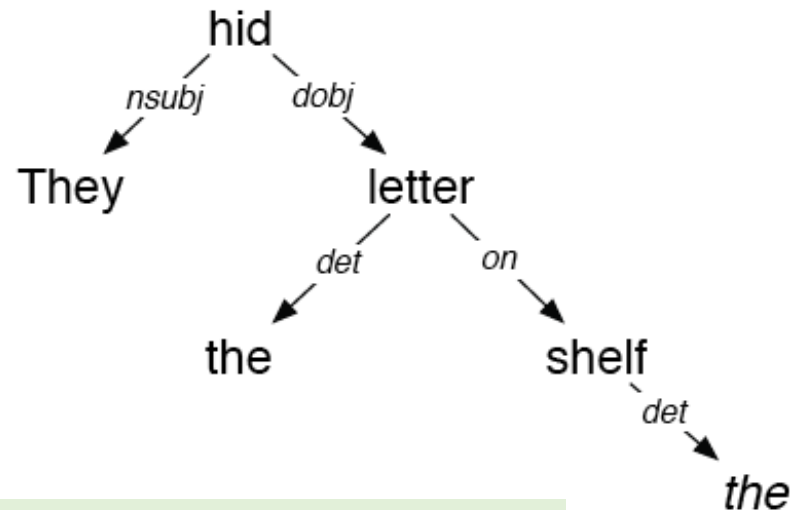
Q3. Draw typed dependency structures of the sentences

- a) Does American airlines have a flight between five a.m. and six a.m.?
- b) I would like to fly on American airlines.
- c) Please repeat that.
- d) I need to fly between Philadelphia and Atlanta.
- e) What is the fare from Atlanta to Denver?



Dependency structure

- Represents grammatical (dependency) relations between pairs of words (i.e., head, dependent)
- Head: Grammatically most important word in a phrase
 - Verb of VP
 - Noun of NP
 - Prep of PP
 - Adj of AdjP
 - ...



They hid the letter on the shelf

Dependency Relations

➤ Verb relations

- nsubj : nominal subject
- dobj : direct object
- aux (auxiliary verb – main verb)
- xmod (verb – adverb)
- xcomp_{to}
(verb – to-infinitive)

➤ Noun relations

- nmod: nominal modifier
- det

➤ Preposition relations

- prep_x (e.g. prep_{at})

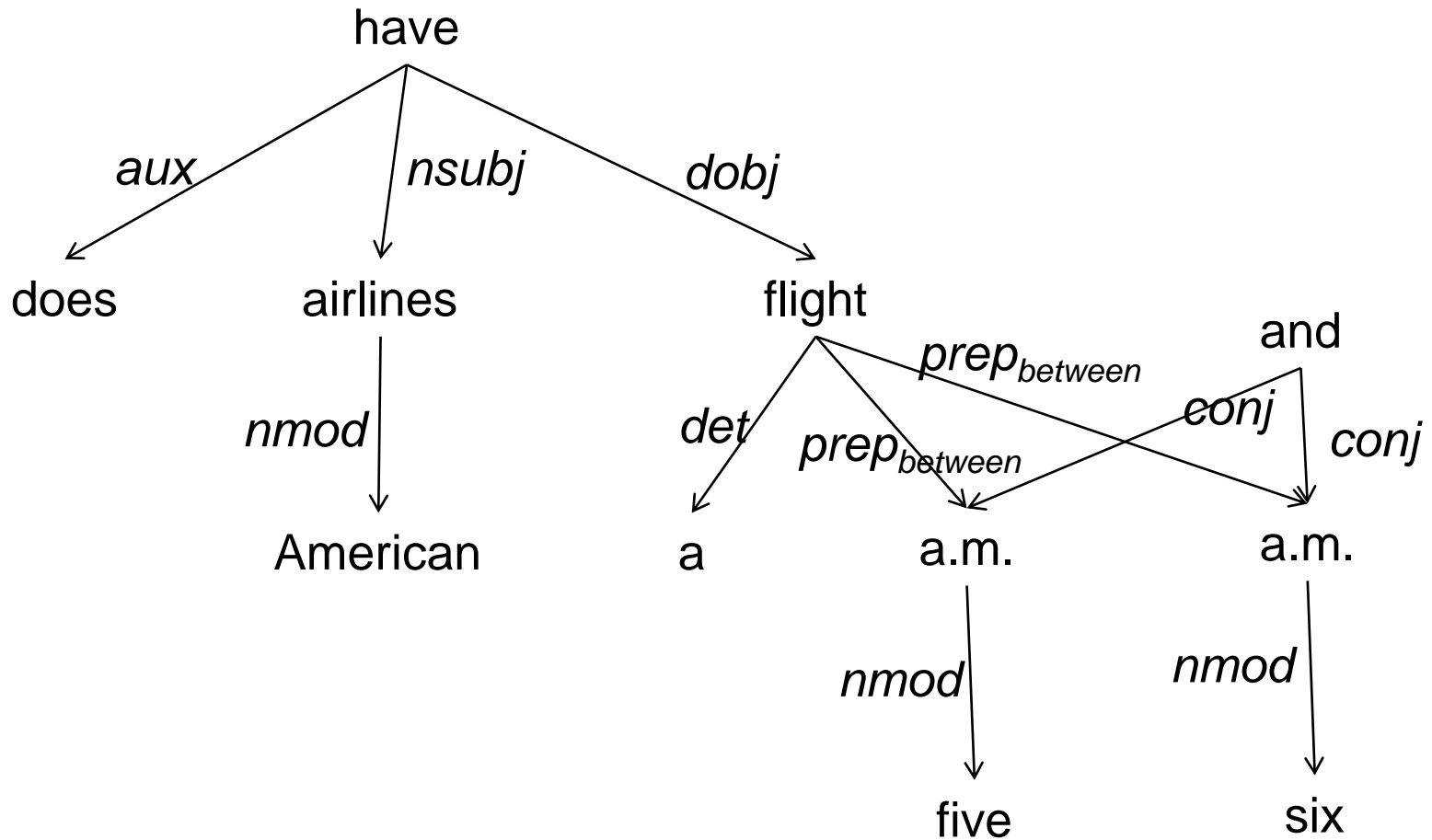
➤ Coordination

- conj

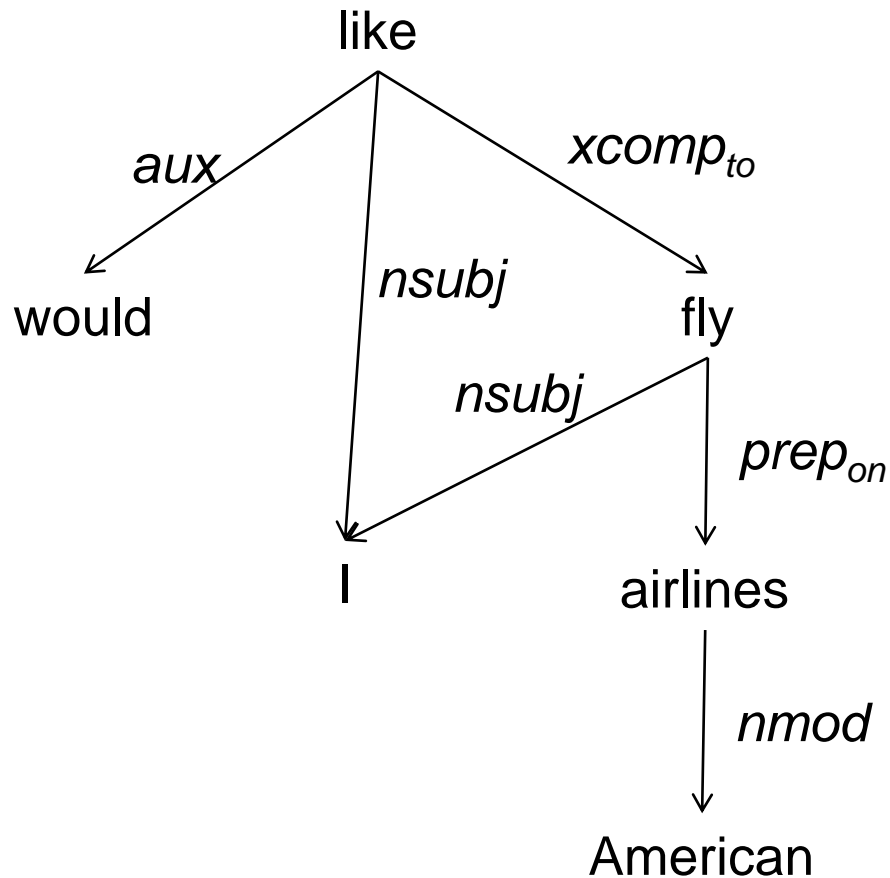
<http://universaldependencies.org/u/dep/all.html>



(a). Does American airlines have a flight between five a.m. and six a.m.?



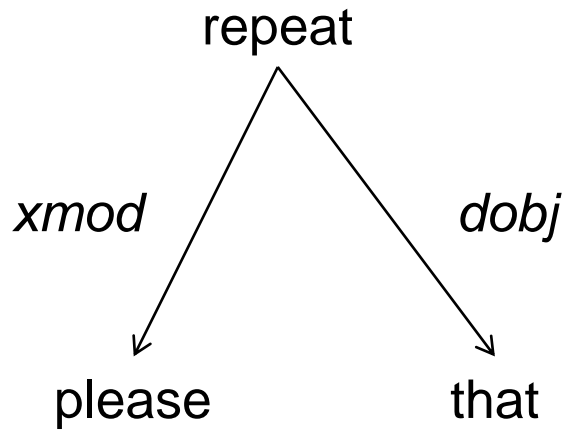
(b). I would like to fly on American airlines.



➤ Verb relations

- nsubj
- dobj
- aux (auxiliary verb – main verb)
- xmod (verb – adverb)
- xcomp_{to} (verb – to-infinitive)

(c). Please repeat that.



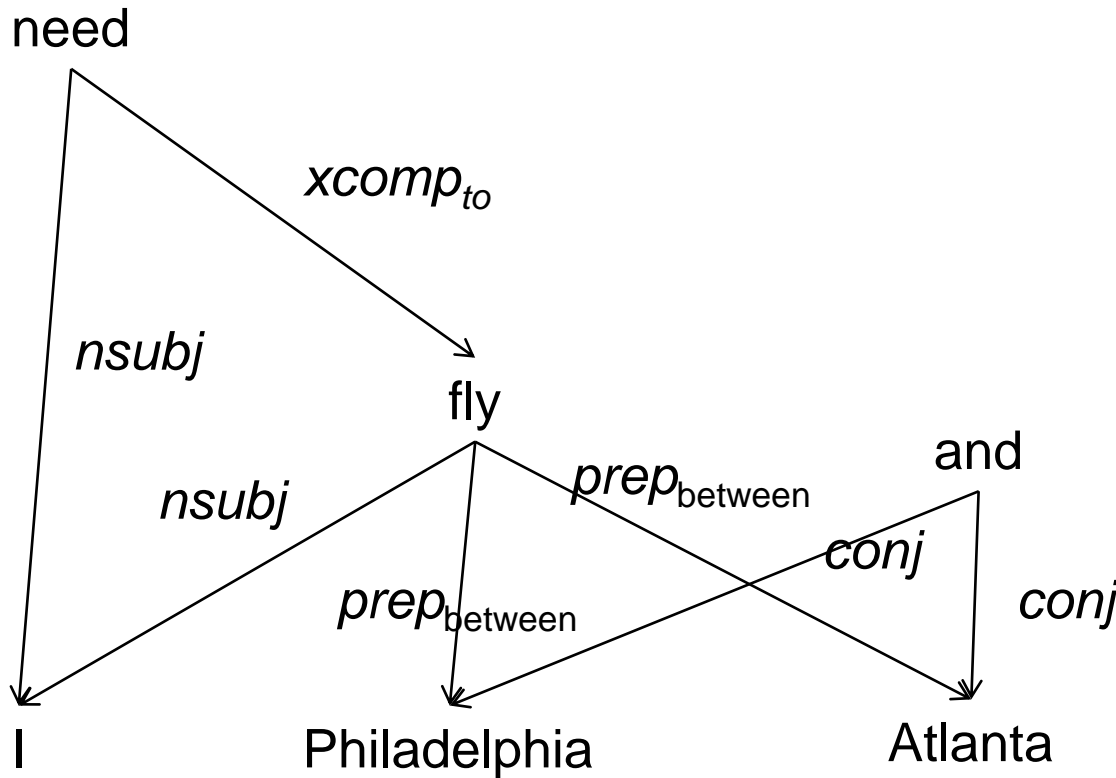
➤ Verb relations

- nsubj
- dobj
- aux (auxiliary verb – main verb)
- xmod (verb – adverb)
- xcomp_{to} (verb – to-infinitive)

(d). I need to fly between Philadelphia and Atlanta.

➤ Verb relations

- nsubj
- dobj
- aux (auxiliary verb – main verb)
- xmod (verb – adverb)
- xcomp_{to} (verb – to-infinitive)



(e). What is the fare from Atlanta to Denver?

➤ Verb relations

- nsubj
- dobj
- aux (auxiliary verb – main verb)
- xmod (verb – adverb)
- xcomp_{to} (verb – to-infinitive)

