Natural Language Processing

Tutorial 5: Grammar and Parsing

Dr. Sun Aixin

Q1. Consider the L1 grammar used in our lectures.

S→ NP VP	Nominal → Noun	NP→ Verb PP
S→ Aux NP VP	Nominal → Nominal Noun	VP → VP PP
S→ VP	Nominal → Nominal PP	PP→ Preposition NP
NP→ Pronoun	VP→ Verb	
NP→ Proper-Noun	VP→ Verb NP	
NP→ Det Nominal	VP → Verb NP PP	

- *Draw the parse table for the following sentence using the L1 grammar*
  - *Reserve a room at MBS*
- Parse table → CKY Parsing

The CKY algorithm

Review

- CKY algorithm requires grammars to be in Chomsky Normal Form (CNF).
  - CNF rules can only be in two forms: $A \rightarrow B\ C$ 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 → to VP*. Create a dummy non-terminal *TO*
    - *INF-VP → to VP* becomes *INF-VP → TO VP* and *TO → to*
  - Rules that have a single non-terminal on the right-hand side
    - e.g., *S→ VP*. Rewrite the right-hand side and expand *VP* with all its corresponding rules. *S→ VP* becomes *S→ Verb NP*, *S→ Verb NP PP*, and …
  - Rules that the length of the right-hand side is greater than 2
    - e.g., *S→ Verb NP PP*. Create a dummy non-terminal *X1*. *S→ Verb NP PP* becomes *S→X1 NP*, *X1→Verb NP*

An example CFG grammar in its CNF form

Review

$\mathcal{L}_1$ Grammar	$\mathcal{L}_1$ in CNF
$S \rightarrow NP\ VP$	$S \rightarrow NP\ VP$
$S \rightarrow Aux\ NP\ VP$	$S \rightarrow X1\ VP$
	$X1 \rightarrow Aux\ NP$
$S \rightarrow VP$	$S \rightarrow book \mid include \mid prefer$
	$S \rightarrow Verb\ NP$
	$S \rightarrow X2\ PP$
	$S \rightarrow Verb\ PP$
	$S \rightarrow VP\ PP$
$NP \rightarrow Pronoun$	$NP \rightarrow I \mid she \mid me$
$NP \rightarrow Proper\text{-}Noun$	$NP \rightarrow TWA \mid Houston$
$NP \rightarrow Det\ Nominal$	$NP \rightarrow Det\ Nominal$
$Nominal \rightarrow Noun$	$Nominal \rightarrow book \mid flight \mid meal \mid money$
$Nominal \rightarrow Nominal\ Noun$	$Nominal \rightarrow Nominal\ Noun$
$Nominal \rightarrow Nominal\ PP$	$Nominal \rightarrow Nominal\ PP$
$VP \rightarrow Verb$	$VP \rightarrow book \mid include \mid prefer$
$VP \rightarrow Verb\ NP$	$VP \rightarrow Verb\ NP$
$VP \rightarrow Verb\ NP\ PP$	$VP \rightarrow X2\ PP$
	$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$	$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$	$VP \rightarrow VP\ PP$
$PP \rightarrow Preposition\ NP$	$PP \rightarrow Preposition\ NP$

CNF rules can only be in two forms: ***A → B C*** or ***A → 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

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

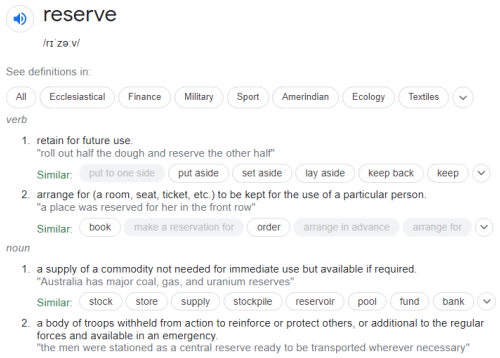
|reserve

|MBS

|reserve

Reserve a room at MBS

reserve|room



Q2(i)

$\mathscr{L}_1$ in CNF
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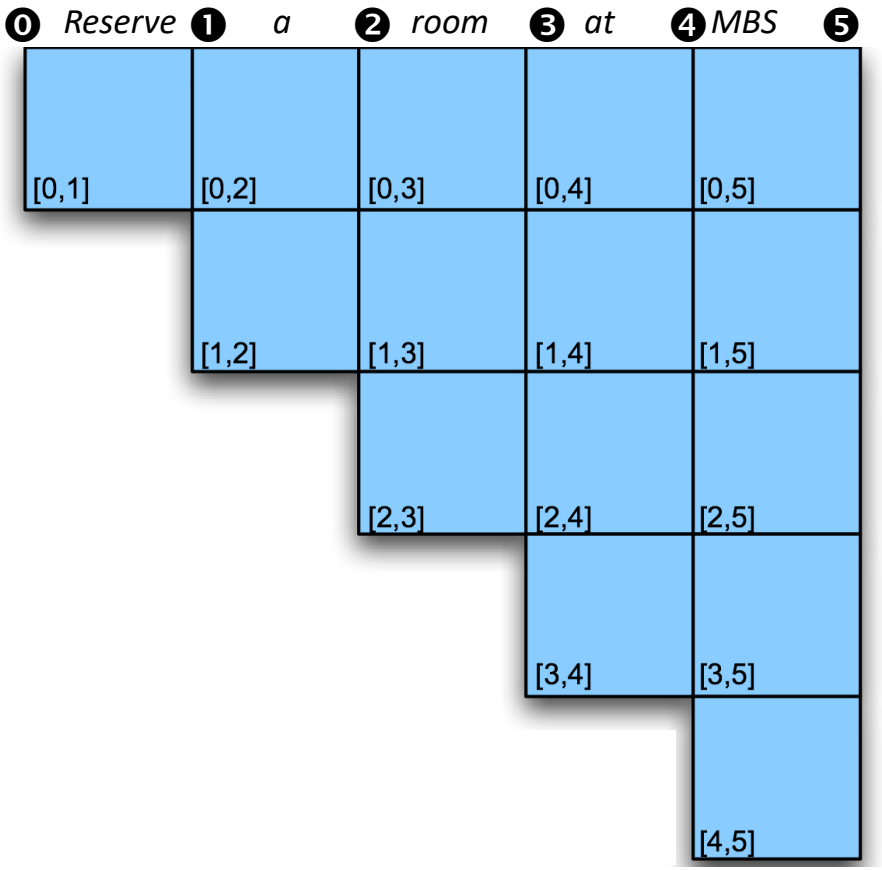

"reserve" can be a noun or verb, similar to "book"

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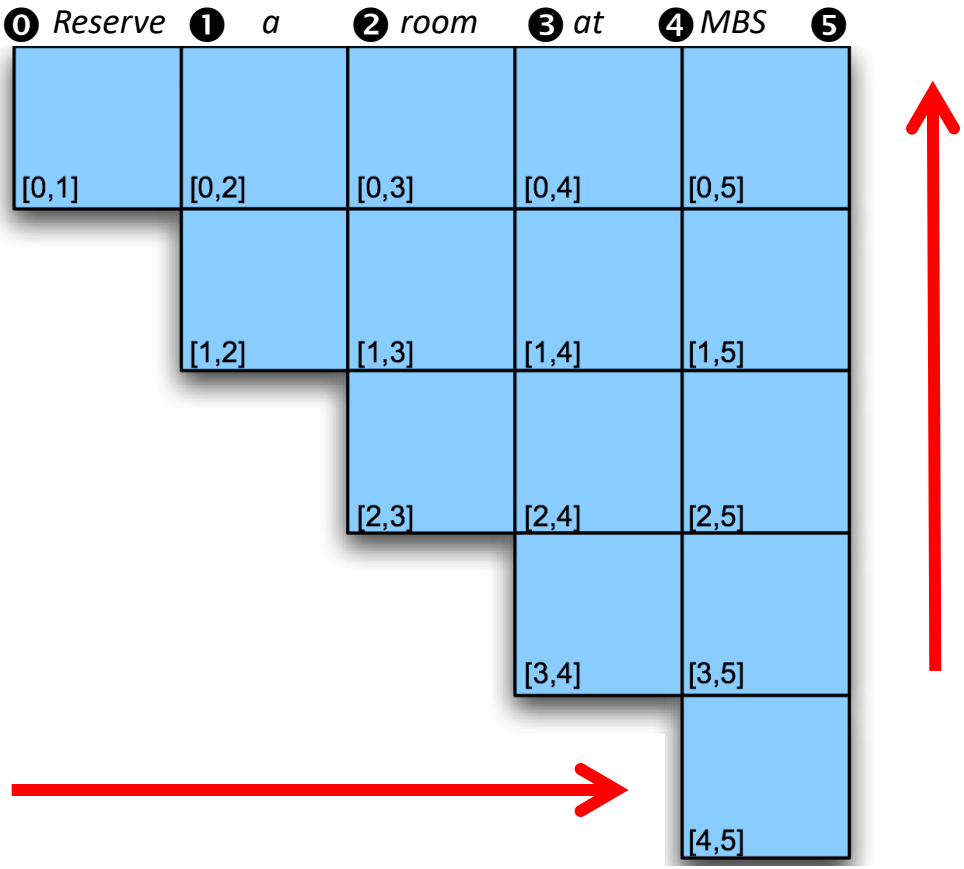

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$Nominal \rightarrow Nominal\ Noun$
$Nominal \rightarrow Nominal\ PP$
$VP \rightarrow book \mid include \mid prefer$ |reserve
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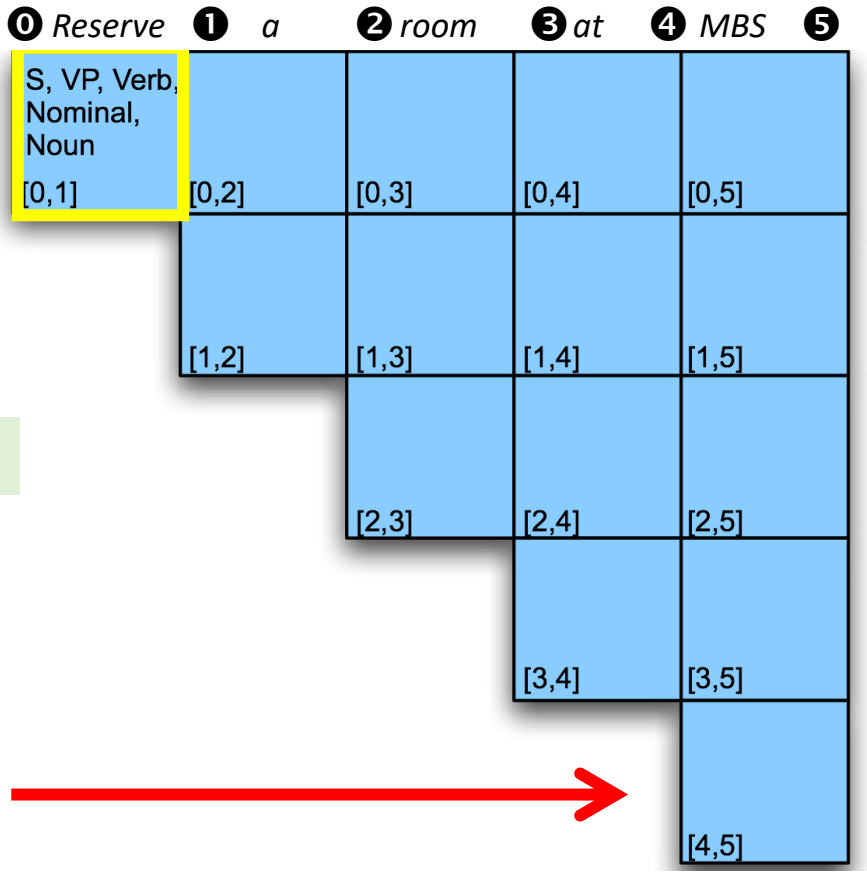

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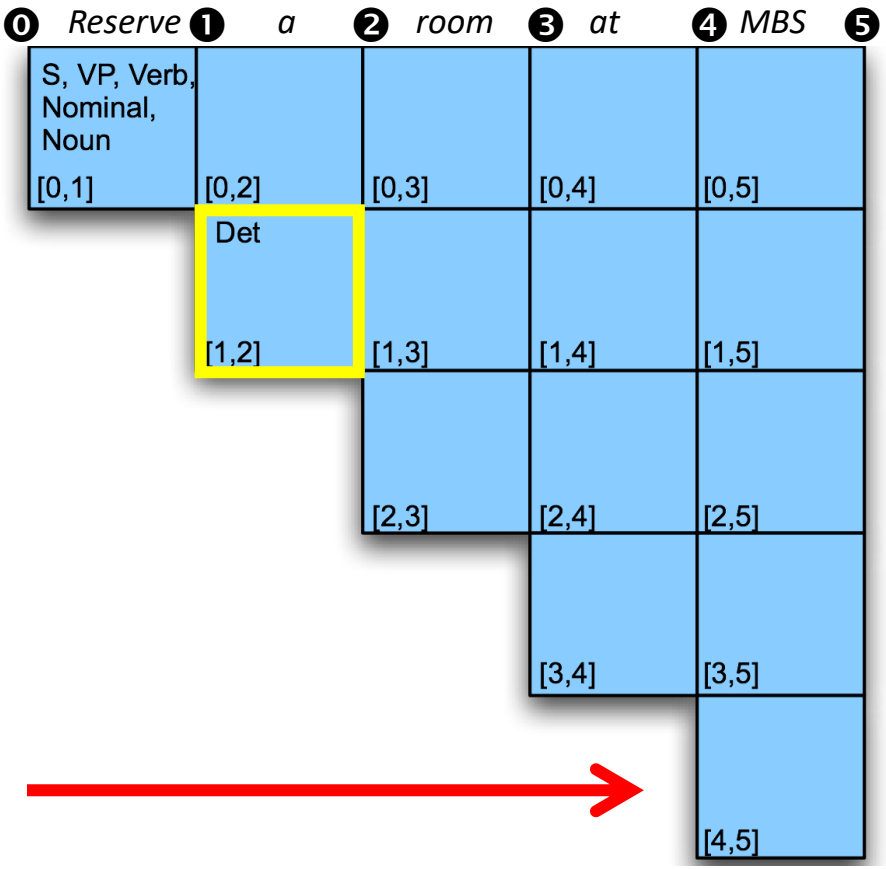

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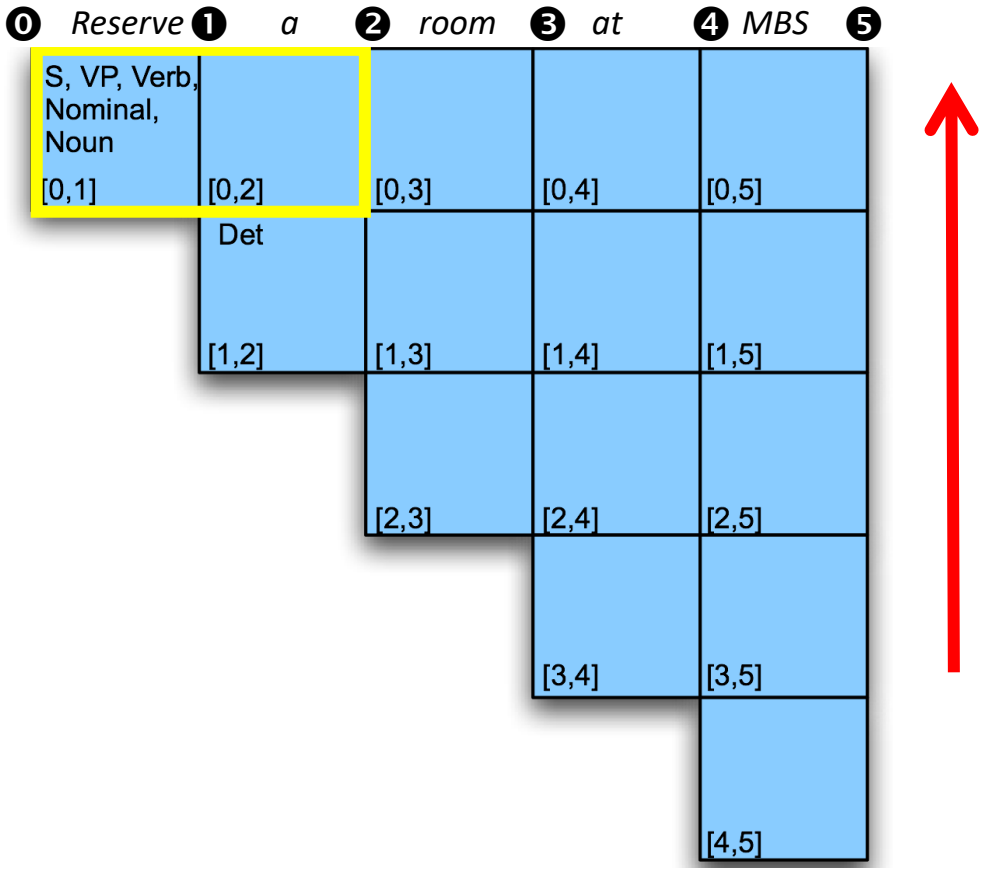

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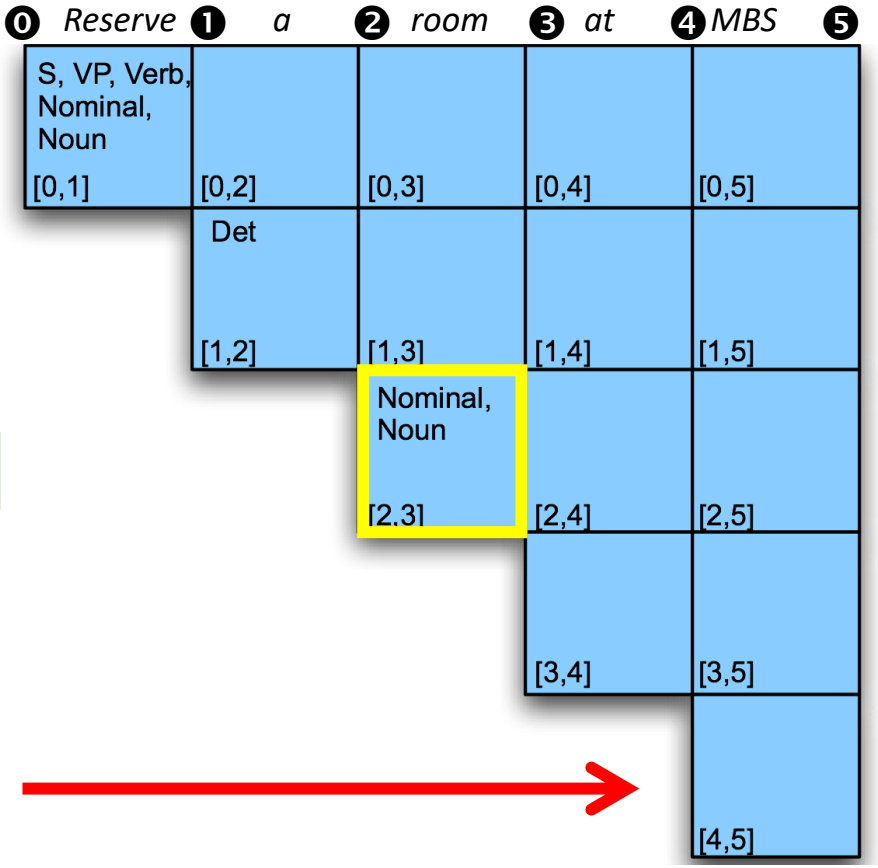
|room



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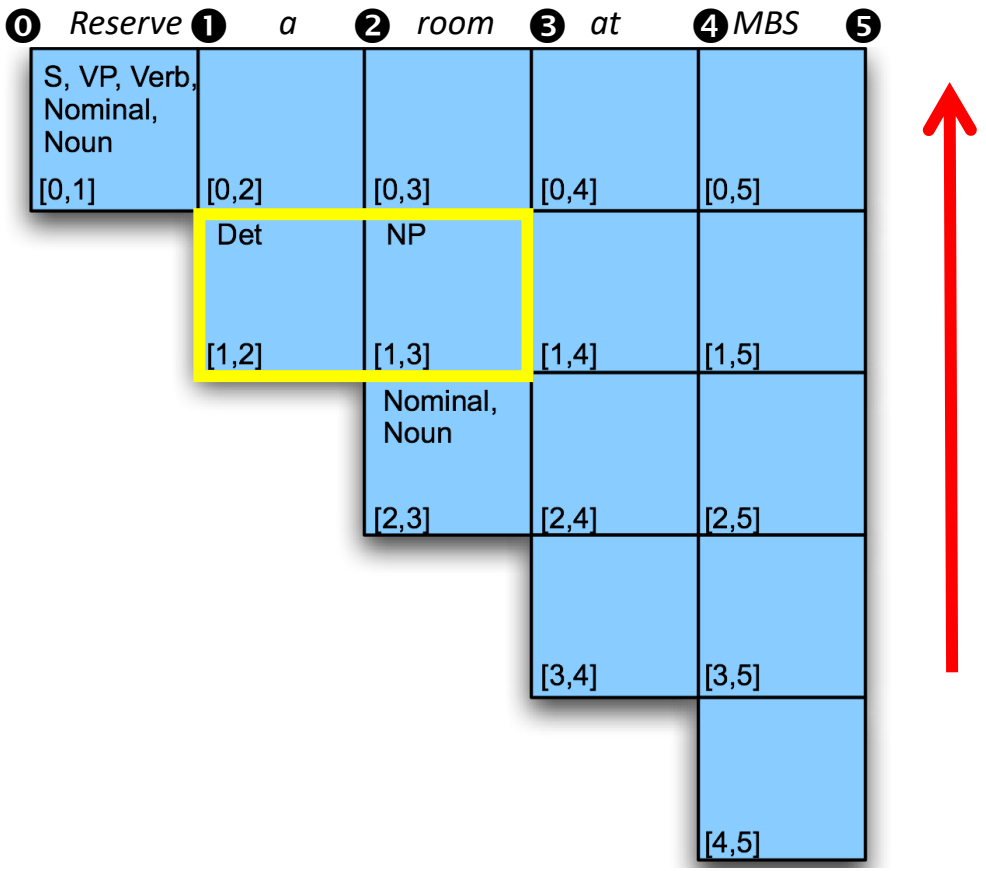

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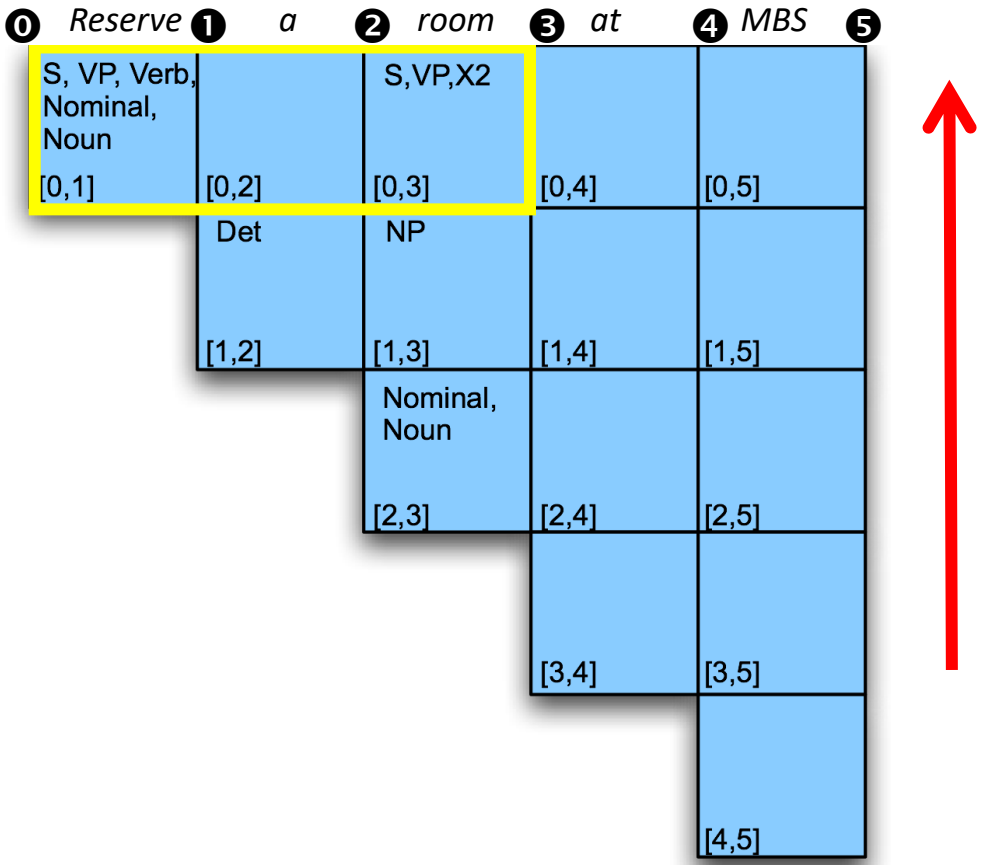

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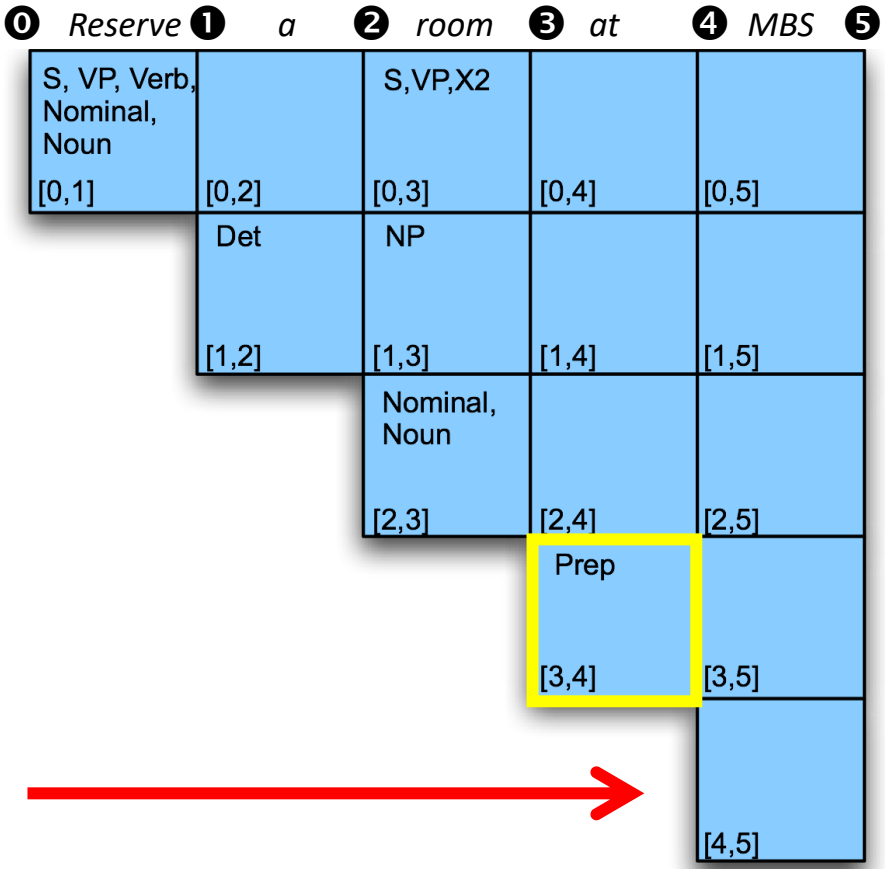

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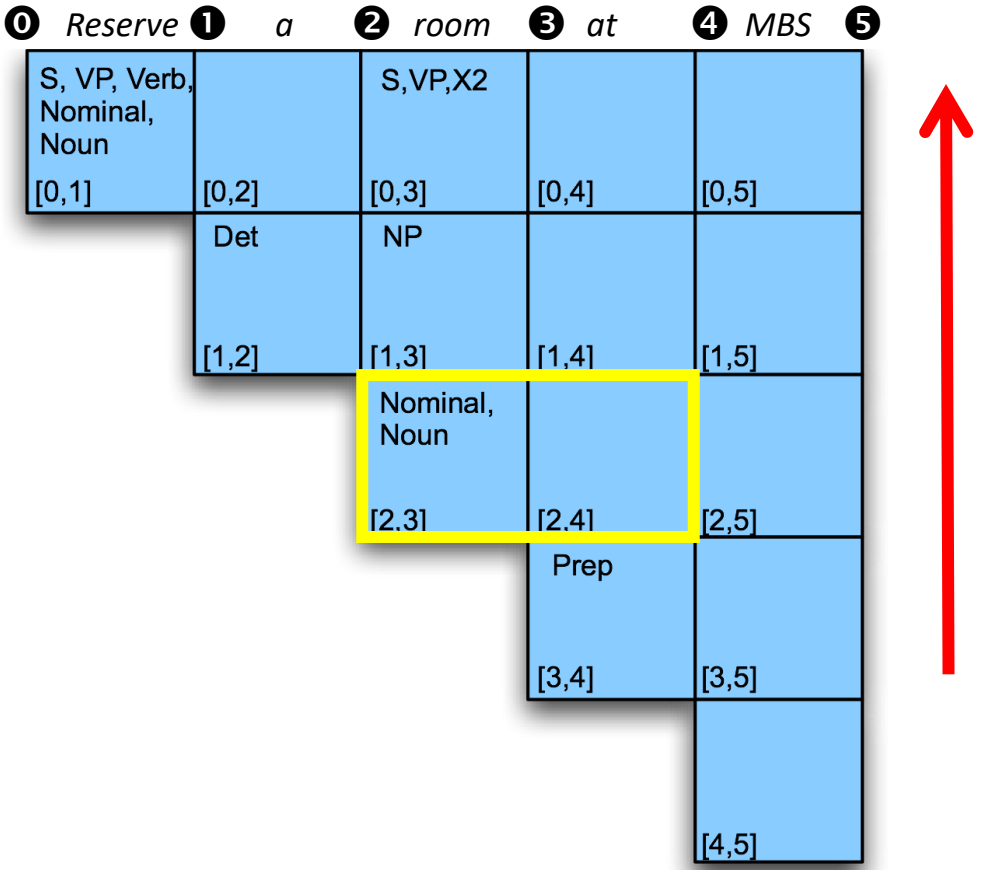

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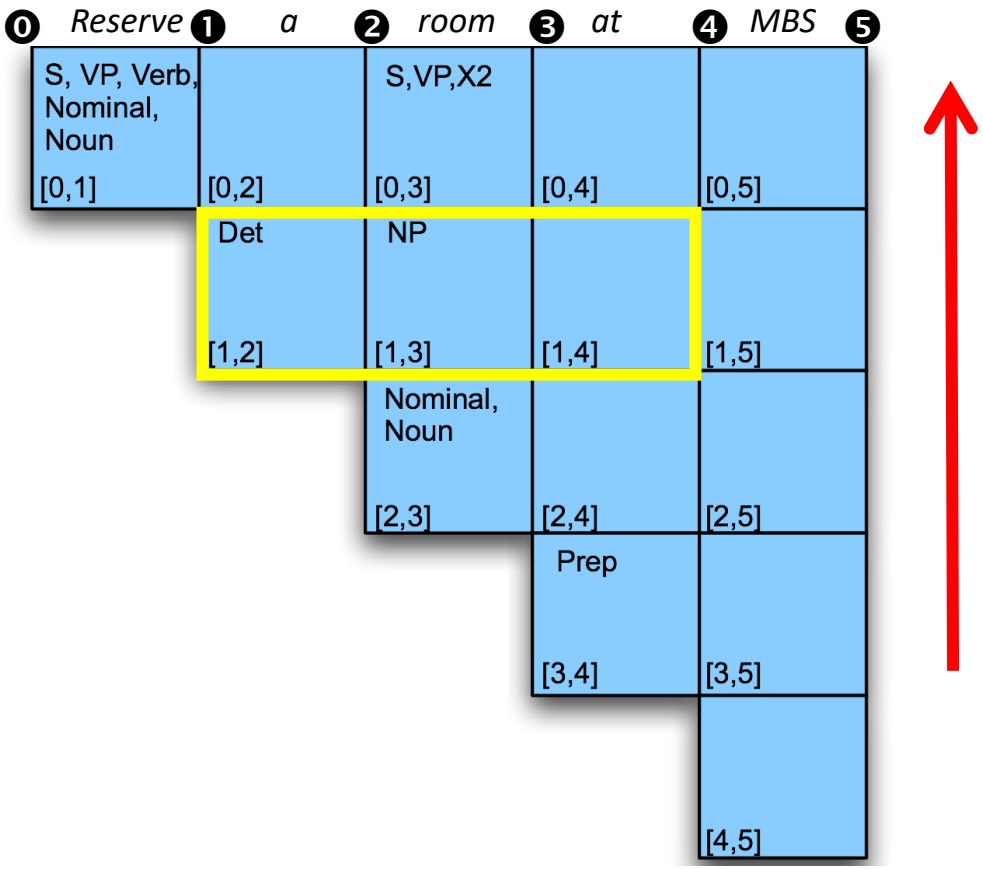

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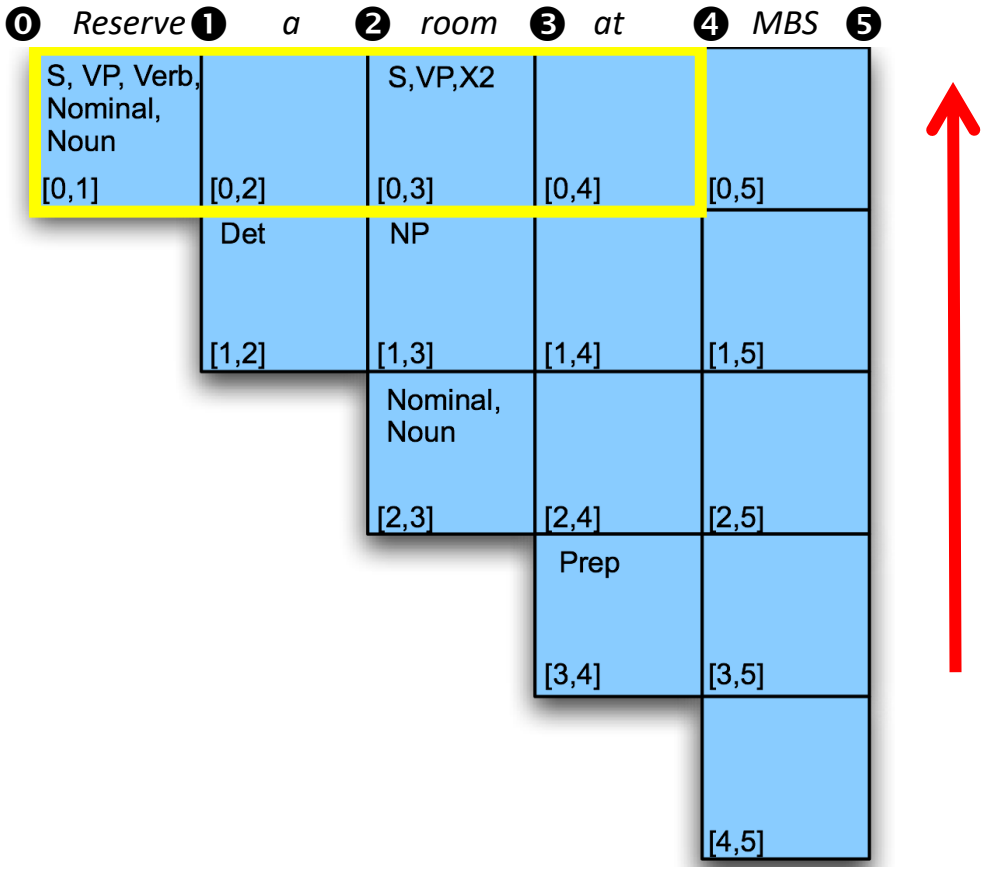

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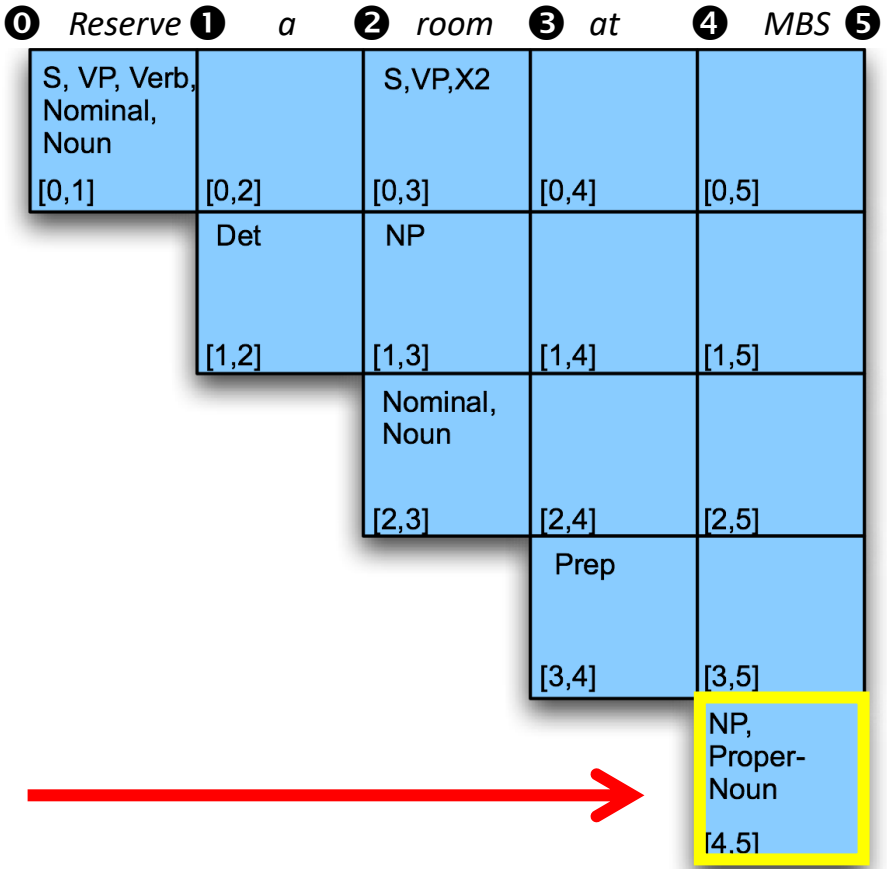

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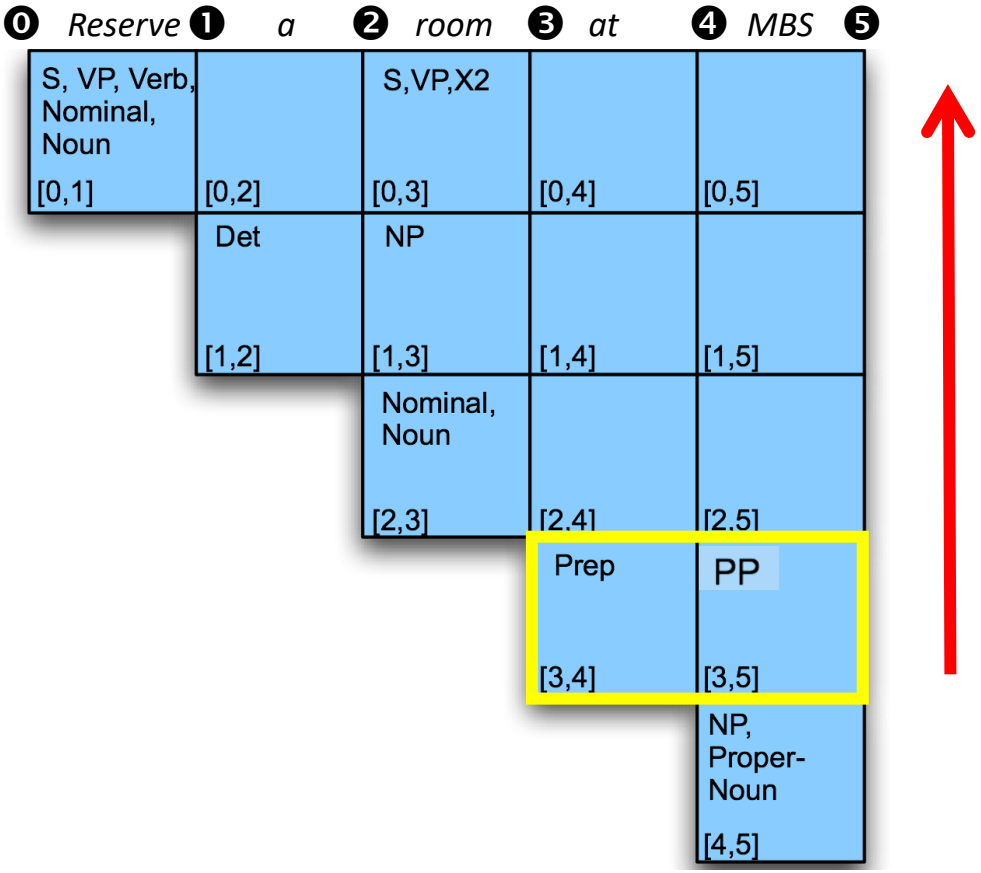

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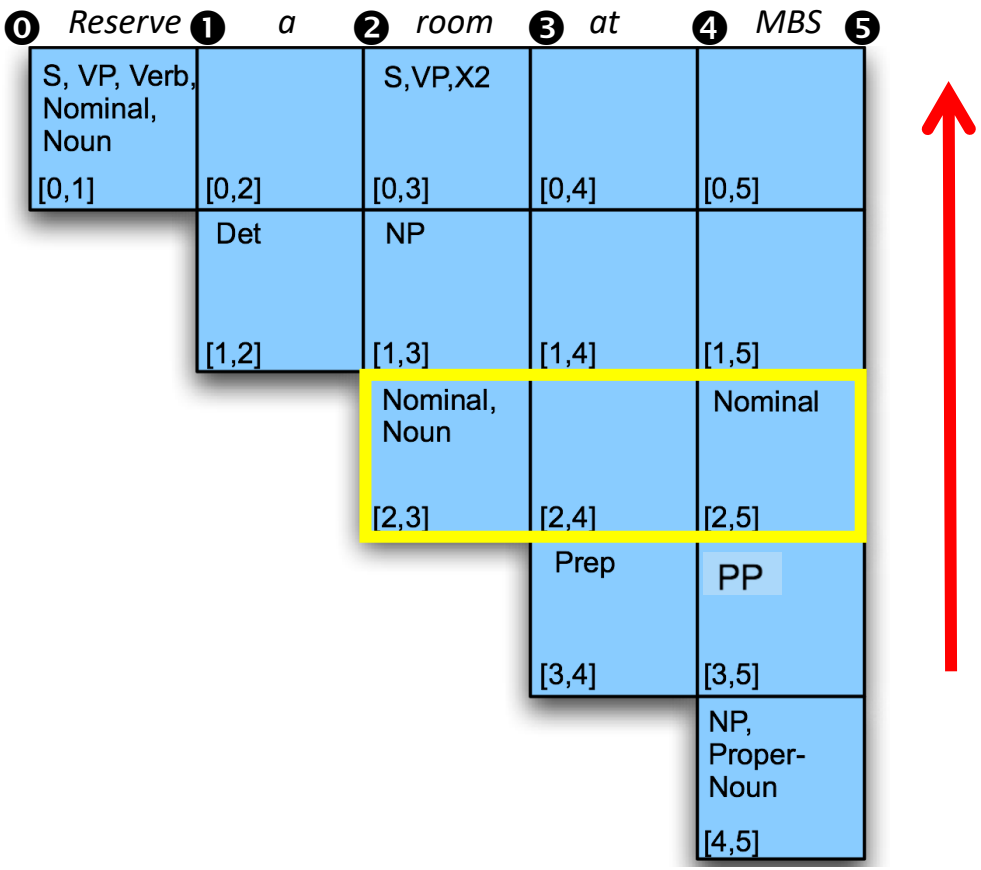

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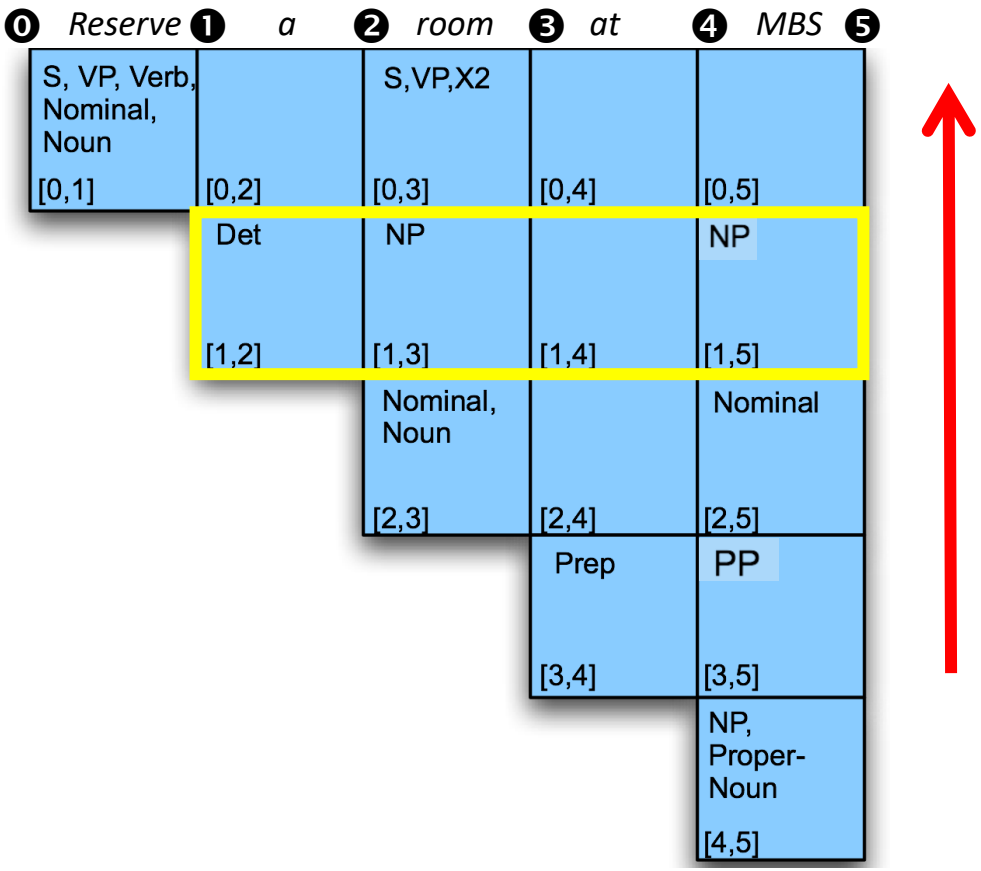

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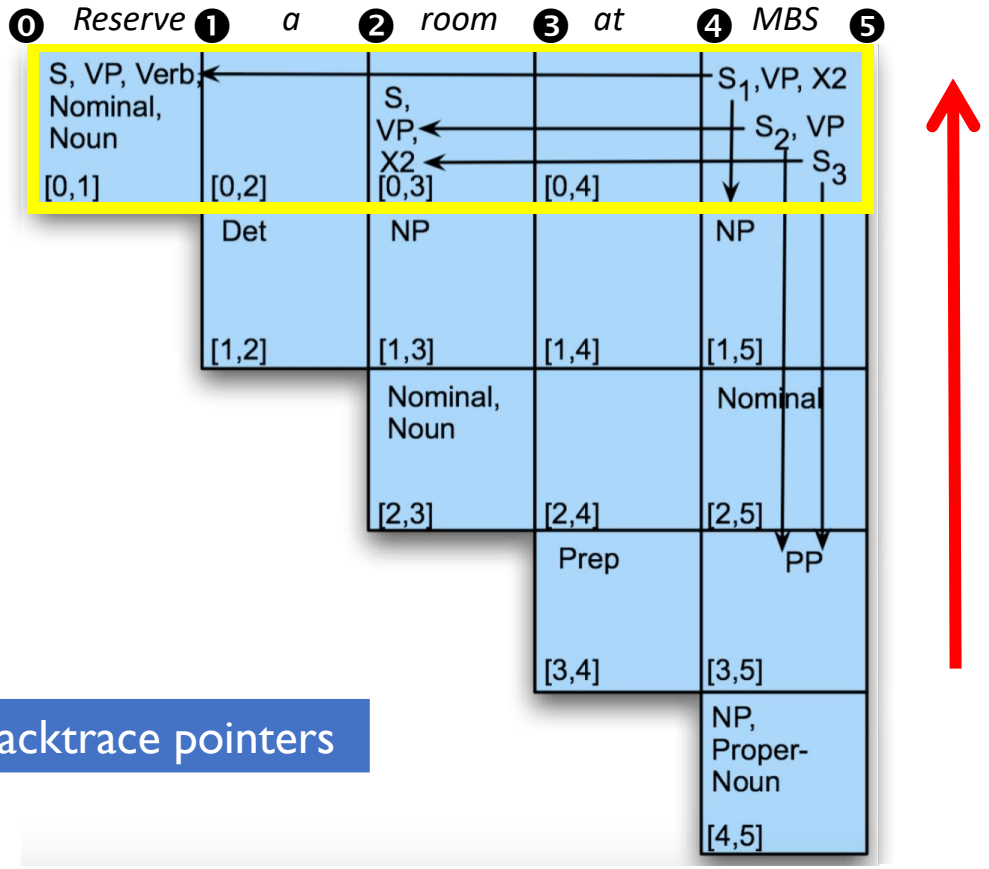
$NP \rightarrow Det\ Nominal$
$Nominal \rightarrow book \mid flight \mid meal \mid money$
$Nominal \rightarrow Nominal\ Noun$
$Nominal \rightarrow Nominal\ PP$
$VP \rightarrow book \mid include \mid prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$
$PP \rightarrow Preposition\ NP$



Q2 You are provided with the phrase structures for the following sentences:

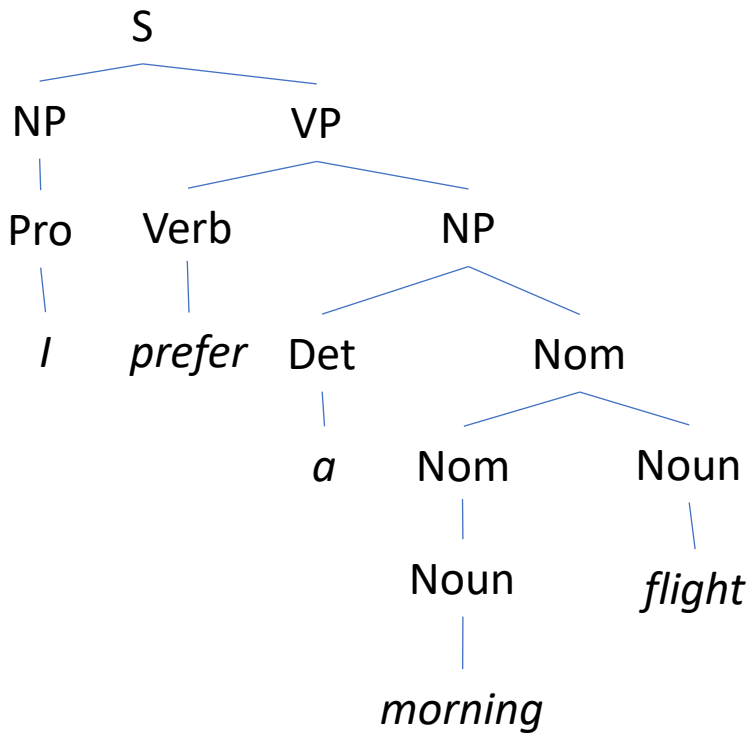
- Sentences:
  - I would like to fly on American airlines.
  - Please repeat that.
  - I need to fly between Philadelphia and Atlanta.
  - What is the fare from Atlanta to Denver?
- **Revise the L1 grammar Q1 such that the revised grammar can be used to parse the above four sentences**

S→ NP VP	Nominal → Noun	NP→ Verb PP
S→ Aux NP VP	Nominal → Nominal Noun	VP → VP PP
S→ VP	Nominal → Nominal PP	PP→ Preposition NP
NP→ Pronoun	VP→ Verb	
NP→ Proper-Noun	VP→ Verb NP	
NP→ Det Nominal	VP → Verb NP PP	

Derivation

Review

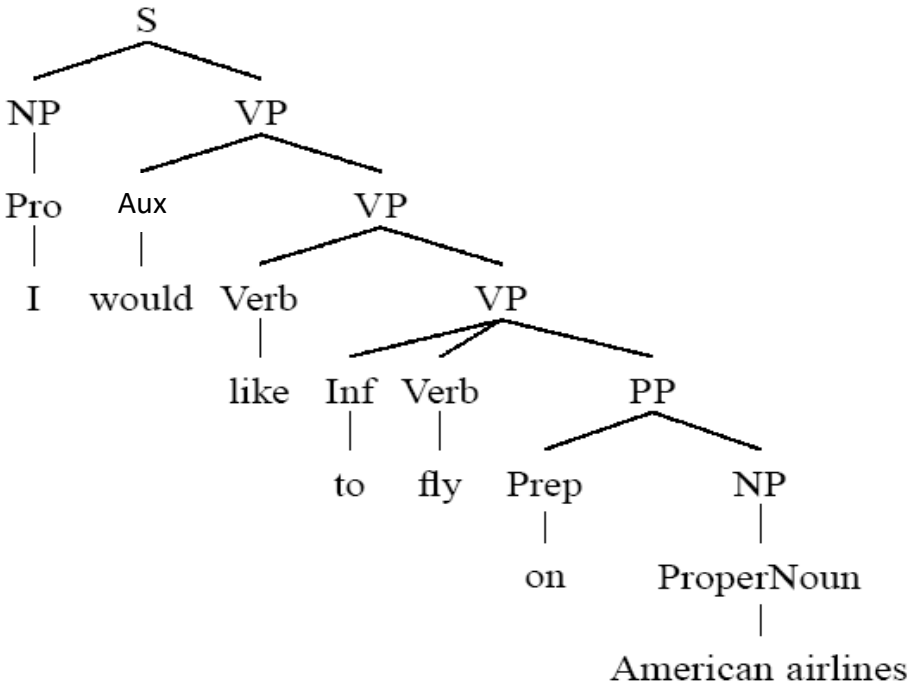
- A derivation (parse tree) consists of the bag of grammar rules that are in the tree

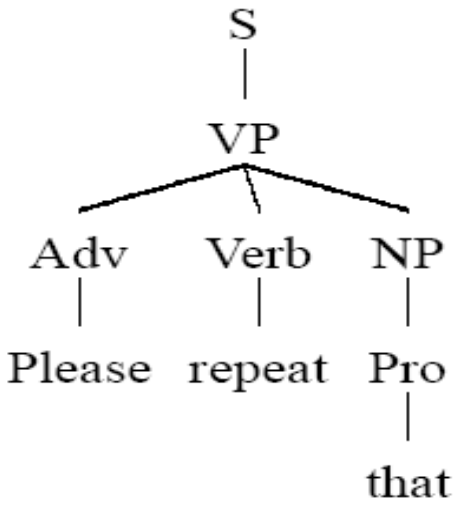


1. S → NP VP
2. NP → Pro
   Pro → I
3. VP → Verb NP
   Verb → prefer
4. NP → Det Nom
   Det → a
5. Nom → Nom Noun
   Noun → morning
6. Nom → Noun
   Noun → flight

The first two sentences

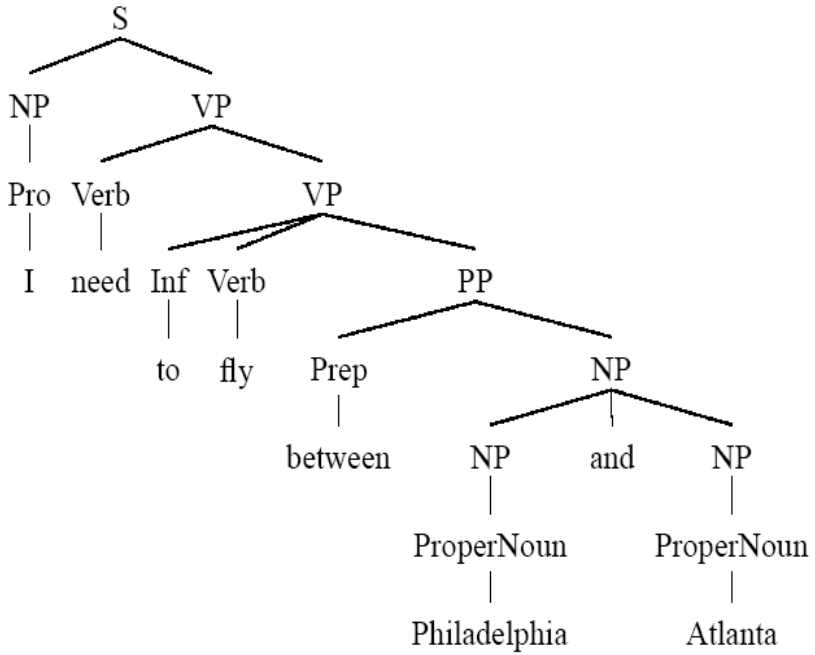
- I would like to fly on American airlines.
- Please repeat that.

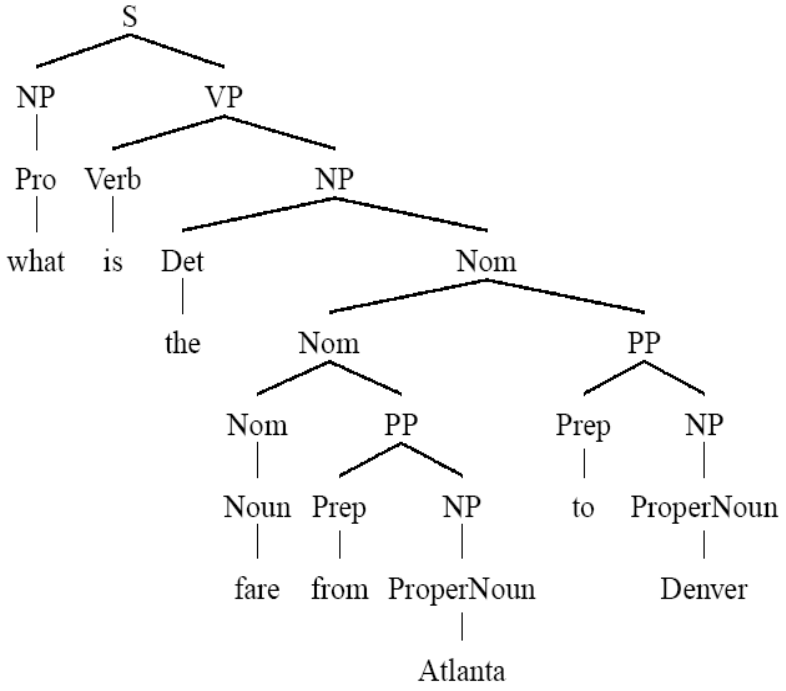




The next two sentences

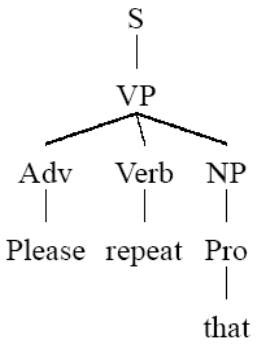
- I need to fly between Philadelphia and Atlanta.
- What is the fare from Atlanta to Denver?





Q2 Solution: Include the rules that are not listed in L I

- S → NP VP
- S → Aux NP VP
- S → VP
- NP → Pronoun
- NP → ProperNoun
- NP → Det Nominal
- NP → NP Conj NP
- Nominal → Noun
- Nominal → Nominal Noun
- Nominal → Nominal PP
- VP → Verb
- VP → Verb NP
- VP → Verb NP PP
- VP → Verb PP



- VP → VP PP
- VP → Aux VP
- VP → Verb VP
- VP → Inf Verb PP
- VP → Adv Verb NP
- PP → Preposition NP
- ----------
- Det → the
- Noun → fare
- Verb → like | fly | repeat | need | is
- Pronoun → I | that | what
- ProperNoun → American airlines | Philadelphia | Atlanta | Denver
- Aux → would
- Preposition → from | to | on | between
- Conj → and
- Inf → to
- Adv → please

Q3. Use the following sentences as examples to observe the dependency structures

https://demos.explosion.ai/displacy

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

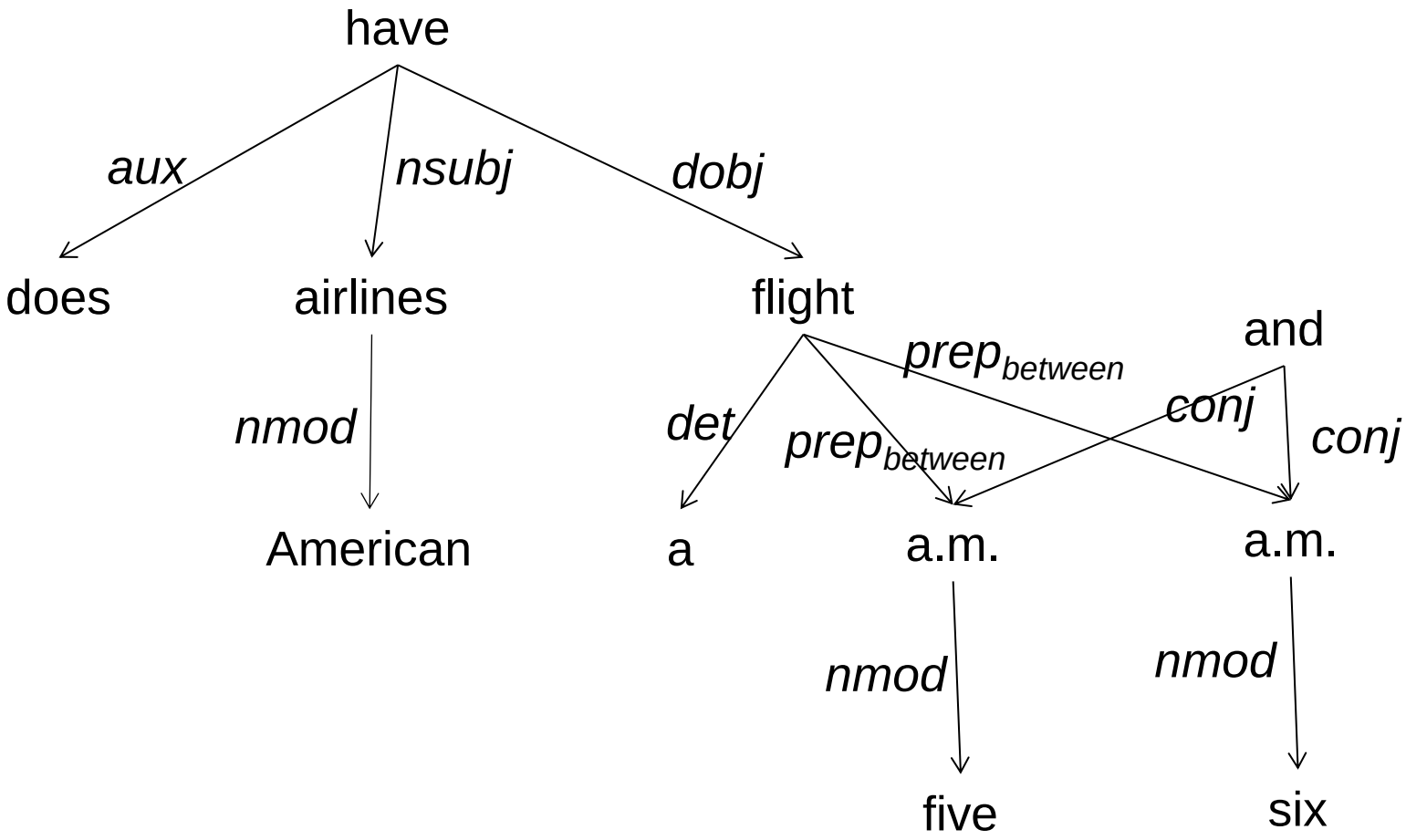
b) I would like to fly on American airlines.

c) Please repeat that.

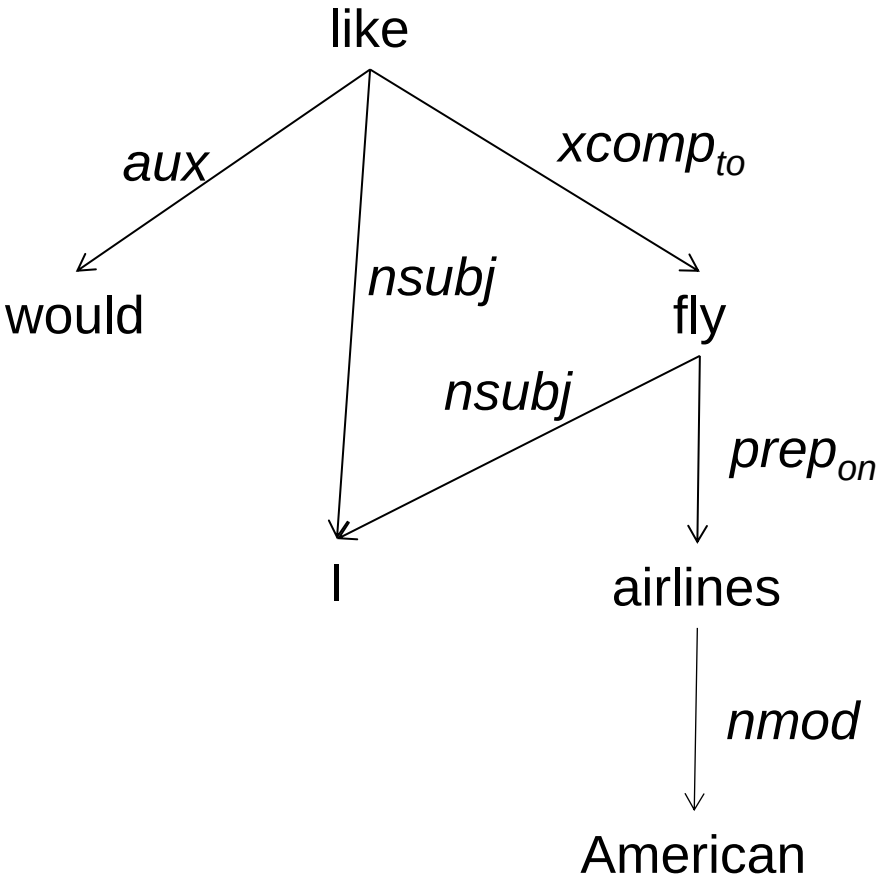
d) I need to fly between Philadelphia and Atlanta.

e) What is the fare from Atlanta to Denver?

Q3 a). Does American airlines have a flight between five a.m. and six a.m.?

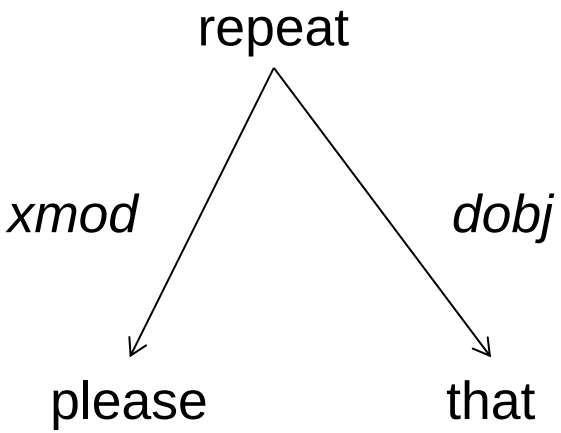


Q3 b). I would like to fly on American airlines.



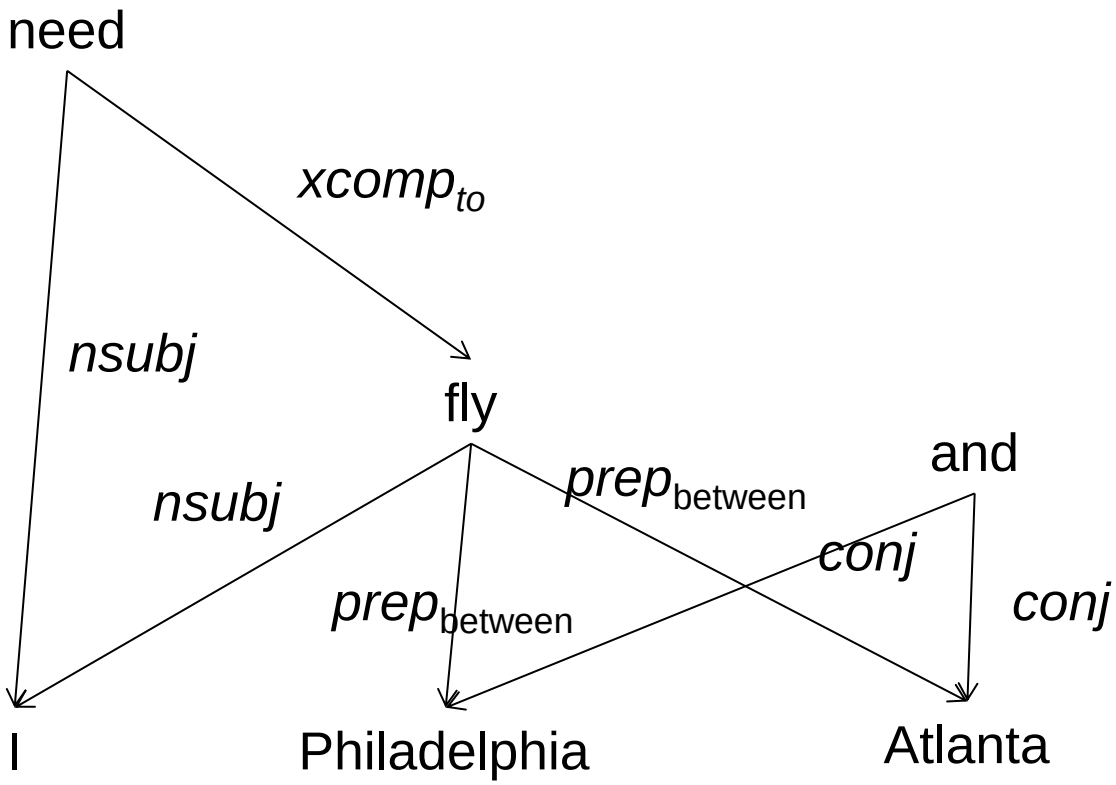
- Verb relations
  - nsubj
  - dobj
  - aux (auxiliary verb – main verb)
  - xmod (verb – adverb)
  - xcomp$_{to}$ (verb – to-infinitive)

Q3 c). Please repeat that.



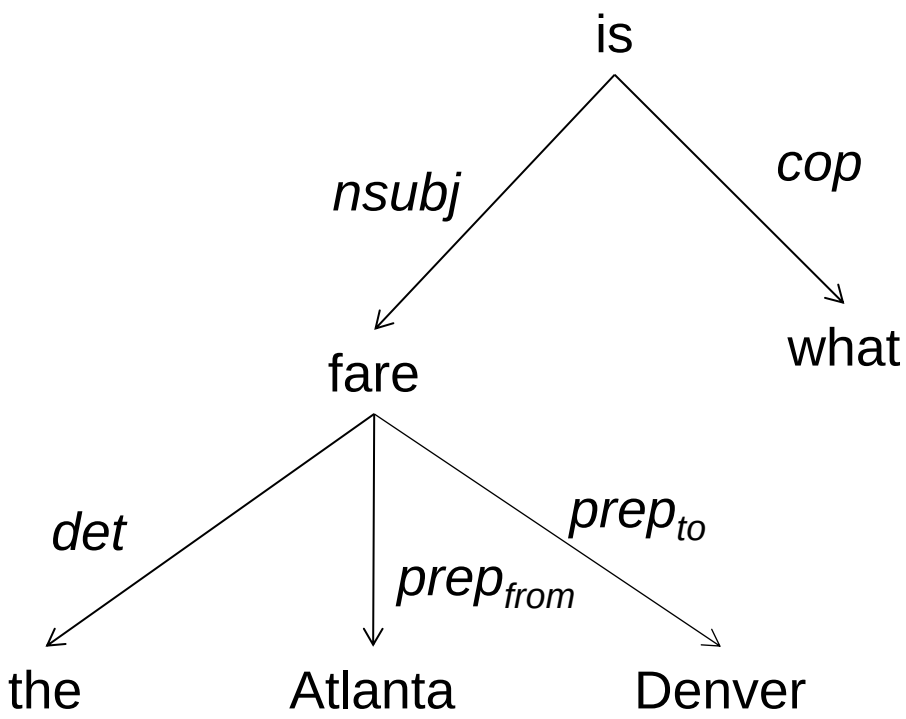
- Verb relations
  - nsubj
  - dobj
  - aux (auxiliary verb – main verb)
  - xmod (verb – adverb)
  - $xcomp_{to}$ (verb – to-infinitive)

Q3 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)

Q3 e). What is the fare from Atlanta to Denver?



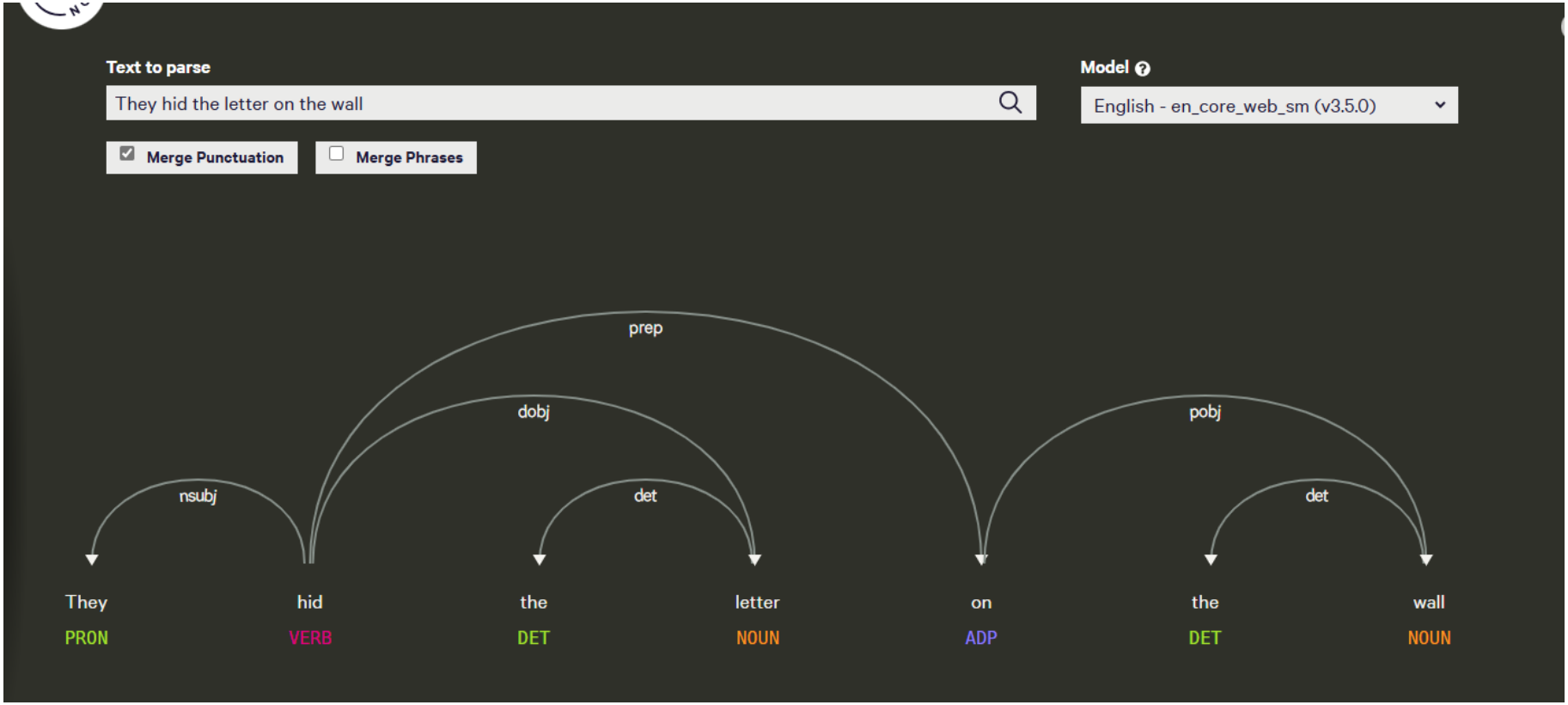
- Verb relations
  - nsubj
  - dobj
  - aux (auxiliary verb – main verb)
  - xmod (verb – adverb)
  - $xcomp_{to}$ (verb – to-infinitive)

Q4 Draw two dependency structures for the following sentence: *They hid the letter on the wall.*

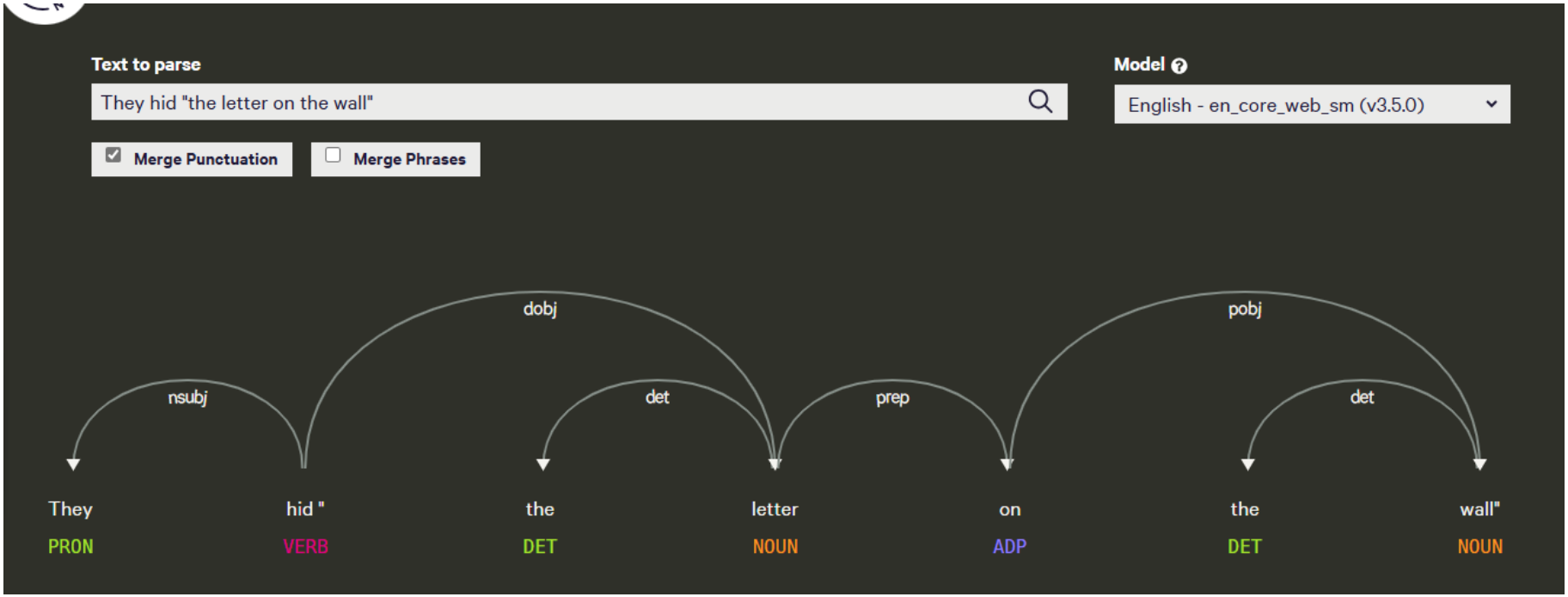
- There was a letter on the wall, but they hid it, and now I've searched the entire wall and can't find it anymore.

- There was a letter on the table, and they hid it on the wall, like behind a painting

Structure I


Text to parse
They hid the letter on the wall
Model
English - en_core_web_sm (v3.5.0)
Merge Punctuation
Merge Phrases
prep
dobj
pobj
nsubj
det
det
They
PRON
hid
VERB
the
DET
letter
NOUN
on
ADP
the
DET
wall
NOUN

Structure 2


Text to parse
They hid "the letter on the wall"
Model
English - en_core_web_sm (v3.5.0)
Merge Punctuation
Merge Phrases
nsubj
dobj
det
prep
pobj
det
They
PRON
hid "
VERB
the
DET
letter
NOUN
on
ADP
the
DET
wall"
NOUN

Q5.Open question

- Try and explore the Rule-based Matcher

  https://demos.explosion.ai/matcher

- Define a pattern and explain why it could be useful for a real-life use case for some text data (e.g., news articles, financial reports, medical reports, product reviews)