SWE1017

Natural Language Processing

Venue:AB2-205 *Topic: Basic Parsing Strategy*

Prof. Tulasi Prasad Sariki,

SCSE, VIT Chennai Campus

www.learnersdesk.weebly.com

Simple CFG for ATIS English

Grammar

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

Lexicon

Det → the | a | that | this
Noun → book | flight | meal | money
Verb → book | include | prefer
Pronoun → I | he | she | me
Proper-Noun → Houston | NWA
Aux → does
Prep → from | to | on | near | through

A Fragment of English Grammar

S → NP VP

VP → V NP

NP → NNP | ART N

NNP → Ram

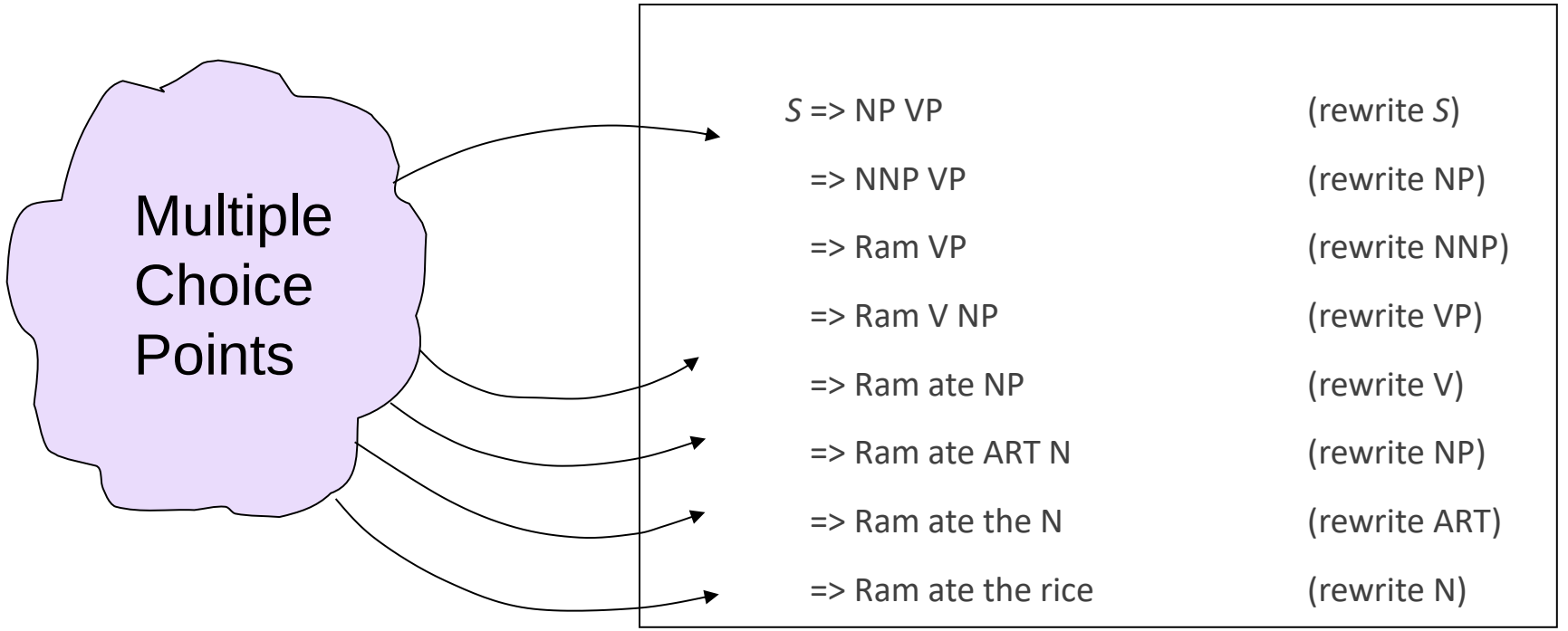
V → ate | saw

ART → a | an | the

N → rice | apple | movie

Derivation

- *S* is a special symbol called start symbol.



Two Strategies : Top-Down & Bottom-Up

Top down : Start with *S* and generate the sentence.

Bottom up : Start with the words in the sentence and use the rewrite rules backwards to reduce the sequence of symbols to produce *S*.

Previous slide showed top-down strategy.

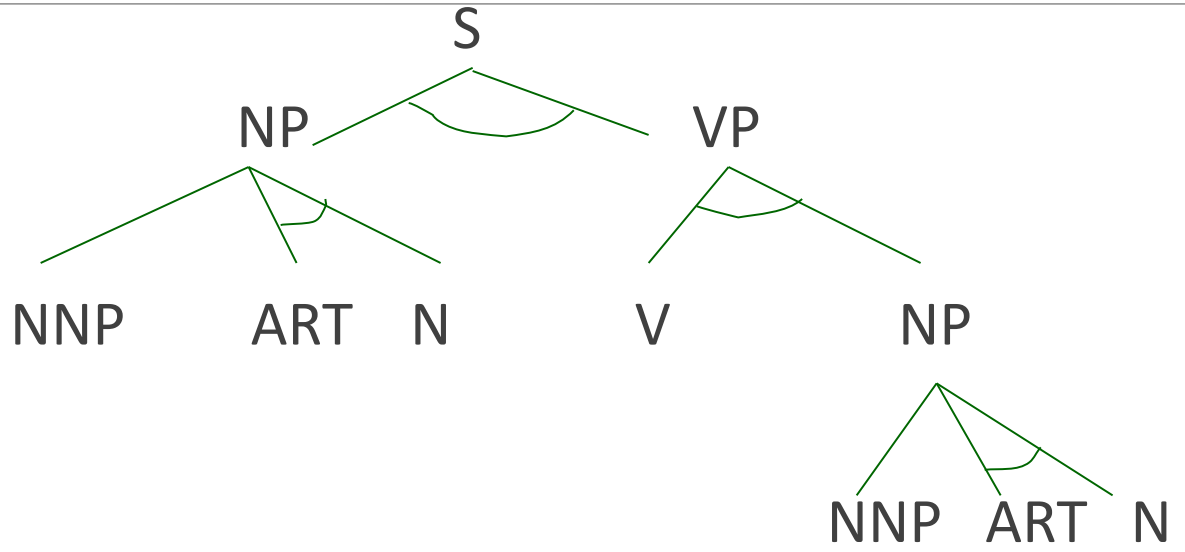
Bottom-Up Derivation

	Ram ate the rice	
=>	NNP ate the rice	(rewrite Ram)
=>	NNP V the rice	(rewrite ate)
=>	NNP V ART rice	(rewrite the)
=>	NNP V ART N	(rewrite rice)
=>	NP V ART N	(rewrite NNP)
=>	NP V NP	(rewrite ART N)
=>	NP VP	(rewrite V NP)
=>	S	

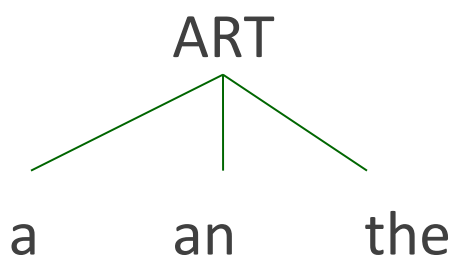
Parsing Algorithm

A procedure that “searches” through the grammatical rules to find a combination that generates a tree which stands for the structure of the sentence.

Parsing as Search (State Space : AND–OR Graph)



The leaves have links to words in the language, *e.g.,*



→ AND node

→ OR node

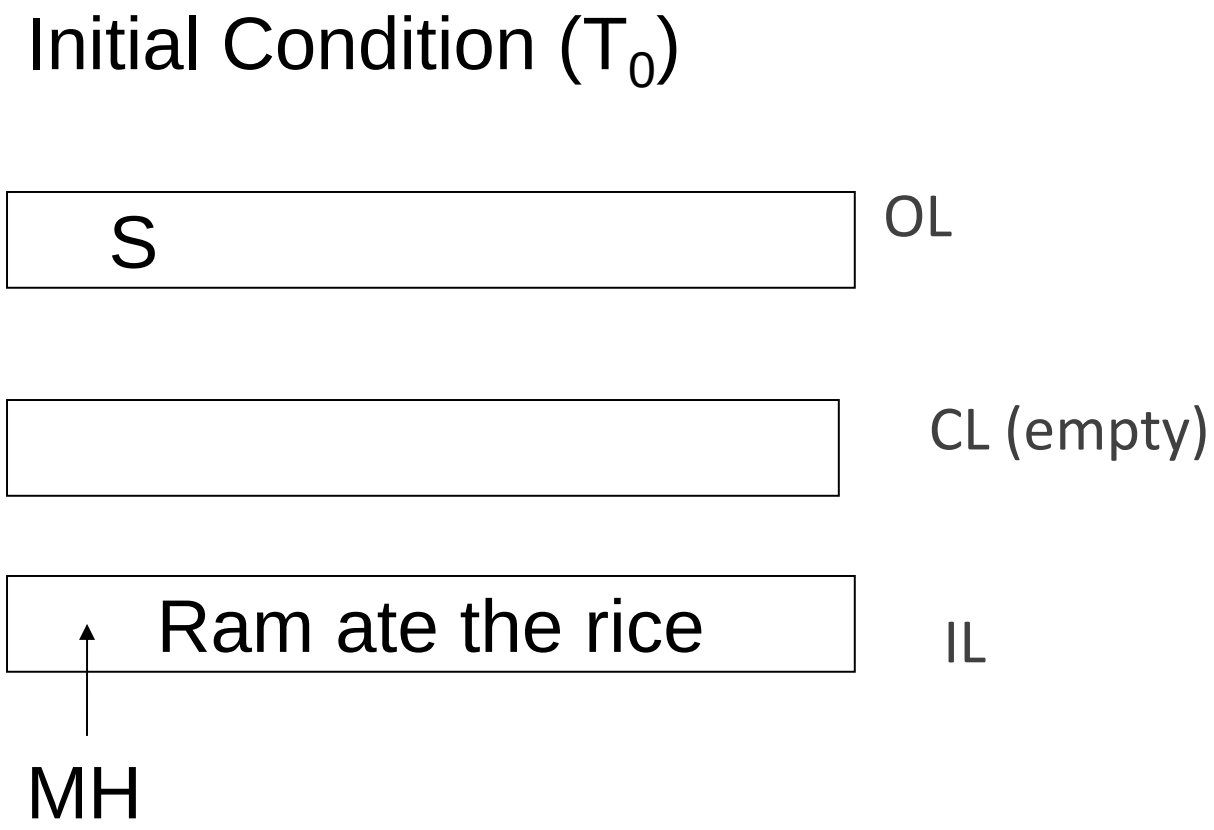
Top-Down Parsing

DFS on the AND-OR graph

Data structures:

- *Open List (OL)*: Nodes to be expanded
- *Closed List (CL)*: Expanded Nodes
- *Input List (IL)*: Words of sentence to be parsed
- *Moving Head (MH)*: Walks over the IL

Trace of Top-Down Parsing



Trace of Top-Down Parsing

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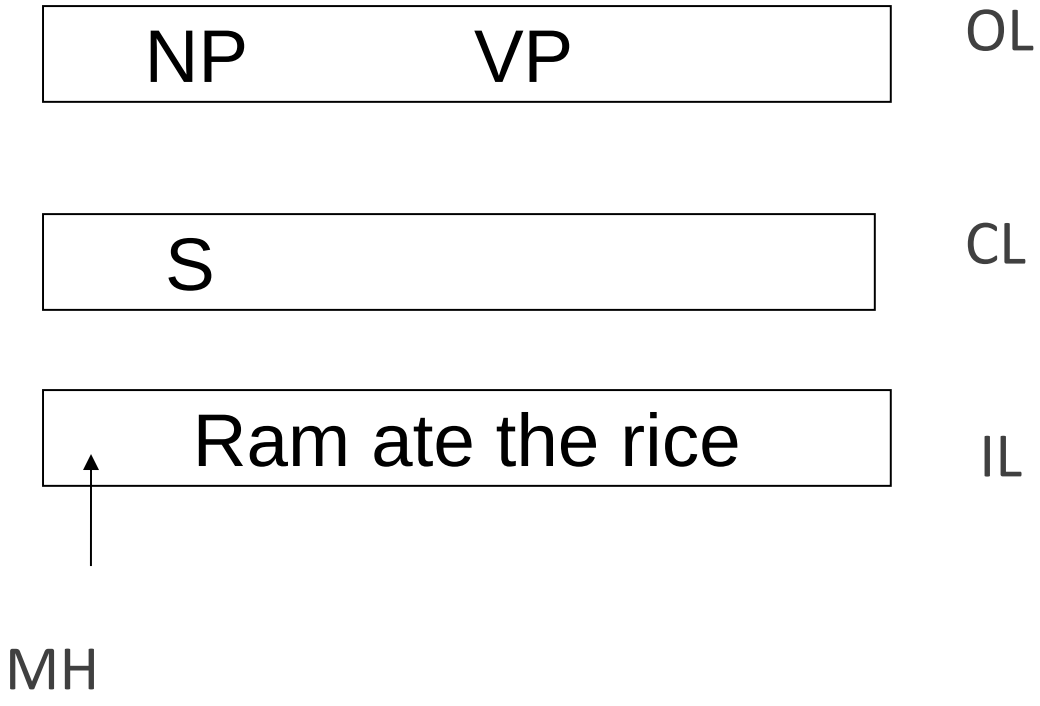
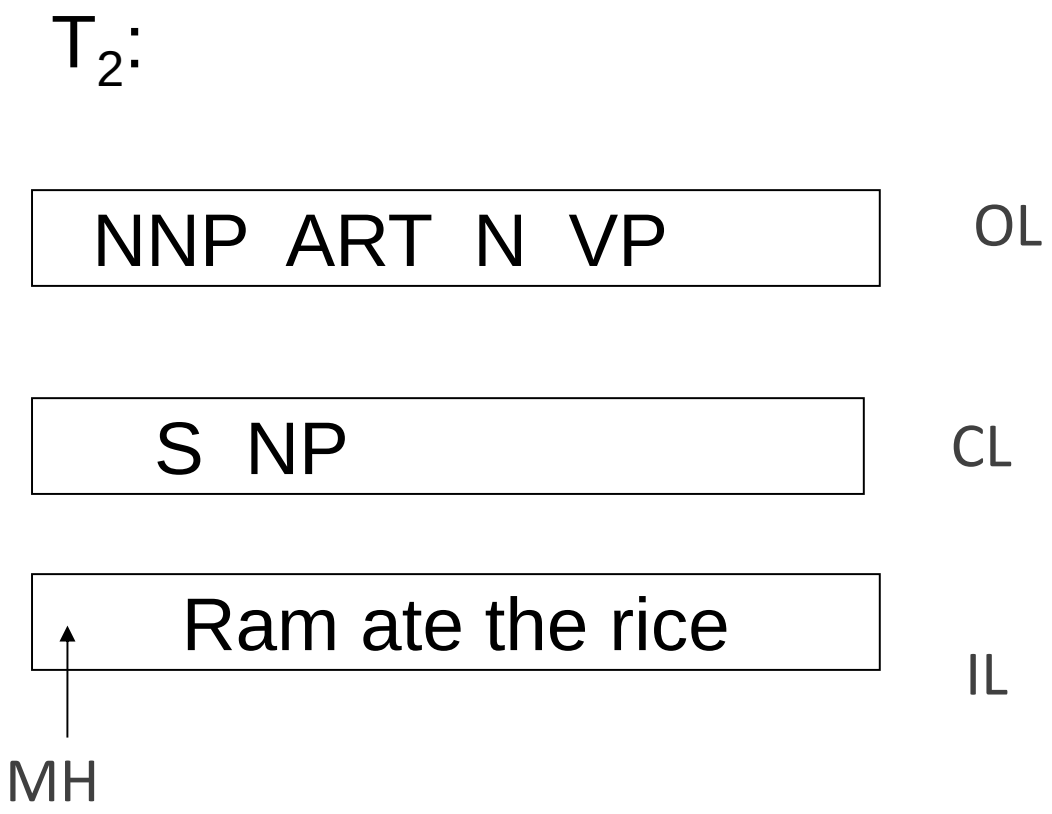


Trace of Top-Down Parsing



Trace of Top-Down Parsing

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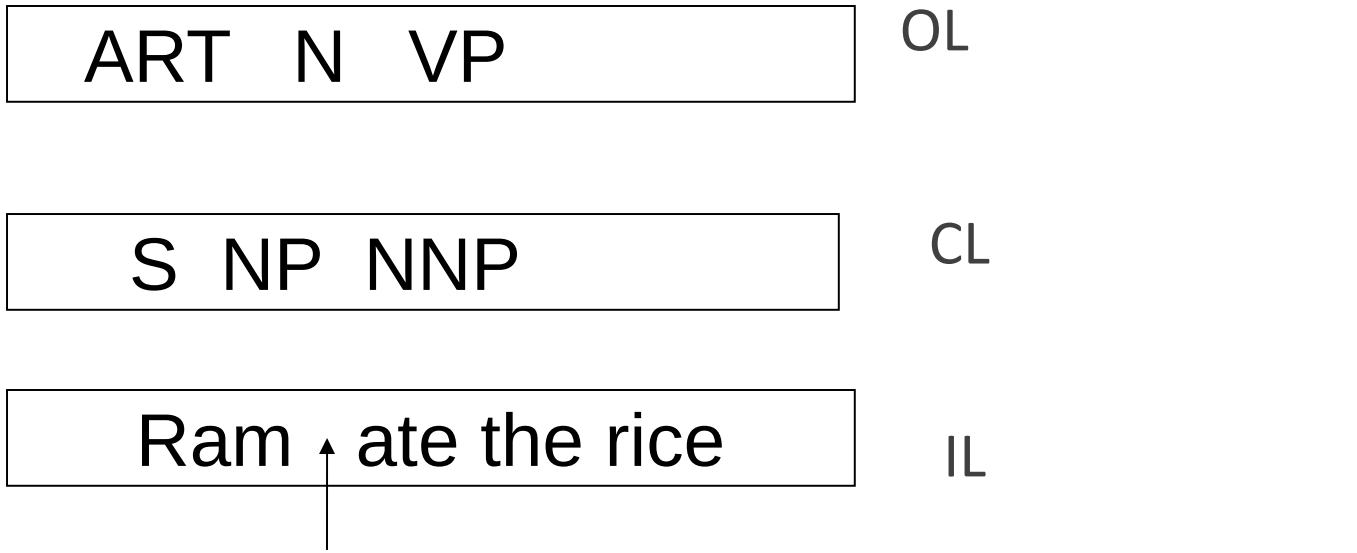

Trace of Top-Down Parsing

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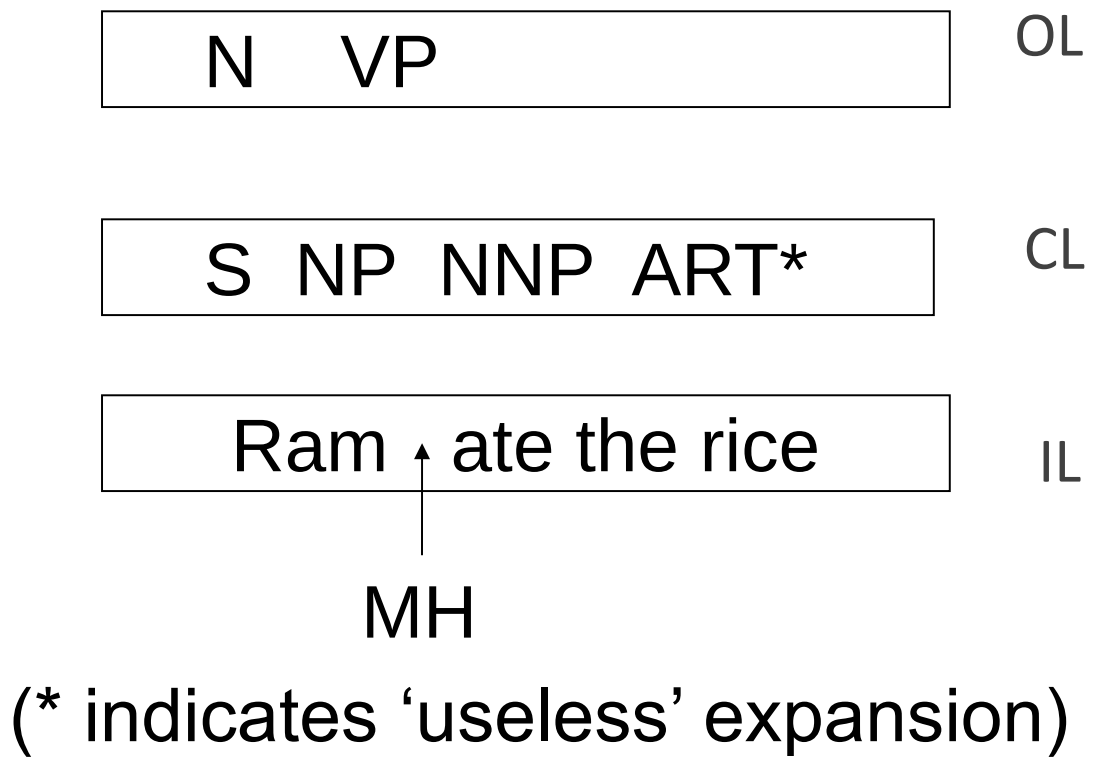
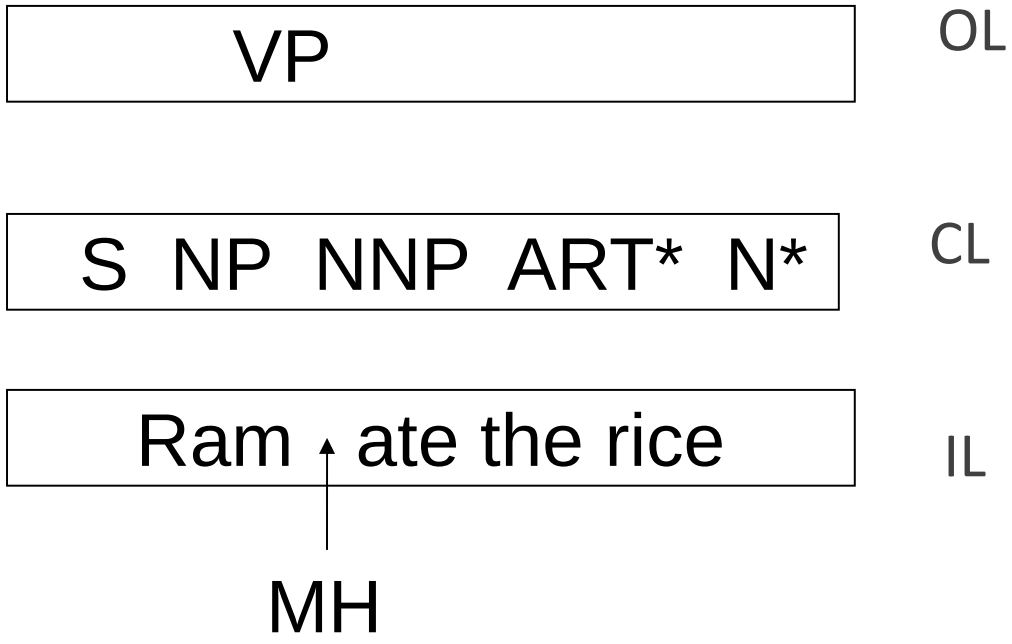


(* indicates ‘useless’ expansion)

Trace of Top-Down Parsing

T_5:



Trace of Top-Down Parsing

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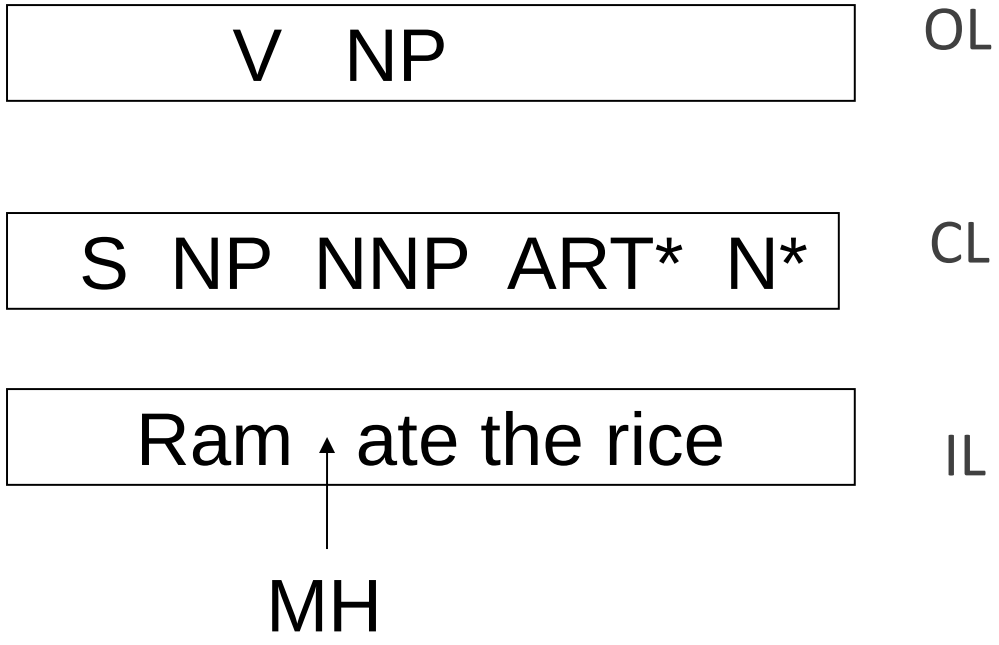

Trace of Top-Down Parsing

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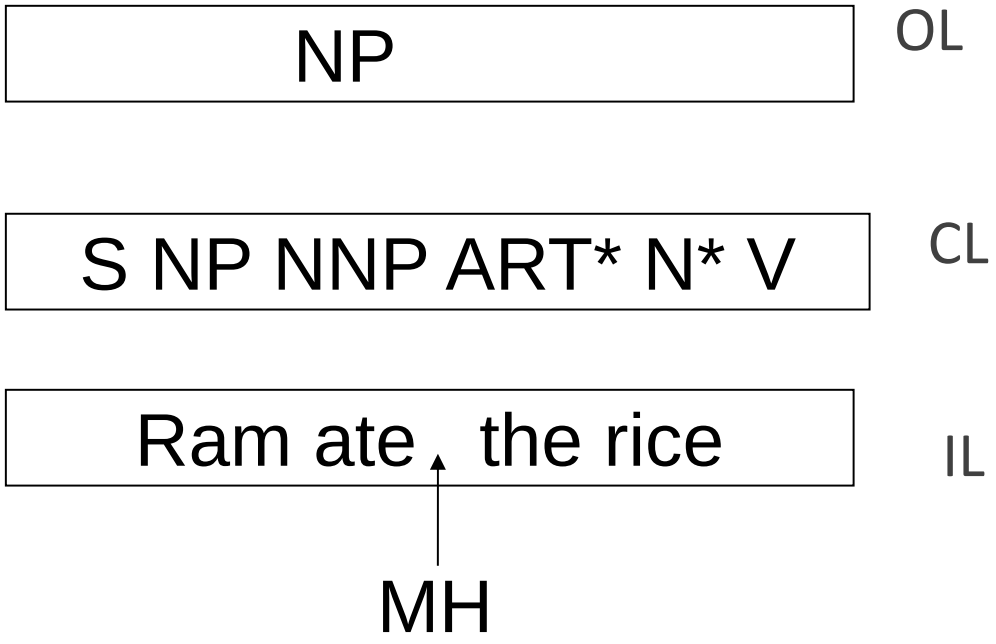

Trace of Top-Down Parsing

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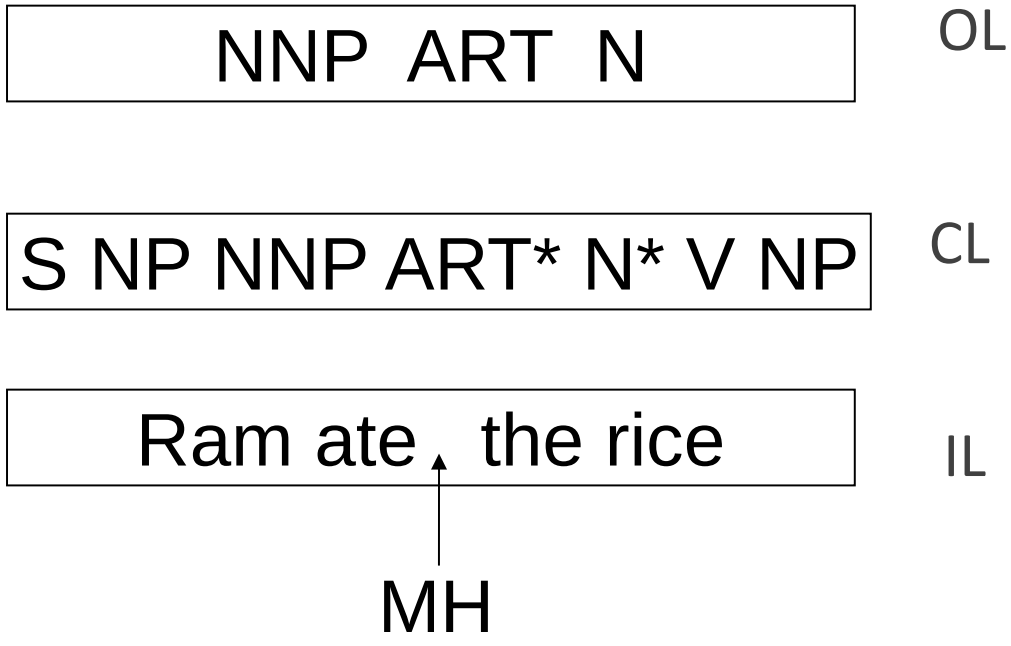

Trace of Top-Down Parsing

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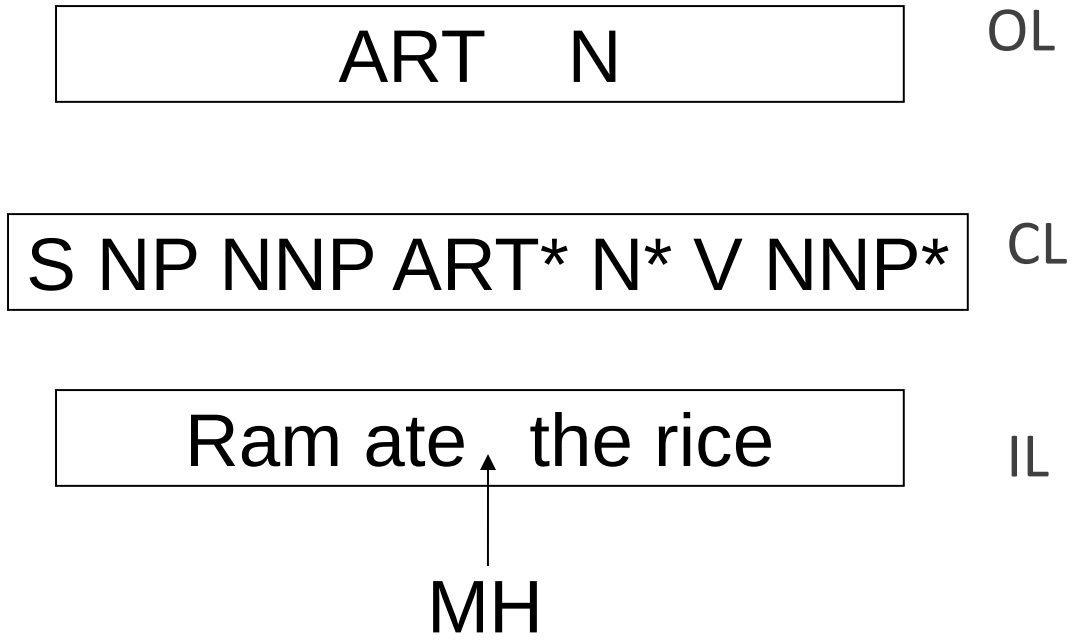

Trace of Top-Down Parsing

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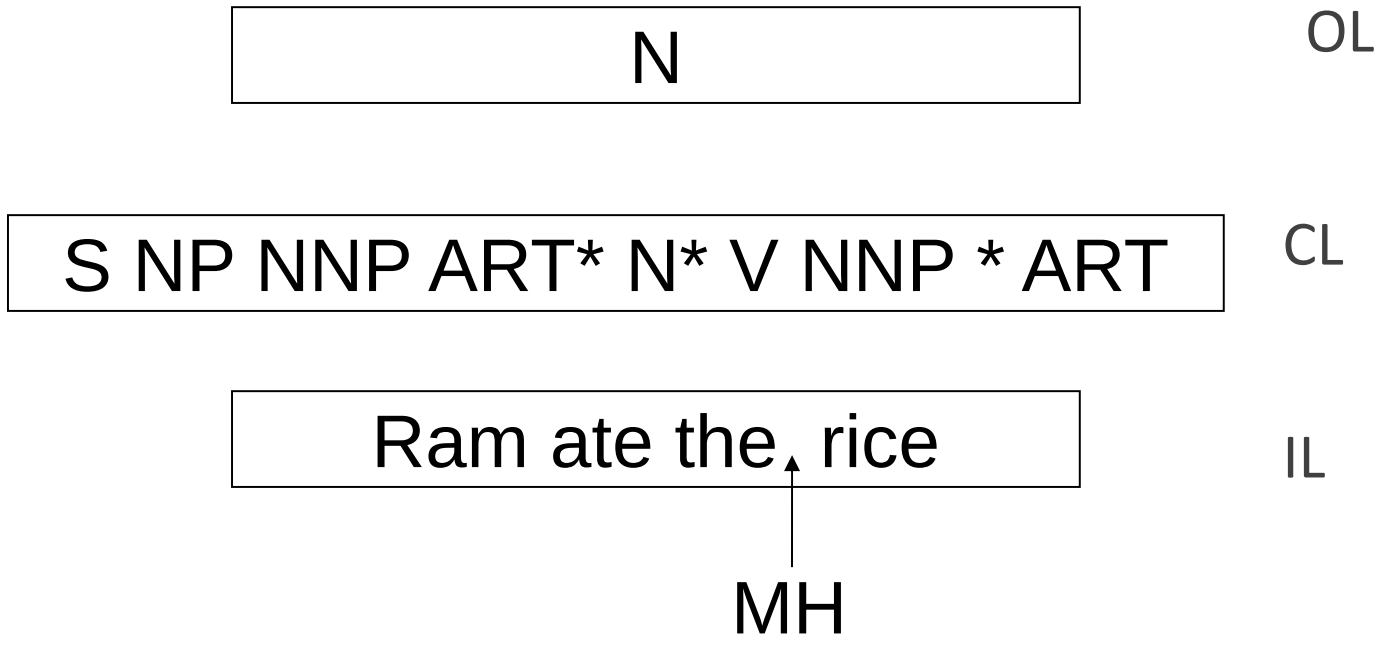
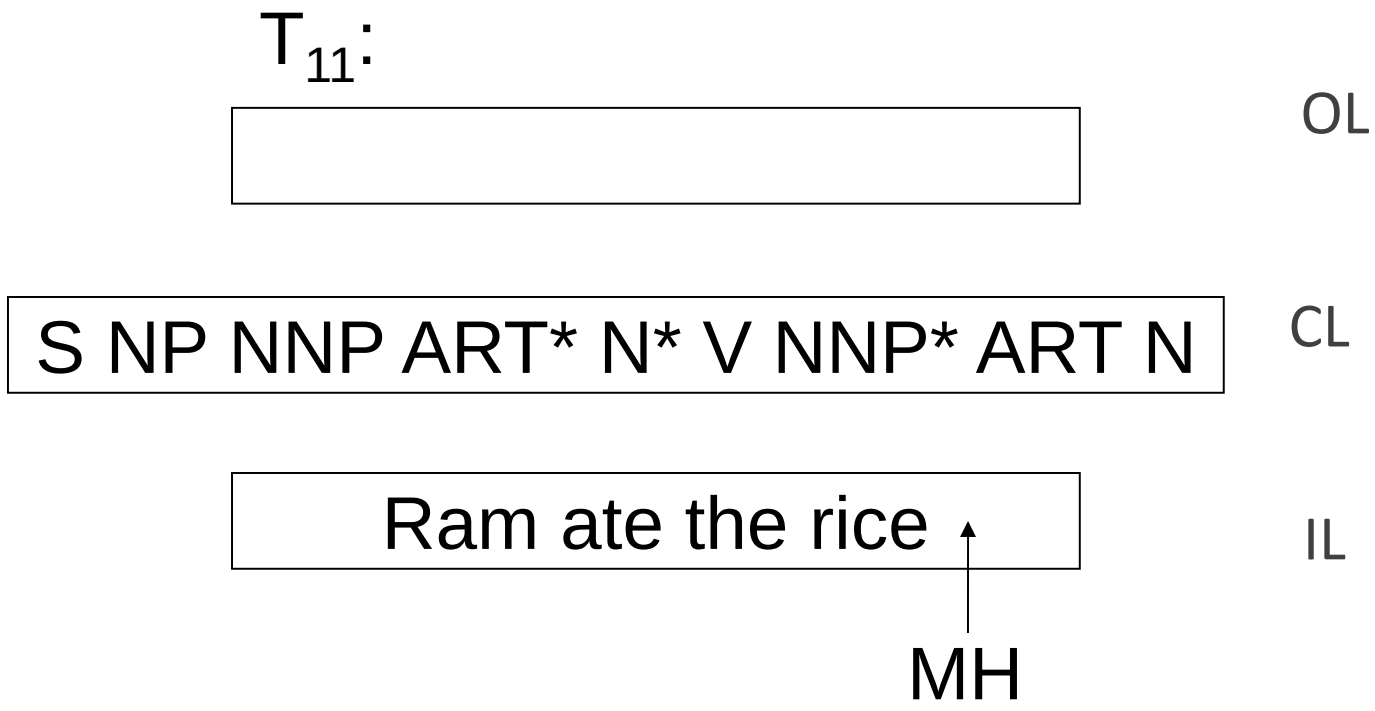


Trace of Top-Down Parsing



Successful Termination: OL empty AND MH at the end of IL.

Bottom-Up Parsing

Basic idea:

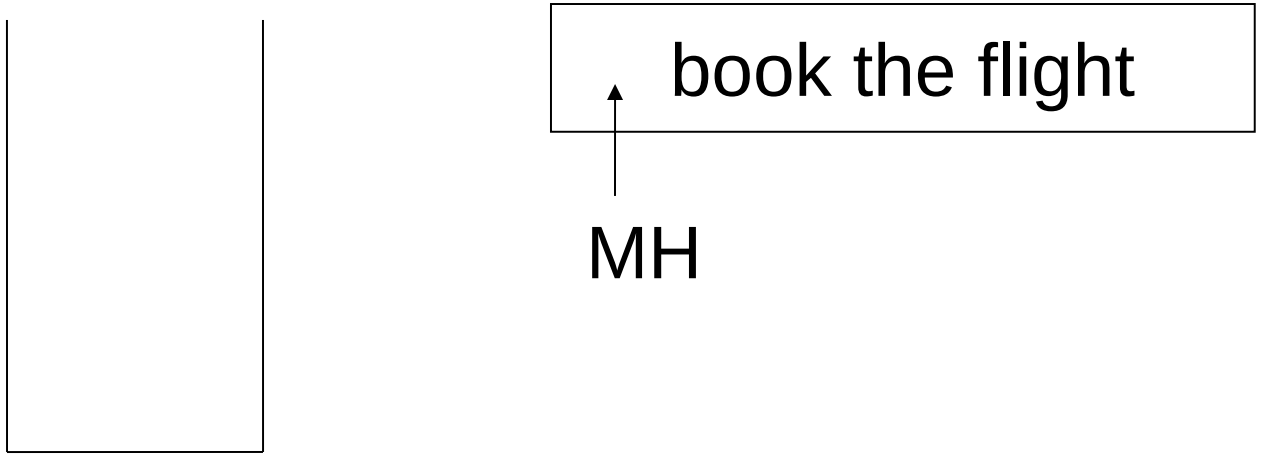
- Refer to words from the lexicon.
- Obtain all POSs for each word.
- Keep combining until *S* is obtained.

Implementation of Bottom-up Parsing

- Through a stack
- Push words into the stack
- Look for a “handle” to reduce to a non-terminal
- Termination by “start symbol on stack” and “end of sentence”.

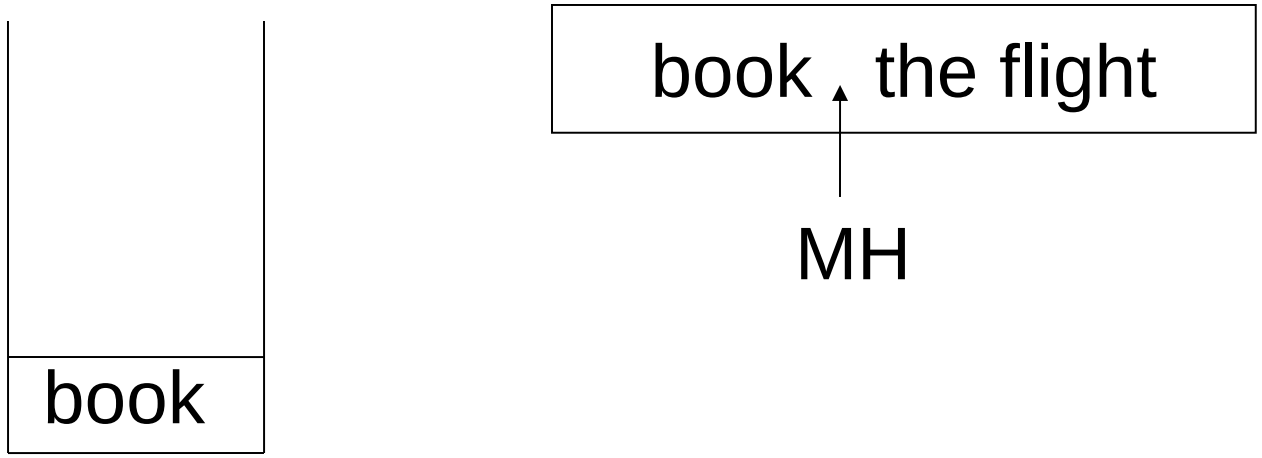
Trace of Bottom-Up Parsing

T_0



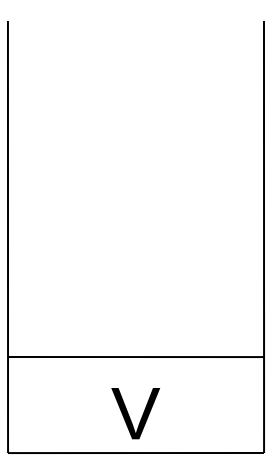
Trace of Bottom-Up Parsing

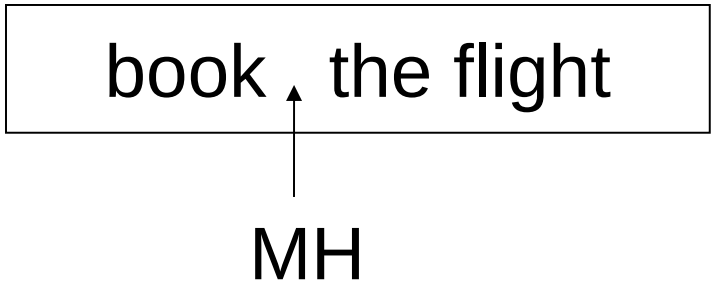
Push ‘book’; advance input pointer



Trace of Bottom-Up Parsing

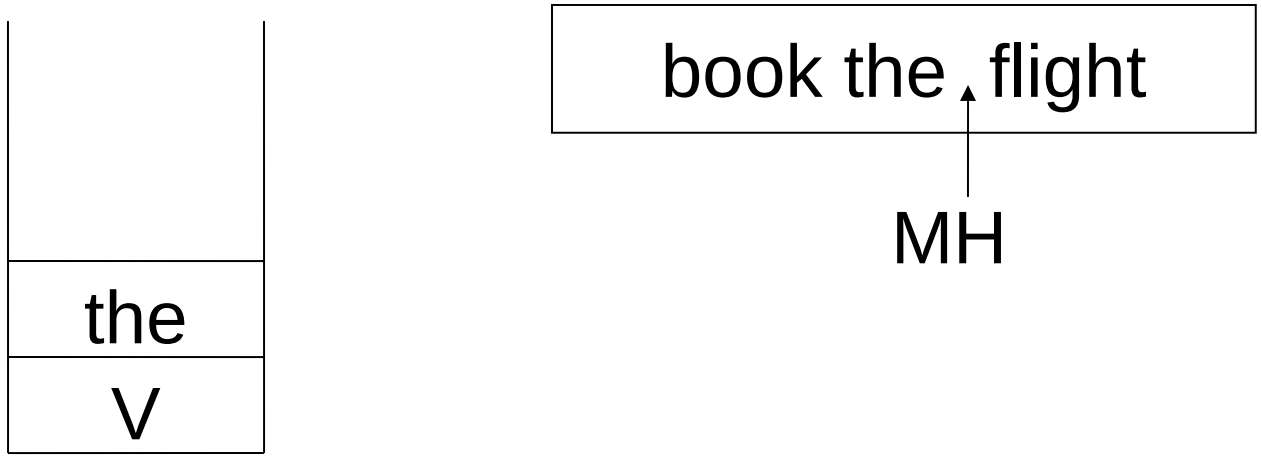
Reduce ‘book’





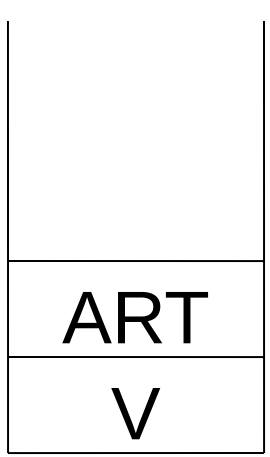
Trace of Bottom-Up Parsing

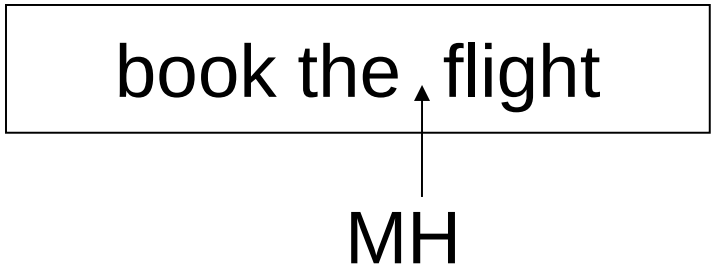
Push ‘the’; advance input pointer



Trace of Bottom-Up Parsing

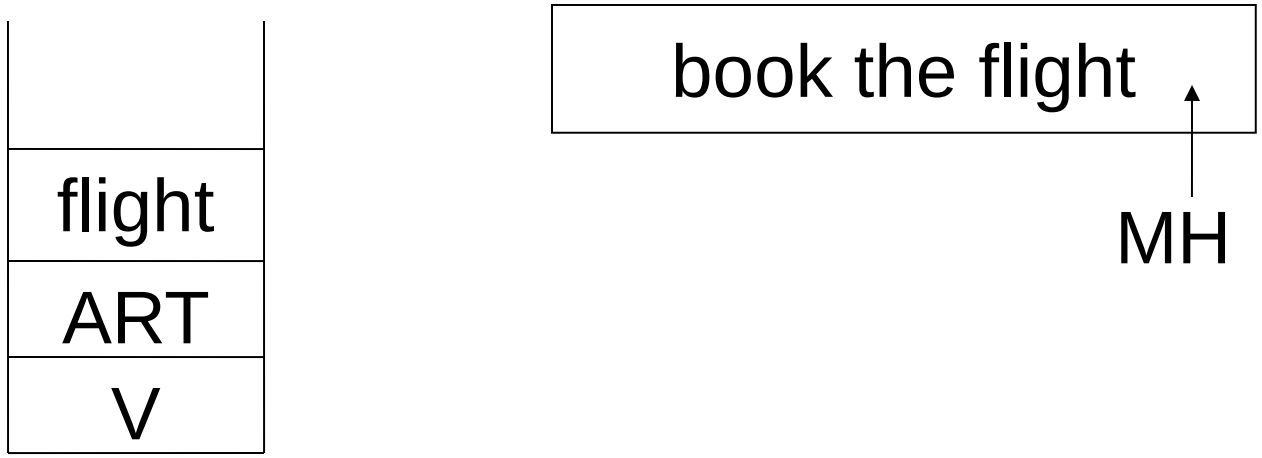
Reduce ‘the’





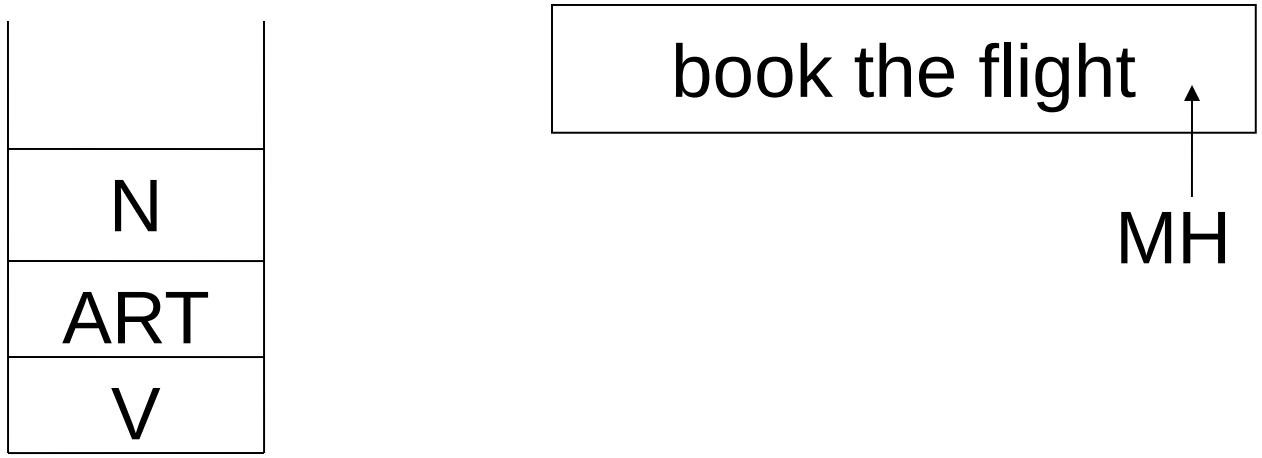
Trace of Bottom-Up Parsing

Push ‘flight’; advance pointer



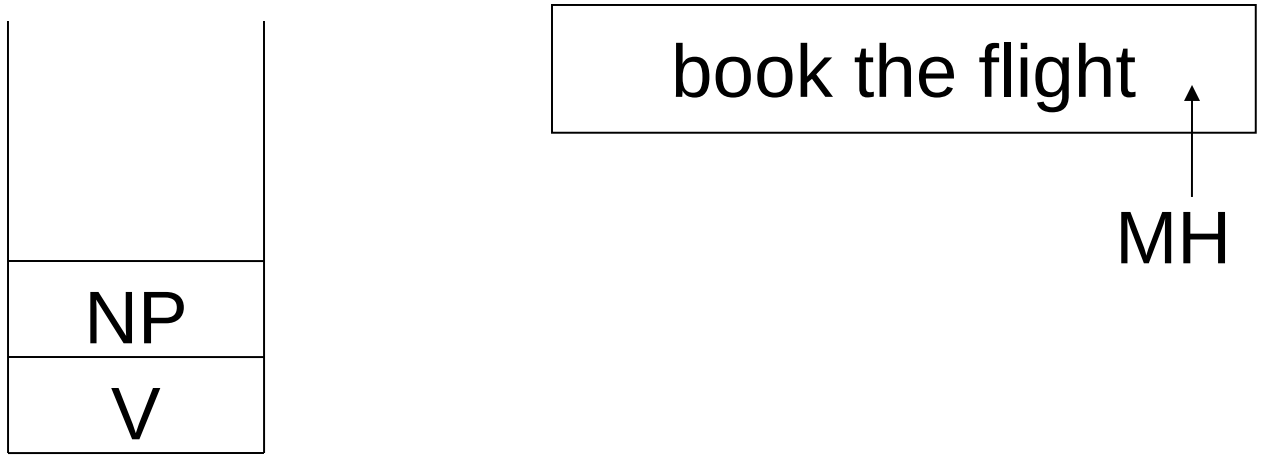
Trace of Bottom-Up Parsing

Reduce ‘flight’



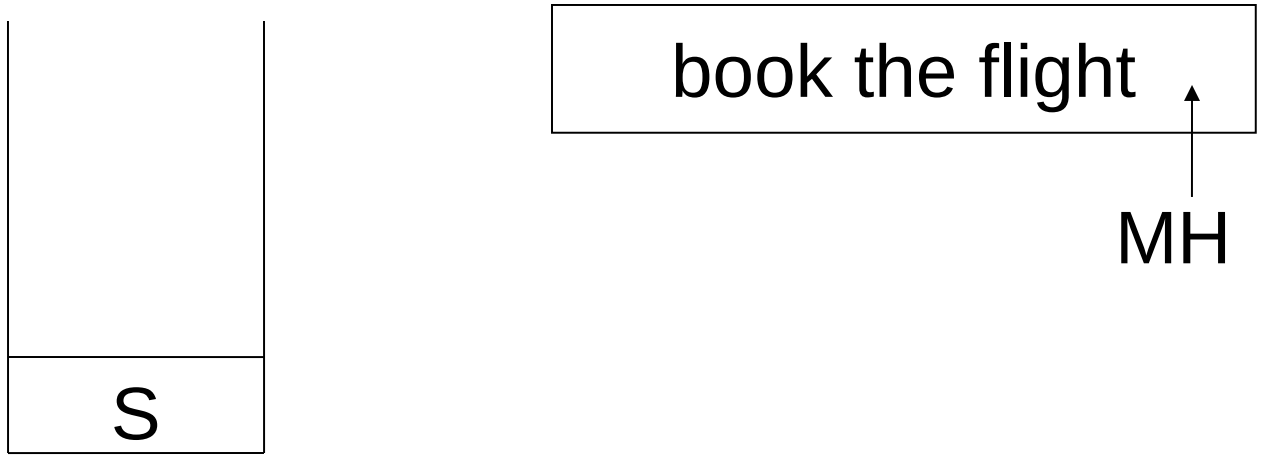
Trace of Bottom-Up Parsing

Reduce ‘ART N’ by ‘NP’

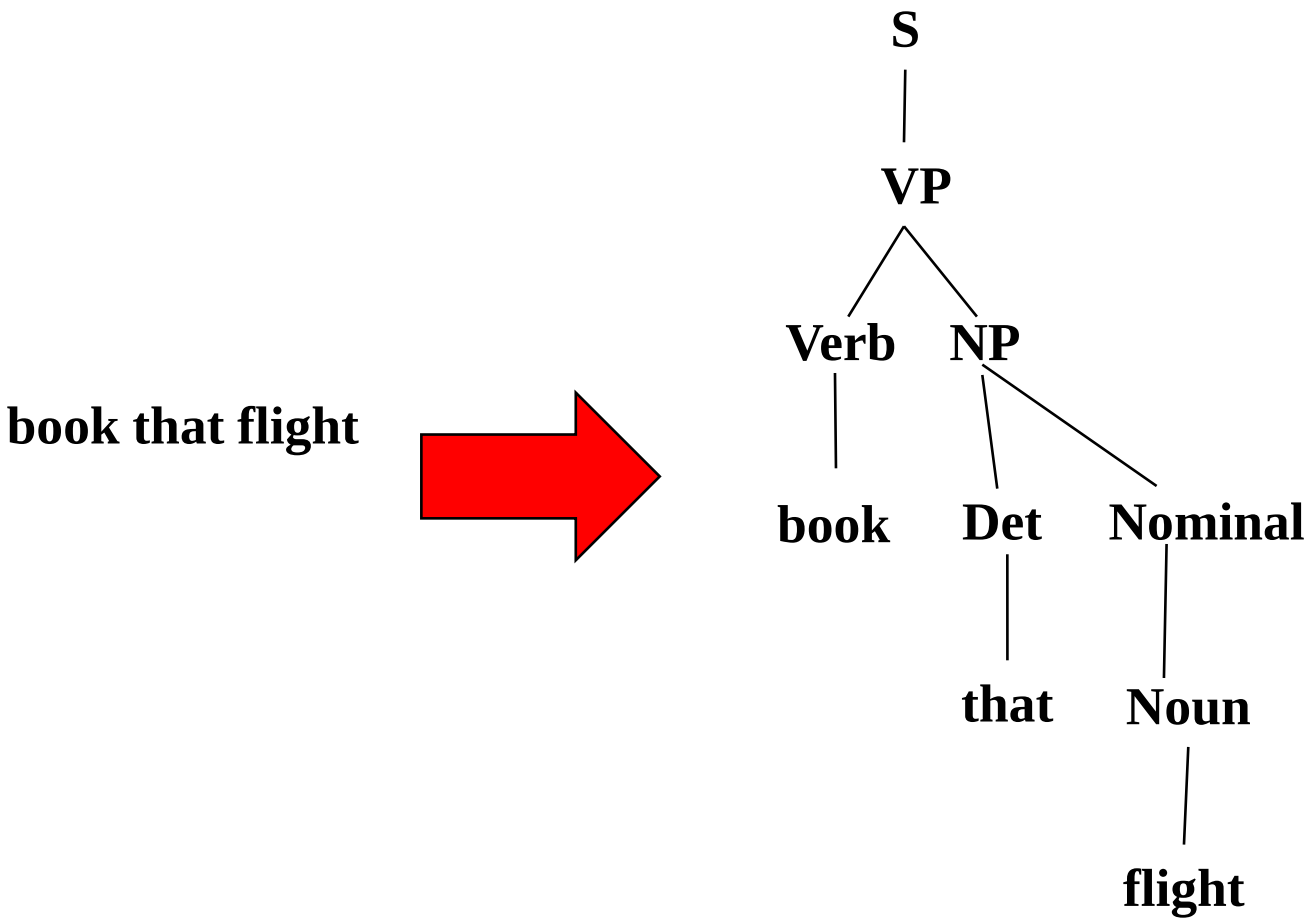


Trace of Bottom-Up Parsing

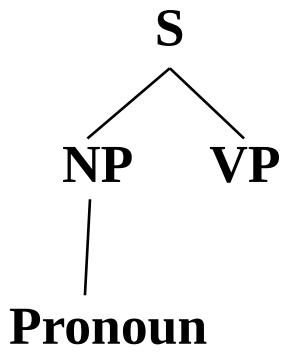
Reduce ‘V NP’ by ‘S’; *termination* by *S* on stack and input exhausted.



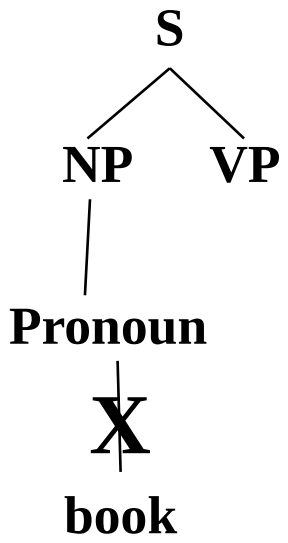
Parsing Example



Top Down Parsing



Top Down Parsing



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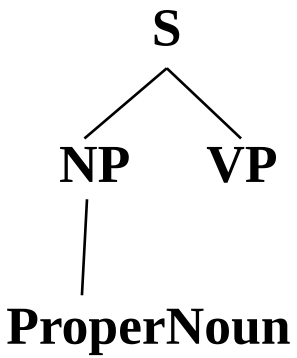

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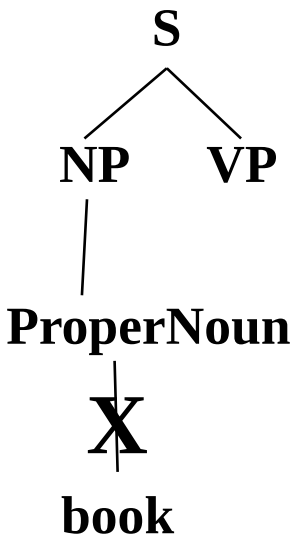

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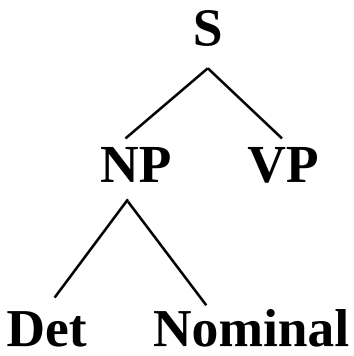
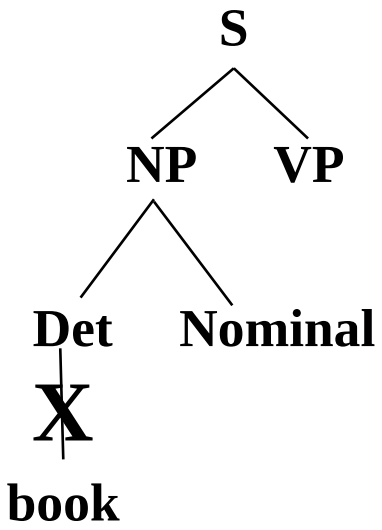


Top Down Parsing



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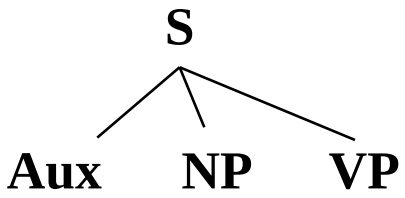

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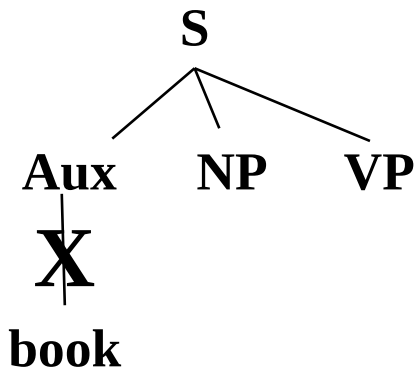

Top Down Parsing

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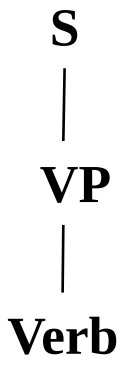
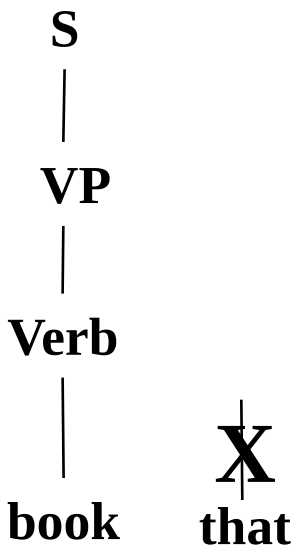


Top Down Parsing

Top Down Parsing



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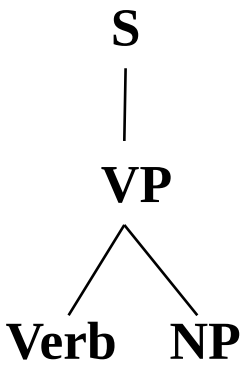

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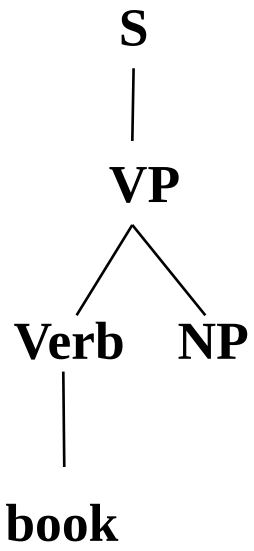

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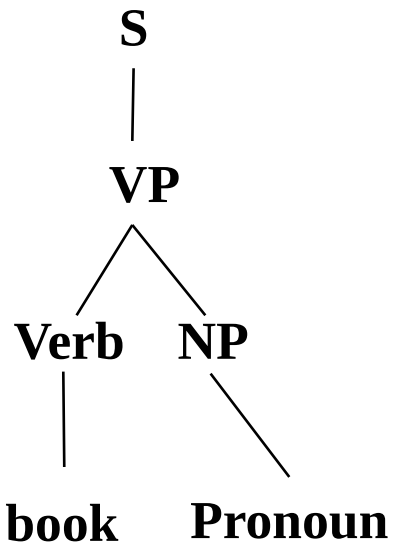

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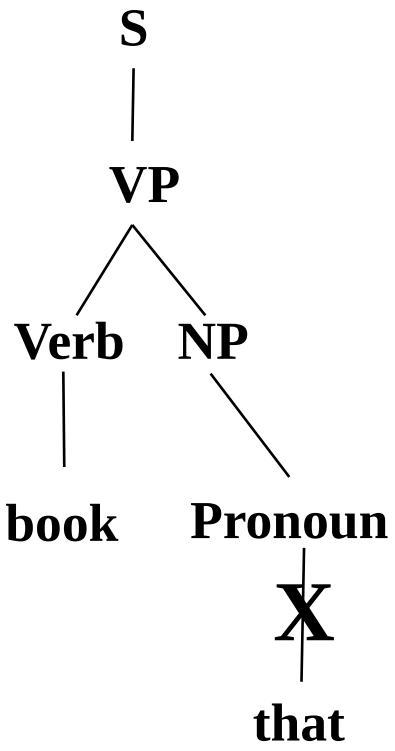

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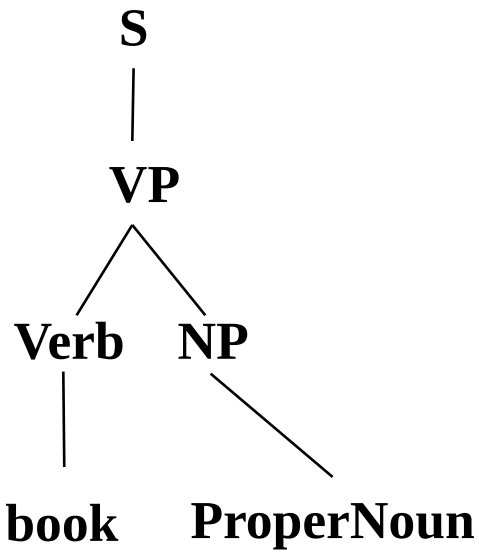

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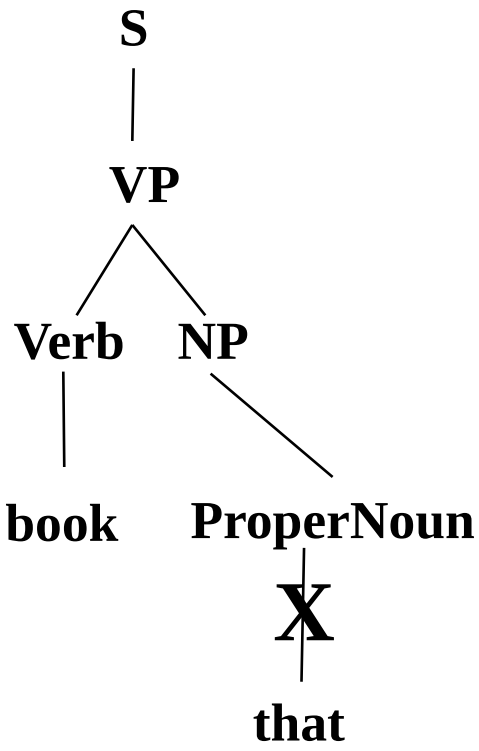

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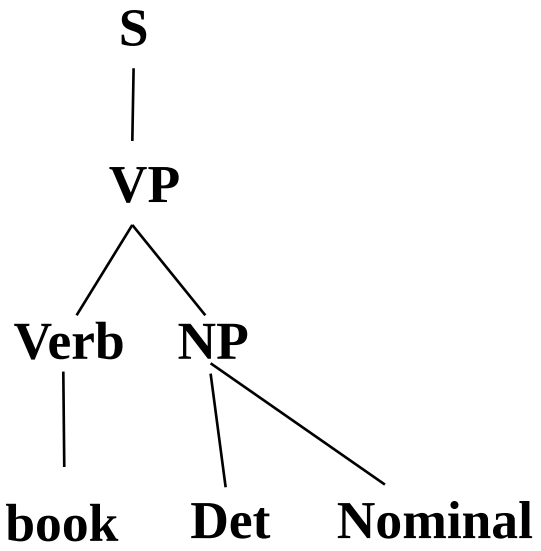

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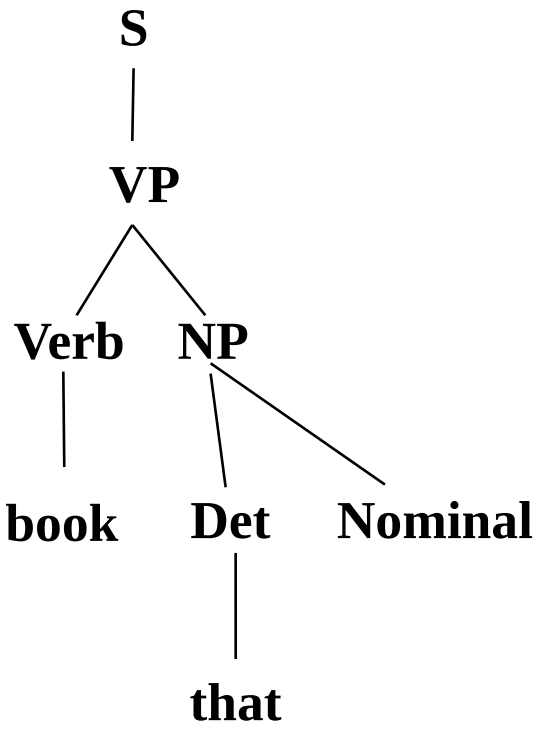

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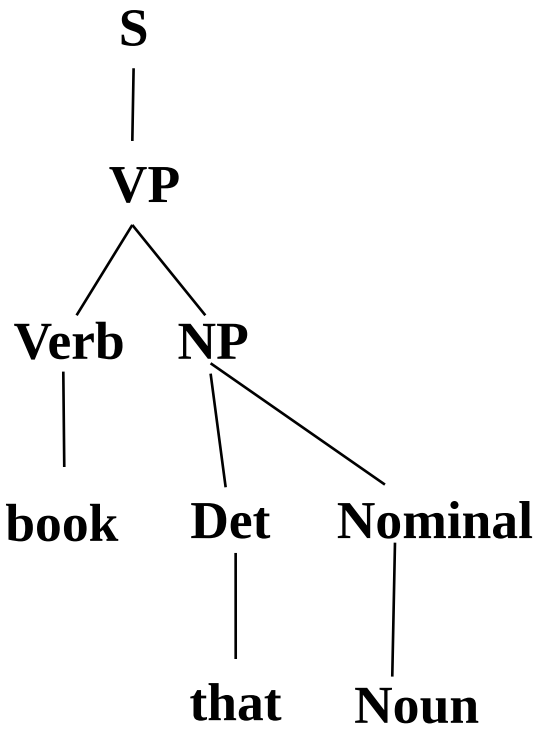

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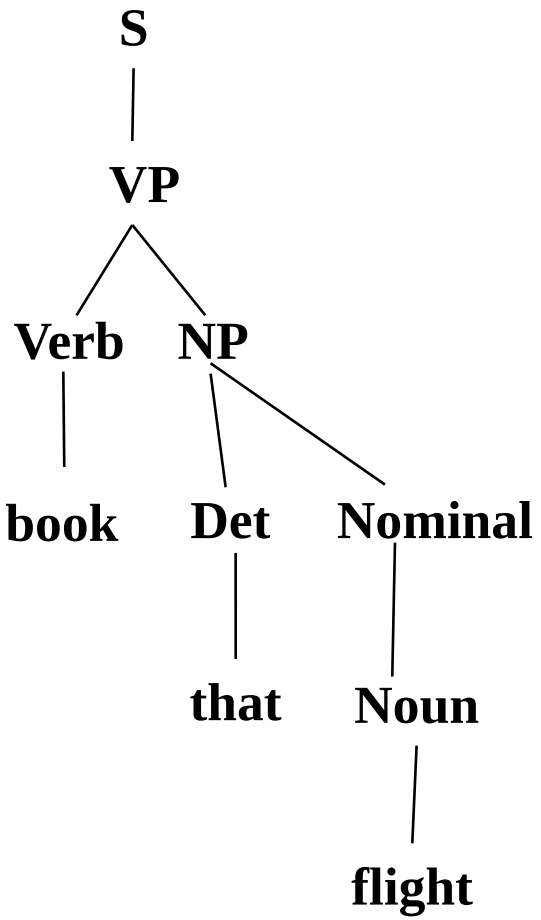
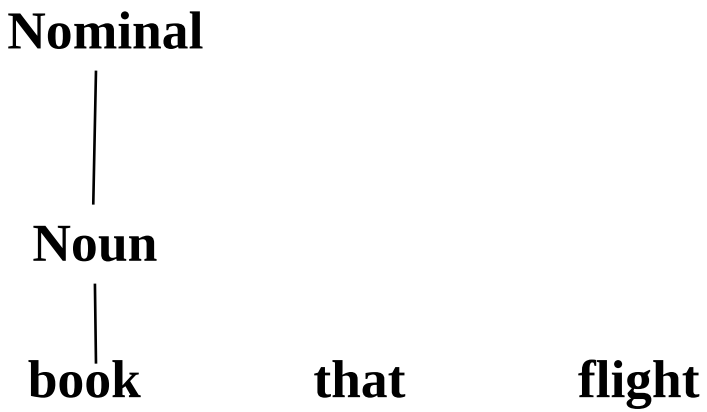


Bottom Up Parsing

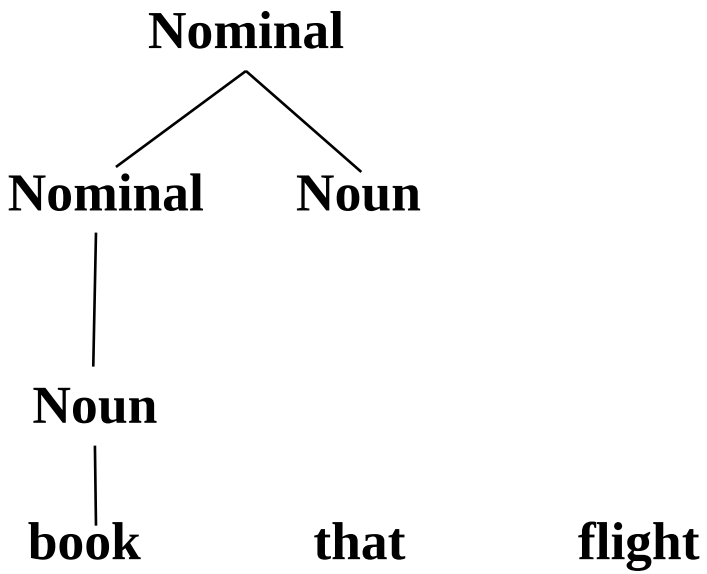
book **that** **flight**

Bottom Up Parsing

Bottom Up Parsing



Bottom Up Parsing



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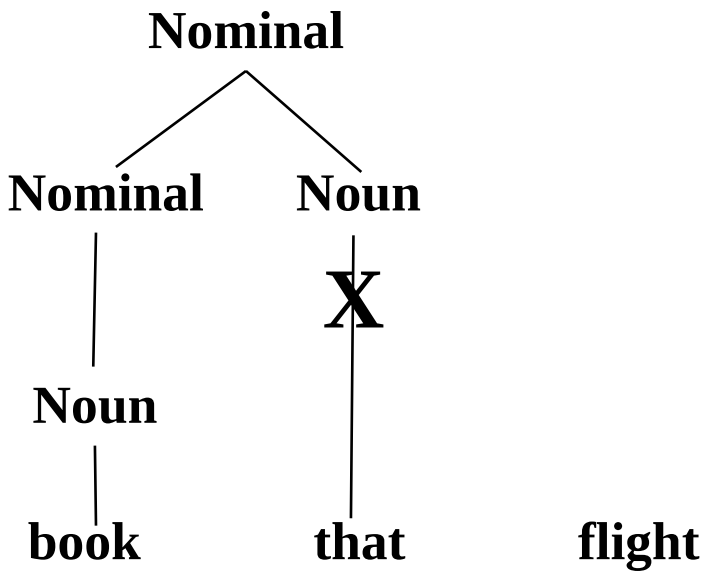

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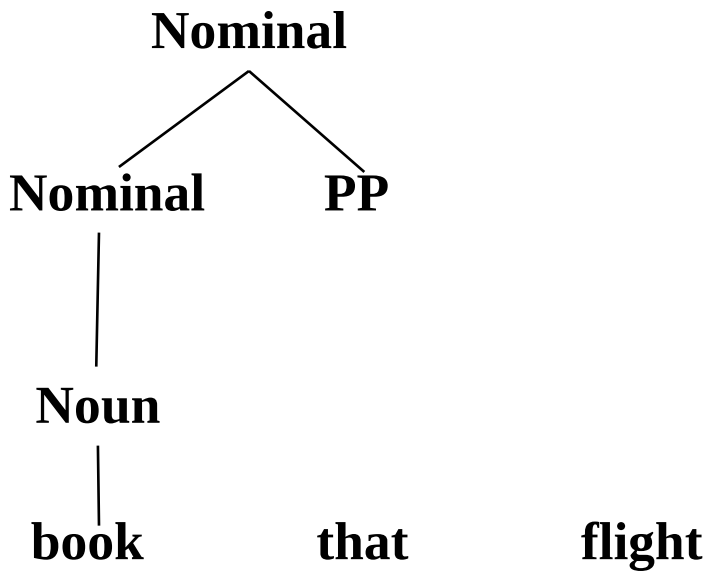
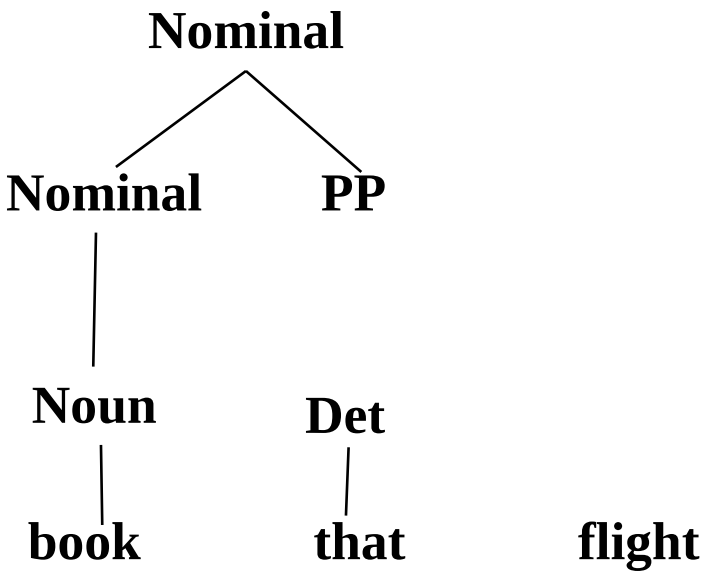
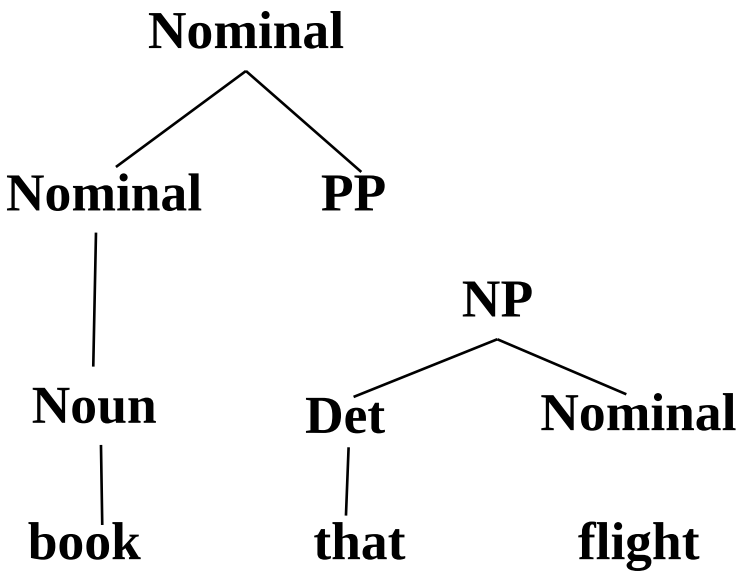


Bottom Up Parsing



Bottom Up Parsing



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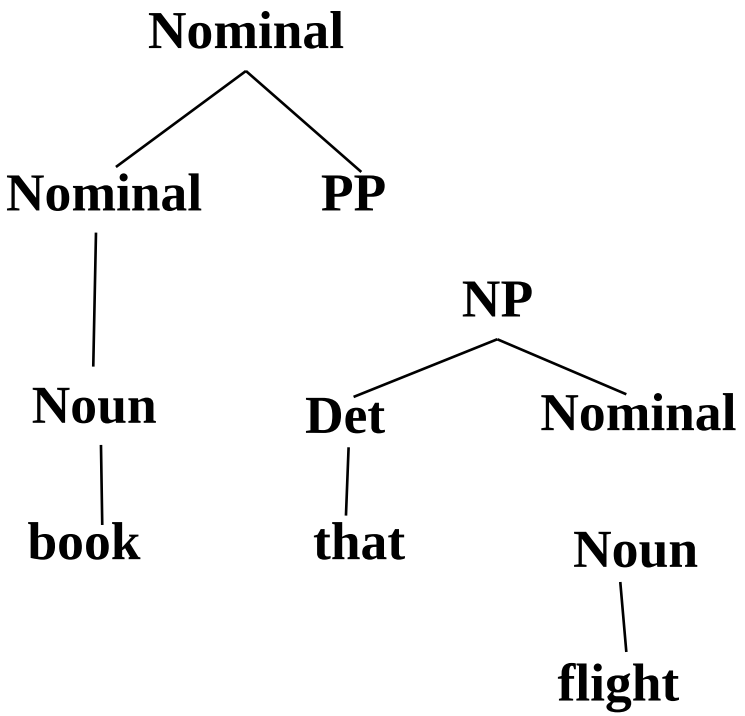

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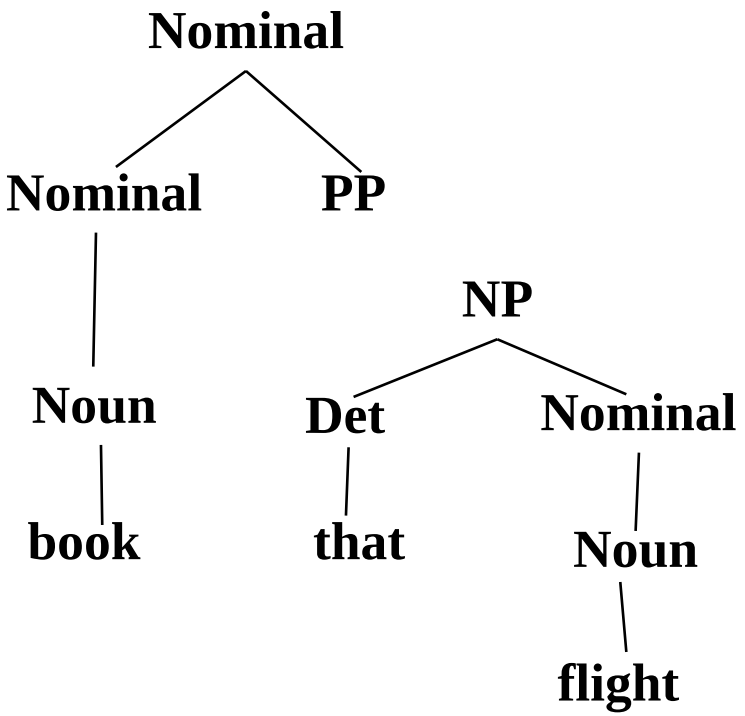

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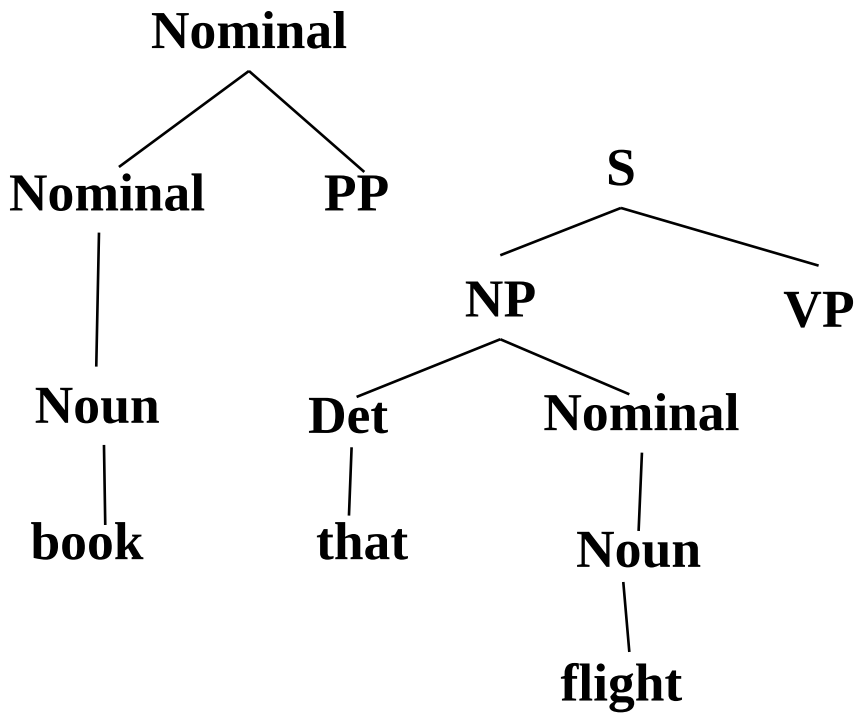

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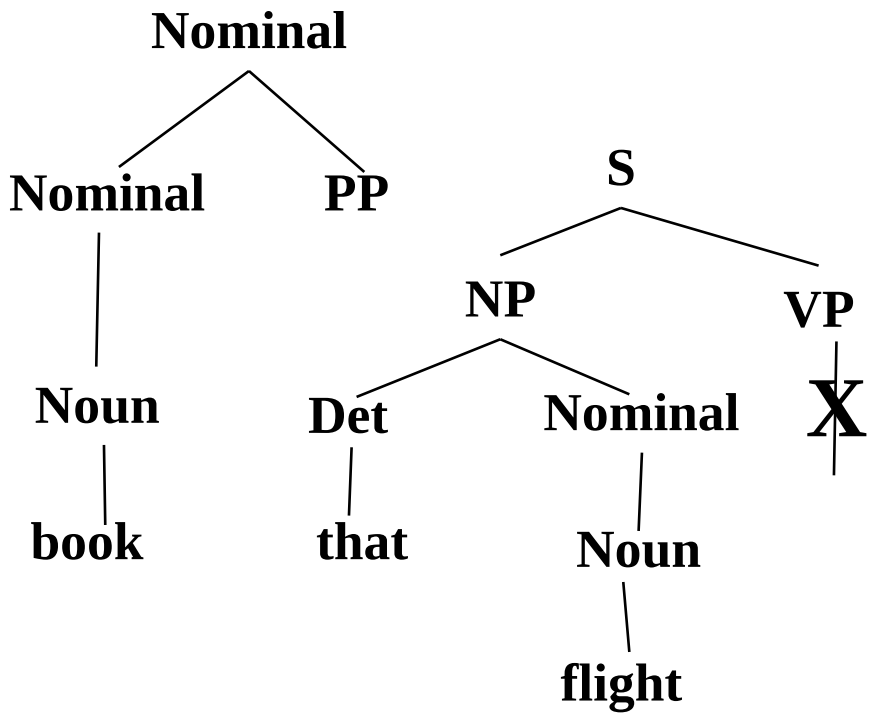

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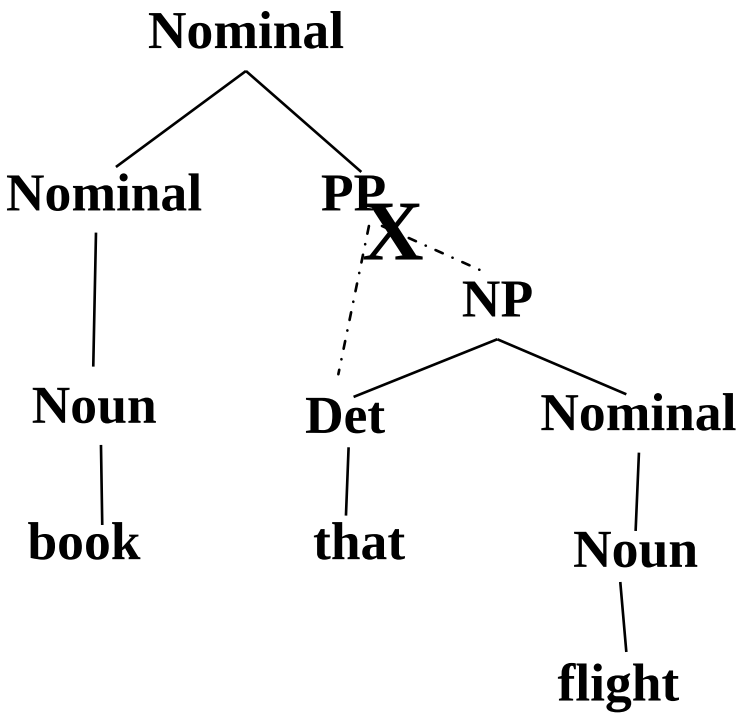

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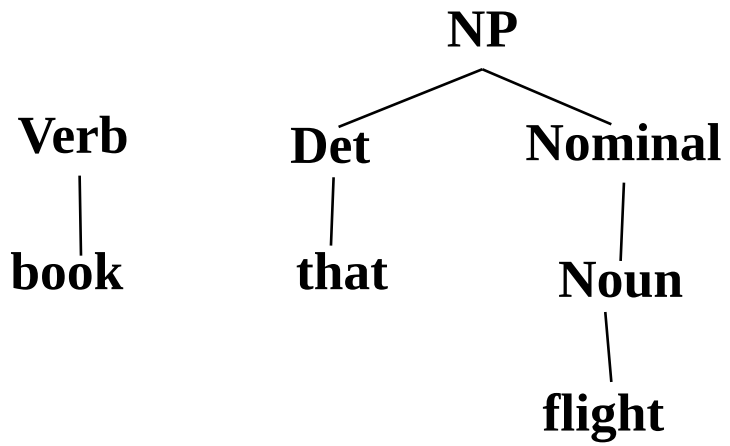

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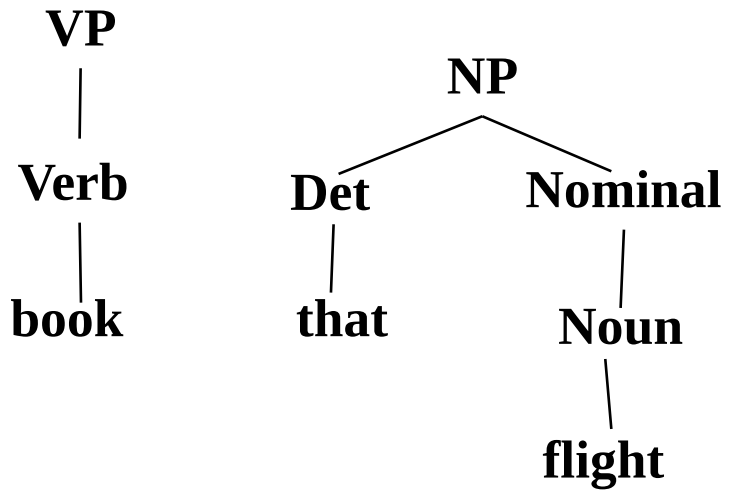

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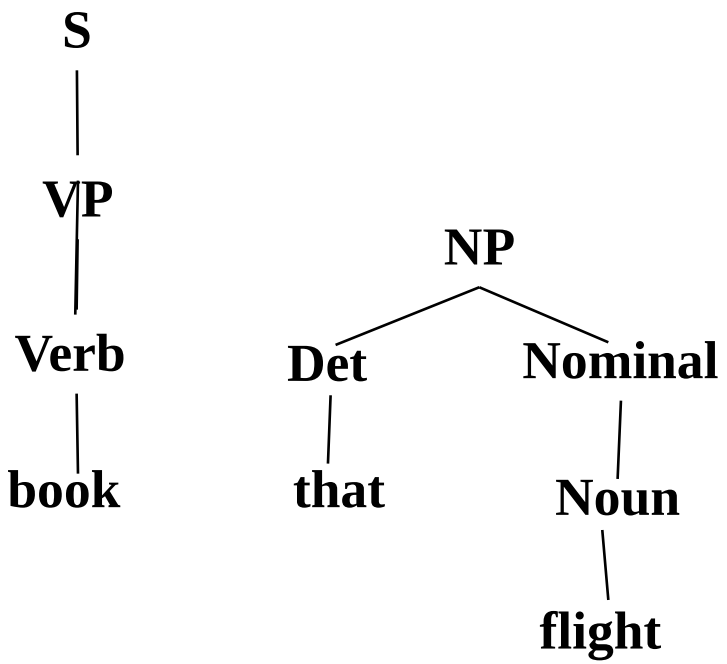

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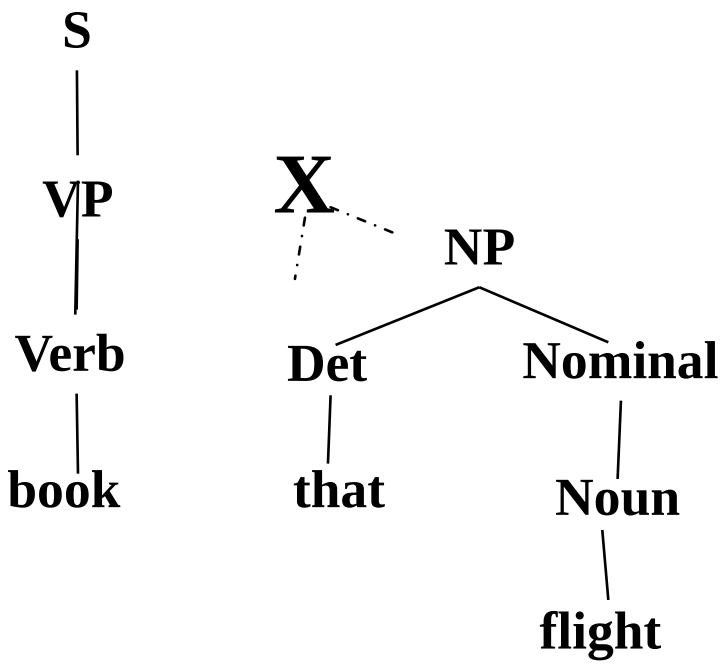

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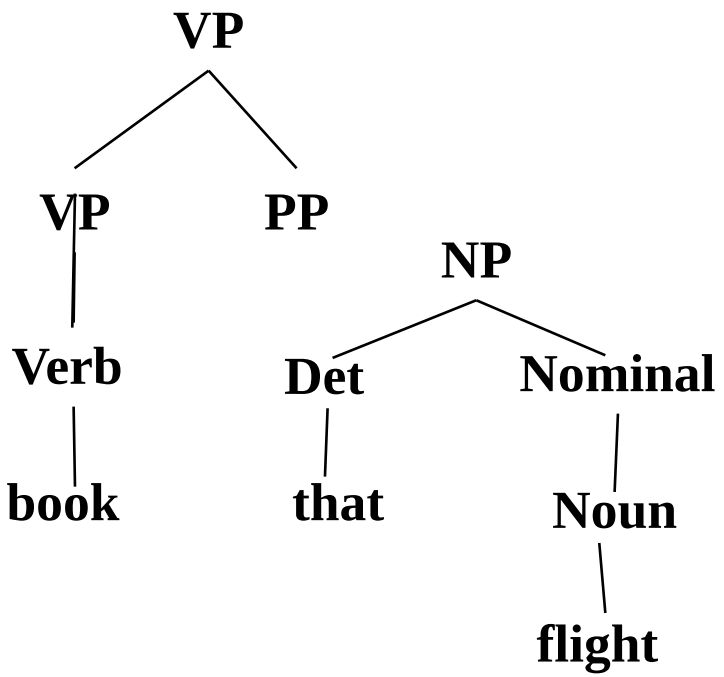

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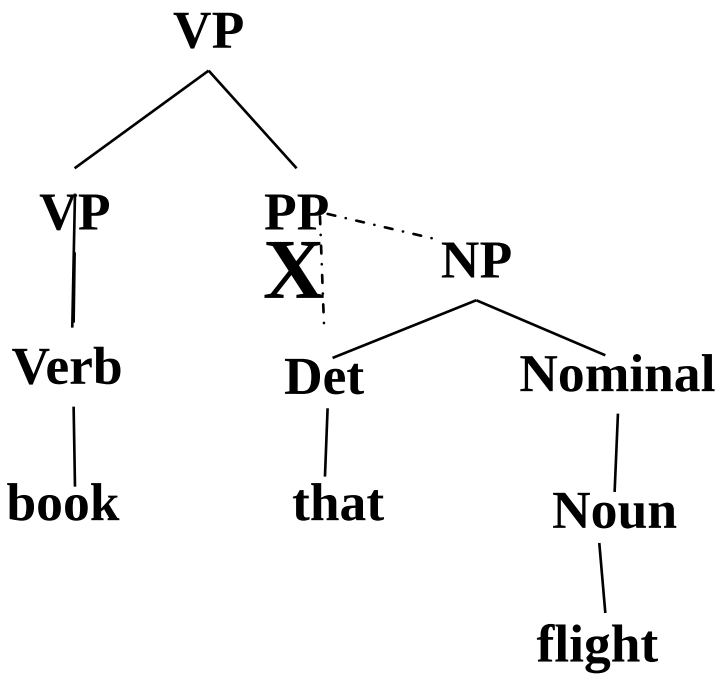

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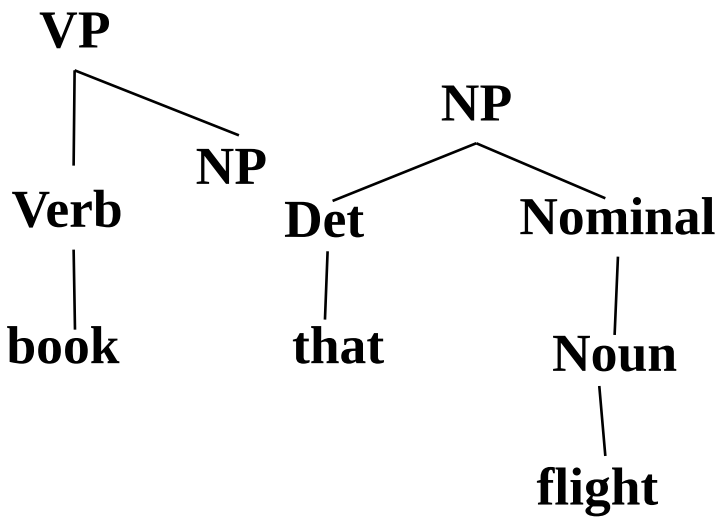
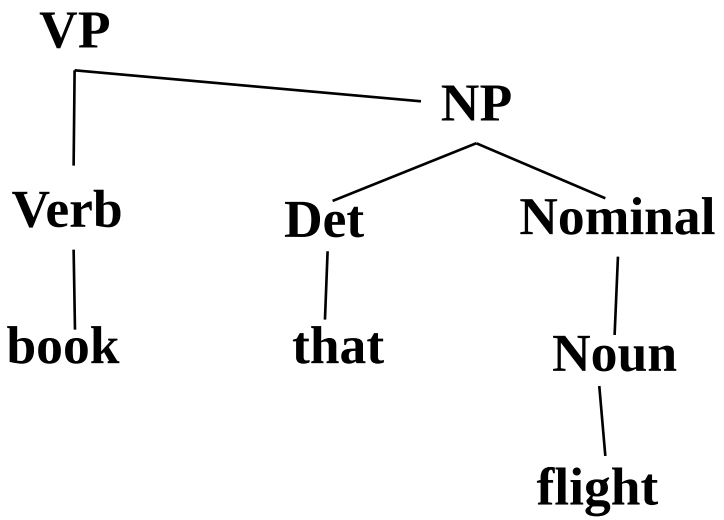
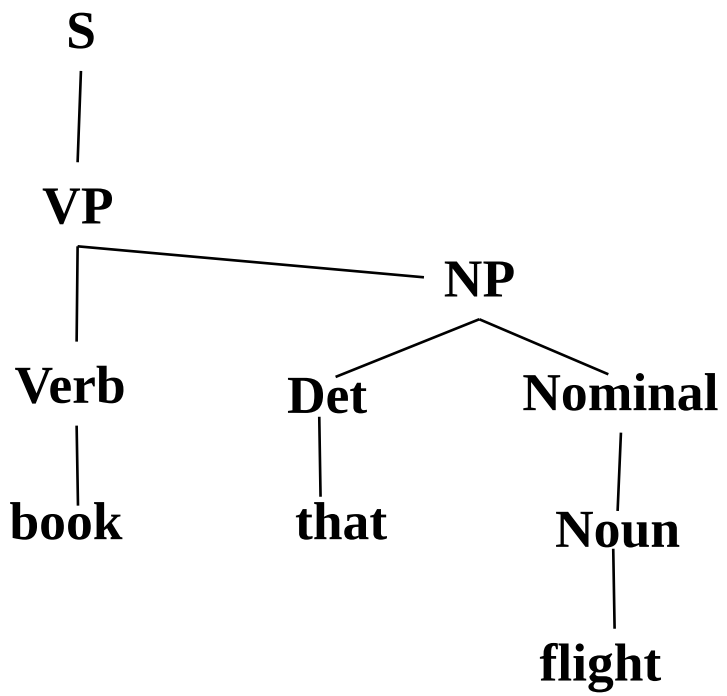


Bottom Up Parsing



Bottom Up Parsing



Top Down vs. Bottom Up

- Top down never explores options that will not lead to a full parse, but can explore many options that never connect to the actual sentence.
- Bottom up never explores options that do not connect to the actual sentence but can explore options that can never lead to a full parse.
- Relative amounts of wasted search depend on how much the grammar branches in each direction.

Efficiency Issues

To reuse the work already done for constituent subtrees.

Ex of inefficiency: Consider the sentence *the train from Chennai to Vizag via Nellore*

Grammar:

S ⟶ NP

NP ⟶ NP PP | ART N| NNP

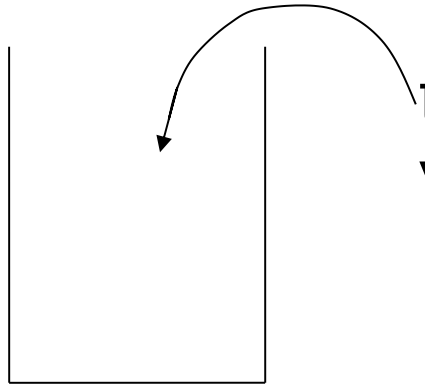
ART ⟶ the

N ⟶ train

NNP ⟶ Chennai | Vizag | Nellore

PP ⟶ P NP

Possible False Steps



the train from Chennai to Vizag via Nellore

push “the”; reduce to “ART”;

push “train”; reduce to “N”;

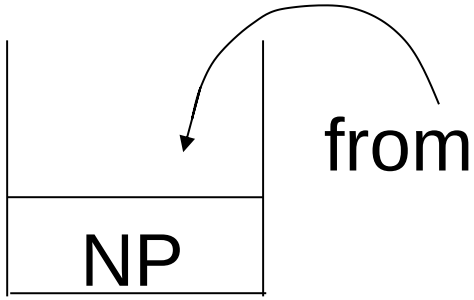
reduce “ART N” to “NP”;

reduce “NP” to “S”.

A

Possible False Steps

Perform A, and then



from Chennai to Vizag via Nellore

push “from”; reduce to “P”;

push “Chennai”; reduce to “NNP”;

reduce to “NP”; reduce “P NP” to “PP”;

Reduce “NP PP” to “NP”;

reduce “NP” to “S”.

B

Possible False Steps

Similarly for

"……. to Vizag via Nellore"

and

"…….. via Nellore"

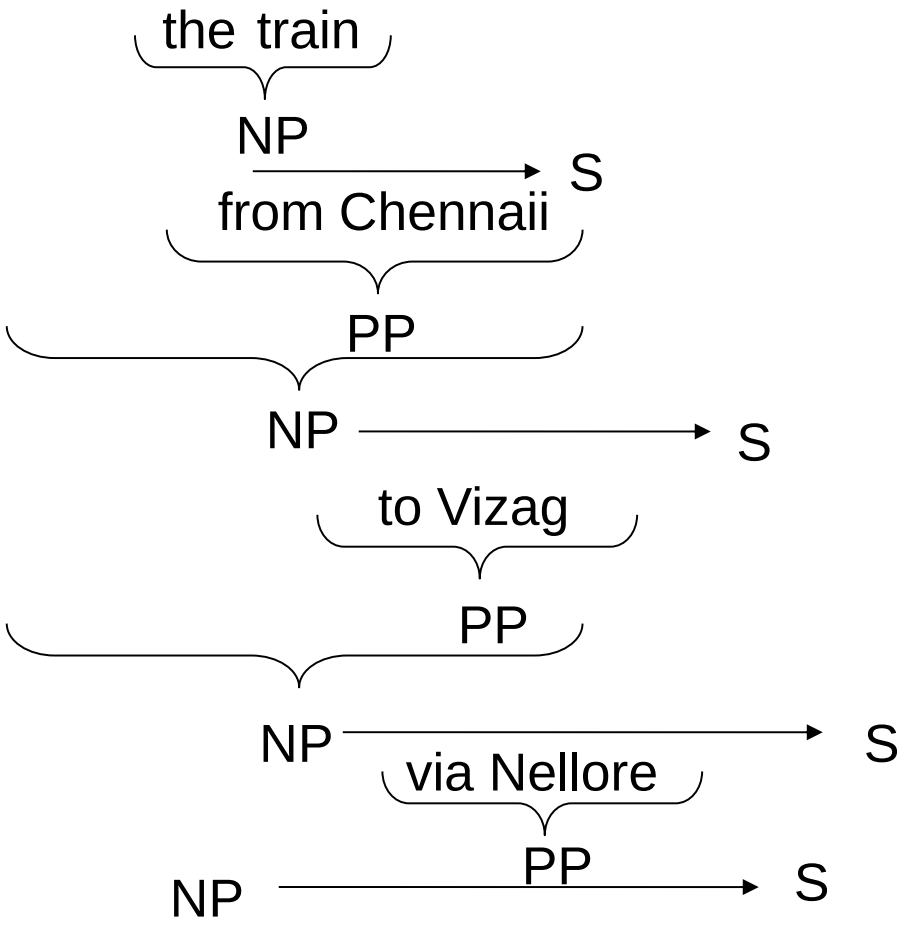
Shift reduce conflicts occur for

S $\longrightarrow$ NP

NP $\longrightarrow$NP PP

Should "NP" be reduced to "S" or should one search for "PP" and then get bigger "NP"?

Reduplication of Work



of Repetitions for Subtree Computation

the train	4 times
from Chennai	3 times
the train from Chennai	3 times
to Vizag	2 times
the train from Chennai to Vizag	2 times
via Nellore	1 time
the train from Chennai to Vizag via Nellore	1 time

Can the “subtrees already computed” be reused?

Chart Parsing : Earley Algorithm (Dynamic Programming based)

Sentence: *book the flight*

Grammar:

S → NP VP | VP

NP → ART N | NNP

VP → V | V NP

ART → a | an | the

N → book | flight

V → book

Definitions

CHART is the data structure that stores the record of *matched constituents* and *expected constituents* through the use of *dotted rules.*

A *dotted rule* is of the form

where *B* is the *matched constituent* and *C* is the *expected constituent.*

Definitions

PREDICTOR is the procedure that records by *transitive closure* the set of dotted rules for a given state of the input processing.

SCANNER is the procedure that consumes the next input token.

COMPLETER is the procedure that

- takes a dotted rule for which the dot is at the rightmost end and
- advances the dots for the rules for which a matched constituent was awaiting completion.

END