CS6320, Spring 2019
Dr. Mithun Balakrishna
Homework 4 Solution

A. Problems:

1. Parse Trees:

Create a CFG to correctly/sensibly parse the following sentences.

1. I would like to fly on American airlines.
2. I need to fly between Philadelphia and Atlanta.

Please draw the correct/sensible parse tree structures for the above sentences.

SOLUTION:

CFG:

S → NP VP

NP → Pro

VP → Verb VP

VP → Inf Verb PP

PP → Prep NP

NP → NP and NP

NP → ProperNoun

Pro → I
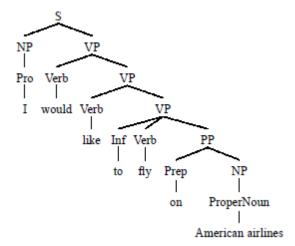
Verb → would like, fly, need

Inf → to
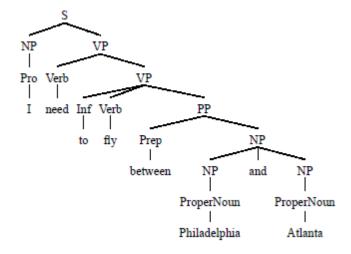
Prep → on, between

ProperNoun → American Airlines, Philadelphia, Atlanta

1. I would like to fly on American airlines.

2. I need to fly between Philadelphia and Atlanta.

2. CKY Parsing

Grammar	Lexicon
S → NP VP	*Det → that | this | a*
S → Aux NP VP	*Noun → book | flight | meal | money*
S → VP	*Verb → book | include | prefer*
NP → Pronoun	*Pronoun → I | she | me*
NP → Proper-Noun	*Proper-Noun → Houston | NWA*
NP → Det Nominal	*Aux → does*
Nominal → Noun	*Preposition → from | to | on | near | through*
Nominal → Nominal Noun	
Nominal → Nominal PP	
VP → Verb	
VP → Verb NP	
VP → Verb NP PP	
VP → Verb PP	
VP → VP PP	
PP → Preposition NP	

Using the above grammar rules, fill out the CKY chart for the sentence:

I prefer a flight on NWA to Houston

SOLUTION:

Step 1: Convert the grammar to CNF

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

Lexicon

$Det \rightarrow that \mid this \mid a$
$Noun \rightarrow book \mid flight \mid meal \mid money$
$Verb \rightarrow book \mid include \mid prefer$
$Pronoun \rightarrow I \mid she \mid me$
$Proper\text{-}Noun \rightarrow Houston \mid NWA$
$Aux \rightarrow does$
$Preposition \rightarrow from \mid to \mid on \mid near \mid through$

STEP 2: Create the CKY Chart

I	prefer	a	flight	on	NWA	to	Houston
NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]	[0,5]	S [0,6]	[0,7]	S [0,8]
	S, VP, Verb [1,2]	[1,3]	S, VP, X2 [1,4]	[1,5]	VP [1,6]	[1,7]	VP [1,8]
		Det [2,3]	NP [2,4]	[2,5]	NP [2,6]	[2,7]	NP [2,8]
			Nominal, Noun [3,4]	[3,5]	Nominal [3,6]	[3,7]	Nominal [3,8]
				Prep [4,5]	PP [4,6]	[4,7]	[4,8]
					NP, Proper-Noun [5,6]	[5,7]	[5,8]
						Prep [6,7]	PP [6,8]
							NP, Proper-Noun [7,8]

3. Chart Parsing

POS Tag Lexicon:
the: ART
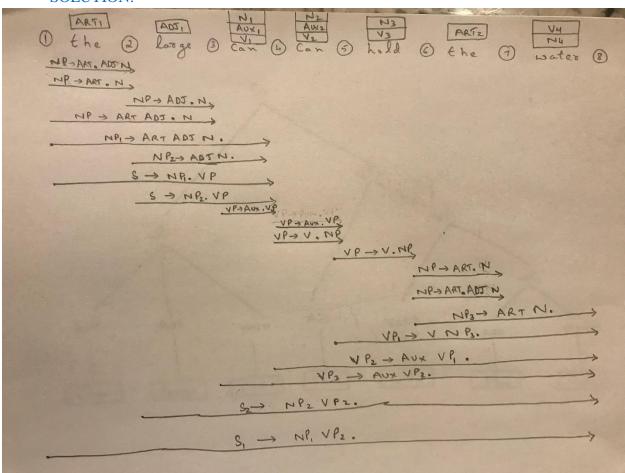large: ADJ
can: N, AUX, V
hold: N, V
water: N,V

Grammar:

1. S → NP VP
2. NP → ART ADJ N
3. NP → ART N
4. NP → ADJ N
5. VP → AUX VP
6. VP → V NP

Using the above lexicon and grammar rules, create all charts for the following sentence applying the bottom-up chart parser:

The large can can hold the water

Using the final chart, please draw the parse tree structure(s) for the above sentence.

SOLUTION:

	ART_1		ADJ_1		N_1 AUX_1 V_1		N_2 AUX_2 V_2		N_3 V_3		ART_2		V_4 N_4	
①	the	②	large	③	Can	④	Can	⑤	hold	⑥	the	⑦	water	⑧

NP→ART. ADJ N

NP → ART . N

NP → ADJ . N

NP → ART ADJ . N

NP_1 → ART ADJ N .

NP_2 → ADJ N .

S → NP_1 . VP

S → NP_2 . VP

VP→Aux . VP

VP → Aux . VP

VP → V . NP

VP → V . NP

NP → ART . N

NP → ART . ADJ N

NP_3 → ART N .

VP_1 → V N P_3 .

VP_2 → Aux VP_1 .

VP_3 → Aux VP_2 .

S_2 → NP_2 VP_2 .

S_1 → NP_1 VP_2 .

S1 (rule 1 with NP1 and VP2)							
S2 (rule 1 with NP2 and VP2)							
		VP3 (rule 5 with AUX1 and VP2)					
	NP2 (rule 4)		VP2 (rule 5)				
NP1 (rule 2)					VP1 (rule 6)		
		N1	N2			NP3 (rule 3)	
		V1	V2	V3			V4
ART1	ADJ1	AUX1	AUX2	N3		ART2	N4
1 the	2 large	3 can	4 can	5 hold	6 the		7 water

Figure 3.15   The final chart