Natural Language Processing ECS763P
Course Work 2: Formal Grammars and Parsing

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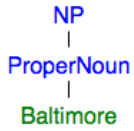
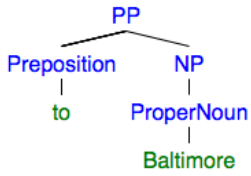
1. The CFG trees have been parsed for the following phrases and the respective rules used have been given.

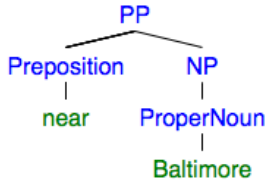
a) Baltimore
NP → ProperNoun



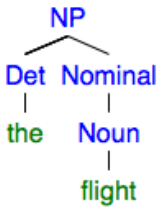
b) to Baltimore
PP → Preposition NP
NP → ProperNoun



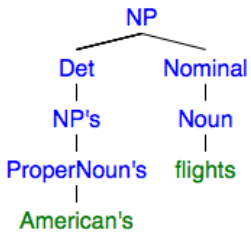
c) near Baltimore
PP → Preposition NP
NP → ProperNoun



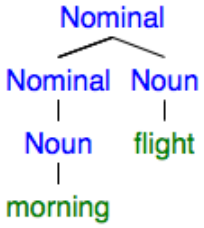
d) the flight
NP → Det Nominal
Nominal → Noun



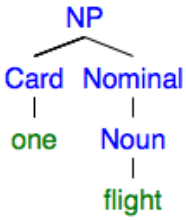
e) American's flights
NP → Det Nominal
Det → NP 's
NP → ProperNoun



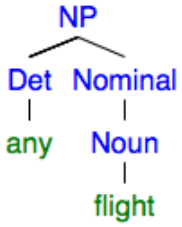
f) morning flight
Nominal → Nominal Noun
Nominal → Noun



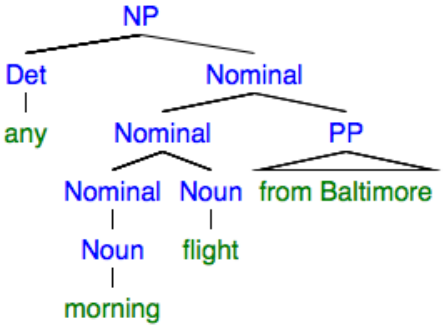
g) one flight
NP → Card Nominal
Nominal → Noun



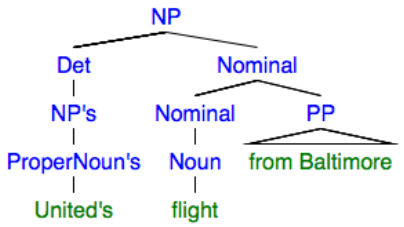
h) any flight
NP → Det Nominal
Nominal → Noun



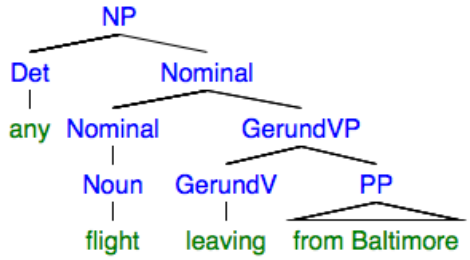
i) any morning flight from Baltimore
NP → Det Nominal
Nominal → Nominal PP
Nominal → Nominal Noun
Nominal → Noun



j) United's flight to Baltimore
NP → Det Nominal
Nominal → Nominal PP
Det → NP's
NP → ProperNoun

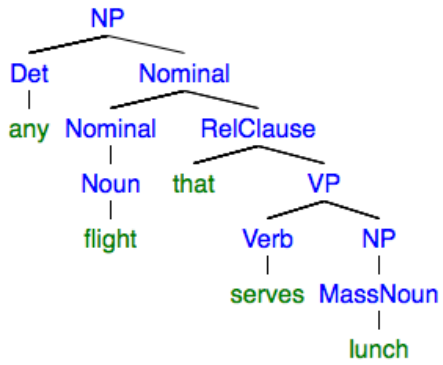


k) any flight leaving from Baltimore
NP → Det Nominal
Nominal → Nominal GerundVP
GerundVP → GerundV PP

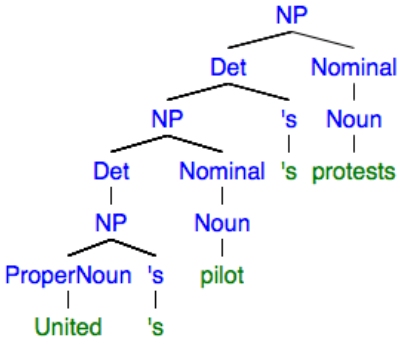


l) Any flight that serves lunch

NP → Det Nominal
Nominal → Nominal RelClause
RelClause → that VP
VP → Verb
NP → MassNoun

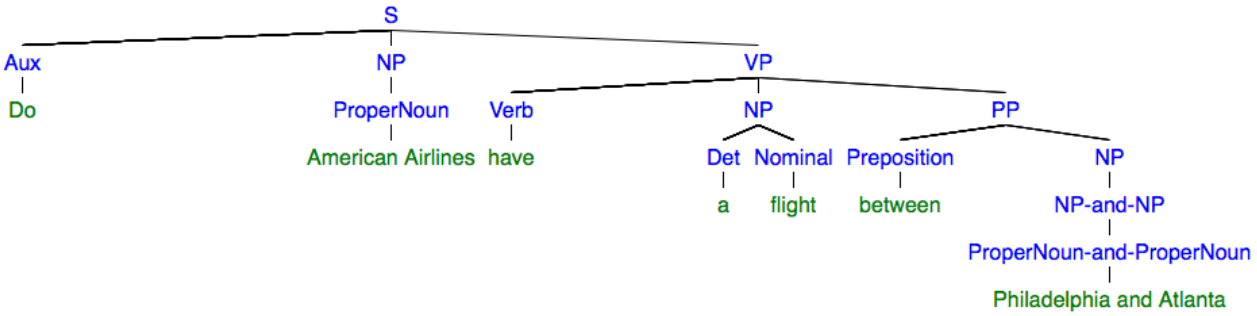


m) United's pilot's protests
NP → Det Nominal
Det → NP's
NP → ProperNoun
Nominal → Noun

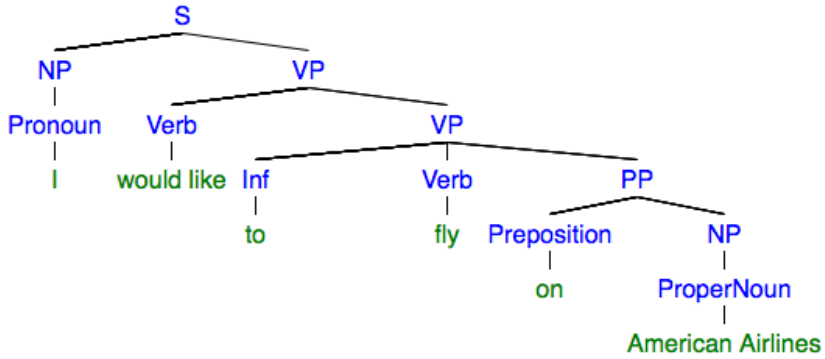


2. The CFG trees have been parsed for the following sentences and the respective rules used have been given.

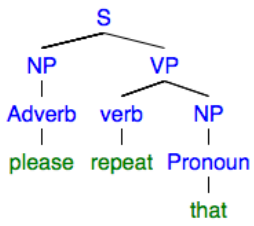
a) Do American Airlines have a flight between Baltimore and Denver?
S → Aux NP VP
VP → Verb NP PP
NP → Det Nominal
PP → Preposition NP
NP → NP and NP
NP → ProperNoun



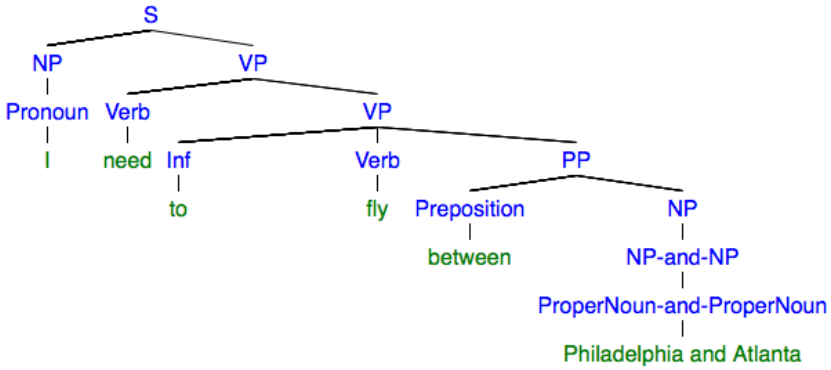
b) I would like to fly on American Airlines
S → NP VP
NP → Pronoun
VP → Verb VP
VP → Inf Verb PP
PP → Preposition NP
NP → NP and NP
NP → ProperNoun



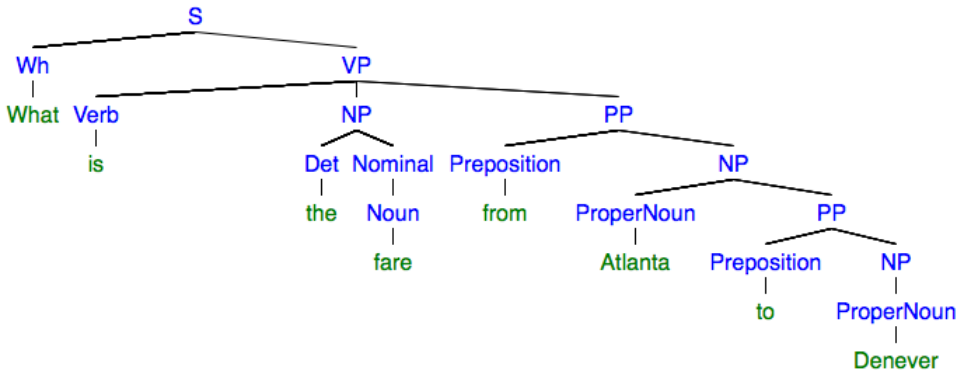
c) Please repeat that
S → NP VP
NP → Adverb
VP → Verb NP
NP → Pronoun



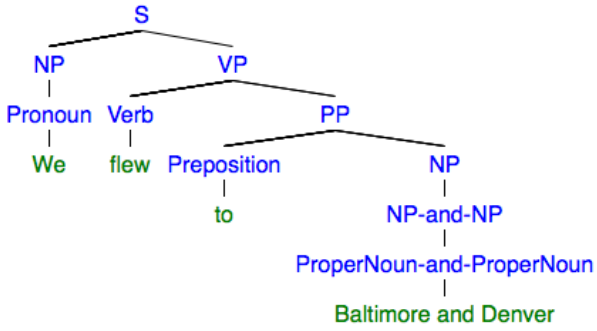
d) I need to fly between Philadelphia and Atlanta
S → NP VP
NP → Pronoun
VP → Verb VP
VP → Inf Verb PP
PP → Preposition NP
NP → NP and NP
NP → ProperNoun



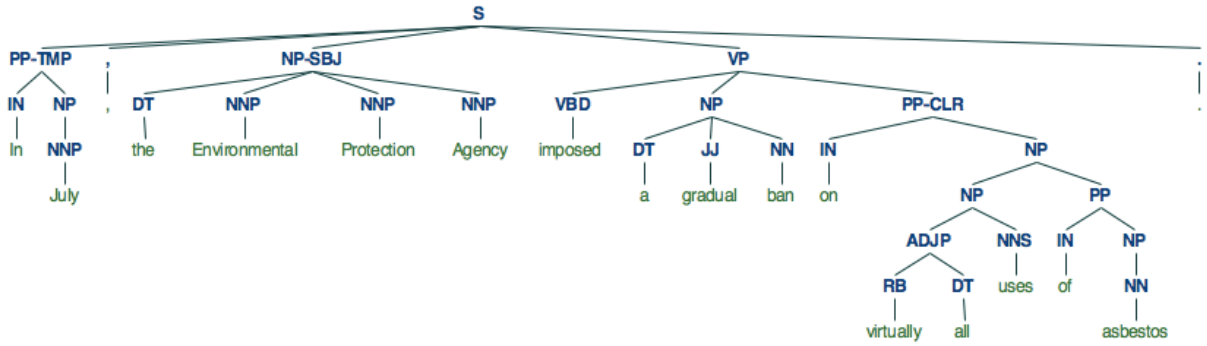
e) What is the fare from Atlanta to Denver?
S → Wh-VP
Wh-VP → Wh VP
VP → Verb NP PP
NP → Det Nominal
Nominal → Nominal PP
Nominal → Noun



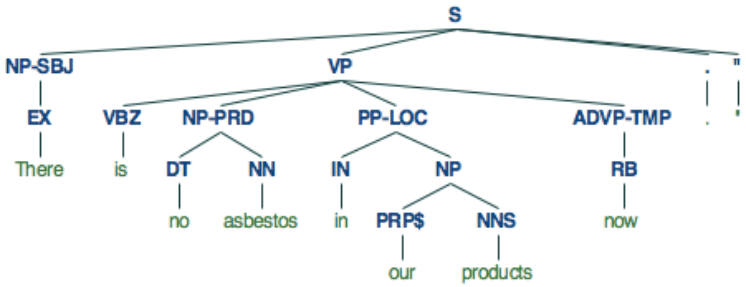
f) We flew to Baltimore and Denver
S → NP VP
NP → Pronoun
VP → Verb PP
PP → Preposition NP
NP → NP and NP
NP → ProperNoun



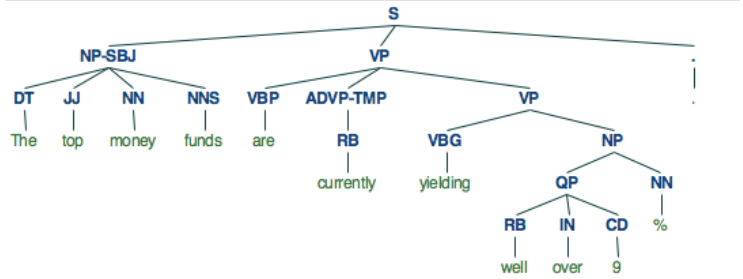
3. The provided script (grammar_script.py) contains three parsed sentences from the Penn Treebank.
Using this script (converted to jupyter notebook), the CFG parse trees for these sentences have been drawn and the set of CFG rules that are needed to parse the original sentences have been extracted.



[S -> PP-TMP , NP-SBJ VP .,
PP-TMP -> IN NP,
IN -> 'In',
NP -> NNP,
NNP -> 'July',
, -> ',',
NP-SBJ -> DT NNP NNP NNP,
DT -> 'the',
NNP -> 'Environmental',
NNP -> 'Protection',
NNP -> 'Agency',
VP -> VBD NP PP-CLR,
VBD -> 'imposed',
NP -> DT JJ NN,
DT -> 'a',
JJ -> 'gradual',
NN -> 'ban',
PP-CLR -> IN NP,
IN -> 'on',
NP -> NP PP,
NP -> ADJP NNS,
ADJP -> RB DT,
RB -> 'virtually',
DT -> 'all',
NNS -> 'uses',
PP -> IN NP,
IN -> 'of',
NP -> NN,
NN -> 'asbestos',
. -> '.']



[S -> NP-SBJ VP . ",
NP-SBJ -> EX,
EX -> 'There',
VP -> VBZ NP-PRD PP-LOC ADVP-TMP,
VBZ -> 'is',
NP-PRD -> DT NN,
DT -> 'no',
NN -> 'asbestos',
PP-LOC -> IN NP,
IN -> 'in',
NP -> PRP$ NNS,
PRP$ -> 'our',
NNS -> 'products',
ADVP-TMP -> RB,
RB -> 'now',
. -> '.',
" -> """]



[S -> NP-SBJ VP .,
NP-SBJ -> DT JJ NN NNS,
DT -> 'The',
JJ -> 'top',
NN -> 'money',
NNS -> 'funds',
VP -> VBP ADVP-TMP VP,
VBP -> 'are',
ADVP-TMP -> RB,
RB -> 'currently',
VP -> VBG NP,
VBG -> 'yielding',
NP -> QP NN,
QP -> RB IN CD,
RB -> 'well',
IN -> 'over',
CD -> '9',
NN -> '%',
. -> '.']

4. “List me the seats on the flight to Denver” – exercised on this sentence

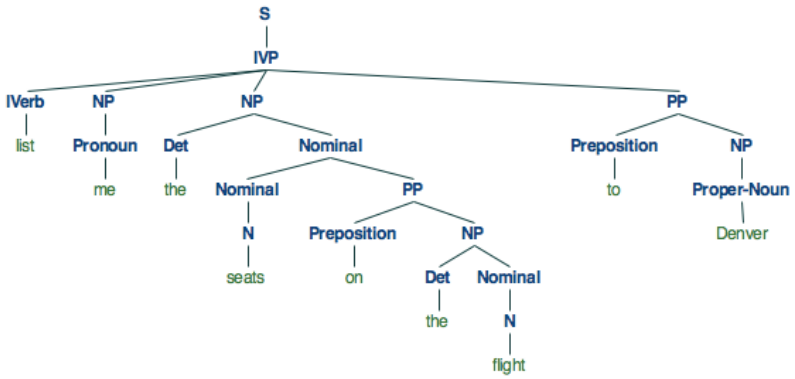
a) As many meanings have been given for this sentence.

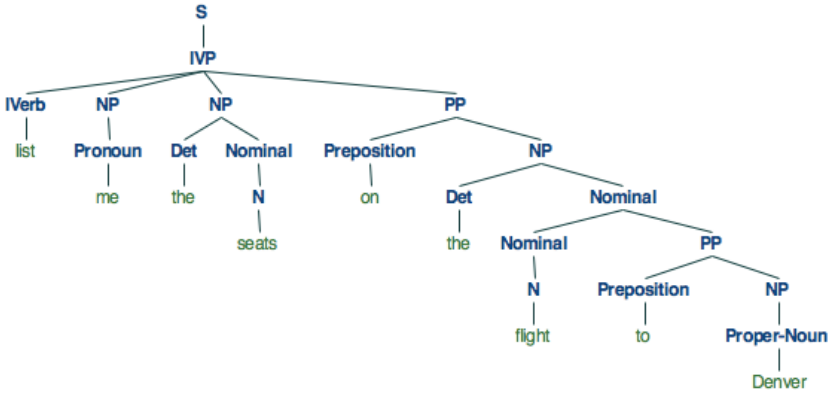
- list the seats of the flight that is going to Denver
- list me the seats while on the flight to Denver
- list me the seats while you are on the flight to Denver
- list me the seats while we are on the flight to Denver
- list me the seats to Denver while you are on the flight
- list me the seats (numbers) of the flight that is going to Denver
- list me the seats (passenger names) of the flight that is going to Denver

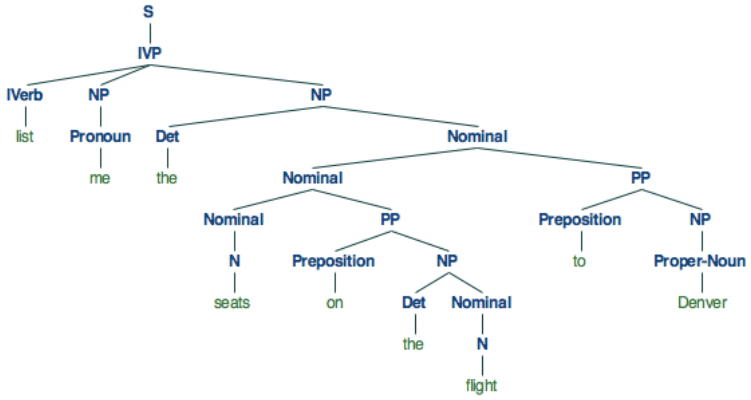
b) The grammar has been replaced in grammar_script.py (jupyter notebook) with the rules given in the coursework by the following:

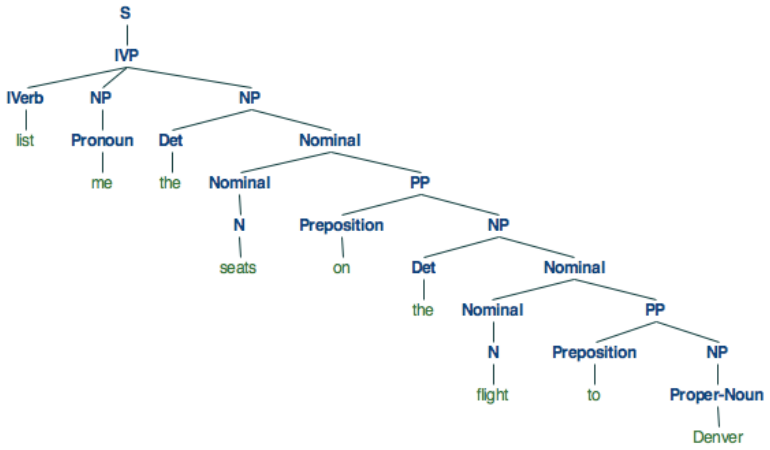
```
grammar = nltk.CFG.fromstring("""
S -> NP VP
S -> Aux NP VP
S -> VP
S -> IVP
NP -> Pronoun
NP -> Proper-Noun
NP -> Det Nominal
Nominal -> N
Nominal -> Nominal N
Nominal -> Nominal PP
VP -> V
VP -> V NP
VP -> V NP PP
VP -> V PP
VP -> VP PP
PP -> Preposition NP
IVP -> IVerb NP NP
IVP -> IVerb NP NP PP
IVerb -> 'list'
Det -> 'the'
N -> 'seats'|'flight'| 'list'
V -> 'list'
Pronoun -> 'me'
Proper-Noun -> 'Denver'
Aux -> 'does'
Preposition -> 'on' | 'to'
""")
```

Original sentence: list me the seats on the flight to Denver





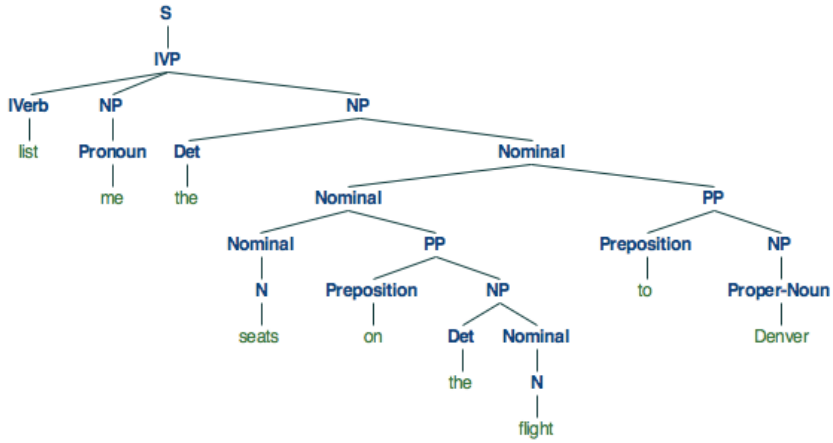




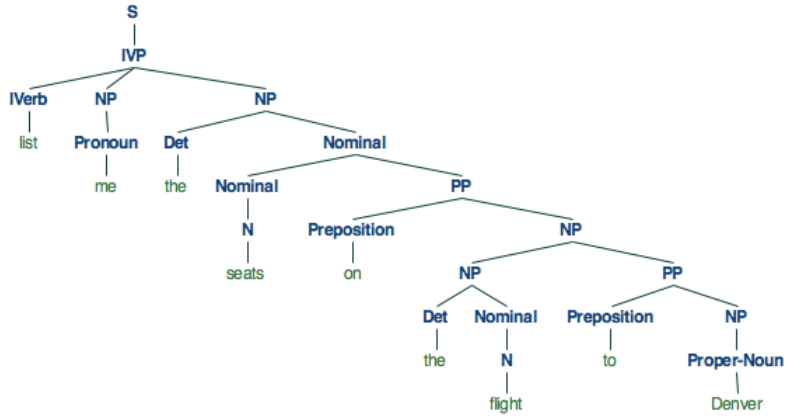
c) The following rule had been added to the above stack of rules:

NP → NP PP

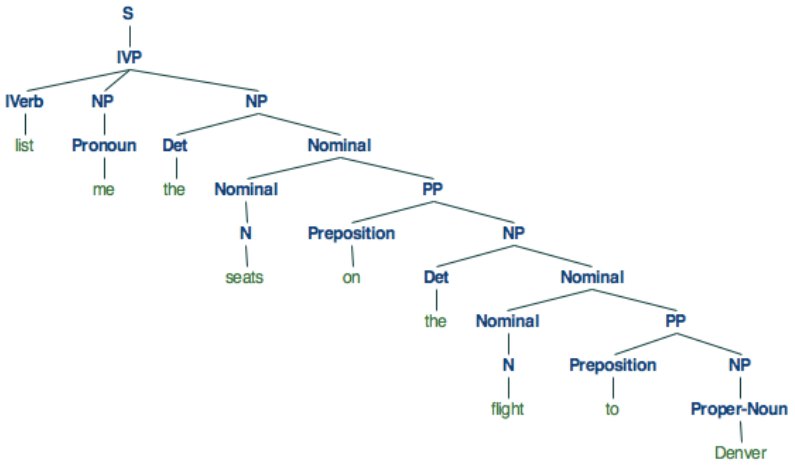
The first four parses in c) are the same as part b) followed by 7 additional parses. Question d) has been answered be low each tree in part C)which includes the 4 parses from part b and extra ones.



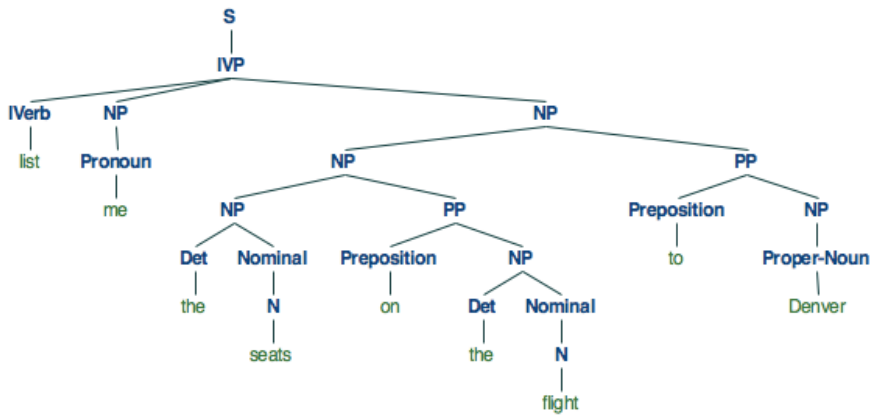
Meaning (4d) – (list me) (the) (seats on the flight)(to Denver)--- list the seats on the flight while going to Denver. (Does not make much sense)



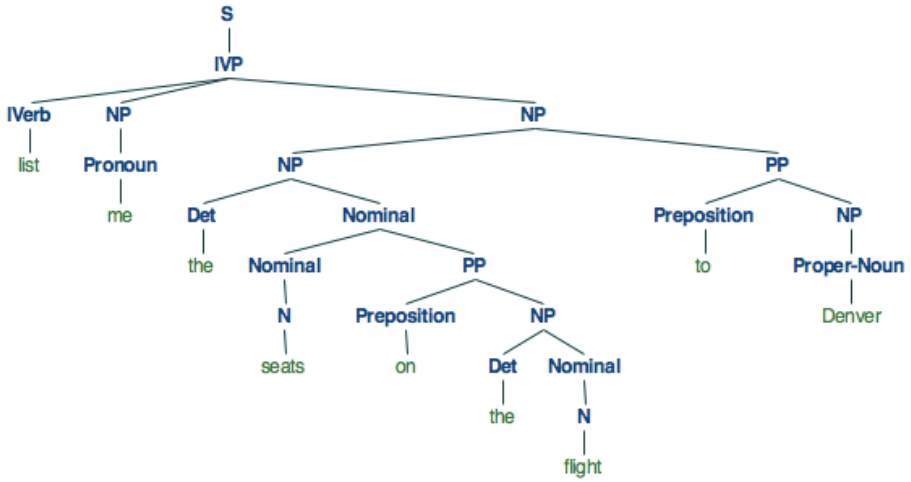
4d) Meaning – (list me)(the seats)(on)(the flight to Denver) – list me the seats while on the flight to Denver. (Does not make much sense)



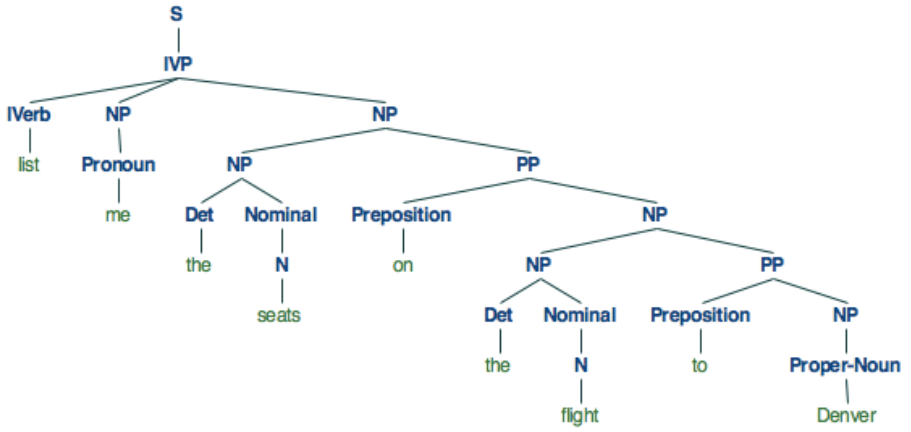
4d) Meaning – (list me)(the seats)(on the flight to Denver) – list me the seats while on the flight to Denver. (Does not make much sense--- which seats)



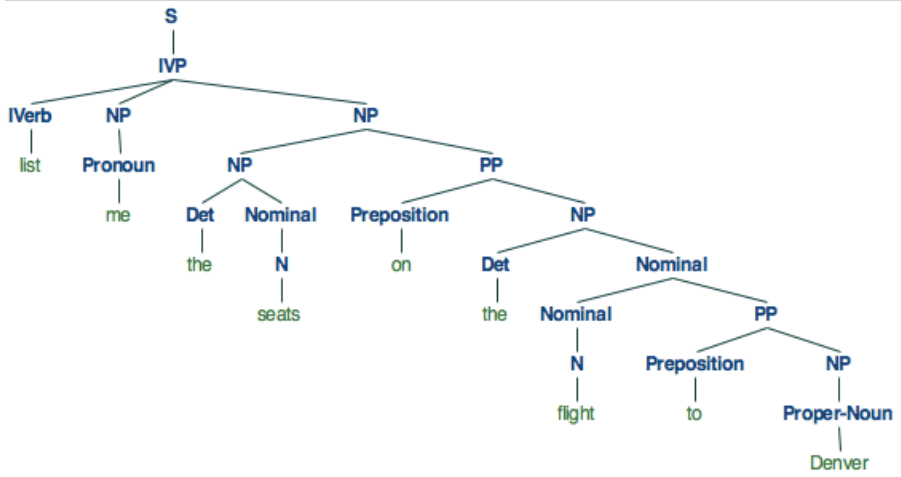
4d) Meaning – (list me)(the seats)(on the flight)(to Denver) --- list me the seats to Denver on the flight – which seats? (Does not make much sense)



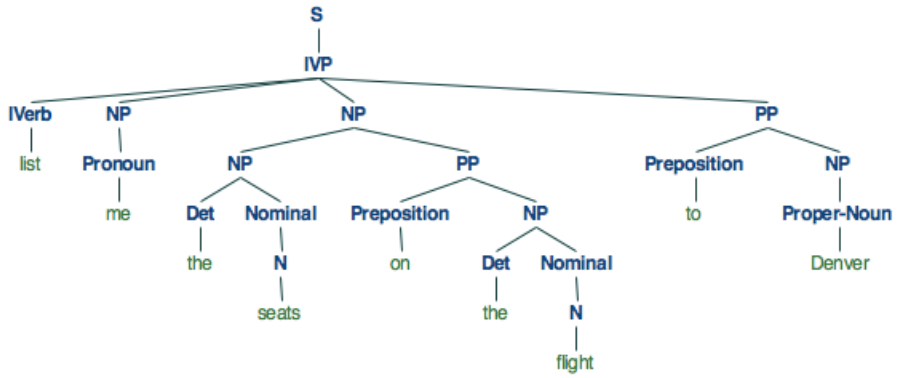
4d) Meaning – (list me)(the seats on the flight) (to Denver) – list me the seats on the flight to Denver . (Makes sense)



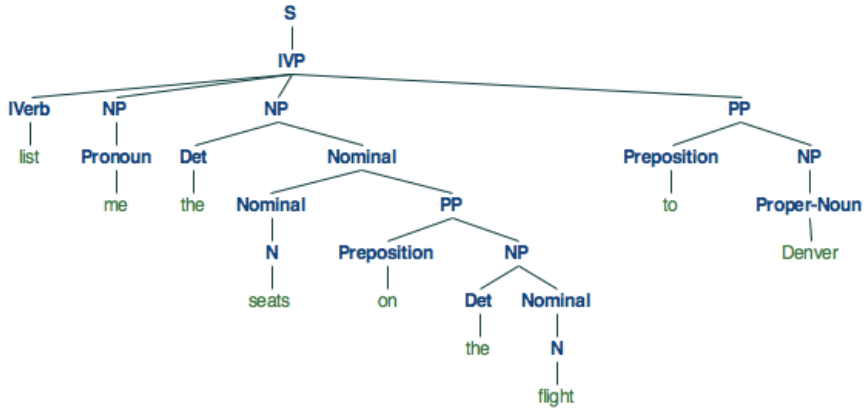
4d) Meaning – (list me)(the seats)(on)(the flight to Denver) – which seats?
(Does not make much sense)



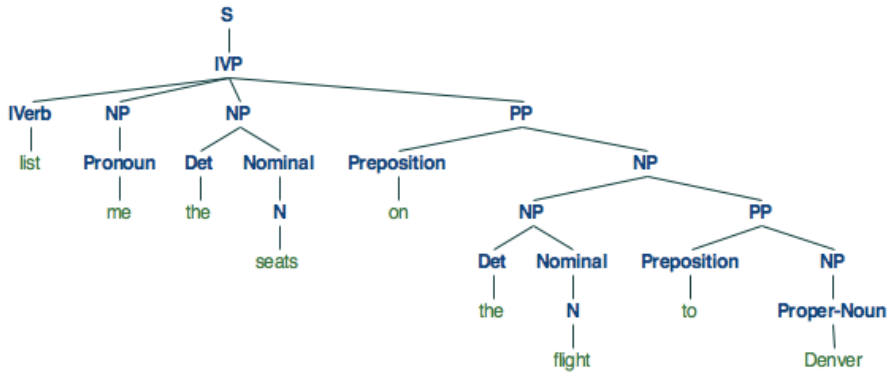
4d) Meaning – (list me)(the seats)(on)(the flight to Denver) – which seats?
(Does not make sense)



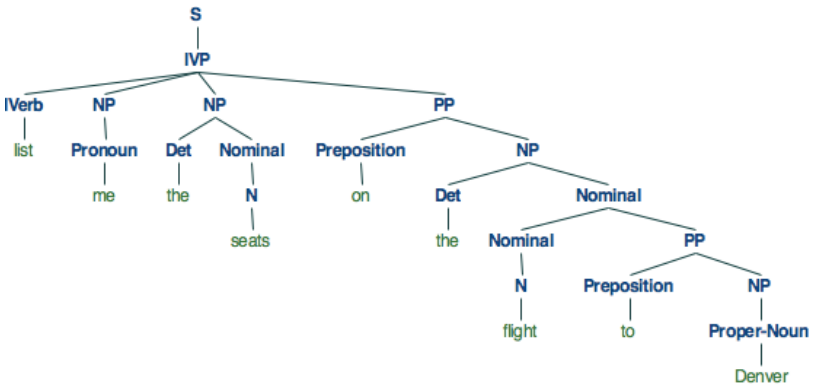
4d) Meaning – (list)(me)(the seats)(on the flight)(to Denver)—list me the seats on the flight to Denver – (does not make much sense) – seats and flight are disconnected.



4d) Meaning – (list me)(the)(seats on the flight)(to Denver) – list me the seats on the flight that is going to Denver. (Makes sense)



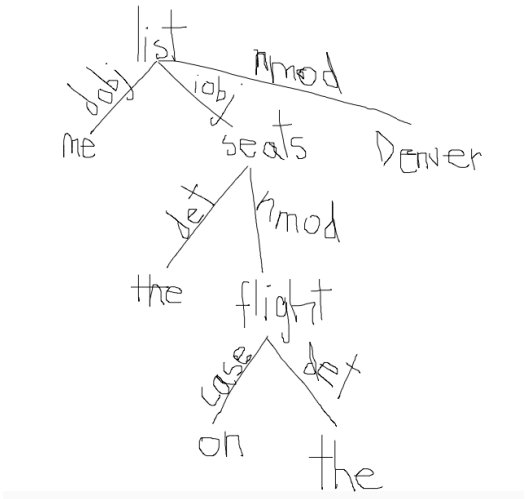
4d) Meaning – (list)(me the seats)(on the flight)(to Denver) – (does not make sense)



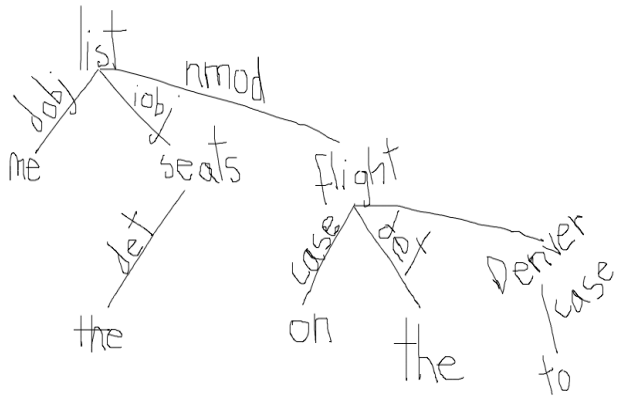
4d)(list)(me)(the seats)(on)(the flight to Denver) – seats and flight disjointed – (does not make sense)

4 e) The CFG trees given in 4b) have been transformed into dependency tress using the dependency labels given in the coursework and textbook. The format given in the lecture slides has been used to draw the dependency trees for the trees in 4b.

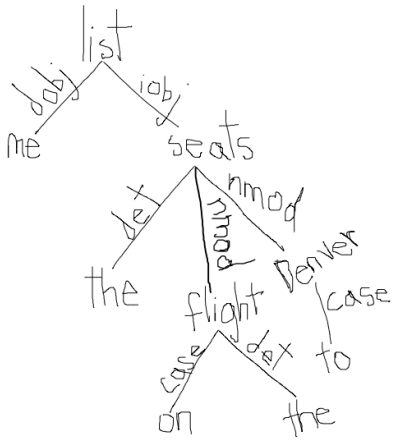
1)



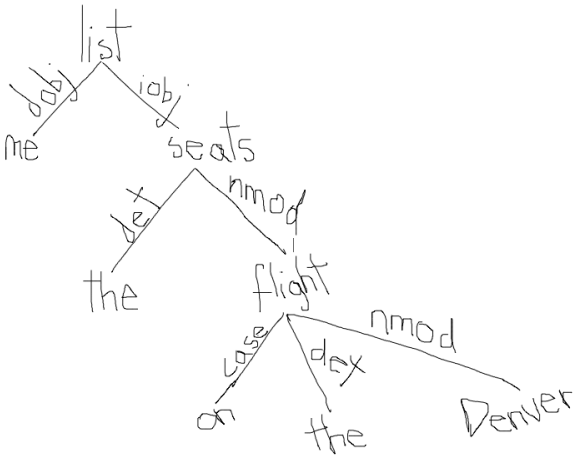
2)



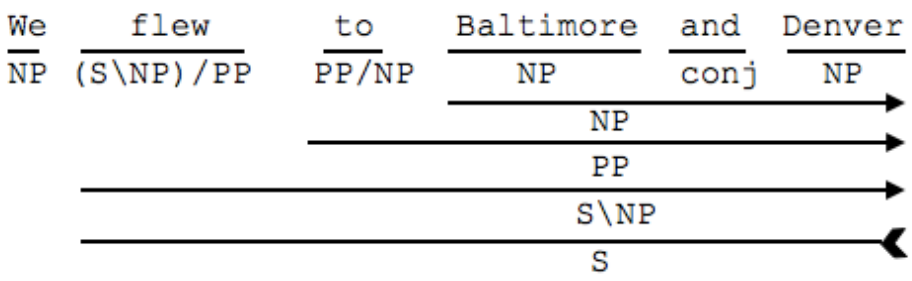
3)



4)



5. CCG parse tree has been drawn for 2f) “We flew to Baltimore and Denver.”



6. The parseTrees.txt has been loaded into NLTK using grammar_prob.py to extract the CFG grammar used to parse it. After learning the probabilities (PCFG) of the grammar, the most likely parse for this sentence has been computed:
“Show me the meals on the flight from Phoenix.”

a) The PCFG for the grammar is listed below after adding the following code:

```
from nltk.draw.tree import TreeView

# Main script

print ("loading data..")
data = loadData('parseTrees.txt')
print ("generating trees..")
treeData = getTreeData(data)
print ("done")
rules = list()
print ("compiling the rules")
for t in treeData:
    rules.extend(t.productions())
print("Number of rules: " + str(len(rules)))
print ("computing PCFG")
S = Nonterminal('S')
grammar = induce_pcfg(S, rules)
print ("PCFG:")
print(grammar)
```

PCFG:
Grammar with 566 productions (start state = S)
S -> DECL_MD [0.428924]
DECL_MD -> NP_PPSS VERB_MD NP_NN AVPNP_NP pt_char_per [0.0705036]
NP_PPSS -> PRON_PPSS [1.0]
PRON_PPSS -> i [0.998601]
i -> 'i' [1.0]
VERB_MD -> pt_verb_md [0.998134]
pt_verb_md -> 'need' [0.974299]
NP_NN -> ADJ_AT NOUN_NN PREP_IN [0.0736596]
ADJ_AT -> a [0.394803]
a -> 'a' [1.0]
NOUN_NN -> flight [0.40036]
flight -> 'flight' [1.0]
PREP_IN -> pt_prep_in [0.307885]
pt_prep_in -> 'from' [0.997651]
AVPNP_NP -> NOUN_NP PP_NN [0.0218978]
NOUN_NP -> charlotte [0.113329]
charlotte -> 'charlotte' [1.0]
PP_NN -> PREP_IN NP_NP NOUN_NN PP_NP [0.0644788]
PREP_IN -> to [0.302821]
to -> 'to' [1.0]
NP_NP -> NOUN_NP RELCL_VBZ [0.106612]
NOUN_NP -> las vegas [0.112429]
las -> 'las' [1.0]
vegas -> 'vegas' [1.0]
RELCL_VBZ -> NP_WPS VERB_VBZ NP_NP [0.155709]
NP_WPS -> PRON_WPS [1.0]
PRON_WPS -> that [1.0]
that -> 'that' [1.0]
VERB_VBZ -> pt_verb_vbz [0.998559]
pt_verb_vbz -> 'makes' [0.601732]
NP_NP -> NOUN_NP [0.293477]
NOUN_NP -> a [0.111052]
NOUN_NN -> pt217 [0.230561]
pt217 -> 'stop' [0.945422]
PP_NP -> PREP_IN NOUN_NP NAPPOS_NP [0.0666257]
PREP_IN -> in [0.228579]
in -> 'in' [1.0]

NOUN_NP -> saint [0.0864269]
saint -> 'saint' [1.0]
NAPPOS_NP -> NOUN_NP [0.81677]
NOUN_NP -> louis [0.0864269]
louis -> 'louis' [1.0]
pt_char_per -> '.' [1.0]
NP_NP -> NP_NP NOUN_NP [0.0566927]
RELCL_VBZ -> NP_WPS VERB_VBZ [0.331027]
PP_NP -> PREP_IN NOUN_NP AVPNP_NP [0.0677532]
AVPNP_NP -> NOUN_NP [0.89635]
PP_NP -> PREP_IN NP_NP NOUN_NP [0.167999]
PP_NP -> PREP_IN NOUN_NP [0.227245]
NOUN_NP -> saint louis [0.0239898]
NP_NN -> NP_NP NOUN_NN PREP_IN [0.0614665]
NP_NN -> ADJ_AT NOUN_NN PP_NP [0.0923668]
NP_NP -> NOUN_NP PP_NP [0.0625828]
PP_NP -> PREP_IN NOUN_NP RELCL_VBZ [0.201517]
RELCL_VBZ -> NP_WPS VERB_VBZ NP_NN [0.112457]
PP_NP -> PREP_IN NOUN_NP PP_NP [0.0835383]
NP_NP -> NP_NN NOUN_NP [0.131939]
RELCL_VBZ -> NP_WPS VERB_VBZ PP_NN PP_NP [0.0905421]
PP_NN -> PREP_IN NOUN_NN [0.0814672]
PREP_IN -> a [0.0282107]
RELCL_VBZ -> NP_WPS VERB_VBZ NP_NN PP_NP [0.0495963]
NP_NN -> ADJ_AT NOUN_NN [0.0571238]
NP_NN -> NP_NP NOUN_NN [0.0649741]
RELCL_VBZ -> NP_WPS VERB_VBZ PP_NN [0.239331]
PP_NN -> PREP_IN NOUN_NN PP_NP [0.0694981]
PP_NP -> PREP_IN NP_NP NOUN_NP RELCL_VBZ [0.0794383]
NP_NP -> NOUN_NP PREP_IN [0.107495]
PP_NP -> PREP_IN NOUN_NP PP_NN [0.0144526]
PP_NP -> PREP_IN NOUN_NP PP_NP PP_NN [0.0159902]
PP_NP -> PREP_IN NOUN_NP PP_NP PP_NP [0.0130176]
NP_NP -> NOUN_NP INFCL_VB [0.0326903]
INFCL_VB -> VERB_VB [0.850575]
VERB_VB -> pt217 [0.112224]
NP_NN -> ADJ_AT NOUN_NN PP_NP PP_NP [0.0367463]
PP_NP -> PREP_IN NOUN_NP AVPNP_NN [0.00461255]
AVPNP_NN -> AVP_RB NP_NP NOUN_NN [0.144928]
AVP_RB -> ADV_RB [0.995822]
ADV_RB -> to [0.137883]
PP_NN -> PREP_IN NP_NP NOUN_NN [0.0555985]
PP_NN -> PREP_IN NP_NP NP_NP NOUN_NN [0.0324324]
NP_NN -> NP_NP NOUN_NN PP_NP PP_NP [0.0369133]
S -> IVP [0.0203662]
IVP -> IVerb NP NP [0.626263]
IVerb -> 'show' [1.0]
NP -> Pronoun [0.166667]
Pronoun -> 'me' [1.0]
NP -> Det Nominal [0.333333]
Det -> 'the' [1.0]
Nominal -> Nominal PP [0.346535]
Nominal -> Noun [0.653465]
Noun -> 'meals' [0.257576]
PP -> Preposition NP [1.0]
Preposition -> 'on' [0.36803]
Noun -> 'flight' [0.5]
Preposition -> 'from' [0.356877]
NP -> Proper_Noun [0.286195]
Proper_Noun -> 'NWA' [0.5]

NP -> NP PP [0.213805]
IVP -> IVerb NP NP PP [0.373737]
NP_NN -> ADJ_AT NOUN_NN PP_NP PP_NN PP_NP [0.00501086]
NP_NN -> ADJ_AT NOUN_NN PP_NN PP_NP [0.00601303]
NP_NN -> ADJ_AT NOUN_NN PP_NN [0.0070152]
NP_NN -> NP_NP NOUN_NN PP_NN [0.0070152]
NP_NN -> NP_NN NOUN_NN PP_NP [0.0248873]
NP_NN -> ADJ_AT NP_NN NOUN_NN PP_NP [0.0228829]
NP_NN -> NOUN_NN PP_NP [0.017371]
NP_NN -> NOUN_NN PP_NP PP_NP [0.00601303]
NP_NN -> ADJ_AT NOUN_NN PP_NP PP_NN [0.00734926]
NP_NN -> ADJ_AT NOUN_NN PP_NP PP_NP AVPNP_NN [0.00300651]
AVPNP_NN -> NP_NP NOUN_NN PP_NP [0.253623]
NP_NN -> ADJ_AT NOUN_NN PP_NP PP_NP PP_NN [0.00167029]
NP_NN -> ADJ_AT NOUN_NN PP_NP PP_NP PP_NP [0.00417571]
NP_NP -> NP_NN NOUN_NP PP_NP [0.0366662]
NP_NP -> NOUN_NP NAPPOS_NP [0.00721543]
NAPPOS_NP -> NP_NP NOUN_NP [0.171843]
NP_NN -> NOUN_NN PREP_IN [0.0190413]
DECL_MD -> NP_PPSS VERB_MD NP_NN PP_NP pt_char_per [0.306954]
AVPNP_NN -> NOUN_NN [0.514493]
AVPNP_NN -> NP_NP NOUN_NN [0.0181159]
NP_NN -> ADJ_AT NP_NP NOUN_NN [0.00400869]
NP_NN -> NP_NN NOUN_NN [0.0245532]
NP_NN -> ADJ_AT NP_NN NOUN_NN [0.0182061]
NP_NN -> NP_NN NP_NP NOUN_NN [0.0106898]
PP_NP -> PREP_IN NOUN_NP PREP_IN [0.00287003]
PP_NP -> PREP_IN NOUN_NP AVP_RB [0.00317753]
NP_NN -> ADJ_AT NOUN_NN PP_NP AVP_RB [0.00300651]
Noun -> 'flights' [0.242424]
Proper_Noun -> 'Phoenix' [0.217647]
Preposition -> 'to' [0.275093]
RELCL_VBZ -> NP_WPS VERB_VBZ PP_NP [0.0204729]
NP_NP -> NOUN_NP PP_NN [0.010455]
NP_NP -> NOUN_NP PP_NP PP_NP [0.0041231]
DECL_MD -> NP_PPSS VERB_MD NP_NN PP_NP PP_NP PP_NP pt_char_per [0.016307]
DECL_MD -> NP_PPSS VERB_MD NP_NP PP_NP pt_char_per [0.134293]
NP_NP -> NOUN_NP RELCL_VB [0.0038286]
RELCL_VB -> NP_NP VERB_VB [0.464286]
NP_NP -> NOUN_NP NAPPOS_NN [0.00427036]
NAPPOS_NN -> NP_NP NOUN_NN [0.705882]
VERB_VB -> flight [0.0921844]
DECL_MD -> NP_PPSS VERB_MD NP_NN pt_char_per [0.229736]
DECL_MD -> NP_PPSS VERB_MD NP_NP pt_char_per [0.136691]
VERB_VB -> saint [0.00133601]
Proper_Noun -> 'SF' [0.217647]
Proper_Noun -> 'Houston' [0.0647059]
DECL_MD -> NP_PPSS VERB_MD NP_NN NP_NN pt_char_per [0.0230216]
DECL_MD -> NP_PPSS VERB_MD NP_NN AVPNP_NN pt_char_per [0.0306954]
DECL_MD -> NP_PPSS VERB_MD NP_NN PP_NN pt_char_per [0.0230216]
DECL_MD -> NP_PPSS VERB_MD NP_NP PP_NP PP_NN pt_char_per [0.0115108]
DECL_MD -> NP_PPSS VERB_MD NP_NN PP_NP PP_NN pt_char_per [0.0172662]
S -> DECL_BEZ [0.263526]
DECL_BEZ -> NP_DT VERB_BEZ NP_NP pt_char_per [0.0741608]
NP_DT -> PRON_DT [1.0]
PRON_DT -> what [1.0]
what -> 'what' [1.0]
VERB_BEZ -> pt_verb_bez [1.0]
pt_verb_bez -> 'is' [1.0]
NP_NN -> ADJ_AT AJP_JJ NOUN_NN PP_NP [0.0168699]

ADJ_AT -> the [0.605197]
the -> 'the' [1.0]
AJP_JJ -> AVP_RBT ADJ_JJ [0.348891]
AVP_RBT -> ADV_RBT [0.570175]
ADV_RBT -> pt329 [1.0]
pt329 -> 'cheapest' [1.0]
ADJ_JJ -> one way [0.44606]
one -> 'one' [1.0]
way -> 'way' [1.0]
PP_NP -> PREP_IN NP_NP AJP_JJ NOUN_NP [0.0115826]
NOUN_NP -> phoenix [0.0730816]
phoenix -> 'phoenix' [1.0]
NOUN_NP -> san diego [0.060107]
san -> 'san' [1.0]
diego -> 'diego' [1.0]
pt_verb_vbz -> 'arrives' [0.398268]
PP_NN -> PREP_IN ADJ_AT NOUN_NN [0.268726]
NOUN_NN -> pt_noun_nn [0.155733]
pt_noun_nn -> 'morning' [0.99711]
AJP_JJ -> ADJ_JJ [0.286917]
ADJ_JJ -> on [0.142311]
on -> 'on' [1.0]
NOUN_NP -> thursday [0.129164]
thursday -> 'thursday' [1.0]
NOUN_NP -> june second [0.0730816]
june -> 'june' [1.0]
second -> 'second' [1.0]
PREP_IN -> on [0.0856185]
PP_NN -> PREP_IN ADJ_AT NOUN_NN PP_NP [0.162934]
NP_NP -> NOUN_NP PP_NPS [0.0631718]
PP_NPS -> PREP_IN NOUN_NPS [0.963203]
NOUN_NPS -> san [0.379257]
NOUN_NP -> diego [0.0129746]
NP_NN -> NP_CD NOUN_NN [0.0835143]
NP_CD -> ADJ_AT AJP_JJT NOUN_CD [0.446381]
AJP_JJT -> ADJ_JJT [1.0]
ADJ_JJT -> pt329 [1.0]
NOUN_CD -> one [0.359656]
NOUN_NN -> way [0.0953078]
NP_NN -> AJP_JJT QUANP_CD NOUN_NN [0.0434274]
QUANP_CD -> ADJ_CD [0.894137]
ADJ_CD -> one [0.630293]
NP_NN -> ADJ_AT AJP_JJ NOUN_NN PP_NP PP_NP [0.0070152]
NP_NN -> AJP_JJ NOUN_NN PP_NP PP_NP [0.0070152]
AVP_RBT -> AVP_RB ADV_RBT [0.429825]
ADV_RB -> the [0.286908]
NP_NN -> ADJ_AT AJP_JJT AJP_JJ NOUN_NN PP_NP PP_NP [0.0070152]
NP_NN -> NP_NN NOUN_NN PP_NP PP_NP [0.0070152]
NP_NN -> ADJ_AT NP_NN NOUN_NN PP_NP PP_NP [0.0070152]
NP_NN -> ADJ_AT AJP_JJT NP_NN NOUN_NN PP_NP PP_NP [0.0140304]
NP_NN -> QUANP_CD NOUN_NN [0.0278938]
NP_CD -> NOUN_CD [0.391421]
NP_NN -> ADJ_AT NP_NN NOUN_NN PP_NP PP_NP PP_NP [0.000835143]
NP_NN -> ADJ_AT AJP_JJ NOUN_NN PP_NP PP_NN [0.00400869]
NP_NN -> NP_NN NOUN_NN PP_NP PP_NN [0.00400869]
NP_NN -> ADJ_AT AJP_JJ NOUN_NN PP_NP PP_NP PP_NN [0.00133623]
NP_NN -> NP_NN NOUN_NN PP_NP PP_NP PP_NN [0.00133623]
DECL_BEZ -> NP_DT VERB_BEZ NP_NN PP_NP pt_char_per [0.333333]
NP_NN -> ADJ_AT AJP_JJ NOUN_NN [0.0141974]
NP_NN -> AJP_JJ NOUN_NN [0.0141974]

NP_NN -> ADJ_AT AJP_JJT AJP_JJ NOUN_NN [0.0141974]
NP_NN -> ADJ_AT ADJ_JJT NP_NN NOUN_NN [0.0283949]
PP_NN -> PREP_IN ADJ_AT NOUN_NN NAPPOS_NP [0.0451737]
NP_NP -> AJP_JJ NOUN_NP [0.0172287]
NP_NP -> NP_NP AJP_JJ NOUN_NP [0.00647916]
DECL_BEZ -> NP_DT VERB_BEZ NP_NN PP_NP PP_NP pt_char_per [0.156909]
DECL_BEZ -> NP_DT VERB_BEZ NP_NN PP_NP PP_NP PP_NP pt_char_per [0.0218579]
DECL_BEZ -> NP_DT VERB_BEZ NP_NN pt_char_per [0.274005]
DECL_BEZ -> NP_DT VERB_BEZ NP_NN PP_NP PP_NN pt_char_per [0.0749415]
DECL_BEZ -> NP_DT VERB_BEZ NP_NN PP_NN pt_char_per [0.049961]
S -> NREL_BEZ [0.0347665]
NREL_BEZ -> NP_DT VERB_BEZ NP_NN [1.0]
NP_NN -> NP_NN NOUN_NN PP_NP PP_NP PP_NN pt_char_per [0.000668114]
NP_NN -> AJP_JJ NOUN_NN PP_NP pt_char_per [0.0070152]
NP_NN -> NP_NN NOUN_NN PP_NP pt_char_per [0.0070152]
NP_NN -> AJP_JJ NOUN_NN PP_NP PP_NP pt_char_per [0.00450977]
NP_NN -> NP_NN NOUN_NN PP_NP PP_NP pt_char_per [0.00450977]
NP_NN -> ADJ_AT NP_NN NOUN_NN PP_NP PP_NP pt_char_per [0.00450977]
NOUN_NP -> columbus [0.00264788]
columbus -> 'columbus' [1.0]
NOUN_NP -> indianapolis [0.00264788]
indianapolis -> 'indianapolis' [1.0]
DECL_BEZ -> VERB_BEZ NP_NN pt_char_per [0.00078064]
NP_NP -> AVP_RB NOUN_NP [0.00161979]
ADV_RB -> there [0.0250696]
there -> 'there' [1.0]
NOUN_NP -> memphis [0.000953238]
memphis -> 'memphis' [1.0]
NOUN_NP -> los angeles [0.000953238]
los -> 'los' [1.0]
angeles -> 'angeles' [1.0]
DECL_BEZ -> VERB_BEZ AVP_RB NP_NP pt_char_per [0.0039032]
DECL_BEZ -> VERB_BEZ AVP_RB NP_NN PP_NP pt_char_per [0.0039032]
DECL_BEZ -> VERB_BEZ AVP_RB NP_NP NP_NN pt_char_per [0.00234192]
DECL_BEZ -> VERB_BEZ AVP_RB NP_NN pt_char_per [0.00312256]
S -> IMPR_VB [0.228348]
IMPR_VB -> AVP_RB VERB_VB NP_PPO NP_NNS PP_NP PP_NP pt_char_per [0.0018018]
ADV_RB -> please [0.0278552]
please -> 'please' [1.0]
VERB_VB -> show [0.734135]
show -> 'show' [1.0]
NP_PPO -> pt_pron_ppo [0.991811]
pt_pron_ppo -> 'me' [1.0]
NP_NNS -> ADJ_AT NOUN_NNS [0.00171969]
NOUN_NNS -> pt207 [0.953568]
pt207 -> 'flights' [0.998205]
NOUN_NP -> chicago [0.0571413]
chicago -> 'chicago' [1.0]
PP_NP -> PREP_IN NOUN_NP RELCL_VB [0.00102501]
NOUN_NP -> detroit [0.00195943]
detroit -> 'detroit' [1.0]
RELCL_VB -> NP_WPS VERB_VB PP_CD [0.178571]
VERB_VB -> pt_verb_vb [0.0153641]
pt_verb_vb -> 'arrive' [0.869565]
PP_CD -> PREP_IN NOUN_CD AVPNP_NP [0.220096]
PREP_IN -> at [0.00131518]
at -> 'at' [1.0]
NOUN_CD -> six p_m_ [0.0156372]
six -> 'six' [1.0]

p_m_ -> 'p.m.' [1.0]

AVPNP_NP -> AJP_AP NOUN_NP [0.0145985]
AJP_AP -> ADJ_AP [1.0]
ADJ_AP -> pt_adj_ap [1.0]
pt_adj_ap -> 'next' [1.0]
NOUN_NP -> tuesday [0.00105915]
tuesday -> 'tuesday' [1.0]
NP_NNS -> AVP_RB NOUN_NNS [0.00257954]
IMPR_VB -> AVP_RB VERB_VB NP_PPO NP_NNS PP_CD pt_char_per [0.00720721]
NP_NNS -> ADJ_AT NOUN_NNS PP_NP PP_NP RELCL_VB [0.00171969]
RELCL_VB -> NP_WPS VERB_VB [0.178571]
NP_NNS -> ADJ_AT NOUN_NNS PP_NP RELCL_VB [0.00343938]
NP_NNS -> ADJ_AT NOUN_NNS PP_NP [0.00429923]
PP_NP -> PREP_IN NP_NP NOUN_NP RELCL_VB [0.000410004]
NP_NNS -> AVP_RB NOUN_NNS PP_NP [0.00773861]
NP_NNS -> ADJ_AT NOUN_NNS PP_NP PP_NP [0.00171969]
IMPR_VB -> AVP_RB VERB_VB NP_PPO NP_NNS pt_char_per [0.00900901]
PP_NP -> PREP_IN NOUN_NP PP_NP PP_CD [0.00123001]
IMPR_VB -> VERB_VB NP_PPO NP_NP pt_char_per [0.0810811]
NP_NN -> NP_NNS QUANP_CD NOUN_NN [0.00484383]
NP_NNS -> NOUN_NNS PP_NP PP_NP [0.0765262]
PP_NP -> PREP_IN NOUN_NP AJP_JJ [0.00656007]
NOUN_NP -> kansas city [0.0366467]
kansas -> 'kansas' [1.0]
city -> 'city' [1.0]
AJP_JJ -> ADJ_JJ PREP_IN [0.0451415]
ADJ_JJ -> pt347 [0.3772]
pt347 -> 'leaving' [1.0]
PREP_IN -> around [0.0455711]
around -> 'around' [1.0]
ADJ_CD -> seven [0.369707]
seven -> 'seven' [1.0]
NOUN_NN -> p_m_ [0.089344]
AJP_JJ -> ADJ_JJ AVP_RB [0.0451415]
ADV_RB -> around [0.509749]
PP_NP -> PREP_IN NOUN_NP PRPRTCL_VBG [0.0153752]
PRPRTCL_VBG -> VERB_VBG PREP_IN [0.0407725]
VERB_VBG -> pt347 [1.0]
PRPRTCL_VBG -> VERB_VBG AVP_RB [0.0407725]
NP_NNS -> NOUN_NNS PP_NP [0.33276]
PP_NP -> PREP_IN NP_NP NOUN_NP PRPRTCL_VBG [0.00779008]
NOUN_NPS -> kansas [0.568111]
NOUN_NP -> city [0.012498]
NP_NNS -> NOUN_NNS PP_NN [0.121238]
PP_NN -> PREP_IN NP_NP NOUN_NN PRPRTCL_VBG [0.0135135]
NOUN_NN -> city [0.0158659]
PRPRTCL_VBG -> VERB_VBG [0.100858]
QUANP_CD -> AVP_RB ADJ_CD [0.105863]
NP_NNS -> NOUN_NNS PP_NP PP_VBG [0.0206363]
PP_VBG -> PREP_IN NP_NP VERB_VBG [0.16]
NP_NP -> NP_NPS NOUN_NP [0.009866]
NP_NPS -> NOUN_NPS [0.766304]
NP_NNS -> NOUN_NNS PP_VBG [0.0653482]
NP_NPS -> NP_NP NOUN_NPS [0.233696]
PP_NP -> PREP_IN NP_NPS NOUN_NP [0.00533005]
PP_NN -> PREP_IN NP_NPS NOUN_NN [0.019305]
NP_NN -> NP_NNS NOUN_NN [0.0101887]
PRPRTCL_VBG -> VERB_VBG PP_DTS [0.0536481]
PP_DTS -> PREP_IN PRON_DTS [1.0]
PRON_DTS -> seven [1.0]
PRPRTCL_VBG -> VERB_VBG AVP_RB NP_CD [0.113734]

NOUN_CD -> seven [0.417514]
PRPRTCL_VBG -> VERB_VBG NP_CD [0.0793991]
NP_CD -> AVP_RB NOUN_CD [0.103217]
PRPRTCL_VBG -> VERB_VBG AVPNP_CD [0.0793991]
AVPNP_CD -> AVP_RB NOUN_CD [0.6]
PRPRTCL_VBG -> VERB_VBG PP_CD [0.139485]
PP_CD -> PREP_IN NOUN_CD [0.528708]
AJP_JJ -> ADJ_JJ PP_CD [0.157613]
PP_NN -> PREP_IN NP_NP NOUN_NN AVPNP_CD [0.0015444]
AVPNP_CD -> AJP_JJ NOUN_CD [0.4]
PP_VBG -> PREP_IN NP_NP VERB_VBG PP_DTS [0.08]
PP_VBG -> PREP_IN NP_NP VERB_VBG AVPNP_CD [0.16]
PP_VBG -> PREP_IN NP_NP VERB_VBG PP_CD [0.32]
PP_VBG -> PREP_IN NP_NN VERB_VBG PP_CD [0.04]
NP_NNS -> NOUN_NNS PP_NP PP_NP PP_CD [0.00687876]
IMPR_VB -> VERB_VB NP_PPO NP_NNS PP_NN pt_char_per [0.0441441]
NP_NNS -> NOUN_NNS [0.204643]
PP_NN -> PREP_IN NP_NP QUANP_CD NOUN_NN NAPPOS_NP [0.023166]
NP_NP -> NP_NP NOUN_NP AJP_JJ [0.00589015]
NP_NP -> NOUN_NP AJP_JJ [0.00927698]
NP_NP -> NOUN_NP PRPRTCL_VBG [0.0228243]
PP_NN -> PREP_IN NP_NP NP_NN NOUN_NN NAPPOS_NP [0.0023166]
NP_NN -> NOUN_NN AVPNP_CD [0.00100217]
NP_NN -> NOUN_NN AJP_JJ [0.000501086]
PP_NN -> PREP_IN NP_NN NOUN_NN NAPPOS_NP [0.003861]
NP_NN -> NP_NP NOUN_NN PRPRTCL_VBG [0.00250543]
PP_NN -> PREP_IN NP_NP NOUN_NN NAPPOS_NP [0.0247104]
NP_NP -> NOUN_NP AVPNP_CD [0.00530113]
PRPRTCL_VBG -> VERB_VBG AVPNP_CD AVPNP_NP [0.0343348]
NOUN_CD -> seven p_m_ [0.207193]
NP_CD -> NOUN_CD AVPNP_NP [0.0214477]
PRPRTCL_VBG -> VERB_VBG PP_CD AVPNP_NP [0.0686695]
PP_CD -> PREP_IN NOUN_CD AVPNP_NN [0.251196]
PRPRTCL_VBG -> VERB_VBG NP_NP [0.0686695]
IMPR_VB -> VERB_VB NP_PPO NP_NNS pt_char_per [0.221622]
NP_NNS -> NOUN_NNS PP_NP PP_NN [0.0438521]
AVPNP_NP -> AJP_JJ NOUN_NP [0.0467153]
AJP_JJ -> ADJ_JJ PP_NN [0.0979342]
PP_NN -> PREP_IN QUANP_CD NOUN_NN [0.0355212]
PP_NN -> PREP_IN NP_CD NOUN_NN [0.0355212]
PRPRTCL_VBG -> VERB_VBG PP_CD AVPNP_NN [0.0257511]
PRPRTCL_VBG -> VERB_VBG NP_NN [0.0515021]
PRPRTCL_VBG -> VERB_VBG AVP_RB NP_NN [0.0515021]
PRPRTCL_VBG -> VERB_VBG PP_NN [0.0515021]
NAPPOS_NN -> AJP_JJ NOUN_NN [0.294118]
NAPPOS_NP -> NP_NP AJP_JJ NOUN_NP [0.00828157]
PP_NP -> PREP_IN NOUN_NP NAPPOS_NN [0.000410004]
AVPNP_NN -> AJP_JJ NOUN_NN [0.0217391]
PP_NN -> PREP_IN NP_NP AJP_JJ NOUN_NN [0.00540541]
PP_NN -> PREP_IN NP_NP NP_CD NOUN_NN [0.0247104]
NP_CD -> AJP_JJ NOUN_CD [0.0375335]
IMPR_VB -> VERB_VB NP_PPO NP_NNS PP_NP PP_NN pt_char_per [0.0126126]
IMPR_VB -> VERB_VB NP_PPO NP_NNS AVPNP_NP pt_char_per [0.325225]
NP_NNS -> NOUN_NNS PREP_IN [0.0197764]
PP_NN -> PREP_IN NP_NP NOUN_NN NAPPOS_NN [0.0003861]
PP_NN -> PREP_IN NP_NP NP_NN NOUN_NN [0.0011583]
PP_NN -> PREP_IN NP_NN NOUN_NN [0.00656371]
PP_VBG -> PREP_IN NP_NP VERB_VBG PP_CD AVPNP_NN [0.08]
PP_VBG -> PREP_IN NP_NP VERB_VBG PP_NN [0.16]
NP_NNS -> NOUN_NNS PP_NP PP_NP AVPNP_NN [0.0120378]

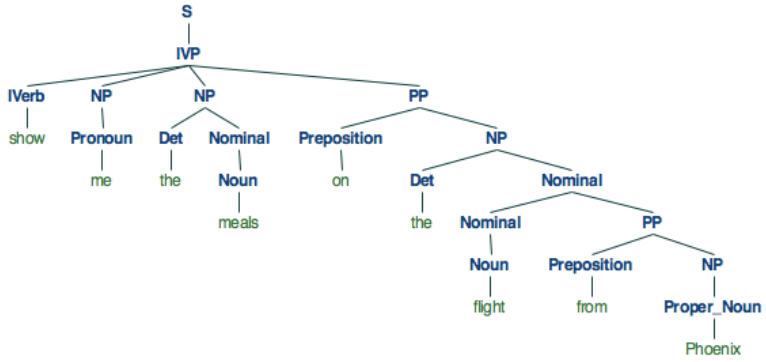
AVPNP_NN -> QUANP_CD NOUN_NN [0.0217391]
NP_NNS -> NOUN_NNS PP_NP PP_NP PP_NN [0.00343938]
AVPNP_NP -> NOUN_NP PRPRTCL_VBG [0.020438]
NP_NNS -> NOUN_NNS PP_NP PP_NPS [0.00687876]
PP_NP -> PREP_IN NOUN_NP PP_NPS [0.00174252]
IMPR_VB -> VERB_VB NP_PPO NP_NNS PP_NP pt_char_per [0.168468]
IMPR_VB -> VERB_VB NP_PPO NP_NNS AJP_JJ AVPNP_NP pt_char_per [0.0396396]
IMPR_VB -> VERB_VB NP_PPO NP_NNS PP_NP PP_NP pt_char_per [0.0351351]
IMPR_VB -> VERB_VB NP_PPO NP_NNS AVPNP_NN pt_char_per [0.00630631]
AVPNP_NN -> NP_NP NOUN_NN PRPRTCL_VBG [0.0253623]
IMPR_VB -> VERB_VB NP_PPO NP_NNS PP_NP PP_CD pt_char_per [0.00540541]
IMPR_VB -> VERB_VB NP_PPO NP_NNS PP_CD pt_char_per [0.0135135]
IMPR_VB -> VERB_VB NP_PPO NP_NNS AJP_JJ pt_char_per [0.00990991]
IMPR_VB -> VERB_VB NP_PPO NP_NNS PP_NP PP_NP AJP_JJ pt_char_per [0.0018018]
IMPR_VB -> VERB_VB NP_PPO NP_NN AJP_JJ pt_char_per [0.0018018]
S -> DECL_DOZ [0.0086402]
DECL_DOZ -> AJP_DTI VERB_DOZ NP_NN pt_char_per [1.0]
AJP_DTI -> how ADJ_DTI [1.0]
how -> 'how' [1.0]
ADJ_DTI -> much [1.0]
much -> 'much' [1.0]
VERB_DOZ -> does [1.0]
does -> 'does' [1.0]
NP_NN -> NP_NN NOUN_NN PP_NN [0.00400869]
NP_NN -> NOUN_NN PP_CC [0.00501086]
NOUN_NN -> first class [0.00337572]
first -> 'first' [1.0]
class -> 'class' [1.0]
PP_CC -> PREP_IN NP_NN CONJ_CC NP_NNS [1.0]
NP_NN -> ADJ_DT NOUN_NN [0.00501086]
ADJ_DT -> that [1.0]
NOUN_NN -> pt60 [0.00877687]
pt60 -> 'cost' [1.0]
CONJ_CC -> and [1.0]
and -> 'and' [1.0]
NP_NNS -> QUANP_DTI NOUN_NNS [0.0232158]
QUANP_DTI -> how ADJ_DTI [1.0]
NOUN_NNS -> does [0.0464316]
pt217 -> 'coach' [0.0243572]
PP_NN -> PREP_IN ADJ_DT NOUN_NN [0.011583]
NP_NN -> ADJ_DT NP_NN NOUN_NN [0.00300651]
NP_NN -> NOUN_NN [0.00684817]
NP_NN -> ADJ_DT NOUN_NN AJP_JJ [0.00300651]
ADJ_JJ -> pt60 [0.013772]
NP_NNS -> AVP_QL NOUN_NNS [0.0232158]
AVP_QL -> how ADV_QL [1.0]
ADV_QL -> much [1.0]
NP_NN -> AJP_JJ NOUN_NN PP_NN [0.00400869]
AJP_JJ -> ADJ_JJ PP_CC [0.0183627]
ADJ_JJ -> first class [0.0183627]
NP_NN -> NP_NN NP_NN NOUN_NN [0.00100217]
NP_NN -> NOUN_NN PP_NN [0.00100217]
PP_NN -> PREP_IN ADJ_DT NP_NN NOUN_NN [0.0046332]
S -> DECL_VB [0.0144003]
DECL_VB -> AJP_DTI VERB_DOZ NP_NN VERB_VB pt_char_per [0.171429]
VERB_VB -> pt60 [0.00801603]
DECL_VB -> VERB_MD NP_PPSS VERB_VB NP_PPO NP_NNS pt_char_per [0.0428571]
VERB_MD -> can [0.00186567]
can -> 'can' [1.0]
PRON_PPSS -> you [0.00139925]

you -> 'you' [1.0]
pt_verb_vb -> 'tell' [0.130435]
AVP_RB -> AVP_RB ADV_RB [0.00417827]
ADV_RB -> about [0.00417827]
about -> 'about' [1.0]
NOUN_NP -> saint petersburg [5.29577e-05]
petersburg -> 'petersburg' [1.0]
NOUN_NP -> toronto [0.000158873]
toronto -> 'toronto' [1.0]
ADV_RB -> again [0.00417827]
again -> 'again' [1.0]
NAPPOS_NP -> NOUN_NP PP_NP [0.0010352]
NOUN_NP -> petersburg [0.000105915]
PP_NP -> PREP_IN NP_NP NOUN_NP PP_NP [0.000102501]
DECL_VB -> NP_PPSS VERB_MD VERB_VB PP_NN pt_char_per [0.228571]
pt_verb_md -> 'would' [0.0257009]
VERB_VB -> like [0.0367401]
like -> 'like' [1.0]
pt217 -> 'find' [0.0248083]
PP_NPS -> PREP_IN NP_NPS NOUN_NPS [0.0324675]
NOUN_NPS -> las [0.0263158]
NOUN_NPS -> vegas [0.0263158]
PP_NN -> PREP_IN NP_NN NOUN_NN PP_NP [0.0023166]
NP_NN -> NOUN_NN NAPPOS_NP [0.000668114]
PP_NN -> PREP_IN NOUN_NN PP_NN [0.0015444]
PP_NN -> PREP_IN NOUN_NN PP_NP PP_NP [0.000772201]
PP_NN -> PREP_IN NP_NP NOUN_NN PP_NP PP_NP [0.0003861]
PP_NN -> PREP_IN NP_NN NOUN_NN PP_NP PP_NP [0.000772201]
DECL_VB -> NP_PPSS VERB_MD VERB_VB INFCL_VB pt_char_per [0.557143]
INFCL_VB -> to VERB_VB NP_NN PP_NPS [0.0191571]
PP_NPS -> PREP_IN NP_NP NOUN_NPS [0.004329]
INFCL_VB -> to VERB_VB NP_NN [0.0229885]
NP_NN -> ADJ_AT NOUN_NN PP_NP PP_NPS [0.000167029]
INFCL_VB -> to VERB_VB NP_NP [0.0268199]
NP_NP -> NP_NN NOUN_NP PP_NPS [0.000294507]
INFCL_VB -> to VERB_VB NP_NN PP_NP [0.0268199]
INFCL_VB -> to VERB_VB PP_NN [0.0153257]
INFCL_VB -> to VERB_VB NP_NP PP_NP [0.0191571]
INFCL_VB -> to VERB_VB PP_NN PP_NP PP_NP [0.00383142]
INFCL_VB -> to VERB_VB AVPNP_NN PP_NP PP_NP [0.00383142]
INFCL_VB -> to VERB_VB NP_NN PP_NP PP_NP [0.00766284]
INFCL_VB -> to VERB_VB NP_NP PP_NP PP_NP [0.00383142]
DECL_BEZ -> AVP_RB VERB_BEZ NP_PPS PP_NN PP_NP pt_char_per [0.00078064]
ADV_RB -> how far [0.00139276]
far -> 'far' [1.0]
NP_PPS -> pt_pron_pps [1.0]
pt_pron_pps -> 'it' [1.0]
pt_noun_nn -> 'airport' [0.000722543]
PP_NP -> PREP_IN ADJ_AT NOUN_NP [0.000102501]
S -> DECL_HV [0.000205719]
DECL_HV -> VERB_MD NP_PPSS VERB_HV NP_NN pt_char_per [1.0]
VERB_HV -> have [1.0]
have -> 'have' [1.0]
pt217 -> 'fare' [0.00045106]
S -> NP_NN [0.000411438]
NP_NN -> NOUN_NN AVPNP_NN pt_char_per [0.000167029]
NOUN_NN -> show [0.000225048]
pt_noun_nn -> 'availability' [0.00216763]
NP_NN -> NP_NN NOUN_NN pt_char_per [0.000167029]
IMPR_VB -> VERB_VB NP_NN pt_char_per [0.0018018]

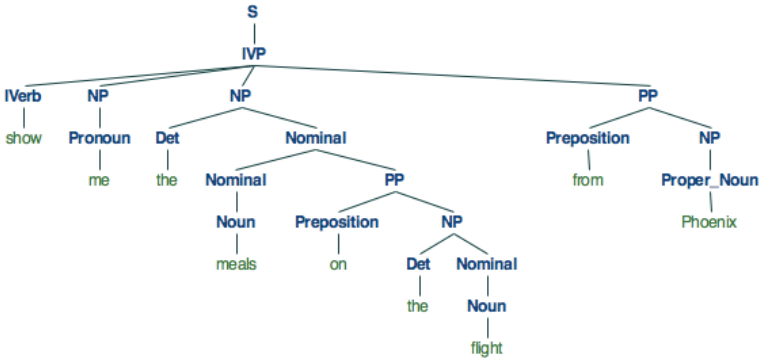
NP_PPO -> pt_pron_ppo NAPPOS_NP [0.00545951]
NOUN_NP -> northwest [0.000476619]
northwest -> 'northwest' [1.0]
NP_NNS -> AJP_JJ NOUN_NNS PP_NP [0.000859845]
ADJ_JJ -> northwest [0.00153022]
ADV_RB -> northwest [0.00278552]
NP_NNS -> NP_NN NOUN_NNS PP_NP [0.000859845]
NOUN_NN -> northwest [0.000450096]
NP_PPO -> pt_pron_ppo RELCL_VBZ [0.00272975]
RELCL_VBZ -> NP_NP VERB_VBZ PREP_IN [0.000288351]
VERB_VBZ -> pt207 [0.00144092]
RELCL_VBZ -> NP_NN VERB_VBZ [0.000288351]
RELCL_VBZ -> NP_NP VERB_VBZ [0.000288351]
IMPR_VB -> VERB_VB NP_PPO COMPCL_VBZ pt_char_per [0.000900901]
COMPCL_VBZ -> NP_NN VERB_VBZ AVP_RB NP_NP [1.0]
NP_NNS -> NOUN_NNS AVP_RB [0.00171969]
IMPR_VB -> VERB_VB NP_PPO pt_char_per [0.0018018]
NAPPOS_NP -> NP_NP NP_NNS NOUN_NP [0.00207039]
NP_NNS -> AJP_JJ NOUN_NNS [0.000859845]
NP_NNS -> NP_NN NOUN_NNS [0.000859845]
NP_NNS -> NP_NP NOUN_NNS [0.000859845]
IMPR_VB -> VERB_VB NP_NNS pt_char_per [0.00720721]
S -> NP_NNS [0.000205719]
NP_NNS -> NOUN_NNS pt_char_per [0.000859845]
pt207 -> 'prices' [0.00179533]
S -> DECL_VBZ [0.000205719]
DECL_VBZ -> VERB_VBZ pt_char_per [1.0]
IMPR_VB -> VERB_VB NP_NNS NP_NN PP_NN pt_char_per [0.000900901]
pt217 -> 'list' [0.00496166]
NP_NNS -> pt197 NOUN_NNS [0.000859845]
pt197 -> 'those' [1.0]
NP_NN -> ADJ_DT NOUN_NN PREP_IN [0.000167029]
pt_prep_in -> 'over' [0.00234942]
NOUN_NP -> salt lake [0.000476619]
salt -> 'salt' [1.0]
lake -> 'lake' [1.0]
NP_NNS -> pt197 NOUN_NNS RELCL_VB [0.00859845]
RELCL_VB -> NP_WPS VERB_VB PREP_IN PP_NP [0.178571]
PP_NP -> PREP_IN AJP_JJ NOUN_NP [0.000102501]
ADJ_JJ -> salt [0.000765111]
NOUN_NP -> lake city [5.29577e-05]
NOUN_NP -> salt lake city [5.29577e-05]
IMPR_VB -> VERB_VB NP_NNS AVPNP_NP pt_char_per [0.000900901]
IMPR_VB -> VERB_VB NP_NNS NP_NN pt_char_per [0.000900901]
IMPR_VB -> VERB_VB NP_NNS AVPNP_NN pt_char_per [0.000900901]
NOUN_NP -> e w r [5.29577e-05]
e -> 'e' [1.0]
w -> 'w' [1.0]
r -> 'r' [1.0]

b) The probabilities of each of the parse trees of the sentences have been given below. The InsideChartParser has been used to compute the probabilities for the parses. The one with the highest probability is the best parse of the sentence. The following code has been implemented to generate the parses and probability.

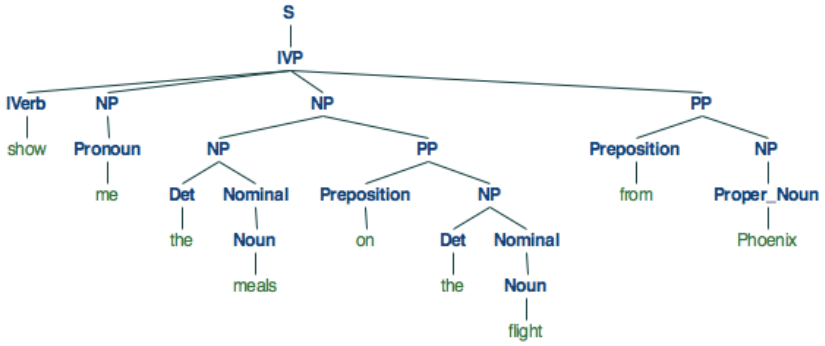
```
In [7]: sentence = "show me the meals on the flight from Phoenix".split()
        print ("parsing with InsideChart parser...")
        inside_parser = nltk.InsideChartParser(grammar)
        inside_parser.trace(3)
        for tree in inside_parser.parse(sentence):
            print(tree)
            tree.draw()
        print ("done!")
```



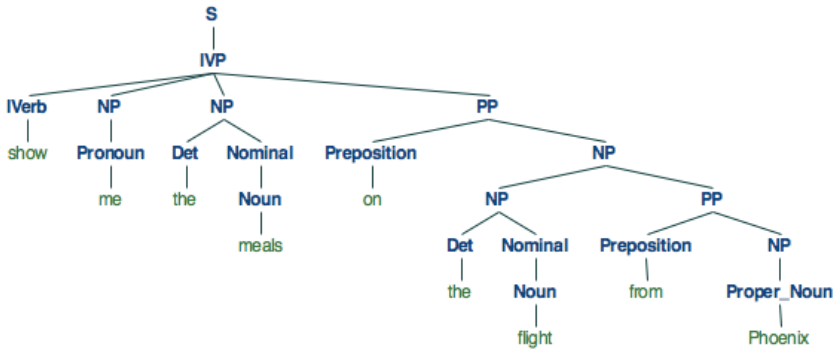
(p=2.19769e-08) (most likely parse)



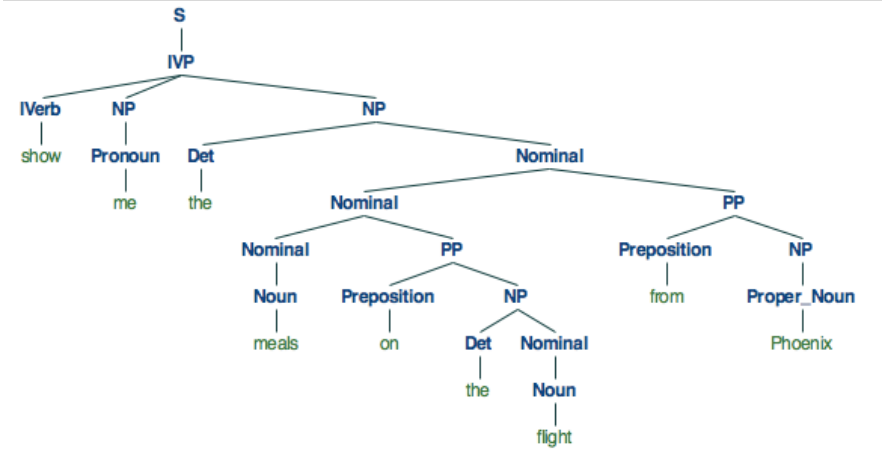
(p=2.19769e-08) (most likely parse)



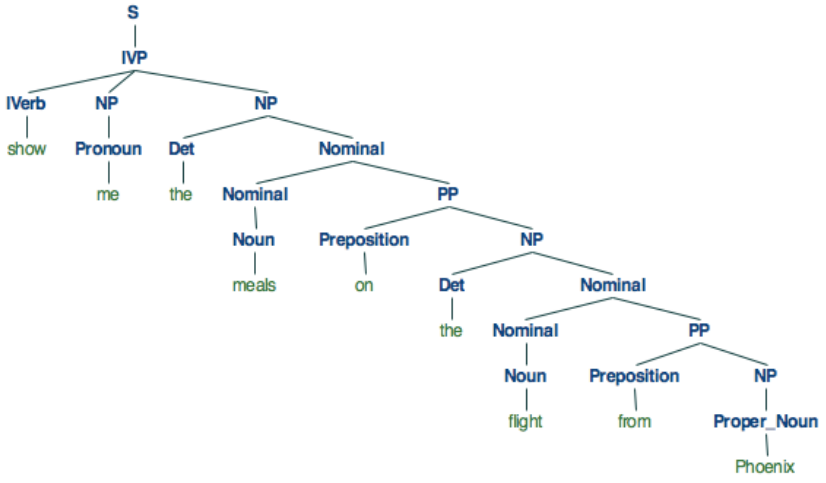
(p=1.35593e-08)



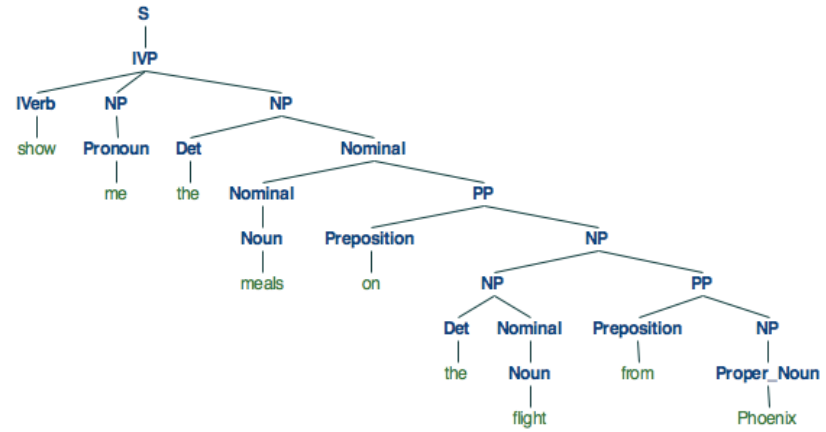
(p=1.35593e-08)



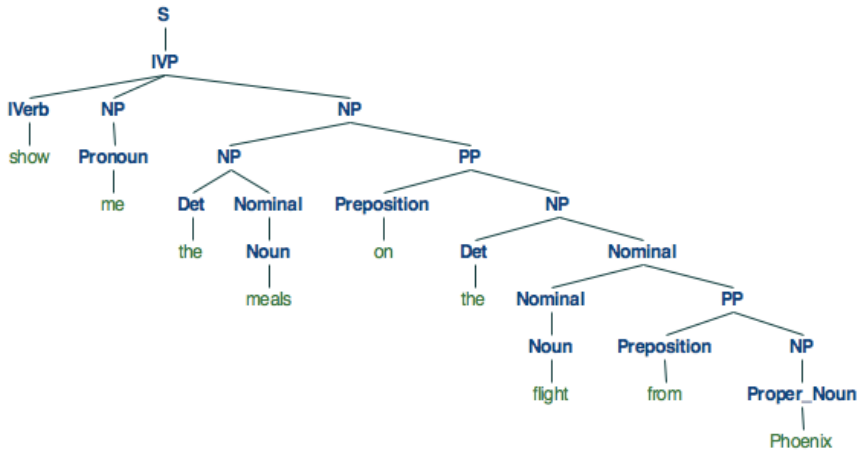
(p=1.27615e-08)



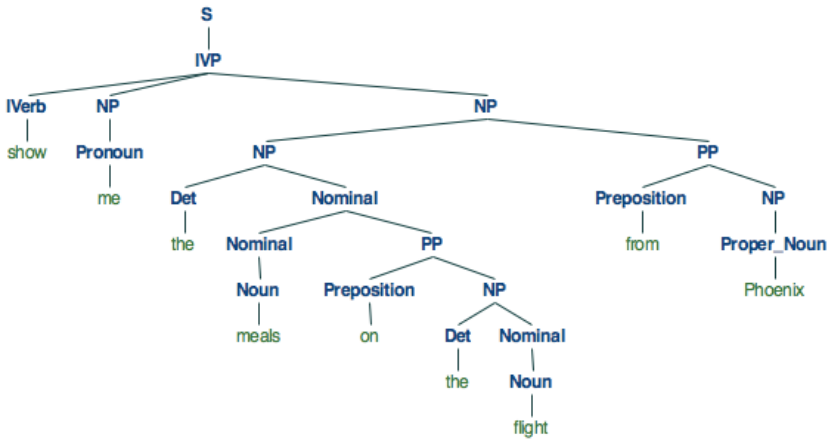
(p=1.27615e-08)



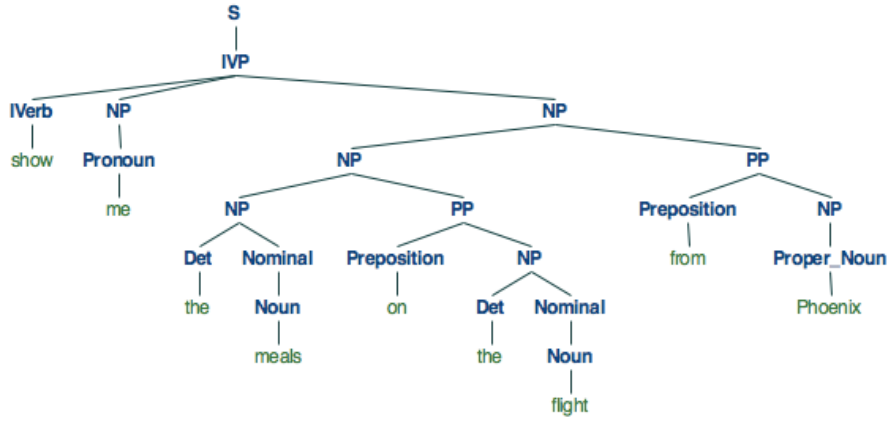
(p=7.8736e-09)



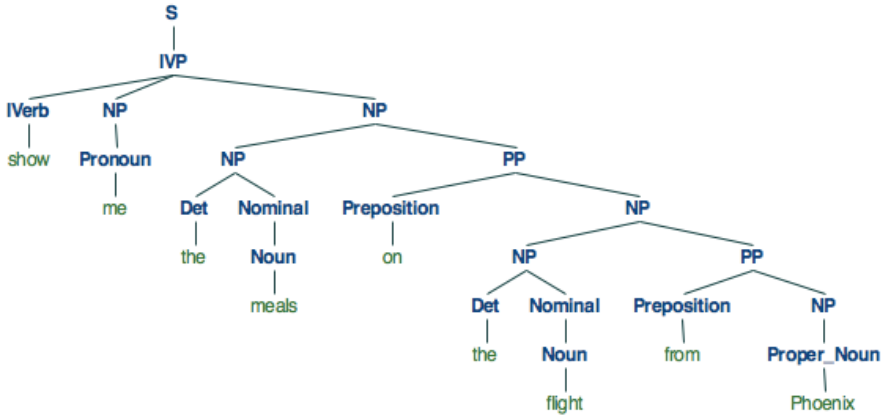
(p=7.8736e-09)



(p=7.8736e-09)



(p=4.85785e-09)



(p=4.85785e-09)

As can be seen, the most likely parses are the first two parses with a probability of 2.19769e-08.

In conclusion, the following report covers formal grammar and parsing. For the code, please run the jupyter notebo oks for the respective questions.

References

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