

Part 1

(1) $S \rightarrow NP VP$

(2) $S \rightarrow NP VP PP$

(2a) $VP \rightarrow VP PP$

(3) $NP \rightarrow det n$

(3a) $NP \Rightarrow D NP$

(3b) $D \Rightarrow det$

(4) $NP \rightarrow n$

(5) $NP \rightarrow NP PP$

(6) $VP \rightarrow aux VP$

(6a) $VP \Rightarrow A VP$

(6b) $A \Rightarrow aux$

(7) $VP \rightarrow v NP$

(7a) $VP \Rightarrow V NP$

(7b) $V \Rightarrow v$

(8) $PP \rightarrow p NP$

(8a) $PP \Rightarrow P NP$

(8b) $P \Rightarrow p$

Modification of the original grammar:

- Italicized rules are omitted, and the bolded ones are the new grammar in CNF.

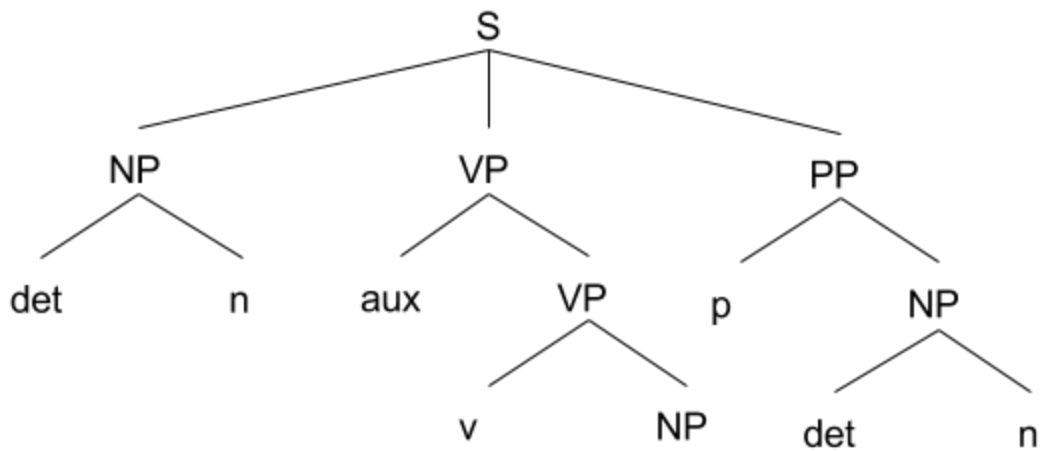
Part 2

| | | | | | | | | |
|---|---|--|--|--|--|---|---|--|
| 8 | S $S \Rightarrow NP VP$ (0,2) (2,6) | | | | | | | |
| 7 | | | | | | | | |
| 6 | | | VP $VP \Rightarrow VP PP$ (2,3) (5,3) | | | | | |
| 5 | S $S \Rightarrow NP VP$ (0,2) (2,3) | | | VP $VP \Rightarrow VP PP$ (3,2) (5,3) | | | | |
| 4 | | S $S \Rightarrow NP VP$ (1,1) (2,3) | | | NP $NP \Rightarrow NP PP$ (4,1) (5,3) | | | |
| 3 | | | VP $VP \Rightarrow A VP$ (2,1) (3,2) | | | PP $PP \Rightarrow P NP$ (5,1) (6,2) | | |
| 2 | NP $NP \Rightarrow D NP$ (0,1) (1,1) | | | VP $VP \Rightarrow V NP$ (3,1) (4,1) | | | NP $NP \Rightarrow D NP$ (6,1) (7,1) | |
| 1 | D $D \Rightarrow det$ (0,0) | NP $NP \Rightarrow n$ (1,0) | A $A \Rightarrow aux$ (2,0) | V $V \Rightarrow v$ (3,0) | NP $NP \Rightarrow n$ (4,0) | P $P \Rightarrow p$ (5,0) | D $D \Rightarrow det$ (6,0) | NP $NP \Rightarrow n$ (7,0) |
| 0 | <i>det</i> | <i>n</i> | <i>aux</i> | <i>v</i> | <i>n</i> | <i>p</i> | <i>det</i> | <i>n</i> |
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

Part 3

There's only one possible parse tree constructed by this algorithm. This is indicated by the fact that the S in (0,8) is constructed only from one rule joining (0,2) and (2,6).

Part 4



Part 5

det \Rightarrow the

det \Rightarrow a

n \Rightarrow boy

n \Rightarrow girl

n \Rightarrow store

aux \Rightarrow is

aux \Rightarrow was

v \Rightarrow going

v \Rightarrow running

p \Rightarrow to

1. The boy is going to the store.
2. The girl was going to a store.
3. A store is running to the girl.