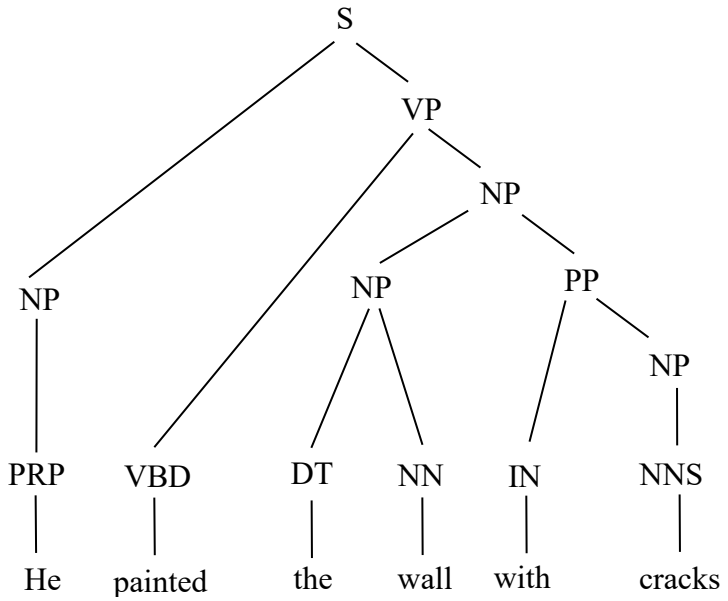
CS4248
AY 2022/23 Semester 1
Tutorial 6

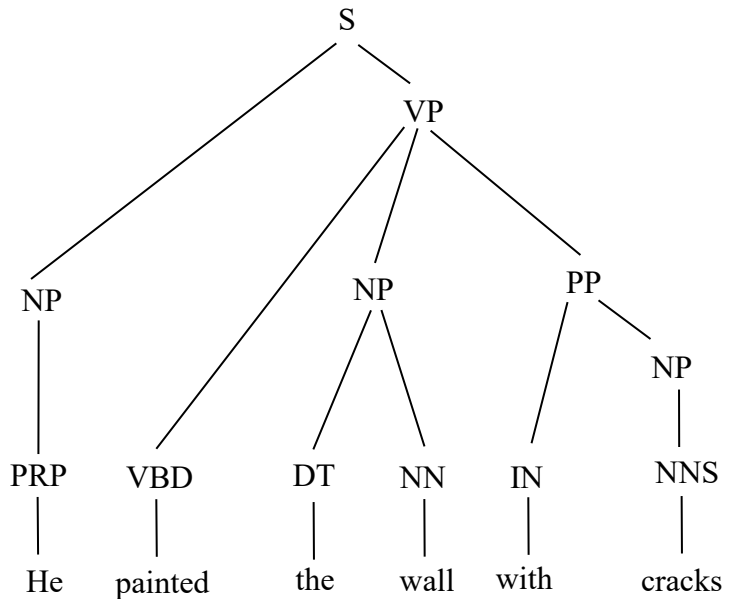
1. Consider the following probabilistic context-free grammar in Chomsky Normal Form:

S → NP VP	[0.4]
S → V NP	[0.4]
S → time	[0.1]
S → flies	[0.1]
NP → N N	[1.0]
VP → V NP	[0.5]
VP → time	[0.3]
VP → flies	[0.2]
N → time	[0.4]
N → flies	[0.4]
N → fruit	[0.2]
V → time	[0.6]
V → flies	[0.4]

Give a trace of the probabilistic CKY algorithm on the input "time fruit flies". The start symbol is S. Draw the parse tree with the highest probability.

2. Consider the following two parse trees. The first parse tree is annotated by a human and is considered the correct parse tree of the sentence (i.e., the "gold standard"). The second parse tree is the output of a parser.





What is the labeled recall of the parser on this sentence?
What is the labeled precision of the parser on this sentence?

3. Consider the following context-free grammar with semantic attachment:

$S \rightarrow NP\ \ VP$	$\{\ NP.sem(VP.sem)\ \}$
$NP \rightarrow DT\ \ NN$	$\{\ DT.sem(NN.sem)\ \}$
$NP \rightarrow NNP$	$\{\ NNP.sem\ \}$
$VP \rightarrow VBD\ \ NP$	$\{\ VBD.sem(NP.sem)\ \}$
$NNP \rightarrow$ Ray	$\{\ \lambda r.r(\text{Ray})\ \}$
$VBD \rightarrow$ opened	$\{\ \lambda w.\lambda z.w(\lambda x.\exists e\ \text{Opened}(e) \wedge \text{Opener}(e,z) \wedge \text{OpenedObj}(e,x))\ \}$
$DT \rightarrow$ a	$\{\ \lambda P.\lambda Q.\exists x P(x) \wedge Q(x)\ \}$
$NN \rightarrow$ store	$\{\ \lambda s.\text{Store}(s)\ \}$

Derive the first-order logic representation of the sentence "Ray opened a store". Show clearly the steps of your derivation.

4. For each of the following English sentences, several first-order logic (FOL) formulas are given. If a FOL formula is a correct meaning representation of the English sentence, put "Y" as the answer in the square bracket before the formula. If a FOL formula is **not** a correct meaning representation of the English sentence, put "N" as the answer in the square bracket.

In the meaning representations, the constant symbols are:
A: Alice
B: Barbara
C: Christopher
and the predicate symbols are:

$M(x)$: x is a man
$L(x, y)$: x likes y

a. Both Alice and Barbara like Christopher.
(i) [ ] $L(A, C) \vee L(B, C)$
(ii) [ ] $L(A \wedge B, C)$
(iii) [ ] $L(A, C) \wedge L(B, C)$

b. There is a man who likes both Alice and Barbara.
(i) [ ] $\exists x[M(x) \wedge L(x, A) \wedge L(x, B)]$
(ii) [ ] $\exists x[M(x) \Rightarrow [L(x, A) \wedge L(x, B)]]$
(iii) [ ] $[\exists x M(x)] \Rightarrow [L(x, A) \wedge L(x, B)]$

c. All men who like Alice also like Barbara.
(i) [ ] $\forall x[[M(x) \wedge L(x, A)] \Rightarrow L(x, B)]$
(ii) [ ] $\forall x[M(x) \Rightarrow [L(x, A) \Rightarrow L(x, B)]]$
(iii) [ ] $\forall x[M(x) \wedge L(x, A) \wedge L(x, B)]$