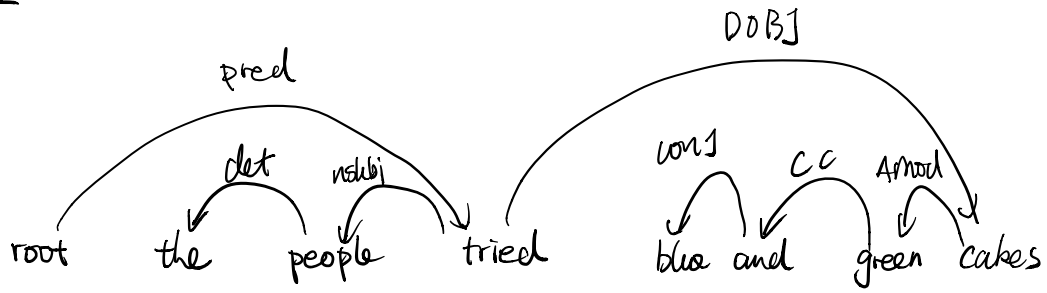
Q 1.2



Q 2.1 (START, dog) = 3 24 bigrams

(dog, eats) = 1

(eats, salads) = 1

P(dog | start) · P(eats | dog) · P(salads | eats) · P(End | salads)

$\geq \frac{3+1}{6+6} \cdot \frac{1+1}{3+6} \cdot \frac{1+1}{3+6} \cdot \frac{1+1}{6+1}$

$= \frac{1}{3} \times \frac{2}{9} \times \frac{2}{9} \times \frac{2}{7} = \frac{8}{1701} \approx 0.0047$

count S.E: $\frac{4}{6+8} \cdot \frac{2}{3+8} \cdot \frac{2}{3+8} \cdot \frac{2}{9} = \frac{32}{15246} \approx 0.00209$

Q3.

$(\sigma|root, I|\beta, \{\}) \xrightarrow{shift} (\sigma|I, drank|\beta, \{\}) \xrightarrow{left\text{-}arc}$

$(\sigma|root, drank|\beta, \{(drank, R, I)\}) \xrightarrow{shift} (\sigma|drank, water|\beta, A)$

$\xrightarrow{shift} (\sigma|water, from|\beta, A) \xrightarrow{shift} (\sigma|from, a|\beta, A) \xrightarrow{shift} (\sigma|a, big|\beta, A)$

$\xrightarrow{left\text{-}arc} (\sigma|from, big|\beta, \{(drank, R, I), (big, R, a)\}) \xrightarrow{shift}$

$(\sigma|big, bottle|\beta, A) \xrightarrow{Left\text{-}Arc} (\sigma|from, bottle|\beta,$

$\{(drank, R, I), (big, R, a), (bottle, R, b)\}) \xrightarrow{right\text{-}arc}$

$(\sigma|water, from|\beta, (from, R, bottle) \cup A) \xrightarrow{right\text{-}arc}$

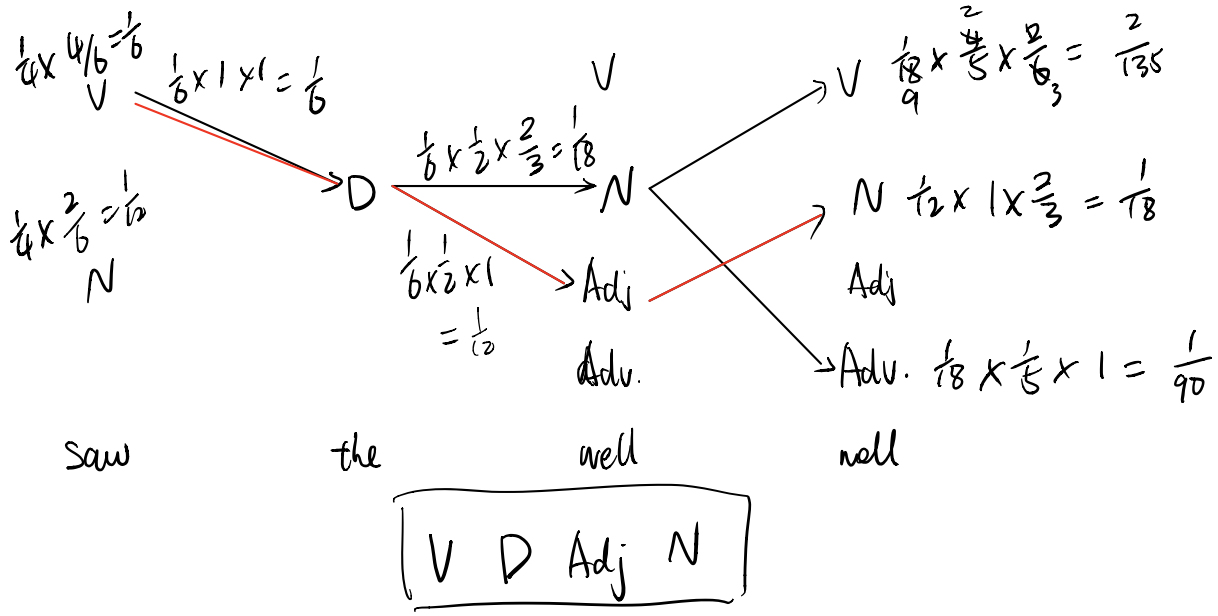
$(\sigma|drank, water|\beta, (water, R, from) \cup A) \xrightarrow{shift}$

$(\sigma \mid \text{water}, \cdot\beta, A) \xrightarrow{\text{right-arc}} (\sigma \mid \text{drank}, \text{water}\mid\beta, (\text{water}, R, \cdot) \cup A)$

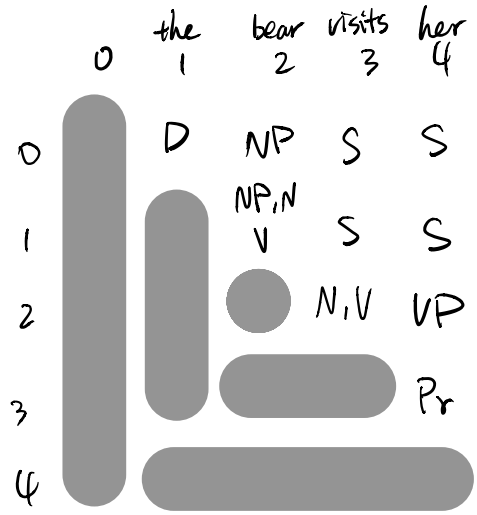
$\xrightarrow{\text{right-arc}} (\sigma \mid \text{root}, \text{drank}\mid\beta, (\text{root}, R, \text{drank}) \cup A)$

$\xrightarrow{\text{right-arc}} (\sigma, \text{root}\mid\beta, A) \rightarrow \text{terminal}$

Q4

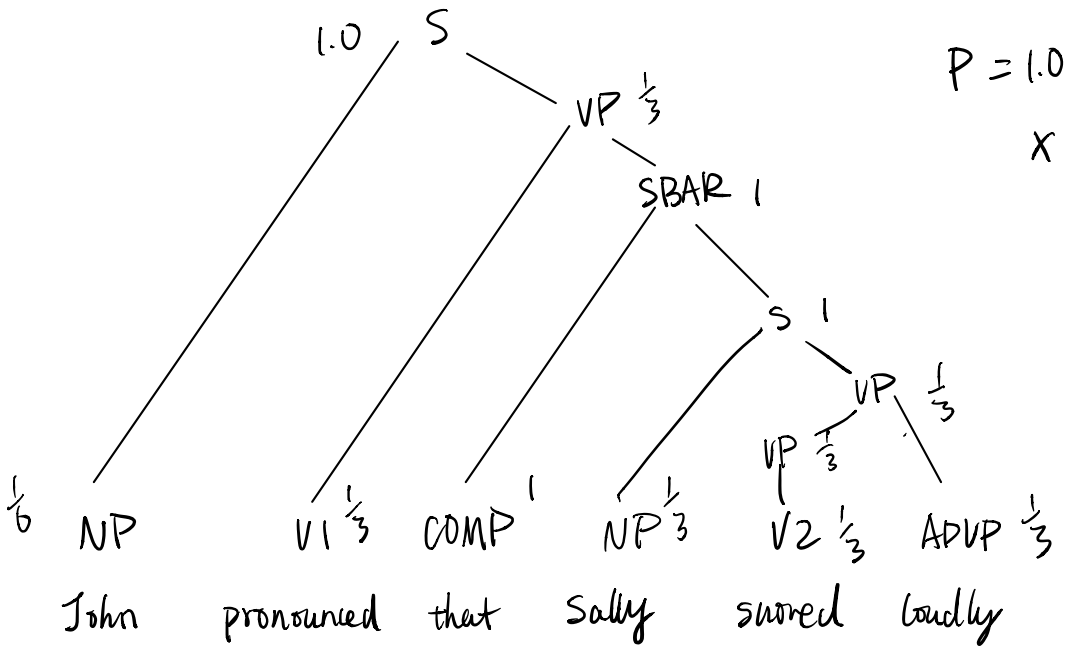


Q5



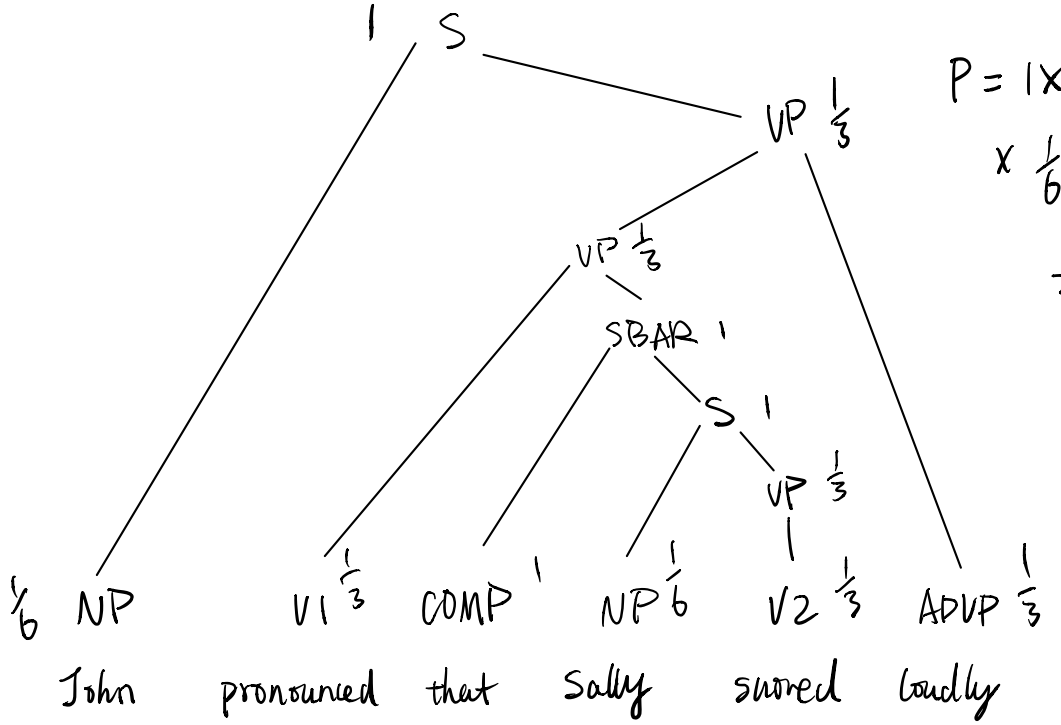
Q6

S → NP VP	1.0	NP → John	$\frac{1}{6}$	V2 → snored	$\frac{1}{3}$
VP → V1 SBAR	$\frac{1}{3}$	NP → Sally	$\frac{2}{6}$	V2 → ran	$\frac{1}{3}$
VP → VP ADVP	$\frac{1}{3}$	NP → Bill	$\frac{1}{6}$	V2 → swam	$\frac{1}{3}$
VP → V2	$\frac{1}{3}$	V1 → said	$\frac{1}{3}$	ADVP → loudly	$\frac{1}{3}$
SBAR → COMP S	1	V1 → declared	$\frac{1}{3}$	ADVP → quickly	$\frac{1}{3}$
NP → Jeff	$\frac{1}{6}$	V1 → pronounced	$\frac{1}{3}$	ADVP → elegantly	$\frac{1}{3}$
NP → Fred	$\frac{1}{6}$	COMP → that	1.0		



$$P = 1.0 \times \tfrac{1}{6} \times \tfrac{1}{3} \times \tfrac{1}{3} \times 1 \times 1 \times 1 \times \tfrac{1}{3} \times \tfrac{1}{3} \times \tfrac{1}{3} \times \tfrac{1}{3} \times \tfrac{1}{3}$$

$$(\tfrac{1}{6})^1 \times (\tfrac{1}{3})^7$$



$$P = 1 \times \tfrac{1}{6} \times \tfrac{1}{3} \times \tfrac{1}{3} \times \tfrac{1}{3} \times 1 \times 1 \times 1 \times \tfrac{1}{6} \times \tfrac{1}{3} \times \tfrac{1}{3} \times \tfrac{1}{3}$$

$$= \tfrac{1}{6} (\tfrac{1}{3})^7$$