Natural Language Processing (COS4861)

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1 Question 1

1.1

2 Question 2

For $V_2(1)$:

$$\begin{aligned} V_1(1)P(PPSS \mid PPSS) &= (0.025)(0.00014) \\ &= 0.0000035 \end{aligned} \tag{1}$$

$$\begin{aligned} V_1(2)P(PPSS \mid VB) &= (0)(0.007) \\ &= 0 \end{aligned} \tag{2}$$

$$\begin{aligned} V_1(3)P(PPSS \mid TO) &= (0)(0) \\ &= 0 \end{aligned} \tag{3}$$

$$\begin{aligned} V_1(4)P(PPSS \mid NN) &= (0)(0.0045) \\ &= 0 \end{aligned} \tag{4}$$

$$\begin{aligned} V_2(1) &= max(0.0000035, 0, 0, 0)P(want \mid PPSS) \\ &= (0.0000035)(0) \\ &= 0 \end{aligned} \tag{5}$$

For $V_2(3)$:

$$\begin{aligned} V_1(1)P(TO \mid PPSS) &= (0.025)(0.00079) \\ &= 0.00001975 \end{aligned} \tag{6}$$

$$\begin{aligned} V_1(2)P(TO \mid VB) &= (0)(0.035) \\ &= 0 \end{aligned} \tag{7}$$

$$\begin{aligned} V_1(3)P(TO \mid TO) &= (0)(0) \\ &= 0 \end{aligned} \tag{8}$$

$$\begin{aligned} V_1(4)P(TO \mid NN) &= (0)(0.016) \\ &= 0 \end{aligned} \tag{9}$$

$$\begin{aligned} V_2(3) &= max(0.00001975, 0, 0, 0)P(want \mid TO) \\ &= (0.00001975)(0) \\ &= 0 \end{aligned} \tag{10}$$

For $V_2(4)$:

$$\begin{aligned} V_1(1)P(NN \mid PPSS) &= (0.025)(0.0012) \\ &= 0.00003 \end{aligned} \tag{11}$$

$$\begin{aligned} V_1(2)P(NN \mid VB) &= (0)(0.047) \\ &= 0 \end{aligned} \tag{12}$$

$$\begin{aligned} V_1(3)P(NN \mid TO) &= (0)(0.00047) \\ &= 0 \end{aligned} \tag{13}$$

$$\begin{aligned} V_1(4)P(NN \mid NN) &= (0)(0.087) \\ &= 0 \end{aligned} \tag{14}$$

$$\begin{aligned} V_2(4) &= max(0.00003, 0, 0, 0)P(want \mid NN) \\ &= (0.00003)(0.000054) \\ &= 0.00000000162 \end{aligned} \tag{15}$$

For $V_3(1)$:

$$\begin{aligned} V_2(1)P(PPSS \mid PPSS) &= (0)(0.00014) \\ &= 0 \end{aligned} \tag{16}$$

$$\begin{aligned} V_2(2)P(PPSS \mid VB) &= (0.000051)(0.007) \\ &= 0.000000357 \end{aligned} \tag{17}$$

$$\begin{aligned} V_2(3)P(PPSS \mid TO) &= (0)(0) \\ &= 0 \end{aligned} \tag{18}$$

$$\begin{aligned} V_2(4)P(PPSS \mid NN) &= (0.00000000162)(0.0045) \\ &= 0 \end{aligned} \tag{19}$$

$$\begin{aligned} V_3(1) &= max(0, 0.000000357, 0, 7.29 * 10^{-12})P(to \mid PPSS) \\ &= (0.000000357)(0) \\ &= 0 \end{aligned} \tag{20}$$

For $V_3(2)$:

$$\begin{aligned} V_2(1)P(VB \mid PPSS) &= (0)(0.23) \\ &= 0 \end{aligned} \tag{21}$$

$$V_2(2)P(VB \mid VB) = (0.000051)(0.0038) = 1.938 * 10^{-7} \tag{22}$$

$$V_2(3)P(VB \mid TO) = (0)(0.83) = 0 \tag{23}$$

$$V_2(4)P(VB \mid NN) = (1.62 * 10^{-9})(0.0045) = 6.48 * 10^{-12} \tag{24}$$

$$\begin{aligned} V_3(2) &= max(0, 1.938 * 10^{-7}, 0, 6.48 * 10^{-12})P(to \mid VB) \\ &= (1.938 * 10^{-7})(0) \\ &= 0 \end{aligned} \tag{25}$$

For $V_3(3)$:

$$V_2(1)P(TO \mid PPSS) = (0)(0.00079) = 0 \tag{26}$$

$$V_2(2)P(TO \mid VB) = (0.000051)(0.0035) = 0.000001785 \tag{27}$$

$$V_2(3)P(TO \mid TO) = (0)(0) = 0 \tag{28}$$

$$V_2(4)P(TO \mid NN) = (1.62 * 10^{-9})(0.016) = 2.592 * 10^{-11} \tag{29}$$

$$\begin{aligned} V_3(3) &= max(0, 0.000001785, 0, 2.592 * 10^{-11})P(to \mid TO) \\ &= (0.000001785)(0.99) \\ &= 0.00000176715 \end{aligned} \tag{30}$$

For $V_3(4)$:

$$V_2(1)P(TO \mid PPSS) = (0)(0.0012) = 0 \tag{31}$$

$$V_2(2)P(TO \mid VB) = (0.000051)(0.047) = 0.000002397 \tag{32}$$

$$V_2(3)P(TO \mid TO) = (0)(0.00047) = 0 \tag{33}$$

$$V_2(4)P(TO \mid NN) = (1.62 * 10^{-9})(0.087) = 1.4094 * 10^{-10} \tag{34}$$

$$\begin{aligned} V_3(4) &= max(0, 0.000002397, 0, 1.4094 * 10^{-10}) P(to \mid NN) \\ &= (0.000002397)(0) \\ &= 0 \end{aligned} \tag{35}$$

For $V_4(1)$:

$$\begin{aligned} V_3(1)P(PPSS \mid PPSS) &= (0)(0.00014) \\ &= 0 \end{aligned} \tag{36}$$

$$\begin{aligned} V_3(2)P(PPSS \mid VB) &= (0)(0.007) \\ &= 0 \end{aligned} \tag{37}$$

$$\begin{aligned} V_3(3)P(PPSS \mid TO) &= (0.00000176715)(0) \\ &= 0 \end{aligned} \tag{38}$$

$$\begin{aligned} V_3(4)P(PPSS \mid NN) &= (0.00000000162)(0.0047) \\ &= 0 \end{aligned} \tag{39}$$

$$\begin{aligned} V_4(1) &= max(0, 0, 0, 0) P(race \mid PPSS) \\ &= (0)(0) \\ &= 0 \end{aligned} \tag{40}$$

For $V_4(2)$:

$$\begin{aligned} V_3(1)P(VB \mid PPSS) &= (0)(0.023) \\ &= 0 \end{aligned} \tag{41}$$

$$\begin{aligned} V_3(2)P(VB \mid VB) &= (0)(0.0038) \\ &= 0 \end{aligned} \tag{42}$$

$$\begin{aligned} V_3(3)P(VB \mid TO) &= (0.00000176715)(0.83) \\ &= 0.0000014667345 \end{aligned} \tag{43}$$

$$\begin{aligned} V_3(4)P(VB \mid NN) &= (0)(0.0040) \\ &= 0 \end{aligned} \tag{44}$$

$$\begin{aligned} V_4(2) &= max(0, 0, 0.0000014667345, 0) P(race \mid VB) \\ &= (0.0000014667345)(0.00012) \\ &= 1.7600814 * 10^{-10} \end{aligned} \tag{45}$$

For $V_4(3)$:

$$\begin{aligned} V_3(1)P(TO \mid PPSS) &= (0)(0.00079) \\ &= 0 \end{aligned} \tag{46}$$

$$V_3(2)P(TO \mid VB) = (0)(0.035) \\ = 0 \tag{47}$$

$$V_3(3)P(TO \mid TO) = (0.00000176715)(0) \\ = 0 \tag{48}$$

$$V_3(4)P(TO \mid NN) = (0)(0.016) \\ = 0 \tag{49}$$

$$V_4(3) = max(0,0,0,0)P(race \mid TO) \\ = (0)(0) \\ = 0 \tag{50}$$

For $V_4(4)$:

$$V_3(1)P(NN \mid PPSS) = (0)(0.0012) \\ = 0 \tag{51}$$

$$V_3(2)P(NN \mid VB) = (0)(0.047) \\ = 0 \tag{52}$$

$$V_3(3)P(NN \mid TO) = (0.00000176715)(0.00047) \\ = 8.305605 * 10^{-10} \tag{53}$$

$$V_3(4)P(NN \mid NN) = (0)(0.087) \\ = 0 \tag{54}$$

$$V_4(4) = max(0,0,8.305605 * 10^{-10},0)P(race \mid NN) \\ = (8.305605 * 10^{-10})(0.00057) \\ = 4.73419 * 10^{-13} \tag{55}$$

The path can be seen in Figure 1. In each step going to the node with the highest probability. Thus the pat is PPSS VB TO VB

3 Question 3

3.1

4 Question 4

4.1 Question 4.1

The parse tree for this question can be found in Figure 2.

The following will be added to the lexicon. The verbs: "would", "like" and "ride". The infinitive marker "to". The preposition "with". The proper noun "Golden Arrow".

The following grammar rules will also be added:

VP $\rightarrow$ VP VP

VP $\rightarrow$ Infinitive marker VP

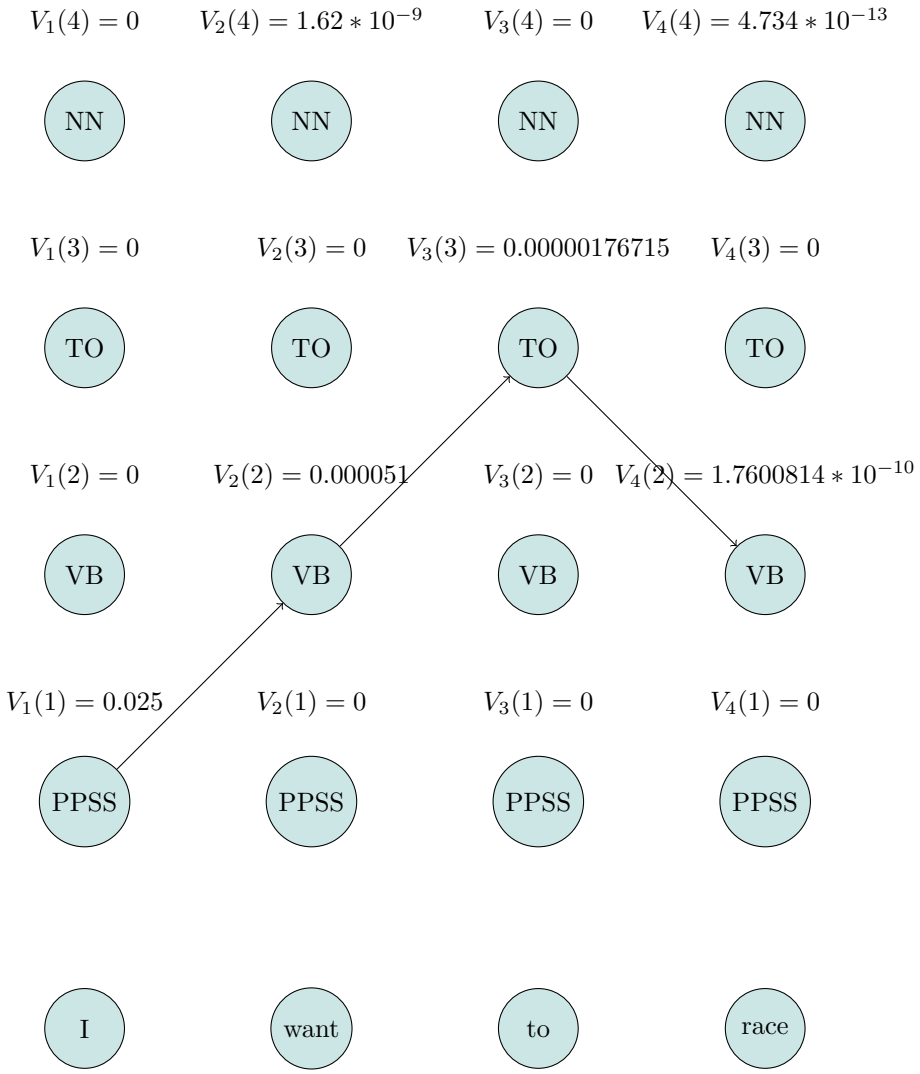

Figure 1: Showing path for question 2

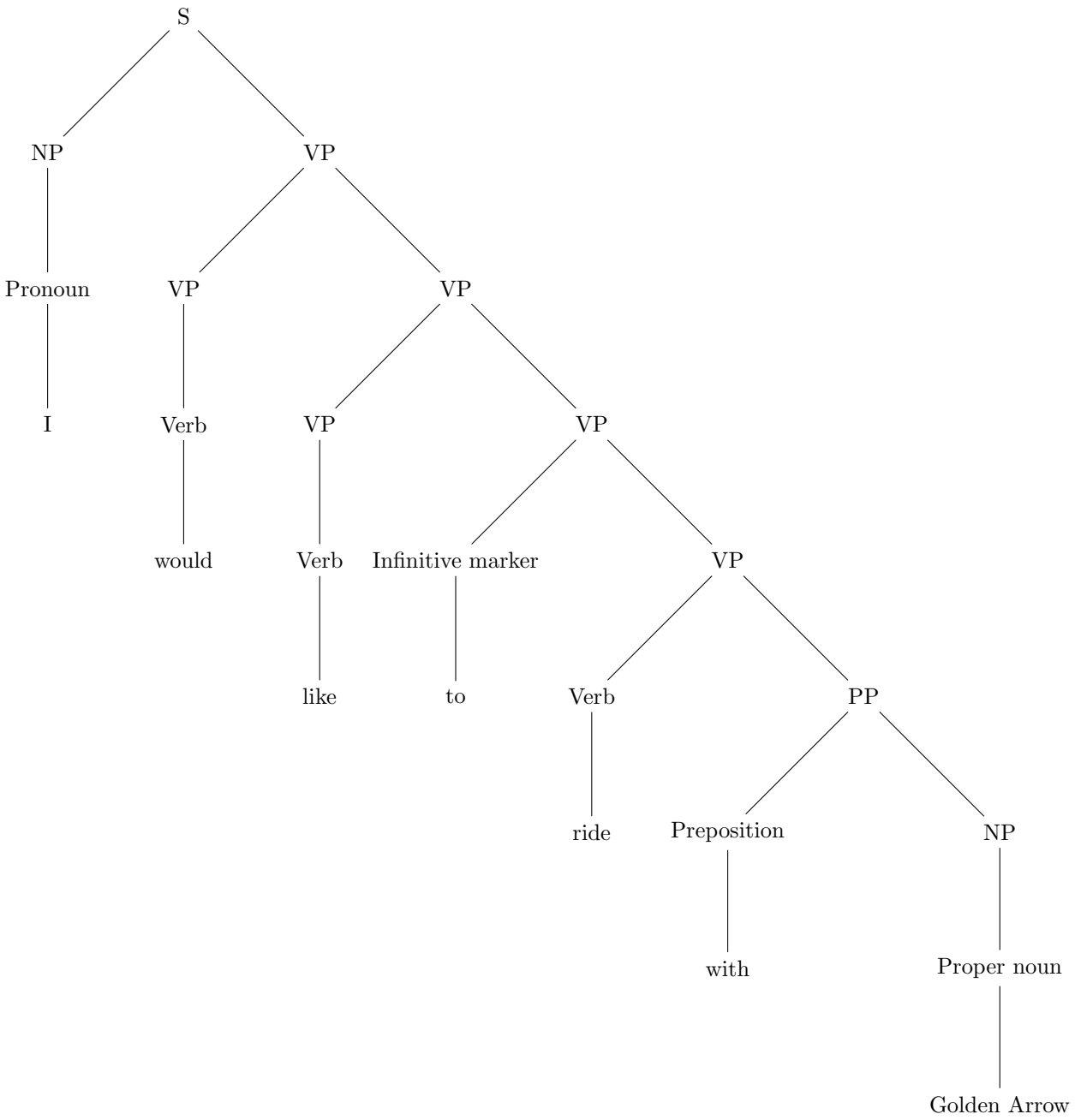

Figure 2: Parse tree for question 4.1

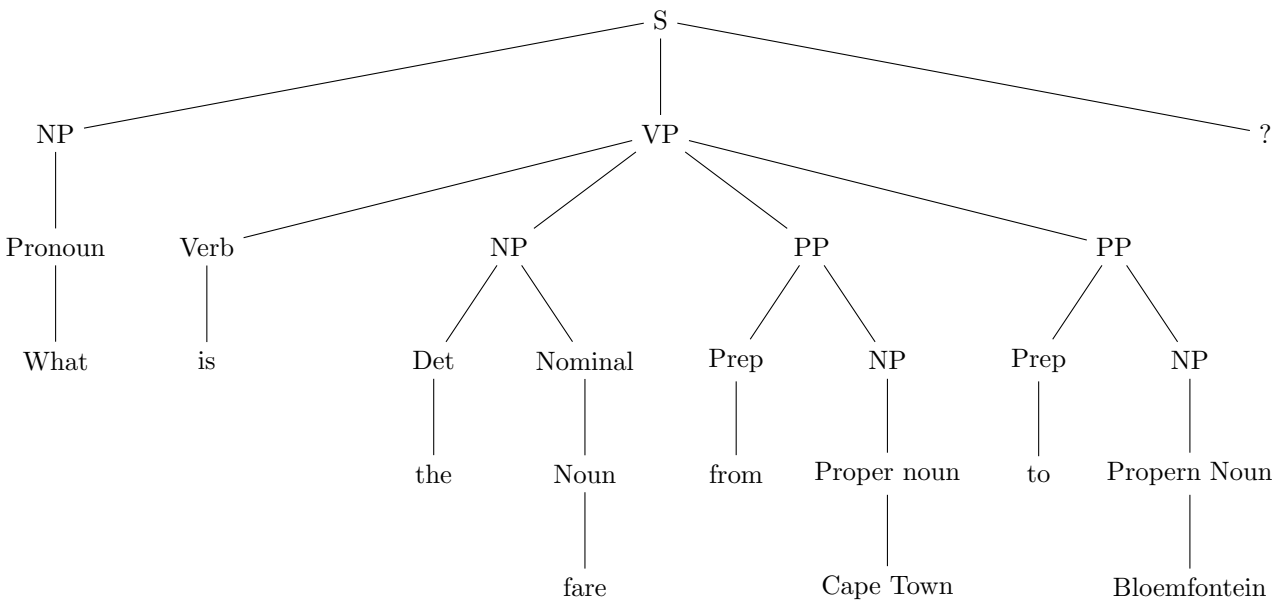

Figure 3: Parse tree for question 4.2

4.2 Question 4.2

The parse tree for this question can be found in Figure 3.

We add the following words to the lexicon. The pronoun "What", noun "fare", and Propen nouns "Cape Town" and "Bloemfontein".

The following grammar rules will also be added:

S → NP VP ?

VP → Verb NP PP PP

4.3 Question 4.3

The parse tree for this question can be found in Figure 3.

We add the following words to the lexicon. The adverb "there", Nouns "Greyhound" and "route" and proper nouns "Durban" and "Bela-Bela".

The following grammar rules will also be added:

S → VP NP PP PP ?

VP → VP Adverb

5 Question 5

5.1 Question 5.1

[Rapunzel]$_{NP}$[let]$_{VP}$down[her goldern hair]$_{NP}$

5.2 Question 5.2

How[do]$_{VP}$[I]$_{NP}$[get]$_{VP}$to[Mozambique]$_{NP}$?

5.3 Question 5.3

[Can]$_{VP}$[the manager]$_{NP}$[give]$_{VP}$me[another room]$_{NP}$?

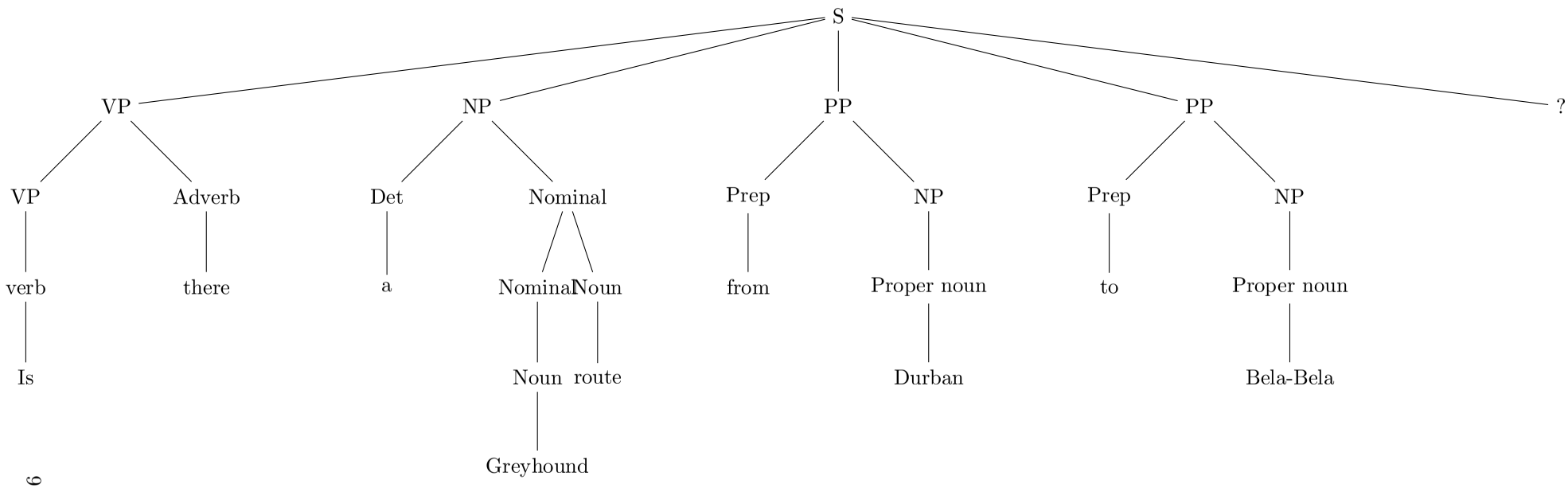

Figure 4: Tree for question 4.3