Izmir Institute of Technology
Computer Engineering Department
CENG513 Midterm Exam Spring 2024
Question 2

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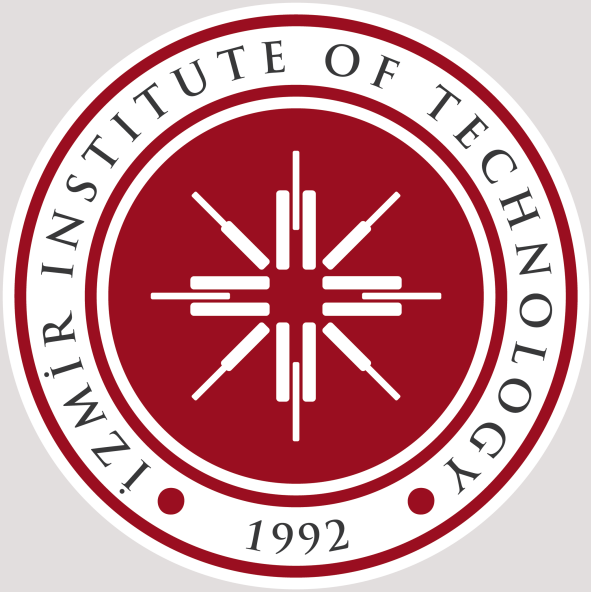

Question 2

a-) Context-free grammar for the example given in 1-8 can be constructed as follows:

Rule 0 sentence —> `simple_sentence`

Rule 1 | `compound_sentence`

Rule 2 `simple_sentence` —> subject verb object

Rule 3 | subject verb object `prep_phrase`

Rule 4 `compound_sentence` —> `simple_sentence` CONJUNCTION `simple_sentence`

Rule 5 | `compound_sentence` CONJUNCTION `simple_sentence`

Rule 6 subject —> NOUN

Rule 7 | PRONOUN

Rule 8 | ADJECTIVE subject

Rule 9 verb —> VERB

Rule 10 | ADVERB VERB

Rule 11 | verb VERB

Rule 12 object —> NOUN

Rule 13 | ADJECTIVE object

Rule 14 `prep_phrase` —> PREPOSITION NOUN

According to above context-free grammar `simple_sentence` "I love compilers" can be derived as follows:

- sentence

0 `simple_sentence`

2 subject verb object

7 PRONOUN verb object

9 PRONOUN VERB object

12 PRONOUN VERB NOUN

Parse tree for the simple sentence derived above is as follows:

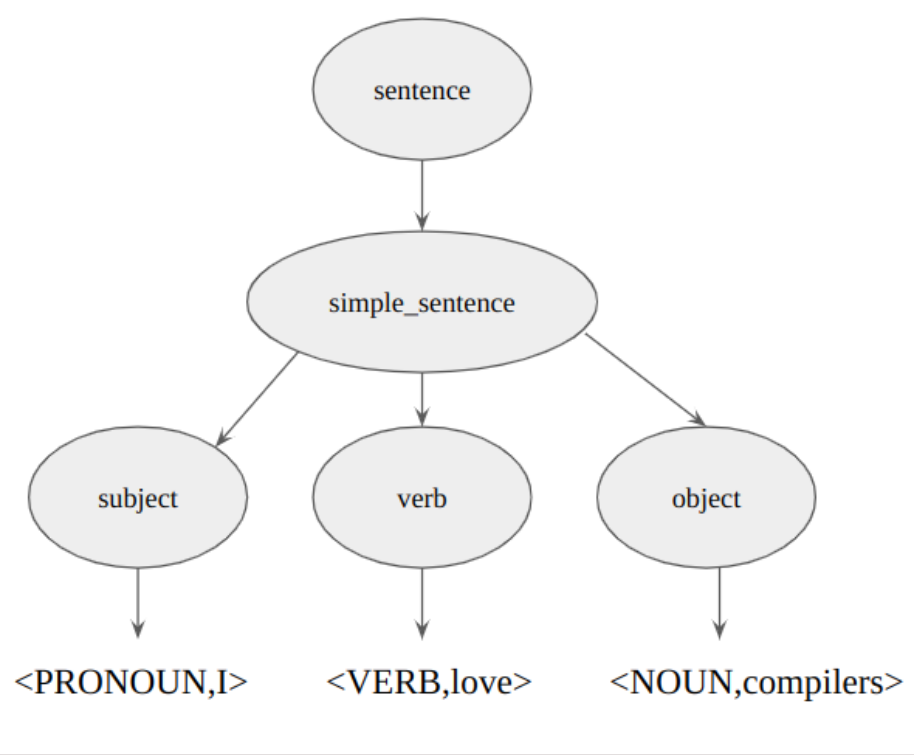

Figure 1: Parse tree for a simple sentence

According to above context-free grammar, `compound_sentence` "I am experienced programmer and I love Cryptography" can be derived as follows:

1 `compound_sentence`

4 `simple_sentence` CONJUNCTION `simple_sentence`

2 subject verb object CONJUNCTION `simple_sentence`

7 PRONOUN verb object CONJUNCTION `simple_sentence`

9 PRONOUN VERB object CONJUNCTION `simple_sentence`

13 PRONOUN VERB ADJECTIVE object CONJUNCTION `simple_sentence`

12 PRONOUN VERB ADJECTIVE NOUN CONJUNCTION `simple_sentence`

2 PRONOUN VERB ADJECTIVE NOUN CONJUNCTION subject verb object

2 PRONOUN VERB ADJECTIVE NOUN CONJUNCTION PRONOUN verb object

9 PRONOUN VERB ADJECTIVE NOUN CONJUNCTION PRONOUN VERB object

6 PRONOUN VERB ADJECTIVE NOUN CONJUNCTION PRONOUN VERB NOUN

Parse tree for the compound sentence derived above is as follows:

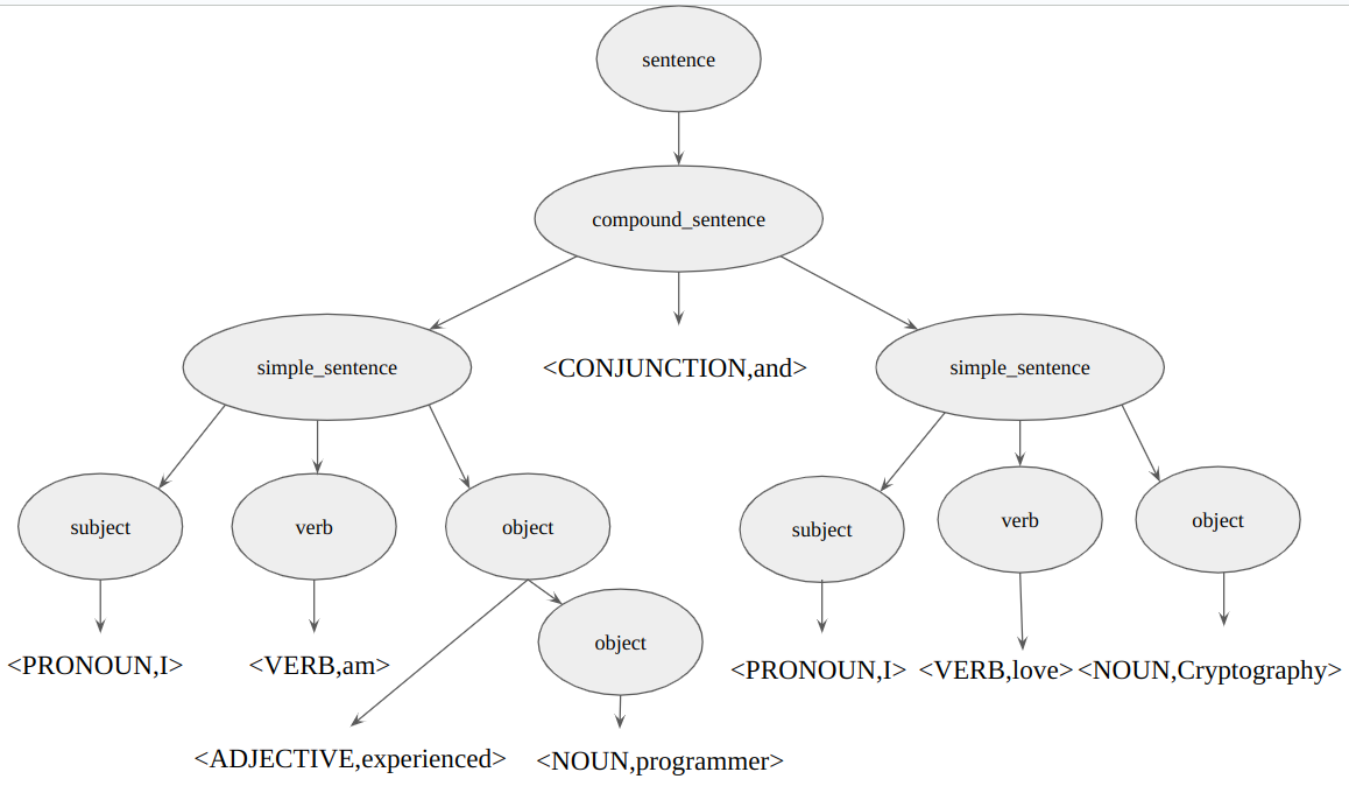

Figure 2: Parse tree for compound sentence

b-) Currently there is a left-recursion for `compound_sentence` definition in grammar, if we take sample derivation "I like İzmir and I study compilers", it can cause infinite recursion as follows:

1-) `compound_sentence` CONJUNCTION `simple_sentence` (trying to match "I")

2-) `compound_sentence` CONJUNCTION `simple_sentence` CONJUNCTION `simple_sentence` (it takes the same production and tries to match "I" again)

3-) `compound_sentence` CONJUNCTION `simple_sentence` CONJUNCTION `simple_sentence` CONJUNCTION `simple_sentence` (repeatedly trying to match without advancing)

Left recursion can be eliminated according to following rule:

X —> Xα

| β

X –> βX'

X' –> αX'

| ε

where X' is a newly introduced non-terminal, also neither α nor β starts with X. If we apply the rule to left-recursive grammar we get the following grammar:

`compound_sentence` —> `simple_sentence` **compound_sentence_prime**

compound_sentence_prime —> CONJUNCTION `simple_sentence` **compound_sentence_prime**

| ε

After eliminating left-recursion if we try to derive above sentence, derivation can be as follows:

1-) `compound_sentence_prime`

2-) `simple_sentence compound_sentence_prime`

3-) subject verb object `compound_sentence_prime`

4-) NOUN verb object `compound_sentence_prime` (matches "I")

5-) <NOUN,I> VERB object `compound_sentence_prime` (matches "like")

6-) <NOUN,I> <VERB,like> NOUN `compound_sentence_prime` (matches "İzmir")

7-) <NOUN,I> <VERB,like> <NOUN,İzmir> `compound_sentence_prime`

8-) <NOUN,I> <VERB,like> <NOUN,İzmir> CONJUNCTION `simple_sentence` `compound_sentence_prime` (matches "and")

9-) <NOUN,I> <VERB,like> <NOUN,İzmir> <CONJUNCTION,and> `simple_sentence` `compound_sentence_prime`

10-) <NOUN,I> <VERB,like> <NOUN,İzmir> <CONJUNCTION,and> subject verb object `compound_sentence_prime`

11-) <NOUN,I> <VERB,like> <NOUN,İzmir> <CONJUNCTION,and> NOUN verb object `compound_sentence_prime` (matches "I")

12-) <NOUN,I> <VERB,like> <NOUN,İzmir> <CONJUNCTION,and> <NOUN,I> VERB object `compound_sentence_prime` (matches "study")

13-) <NOUN,I> <VERB,like> <NOUN,İzmir> <CONJUNCTION,and> <NOUN,I> <VERB,study> NOUN `compound_sentence_prime` (matches "compilers")

14-) <NOUN,I> <VERB,like> <NOUN,İzmir> <CONJUNCTION,and> <NOUN,I> <VERB,study> <NOUN,compilers> (replace `compound_sentence_prime` with ε)