Yoav Levi - H00347035

Language processing cw 1.2, grammar and parse trees.

Notes:

- For every grammar, S is the start symbol.
- T is the set of terminals in every grammar.
- N is the set of non-terminals in every grammar.

1. $/a*b*/$

$$\{a^n b^m | n, m \in \mathbb{N}\}$$

2.

$$N = \{S, A\},\ T = \{a, b\}$$

$$\begin{gathered} S \to aS|bA \\ A \to bA|\epsilon \end{gathered}$$

3. $/(ab)*/$

$$\{(ab)^n | n \in \mathbb{N}\}$$

4.

$$N = \{S, A\},\ T = \{a, b\}$$

$$\begin{gathered} S \to aA \,|\, \epsilon \\ A \to bA \end{gathered}$$

5.$/Whiske?y/$

$$\{W^n h^n i^n s^n k^n e^m y^n | n = 1 | m \leq 1 | m \geq 0\}$$

6.

$$N = \{S, B, C, D, E, F, G\}, T = \{h, i, s, k, e, y\}$$

$$\begin{gathered} \text{Notice: "W" is terminal!} \\ S \to WB \\ B \to hC \\ C \to iD \\ D \to sE \\ E \to kF \\ F \to eG \,|\, y \\ G \to y \end{gathered}$$

7.

$$N = \{S, B, C\},\ T = \{0, 1, 2, 3, 4, 5, 6, 7, 8, 9, .\}$$

$$\begin{gathered} S \to 1B|2B|3B|4B|5B|6B|7B|8B|9B|0B \\ B \to 1B|2B|3B|4B|5B|6B|7B|8B|9B \\ \text{Notice: "." is terminal} \\ B \to .C|\epsilon \\ C \to 0C|1C|2C|3C|4C|5C|6C|7C|8C|9C \\ C \to 1|2|3|4|5|6|7|8|9 \end{gathered}$$

8. $\{a^n b^n | n \in \mathbb{N}\}$ - Context free

$$N = \{S\},\, T = \{a, b\}$$

$$S \to aSb$$
$$S \to \epsilon$$

9.

$$N = \{S\},\, T = \{(,), 0\}$$

Notice: "(" and ")" are terminal

$$S \to (\, S\,)$$
$$S \to 0$$

10.

$$N = \{S, A, D, B, E\},\, T = \{0, 1, 2, 3, 4, 5, 6, 7, 8, 9, +, *, (,)\}$$

$$S \to (A) | A$$
$$D \to 0|1|2|3|4|5|6|7|8|9$$
$$A \to DB$$
$$B \to EDB$$
$$B \to \epsilon$$
$$E \to +|*$$

11. palindromes with {a,b}

$$N = \{S\},\, T = \{a, b\}$$

$$S \to aSa|bSb$$
$$S \to a|b$$
$$S \to \epsilon$$

12. parity seq

$$N = \{S, A, B\},\, T = \{0, 1\}$$

$$S \to 0S|1A$$
$$A \to 0A|1B$$
$$B \to 0B|1A|\epsilon$$

13. numbers divsable by 4.

$$N = \{S, A, B, C\},\, T = \{0, 1, 2, 3, 4, 5, 6, 7, 8, 9\}$$

$$S \to 0C|1B|2C|3B|4C|5B|6C|7B|8C|9B|A$$
$$A \to 0|4|8$$
$$B \to 2|6|0E|1B|2C|3B|4C|5B|6C|7B|8C|9B$$
$$C \to 0|4|8|0E|1B|2C|3B|4C|5B|6C|7B|8C|9B$$
$$E \to 0|0E$$

16.

1. none
2. Context-free
3. Left-recursive and left-regular
4. Context-free, left-recursive and right-recursive

17.

$$X \to Xa \text{ is not an object language, it's part of the meta language}$$
$$\text{as X is a non terminal and therefore not part of the object language.}$$

18.

1.$(ab|ba)*$

$$N = \{S\}, T = \{a, b\}$$

$$S \to abS|baS|\epsilon$$

2.$\{(ab)^n a^n | n \geq 1\}$

$$N = \{S, A\}, T = \{a, b\}$$

$$S \to abA$$
$$A \to aS|a$$

3.

$$N = \{S\}, T = \{a, b\}$$

$$S \to aSa|bSb$$
$$S \to a|b$$
$$S \to \epsilon$$

4.

$$N = \{S, A\}, T = \{a, b\}$$

$$S \to bbA|\epsilon$$
$$A \to aA|\epsilon$$

5.

$$N = \{S\}, T = \{a, b\}$$

$$S \to aSb|aSbb|\epsilon$$

20.

1.Is ambiguous as there are two or more different ways to parse the sentence "aaabaaa"

Step	Application	Outcome	Production Rule
1	**S**	**aSbSa**	S → aSbSa
2	a**S**bSa	aa**Sa**bSa	S → aSa
3	aa**S**abSa	abSa	S → ε
4	aaab**S**a	aaaba**Sa**a	S → aSa
5	aaaba**S**aa	aaabaaa	S → ε

and

Step	Application	Outcome	Production Rule
1	**S**	**aSa**	S → aSa
2	a**S**a	a**aSa**a	S → aSa
3	aa**S**aa	aa**aSbSa**aa	S → aSbSa
4	aaa**S**bSaaa	aaabSaaa	S → ε
5	aaab**S**aaa	aaabaaa	S → ε

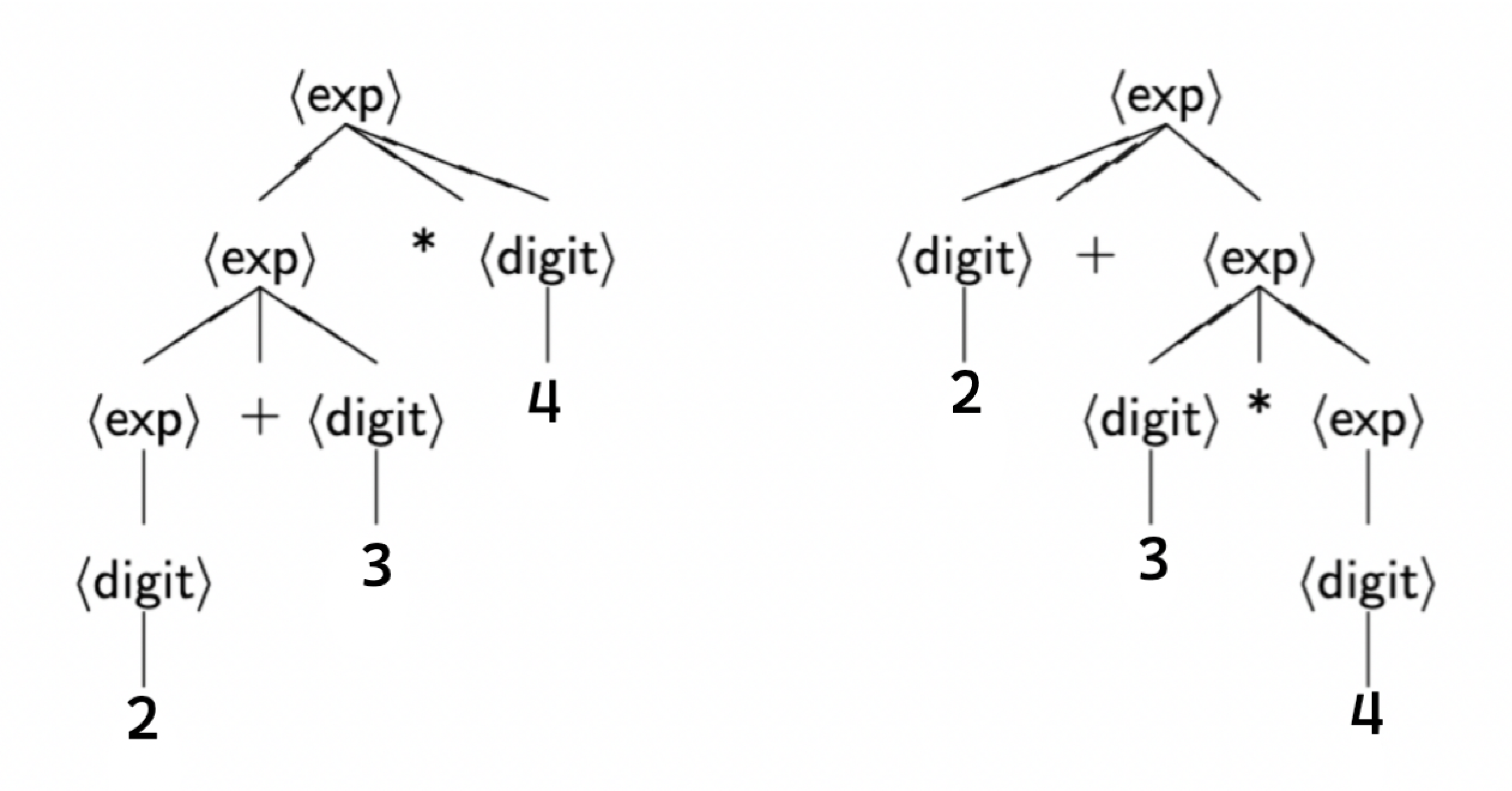
2.The problem of finding ambiguousy is unsolved, meaning no one can compute ambiguousy, meaning this grammar with these production rules can very possibly be ambiguous, but we simply do not have a straight answer.

23.

Consider the following grammar:

$$\langle exp \rangle ::= \langle digit \rangle | \langle exp \rangle * \langle digit \rangle | \langle digit \rangle + \langle exp \rangle$$
$$\langle digit \rangle ::= 2|3|4$$

With the following parse trees:



Both parse trees accept and present the string $2 + 3 * 4$ however, they will be evaluated quite differently as one(to the right) would be evaluated as $2 + (3 * 4) = 14$.
While the other one(to the left) would be incorrectly evaluated as $(2 + 3) * 4 = 20$.