

# CSC236 Worksheet 9 Solution

Hyungmo Gu

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## Question 1

a. I need to evaluate the reg. expressions for

$$L = \{x \in \Sigma \mid x \text{ has even number of 1s or an odd number of 0s}\}$$

I will do so in parts.

### Part 1 (Finding reg. expressions for even number of 1s):

In this part, I will find the reg. expressions for even number of 1's.

I will do so by finding patterns in series of small examples.

Starting with  $L = \{x \in \Sigma \mid x \text{ has 0 number of 1s}\}$ , it's reg. expressions is

$$0^* \tag{1}$$

Now for  $L = \{x \in \Sigma \mid x \text{ has 2 number of 1s}\}$ , it's reg. expressions is

$$0^*10^*10^* \tag{2}$$

Now for  $L = \{x \in \Sigma \mid x \text{ has 4 number of 1s}\}$ , it's reg. expressions is

$$0^*10^*10^*10^*10^* \quad (3)$$

From above, I see a pattern that

$$(0^*10^*1)(0^*10^*1)0^* \quad (4)$$

Using the pattern, I can conclude that the regular expression for even number of 1s is

$$(0^*10^*1)^*0^* \quad (5)$$

## **Part 2 (Finding reg. expressions for odd number of 0s):**

In this part, I will find the reg. expressions for odd number of 0's.

I will do so by finding patterns in series of small examples.

Starting with  $L = \{x \in \Sigma \mid x \text{ has 1 number of 0s}\}$ , it's reg. expressions is

$$1^*01^* \quad (6)$$

Now for  $L = \{x \in \Sigma \mid x \text{ has 3 number of 0s}\}$ , it's reg. expressions is

$$1^*01^*01^*01^* \quad (7)$$

Now for  $L = \{x \in \Sigma \mid x \text{ has 5 number of 0s}\}$ , it's reg. expressions is

$$1^*01^*01^*01^*01^*01^* \quad (8)$$

From above, I see a pattern that

$$1^*(01^*)(01^*)(01^*)(01^*)(01^*) \quad (9)$$

Using the pattern, I can conclude that the regular expression for odd number of 0s is

$$1^*(01^*)^* \quad (10)$$

Thus, by combining the two parts with union, we have

$$(0^*10^*1)^*0^* + 1^*(01^*)^* \quad (11)$$

### Notes:

- Regular Expression
  - Quick Guide

$$(0 + 1)((01)^*0) \quad (12)$$

The expression implies that

1. Starts with 0 **or** 1
    - \* indicated by  $(0 + 1)$
  2. Are then followed by **one or more repetitions** of 01
    - \* indicated by  $(01)^*$
  3. Ends with 0
    - \* indicated by the final 0
- Examples
    1.  $L = \{w \in \{a, b\}^* \mid w \text{ has an } a\}$

### Answer:

$$(a + b)^*a(a + b)^* \quad (13)$$

- Means there is one or more repetitions of  $a$  or  $b$  at front
- Means there is  $a$  in the middle

– Means there is zero or more repetitions of  $a$  or  $b$  at end

2.  $L = \{w \in \{a, b\}^* \mid w \text{ has at least two } as\}$

Answer:

$$(a + b)^*a(a + b)^*a(a + b)^* \quad (14)$$

3.  $L = \{w \in \{a, b\}^* \mid |w| \geq 2\}$

Answer:

$$(0 + 1)(0 + 1)(0 + 1)^* \quad (15)$$

In this example,

- Two characters are created (indicated by  $(0 + 1)(0 + 1)$ )
- And more :D!! (indicated by  $(0 + 1)^*$ )

b. I need to find the reg. expressions for  $L = \{x \in \Sigma \mid x \text{ has at least one } 1 \text{ and at least one } 0\}$ . That is, regex expressions for  $\{x \in \Sigma \mid x \text{ has at least one } 1 \text{ followed by at least one } 0\}$  plus  $\{x \in \Sigma \mid x \text{ has at least one } 0 \text{ followed by at least one } 1\}$ .

First, I need to find reg. expressions for

$$\{x \in \Sigma \mid x \text{ has at least one } 1 \text{ followed by at least one } 0\} \quad (1)$$

Since the reg expressions for  $x$  with at least one 1 is  $(0+1)^*1(0+1)^*$  and the reg expressions for  $x$  with at least one 0 is  $(0 + 1)^*0(0 + 1)^*$ , we have

$$(0 + 1)^*1(0 + 1)^*0(0 + 1)^* \quad (2)$$

Second, I need to find reg. expressions for

$$\{x \in \Sigma \mid x \text{ has at least one } 0 \text{ followed by at least one } 1\} \quad (3)$$

Using the facts provided above, we have

$$(0 + 1)^*0(0 + 1)^*1(0 + 1)^* \tag{4}$$

Thus, by combining the two, we can conclude

$$(0 + 1)^*1(0 + 1)^*0(0 + 1)^* + (0 + 1)^*0(0 + 1)^*1(0 + 1)^* \tag{5}$$