JACOBS UNIVERSITY BREMEN

Assignment #11

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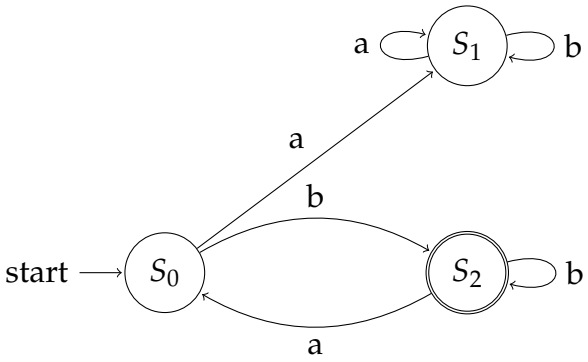
Course: *Introduction to Computer Science*
Date: *December, 2018*

Problem 11.1: finite state machine

1.

$$FSM(\Sigma, S, s_0, \delta, F)$$
$$\Sigma = \{a, b\}$$
$$S = \{S_0, S_1, S_2\}$$
$$s_0 = S_0$$
$$F = \{S_2\}$$
$$\delta = \{((S_0, a), S_1), ((S_0, b), S_2),$$
$$((S_1, a), S_1), ((S_1, b), S_1),$$
$$((S_2, a), S_0), ((S_2, b), S_2)\}$$

2.



3.

```
data State = S0 | S1 | S2 --S

accepts :: State -> String -> Bool
accepts S0 ('a':xs) = accepts S1 xs
accepts S0 ('b':xs) = accepts S2 xs
accepts S1 ('a':xs) = accepts S1 xs
accepts S1 ('b':xs) = accepts S1 xs
accepts S2 ('a':xs) = accepts S0 xs
accepts S2 ('b':xs) = accepts S2 xs
accepts S2 [] = True --final (halting) state
accepts _ _ = False

decide :: String -> Bool
decide = accepts S0 --initial state
```

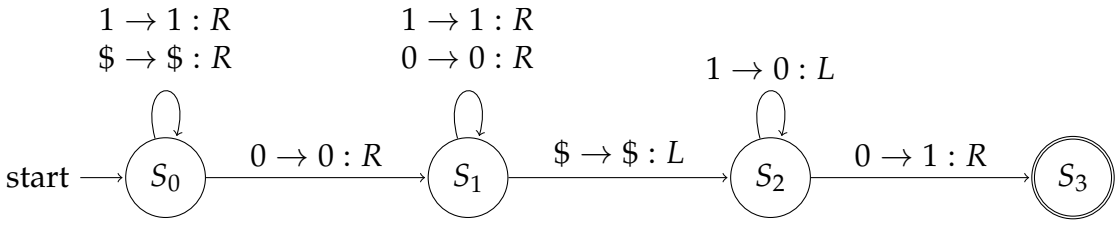
4.

Left regular grammar:
$G_l = (N, \Sigma, P_l, S)$
$N = \{S, T\}$
$\Sigma = \{a, b\}$
$S =$ start symbol
$P_l = \{S \to Tb, T \to Tb, T \to Tba, T \to \epsilon\}$

Right regular grammar:
$G_l = (N, \Sigma, P_r, S)$
$N = \{S, T\}$
$\Sigma = \{a, b\}$
$S =$ start symbol
$P_r = \{S \to bT, T \to bT, T \to abT, T \to \epsilon\}$

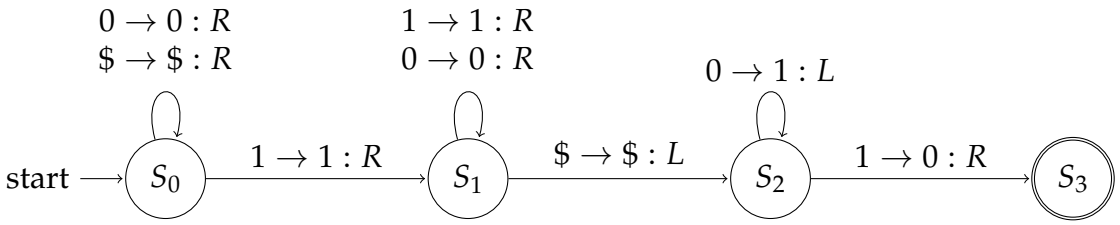
Problem 11.2: turing machines to increment, decrement, and add numbers

a.



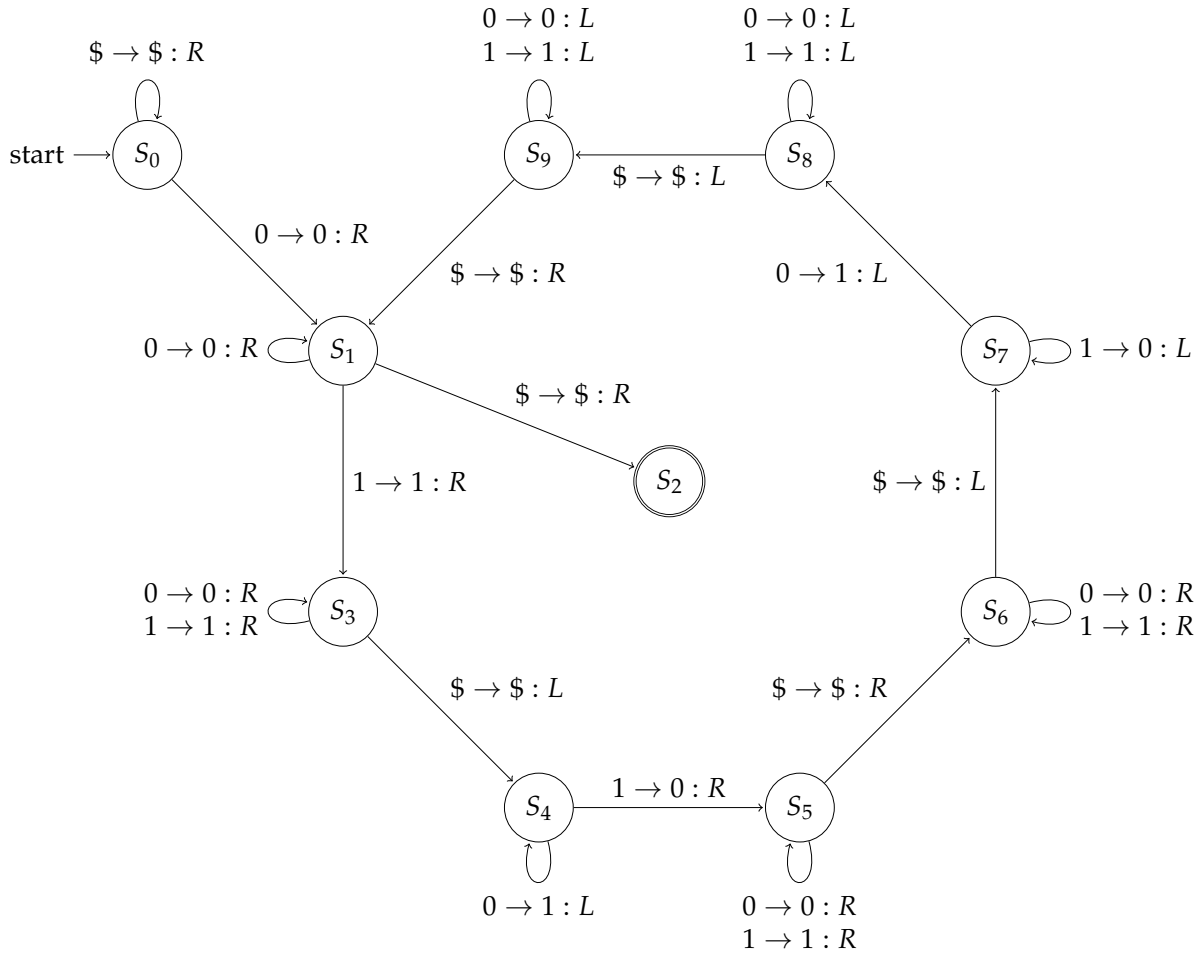
$TM(\Sigma, S, s_0, \Gamma, b, \delta, F)$
$\Sigma = \{0, 1\}$
$S = \{S_0, S_1, S_2, S_3\}$
$s_0 = S_0$
$\Gamma = \{0, 1, \$\}$
$b = \$$
$F = \{S_3\}$
$\delta = \{(S_0, \$, S_0, \$, R), (S_0, 0, S_1, 0, R), (S_0, 1, S_0, 1, R), (S_1, \$, S_2, \$, L),$
$(S_1, 0, S_1, 0, R), (S_1, 1, S_1, 1, R), (S_2, 1, S_2, 0, L), (S_2, 0, S_3, 1, R)\}$

b.



$TM(\Sigma, S, s_0, \Gamma, b, \delta, F)$
$\Sigma = \{0, 1\}$
$S = \{S_0, S_1, S_2, S_3\}$
$s_0 = S_0$
$\Gamma = \{0, 1, \$\}$
$b = \$$
$F = \{S_3\}$
$\delta = \{(S_0, \$, S_0, \$, R), (S_0, 0, S_0, 0, R), (S_0, 1, S_1, 1, R), (S_1, 0, S_1, 0, R),$
$(S_1, 1, S_1, 1, R), (S_1, \$, S_2, \$, L), (S_2, 0, S_2, 1, L), (S_2, 1, S_3, 0, R)\}$

c.



$TM(\Sigma, S, s_0, \Gamma, b, \delta, F)$

$\Sigma = \{0, 1\}$

$S = \{S_0, S_1, S_2, S_3, S_4, S_5, S_6, S_7, S_8, S_9\}$

$s_0 = S_0$

$\Gamma = \{0, 1, \$\}$

$b = \$$

$F = \{S_2\}$

$\delta = \{(S_0, \$, S_0, \$, R), (S_0, 0, S_1, 0, R), (S_1, \$, S_2, \$, R), (S_1, 0, S_1, 0, R),$
$(S_1, 1, S_3, 1, R), (S_3, \$, S_4, \$, L), (S_3, 0, S_3, 0, R), (S_3, 1, S_3, 1, R),$
$(S_4, 0, S_4, 1, L), (S_4, 1, S_5, 0, R), (S_5, \$, S_6, \$, R), (S_5, 0, S_5, 0, R),$
$(S_5, 1, S_5, 1, R), (S_6, \$, S_7, \$, L), (S_6, 0, S_6, 0, R), (S_6, 1, S_6, 1, R),$
$(S_7, 0, S_8, 1, L), (S_7, 1, S_7, 0, L), (S_8, \$, S_9, \$, L), (S_8, 0, S_8, 0, L),$
$(S_8, 1, S_8, 1, L), (S_9, \$, S_1, \$, R), (S_9, 0, S_9, 0, L), (S_9, 1, S_9, 1, L)\}$