Aaron Grabowy: 345766
Timo Bergerbusch: 344408

Exercise 1

a)

The transition system TS_1 can be formally given as: $TS_1 = (S, Act, \to, AP, L)$ with:

- $S = \{s_0, s_1, s_2, s_3, s_4\}$
- $Act = \{\alpha, \beta, \gamma\}$
- $\to = \{(s_0, \gamma, s_1), (s_0, \alpha, s_2), (s_1, \gamma, s_1), (s_1, \alpha, s_3), (s_1, \beta, s_4),$
  $s_2, \alpha, s_0), (s_2, \beta, s_4), (s_4, \alpha, s_2), (s_4, \gamma, s_3)\} \subset S \times Act \times S$
- $S_0 = \{s_0\}$
- $AP = \{a, b\}$
- $L : S \to 2^{AP}, s_0 \mapsto \{a\}, s_1 \mapsto \{a\}, s_2 \mapsto \{a, b\}, s_3 \mapsto \{b\}, s_4 \mapsto \{a, b\}$

b)

1.2.1 finite execution:

$$s_0 \xrightarrow{\alpha} s_2$$

1.2.2 infinite execution:

$$s_0 \xrightarrow{\gamma} s_1 \xrightarrow{\gamma} s_1 \xrightarrow{\gamma} \dots$$

c)

i) AP-deterministic:
The given transition system TS_1 is AP-deterministic, since $|S_0| \leq 1$ and there are no two transitions $t_1 = (s, \eta, s'), = (s, \tau, s'') \in \to$, $\eta, \tau \in Act$, $s, s', s'' \in S$,such that $L(s') = L(s'')$

ii) action-deterministic:
The given transition system TS_1 is action-deterministic, since $|S_0| \leq 1$ and there are no two $t_1 = (s, \eta, s'), = (s, \eta, s'') \in \to$, $\eta \in Act$, $s, s', s'' \in S$ with $s' \neq s''$

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Exercise 2

a)

- $\lambda_y = r_1 \land r_2$
- $\delta_{r_1} = (x \land \neg r_1) \lor (r_1 \land \neg x) = x \oplus r_1$
- $\delta_{r_2} = (\neg x \land r_2) \lor (x \land r_1)$

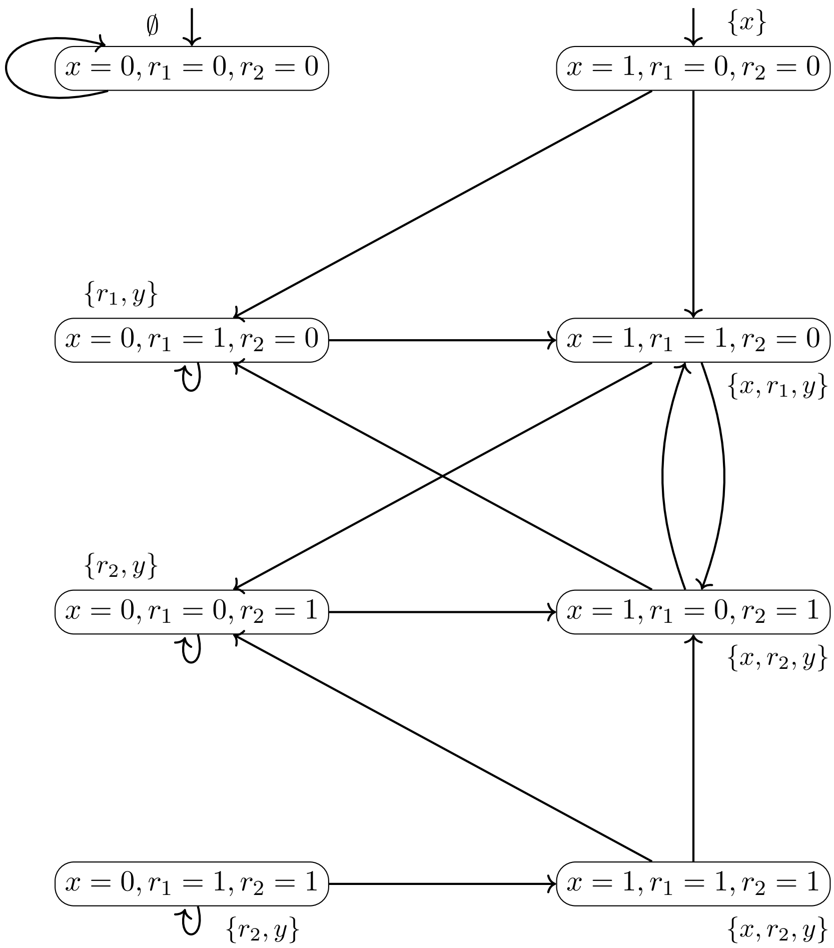
b)

The state space can be given as all possible combinations of the values of x, r_1 and r_2.

$$
\begin{aligned}
S = \{&(x = 0, r_1 = 0, r_2 = 0), (x = 0, r_1 = 0, r_2 = 1), (x = 0, r_1 = 1, r_2 = 0), \\
&(x = 0, r_1 = 1, r_2 = 1), x = 1, r_1 = 0, r_2 = 0), (x = 1, r_1 = 0, r_2 = 1), \\
&(x = 1, r_1 = 1, r_2 = 0), (x = 1, r_1 = 1, r_2 = 1)\}
\end{aligned}
$$

This is valid, since the we have to consider all possible inputs for x which are 0 and 1, and all the possible initial values of the registers r_1 and r_2.

c)



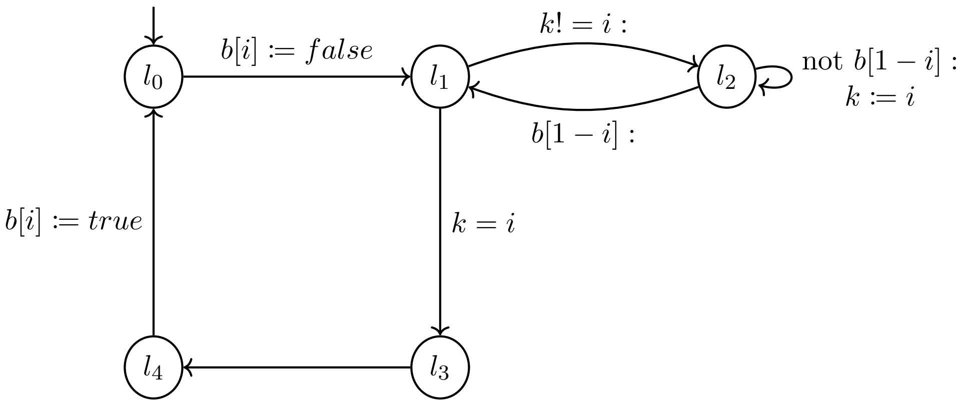
d)

The set $Reach(TS)$ follows from c) with:

$$
\begin{aligned}
Reach(TS) = \{&(x = 0, r_1 = 0, r_2 = 0), (x = 1, r_1 = 0, r_2 = 0),\\
&(x = 0, r_1 = 1, r_2 = 0), (x = 1, r_1 = 1, r_2 = 0),\\
&(x = 0, r_1 = 0, r_2 = 1), (x = 1, r_1 = 0, r_2 = 1)\}
\end{aligned}
$$

Exercise 3

a)



b)