Introduction to Discrete Event Systems

Course code: SSY165

Examination 2007-10-25

Time: 14:00-18:00, Lokal: M-building

Teacher: Bengt Lennartson, phone 3722

The examination includes 25 points, where grade three requires 10 points, grade four 15 points and grade five 20 points.

The result of this examination will be announced latest on Thursday *November 8* on the notice board of the division, at the entrance in the south east corner on floor 5 of the E-building. *Inspection* of the grading is done on *November 8 and 9* at 12:30-13:00 in Avenir Kobetski's room on floor 5.

Allowed aids at the examination:

- Standard mathematical tables such as Beta, see also Table 1.1 and 1.2 in the end of this examination.
- Pocket calculator.

Good luck!

Department of Signals and Systems
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1

Show the following implication by a contradiction.

$$(p \vee q) \wedge (p \rightarrow r) \wedge (q \rightarrow r) \Rightarrow r$$

Observe that a general implication $p \Rightarrow q$ can be expressed as the contradiction $p \wedge \neg q \Leftrightarrow \mathbf{F}$.

(3 p)

2

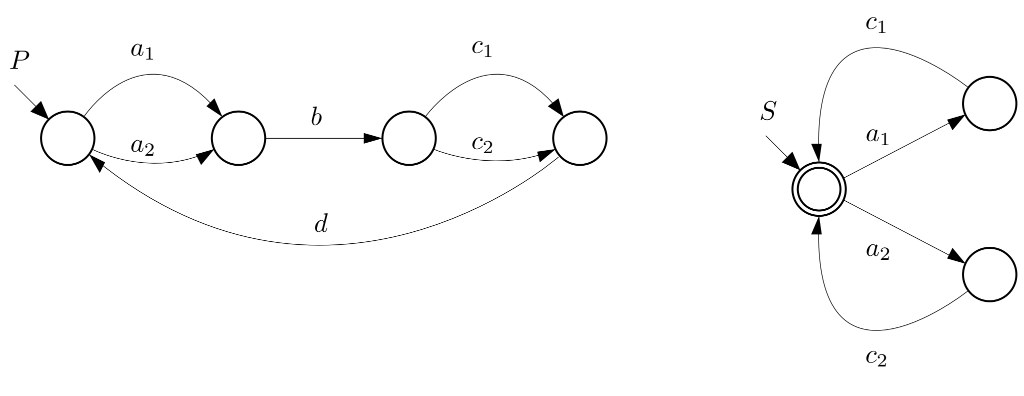
Show the following set equivalence by a membership table

$$A \subseteq B \Leftrightarrow A \cap B = A$$

(2 p)

3

Consider the following plant model P and supervisor S.



a) Give a model for the closed loop system $P||S$ as a Petri net.

(1 p)

b) Generate the corresponding single automaton for $P||S$ where a marked state is included.

(2 p)

c) Give the formal language for the plant $L(P)$.

(1 p)

d) Give the formal language for the closed loop system $L(P||S)$ including the marked language $L_m(P||S)$.

(2 p)

4

a) Model a buffer with a capacity of six elements as an automaton.

(1 p)

b) Model the same buffer as a Petri net.

(1 p)

c) Model the same buffer as a state space equation.

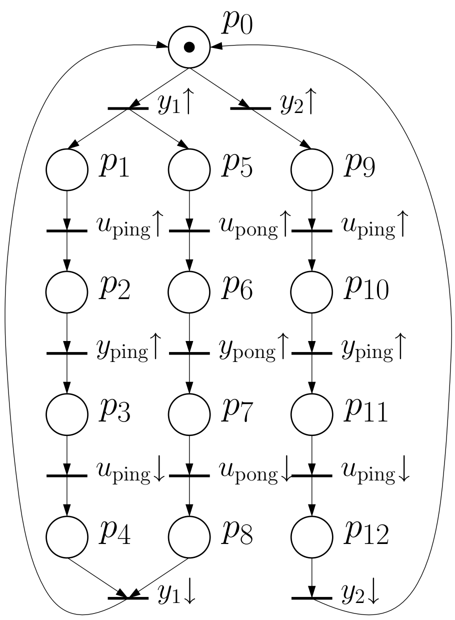
(1 p)

d) What is the principal difference between this state space model and a state space model for an ordinary continuous-time system, for instance a spring mass system?

(1 p)

5

The below Petri net is a model of the controller in a machine that goes "ping". Depending on the input, $y_1\uparrow$ or $y_2\uparrow$, the machine either (in case of $y_1\uparrow$) goes "ping" *and* "pong" simultaneously (or rather in parallel), or (in case of $y_2\uparrow$) just "ping".



a) Draw a Sequential Function Chart implementing the controller. Collapse the places in request/answer pairs (e.g. collapse p_1 with p_2, and p_3 with p_4).

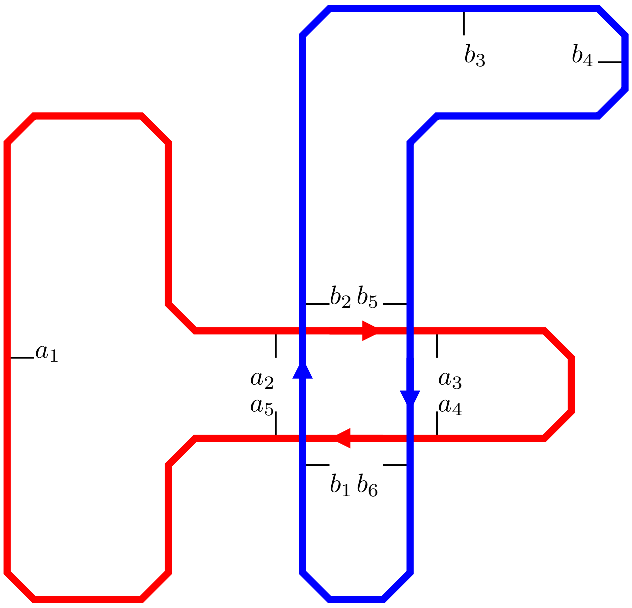
(2 p)

b) Give boolean state equations for the model. Collapse the request/answer place pairs.

(3 p)

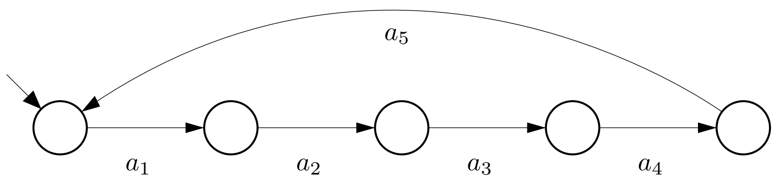
6

Consider the following automated guided vehicle (AGV) system, where only one AGV is allowed in the area where the two AGV paths are crossing each other. Also

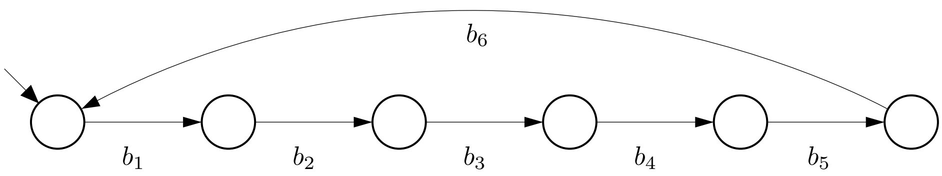


consider the local plant models P_1 and P_2 which model the states between the events $a_1 - a_5$ and $b_1 - b_6$.

P_1



P_2



a) Generate the complete plant model $P_1||P_2$ and identify forbidden states such that only one AGV is in the crossing area between the events b_1 and b_2, b_5 and b_6, a_2 and a_3, as well as a_4 and a_5.

(1 p)

b) Assume that all events are controllable and suggest a supervisor S such that the closed loop system is nonblocking.

(1 p)

c) Now assume that the events a_2, b_4 and b_5 are uncontrollable, and design a controllable and nonblocking supervisor S.

(3 p)

Table 1.1 Equivalence relations.

E_1	$\neg\neg p \Leftrightarrow p$		
E_2	$\neg(p \vee q) \Leftrightarrow \neg p \wedge \neg q$	E_3	$\neg(p \wedge q) \Leftrightarrow \neg p \vee \neg q$
E_4	$p \vee q \Leftrightarrow q \vee p$	E_5	$p \wedge q \Leftrightarrow q \wedge p$
E_6	$p \vee (q \vee r) \Leftrightarrow (p \vee q) \vee r$	E_7	$p \wedge (q \wedge r) \Leftrightarrow (p \wedge q) \wedge r$
E_8	$p \wedge (q \vee r) \Leftrightarrow (p \wedge q) \vee (p \wedge r)$	E_9	$p \vee (q \wedge r) \Leftrightarrow (p \vee q) \wedge (p \vee r)$
E_{10}	$p \vee p \Leftrightarrow p$	E_{11}	$p \wedge p \Leftrightarrow p$
E_{12}	$p \vee \mathbf{F} \Leftrightarrow p$	E_{13}	$p \wedge \mathbf{T} \Leftrightarrow p$
E_{14}	$p \vee \mathbf{T} \Leftrightarrow \mathbf{T}$	E_{15}	$p \wedge \mathbf{F} \Leftrightarrow \mathbf{F}$
E_{16}	$p \vee \neg p \Leftrightarrow \mathbf{T}$	E_{17}	$p \wedge \neg p \Leftrightarrow \mathbf{F}$
E_{18}	$p \vee (p \wedge q) \Leftrightarrow p$	E_{19}	$p \wedge (p \vee q) \Leftrightarrow p$
E_{20}	$p \to q \Leftrightarrow \neg p \vee q$	E_{21}	$\neg(p \to q) \Leftrightarrow p \wedge \neg q$
E_{22}	$p \to q \Leftrightarrow \neg q \to \neg p$	E_{23}	$p \to (q \to r) \Leftrightarrow (p \wedge q) \to r$
E_{24}	$\neg(p \leftrightarrow q) \Leftrightarrow p \leftrightarrow \neg q$	E_{25}	$p \leftrightarrow q \Leftrightarrow (p \to q) \wedge (q \to p)$
E_{26}	$p \leftrightarrow q \Leftrightarrow (p \wedge q) \vee (\neg p \wedge \neg q)$		

Table 1.2 Implication relations.

I_1	$p \wedge q \Rightarrow p$	I_2	$p \wedge q \Rightarrow q$
I_3	$p \Rightarrow p \vee q$	I_4	$q \Rightarrow p \vee q$
I_5	$\neg p \Rightarrow p \to q$	I_6	$q \Rightarrow p \to q$
I_7	$\neg(p \to q) \Rightarrow p$	I_8	$\neg(p \to q) \Rightarrow \neg q$
I_9	$\neg p \wedge (p \vee q) \Rightarrow q$	I_{10}	$p \wedge (p \to q) \Rightarrow q$
I_{11}	$\neg q \wedge (p \to q) \Rightarrow \neg p$	I_{12}	$(p \to q) \wedge (q \to r) \Rightarrow p \to r$
I_{13}	$(p \vee q) \wedge (p \to r) \wedge (q \to r) \Rightarrow r$		