RHEINISCH-
WESTFÄLISCHE
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AACHEN

LEHRSTUHL FÜR INFORMATIK 2

RWTH Aachen · D-52056 Aachen · GERMANY

Winter term 2009/10

Prof. Dr. Ir. J.-P. Katoen

Exam for *Foundations of the UML*

February 18, 2010

Family name: ______________________________

First name: ______________________________

Student number: ______________________________

Field of study: ☐ **Software Systems Engineering**
☐ **Informatik (Diplom)**
☐ **Others:** ______________________________

Please note the following hints:

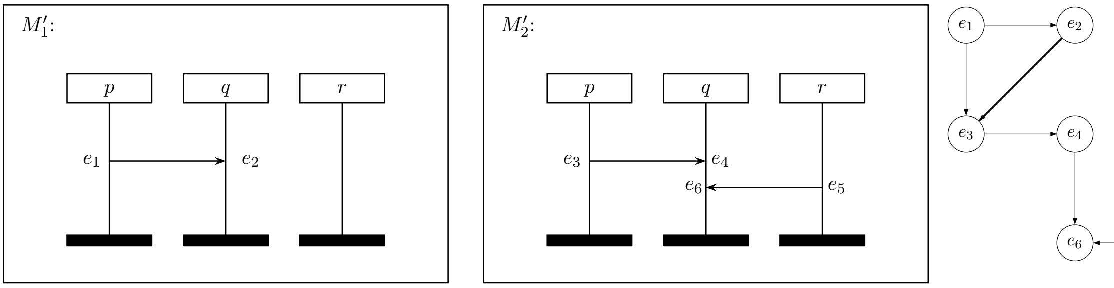
- Keep your student id card and a passport ready.
- The only allowed material is a copy of the lecture slides.
  No other materials (i.e. lecture notes, exercises, solutions, handwritten notes) are admitted.
- This test should have 5 pages (including this cover sheet).
- Write your name and student number on every sheet.
- Also use the back side of the pages if needed.
- Write with blue or black ink; do not use a pencil.
- Any attempt at deception leads to failure for this exam, even if it is detected only later.
- The editing time is **90 minutes**.

Question	Possible	Received
1	10	
2	10	
3	10	
4	10	
Total	40	
Grade		

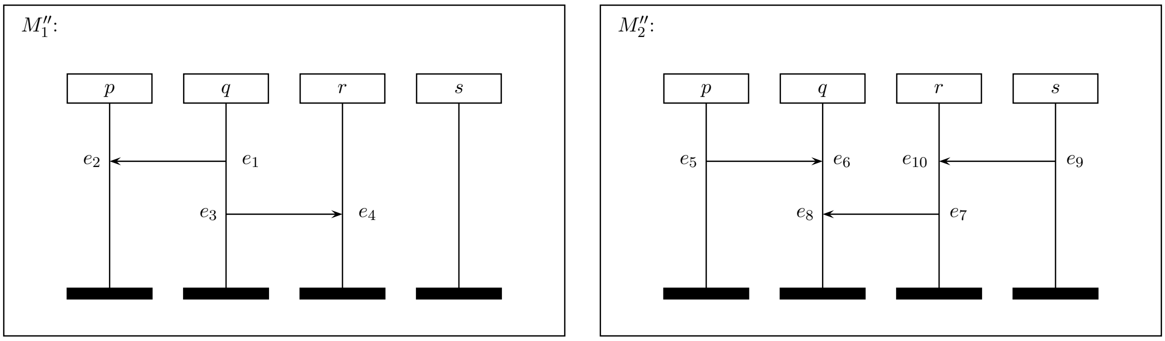
Question 1

(2+5+3=10 points)

Consider the following notion of concatenation $\odot$ of MSCs M_1 and M_2: *all (and only) the processes that are active in M_1 must finish before any process of M_2 that was also active in M_1 can start executing again.* For example, given the following M_1' and M_2', the partial order $<_c$ in $M_1' \odot M_2'$ is shown in the rightmost figure.



(a) Given the following MSCs M_1'', M_2'', write down the partial order relation $<_c$ in $M_1'' \odot M_2''$, preferably in the graphical form as shown above.

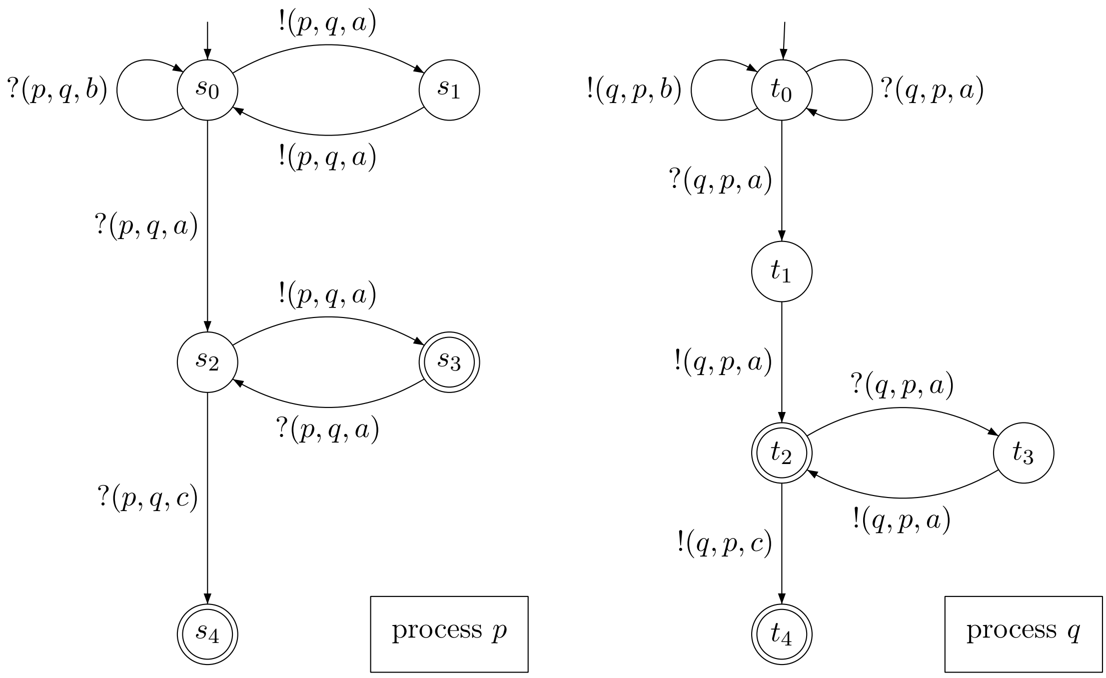


(b) Provide a formal definition of the new concatenation operator $\odot$.

(c) Prove or disprove that the operator $\odot$ is associative, i.e., $(M_1 \odot M_2) \odot M_3 = M_1 \odot (M_2 \odot M_3)$.

Question 2 (3+4+3=10 points)

Given the CFM $\mathcal{A}$ below, where the set of global final states is $F = \{(s_3, t_2), (s_4, t_4)\}$:



(a) Give a characterization of $Lin(\mathcal{A})$.

(b) Prove that $\mathcal{A}$ is deadlock-free, or give a counterexample showing that it is not.

(c) Is $\mathcal{A}$ universally/existentially bounded? If yes, find the smallest B such that $\mathcal{A}$ is $\forall B$-/$\exists B$-bounded.

Question 3 (2+2+2+2+2=10 points)

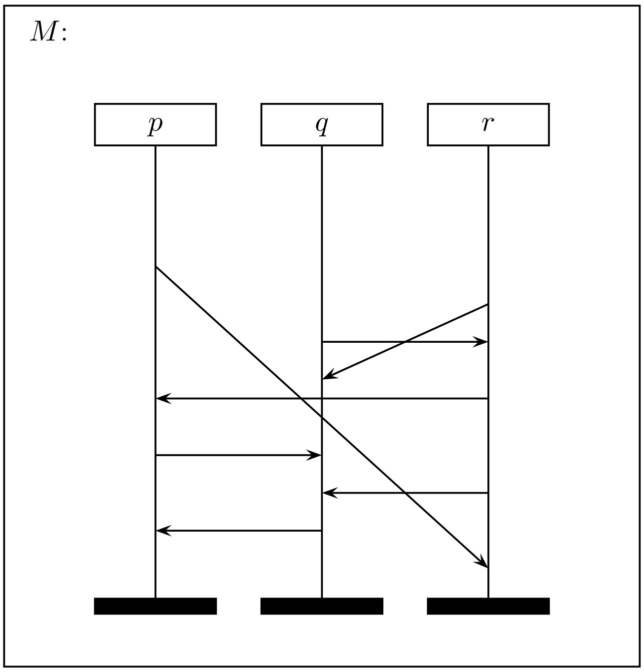
1) Prove the equivalence of the following PDL formulas:

   a) $\langle \alpha; \beta \rangle \varphi \equiv \langle \alpha \rangle \langle \beta \rangle \varphi$,

   b) $\langle \alpha + \beta \rangle \varphi \equiv \langle \alpha \rangle \varphi \vee \langle \beta \rangle \varphi$,

   where α, β are path formulas and φ is a local formula.

2) For the following MSC M with the set of processes $\mathcal{P} = \{p, q, r\}$



   determine whether M satisfies the following formulas or not:

   a) $\exists \langle (proc + msg)^*; \{?(p, q, \cdot)\}; [proc]^{-1}; (proc + msg)^* \rangle ?(p, q, \cdot)$

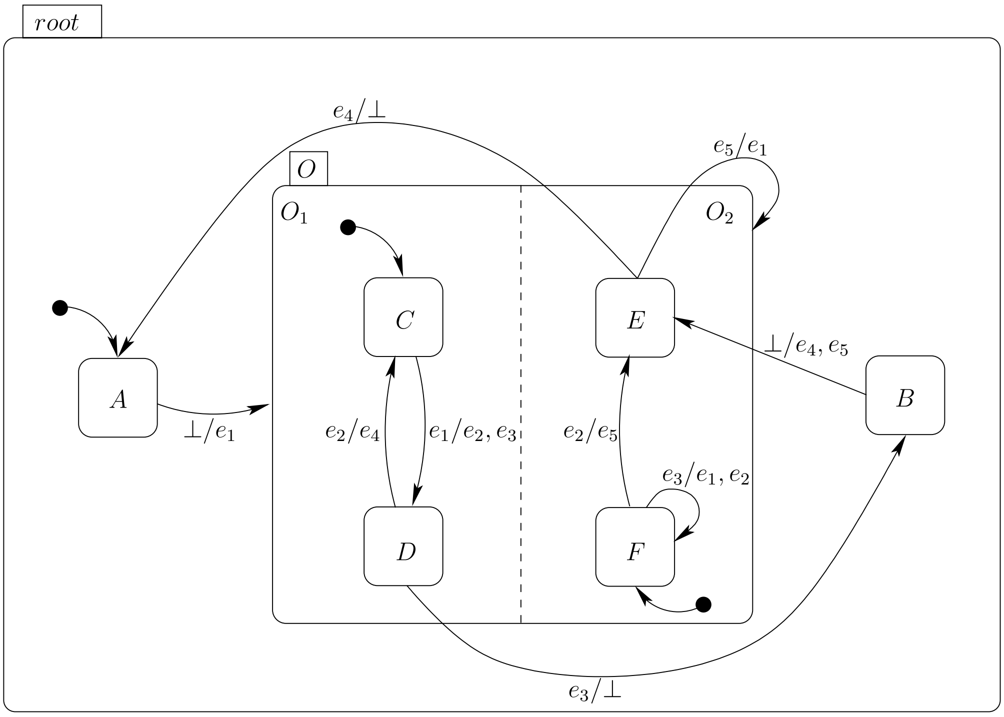
   b) $\exists \langle \{!p\}; (proc + msg; \{!q \vee ?q\})^* \rangle ?p$

   c) $\exists \langle msg; [proc]^{-1}; msg; [proc]^{-1}; [proc]^{-1} \rangle false$

   where $?p_1 = \bigvee_{p' \neq p_1} ?(p_1, p', \cdot)$ and $!p_1 = \bigvee_{p' \neq p_1} !(p_1, p', \cdot)$, $p_1 \in \mathcal{P}$.

Question 4

(1+1+2+6=10 points)



a) Describe the statechart formally, i.e., give the components $(N, E, Edges)$.

b) Construct the tree that represents the node hierarchy of the statechart. Determine the types of the nodes of the statechart.

c) Find all pairs of consistent edges.

d) Construct the related Mealy machine (write down all your calculations).