

2IW05 Final Examination

Software Specification

Faculteit Wiskunde en Informatica
Technische Universiteit Eindhoven (TU/e)

January 30, 2012, 14.00 – 17.00

Important Notes. It is not allowed to use study material, computers, and calculators during the examination. The examination comprises 6 question in 3 pages. Please check beforehand whether your copy is properly printed. Justify each step and do not confine yourself to giving the final answer. The answers may be given in Dutch or English. **Good luck!**

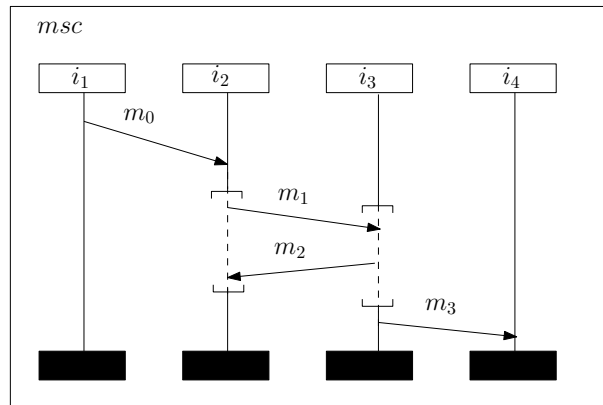
Exercise 1 (Z, 20 points) Consider the following specification in Z . Give the definition of Add ; $Remove$ and simplify it as much as possible.

$BQueue$ $q : seq \mathbb{Z}$ $s : \mathbb{Z}$
$\#q \leq 10$

Add $\Delta BQueue$ $i? : \mathbb{Z}$
$q' = i? \frown q$ $s' = \#q'$

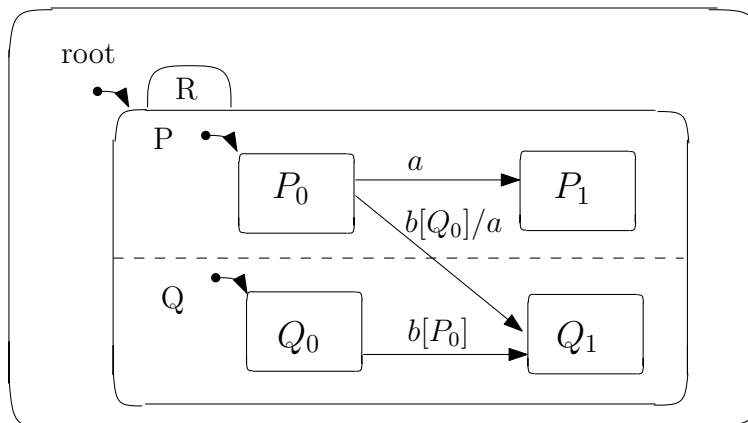
$Remove$ $\Delta BQueue$ $o! : \mathbb{Z}$
$\#q > 0$ $q' = tail(q)$ $o! = head(q)$

Exercise 2 (MSC, 20 points) Consider the following MSC specification.



1. Give an LTS that is consistent with the above-given MSC. The LTS may have at most 3 outgoing transitions from each state and may not contain loops. (10 points)
2. Abstract from the message $m1$ and draw the outcome. (5 points)
3. Combine the entities $i2$ and $i3$ in the *original (not the abstracted)* MSC and draw the outcome. (5 points)

Exercise 3 (Statecharts, 20 points) Consider the following statechart.



1. Determine the scope of the transitions labeled a and $b[Q_0]/a$.
2. Draw the LTS of the statechart with one step from the environment interleaved with one step from the statechart. Assume that the set of all triggers is $\{a, b\}$.

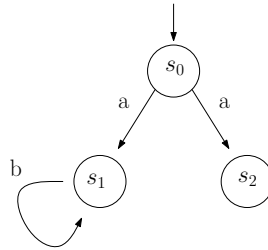
Exercise 4 (Class Diagram, 10 points) Give a class diagram for the following informal specification.

A car rental company has a number of clients. Among those clients, some are called club members, which have a regular contract to rent a number of cars per month with a reduced rate. The regular and the reduced rates are fixed for each type of car. For each client, the name, the address and the credit card number should be registered. In addition to recording the current cars rented by each client, the history of car rental for each client should be recorded. A client should obviously be able to rent a car, and return it. The company has a number of cars from each type, for which the availability should be recorded.

Exercise 5 (Modal Formulae Syntax, 20 points) Specify the following properties in the modal μ -calculus syntax. You may use regular expressions or fixed point equations at will.

1. Everywhere, in between each two instances of the action *start*, there should always be an instance of the action *exit*.
2. Everywhere, immediately after each *start* action, an *exit* action must be taken.
3. Everywhere, after each *start* action, eventually an *exit* action must be taken.
4. Nowhere, there can be an infinite sequence of *start* actions.

Exercise 6 (Modal Formulae Semantics, 10 points) Translate the formula $[true.true^*.a]false$ into the modal μ -calculus with fixed points. Specify in which states of the following LTS the translated (and this the original) formula hold. Explain the steps towards the final answers in both items. Assume that the set of all actions is called *Act*.



Answer 1

pre *Add* ; *Remove* =

$\exists q'' : \text{seq } \mathbb{Z}, s'' : \mathbb{Z} \bullet$

$Add[''/']$
$q, q'' : \text{seq } \mathbb{Z}$ $s, s'' : \mathbb{Z}$ $i? : \mathbb{Z}$
$\#q \leq 10$ $\#q'' \leq 10$ $q'' = i? \frown q$ $s'' = \#q''$

\wedge

$Remove[''/']$
$q, q'' : \text{seq } \mathbb{Z}$ $s, s'' : \mathbb{Z}$ $o! : \mathbb{Z}$
$\#q'' \leq 10$ $\#q \leq 10$ $q' = \text{tail}(q'')$ $o! = \text{head}(q'')$

=

$\exists q'' : \text{seq } \mathbb{Z}, s'' : \mathbb{Z} \bullet$

$Add[\"/\"] \wedge Remove[\"/\"]$
$q, q', q'' : \text{seq } \mathbb{Z}$ $s, s', s'' : \mathbb{Z}$ $i? : \mathbb{Z}$ $o! : \mathbb{Z}$
$\#q \leq 10$ $\#q' \leq 10$ $\#q'' \leq 10$ $q'' = i? \frown q$ $q' = \text{tail}(q'')$ $s'' = \#q''$ $o! = \text{head}(q'')$

=

$Add \S Remove$
$q, q' : \text{seq } \mathbb{Z}$ $s, s' : \mathbb{Z}$ $i? : \mathbb{Z}$ $o! : \mathbb{Z}$
$\exists q'' : \text{seq } \mathbb{Z}, s'' : \mathbb{Z} \bullet$ $\#q \leq 10$ $\#q' \leq 10$ $\#q'' \leq 10$ $q'' = i? \frown q$ $q' = \text{tail}(q'')$ $s'' = \#q''$ $o! = \text{head}(q'')$

=

$Add \S Remove$
$q, q' : \text{seq } \mathbb{Z}$ $s, s' : \mathbb{Z}$ $i? : \mathbb{Z}$ $o! : \mathbb{Z}$
$\exists s'' : \mathbb{Z} \bullet$ $i? \frown q \in \text{seq } \mathbb{Z}$ $\#q \leq 10$ $\#q' \leq 10$ $\#(i? \frown q) \leq 10$ $q' = \text{tail}(i? \frown q)$ $s'' = \#(i? \frown q)$ $o! = \text{head}(i? \frown q)$

=

$Add \ ; \ Remove$ $q, q' : seq \ \mathbb{Z}$ $s, s' : \mathbb{Z}$ $i? : \mathbb{Z}$ $o! : \mathbb{Z}$
$\exists s'' : \mathbb{Z} \bullet$ $\#q \leq 10$ $\#q' \leq 10$ $1 + \#q \leq 10$ $q' = q$ $s'' = 1 + \#q$ $o! = i?$

=

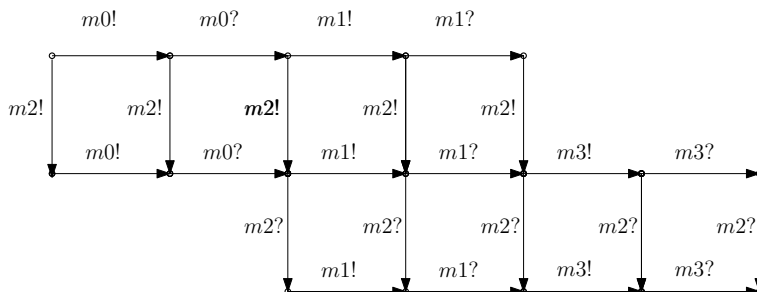
$Add \ ; \ Remove$ $q, q' : seq \ \mathbb{Z}$ $s, s' : \mathbb{Z}$ $i? : \mathbb{Z}$ $o! : \mathbb{Z}$
$s'' \in \mathbb{Z}$ $\#q \leq 10$ $\#q' \leq 10$ $\#q \leq 9$ $q' = q$ $o! = i?$

=

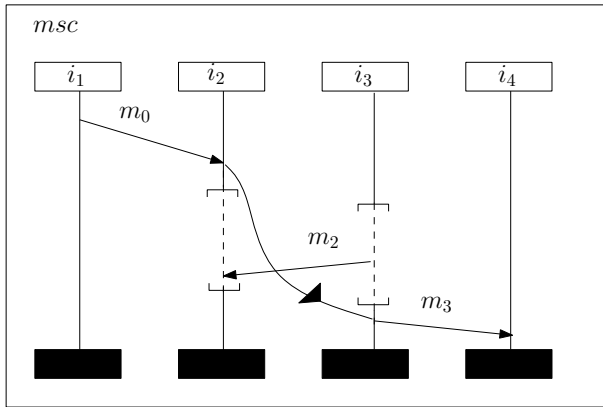
$Add \ ; \ Remove$ $\Delta BQueue$ $i? : \mathbb{Z}$ $o! : \mathbb{Z}$
$\#q \leq 9$ $q' = q$ $o! = i?$

Answer 2

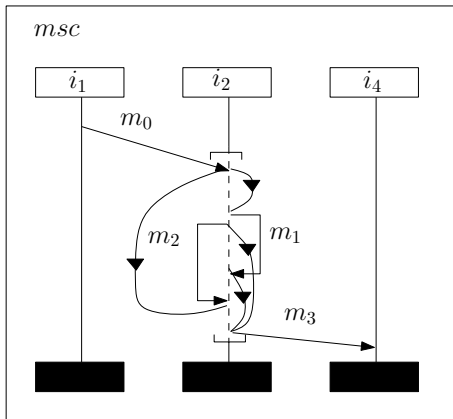
1.



2.



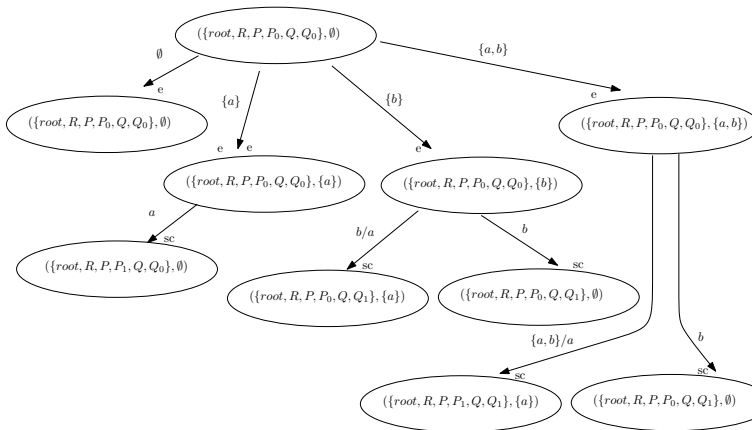
3.



Answer 3

1. P and $root$, respectively.

2.



Answer 4

Answer 5

1. $[true^*.start.\overline{exit}^*.start]false$
2. $[true^*.start](\langle exit \rangle true \wedge \overline{[exit]}false)$
3. $[true^*.start]X$ where $X \stackrel{\min}{=} \overline{[exit]}X \wedge \langle true \rangle true$
4. $[true^*]X$ where $X \stackrel{\min}{=} [start]X$

Answer 6 The following are only the final answers to the question; sufficient explanation should be provided for the steps towards this answer.

1. $[true]X$ where $X \stackrel{\max}{=} [Act]X \wedge [a]false$.
2. s_0, s_1, s_2 .