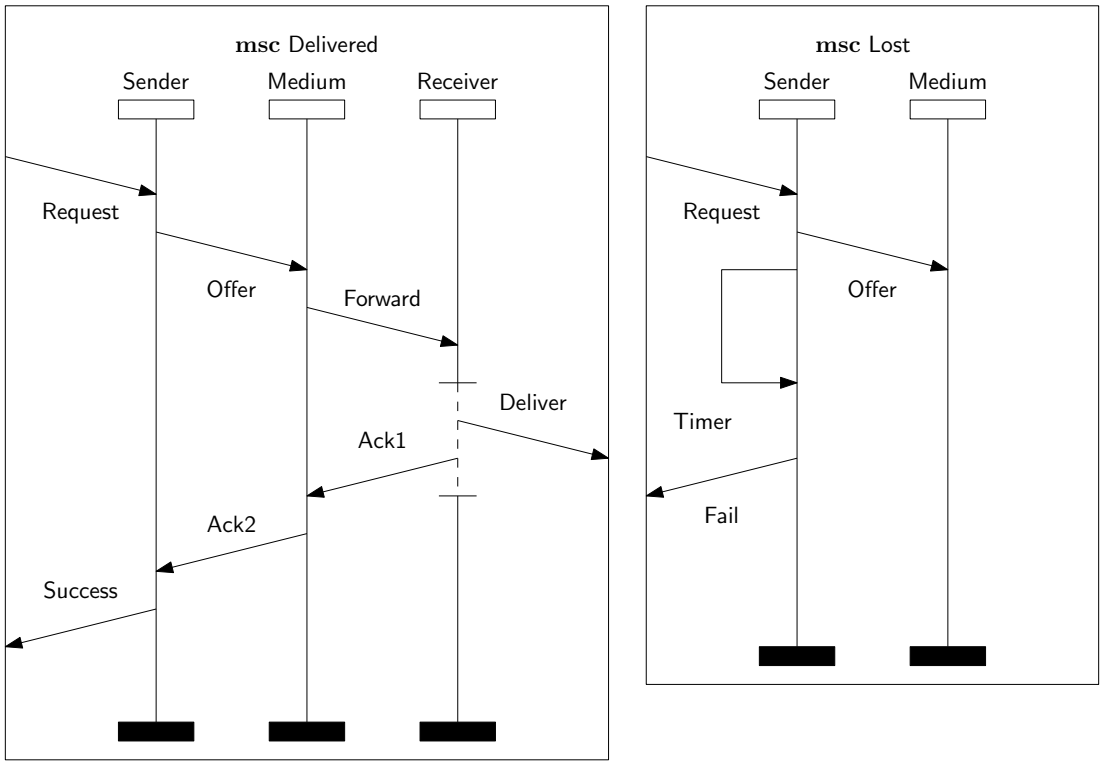
2IW05 Examination – Software Specification

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

June 20, 2009, 9.00 – 12.00

Exercise 1 Consider the following Message Sequence Charts.



1. Give a Basic Message Sequence Chart that represents the vertical composition of the Basic Message Sequence Charts Lost and Delivered, i.e., Lost ∘ Delivered. **(10 points)**
2. For Basic Message Sequence Chart Delivered, give a Basic Message Sequence Chart that represents the result of abstraction of the messages Offer, Forward, Ack1, and Ack2. **(10 points)**

Exercise 2 Consider the following algebraic specification N of sort $\mathbb{N}$.

constructor function symbols:

$$\begin{array}{lcl} 0 & : & \rightarrow \mathbb{N} \\ S & : & \mathbb{N} \rightarrow \mathbb{N} \end{array}$$

additional function symbols:

$$\begin{array}{lcl} min & : & \mathbb{N} \times \mathbb{N} \to \mathbb{N} \\ max & : & \mathbb{N} \times \mathbb{N} \to \mathbb{N} \end{array}$$

equations:

$$\begin{array}{lcllcl} min(0,x) & = & 0 & max(0,x) & = & x \\ min(x,0) & = & 0 & max(x,0) & = & x \\ min(S(x),S(y)) & = & S(min(x,y)) & max(S(x),S(y)) & = & S(max(x,y)) \end{array}$$

1. Define an additional function symbol $middle : \mathbb{N} \times \mathbb{N} \times \mathbb{N} \to \mathbb{N}$ that gives the middle one of three natural numbers. Besides the function *middle* you can only use the function symbols given above. Note that for any closed terms p and q of sort $\mathbb{N}$ it should be the case that $middle(p,q,p) = p$ and $middle(p,p,p) = p$ are derivable from your extended algebraic specification. **(10 points)**
2. Prove the property $N \vdash min(x, max(y,x)) = x$. **(10 points)**

Exercise 3 Consider the following specification in Z.

$$bound : \mathbb{Z}$$
$$\hline$$
$$bound = 10$$

Stack

$$stack : \text{seq } \mathbb{Z}$$
$$\hline$$
$$\#stack \leq bound$$

Push

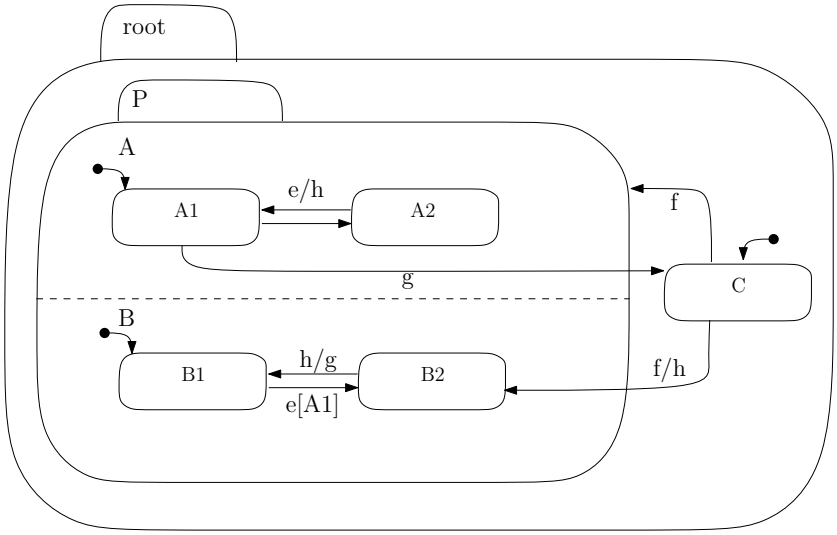
$$\Delta Stack$$
$$el? : \mathbb{Z}$$
$$\hline$$
$$stack' = \langle el \rangle \frown stack$$

Pop

$$\Delta Stack$$
$$el! : \mathbb{Z}$$
$$\hline$$
$$\#stack > 0$$
$$el! = head(stack)$$
$$stack' = tail(stack)$$

1. Calculate and simplify the pre-condition of *Push*. **(8 points)**
2. Calculate and simplify the schema-calculus expression $Push \fatsemi Pop$. **(12 points)**

Exercise 4 Consider the following statechart.



1. Assume that the current situation is $(\{\text{root}, \text{C}\}, \{\text{f}\})$. Calculate the exit and enter sets of the transitions labeled f and f/h. **(5 points)**
2. Starting from the initial configuration $\{\text{root}, \text{C}\}$, draw the LTS of the statechart up to depth two (i.e., two transitions from the environment interleaved with two transitions from the statechart), assuming that the transitions of the environment are labeled $\{f\}$ and $\varnothing$, respectively. **(15 points)**

Exercise 5 Consider the following simplified railroad system. For the system the following events are modeled:

- *enter*: a train enters the crossing
- *leave*: a train leaves the crossing
- *down*: the gate is closed
- *up*: the gate is opened

Express the following properties by means of temporal logic formulas:

1. The gate must remain closed until the train has left the crossing. **(10 points)**
2. The closing and opening of the gate only occur alternatingly. **(10 points)**

Answer 1

1. $middle(x, y, z) = middle(x, z, y)$
   $middle(x, y, z) = middle(y, x, z)$
   $middle(x, y, z) = middle(z, y, x)$
   $middle(0, x, y) = min(x, y)$
   $middle(S(x), S(y), S(z)) = S(middle(x, y, z))$
2. By induction on x. In the induction case use induction on y. Trivial.

Answer 2

1. Precondition:

$$\exists\, stack' : \mathrm{seq}\ \mathbb{Z} \bullet$$

Push

$Stack$
$stack' : \mathrm{seq}\, \mathbb{Z}$
$el? : \mathbb{Z}$
$\#stack' < bound$
$stack' = \langle el \rangle \frown stack$

=

Push

$Stack$
$el? : \mathbb{Z}$
$\exists\, stack' : \mathrm{seq}\, \mathbb{Z} \bullet$
$\#stack' < bound$
$stack' = \langle el \rangle \frown stack$

=

Push

$Stack$
$el? : \mathbb{Z}$
$\#\langle el \rangle \frown stack < bound$

=

Push

$Stack$
$el? : \mathbb{Z}$
$1 + \#\ stack < bound$

2. Composition (we do not give the calculations here, but the students should arrive at this using the definitions):

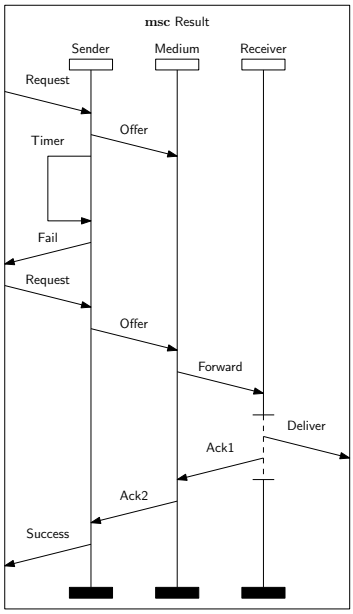
$Push \fatsemi Pop$

$\Delta Stack$
$el? : \mathbb{Z}$
$el! : \mathbb{Z}$

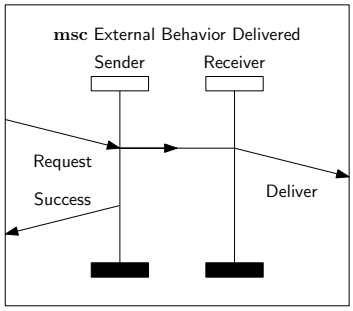
$el! = el?$
$1 + \# \ stack < bound$
$stack' = stack$

Answer 3

1. The result of the vertical composition of the Basic Message Sequence Charts Lost and Delivered is given by Basic Message Sequence Chart Result below.



2. The result of abstraction of all messages involving instance Medium in Basic Message Sequence Chart Delivered is given by the Basic Message Sequence Chart ExternalBehaviorDelivered below.



Answer 4

1. exit and enter set for f: $\{C\}$ and $\{P, A, A1, B, B1\}$. Exit and Enter set for f/h: $\{C\}$ and $\{P, A, A1, B, B2\}$.
2. Steps from the system are:
   (a) Nondeterministic choice between f and f/h leading to $(\{root, P, A, A1, B, B1\}, \varnothing)$ and $(\{root, P, A, A1, B, B2\}, \{h\})$, respectively.
   (b) Followed, respectively, by a single unlabelled step leading to $(\{root, P, A, A2, B, B1\}, \varnothing)$ and simultaneous steps leading to $(\{root, P, A, A2, B, B1\}, \{g\})$.

Answer 5

1. The gate must remain down until the train has left the crossing.

   $$[true^* \cdot down \cdot \overline{leave}^* \cdot up] false$$

2. The closing and opening of the gate only occur alternatingly.

   $$[true^* \cdot up \cdot \overline{down}^* \cdot up \cdot true^*] false$$

   $$\wedge$$

   $$[true^* \cdot down \cdot \overline{up}^* \cdot down \cdot true^*] false$$