Theoretical Foundations of the UML - SS 2020
— Exercise Sheet 5 —

Hand in until Monday May 25, 09:00 am via RWTHmoodle

General Remarks

- The exercises should be solved in groups of three students.
- Only one student per group is supposed to upload a solution sheet as a PDF file, where the names and matriculation numbers of all the group members have to be explicitly indicated.
- Questions regarding the lectures and exercises, if any, are expected in the Q&A session via Zoom (instead of emails), with the next on Thursday 21 May, at 16:00. Zoom ID: 369 366 110, Password: FUML-QA

Exercise 1 (CMSG Review) (2 Points)

Consider the following CMSCs. Construct a safe CMSG $G$ containing the all of the vertices $M_1, M_2, M_3, M_4,$ and $M_5$, and at least one loop (not necessarily a self-loop). Furthermore, there must be at least one accepting path traversing all vertices. You may use vertices multiple times.

Exercise 2 (Language of CFM) (2.5 Points)

Consider the following weak CFM $A$ with processes $p, q, r$. The shorthand $!s$ indicates a send event to process $s \in \{p, q, r\}$ with message content $m$. $?s$ is defined similarly.
Exercise 3 (CFM Boundedness) (2.5 Points)

Reconsider $\mathcal{A}$ from the previous question. Determine if $\mathcal{A}$ is universally ($\forall$-) bounded.

In case it is $\forall$-bounded, determine the smallest $B$ such that $\mathcal{A}$ is $\forall$-$B$-bounded. In this case it suffices to show why $\mathcal{A}$ is not $\forall$-$(B-1)$-bounded.

In case it is not $\forall$-bounded, give the channel which is unbounded and argue, why this channel is unbounded.

Exercise 4 (Determinism and Deadlock in CFM) (3 Points)

Consider the following CFM $\mathcal{A}_2$ with accepting states $F = \{(p_1, q_1), (p_3, q_1)\}$ and synchronization messages $D = \{m_1, m_2\}$. A transition label $!(p, q, a), m_1$ refers to action $!(p, q, a)$ with synchronization message $m_1$. 

Give a MSC $M$ which is in the language of $\mathcal{A}$, that is $M \in \mathcal{L}(\mathcal{A})$. $M$ should contain at least two send events.
$A_2$: 

process $p$: 

\[
\begin{align*}
p_0 & \overset{!(p, q, a), m_1}{\rightarrow} p_2 \overset{!(p, q, a), m_1}{\rightarrow} p_3 \\
p_1 & \overset{!(p, q, b), m_1}{\rightarrow} \\
\end{align*}
\]

process $q$: 

\[
\begin{align*}
q_0 & \overset{?(q, p, a), m_1}{\rightarrow} q_2 \overset{?(q, p, b), m_1}{\rightarrow} \\
q_1 & \overset{?(q, p, a), m_1}{\rightarrow} \\
\end{align*}
\]

a) Is $A_2$ deterministic? If yes, justify your answer. If no, give all pairs of transitions which violate the determinism.

b) Does $A_2$ contain a deadlock? If yes, give a run in $A_2$ reaching the deadlock. You may omit the channel contents $\eta$ and the synchronization data $m_i \in \mathbb{D}$ from the run. If no, justify your answer.