Theoretical Foundations of the UML - SS 2020
— Exercise Sheet 7 —

Hand in until Monday June 15, 09:00 am via RWTHmoodle

General Remarks

• There will be NO lecturing, exercise-class, or Q&A activities in the week after Pentecost (“excursion week” in Aachen), i.e., week 23 (June 1 - 5).

• Questions regarding the lectures and exercises, if any, are expected in the Q&A session via Zoom (instead of emails), with the next on Wednesday 10 June, at 16:00. Zoom ID: 369 366 110, Password: FUML-QA

Exercise 1 (Communication-Closedness) (1+2 Points)

Consider the following MSG $G$.

![Diagram of MSG G]

1. Check whether $G$ is locally communication-closed;
2. Find a CFM $A$, such that $L(A) = L(G)$.

Exercise 2 (MSG Properties) (4+4+4 Points)

Consider the following MSGs:

$G_1$:

$G_2$:

$G_3$:

![Diagrams of MSGs G1, G2, and G3]
Exercise 3 (Regularity and Well-Formedness) (2.5 Points)

Consider the following CFM $A$.

$A$:  

process $p$:  

1 \rightarrow 2 \rightarrow 3 \rightarrow 4 \rightarrow 1 
\text{ !}(p, q, a), m_1 \text{ !}(p, q, c), m_1 \text{ ?}(p, q, b), m_1 

process $q$:  

\text{ !}(q, p, b), m_1 \text{ ?}(q, p, a), m_1 \text{ ?}(q, p, c), m_1 

a) Determine whether $L(A)$ is regular.  
b) Determine the configuration graph of CFM $A$.  
c) Apply the construction using channel capacity functions (Lecture 12, slides 11 and 12) to determine the smallest $B$ such that $A$ is $\forall B$-bounded.

Exercise 4 (3-SAT Reduction) (2.5 Points)

Consider the 3-SAT Formula $\Phi = (\overline{x}_1 \lor x_2 \lor x_3) \land (x_1 \lor \overline{x}_2 \lor x_3)$.

a) According to the reduction schema in Lecture 12, reduce $\Phi$ to the MSG $G$, in a way that ensures:  

$\Phi$ is satisfiable iff $G$ is not communication closed.  
b) Provide the communication graph of MSG $G$ and check the connectivity from $p_0$ (the initial process) to $p_3$ (the last process) for the evaluation $x_1 = false$, $x_2 = true$, and $x_3 = false$.  

Decide for each MSG $G_i$, $i \in \{1, 2, 3\}$ whether it is . . .

a) communication-closed  
b) locally communication-closed  
c) regular  
d) realizable  
Justify each (positive or negative) answer.