Software Design, Modeling, and Analysis in UML

`http://swt.informatik.uni-freiburg.de/teaching/WS2014-15/sdmauml`

Exercise Sheet 2

Early submission: Monday, 2014-11-17, 12:00 Regular submission: Tuesday, 2014-11-18, 8:00

Exercise 1 – OCL Abbreviations (5/20 Points)

Consider the following basic object signature for a WSN:

$$\mathscr{S} = (\{Float\}, \{Node\}, \{r : Float, m : Node_{0,1}, s : Node_*\}, \{Node \mapsto \{r, m, s\}\})$$

with r modelling sensor reading, m the master of a node, and s its slaves.

(i) Fully un-abbreviate the following OCL expression: $self.s$ -> size (1)

(ii) Fully un-abbreviate the following OCL expression: $self.s < self.m$ -> r.
Is it a proper OCL expression? (1)

(iii) Fully un-abbreviate the following OCL expression:
context $Node$ inv : s -> forAll($i \mid i.r \geq r$) (2)

(iv) Bring the fully un-abbreviated expression from (iii) to prefix-normal form,
i.e. $\omega(expr_1, \ldots, expr_1)$. (1)

Hint: for (ii), if yes, state why, if not, explain why not.

Exercise 2 – Evaluating OCL Expressions (10/20 Points)

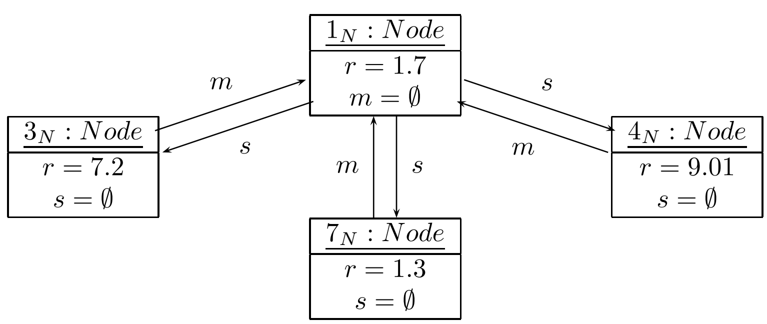

Figure 1: Object Diagram for Exercise 2.

Consider the system state σ described by the complete object diagram in Figure 1 and the OCL expression from Exercise 1.(iii).
As structure of $\mathscr{S}$, we want to use $\mathscr{D}$ with $\mathscr{D}(Float) = \mathbb{R}$ and $\mathscr{D}(Node) = \{1_N, 2_N, 3_N, \ldots\}$.

(i) Which system state σ does Figure 1 describe? Spell it out using the function-notation for system states which we used before introducing object diagrams. (3)

(ii) To which value does the considered OCL expression evaluate to in σ? (6)

Hint: Prove your answer by "stupidly" and mechanically applying the definition of the interpretation function I. To make it a little bit less "stupid", you need not apply the definition of iterate *if you are able to convince the tutor that actually using I would yield exactly the result you claim to be correct.*

(iii) What does the considered OCL expression mean informally? (1)

Exercise 3 – Formalising Requirements in OCL (5/20 Points)

Consider the basic object signature for WSN from Exercise 1 with the structure given in Exercise 2 (or, if you like, your own proposal from the previous exercise sheet – please state, which one you're using and in the latter case, repeat your proposal for self-containedness of your submission).

Consider the following requirements on system states. Formalise each requirement in the OCL fragment from the lecture.

"Test" your formalisations by providing two system states σ_1 and σ_2 such that σ_1 satisfies the requirement and σ_2 does not (explain, why this is supposed to be the case). Convince the tutor that $I[\![expr]\!](\sigma_1, \emptyset) = true$ and $I[\![expr]\!](\sigma_2, \emptyset) = false$ as expected for a correct formalisation.

(i) The sensor reading ranges from 0.0 to 10.0. (1)

(ii) A node n_1 is master of a node n_2 if and only if n_2 is slave of n_1. (1)

(iii) The sensor readings of all slaves of one master do not differ by more than 3. (1)

(iv) Is it possible to characterise with an OCL expression the set of system states which comprise at least one node?
If yes, tell how, if no, explain why not. (1)

(v) Consider the OCL requirement

$$expr = \mathsf{context}\ Node\ \mathsf{inv} : r \leq m.r$$

Provide a system state σ such that $I[\![expr]\!](\sigma, \emptyset) = \bot$ and prove that your σ has this property.

Give an intuition of why $I[\![expr]\!](\sigma, \emptyset)$ yields $\bot$.

Can you fix the OCL expression such that there is no system state for which the fixed OCL expression evaluates to $\bot$? (1)

Hint: You may use object diagrams to represent system states. Proofs are a very strong means to convince tutors.

Exercise 4 (5 Bonus)

Is I (as defined in Annex A of the OCL standard document [OMG, 2006]) a function or not?

Hint: Recall the mathematical definition of "function" and then prove or disprove I to be one.

References

[OMG, 2006] OMG (2006). Object Constraint Language, version 2.0. Technical Report formal/06-05-01.