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Software Design, Modeling, and Analysis in UML

http://swt.informatik.uni-freiburg.de/teaching/WS2016-17/sdmauml

Exercise Sheet 2

Early submission: Monday, 2016-11-07, 12:00 Regular submission: Tuesday, 2016-11-08, 8:00

Exercise 1 – OCL Typing and Abbreviations (6/20 Points)

Consider the following basic object signature for a WSN:

$$\mathscr{S} = (\{Int\}, \{Node\}, \{m : Node_{0,1}, s : Node_*, v : Int\}, \{Node \mapsto \{m, s, v\}\}).$$

Assume that $\mathscr{D}(Int)$ is type-compatible with OCL's Int.

Check the following OCL expressions for well-typedness:

(i) $v(self_{Node}) > 0$ (1)

(ii) $v(m(self_{Node})) > 0$ (1)

(iii) $self_{Node} \,.\, s$ -> size > 0 (1)

(iv) $self_{Node} \,.\, m$ -> size > 0 (1)

(v) $s(self_{Node}) = self_{Node}$ (1)

(vi) $self_{Node} \,.\, s$ -> $v > 0$ (1)

Exercise 2 – OCL Abbreviations and Semantics (6/20 Points)

Consider the OCL constraint

$$F_0 := \mathsf{context}\ Node\ \mathsf{inv} : v \leq m.v$$

wrt. the signature from Exercise 1.

(i) Fully un-abbreviate F_0 and convert it to prefix normal form. (2)

(ii) To which truth value does F_0 evaluate for the following system state σ_1?

$$\sigma_1 = \{1_N \mapsto \{m \mapsto \{1_N\}, s \mapsto \{2_N\}, v \mapsto 3\}, 2_N \mapsto \{m \mapsto \{1_N\}, s \mapsto \emptyset, v \mapsto 2\}\}$$

Prove your claim. (2)

(iii) To which truth value does F_0 evaluate for the following system state σ_2?

$$\sigma_2 = \{1_N \mapsto \{m \mapsto \{1_N\}, s \mapsto \{2_N\}, v \mapsto 3\}, 2_N \mapsto \{m \mapsto \{1_N\}, s \mapsto \emptyset, v \mapsto 27\}\}$$

Prove your claim. (2)

Exercise 3 – Formalising Requirements in OCL (8/20 Points + 2 Bonus)

Consider the basic object signature for WSN from Exercise 1 with the structure

$$\mathscr{D}(Int) = \mathbb{Z}, \qquad \mathscr{D}(Node) = \{1_N, 2_N, 3_N, \dots\}$$

(or, if you like, use your own proposal from the previous exercise sheet – just state which one you're using, and in case you use your own proposal, please provide it in your submission for self-containedness).

Consider the following natural language requirements on system states. Formalise your understanding of each requirement using the OCL fragment introduced in the lecture such that the your corresponding OCL constraint evaluates to *true* if and only if the requirement is satisfied.

"Test" each of your formalisations *expr* by providing two system states σ_1 and σ_2 such that σ_1 satisfies the requirement and σ_2 does not, and argue (informally) to which value your corresponding OCL constraint evaluates.

(i) "The sensor reading value of nodes ranges from 0 to 10." (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) "There is exactly one node, and it has no master or slave, and its sensor reading value is 7." (1)

(v) Choose one of your OCL constraints provided for (i) to (iv) as F and either the positive or the negative corresponding example system state σ and compute the value to which F evaluates for this σ. (2)

(vi) Consider the OCL constraint F_0 from Exercise 2.

Provide a system state σ such that F_0 evaluates to $\bot$, prove that your σ has this property, and give an intuition of why F_0 evaluates to $\bot$ for your σ. (2)

(vii) Can you fix F_0 such that it still evaluates to *true* for exactly all desired system states (which ones are that?) and to *false* otherwise (but never to $\bot$)? (2 Bonus)

Bonus Exercise (3 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). Object Constraint Language, version 2.0. Technical Report formal/06-05-01.