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:
\[ \mathcal{S} = (\{\text{Int}\}, \{\text{Node}\}, \{m : \text{Node}_{0,1}, s : \text{Node}_*, v : \text{Int}\}, \{\text{Node} \mapsto \{m, s, v\}\}). \]
Assume that \( \mathcal{D}(\text{Int}) \) is type-compatible with OCL’s \( \text{Int} \).
Check the following OCL expressions for well-typedness:

(i) \( v(\text{self}_\text{Node}) > 0 \)  
(ii) \( v(m(\text{self}_\text{Node})) > 0 \)  
(iii) \( \text{self}_\text{Node}.s \mapsto \text{size} > 0 \)  
(iv) \( \text{self}_\text{Node}.m \mapsto \text{size} > 0 \)  
(v) \( s(\text{self}_\text{Node}) = \text{self}_\text{Node} \)  
(vi) \( \text{self}_\text{Node}.s \mapsto v > 0 \)

Exercise 2 – OCL Abbreviations and Semantics (6/20 Points)
Consider the OCL constraint
\[ F_0 := \text{context Node inv : } v \leq m.v \]
\( \) 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 \( \sigma_1 \)?
\[ \sigma_1 = \{1N \mapsto \{m \mapsto \{1N\}, s \mapsto \{2N\}, v \mapsto 3\}, 2N \mapsto \{m \mapsto \{1N\}, s \mapsto \emptyset, v \mapsto 2\}\} \]
Prove your claim. (2)

(iii) To which truth value does \( F_0 \) evaluate for the following system state \( \sigma_2 \)?
\[ \sigma_2 = \{1N \mapsto \{m \mapsto \{1N\}, s \mapsto \{2N\}, v \mapsto 3\}, 2N \mapsto \{m \mapsto \{1N\}, s \mapsto \emptyset, v \mapsto 27\}\} \]
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

$$\mathcal{D}(\text{Int}) = \mathbb{Z}, \quad \mathcal{D}(\text{Node}) = \{1_N, 2_N, 3_N, \ldots \}$$

(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-containment).

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 \(\text{true}\) if and only if the requirement is satisfied.

“Test” each of your formalisations \(\text{expr}\) by providing two system states \(\sigma_1\) and \(\sigma_2\) such that \(\sigma_1\) satisfies the requirement and \(\sigma_2\) 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 \(\sigma\) and compute the value to which \(F\) evaluates for this \(\sigma\). (2)

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

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

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

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Bonus Exercise

(3 Bonus)

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

\(\text{Hint: Recall the mathematical definition of “function” and then prove or disprove } I \text{ to be one.}\)

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References