Nils Hagner 4346038 Felix Karg 4342014
Michael Fleig 4340085 Anush Davtyan 4368689

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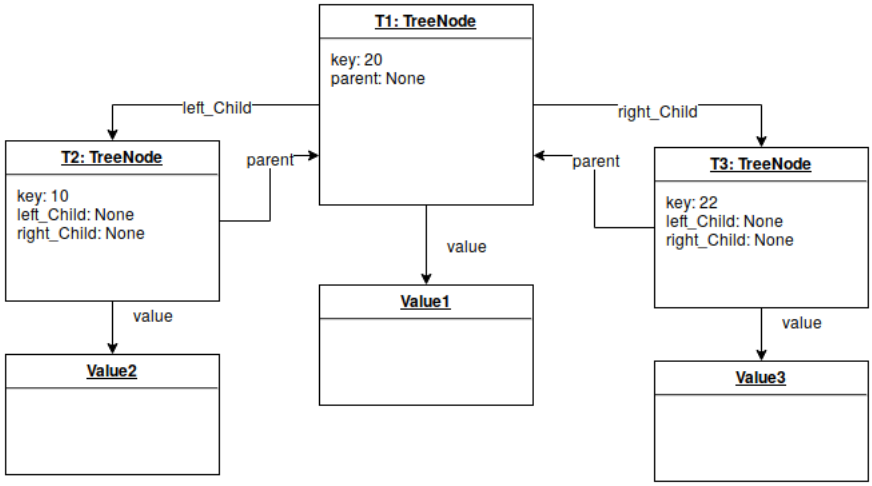
Solutions for Excercise sheet 2

Exercise 1 – OCL

i $\mathcal{S} = (\{Int\}, TreeNode, Object, \{key : Int, left\_Child : TreeNode, right_Child : TreeNode, parent : TreeNode, value : Object\}, \{TreeNode \mapsto \{key, left\_Child, right\_Child, parent, \{\}\}, \{\}, \{TreeNode \mapsto \emptyset, Object \mapsto \{\}\})\mathcal{D}(Int) = Z, \mathcal{D}(TreeNode) = \{T1, T2, T3, ...\}, \mathcal{D}(Object) = \{O1, O2, O3, ...\}$

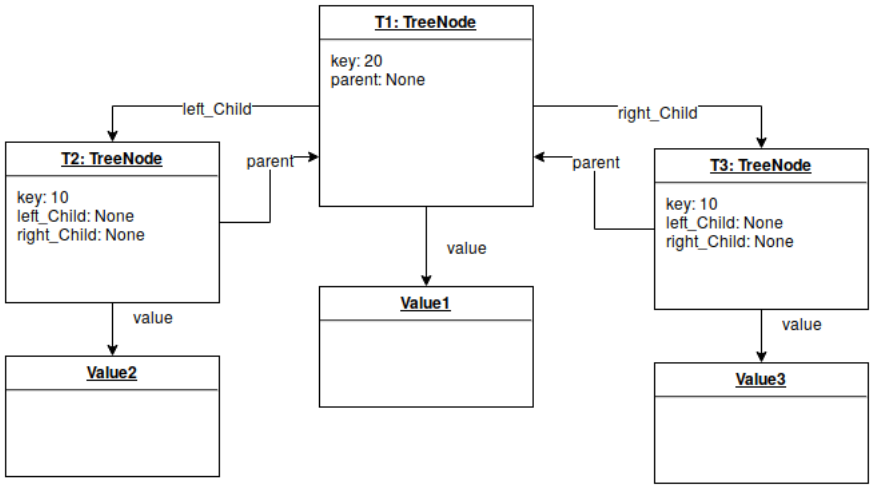
a)

$$\sigma_1 = \{T_1 \mapsto \{key \mapsto 20, left\_Child \mapsto \{T2\}, right\_Child \mapsto \{T3\}, parent \mapsto \emptyset, value \mapsto O_1\}$$
$$T_2 \mapsto \{key \mapsto 10, left\_Child \mapsto \emptyset, right\_Child \mapsto \emptyset, parent \mapsto \{T1\}, value \mapsto O_2\}$$
$$T_3 \mapsto \{key \mapsto 20, left\_Child \mapsto \emptyset, right\_Child \mapsto \emptyset, parent \mapsto \{T1\}, value \mapsto O_3\}$$
$$O_1 \mapsto \{\}$$
$$O_2 \mapsto \{\}$$
$$O_3 \mapsto \{\}$$
$$\}$$



The system state σ_1 evaluates to true because $key(left\_Child(T_1)) \leq key(T_1) \leq key(right\_Child(T_1))$

$$\sigma_2 = \{T_1 \mapsto \{key \mapsto 20, left\_Child \mapsto \{T2\}, right\_Child \mapsto \{T3\}, parent \mapsto \emptyset, value \mapsto O_1\}$$
$$T_2 \mapsto \{key \mapsto 10, left\_Child \mapsto \emptyset, right\_Child \mapsto \emptyset, parent \mapsto \{T1\}, value \mapsto O_2\}$$
$$T_3 \mapsto \{key \mapsto 10, left\_Child \mapsto \emptyset, right\_Child \mapsto \emptyset, parent \mapsto \{T1\}, value \mapsto O_3\}$$
$$O_1 \mapsto \{\}$$
$$O_2 \mapsto \{\}$$
$$O_3 \mapsto \{\}$$
$$\}$$



The system state σ_2 evaluates to false because
$key(left\_Child(T_1)) < key(right\_Child(T_1)) = key(T_1)$

$$\sigma_3 = \{\}$$

The system state σ_3 evaluates to $\perp$ because there are no Instances of TreeNode and the formula can not be evaluated to true or false.

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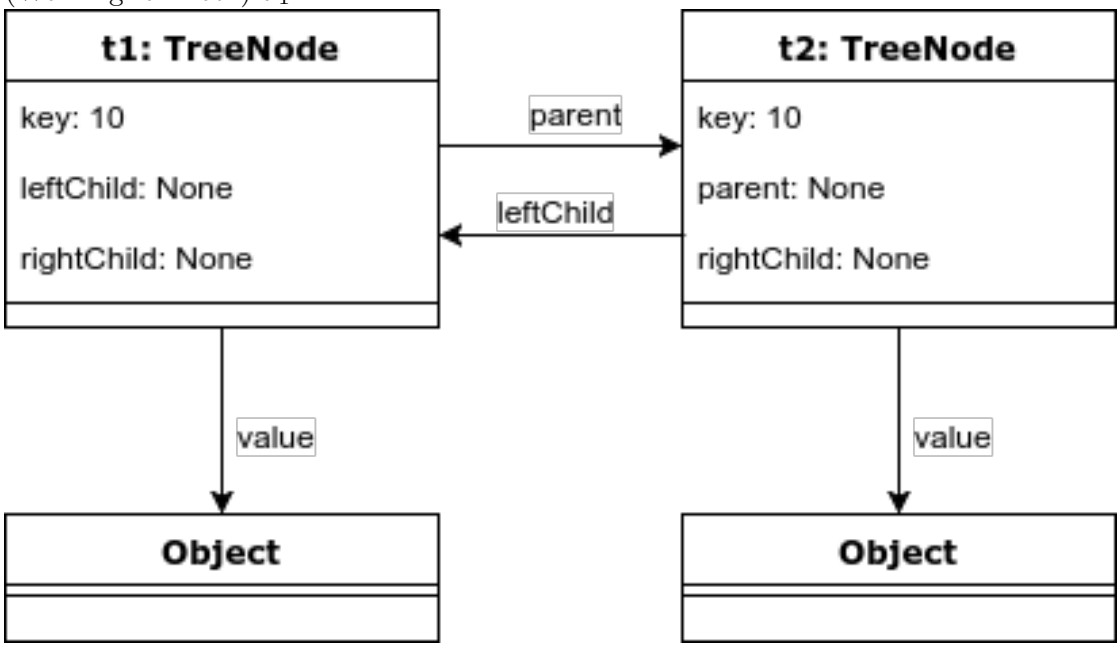
a) $\forall o \in allInstances_{Object} \bullet \forall t_1 \in allInstances_{TreeNode} \bullet \forall t_2 \in allInstances_{TreeNode} \bullet (value(t_1) = o \Rightarrow value(t_2) \neq o)$

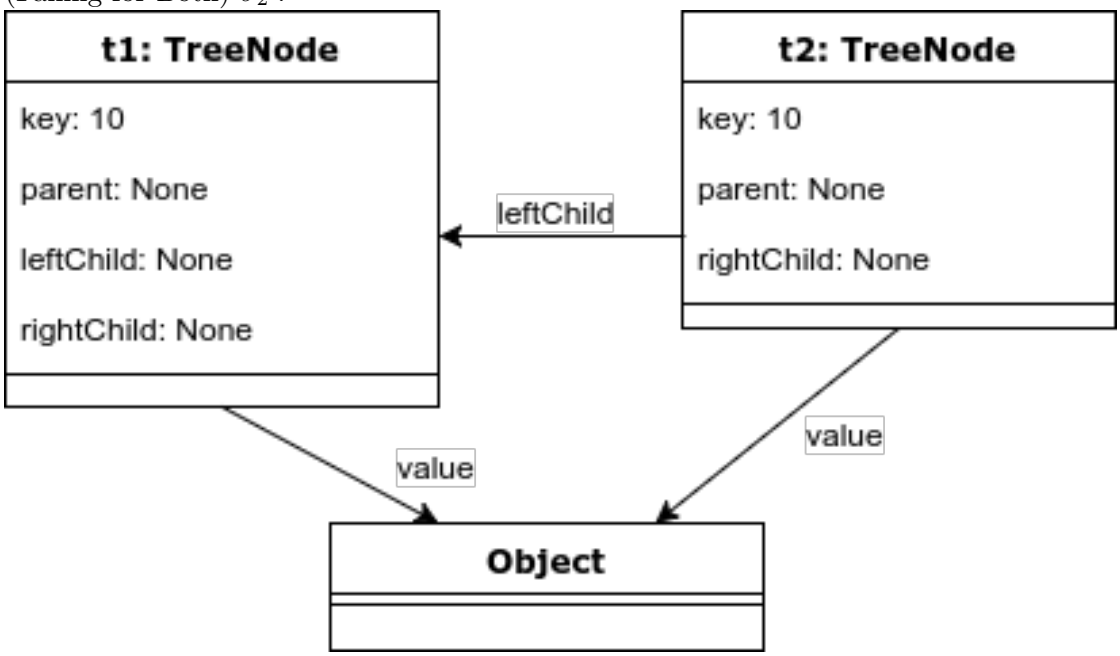
b) $\forall t_1 \in allInstances_{TreeNode} \bullet \forall t_2 \in allInstancesTreeNode \bullet (t_1 = leftChild(t_2) \Leftrightarrow t_2 = parent(t_1))$

Some System States:

(Working for Both) σ_1 :



(Failing for Both) σ_2 :



Exercise 2

Uppaal-checks:
E¡¿ worker.BROKEN

(Property is Satisfied) E¡¿ (P1.CRITICAL && P2.CRITICAL)
(Property is Satisfied)

Exercise 3

A[] not ((Process(0).CRITICAL + Process(1).CRITICAL + Process(2).CRITICAL + Process(3).CRITICAL) ¿ 1)
(or generally from 0 to n)
A and B do not satisfy the Mutual exclusion.