

Formal Methods for Java

Lecture 20: Jahob Syntax

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The Jahob system

Focus of Jahob: verifying properties of **data structures**.

Developed at

- EPFL, Lausanne, Switzerland (Viktor Kuncak)
- MIT, Cambridge, USA (Martin Rinard)
- Freiburg, Germany (Thomas Wies)

References

- Jahob webpage: http://lara.epfl.ch/w/jahob_system
- Viktor Kuncak's PhD thesis

Jahob Specification

Jahob and JML have similar keywords:

JML	Jahob
ensures	ensures
modifies	modifies
requires	requires
assert	assert
assume	assume
invariant	invariant
loop_invariant	invariant
models	specvar
represents	vardefs
ghost	ghost specvar
assert; assume	noteThat

The position of the specification slightly differs.

Example: Jahob Specification

```
public class ArrayList
{
    private Object[] elementData;
    private int size;

    /*: public specvar init :: bool;
       public specvar content :: "(int * obj) set";
       ...
       vardefs "init == elementData ~= null"
       vardefs "content == {(i, n). 0 <= i & i < size & n = elementData.[i]
       ...
       invariant InitInv:
           "~init --> size = 0 & elementData = null"
       ...
    */
```

Example: Jahob Specification (cont.)

```
private boolean add(Object o1)
  /*: requires "init & theinus"
     modifies "Array.arrayState", elementData, msize, "ArrayList.hidden",
     ensures "... "
  */
  {
    elementData[size] = o1;
    size = size + 1;
    //: noteThat "old csize < size";
    return true;
  }
}
```

Core syntax of HOL

Jahob's assertion language is a subset of the interactive theorem prover *Isabelle/HOL* which is built on the **simply typed lambda calculus**.

Terms and Formulas:

$f ::=$	$\lambda x :: t. f$	lambda abstraction (λ is also written $\%$)
	$f_1 f_2$	function application
	x	variable or constant
	$f :: t$	typed formula

Types:

$t ::=$	<code>bool</code>	truth values
	<code>int</code>	integers
	<code>obj</code>	uninterpreted objects
	$t_1 \Rightarrow t_2$	total functions
	t set	sets
	$t_1 * t_2$	<i>pairs</i>

Predefined constants in HOL

Core syntax is enriched with predefined constants:

- Boolean connectives: $\sim F$, $F \& G$, $F | G$, $F \rightarrow G$, $F \leftrightarrow G$
- (dis)equality: $f = g$, $f \sim = g$
- sets and set operations:
 $\{f_1, \dots, f_n\}$, $\{x. F\}$, $f : S$, $S \text{ Un } T$, $S \text{ Inter } T$, $S - T$
- quantification: $\text{ALL } x. F$, $\text{EX } x. F$
- reflexive transitive closure of predicates: $\text{rtrancl_pt } P \ a \ b$
- the null object: `null`
- ...

Field access is handled by functions, alternatively `..` can be used:

```
/*:  
  requires "Node.next obj ~= null"  
  or requires "obj..Node.next ~=null"  
*/
```

Array access also requires an additional dot:

```
/*:  
  requires "arr.[k] ~= null"  
*/
```


Example HOL-formulas

On input, array *arr* is not null and contains non-null elements.

```
/*:  
  requires "arr ~= null &&  
    (ALL k. (0 <= k && k < (Array.length arr)) --> arr.[k] ~= null)"  
*/
```

On output, array *arr* is sorted.

```
/*:  
  ensures  
    "(ALL k. ((0 <= k && k < ((Array.length arr) - 1)) -->  
      (arr.[k]..InsertionSortNode.key  
        <= arr.[k+1]..InsertionSortNode.key)))"  
*/
```

Demo: Insertion Sort