

COMP 340-08B

Reasoning about Programs

Assignment 10

This assignment introduces the Java Modelling Language (JML). Please refer to the separate handout for more information on these tools.

The assignment tasks are contained in the Java file `ArrayTests.java`, which can be downloaded from the COMP 340-08B course home page in Moodle at

<http://elearn.waikato.ac.nz/course/view.php?id=2567>

It contains three simple array-based algorithms that have been annotated with pre- and postconditions in JML notation, and a short main program for testing.

Exercise 1 (1+1 marks)

Download and study the `ArrayTests.java` file, and experiment with the JML Runtime Assertion Checker `jmlrac` and the Extended Static Checker for Java `escj` to get to know them.

In particular, answer the following questions.

- a) When you delete the precondition “`requires a.length >= 1;`” of the method `findMaximum()`, static checking produces an error. What message do you get, and what does it mean?
- b) Look at the `bubbleSort()` method, a simple sorting algorithm that has been fully annotated with assertions sufficient to completely prove that the indicated postcondition is satisfied in all cases.

However, the specification of the postcondition is incomplete, because it does not contain all the requirements that we would expect a sorting algorithm to satisfy. Can you find input and output contents of the array `a[]` that satisfy the given pre- and postconditions, but such that the output is not a properly sorted version of the input?

Exercise 2 (9 marks)

Annotate the `sequentialSearch()` method in file `ArrayTests.java` with so many assertions as are needed to completely *prove* that the indicated postcondition is satisfied in all cases. Insert assertions before and after every statement, and use the JML tools to confirm that they are satisfied.

```
public static int sequentialSearch(final int[] a, final int item)
{
    int index = 0;
    while (index < a.length && a[index] != item) {
        index++;
    }
    return index;
}
```

When you are satisfied that your assertions are sufficient to verify the method, extract all the predicate logic formulas that have to be proven and sketch their proofs on paper.

Exercise 3 (9 marks)

Repeat exercise 2 for the `findMaximum()` method.

```
public static int findMaximum(final int[] a)
{
    int index = 1;
    int max = a[0];
    while (index < a.length) {
        if (a[index] > max) {
            max = a[index];
        }
        index++;
    }
    return max;
}
```

Submission

Please put your written answers to the exercises in the COMP340 slot on level 3 of G Block, and submit your annotated Java file electronically through the COMP 340-08B course home page in Moodle at

<http://elearn.waikato.ac.nz/course/view.php?id=2567>

before the due date.

Due date: Wednesday 8 October 2008, 17:00