EE360T/EE382C-16: Software Testing
Problem Set 1

Out: Sep 5, 2024; **Due: Sep 20, 2024 11:59pm**
Submission: *.zip via Canvas
Maximum points: 40

1 Testing data structures

Consider the following implementation of a singly-linked list data structure, which represents a sequential container for boolean values:

```
package pset1;

import java.util.HashSet;
import java.util.Set;

public class SLList {
    Node first; // first node in <this> list
    Node last; // last node in <this> list

    static class Node {
        boolean elem;
        Node next;
    }

    boolean repOk() {
        // postcondition: returns true iff <this> is an acyclic list, i.e.,
        //                          there is no path from a node to itself

        if (first == null || last == null) {
            return first == last;
        }
        Set<Node> visited = new HashSet<Node>();
        Node n = first;
        while (n != null) {
            if (!visited.add(n)) {
                return false;
            }
            if (n.next == null) {
                return n == last;
            }
            n = n.next;
        }
        return true;
    }

    void add(boolean e) {
        // precondition: this.repOk()
        // postcondition: adds <e> in a new node at the end of <this>
        //                list; the rest of <this> list is unmodified

        // your code goes here
```

```
    }
}
```

1.1 Implementing `add` [4 points]

Implement the method `add` as specified.

1.2 Testing `add` [6 points]

Implement the two test methods in the following class `SLListAddTester` as specified:

```
package pset1;

import static org.junit.Assert.*;
import org.junit.Test;

public class SLListAddTester {
    @Test public void test0() {
        SLList l = new SLList();
        assertTrue(l.repOk());
        l.add(true);

        // write a sequence of assertTrue method invocations that
        // perform checks on the values for all the declared fields
        // of list and node objects reachable from l

        assertTrue(l.first != null);
        // your code goes here

    }

    @Test public void test1() {
        SLList l = new SLList();
        assertTrue(l.repOk());
        l.add(true);
        assertTrue(l.repOk());
        l.add(false);
        assertTrue(l.repOk());

        // write a sequence of assertTrue method invocations that
        // perform checks on the values for all the declared fields
        // of list and node objects reachable from l

        assertTrue(l.first != null);
        // your code goes here
    }
}
```

1.3 Testing `repOk` [10 points]

Consider testing the method `repOk` by writing a test suites that consists of valid or invalid lists. Specifically, implement test methods in the following class `SLListRepOkTester` such that: (1) each test allocates exactly one list `l`; (2) each test method makes exactly one invocation `l.repOk()`; (3) each test method invokes `assertTrue(l.repOk())` or `assertFalse(l.repOk())` as its last statement; (4) no invocation of `add` is made in any test method; (5) the test suite as a whole consists of all singly-linked list data structures – whether acyclic or not – that can possibly be constructed using up to 2 nodes.

```
package pset1;
```

```
import static org.junit.Assert.*;
import org.junit.Test;
import pset1.SLList.Node;

public class SLListRepOkTester {
    @Test public void t0() {
        SLList l = new SLList();
        assertTrue(l.repOk());
    }

    @Test public void t1() {
        SLList l = new SLList();
        Node n = new Node();
        // your code goes here

    }

    // your code goes here
}
```

2 Testing contracts

Consider the following code snippet that declares a class `C`:

```
package pset1;

public class C {
    int f;

    public C(int f) {
        this.f = f;
    }

    @Override
    public boolean equals(Object o) {
        // assume this method is implemented for you
    }

    @Override
    public int hashCode() {
        // assume this method is implemented for you
    }
}
```

Consider next the following code snippet that declares a class `D` as a subclass of `C`:

```
package pset1;

public class D extends C {
    int g;

    public D(int f, int g) {
        super(f);
        this.g = g;
    }

    @Override
    public boolean equals(Object o) {
        // assume this method is implemented for you
    }

    @Override
```

```
    public int hashCode() {
        // assume this method is implemented for you
    }
}
```

2.1 Testing `equals` [15 points]

According to the contract for `java.lang.Object` any correct Java program must satisfy certain properties with respect to the `equals` methods; these properties include[1]:

> P_1: For any non-null reference value x, $x.equals(null)$ should return false;
>
> P_2: It is reflexive: for any non-null reference value x, $x.equals(x)$ should return true;
>
> P_3: It is symmetric: for any non-null reference values x and y, $x.equals(y)$ should return true if and only if $y.equals(x)$ returns true; and
>
> P_4: It is transitive: for any non-null reference values x, y, and z, if $x.equals(y)$ returns true and $y.equals(z)$ returns true, then $x.equals(z)$ should return true;

You are to implement a test suite that checks three of the four properties – namely, P_1, P_2, and P_3 – with respect to the `equals` methods implemented in the three classes `pset1.C`, `pset1.D`, and `java.lang.Object`. Specifically, implement test methods in the following class `EqualsTester` such that: (1) each test method has exactly one invocation of `assertTrue(...)` or `assertFalse(...)`; (2) each property is tested with respect to each of the three `equals` methods, e.g., the test suite must have three test methods for P_1; (3) each property is tested with respect to each combination of the three object types (`C`, `D`, or `Object`) for the inputs to `equals`, e.g., the test suite must have at least nine tests for P_3:

```
package pset1;

import static org.junit.Assert.*;
import org.junit.Test;

public class EqualsTester {
    /*
     * P1: For any non-null reference value x, x.equals(null) should return false.
     */

    @Test public void t0() {
        assertFalse(new Object().equals(null));
    }

    // your test methods for P1 go here

    /*
     * P2: It is reflexive: for any non-null reference value x, x.equals(x)
     * should return true.
     */

    // your test methods for P2 go here

    /*
     * P3: It is symmetric: for any non-null reference values x and y, x.equals(y)
     * should return true if and only if y.equals(x) returns true.
     */

    // your test methods for P3 go here

    /*
     * P4: It is transitive: for any non-null reference values x, y, and z,
     * if x.equals(y) returns true and y.equals(z) returns true, then
```

```
     * x.equals(z) should return true.
     */

    // you do not need to write tests for P4

}
```

2.2 Testing `hashCode` [5 points]

The contract for `java.lang.Object` additionally requires the following property that relates `equals` and `hashCode`[1]:

> P_5 : If two objects are equal according to the *equals*(*Object*) method, then calling the *hashCode* method on each of the two objects must produce the same integer result.

Implement test methods in the following class `HashCodeTester` such that: (1) each test method has exactly one invocation of `assertTrue(...)` or `assertFalse(...)`; (2) the property is tested with respect to each combination of the three object types (`C`, `D`, or `Object`) for the inputs to `equals`, so the test suite must have at least nine tests:

```
package pset1;

import static org.junit.Assert.*;
import org.junit.Test;

public class HashCodeTester {
    /*
     * P5: If two objects are equal according to the equals(Object)
     * method, then calling the hashCode method on each of
     * the two objects must produce the same integer result.
     */

     // your test methods go here

}
```

[1] `http://docs.oracle.com/javase/7/docs/api/java/lang/Object.html`