Submitted By: Akshay Malhotra

CSE565 - Assignment 1 - Software Unit Testing Frameworks

Part 1

What is a unit testing framework?

Understanding Unit Testing - Unit Testing is a method through which individual components or units of software can be tested. These units can be procedures, functions or classes. The motivation behind unit testing is to break your program into discrete, testable chunks and ensure that as a unified component, the program executes without any issues. There are 2 types of unit testing - manual and automated.

Understanding Unit Testing Frameworks - Unit Testing frameworks are tools that help developers/testers with writing and executing unit test cases. Frameworks provide a wireframe for developers/testers to build and test the functionality of their programs. Additionally, they also provide comprehensive reports of test results. These frameworks are used in every stage of a software development life cycle including requirement gathering, performance optimization and quality assurance. Using frameworks, a software developer/tester can simulate different scenarios to test the program and check if it fails. Moreover, it also ensures that existing functionality does not break when new functionality/logic is introduced. When integrated properly, it helps software developers/testers ensure that no existing functionality has been amended and the new functionality works well together. In a CI/CD environment, this process is automated and requires minimal human intervention.

How would a developer utilize a framework?

A developer can utilize the framework by writing unit tests cases that test the functionality of a component. This component can be a complex logic that can be further broken down into various chunks. Breaking a component into chunks helps evaluate the performance and functionality of each chunk independently. A developer can take advantage of unit testing in all stages of the software development life cycle such as requirement gathering, development, optimization and many more. It will help the developer/tester write test cases quicker as he/she would be familiar with the APIs, execute tests quicker than usual and generate comprehensive performance metrics. The developer is provided with base classes/interfaces that need to be inherited for testing purposes. He/she is also provided with attributes that can be placed in the program to mark certain functions/classes as test-based functions/classes. There are many more utilities that a framework provides to a developer to support development. If integrated properly with the software, the unit testing framework will automate all the unit tests and be an integral part of the production pipeline, thereby requiring minimal human intervention.

What benefits does a framework provide?

There are many benefits of using a unit testing framework. Some of them are mentioned below:

1. Helps with easier and quicker creation of test cases as the framework provides a base class to inherit from and attributes that have to be placed in the code.
2. These frameworks help save time and money in the long run. As the software improves and expands, unit testing ensures that existing functionality does not break.
3. These frameworks help in easy and early bug detection and refactoring of source code.
4. Unit Test frameworks help improve the quality of code. It helps identify defects before the code goes into integration testing and makes you think of edge cases.
5. It helps you understand the performance metrics of your software.

Identify 2 frameworks for a language such as Java, C++, Python, Javascript for further consideration. Compare the frameworks in terms of common capabilities as well as any differences.

I compare 2 Java-based testing frameworks - JUnit and TestNG. As the frameworks deal with similar technologies, they are more comparable. Mentioned below are my comparison results.

Submitted By: Akshay Malhotra

Category	**JUnit**	**TestNG**
Parallel Test Runs	Not Supported Running parallel tests is not supported	Supported Running multiple tests in parallel is permitted.
Dependency Tests	Not Supported If initial tests fail, all dependent tests are marked as failed.	Supported If the initial test fails, all dependent tests will be marked as skipped.
Implementation of Assumptions	Supported Assumptions can be used to skip certain test cases.	Not Supported No notion of assumptions.
Annotation Support	Included This was not there in older versions.	Included Annotation support was always included.
Order of Test Execution	No implicit order of execution	No implicit order of execution
Test Time Out (test should be executed in a specified time range)	Supported	Supported

Submitted By: Akshay Malhotra

Part 2

There are 2 Java files.

- HeapSort.java - This class has all the core logic for heapsort.
- HeapSortTest.java - This class has all the test cases for HeapSort.java

HeapSort.java

```
import java.util.ArrayList;

import java.util.Arrays;

import java.util.Collections;


public class HeapSort {


   void sort(ArrayList<Integer> inputArray)

   {

       int n = inputArray.size();


       for (int i = n / 2 - 1; i >= 0; i--){

           heapify(inputArray, n, i);

       }


       for (int i = n - 1; i > 0; i--) {

           Collections.swap(inputArray, 0, i);

           heapify(inputArray, i, 0);

       }

   }
```

```
    void heapify(ArrayList<Integer> inputArray, int n, int i) {
        int largest = i; // Initialize largest as root
        int l = 2 * i + 1; // left = 2*i + 1
        int r = 2 * i + 2; // right = 2*i + 2

        if (l < n && inputArray.get(l) > inputArray.get(largest))
            largest = l;
        if (r < n && inputArray.get(r) > inputArray.get(largest))
            largest = r;

        if (largest != i) {
            Collections.swap(inputArray, i, largest);
            heapify(inputArray, n, largest);
        }
    }

    // Driver code
    public static void main(String args[])
    {
        ArrayList<Integer> inputArray = new
ArrayList<Integer>(Arrays.asList(6,5,3,10,8,9));
        HeapSort ob = new HeapSort();
        ob.sort(inputArray);
        System.out.print(inputArray);
    }
}
```

Submitted By: Akshay Malhotra

HeapSortTest.java

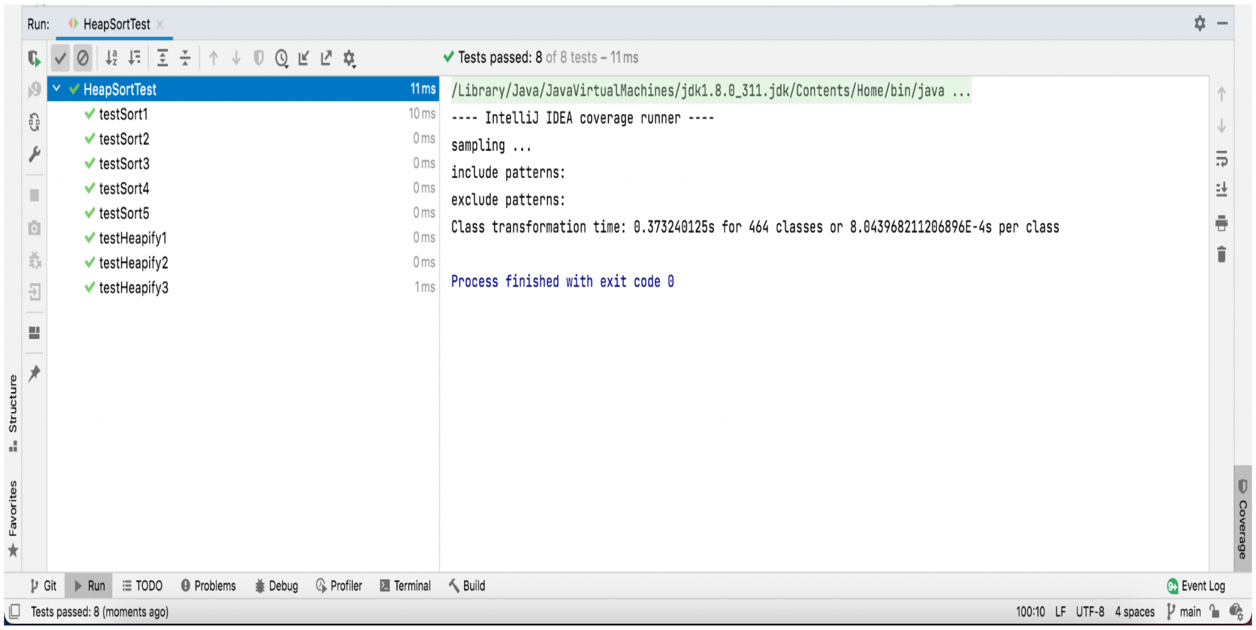
```
import org.junit.Before;

import org.junit.Test;


import static org.junit.Assert.assertArrayEquals;


import java.util.ArrayList;

import java.util.Arrays;

import java.util.Collections;


public class HeapSortTest {


   private HeapSort heatSortTester;


   // Test array used in tests

   private final static ArrayList<Integer> testSortArray_1 = new
ArrayList<Integer>(Arrays.asList(9,5,3,6));

   private final static ArrayList<Integer> testSortArray_2 = new
ArrayList<Integer>(Arrays.asList(Integer.MAX_VALUE, Integer.MIN_VALUE));

   private final static ArrayList<Integer> testSortArray_3 = new
ArrayList<Integer>();

   private final static ArrayList<Integer> testSortArray_4 = new
ArrayList<Integer>(Collections.singletonList(0));
```

```
   private final static ArrayList<Integer> testSortArray_5 = new
ArrayList<Integer>(Arrays.asList(10,5,15,6,7,4,5,2,3,5,2,3,2));

   private final static ArrayList<Integer> testHeapifyArray_1 = new
ArrayList<Integer>(Arrays.asList(Integer.MAX_VALUE, Integer.MIN_VALUE));
   private final static ArrayList<Integer> testHeapifyArray_2 = new
ArrayList<Integer>(Collections.singletonList(0));
   private final static ArrayList<Integer> testHeapifyArray_3 = new
ArrayList<Integer>(Arrays.asList(10,5,15,6,7,4,5,2,3,5,2,3,2));




   @Before
   public void setUp() {
       heatSortTester = new HeapSort();
   }

   @Test
   public void testSort1() {
       ArrayList<Integer> result = new ArrayList<Integer>(testSortArray_1);
       Collections.sort(result);

       heatSortTester.sort(testSortArray_1);

       assertArrayEquals(testSortArray_1.toArray(), result.toArray());
   }

   @Test
   public void testSort2() {
       ArrayList<Integer> result = new ArrayList<Integer>(testSortArray_2);
```

```
        Collections.sort(result);

        heatSortTester.sort(testSortArray_2);

        assertArrayEquals(testSortArray_2.toArray(), result.toArray());
    }

    @Test
    public void testSort3() {
        ArrayList<Integer> result = new ArrayList<Integer>(testSortArray_3);
        Collections.sort(result);

        heatSortTester.sort(testSortArray_3);

        assertArrayEquals(testSortArray_3.toArray(), result.toArray());
    }

    @Test
    public void testSort4() {
        ArrayList<Integer> result = new ArrayList<Integer>(testSortArray_4);
        Collections.sort(result);

        heatSortTester.sort(testSortArray_4);

        assertArrayEquals(testSortArray_4.toArray(), result.toArray());
    }

    @Test
    public void testSort5() {
        ArrayList<Integer> result = new ArrayList<Integer>(testSortArray_5);
        Collections.sort(result);

        heatSortTester.sort(testSortArray_5);

        assertArrayEquals(testSortArray_5.toArray(), result.toArray());
    }

    @Test
    public void testHeapify1() {
        ArrayList<Integer> result = new
ArrayList<Integer>(Arrays.asList(Integer.MAX_VALUE, Integer.MIN_VALUE));

        heatSortTester.heapify(testHeapifyArray_1, result.size(), 0);

        assertArrayEquals(testHeapifyArray_1.toArray(), result.toArray());
    }

    @Test
    public void testHeapify2() {
        ArrayList<Integer> result = new ArrayList<Integer>(testHeapifyArray_2);

        heatSortTester.heapify(testHeapifyArray_2, result.size(), 0);

        assertArrayEquals(testHeapifyArray_2.toArray(), result.toArray());
    }

    @Test
    public void testHeapify3() {
        ArrayList<Integer> result = new
ArrayList<Integer>(Arrays.asList(10,7,15,6,5,4,5,2,3,5,2,3,2));
```

```
        heatSortTester.heapify(testHeapifyArray_3, result.size(), 1);


        assertArrayEquals(testHeapifyArray_3.toArray(), result.toArray());
    }
}
```

Output Report



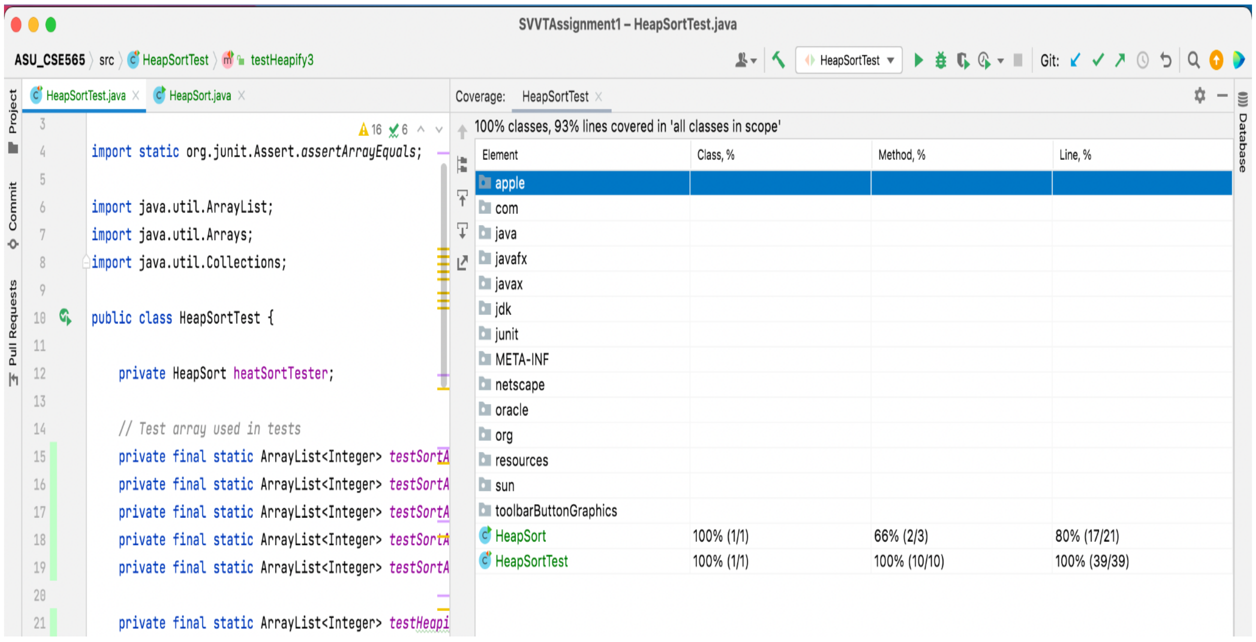
```
HeapSortTest        11ms
  testSort1         10ms
  testSort2          0ms
  testSort3          0ms
  testSort4          0ms
  testSort5          0ms
  testHeapify1       0ms
  testHeapify2       0ms
  testHeapify3       1ms
```

```
Tests passed: 8 of 8 tests – 11 ms

/Library/Java/JavaVirtualMachines/jdk1.8.0_311.jdk/Contents/Home/bin/java ...
---- IntelliJ IDEA coverage runner ----
sampling ...
include patterns:
exclude patterns:
Class transformation time: 0.373240125s for 464 classes or 8.043968211206896E-4s per class


Process finished with exit code 0
```

Tests passed: 8 (moments ago)

General Test Results - Time per test and Class Transformation Time

Submitted By: Akshay Malhotra


SVVTAssignment1 – HeapSortTest.java

ASU_CSE565 〉 src 〉 HeapSortTest 〉 testHeapify3

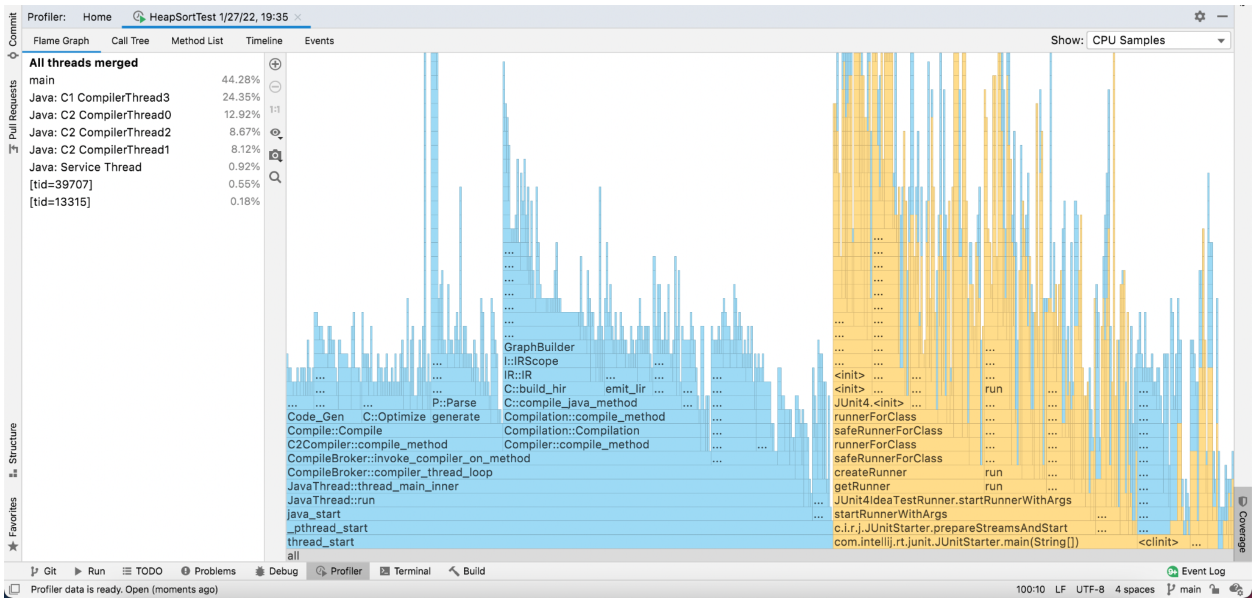
```java
import static org.junit.Assert.assertArrayEquals;

import java.util.ArrayList;
import java.util.Arrays;
import java.util.Collections;

public class HeapSortTest {

    private HeapSort heatSortTester;

    // Test array used in tests
    private final static ArrayList<Integer> testSortA
    private final static ArrayList<Integer> testSortA
    private final static ArrayList<Integer> testSortA
    private final static ArrayList<Integer> testSortA
    private final static ArrayList<Integer> testSortA

    private final static ArrayList<Integer> testHeapi
```

Coverage: HeapSortTest

100% classes, 93% lines covered in 'all classes in scope'

Element	Class, %	Method, %	Line, %
apple			
com			
java			
javafx			
javax			
jdk			
junit			
META-INF			
netscape			
oracle			
org			
resources			
sun			
toolbarButtonGraphics			
HeapSort	100% (1/1)	66% (2/3)	80% (17/21)
HeapSortTest	100% (1/1)	100% (10/10)	100% (39/39)

General Test Results - Coverage Report



All threads merged	
main	44.28%
Java: C1 CompilerThread3	24.35%
Java: C2 CompilerThread0	12.92%
Java: C2 CompilerThread2	8.67%
Java: C2 CompilerThread1	8.12%
Java: Service Thread	0.92%
[tid=39707]	0.55%
[tid=13315]	0.18%

General Test Results - Profiler Report

References

1. Tutorialspoint.com. 2022. *UnitTest Framework - Overview*. [online] Available at: <https://www.tutorialspoint.com/unittest_framework/unittest_framework_overview.htm>
2. O'Reilly Online Learning. 2022. *Unit Test Frameworks*. [online] Available at: <https://www.oreilly.com/library/view/unit-test-frameworks/0596006896/ch01.html>
3. 2022. [online] Available at: <https://www.baeldung.com/junit-vs-testng>

4. 2022. [online] Available at: <https://www.softwaretestinghelp.com/junit-vs-testng/>

5. 2022. [online] Available at: <https://en.wikipedia.org/wiki/Unit_testing/>

6. GeeksforGeeks. 2022. *HeapSort - GeeksforGeeks*. [online] Available at: <https://www.geeksforgeeks.org/heap-sort/>