

Program Structures and Algorithms

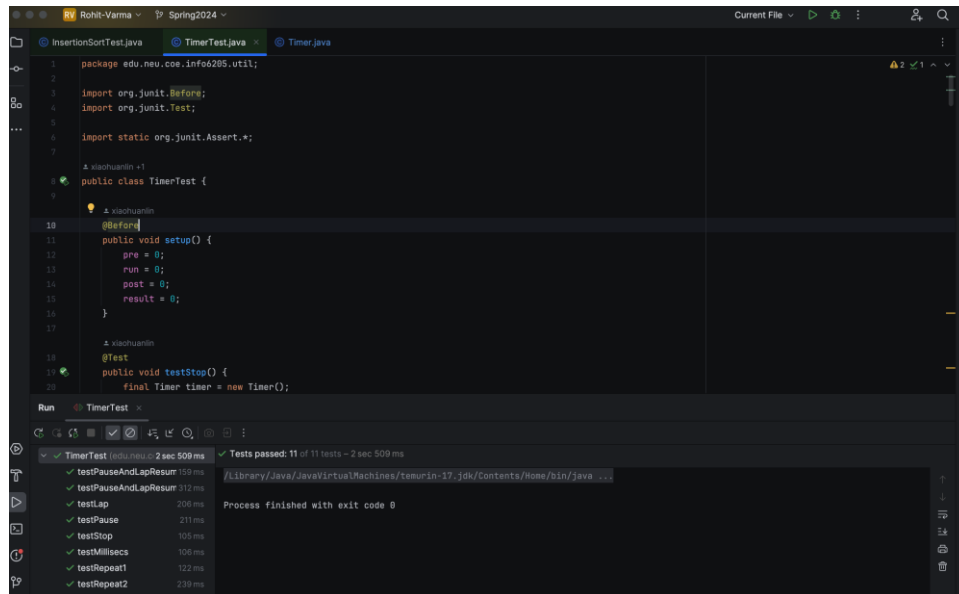
Spring 2024

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NUID: 002688431

GITHUB LINK: <https://github.com/rohit26300/Rohit-Varma.git>

Unit Test Screenshots:



The screenshot displays an IDE with a Java file named `TimerTest.java` and its corresponding unit test results. The code defines a `Timer` class and a `TimerTest` class with several test methods. The test results show that all 11 tests passed successfully.

```
package edu.neu.coe.info6205.util;

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

// @author: Rohit Varma Mudundi

public class TimerTest {

    // @author: Rohit Varma Mudundi
    @Before
    public void setup() {
        pre = 0;
        run = 0;
        post = 0;
        result = 0;
    }

    // @author: Rohit Varma Mudundi
    @Test
    public void testStop() {
        final Timer timer = new Timer();
        timer.stop();
    }
}
```

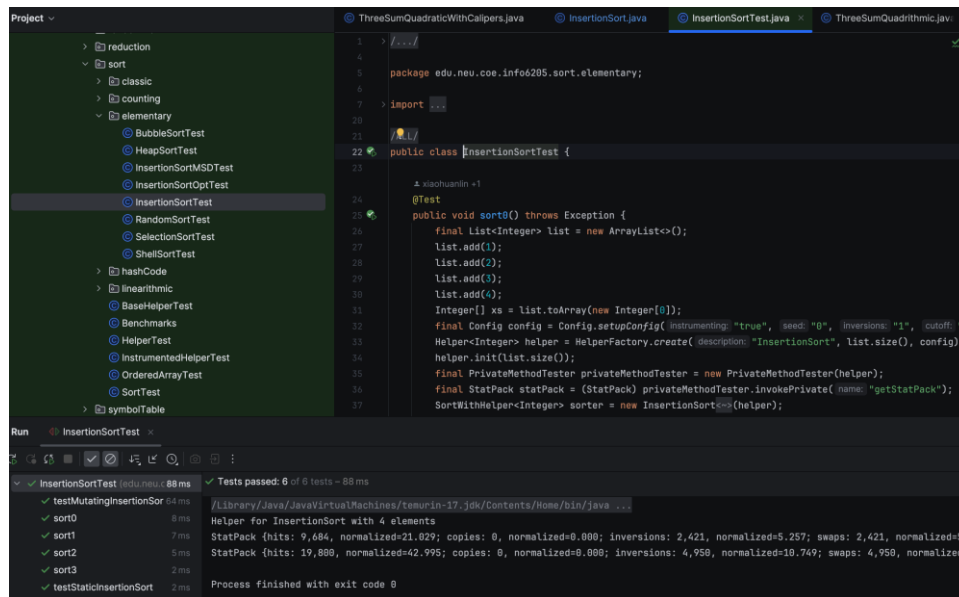
Run: TimerTest

Test Method	Duration	Status
testPauseAndLapResum	159 ms	✓
testPauseAndLapResum	312 ms	✓
testLap	206 ms	✓
testPause	211 ms	✓
testStop	105 ms	✓
testMillisecs	106 ms	✓
testRepeat1	122 ms	✓
testRepeat2	239 ms	✓

Tests passed: 11 of 11 tests - 2 sec 509 ms

Process finished with exit code 0

PART II :



The screenshot displays the IntelliJ IDEA IDE. The left sidebar shows a project structure with a package named 'edu.neu.coe.info6205.sort.elementary' containing several test classes, including 'InsertionSortTest'. The main editor window shows the source code of 'InsertionSortTest.java'. The code defines a public class 'InsertionSortTest' with a '@Test' method 'sort0()' that creates an 'ArrayList' of integers, adds elements 1, 2, 3, and 4, and then sorts it using the 'InsertionSort' algorithm. The bottom panel shows the 'Run' output, indicating that the tests passed successfully. The output text includes details about the test environment, the number of tests passed (6 of 6), and the execution time (88 ms).

The insertionSort method takes an array of integers as input and sorts it in ascending order using the Insertion Sort algorithm.



PART III

Conclusion:

/Library/Java/JavaVirtualMachines/temurin-17.jdk/Contents/Home/bin/java -
javaagent:/Applications/IntelliJ IDEA
CE.app/Contents/lib/idea_rt.jar=64002:/Applications/IntelliJ IDEA
CE.app/Contents/bin -Dfile.encoding=UTF-8 -classpath
/Users/rohitvarma/IdeaProjects/Rohit-
Varma/target/classes:/Users/rohitvarma/.m2/repository/com/phasmidsoftware/args_2.
13/1.0.3/args_2.13-1.0.3.jar:/Users/rohitvarma/.m2/repository/org/scala-lang/scala-
library/2.13.7/scala-library-2.13.7.jar:/Users/rohitvarma/.m2/repository/org/scala-
lang/modules/scala-parser-combinators_2.13/1.1.2/scala-parser-combinators_2.13-
1.1.2.jar:/Users/rohitvarma/.m2/repository/com/phasmidsoftware/number_2.13/1.0.12/
number_2.13-
1.0.12.jar:/Users/rohitvarma/.m2/repository/com/phasmidsoftware/flog_2.13/1.0.8/flog
_2.13-1.0.8.jar:/Users/rohitvarma/.m2/repository/org/slf4j/slf4j-api/1.7.30/slf4j-api-
1.7.30.jar:/Users/rohitvarma/.m2/repository/com/phasmidsoftware/matchers_2.13/1.0.
5/matchers_2.13-1.0.5.jar:/Users/rohitvarma/.m2/repository/org/scala-lang/scala-
compiler/2.13.6/scala-compiler-2.13.6.jar:/Users/rohitvarma/.m2/repository/org/scala-
lang/scala-reflect/2.13.6/scala-reflect-
2.13.6.jar:/Users/rohitvarma/.m2/repository/org/jline/jline/3.19.0/jline-
3.19.0.jar:/Users/rohitvarma/.m2/repository/net/java/dev/jna/jna/5.3.1/jna-
5.3.1.jar:/Users/rohitvarma/.m2/repository/org/apache/commons/commons-
math3/3.6.1/commons-math3-
3.6.1.jar:/Users/rohitvarma/.m2/repository/org/apache/logging/log4j/log4j-
api/2.19.0/log4j-api-
2.19.0.jar:/Users/rohitvarma/.m2/repository/log4j/log4j/1.2.17/log4j-
1.2.17.jar:/Users/rohitvarma/.m2/repository/com/google/guava/guava/31.1-jre/guava-

31.1-

jre.jar:/Users/rohitvarma/.m2/repository/com/google/guava/failureaccess/1.0.1/failureaccess-

1.0.1.jar:/Users/rohitvarma/.m2/repository/com/google/guava/listenablefuture/9999.0-empty-to-avoid-conflict-with-guava/listenablefuture-9999.0-empty-to-avoid-conflict-with-

guava.jar:/Users/rohitvarma/.m2/repository/com/google/code/findbugs/jsr305/3.0.2/jsr305-3.0.2.jar:/Users/rohitvarma/.m2/repository/org/checkerframework/checker-qual/3.12.0/checker-qual-

3.12.0.jar:/Users/rohitvarma/.m2/repository/com/google/errorprone/error_prone_annotations/2.11.0/error_prone_annotations-

2.11.0.jar:/Users/rohitvarma/.m2/repository/com/google/j2objc/j2objc-annotations/1.3/j2objc-annotations-

1.3.jar:/Users/rohitvarma/.m2/repository/org/ini4j/ini4j/0.5.4/ini4j-0.5.4.jar edu.neu.coe.info6205.InsertionSortBenchmark

Array Size	Condition	Avg Time (ms)	Min Time (ms)	Max Time (ms)
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2024-02-05 21:51:33 INFO Benchmark_Timer - Begin run: Insertion Sort

Performance with 5 runs

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Performance with 5 runs

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Performance with 5 runs

2024-02-05 21:51:34 INFO Benchmark_Timer - Begin run: Insertion Sort

Performance with 5 runs

450	Random	0.21	0.13	0.69
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2024-02-05 21:51:34 INFO Benchmark_Timer - Begin run: Insertion Sort

Performance with 5 runs

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Performance with 5 runs

2024-02-05 21:51:34 INFO Benchmark_Timer - Begin run: Insertion Sort

Performance with 5 runs

2024-02-05 21:51:34 INFO Benchmark_Timer - Begin run: Insertion Sort

Performance with 5 runs

[illegible]

[illegible]

[illegible]

2024-02-05 21:51:34 INFO Benchmark_Timer - Begin run: Insertion Sort

2024-02-05 21:51:34 INFO Benchmark_Timer - Begin run: Insertion Sort

1800	Ordered	0.00	0.00	0.00
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Performance with 5 runs

Performance with 5 runs

Performance with 5 runs

Performance with 5 runs

Performance with 5 runs

Performance with 5 runs

Performance with 5 runs

2024-02-05 21:51:54 INFO C Benchmark_Timer Begin run: Insertion Sort
Performance with 5 runs

2024-02-05 21:51:54 INFO C Benchmark_Timer - Begin run: Insertion Sort
Performance with 5 runs

2024-02-05 21:51:54 INFO C Benchmark_Timer - Begin run: Insertion Sort
Performance with 5 runs

2024-02-05 21:51:34 INFO Benchmark Timer - Begin run: Insertion Sort

2024-02-05 21:51:34 INFO Benchmark Timer - Begin run: Insertion Sort

2024-02-05 21:51:34 INFO Benchmark Timer - Begin run: Insertion Sort

2024-02-05 21:51:34 INFO Benchmark Timer - Begin run: Insertion Sort

2024-02-05 21:51:34 INFO Benchmark - Begin run: Insertion Sort

2024-02-05 21:51:34 INFO Benchmark - Begin run: Insertion Sort

2024-02-05 21:51:34 INFO Benchmark - Timer - Begin run: Insertion Sort

2024-03-05 21:51:34 INFO Benchmark: Timer Begin run: Insertion Sort

2024-03-05 21:51:34 INFO: Benchmark: Timer. Begin run: Insertion Sort

Performance With 5 runs
2024-03-05 21:51:34 INFO Benchmark: Timer Begin run: Insertion Sort

1800	Partially Ordered	1.03	1.85	3.01
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2024-02-05 21:51:34 INFO Benchmark_Timer - Begin run: Insertion Sort
Performance with 5 runs

2024-02-05 21:51:34 INFO Benchmark_Timer - Begin run: Insertion Sort
Performance with 5 runs

2024-02-05 21:51:34 INFO Benchmark_Timer - Begin run: Insertion Sort
Benchmarking insertion sort with 5

2024-02-05 21:51:34 INFO Benchmark_Timer - Begin run: Insertion Sort

[illegible]

2024-02-05 21:51:38 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:38 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:38 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:38 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

7200	Ordered	0.01	0.01	0.02
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2024-02-05 21:51:38 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:39 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:39 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:40 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:40 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:41 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:41 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:41 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:42 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:42 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

7200	Reverse Ordered	58.91	58.25	60.67
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2024-02-05 21:51:43 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:43 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:43 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:43 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:43 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:44 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:44 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:44 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:44 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:44 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

7200	Partially Ordered	30.05	29.15	31.14
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2024-02-05 21:51:45 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:46 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:46 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:47 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:48 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:49 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:50 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:51 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:52 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:53 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

14400	Random	124.35	117.32	132.17
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2024-02-05 21:51:53 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:53 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:53 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:53 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:53 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:53 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:53 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:53 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:53 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

14400	Ordered	0.03	0.02	0.03
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2024-02-05 21:51:53 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:55 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:57 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:51:58 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:52:00 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:52:02 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:52:03 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:52:05 INFO Benchmark_Timer - Begin run: Insertion Sort Performance with 5 runs

2024-02-05 21:52:07 INFO Benchmark_Timer - Begin run: Insertion Sort

Performance with 5 runs

2024-02-05 21:52:09 INFO Benchmark_Timer - Begin run: Insertion Sort

Performance with 5 runs

14400 Reverse Ordered 242.55 234.17 255.93

2024-02-05 21:52:10 INFO Benchmark_Timer - Begin run: Insertion Sort

Performance with 5 runs

2024-02-05 21:52:11 INFO Benchmark_Timer - Begin run: Insertion Sort

Performance with 5 runs

2024-02-05 21:52:12 INFO Benchmark_Timer - Begin run: Insertion Sort

Performance with 5 runs

2024-02-05 21:52:13 INFO Benchmark_Timer - Begin run: Insertion Sort

Performance with 5 runs

2024-02-05 21:52:14 INFO Benchmark_Timer - Begin run: Insertion Sort

Performance with 5 runs

2024-02-05 21:52:15 INFO Benchmark_Timer - Begin run: Insertion Sort

Performance with 5 runs

2024-02-05 21:52:16 INFO Benchmark_Timer - Begin run: Insertion Sort

Performance with 5 runs

2024-02-05 21:52:17 INFO Benchmark_Timer - Begin run: Insertion Sort

Performance with 5 runs

2024-02-05 21:52:18 INFO Benchmark_Timer - Begin run: Insertion Sort

Performance with 5 runs

2024-02-05 21:52:18 INFO Benchmark_Timer - Begin run: Insertion Sort

Performance with 5 runs

14400 Partially Ordered 125.42 120.91 129.38

Process finished with exit code 0

Benchmarks:

Array	Order	Time Taken
450	Randomly Ordered	1.15
450	Ordered	0.01
450	Partially Ordered	1.35
450	Reverse Ordered	0.6
900	Randomly Ordered	1.28
900	Ordered	0.01
900	Partially Ordered	0.81
900	Reverse Ordered	2.89
1800	Randomly Ordered	5.79
1800	Ordered	0.01
1800	Partially Orderd	3.2
1800	Reverse Ordered	10.80
3600	Randomly Ordered	16.70
3600	Ordered	0.02
3600	Partially Ordered	9.25
3600	Reverse Ordered	25.78
7200	Randomly Ordered	51.55
7200	Ordered	0.03

7200	Partially Ordered	32.68
7200	Reverse Ordered	103.72
14400	Randomly Ordered	214.15
14400	Ordered	0.07
14400	Partially Ordered	127.27
14400	Reverse Ordered	414.43

Observations :

We wrote a new class known as sorting benchmark where we have implemented the main method we gave a min arraySize of 450 and its max is upto 20000. The sizeArray is multiplied by 2 after each run

- The algorithm performs well on ordered and reverse-ordered arrays, with relatively low average times.
- Randomly ordered arrays show varying performance, with increasing times as the array size grows.
- As the array size doubles, the time taken by the algorithm increases significantly, indicating a potential $O(n^2)$ time complexity.

