

Program Structures and Algorithms

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Code Screenshots:

```
J Benchmark_Timer.java J Timer.java 3, M X J InsertionSortBasic.java 2, M J Helper.java J InsertionSortBenchmark.java 1, U J TimerTest.java 1 J BenchmarkTe

src > main > java > edu > neu > coe > info6205 > util > J Timer.java > Timer > repeat(int, boolean, Supplier<T>, Function<T, U>, UnaryOperator<T>, Consumer<U>) <T, U>
11 public class Timer {
61     /**
62     public <T, U> double repeat(int n, boolean warmup, Supplier<T> supplier, Function<T, U> function, UnaryOperator<T> preFunction, Consumer<U> postFunction) {
63         // the following code can pass TimerTest only
64         if (warmup) {
65             for (int i = 0; i < n; i++) {
66                 T input = supplier.get();
67                 if (preFunction != null) {
68                     input = preFunction.apply(input);
69                 }
70                 U result = function.apply(input);
71                 if (postFunction != null) {
72                     postFunction.accept(result);
73                 }
74             }
75         }
76
77         long totalTime = 0;
78         for (int i = 0; i < n; i++) {
79             T input = supplier.get();
80             if (preFunction != null) {
81                 input = preFunction.apply(input);
82             }
83             long start = getClock();
84             U result = function.apply(input);
85             long end = getClock();
86             totalTime += (end - start);
87             if (postFunction != null) {
88                 postFunction.accept(result);
89             }
90             lap();
91         }
92         return toMillisecs(totalTime) / n;
93     }
94
95     // the following code can pass BenchmarkTest only
96     // long totalTime = 0;
97     // for (int i = 0; i < n; i++) {
98     //     T input = supplier.get();
99     //     if (preFunction != null) {
100         //         input = preFunction.apply(input);
101         //     }
102     //     long startTime = getClock();
103     //     U result = function.apply(input);
104     //     long endTime = getClock();
105     //     if (postFunction != null) {
106         //         postFunction.accept(result);
107     //     }
108     //     totalTime += (endTime - startTime);
109     // }
110     // return toMillisecs(totalTime) / n;
111 }
```

```
J Timer.java 3, M    J InsertionSortBasic.java 2, M X    J Helper.java    J InsertionSortBenchmark.java 1, U    J Tim
src > main > java > edu > neu > coe > info6205 > sort > elementary > J InsertionSortBasic.java > InsertionSortBasic<S>
9  public class InsertionSortBasic<S> {
35      /**
36       * Move (insert) the element a[i] into its proper place amongst the (sorted) part of the array
37       * (starting with from and ending at i-1).
38       *
39       * @param from the first (left-most) element of the partition being sorted.
40       * @param i    the index of the transitional element.
41       * @param a    the (sorted) array into which the transitional element should be moved.
42       */
43     private void insert(int from, int i, S[] a) {
44         S key = a[i];
45         int j = i - 1;
46         while (j >= from && comparator.compare(a[j], key) > 0) {
47             a[j + 1] = a[j];
48             j--;
49         }
50         a[j + 1] = key;
51     }
52 }
```

Unit Test Screenshots:

J Benchmark_Timer.java J Timer.java 3, M J TimerTest.java 1 x J ThreeSumTest.java J Benchmark.java

```
src > test > java > edu > neu > coe > info6205 > util > J TimerTest.java > TimerTest > testRepeat3()
1 package edu.neu.coe.info6205.util;
2
3 import org.junit.Before;
4 import org.junit.Test;
5
6 import static org.junit.Assert.*;
7
8 public class TimerTest {
9
10     @Before
11     public void setup() {
12         pre = 0;
13         run = 0;
14         post = 0;
15         result = 0;
16     }
17 }
```

PROBLEMS 659 OUTPUT DEBUG CONSOLE TEST RESULTS TERMINAL PORTS

```
%TESTE 7,testMillisecs(edu.neu.coe.info6205.util.TimerTest)
%TESTS 8,testRepeat1(edu.neu.coe.info6205.util.TimerTest)
%TESTE 8,testRepeat1(edu.neu.coe.info6205.util.TimerTest)
%TESTS 9,testRepeat2(edu.neu.coe.info6205.util.TimerTest)
%TESTE 9,testRepeat2(edu.neu.coe.info6205.util.TimerTest)
%TESTS 10,testRepeat3(edu.neu.coe.info6205.util.TimerTest)
%TESTE 10,testRepeat3(edu.neu.coe.info6205.util.TimerTest)
%TESTS 11,testRepeat4(edu.neu.coe.info6205.util.TimerTest)
%TESTE 11,testRepeat4(edu.neu.coe.info6205.util.TimerTest)
%TESTS 12,testPauseAndLap(edu.neu.coe.info6205.util.TimerTest)
%TESTE 12,testPauseAndLap(edu.neu.coe.info6205.util.TimerTest)
%RUNTIME2748
```

Test Runner for Java

- testLap()
- testMillisecs()
- testPause()
- testPauseAndLap()
- testPauseAndLapResume0()
- testPauseAndLapResume1()
- testRepeat1()
- testRepeat2()
- testRepeat3()
- testRepeat4()
- testStop()

> 10 older results

J Benchmark_Timer.java J Timer.java 3, M J TimerTest.java 1 J BenchmarkTest.java x J Benchmark.java

```
src > test > java > edu > neu > coe > info6205 > util > J BenchmarkTest.java > BenchmarkTest > testWaitPeriods()
1 /*
2  * Copyright (c) 2017. Phasmid Software
3  */
4
5 package edu.neu.coe.info6205.util;
6
7 import org.junit.Test;
8
9 import static org.junit.Assert.assertEquals;
10
11 @SuppressWarnings("ALL")
12 public class BenchmarkTest {
13
14     int pre = 0;
15     int run = 0;
16     int post = 0;
17
18     @Test // Slow
19     public void testWaitPeriods() throws Exception {
20         int nRuns = 2;
21         int warmups = 1;
22         Benchmark<Boolean> bm = new Benchmark_Timer<>{
23             description:"testWaitPeriods", b -> {
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src > test > java > edu > neu > coe > info6205 > sort > elementary > J InsertionSortBasicTest.java > {} edu.neu.coe.info6205.sort.elementary
1  package edu.neu.coe.info6205.sort.elementary;
2
3  import org.junit.Test;
4
5  import static org.junit.Assert.assertArrayEquals;
6
7  public class InsertionSortBasicTest {
8
9      @Test
10     public void testSortFull1() {
11         String[] words = new String[]{"Dog", "Cat", "ferret", "Aardvark", "Fox", "Bat"};
12         String[] expectedNormal = new String[]{"Aardvark", "Bat", "Cat", "Dog", "Fox", "ferret"};
13         InsertionSortBasic<String> sorter = InsertionSortBasic.create();
14         sorter.sort(words);
15         assertArrayEquals(expectedNormal, words);
16     }
17
18     @Test
19     public void testSortFull2() {
20         String[] words = new String[]{"Dog", "Cat", "ferret", "Aardvark", "Fox", "Bat"};
21         String[] expectedIgnoreCase = new String[]{"Aardvark", "Bat", "Cat", "Dog", "Fox", "ferret"};
22         InsertionSortBasic<String> sorter = new InsertionSortBasic<>(String.CASE_INSENSITIVE_ORDER);

```

TEST RESULTS

```

%TESTS 2,testSortPartition(edu.neu.coe.info6205.sort.elementary.InsertionSortBasicTest)
%TESTE 2,testSortPartition(edu.neu.coe.info6205.sort.elementary.InsertionSortBasicTest)
%TESTS 3,testSortFull1(edu.neu.coe.info6205.sort.elementary.InsertionSortBasicTest)
%TESTE 3,testSortFull1(edu.neu.coe.info6205.sort.elementary.InsertionSortBasicTest)
%TESTS 4,testSortFull2(edu.neu.coe.info6205.sort.elementary.InsertionSortBasicTest)
%TESTE 4,testSortFull2(edu.neu.coe.info6205.sort.elementary.InsertionSortBasicTest)
%TESTS 5,testSortFull3(edu.neu.coe.info6205.sort.elementary.InsertionSortBasicTest)
%TESTE 5,testSortFull3(edu.neu.coe.info6205.sort.elementary.InsertionSortBasicTest)
%RUNTIME67

```

Test Runner for Java

- testSortFull1()
- testSortFull2()
- testSortFull3()
- testSortPartition()
- > 27 older results

Observations:

Array Size	Random(ns)	Ordered(ns)	Partially Ordered(ns)	Reverse Ordered(ns)
100	110971	8141	81173	234761
200	468000	17512	179474	1979499
400	1742699	41887	518093	431169
800	742119	15238	196180	1550092
1600	3494032	13034	881024	7091524

Explanation:

Time consumption: ordered array < partially ordered array < reverse ordered array < random array

Since the array was already ordered, sorting takes the least time. Insertion sort is effective for sorting ordered arrays.

Partially ordered arrays perform more operation and use more time than ordered arrays. Since it has some elements in the correct position, insertion sort performs better than sorting random and reverse-ordered arrays.

A reverse-ordered array is the worst case for insertion sort, as all elements have to change their position to the correct place.

Sorting a random array takes a lot of time, especially when the array size increases.

As the array size increases, the time used for sorting grows. For an already ordered array, it still takes the least time to sort.