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Program Structures & Algorithms

Spring 2021

Assignment No. 2

- ## Task

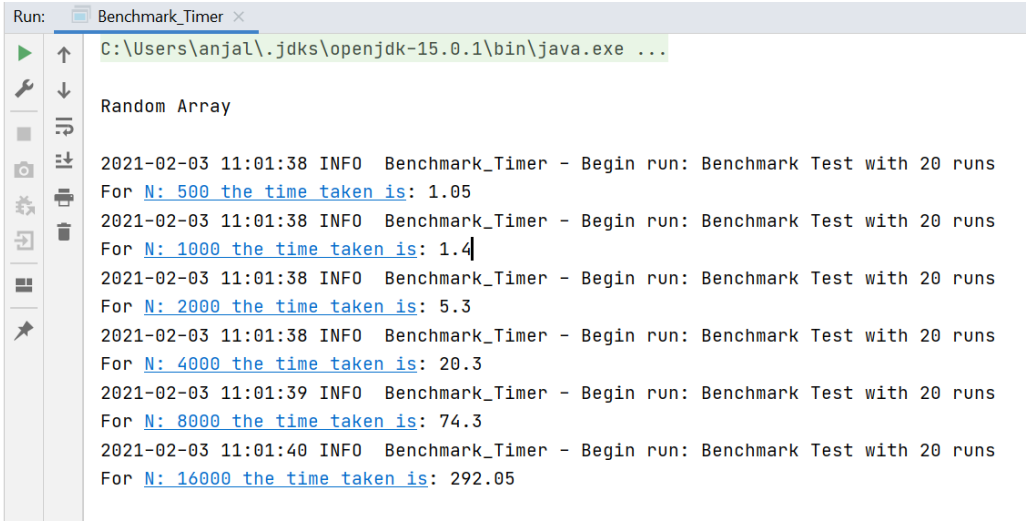
(Part 1) You are to implement three methods of a class called *Timer*. Please see the skeleton class that I created in the repository. *Timer* is invoked from a class called *Benchmark_Timer*which implements the *Benchmark* interface. The APIs of these class are as follows:

(Part 2) Implement *InsertionSort* (in the *InsertionSort* class) by simply looking up the insertion code used by *Arrays.sort.* You should use the *helper.swap* method although you could also just copy that from the same source code. You should of course run the unit tests in *InsertionSortTest*.

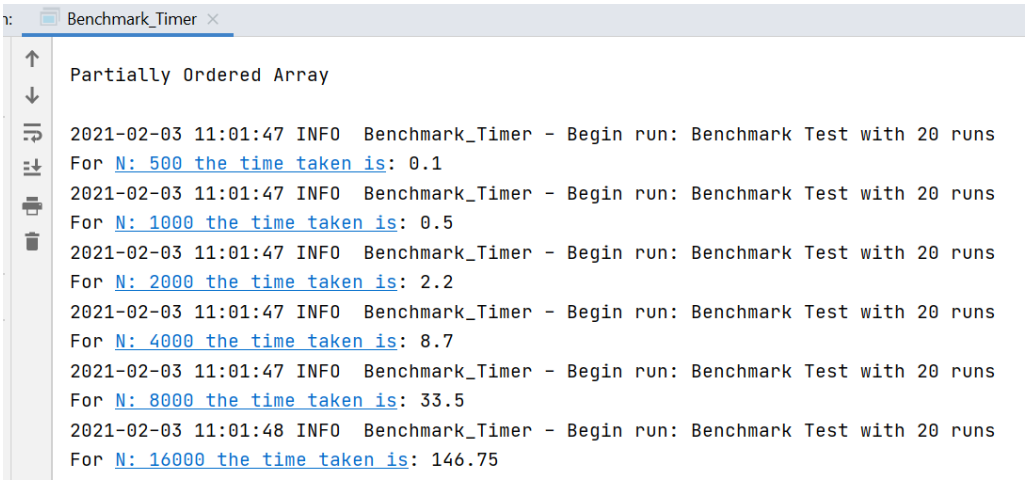
(Part 3) Implement a main program (or you could do it via your own unit tests) to actually run the following benchmarks: measure the running times of this sort, using four different initial array ordering situations: random, ordered, partially ordered and reverse-ordered. I suggest that your arrays to be sorted are of type *Integer*. Use the doubling method for choosing *n* and test for at least five values of *n.* Draw any conclusions from your observations regarding the order of growth.

- ## Solution

The snapshots of the result obtained for different values of n on a random array, sorted array, partially sorted array and reverse array for 20 runs are given below:




Benchmark_Timer
For N: 16000 the time taken is: 292.05
Ordered Array
2021-02-03 11:01:47 INFO Benchmark_Timer - Begin run: Benchmark Test with 20 runs
For N: 500 the time taken is: 0.0
2021-02-03 11:01:47 INFO Benchmark_Timer - Begin run: Benchmark Test with 20 runs
For N: 1000 the time taken is: 0.0
2021-02-03 11:01:47 INFO Benchmark_Timer - Begin run: Benchmark Test with 20 runs
For N: 2000 the time taken is: 0.0
2021-02-03 11:01:47 INFO Benchmark_Timer - Begin run: Benchmark Test with 20 runs
For N: 4000 the time taken is: 0.0
2021-02-03 11:01:47 INFO Benchmark_Timer - Begin run: Benchmark Test with 20 runs
For N: 8000 the time taken is: 0.0
2021-02-03 11:01:47 INFO Benchmark_Timer - Begin run: Benchmark Test with 20 runs
For N: 16000 the time taken is: 0.05


Benchmark_Timer
Partially Ordered Array
2021-02-03 11:01:47 INFO Benchmark_Timer - Begin run: Benchmark Test with 20 runs
For N: 500 the time taken is: 0.1
2021-02-03 11:01:47 INFO Benchmark_Timer - Begin run: Benchmark Test with 20 runs
For N: 1000 the time taken is: 0.5
2021-02-03 11:01:47 INFO Benchmark_Timer - Begin run: Benchmark Test with 20 runs
For N: 2000 the time taken is: 2.2
2021-02-03 11:01:47 INFO Benchmark_Timer - Begin run: Benchmark Test with 20 runs
For N: 4000 the time taken is: 8.7
2021-02-03 11:01:47 INFO Benchmark_Timer - Begin run: Benchmark Test with 20 runs
For N: 8000 the time taken is: 33.5
2021-02-03 11:01:48 INFO Benchmark_Timer - Begin run: Benchmark Test with 20 runs
For N: 16000 the time taken is: 146.75


Run:
Benchmark_Timer
For N: 16000 the time taken is: 146.75
Reversed Array
2021-02-03 11:01:51 INFO Benchmark_Timer - Begin run: Benchmark Test with 20 runs
For N: 500 the time taken is: 0.7
2021-02-03 11:01:51 INFO Benchmark_Timer - Begin run: Benchmark Test with 20 runs
For N: 1000 the time taken is: 2.2
2021-02-03 11:01:51 INFO Benchmark_Timer - Begin run: Benchmark Test with 20 runs
For N: 2000 the time taken is: 9.3
2021-02-03 11:01:51 INFO Benchmark_Timer - Begin run: Benchmark Test with 20 runs
For N: 4000 the time taken is: 37.5
2021-02-03 11:01:52 INFO Benchmark_Timer - Begin run: Benchmark Test with 20 runs
For N: 8000 the time taken is: 143.2
2021-02-03 11:01:55 INFO Benchmark_Timer - Begin run: Benchmark Test with 20 runs
For N: 16000 the time taken is: 568.65
Process finished with exit code 0

- ## Relationship Conclusion:

It can be concluded from the results and the graph obtained as given below :

- The best-case scenario is when that array is sorted. Even if the value of n increases, the least amount of time is taken. In a sorted array there will be no moves per stage and the number of comparisons is going to be 1 per stage hence 1+1+……+1 = (n-1) $\in O(n)$.

- The worst-case scenario is when the array is in reverse order. As the value of n increases, the time taken is highest for the reverse ordered array. In reverse ordered array there will be i comparisons and moves per stage. Where i =1,2…n-1. Hence,

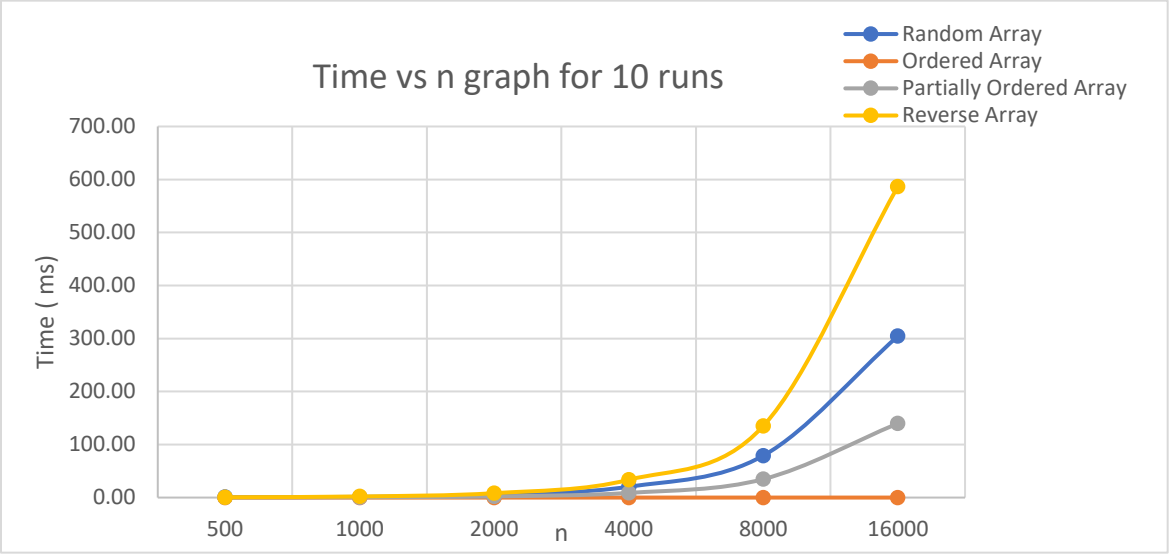
  =1+2+…+(n-1) = $\frac{n(n-1)}{2}$ = $\frac{n^2-n}{2}$ $\in O(n^2)$.

- The time taken for random ordered array is slightly higher than the partially sorted array. They both are better than the worst-case scenario but not as good as the best-case scenario.

- ## Evidence to support the conclusion and graphical representation:

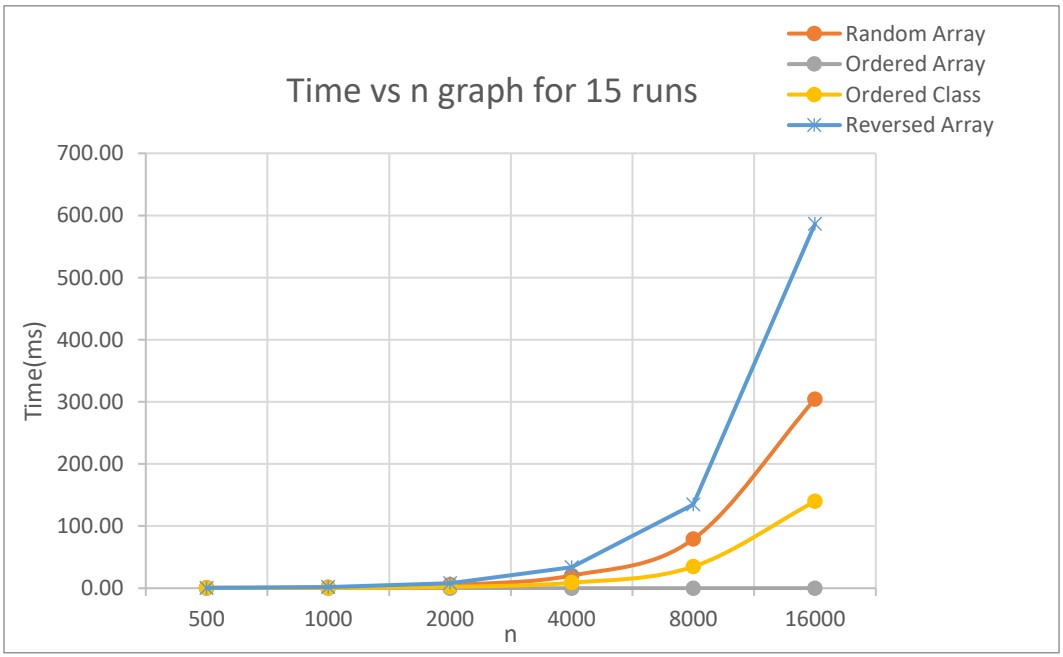
  - For 10 runs

n	Random Array	Ordered Array	Partially Ordered Array	Reversed Array
500	1.00	0.00	0.1	0.5
1000	1.10	0.00	0.5	2.1
2000	5.00	0.00	2.1	8.6
4000	19.30	0.00	8.7	33.6
8000	73.20	0.00	35.6	133
16000	298.50	0.00	141.9	536.3



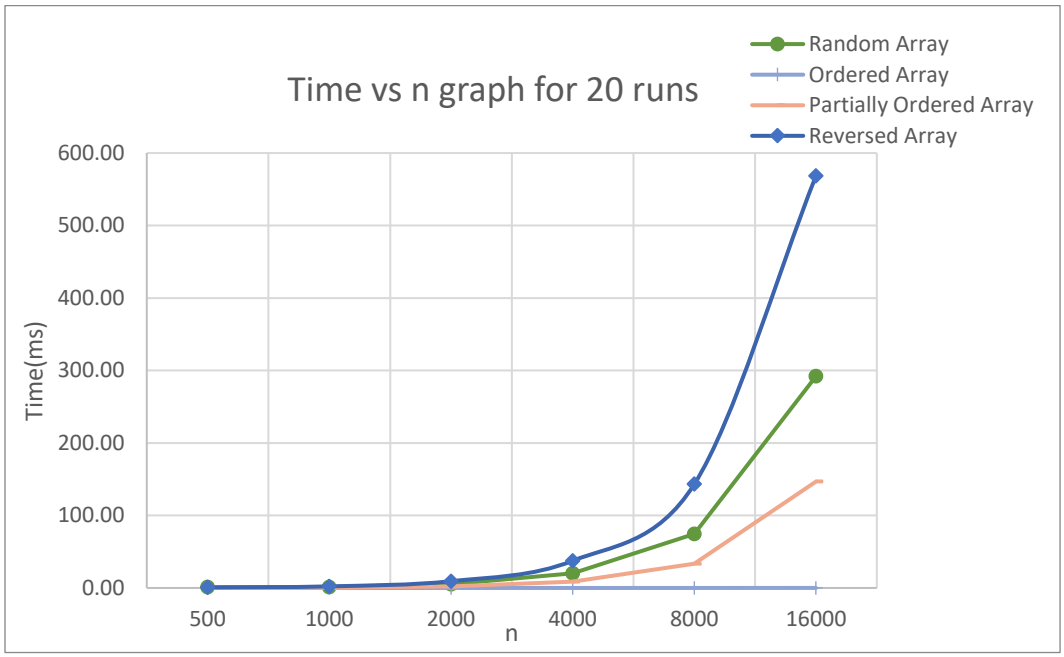
- For 15 runs

n	Random Array	Ordered Array	Partially Ordered Array	Reversed Array
500	0.80	0.00	0.13	0.53
1000	1.27	0.00	0.53	2.07
2000	5.27	0.00	2.13	8.27
4000	20.40	0.00	8.80	33.53
8000	79.00	0.00	34.73	134.93
16000	304.33	0.00	139.73	586.47



- For 20 runs

n	Random Array	Ordered Array	Partially Ordered Array	Reversed Array
500	1.05	0.00	0.10	0.70
1000	1.40	0.00	0.50	2.20
2000	5.30	0.00	2.20	9.30
4000	20.30	0.00	8.70	37.50
8000	74.30	0.00	33.50	143.20
16000	292.05	0.05	146.75	568.65



- # Unit tests result:

1. Timer Test – Test cases result

2.BenchmarkTest – Test cases result

2. Insertion Sort Test – Test cases result.