

Program Structures and Algorithms
Spring 2023(SEC –1)

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Task:

In this assignment, your task is to determine--for sorting algorithms--what is the best predictor of total execution time: comparisons, swaps/copies, hits (array accesses), or something else.

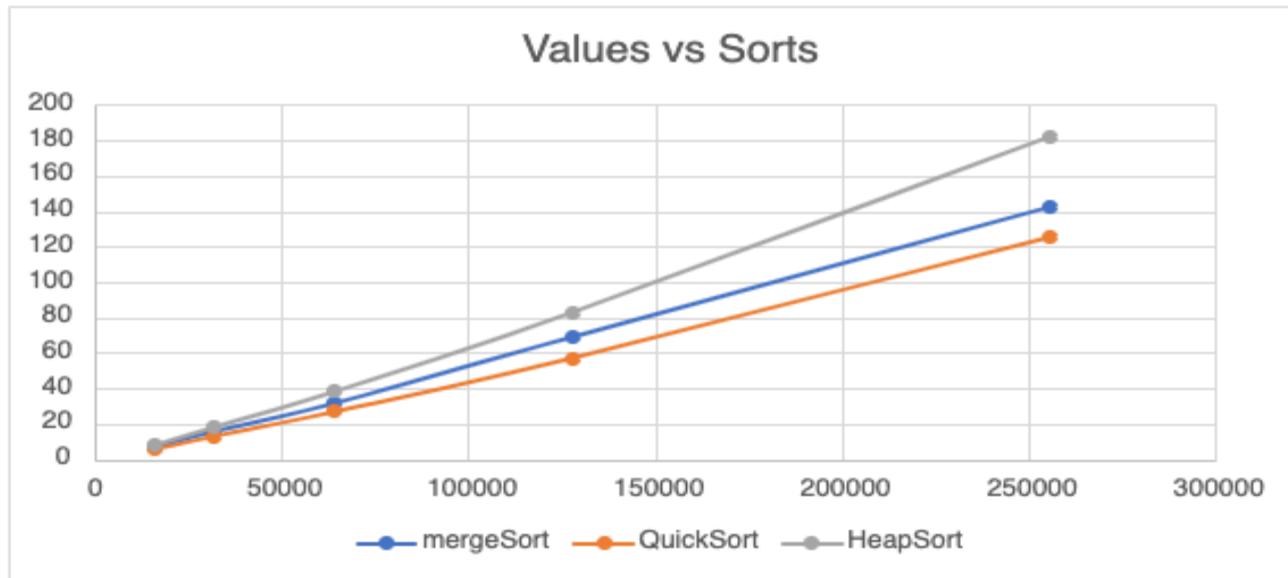
Relationship Conclusion:

From the below table, you can conclude that QuickSortDualPivot is better than MergeSort and HeapSort. Nonetheless, as the size increases, merge sort and dual-pivot rapid sort become equivalent, and time is directly proportional to compares, swaps, and hits. Although swap is an expensive operation and the number of hits has a higher count, the number of compares and the array size have a greater impact on the overall raw time.

Graphical Representation:

Plotted Graphs again different values such as 16k, 32k, 64k, 128k, and 256k for Merge Sort, Quick Sort, and Heap Sort.

Values	mergeSort	QuickSort	HeapSort
16000	6.59	5.58	7.71
32000	15.65	12.83	18.04
64000	31.39	26.69	37.97
128000	68.98	57.1	82.9
256000	142.54	125.5	182.25



MergeSort							
Values	Time	normalized Time	compares	swaps	hits	In(size)	In(time)
16000	6.59	5.48	204,954	14,017	434,694	13.96578428	2.454175893
32000	15.65	6.03	441,911	28,046	933,432	14.96578428	2.592158002
64000	31.39	5.63	1,994,877	56,095	947,824	15.96578428	2.493134922
128000	68.98	5.79	2,023,584	112,123	4,245,485	16.96578428	2.533563348
256000	142.54	5.62	4,303,164	224,245	9,002,965	17.96578428	2.49057013
QuickSort							
Values	Time	normalized Time	compares	swaps	hits	In(size)	In(time)
16000	5.58	4.64	265,098	111,218	702,708	13.96578428	2.480265122
32000	12.83	4.94	577,539	242,338	1,531,742	14.96578428	3.681449265
64000	26.69	4.78	1,238,935	516,471	3,276,095	15.96578428	4.7382274
128000	57.1	4.79	2,620,254	1,098,092	6,952,395	16.96578428	5.83541884
256000	125.5	4.94	5,605,731	2,336,032	14,835,902	17.96578428	6.971543554

HeapSort							
Values	Time	normalized Time	compares	swaps	hits	In(size)	In(time)
16000	7.71	6.41	397,651	209,248	1,632,293	13.96578428	2.94673086
32000	18.04	6.95	859,311	450,506	3,520,646	14.96578428	4.173127433
64000	37.97	6.81	1,846,611	964,995	7,553,203	15.96578428	5.246788094
128000	82.9	6.95	3,949,121	2,057,915	16,129,90	3	16.96578428
256000	182.25	7.18	8,410,397	4,371,964	34,308,65	1	17.96578428
							7.509775004

Evidence to support Conclusion:

```

INFO205 src\main\java\edu\neu\coe\info205\util\SortBenchmark
Project Run: SortBenchmark
/Library/Java/JavaVirtualMachines/jdk-19.jdk/Contents/Home/bin/java ...
2023-03-12 22:18:43 INFO SortBenchmark - SortBenchmark.main: null with word counts: [16000, 32000, 64000, 128000, 256000]
2023-03-12 22:18:43 INFO Benchmark_Timer - Begin run: intArraysorther with 100 runs
2023-03-12 22:18:45 INFO TimeLogger - Raw time per run (mSec): 7.07
2023-03-12 22:18:45 INFO TimeLogger - Normalized time per run (n log n): .78
2023-03-12 22:18:45 INFO Benchmark_Timer - Begin run: integerArraysorther with 100 runs
2023-03-12 22:18:47 INFO TimeLogger - Raw time per run (mSec): 22.75
2023-03-12 22:18:47 INFO TimeLogger - Normalized time per run (n log n): 2.56
2023-03-12 22:18:47 INFO SortBenchmark - Beginning String sorts
2023-03-12 22:18:48 INFO SortBenchmarkHelper - Testing with words: 22,865 from eng-uk_web_2002_10K-sentences.txt
2023-03-12 22:18:49 INFO SortBenchmark - Testing pure sorts with 499 runs of sorting 16,000 words
2023-03-12 22:18:49 INFO SorterBenchmark - run: sort 16,000 elements using SorterBenchmark on class java.lang.String from 22,865 total elements and 499 runs using sorter
2023-03-12 22:18:48 INFO Benchmark_Timer - Begin run: Instrumenting helper for mergesort with 16,000 elements with 499 runs
2023-03-12 22:18:51 INFO TimeLogger - Raw time per run (mSec): 6.59
2023-03-12 22:18:51 INFO TimeLogger - Normalized time per run (n log n): 5.48
2023-03-12 22:18:51 INFO SortBenchmark - mergesort: StatPack {hits: mean=434,694; stdDev=407, normalized=2.807; copies: 189,312, normalized=1.222; inversions: <unset>; s
2023-03-12 22:18:51 INFO SorterBenchmark - run: sort 16,000 elements using SorterBenchmark on class java.lang.String from 22,865 total elements and 499 runs using sorter
2023-03-12 22:18:51 INFO Benchmark_Timer - Begin run: Instrumenting helper for mergesort with 16,000 elements with 499 runs
2023-03-12 22:18:55 INFO TimeLogger - Raw time per run (mSec): 6.55
2023-03-12 22:18:55 INFO TimeLogger - Normalized time per run (n log n): 5.45
2023-03-12 22:18:55 INFO SortBenchmark - mergesort: StatPack {hits: mean=434,311; stdDev=411, normalized=2.804; copies: mean=189,120; stdDev=38, normalized=1.221; invers
2023-03-12 22:18:55 INFO SorterBenchmark - run: sort 16,000 elements using SorterBenchmark on class java.lang.String from 22,865 total elements and 499 runs using sorter
2023-03-12 22:18:55 INFO Benchmark_Timer - Begin run: Instrumenting helper for mergesort with 16,000 elements with 499 runs
2023-03-12 22:18:59 INFO TimeLogger - Raw time per run (mSec): 6.46
2023-03-12 22:18:59 INFO TimeLogger - Normalized time per run (n log n): 5.37
2023-03-12 22:18:59 INFO SortBenchmark - mergesort: StatPack {hits: mean=434,694; stdDev=407, normalized=2.807; copies: 189,312, normalized=1.222; inversions: <unset>; s
2023-03-12 22:18:59 INFO SorterBenchmark - run: sort 16,000 elements using SorterBenchmark on class java.lang.String from 22,865 total elements and 499 runs using sorter
2023-03-12 22:18:59 INFO Benchmark_Timer - Begin run: Instrumenting helper for mergesort with 16,000 elements with 499 runs
2023-03-12 22:19:02 INFO TimeLogger - Raw time per run (mSec): 6.44
2023-03-12 22:19:02 INFO TimeLogger - Normalized time per run (n log n): 5.35
2023-03-12 22:19:02 INFO SortBenchmark - mergesort: StatPack {hits: mean=441,733; stdDev=411, normalized=2.852; copies: 189,312, normalized=1.222; inversions: <unset>; s
2023-03-12 22:19:02 INFO SorterBenchmark - run: sort 16,000 elements using SorterBenchmark on class java.lang.String from 22,865 total elements and 499 runs using sorter
2023-03-12 22:19:02 INFO Benchmark_Timer - Begin run: Instrumenting helper for QuickSort dual pivot with 16,000 elements with 499 runs
2023-03-12 22:19:05 INFO TimeLogger - Raw time per run (mSec): 5.68
2023-03-12 22:19:05 INFO TimeLogger - Normalized time per run (n log n): 4.77
Build completed successfully in 1 sec, 644 ms (5 minutes ago)

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INFO[6205] src/main/java/edu/neu/coe/info6205/util SortBenchmark
2023-03-12 22:20:16 INFO SortBenchmark - mergesort: StatPack {hits: mean=947,513; stdDev=642, normalized=2.854; copies: 410,624, normalized=1.237; inversions: <unset>; swaps: 0}
2023-03-12 22:20:16 INFO SorterBenchmark - run: sort 32,000 elements using SorterBenchmark on class java.lang.String from 81,546 total elements and 231 runs using sorter
2023-03-12 22:20:16 INFO Benchmark_Timer - Begin run: Instrumenting helper for QuicksortDualPivot with 32,000 elements with 231 runs
2023-03-12 22:20:20 INFO TimeLogger - Raw time per run (mSec): 12.83
2023-03-12 22:20:20 INFO TimeLogger - Normalized time per run (n log n): 4.94
2023-03-12 22:20:20 INFO SortBenchmark - QuicksortDualPivot: StatPack {hits: mean=1,531,742; stdDev=67,275, normalized=4.614; copies: 0, normalized=0.000; inversions: <unset>; swaps: 0}
2023-03-12 22:20:20 INFO SorterBenchmark - run: sort 32,000 elements using SorterBenchmark on class java.lang.String from 81,546 total elements and 231 runs using sorter
2023-03-12 22:20:20 INFO Benchmark_Timer - Begin run: Instrumenting helper for Heapsort with 32,000 elements with 231 runs
2023-03-12 22:20:25 INFO TimeLogger - Raw time per run (mSec): 18.04
2023-03-12 22:20:25 INFO TimeLogger - Normalized time per run (n log n): 6.95
2023-03-12 22:20:25 INFO SortBenchmark - Heapsort: StatPack {hits: mean=3,520,646; stdDev=886, normalized=10.606; copies: 0, normalized=0.000; inversions: <unset>; swaps: 0}
2023-03-12 22:20:26 INFO SortBenchmarkHelper - Testing with words: 81,546 from eng-uk_web_2002_100K-sentences.txt
2023-03-12 22:20:26 INFO SortBenchmark - Testing pure sorts with 108 runs of sorting 64,000 words
2023-03-12 22:20:26 INFO SorterBenchmark - run: sort 64,000 elements using SorterBenchmark on class java.lang.String from 81,546 total elements and 108 runs using sorter
2023-03-12 22:20:26 INFO Benchmark_Timer - Begin run: Instrumenting helper for mergesort with 64,000 elements with 108 runs
2023-03-12 22:20:30 INFO TimeLogger - Raw time per run (mSec): 31.39
2023-03-12 22:20:30 INFO TimeLogger - Normalized time per run (n log n): 5.63
2023-03-12 22:20:30 INFO SortBenchmark - mergesort: StatPack {hits: mean=1,994,877; stdDev=867, normalized=2.817; copies: 885,248, normalized=1.250; inversions: <unset>; swaps: 0}
2023-03-12 22:20:30 INFO SorterBenchmark - run: sort 64,000 elements using SorterBenchmark on class java.lang.String from 81,546 total elements and 108 runs using sorter
2023-03-12 22:20:30 INFO Benchmark_Timer - Begin run: Instrumenting helper for mergesort with 64,000 elements with 108 runs
2023-03-12 22:20:34 INFO TimeLogger - Raw time per run (mSec): 30.62
2023-03-12 22:20:34 INFO TimeLogger - Normalized time per run (n log n): 5.49
2023-03-12 22:20:34 INFO SortBenchmark - mergesort: StatPack {hits: mean=1,993,342; stdDev=860, normalized=2.814; copies: mean=884,481; stdDev=73, normalized=1.249; inversions: <unset>; swaps: 0}
2023-03-12 22:20:34 INFO SorterBenchmark - run: sort 64,000 elements using SorterBenchmark on class java.lang.String from 81,546 total elements and 108 runs using sorter
2023-03-12 22:20:34 INFO Benchmark_Timer - Begin run: Instrumenting helper for mergesort with 64,000 elements with 108 runs
2023-03-12 22:20:38 INFO TimeLogger - Raw time per run (mSec): 30.18
2023-03-12 22:20:38 INFO TimeLogger - Normalized time per run (n log n): 5.41
2023-03-12 22:20:38 INFO SortBenchmark - mergesort: StatPack {hits: mean=1,994,877; stdDev=867, normalized=2.817; copies: 885,248, normalized=1.250; inversions: <unset>; swaps: 0}
2023-03-12 22:20:38 INFO SorterBenchmark - run: sort 64,000 elements using SorterBenchmark on class java.lang.String from 81,546 total elements and 108 runs using sorter
2023-03-12 22:20:38 INFO Benchmark_Timer - Begin run: Instrumenting helper for mergesort with 64,000 elements with 108 runs
2023-03-12 22:20:42 INFO TimeLogger - Raw time per run (mSec): 30.23
2023-03-12 22:20:42 INFO TimeLogger - Normalized time per run (n log n): 5.42
2023-03-12 22:20:42 INFO SortBenchmark - mergesort: StatPack {hits: mean=2,023,036; stdDev=860, normalized=2.856; copies: 885,248, normalized=1.250; inversions: <unset>; swaps: 0}
2023-03-12 22:20:42 INFO SorterBenchmark - run: sort 64,000 elements using SorterBenchmark on class java.lang.String from 81,546 total elements and 108 runs using sorter
2023-03-12 22:20:42 INFO Benchmark_Timer - Begin run: Instrumenting helper for QuicksortDualPivot with 64,000 elements with 108 runs
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INFO6205 src main java edu neu coe info6205 util SortBenchmark

Run: SortBenchmark

```
2023-03-12 22:19:21 INFO Benchmark_Timer - Begin run: Instrumenting helper for mergesort with 16,000 elements with 499 runs
2023-03-12 22:19:24 INFO TimeLogger - Raw time per run (mSec): 6.55
2023-03-12 22:19:24 INFO TimeLogger - Normalized time per run (n log n): 5.45
2023-03-12 22:19:24 INFO SortBenchmark - mergesort: StatPack {hits: mean=441,733; stdDev=411, normalized=2.852; copies: 189,312, normalized=1.222; inversions: <unset>; swaps: 0}
2023-03-12 22:19:24 INFO SorterBenchmark - run: sort 16,000 elements using SorterBenchmark on class java.lang.String from 22,865 total elements and 499 runs using sorter
2023-03-12 22:19:24 INFO Benchmark_Timer - Begin run: Instrumenting helper for QuicksortDualPivot with 16,000 elements with 499 runs
2023-03-12 22:19:27 INFO TimeLogger - Raw time per run (mSec): 5.58
2023-03-12 22:19:27 INFO TimeLogger - Normalized time per run (n log n): 4.64
2023-03-12 22:19:27 INFO SortBenchmark - QuicksortDualPivot: StatPack {hits: mean=702,708; stdDev=29,229, normalized=4.537; copies: 0, normalized=0.000; inversions: <unset>}; swaps: 0
2023-03-12 22:19:27 INFO SorterBenchmark - run: sort 16,000 elements using SorterBenchmark on class java.lang.String from 22,865 total elements and 499 runs using sorter
2023-03-12 22:19:27 INFO Benchmark_Timer - Begin run: Instrumenting helper for Heapsort with 16,000 elements with 499 runs
2023-03-12 22:19:32 INFO TimeLogger - Raw time per run (mSec): 7.71
2023-03-12 22:19:32 INFO TimeLogger - Normalized time per run (n log n): 6.41
2023-03-12 22:19:32 INFO SortBenchmark - Heapsort: StatPack {hits: mean=1,632,293; stdDev=587, normalized=10.539; copies: 0, normalized=0.000; inversions: <unset>}; swaps: 0
2023-03-12 22:19:33 INFO SortBenchmarkHelper - Testing with words: 81,546 from eng-uk_web_2002_100K-sentences.txt
2023-03-12 22:19:33 INFO SortBenchmark - Testing pure sorts with 231 runs of sorting 32,000 words
2023-03-12 22:19:33 INFO SorterBenchmark - run: sort 32,000 elements using SorterBenchmark on class java.lang.String from 81,546 total elements and 231 runs using sorter
2023-03-12 22:19:33 INFO Benchmark_Timer - Begin run: Instrumenting helper for mergesort with 32,000 elements with 231 runs
2023-03-12 22:19:37 INFO TimeLogger - Raw time per run (mSec): 15.65
2023-03-12 22:19:37 INFO TimeLogger - Normalized time per run (n log n): 6.03
2023-03-12 22:19:37 INFO SortBenchmark - mergesort: StatPack {hits: mean=933,432; stdDev=634, normalized=2.812; copies: 410,624, normalized=1.237; inversions: <unset>; swaps: 0}
2023-03-12 22:19:37 INFO SorterBenchmark - run: sort 32,000 elements using SorterBenchmark on class java.lang.String from 81,546 total elements and 231 runs using sorter
2023-03-12 22:19:37 INFO Benchmark_Timer - Begin run: Instrumenting helper for mergesort with 32,000 elements with 231 runs
2023-03-12 22:19:41 INFO TimeLogger - Raw time per run (mSec): 15.10
2023-03-12 22:19:41 INFO TimeLogger - Normalized time per run (n log n): 5.82
2023-03-12 22:19:41 INFO SortBenchmark - mergesort: StatPack {hits: mean=932,667; stdDev=642, normalized=2.810; copies: mean=410,241; stdDev=54, normalized=1.236; inversions: <unset>}; swaps: 0
2023-03-12 22:19:41 INFO SorterBenchmark - run: sort 32,000 elements using SorterBenchmark on class java.lang.String from 81,546 total elements and 231 runs using sorter
2023-03-12 22:19:41 INFO Benchmark_Timer - Begin run: Instrumenting helper for mergesort with 32,000 elements with 231 runs
2023-03-12 22:19:44 INFO TimeLogger - Raw time per run (mSec): 15.74
2023-03-12 22:19:44 INFO TimeLogger - Normalized time per run (n log n): 6.06
2023-03-12 22:19:46 INFO SortBenchmark - mergesort: StatPack {hits: mean=933,432; stdDev=634, normalized=2.812; copies: 410,624, normalized=1.237; inversions: <unset>}; swaps: 0
2023-03-12 22:19:46 INFO SorterBenchmark - run: sort 32,000 elements using SorterBenchmark on class java.lang.String from 81,546 total elements and 231 runs using sorter
2023-03-12 22:19:46 INFO Benchmark_Timer - Begin run: Instrumenting helper for mergesort with 32,000 elements with 231 runs
2023-03-12 22:19:50 INFO TimeLogger - Raw time per run (mSec): 15.49
```

INFO6205 src/main/java/edu/neu/coe/info6205/util SortBenchmark

Project Idea Run: SortBenchmark

```
2023-03-12 22:19:21 INFO Benchmark_Timer - Begin run: Instrumenting helper for mergesort with 16,000 elements with 499 runs
2023-03-12 22:19:24 INFO TimeLogger - Raw time per run (mSec): 6.55
2023-03-12 22:19:24 INFO TimeLogger - Normalized time per run (n log n): 5.45
2023-03-12 22:19:24 INFO SortBenchmark - mergesort: StatPack {hits: mean=441,733; stdDev=411, normalized=2.852; copies: 189,312, normalized=1.222; inversions: <unset>; swaps: 0}
2023-03-12 22:19:24 INFO SorterBenchmark - run: sort 16,000 elements using SorterBenchmark on class java.lang.String from 22,865 total elements and 499 runs using sorter
2023-03-12 22:19:24 INFO Benchmark_Timer - Begin run: Instrumenting helper for QuicksortDualPivot with 16,000 elements with 499 runs
2023-03-12 22:19:27 INFO TimeLogger - Raw time per run (mSec): 5.88
2023-03-12 22:19:27 INFO TimeLogger - Normalized time per run (n log n): 4.64
2023-03-12 22:19:27 INFO SortBenchmark - QuicksortDualPivot: StatPack {hits: mean=702,708; stdDev=29,229, normalized=4.537; copies: 0, normalized=0.000; inversions: <unset>; swaps: 0}
2023-03-12 22:19:27 INFO SorterBenchmark - run: sort 16,000 elements using SorterBenchmark on class java.lang.String from 22,865 total elements and 499 runs using sorter
2023-03-12 22:19:27 INFO Benchmark_Timer - Begin run: Instrumenting helper for Heapsort with 16,000 elements with 499 runs
2023-03-12 22:19:32 INFO TimeLogger - Raw time per run (mSec): 7.71
2023-03-12 22:19:32 INFO TimeLogger - Normalized time per run (n log n): 6.41
2023-03-12 22:19:32 INFO SortBenchmark - Heapsort: StatPack {hits: mean=1,632,293; stdDev=587, normalized=10.539; copies: 0, normalized=0.000; inversions: <unset>; swaps: 0}
2023-03-12 22:19:33 INFO SortBenchmarkHelper - Testing with words: 81,546 from eng-uk_web_2002_100K-sentences.txt
2023-03-12 22:19:33 INFO SortBenchmark - Testing pure sorts with 231 runs of sorting 32,000 words
2023-03-12 22:19:33 INFO SortBenchmark - run: sort 32,000 elements using SorterBenchmark on class java.lang.String from 81,546 total elements and 231 runs using sorter
2023-03-12 22:19:33 INFO Benchmark_Timer - Begin run: Instrumenting helper for mergesort with 32,000 elements with 231 runs
2023-03-12 22:19:37 INFO TimeLogger - Raw time per run (mSec): 15.65
2023-03-12 22:19:37 INFO TimeLogger - Normalized time per run (n log n): 6.03
2023-03-12 22:19:37 INFO SortBenchmark - mergesort: StatPack {hits: mean=933,432; stdDev=634, normalized=2.812; copies: 410,624, normalized=1.237; inversions: <unset>; swaps: 0}
2023-03-12 22:19:37 INFO SorterBenchmark - run: sort 32,000 elements using SorterBenchmark on class java.lang.String from 81,546 total elements and 231 runs using sorter
2023-03-12 22:19:37 INFO Benchmark_Timer - Begin run: Instrumenting helper for mergesort with 32,000 elements with 231 runs
2023-03-12 22:19:41 INFO TimeLogger - Raw time per run (mSec): 15.10
2023-03-12 22:19:41 INFO TimeLogger - Normalized time per run (n log n): 5.82
2023-03-12 22:19:41 INFO SortBenchmark - mergesort: StatPack {hits: mean=932,667; stdDev=642, normalized=2.810; copies: mean=410,241; stdDev=54, normalized=1.236; inversions: <unset>; swaps: 0}
2023-03-12 22:19:41 INFO SorterBenchmark - run: sort 32,000 elements using SorterBenchmark on class java.lang.String from 81,546 total elements and 231 runs using sorter
2023-03-12 22:19:41 INFO Benchmark_Timer - Begin run: Instrumenting helper for mergesort with 32,000 elements with 231 runs
2023-03-12 22:19:46 INFO TimeLogger - Raw time per run (mSec): 15.74
2023-03-12 22:19:46 INFO TimeLogger - Normalized time per run (n log n): 6.06
2023-03-12 22:19:46 INFO SortBenchmark - mergesort: StatPack {hits: mean=933,432; stdDev=634, normalized=2.812; copies: 410,624, normalized=1.237; inversions: <unset>; swaps: 0}
2023-03-12 22:19:46 INFO SorterBenchmark - run: sort 32,000 elements using SorterBenchmark on class java.lang.String from 81,546 total elements and 231 runs using sorter
2023-03-12 22:19:46 INFO Benchmark_Timer - Begin run: Instrumenting helper for mergesort with 32,000 elements with 231 runs
2023-03-12 22:19:50 INFO TimeLogger - Raw time per run (mSec): 15.49
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Build completed successfully in 1 sec, 644 ms (5 minutes ago)

INFO6205 src/main/java/edu/neu/coe/info6205/util SortBenchmark

Project Idea Run: SortBenchmark

```
2023-03-12 22:22:38 INFO Benchmark_Timer - Begin run: Instrumenting helper for Heapsort with 256,000 elements with 24 runs
2023-03-12 22:22:35 INFO TimeLogger - Raw time per run (mSec): 182.96
2023-03-12 22:22:35 INFO TimeLogger - Normalized time per run (n log n): 7.21
2023-03-12 22:22:36 INFO SortBenchmarkHelper - Testing with words: 303,172 from eng-uk_web_2002_1M-words.txt
2023-03-12 22:22:36 INFO SortBenchmark - Testing with 24 runs of sorting 256,000 words and instrumented
2023-03-12 22:22:36 INFO SorterBenchmark - run: sort 256,000 elements using SorterBenchmark on class java.lang.String from 303,172 total elements and 24 runs using sorter
2023-03-12 22:22:36 INFO Benchmark_Timer - Begin run: Instrumenting helper for mergesort with 256,000 elements with 24 runs
2023-03-12 22:22:40 INFO TimeLogger - Raw time per run (mSec): 148.79
2023-03-12 22:22:40 INFO TimeLogger - Normalized time per run (n log n): 5.86
2023-03-12 22:22:40 INFO SortBenchmark - mergesort: StatPack {hits: mean=9,002,965; stdDev=1,783, normalized=2.824; copies: 4,052,992, normalized=1.271; inversions: <unset>; swaps: 0}
2023-03-12 22:22:40 INFO SorterBenchmark - run: sort 256,000 elements using SorterBenchmark on class java.lang.String from 303,172 total elements and 24 runs using sorter
2023-03-12 22:22:40 INFO Benchmark_Timer - Begin run: Instrumenting helper for mergesort with 256,000 elements with 24 runs
2023-03-12 22:22:44 INFO TimeLogger - Raw time per run (mSec): 144.29
2023-03-12 22:22:44 INFO TimeLogger - Normalized time per run (n log n): 5.69
2023-03-12 22:22:44 INFO SortBenchmark - mergesort: StatPack {hits: mean=8,996,786; stdDev=1,870, normalized=2.822; copies: mean=4,049,903; stdDev=161, normalized=1.270; inversions: <unset>; swaps: 0}
2023-03-12 22:22:44 INFO SorterBenchmark - run: sort 256,000 elements using SorterBenchmark on class java.lang.String from 303,172 total elements and 24 runs using sorter
2023-03-12 22:22:44 INFO Benchmark_Timer - Begin run: Instrumenting helper for mergesort with 256,000 elements with 24 runs
2023-03-12 22:22:48 INFO TimeLogger - Raw time per run (mSec): 142.88
2023-03-12 22:22:48 INFO TimeLogger - Normalized time per run (n log n): 5.60
2023-03-12 22:22:48 INFO SortBenchmark - mergesort: StatPack {hits: mean=9,002,965; stdDev=1,783, normalized=2.824; copies: 4,052,992, normalized=1.271; inversions: <unset>; swaps: 0}
2023-03-12 22:22:48 INFO SorterBenchmark - run: sort 256,000 elements using SorterBenchmark on class java.lang.String from 303,172 total elements and 24 runs using sorter
2023-03-12 22:22:48 INFO Benchmark_Timer - Begin run: Instrumenting helper for mergesort with 256,000 elements with 24 runs
2023-03-12 22:22:53 INFO TimeLogger - Raw time per run (mSec): 141.96
2023-03-12 22:22:53 INFO TimeLogger - Normalized time per run (n log n): 5.59
2023-03-12 22:22:53 INFO SortBenchmark - mergesort: StatPack {hits: mean=9,115,568; stdDev=1,870, normalized=2.859; copies: 4,052,992, normalized=1.271; inversions: <unset>; swaps: 0}
2023-03-12 22:22:53 INFO SorterBenchmark - run: sort 256,000 elements using SorterBenchmark on class java.lang.String from 303,172 total elements and 24 runs using sorter
2023-03-12 22:22:54 INFO Benchmark_Timer - Begin run: Instrumenting helper for QuicksortDualPivot with 256,000 elements with 24 runs
2023-03-12 22:22:57 INFO TimeLogger - Raw time per run (mSec): 125.50
2023-03-12 22:22:57 INFO TimeLogger - Normalized time per run (n log n): 4.94
2023-03-12 22:22:57 INFO SortBenchmark - QuicksortDualPivot: StatPack {hits: mean=14,835,902; stdDev=424,207, normalized=4.654; copies: 0, normalized=0.000; inversions: <unset>; swaps: 0}
2023-03-12 22:22:57 INFO SorterBenchmark - run: sort 256,000 elements using SorterBenchmark on class java.lang.String from 303,172 total elements and 24 runs using sorter
2023-03-12 22:22:57 INFO Benchmark_Timer - Begin run: Instrumenting helper for Heapsort with 256,000 elements with 24 runs
2023-03-12 22:23:02 INFO TimeLogger - Raw time per run (mSec): 182.25
2023-03-12 22:23:02 INFO TimeLogger - Normalized time per run (n log n): 7.18
2023-03-12 22:23:02 INFO Build completed successfully in 1 sec, 644 ms (5 minutes ago)
```

INFO6205 /src/main/java/edu/neu/coe/info6205/util SortBenchmark

```

2023-03-12 22:22:36 INFO SortBenchmark - run: sort 256,000 elements using SorterBenchmark on class java.lang.String from 303,172 total elements and 24 runs using sorte
2023-03-12 22:22:36 INFO Benchmark_Timer - Begin run: Instrumenting helper for mergesort with 256,000 elements with 24 runs
2023-03-12 22:22:40 INFO TimeLogger - Raw time per run (mSec): 148.79
2023-03-12 22:22:40 INFO SortBenchmark - Normalized time per run (n log n): 5.86
2023-03-12 22:22:40 INFO SortBenchmark - mergesort: StatPack {hits: mean=9,002,965; stdDev=1,783, normalized=2.824; copies: 4,052,992, normalized=1.271; inversions: <uns
2023-03-12 22:22:40 INFO SortBenchmark - run: sort 256,000 elements using SorterBenchmark on class java.lang.String from 303,172 total elements and 24 runs using sorte
2023-03-12 22:22:40 INFO Benchmark_Timer - Begin run: Instrumenting helper for mergesort with 256,000 elements with 24 runs
2023-03-12 22:22:40 INFO TimeLogger - Raw time per run (mSec): 144.29
2023-03-12 22:22:40 INFO SortBenchmark - Normalized time per run (n log n): 5.69
2023-03-12 22:22:44 INFO SortBenchmark - mergesort: StatPack {hits: mean=8,996,786; stdDev=1,870, normalized=2.822; copies: mean=4,049,903; stdDev=161, normalized=1.270;
2023-03-12 22:22:44 INFO SortBenchmark - run: sort 256,000 elements using SorterBenchmark on class java.lang.String from 303,172 total elements and 24 runs using sorte
2023-03-12 22:22:44 INFO Benchmark_Timer - Begin run: Instrumenting helper for mergesort with 256,000 elements with 24 runs
2023-03-12 22:22:44 INFO TimeLogger - Raw time per run (mSec): 142.88
2023-03-12 22:22:48 INFO SortBenchmark - Normalized time per run (n log n): 5.60
2023-03-12 22:22:48 INFO SortBenchmark - mergesort: StatPack {hits: mean=9,002,965; stdDev=1,783, normalized=2.824; copies: mean=4,052,992, normalized=1.271; inversions: <uns
2023-03-12 22:22:48 INFO SortBenchmark - run: sort 256,000 elements using SorterBenchmark on class java.lang.String from 303,172 total elements and 24 runs using sorte
2023-03-12 22:22:48 INFO Benchmark_Timer - Begin run: Instrumenting helper for mergesort with 256,000 elements with 24 runs
2023-03-12 22:22:53 INFO TimeLogger - Raw time per run (mSec): 141.96
2023-03-12 22:22:53 INFO SortBenchmark - Normalized time per run (n log n): 5.59
2023-03-12 22:22:53 INFO SortBenchmark - mergesort: StatPack {hits: mean=9,115,568; stdDev=1,870, normalized=2.859; copies: 4,052,992, normalized=1.271; inversions: <uns
2023-03-12 22:22:53 INFO SortBenchmark - run: sort 256,000 elements using SorterBenchmark on class java.lang.String from 303,172 total elements and 24 runs using sorte
2023-03-12 22:22:53 INFO Benchmark_Timer - Begin run: Instrumenting helper for mergesort with 256,000 elements with 24 runs
2023-03-12 22:22:57 INFO TimeLogger - Raw time per run (mSec): 125.60
2023-03-12 22:22:57 INFO SortBenchmark - Normalized time per run (n log n): 4.94
2023-03-12 22:22:57 INFO SortBenchmark - QuicksortDualPivot: StatPack {hits: mean=14,835,992; stdDev=424,207, normalized=4.654; copies: 0, normalized=0.000; inversions: <uns
2023-03-12 22:22:57 INFO SortBenchmark - run: sort 256,000 elements using SorterBenchmark on class java.lang.String from 303,172 total elements and 24 runs using sorte
2023-03-12 22:22:57 INFO Benchmark_Timer - Begin run: Instrumenting helper for Heapsort with 256,000 elements with 24 runs
2023-03-12 22:23:02 INFO TimeLogger - Raw time per run (mSec): 182.25
2023-03-12 22:23:02 INFO SortBenchmark - Normalized time per run (n log n): 7.18
2023-03-12 22:23:02 INFO SortBenchmark - Heapsort: StatPack {hits: mean=34,308,651; stdDev=1,894, normalized=10.762; copies: 0, normalized=0.000; inversions: <unset>; sw
2023-03-12 22:23:02 INFO SortBenchmark - Beginning LocalDateTime sorts

Process finished with exit code 0

```

Build completed successfully in 1 sec, 644 ms (5 minutes ago)

INFO6205 /src/main/java/edu/neu/coe/info6205/sort linearithmic MergeSort sort

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// FIXME : implement merge sort with insurance and no-copy optimizations

```

int middle = from + (to - from) / 2;
if (nocopy) {
    sort(aux, a, from, middle);
    sort(aux, a, middle, to);
    if (insurance && helper.less(aux, middle - 1, middle)) {
        System.arraycopy(aux, from, a, from, length: to - from);
        helper.incrementCopies( n: to - from );
    } else {
        merge(aux, a, from, middle, to);
    } else {
        sort(a, aux, from, middle);
        sort(a, aux, middle, to);
        System.arraycopy(a, from, aux, from, length: to - from);
        if (insurance && helper.less(a[middle - 1], a[middle])) return;
        merge(a, aux, from, middle, to);
    }
} // END
// CONSTEXPR combining with MergeSortBasic methods

```

Run: MergeSortTest

Tests passed: 15 of 15 tests – 587ms

- MergeSortTest (edu.neu:587ms)
 - testSort11_partials 172ms Instrumenting helper for insertion sort with 128 elements
 - testSort9_partials 93ms partial sorted average time partialsorted_Cutoff + Insurance + NoCopy: 156308
 - testSort1 1ms Instrumenting helper for insertion sort with 128 elements
 - testSort2 8ms partial sorted average time partialsorted_Cutoff + NoCopy: 87820
 - testSort3 3ms Instrumenting helper for merge sort with 128 elements
 - testSort4 82ms StatPack {hits: 1,684, normalized=2.711; copies: 640, normalized=1.030; inversions: 4,224, normalized=6.801; swaps: 101, normalized=0.000; compares: 751}
 - testSort5 42ms Compares751
 - testSort6 43ms Compares769
 - testSort7 36ms Worst Compares769
 - testSort10_partials 55ms Instrumenting helper for insertion sort with 128 elements
 - testSort8_partials 48ms Instrumenting helper for merge sort with 128 elements
 - testSort12 2ms StatPack {hits: 1,792, normalized=2.885; copies: 896, normalized=1.443; inversions: <unset>; swaps: 0, normalized=0.000; fixes: 0, normalized=0.000; compares: 769}

Tests passed: 15 (a minute ago)

Unit Test Cases:

The screenshot shows the IntelliJ IDEA interface during a unit test execution. The left sidebar displays the project structure under 'INFO6205'. The main window shows the 'MergeSortTest' run configuration. The test results pane lists 15 passed tests, each with its name, duration, and a detailed log of the instrumentation process. The logs include statistics like hits, copies, inversions, swaps, and normalized values. The status bar at the bottom indicates 'Tests passed: 15 (moments ago)'.

```
INFO6205 / src / main / java / edu / neu / coe / info6205 / sort / linearithmic / MergeSortBasic
INFO6205 -/Desktop/psa_backup/INFO6205 50 MergeSort.java MergeSort.java MergeSortBasic.java SortBenchmark.java config.ini
Project idea
Run: MergeSortTest
Tests passed: 15 of 15 tests – 587ms
MergeSortTest (edu:587ms)
testSort11_partial 172ms
Instrumenting helper for insertion sort with 128 elements
testSort9_partialso 33ms
partial sorted average time partialsorted_Cutoff + Insurance + NoCopy: 156308
testSort1 1ms
Instrumenting helper for insertion sort with 128 elements
testSort2 8ms
partial sorted average time partialsorted_Cutoff + NoCopy: 87820
testSort3 3ms
Instrumenting helper for merge sort with 128 elements
testSort4 82ms
StatPack {hits: 1,684, normalized=2.71; copies: 640, normalized=1.030; inversions: 4,224, normalized=6.801; swaps: 101, normalized=0.163; fixes: 0, normalized=0.000}
testSort5 42ms
Compare9751
testSort6 43ms
Worst Compare9769
testSort7 36ms
Instrumenting helper for insertion sort with 128 elements
testSort10_partials 55ms
Instrumenting helper for merge sort with 128 elements
testSort8_partials 48ms
StatPack {hits: 1,792, normalized=2.885; copies: 896, normalized=1.443; inversions: <unset>; swaps: 0, normalized=0.000; fixes: 0, normalized=0.000}
testSort12 2ms
Instrumenting helper for insertion sort with 128 elements
testSort13 1ms
Instrumenting helper for insertion sort with 128 elements
testSort14 0ms
average time random_Cutoff: 79781
testSort15 1ms
Instrumenting helper for insertion sort with 128 elements
average time random_Cutoff = NoCopy: 38398
Instrumenting helper for insertion sort with 128 elements
average time random_Cutoff = Insurance: 41484
Instrumenting helper for insertion sort with 128 elements
average time random_Cutoff = Insurance + NoCopy: 33099
Instrumenting helper for insertion sort with 128 elements
partial sorted average time partialsorted_Cutoff + Insurance: 52694
Instrumenting helper for insertion sort with 128 elements
partial sorted average time partialsorted_Cutoff: 46029
testing Instrumenting helper for MergeSort: with insurance comparison with 8 elements
testing Instrumenting helper for MergeSort: with no copy with 8 elements
testing Instrumenting helper for MergeSort: with insurance comparison with no copy with 8 elements

Process finished with exit code 0
```

Git Run Debug TODO Problems Services Build Dependencies

Tests passed: 15 (moments ago)

11:14 LF UTF-8 4 spaces Spring2023