CSCI 423 Assignment 2

SORT COMPARISON ANALYSIS

March 1, 2019

Samy Masadi

CSCI 423

Department of Math and Computer Science

Rhode Island College

smasadi_3138@email.ric.edu

1 Abstract

The Sort Comparison program demonstrates various sorting methods on lists of different types and lengths. The intention of the program is to directly compare the sorting times of method in order to reveal their strengths and weaknesses.

The sorting times recorded from the comparisons revealed inherent traits about each method. Quick sort works well for randomly arranged lists, but because of its pivot, it does not handle in-order or reverse well. Merge sort is consistent across all scenarios, but its additional memory usage creates additional overhead that may impact sorting times, especially for small list lengths. Bubble sort reveals the weaknesses of a brute force method; however, it can perform quickest when the list is already sorted. Improvements made to Quick Sort involving the pivot can improve the its partitioning performance. Finally, a variation of merge sort involving insertion sort for small list lengths reveals that its memory access overhead can be mitigated to further improve its performance.

2 Methodology

After writing out the each sorting method code, I ran each sort comparison on each of the list types and lengths. With three different comparisons, three types of lists, and two list lengths, the total number of comparisons taken were 3 X 3 X 2, or 18 comparisons. The times for each sorting method were then recorded into tables (see next section) for quick comparison.

3 Information on Sort Methods

The Sorts employed in the program:

3.1 Quick Sort

Attempts a divide and conquer approach that partitions the list based on a pivot value. The pivot is always selected from the first element in the list. Elements less than or equal to the pivot are placed in one partition, while elements greater than the pivot are place in the other. Quick Sort is then called recursively on each partition.

3.2 Merge Sort

Another divide and conquer method that splits the list into equal halves. Merge Sort is called recursively on each half. The halves are then merged and sorted in ascending order.

3.3 Bubble Sort

A brute force method that loops through the list, selects the largest element on each pass, and moves the element to the end of the list.

3.4 Quick Sort Variation

This performs a quick sort except the pivot is select from the median value of three elements.

3.5 Merge Sort Variation

This performs a merge sort except halves that are 10 elements or less in length are sorted with an insertion sort. The insertion sort takes the first element in the unsorted portion of the list then inserts it in the proper position in the sorted portion of the list.

4 Sort Comparisons

The following tables show the sorting times for each sorting method on the different list types.

Table 1	Quick	Merge	Bubble
in-order10	2.10E-05	2.56E-05	1.19E-05
reverse10	2.08E-05	2.62E-05	2.50E-05
random10	1.59E-05	2.30E-05	1.82E-05
in-order50	1.19E-04	1.23E-04	1.06E-04
reverse50	1.42E-04	1.21E-04	4.28E-04
random50	8.22E-05	1.33E-04	2.77E-04

Table 2	Quick	Merge	Bubble
Best	$\Omega(n\log n)$	$\Theta(n\log n)$	$\Omega(n)$
Worst	$O(n^2)$	$\Theta(n\log n)$	$O(n^2)$
Average	$\Theta(n\log n)$	$\Theta(n\log n)$	$\Theta(n^2)$

Table 3	Quick	Quick Var	Merge	Merge Var
in-order10	1.85E-05	1.48E-05	2.50E-05	7.97E-06
reverse10	1.93E-05	1.48E-05	2.42E-05	1.39E-05
random10	1.76E-05	1.56E-05	2.50E-05	1.02E-05
in-order50	1.17E-04	1.10E-04	1.21E-04	5.94E-05
reverse50	1.50E-04	1.46E-04	1.22E-04	7.71E-05
random50	8.31E-05	7.71E-05	1.29E-04	7.28E-05

5 Screen Captures

```
Enter a number: 1
Sort Comparison:
Size:  10
Order:  In-Order

Quick Sort
Unsorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
Sorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
Quick Sort CPU time (seconds): 2.1048999997219653e-05

Merge Sort
Unsorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
Sorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
Merge Sort CPU time (seconds): 2.5600000000736145e-05

Bubble Sort
Unsorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
Sorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
Bubble Sort CPU time (seconds): 1.1946999997292096e-05
```

```
Enter a number: 2
Sort Comparison:
Size:  10
Order:  Reverse

Quick Sort
Unsorted:
[9, 8, 7, 6, 5, 4, 3, 2, 1, 0]
Sorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
Quick Sort CPU time (seconds): 2.0764999987932242e-05

Merge Sort
Unsorted:
[9, 8, 7, 6, 5, 4, 3, 2, 1, 0]
Sorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
Merge Sort CPU time (seconds): 2.6168999966103e-05

Bubble Sort
Unsorted:
[9, 8, 7, 6, 5, 4, 3, 2, 1, 0]
Sorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
Bubble Sort CPU time (seconds): 2.503100000694758e-05
```

```
Enter a number: 3
Sort Comparison:
Size:   10
Order:  Random

Quick Sort
Unsorted:
[55, 27, 90, 18, 78, 30, 44, 56, 21, 67]
Sorted:
[18, 21, 27, 30, 44, 55, 56, 67, 78, 90]
Quick Sort CPU time (seconds): 1.5929000028336304e-05

Merge Sort
Unsorted:
[55, 27, 90, 18, 78, 30, 44, 56, 21, 67]
Sorted:
[18, 21, 27, 30, 44, 55, 56, 67, 78, 90]
Merge Sort CPU time (seconds): 2.3039999973661907e-05

Bubble Sort
Unsorted:
[55, 27, 90, 18, 78, 30, 44, 56, 21, 67]
Sorted:
[18, 21, 27, 30, 44, 55, 56, 67, 78, 90]
Bubble Sort CPU time (seconds): 1.8205000003490568e-05
```

```
Enter a number: 4
Sort Comparison:
Size:   50
Order:  In-Order

Quick Sort
Unsorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31,
32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49]
Sorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31,
32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49]
Quick Sort CPU time (seconds): 0.0001186130000405683

Merge Sort
Unsorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31,
32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49]
Sorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31,
32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49]
Merge Sort CPU time (seconds): 0.00012401800000816365

Bubble Sort
Unsorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31,
32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49]
Sorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31,
32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49]
Bubble Sort CPU time (seconds): 0.0001058140000509411
```

6

```
Enter a number: 5
Sort Comparison:
Size:   50
Order:  Reverse

Quick Sort
Unsorted:
[49, 48, 47, 46, 45, 44, 43, 42, 41, 40, 39, 38, 37, 36, 35, 34, 33, 32, 31, 30, 29, 28, 27, 26, 25, 24, 23, 22, 21, 20
, 19, 18, 17, 16, 15, 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1, 0]
Sorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31,
32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49]
Quick Sort CPU time (seconds): 0.0001416540000036548

Merge Sort
Unsorted:
[49, 48, 47, 46, 45, 44, 43, 42, 41, 40, 39, 38, 37, 36, 35, 34, 33, 32, 31, 30, 29, 28, 27, 26, 25, 24, 23, 22, 21, 20
, 19, 18, 17, 16, 15, 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1, 0]
Sorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31,
32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49]
Merge Sort CPU time (seconds): 0.00012088900007256598

Bubble Sort
Unsorted:
[49, 48, 47, 46, 45, 44, 43, 42, 41, 40, 39, 38, 37, 36, 35, 34, 33, 32, 31, 30, 29, 28, 27, 26, 25, 24, 23, 22, 21, 20
, 19, 18, 17, 16, 15, 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1, 0]
Sorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31,
32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49]
Bubble Sort CPU time (seconds): 0.0004280890000245563
```

```
Enter a number: 6
Sort Comparison:
Size:   50
Order:  Random

Quick Sort
Unsorted:
[88, 15, 66, 53, 59, 14, 26, 52, 23, 36, 15, 17, 13, 62, 50, 90, 69, 46, 6, 63, 40, 1, 45, 47, 79, 20, 55, 1, 73, 57, 8,
43, 52, 14, 87, 23, 60, 19, 47, 6, 41, 91, 92, 67, 7, 25, 46, 61, 12, 1]
Sorted:
[1, 1, 1, 6, 6, 7, 8, 12, 13, 14, 14, 15, 15, 17, 19, 20, 23, 23, 25, 26, 36, 40, 41, 43, 45, 46, 46, 47, 47, 50, 52, 52,
 53, 55, 57, 59, 60, 61, 62, 63, 66, 67, 69, 73, 79, 87, 88, 90, 91, 92]
Quick Sort CPU time (seconds): 8.220400002301176e-05

Merge Sort
Unsorted:
[88, 15, 66, 53, 59, 14, 26, 52, 23, 36, 15, 17, 13, 62, 50, 90, 69, 46, 6, 63, 40, 1, 45, 47, 79, 20, 55, 1, 73, 57, 8,
43, 52, 14, 87, 23, 60, 19, 47, 6, 41, 91, 92, 67, 7, 25, 46, 61, 12, 1]
Sorted:
[1, 1, 1, 6, 6, 7, 8, 12, 13, 14, 14, 15, 15, 17, 19, 20, 23, 23, 25, 26, 36, 40, 41, 43, 45, 46, 46, 47, 47, 50, 52, 52,
 53, 55, 57, 59, 60, 61, 62, 63, 66, 67, 69, 73, 79, 87, 88, 90, 91, 92]
Merge Sort CPU time (seconds): 0.00013283599999206441

Bubble Sort
Unsorted:
[88, 15, 66, 53, 59, 14, 26, 52, 23, 36, 15, 17, 13, 62, 50, 90, 69, 46, 6, 63, 40, 1, 45, 47, 79, 20, 55, 1, 73, 57, 8,
43, 52, 14, 87, 23, 60, 19, 47, 6, 41, 91, 92, 67, 7, 25, 46, 61, 12, 1]
Sorted:
[1, 1, 1, 6, 6, 7, 8, 12, 13, 14, 14, 15, 15, 17, 19, 20, 23, 23, 25, 26, 36, 40, 41, 43, 45, 46, 46, 47, 47, 50, 52, 52,
 53, 55, 57, 59, 60, 61, 62, 63, 66, 67, 69, 73, 79, 87, 88, 90, 91, 92]
Bubble Sort CPU time (seconds): 0.0002770500000224274
```

```
Enter a number: 1
Sort Comparison:
Size:   10
Order:  In-Order

Quick Sort
Unsorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
Sorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
Quick Sort CPU time (seconds): 1.848900001277798e-05

Quick Sort Variation
Unsorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
Sorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
Quick Sort Variation CPU time (seconds): 1.4791000012337463e-05
```

```
Enter a number: 2
Sort Comparison:
Size:   10
Order:  Reverse

Quick Sort
Unsorted:
[9, 8, 7, 6, 5, 4, 3, 2, 1, 0]
Sorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
Quick Sort CPU time (seconds): 1.934199997322139e-05

Quick Sort Variation
Unsorted:
[9, 8, 7, 6, 5, 4, 3, 2, 1, 0]
Sorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
Quick Sort Variation CPU time (seconds): 1.4791000012337463e-05
```

```
Enter a number: 3
Sort Comparison:
Size:   10
Order:  Random

Quick Sort
Unsorted:
[55, 27, 90, 18, 78, 30, 44, 56, 21, 67]
Sorted:
[18, 21, 27, 30, 44, 55, 56, 67, 78, 90]
Quick Sort CPU time (seconds): 1.7634999994922313e-05

Quick Sort Variation
Unsorted:
[55, 27, 90, 18, 78, 30, 44, 56, 21, 67]
Sorted:
[18, 21, 27, 30, 44, 55, 56, 67, 78, 90]
Quick Sort Variation CPU time (seconds): 1.5645000075892312e-05
```

```
Enter a number: 4
Sort Comparison:
Size:   50
Order:  In-Order

Quick Sort
Unsorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32
, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49]
Sorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32
, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49]
Quick Sort CPU time (seconds): 0.00011662200017781288

Quick Sort Variation
Unsorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32
, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49]
Sorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32
, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49]
Quick Sort Variation CPU time (seconds): 0.00011008000001311302
```

```
Enter a number: 5
Sort Comparison:
Size:   50
Order:  Reverse

Quick Sort
Unsorted:
[49, 48, 47, 46, 45, 44, 43, 42, 41, 40, 39, 38, 37, 36, 35, 34, 33, 32, 31, 30, 29, 28, 27, 26, 25, 24, 23, 22, 21, 20,
19, 18, 17, 16, 15, 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1, 0]
Sorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32
, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49]
Quick Sort CPU time (seconds): 0.00015018699991742324

Quick Sort Variation
Unsorted:
[49, 48, 47, 46, 45, 44, 43, 42, 41, 40, 39, 38, 37, 36, 35, 34, 33, 32, 31, 30, 29, 28, 27, 26, 25, 24, 23, 22, 21, 20,
19, 18, 17, 16, 15, 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1, 0]
Sorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32
, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49]
Quick Sort Variation CPU time (seconds): 0.0001464890001443564
```

8

```
Enter a number: 6
Sort Comparison:
Size:  50
Order:  Random

Quick Sort
Unsorted:
[88, 15, 66, 53, 59, 14, 26, 52, 23, 36, 15, 17, 13, 62, 50, 90, 69, 46, 6, 63, 40, 1, 45, 47, 79, 20, 55, 1, 73, 57, 8,
43, 52, 14, 87, 23, 60, 19, 47, 6, 41, 91, 92, 67, 7, 25, 46, 61, 12, 1]
Sorted:
[1, 1, 1, 6, 6, 7, 8, 12, 13, 14, 14, 15, 15, 17, 19, 20, 23, 23, 25, 26, 36, 40, 41, 43, 45, 46, 46, 47, 47, 50, 52, 52,
53, 55, 57, 59, 60, 61, 62, 63, 66, 67, 69, 73, 79, 87, 88, 90, 91, 92]
Quick Sort CPU time (seconds): 8.305799997287977e-05

Quick Sort Variation
Unsorted:
[88, 15, 66, 53, 59, 14, 26, 52, 23, 36, 15, 17, 13, 62, 50, 90, 69, 46, 6, 63, 40, 1, 45, 47, 79, 20, 55, 1, 73, 57, 8,
43, 52, 14, 87, 23, 60, 19, 47, 6, 41, 91, 92, 67, 7, 25, 46, 61, 12, 1]
Sorted:
[1, 1, 1, 6, 6, 7, 8, 12, 13, 14, 14, 15, 15, 17, 19, 20, 23, 23, 25, 26, 36, 40, 41, 43, 45, 46, 46, 47, 47, 50, 52, 52,
53, 55, 57, 59, 60, 61, 62, 63, 66, 67, 69, 73, 79, 87, 88, 90, 91, 92]
Quick Sort Variation CPU time (seconds): 7.708500015723985e-05
```

```
Enter a number: 1
Sort Comparison:
Size:  10
Order:  In-Order

Merge Sort
Unsorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
Sorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
Merge Sort CPU time (seconds): 2.5030999999842152e-05

Merge Sort Variation
Unsorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
Sorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
Merge Sort Variation CPU time (seconds): 7.964999999998668e-06
```

```
Enter a number: 2
Sort Comparison:
Size:  10
Order:  Reverse

Merge Sort
Unsorted:
[9, 8, 7, 6, 5, 4, 3, 2, 1, 0]
Sorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
Merge Sort CPU time (seconds): 2.4178000003871603e-05

Merge Sort Variation
Unsorted:
[9, 8, 7, 6, 5, 4, 3, 2, 1, 0]
Sorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
Merge Sort Variation CPU time (seconds): 1.3937999995050632e-05
```

```
Enter a number: 3
Sort Comparison:
Size:  10
Order:  Random

Merge Sort
Unsorted:
[55, 27, 90, 18, 78, 30, 44, 56, 21, 67]
Sorted:
[18, 21, 27, 30, 44, 55, 56, 67, 78, 90]
Merge Sort CPU time (seconds): 2.503100000694758e-05

Merge Sort Variation
Unsorted:
[55, 27, 90, 18, 78, 30, 44, 56, 21, 67]
Sorted:
[18, 21, 27, 30, 44, 55, 56, 67, 78, 90]
Merge Sort Variation CPU time (seconds): 1.0239999994610116e-05
```

```
Enter a number: 4
Sort Comparison:
Size:  50
Order:  In-Order

Merge Sort
Unsorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32
, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49]
Sorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32
, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49]
Merge Sort CPU time (seconds): 0.00012117299999658826

Merge Sort Variation
Unsorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32
, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49]
Sorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32
, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49]
Merge Sort Variation CPU time (seconds): 5.944899999121844e-05
```

```
Enter a number: 5
Sort Comparison:
Size:  50
Order:  Reverse

Merge Sort
Unsorted:
[49, 48, 47, 46, 45, 44, 43, 42, 41, 40, 39, 38, 37, 36, 35, 34, 33, 32, 31, 30, 29, 28, 27, 26, 25, 24, 23, 22, 21, 20,
19, 18, 17, 16, 15, 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1, 0]
Sorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32
, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49]
Merge Sort CPU time (seconds): 0.00012202699997487798

Merge Sort Variation
Unsorted:
[49, 48, 47, 46, 45, 44, 43, 42, 41, 40, 39, 38, 37, 36, 35, 34, 33, 32, 31, 30, 29, 28, 27, 26, 25, 24, 23, 22, 21, 20,
19, 18, 17, 16, 15, 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1, 0]
Sorted:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32
, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49]
Merge Sort Variation CPU time (seconds): 7.708499998670959e-05
```

```
Enter a number: 6
Sort Comparison:
Size:  50
Order:  Random

Merge Sort
Unsorted:
[88, 15, 66, 53, 59, 14, 26, 52, 23, 36, 15, 17, 13, 62, 50, 90, 69, 46, 6, 63, 40, 1, 45, 47, 79, 20, 55, 1, 73, 57, 8,
43, 52, 14, 87, 23, 60, 19, 47, 6, 41, 91, 92, 67, 7, 25, 46, 61, 12, 1]
Sorted:
[1, 1, 1, 6, 6, 7, 8, 12, 13, 14, 14, 15, 15, 17, 19, 20, 23, 23, 25, 26, 36, 40, 41, 43, 45, 46, 46, 47, 47, 50, 52, 52,
53, 55, 57, 59, 60, 61, 62, 63, 66, 67, 69, 73, 79, 87, 88, 90, 91, 92]
Merge Sort CPU time (seconds): 0.000128569000025891

Merge Sort Variation
Unsorted:
[88, 15, 66, 53, 59, 14, 26, 52, 23, 36, 15, 17, 13, 62, 50, 90, 69, 46, 6, 63, 40, 1, 45, 47, 79, 20, 55, 1, 73, 57, 8,
43, 52, 14, 87, 23, 60, 19, 47, 6, 41, 91, 92, 67, 7, 25, 46, 61, 12, 1]
Sorted:
[1, 1, 1, 6, 6, 7, 8, 12, 13, 14, 14, 15, 15, 17, 19, 20, 23, 23, 25, 26, 36, 40, 41, 43, 45, 46, 46, 47, 47, 50, 52, 52,
53, 55, 57, 59, 60, 61, 62, 63, 66, 67, 69, 73, 79, 87, 88, 90, 91, 92]
Merge Sort Variation CPU time (seconds): 7.281799997826965e-05
```

10