**Course: ESO207A – Data Structures and Algorithms**

Indian Institute of Technology Kanpur

**Programming Assignment 5 :** *Quick sort versus Merge Sort*

#### 1.1 Comparisons

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *n*−→ | 102 | 103 | 104 | 105 | 106 |
| Average number of comparisons during Quick Sort | 721 | 10081 | 152191 | 1993051 | 34841146 |
| 2*n*log*en* | 921.034 | 13815.51 | 184206.8 | 2302585 | 27631021.1 |
| Average number of comparisons during Merge Sort | 541 | 8706 | 120453 | 1536375 | 18674200 |
| *n*log2*n* | 200 | 3000 | 40000 | 500000 | 6000000 |

#### Number of comparisons in MergeSort is less than that of Quick Sort. Plot of QuickSort vs 2nlogen and MergeSort vs nlog2n are linear ,which shows growth rate of comparsions is proportional to 2nlogen and nlog2n respectively.

#### 1.2 Number of comparisons and time complexity of quick sort

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *n*−→ | 105 | 3 ∗ 105 | 5 ∗ 105 | 7 ∗ 105 | 9 ∗ 105 |
| Average running time of Quick Sort | 20094 | 66624 | 180230 | 187988 | 273860 |

#### Running Time increases with n but growth is not linear.Chart, line chart Description automatically generated

#### 1.3 Time Complexity

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *n*−→ | 102 | 103 | 104 | 105 | 106 |
| Average running time of Quick Sort | 4 | 78 | 1214 | 15580 | 252412 |
| Average running time of Merge Sort | 24 | 190 | 2088 | 24418 | 268276 |
| Number of times Merge Sort outperformed Quick Sort | 0 | 39 | 18 | 1 | 27 |

It is observed that running time of QuickSort is less than MergeSort for corresoponding values of and only few times(<6%) MergeSort Outperformed QuickSort which shows QuickSort is more efficient than MergeSort.

Chart, line chart

Description automatically generated

**1.4 Can you improve merge-sort ?**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *n*−→ | 102 | 103 | 104 | 105 | 106 |
| Average running time of Quick Sort | 4 | 68 | 1184 | 15262 | 249652 |
| Average running time of Improved-Merge-Sort | 10 | 128 | 1386 | 17110 | 193468 |
| Number of times Improved-Merge Sort outperformed Quick Sort | 2 | 32 | 94 | 25 | 499 |

### After improving MergeSort it takes relatively less running time than previous MergeSort algorithm for corresoponding values of n.But still

### QuickSort takes less running time than MergeSort for array size upto 105

### But after that MergeSort takes lesser running time.It can be inferred that QuickSort is faster algorithm for array sizes upto 105.

### 2. Reliability of Quick Sort

Chart, line chart

Description automatically generated

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *n*−→ | 102 | 103 | 104 | 105 | 106 |
| Average running time of Quick Sort | 4 | 158 | 1594 | 20094 | 316010 |
| No. of cases where run time exceeds average by 5% | 2 | 75 | 253 | 91 | 75 |
| No. of cases where run time exceeds average by 10% | 2 | 75 | 253 | 77 | 29 |
| No. of cases where run time exceeds average by 20% | 2 | 75 | 253 | 47 | 7 |
| No. of cases where run time exceeds average by 30% | 2 | 75 | 41 | 33 | 2 |
| No. of cases where run time exceeds average by 50% | 2 | 75 | 41 | 15 | 1 |
| No. of cases where run time exceeds average by 100% | 2 | 75 | 6 | 4 | 0 |

It can be inferred that relative spread of events from average decreases on the greater side(when it takes more time) as the size of the array increases.

Which shows that only for few events running time will be greater for larger arrays and in case of smaller arrays as size is already is small so is the time taken even in the worst case . Therefore, it can be concluded that QuickSort is practical for sorting .