

Trường Đại Học Quốc Tế - DHQG TP.HCM

# **LAB REPORT**

Course: Algorithms & Data Structures LAB 6

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# 1 PartitionApp.java

## 1.1 Add counters for the number of comparisons and swaps and display them after partitioning



```
1  public int partitionIt(int left, int right, long pivot)
2  {
3      int leftPtr = left - 1;           // right of first elem
4      int rightPtr = right + 1;        // left of pivot
5      while(true)
6      {
7          comparisonCount++;
8          while(leftPtr < right &&      // find bigger item
9                  theArray[++leftPtr] < pivot)
10             comparisonCount++;
11         ; // (nop)
12         comparisonCount++;
13         while(rightPtr > left &&      // find smaller item
14                  theArray[--rightPtr] > pivot)
15
16         ; // (nop)
17         comparisonCount++; // count final comparison
18         if(leftPtr >= rightPtr){      // if pointers cross,
19
20             break;                  // partition done
21         } else{                   // not crossed, so
22             swap(leftPtr, rightPtr); // swap elements
23             swapCount++;
24         }
25     } // end while(true)
26     return leftPtr;                // return partition
27 } // end partitionIt()
```

## 1.2 Investigate the relationship between the index of partitioning, the number of comparison, and the number of swaps.

As the code runs, we can infer that the number of comparison is less than the partition index, while the partition index is greater than or equal the number of swaps.

## 1.3 Compute the average number of comparisons and swaps over 100 runs.

```
● ● ●
1  public static void main(String[] args)
2  {
3      double averageComparisonsIn100Runs = 0;
4      for(int i = 0; i < 100; i++){
5          int maxSize = 16;           // array size
6          ArrayPar arr;             // reference to array
7          arr = new ArrayPar(maxSize); // create the array
8          for(int j=0; j<maxSize; j++) // fill array with
9          {
10              Long n = (int)(java.Lang.Math.random()*199);
11              arr.insert(n);
12          }
13          arr.display();           // display unsorted array
14
15          long pivot = arr.getElement(0);           // pivot value
16          System.out.print("Pivot is " + pivot);
17          int size = arr.size();                  // partition array
18          int partDex = arr.partitionIt(0, size-1, pivot);
19          System.out.println(" with " + arr.getComparisonCount() + " comparisons and " + arr.getSwapCount() + " swaps.");
20          System.out.println(" , Partition is at index " + partDex);
21          averageComparisonsIn100Runs += arr.getComparisonCount()/16.0;
22          arr.display();                     // display partitioned array
23      }
24      System.out.println("Average number of comparisons in 100 runs: " + averageComparisonsIn100Runs/100 + " comparison/element");
25  } // end main()
26 } // end class PartitionApp
```

## 2 Merge Sort



```
1  public static void sort(int[] array, int leftIndex, int rightIndex, int n) {  
2      if (n <=1 || leftIndex >= rightIndex) {  
3          return;  
4      }  
5      int midIndex = leftIndex + (rightIndex - leftIndex) / 2;  
6      sort(array, leftIndex, midIndex, midIndex + 1);  
7      sort(array, midIndex + 1, rightIndex, rightIndex - midIndex);  
8      merge(array, leftIndex, midIndex, rightIndex);  
9  }  
10 }
```



```
1  private static void merge(int[] array, int left, int mid, int right) {
2      int leftSize = mid - left + 1;
3      int rightSize = right - mid;
4      int[] leftArray = new int[leftSize];
5      int[] rightArray = new int[rightSize];
6      for (int i = 0; i < leftSize; i++) {
7          leftArray[i] = array[left + i];
8          copies++;
9      }//copy data to temp arrays
10     for (int j = 0; j < rightSize; j++) {
11         rightArray[j] = array[mid + 1 + j];
12         copies++;
13     }
14     int i = 0, j = 0;
15     int k = left;
16     while (i < leftSize && j < rightSize) {
17         comparison++;
18         if (leftArray[i] <= rightArray[j]) {
19             array[k] = leftArray[i];//corrected from rightArray to LeftArray
20             i++;
21             copies++;
22         } else {
23             array[k] = rightArray[j];//corrected from LeftArray to rightArray
24             j++;
25             copies++;
26         }//merge the temp arrays
27         k++;
28     }
29
30     while (i < leftSize) {
31         array[k] = leftArray[i];
32         i++;
33         k++;
34         copies++;
35     }//copy remaining elements
36     while (j < rightSize) {
37         array[k] = rightArray[j];
38         j++;
39         k++;
40         copies++;
41     }
42 }
```

### 3 Shell Sort

```
1  public static void sort(int[] array) {
2      int h = 1;
3      int temp, i, j;
4      int n = array.Length;
5      while(h <= n / 3) {
6          h = h * 3 + 1; //Using Knuth's sequence to determine initial gap
7      }
8      while (h > 0) {
9          for(i = h; i < n; i++) {
10              temp = array[i];
11              copies++;
12              j = i;
13              while (j >= h && array[j - h] > temp) {
14                  array[j] = array[j - h];
15                  j -= h;
16                  copies++;
17                  comparison++;
18              }
19              array[j] = temp;
20              copies++;
21              if (j != i) {
22                  swaps++;
23              }
24          }
25          h = (h - 1) / 3; //Reduce the gap for the next pass
26      }
27  }
```

## 4 Quick Sort

```
1  public static void quickSort(int a[], int l, int r){  
2      int p = a[(l+r)/2];  
3      copies++;  
4      int i = l, j = r;  
5      while (i < j){  
6          while (a[i] < p){// shift left pointer right if element is Less than pivot  
7              i++;  
8              comparison++;  
9          }  
10         while (a[j] > p){// shift right pointer left if element is greater than pivot  
11             j--;  
12             comparison++;  
13         }  
14         comparison++;  
15         if (i <= j){  
16             int temp = a[i];  
17             a[i] = a[j];  
18             a[j] = temp;  
19             copies += 3;  
20             swaps++;  
21             i++;  
22             j--;  
23         }  
24         comparison++;  
25     }  
26     comparison++;  
27     if (i < r){  
28         quickSort(a, i, r); // sort right half  
29     }  
30     comparison++;  
31     if (l < j){  
32         quickSort(a, l, j); // sort left half  
33     }  
34 }
```

Table for analyzing:

COPIES/COMPARISONS/SWAPS

	Merge Sort	Shell Sort	Quick Sort
<b>10000</b>	267232/120408/0	312353/161875/49718	170963/190707/52378
<b>15000</b>	417232/189266/0	524361/283883/78820	271416/281647/83471
<b>20000</b>	574464/260857/0	747739/417261/109748	372464/405189/114788
<b>25000</b>	734464/334069/0	923791/503313/140213	483572/503806/149056
<b>30000</b>	894464/408774/0	1138810/627381/171385	587429/624249/181513
<b>35000</b>	1058928/484356/0	1358798/747369/202412	699025/736104/216084
<b>40000</b>	1228928/561616/0	1635252/923823/236450	800292/894034/247940
<b>45000</b>	1398928/639592/0	1815185/1003756/269026	922667/949245/286286
<b>50000</b>	1568928/718172/0	2213452/1302023/306578	1040596/1092654/322439

This table shows the number of COPIES/COMPARISONS/SWAPS with respect to number of elements in the arrays. As illustrated on the table. Comparing to the simple sort table previously, it is inferred that the advanced sorts take fewer operations than the basic one.

## 5 Problem 5

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*This is the end of the report*

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