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Experiment No.	**02**
Aim	**Experiment based on divide and conquer approach.**
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Objective: To understand the running time of algorithms by implementing two sorting algorithms based on divide and conquers approach namely Merge and Quick sort.

Theory:

Merge sort is a sorting algorithm that works by dividing an array into smaller subarrays, sorting each subarray, and then merging the sorted subarrays back together to form the final sorted array. In simple terms, we can say that the process of merge sort is to divide the array into two halves, sort each half, and then merge the sorted halves back together. This process is repeated until the entire array is sorted.

Quick sort– Like Merge Sort, QuickSort is a Divide and Conquer algorithm. It picks an element as a pivot and partitions the given array around the picked pivot. There are many different versions of quickSort that pick pivot in different ways.

- Always pick the first element as a pivot.
- Always pick the last element as a pivot (implemented below)
- Pick a random element as a pivot.
- Pick median as the pivot.

It is mainly divided in three basic steps:

Divide: In Divide, first pick a pivot element. After that, partition or rearrange the array into two sub-arrays such that each element in the left sub-array is less than or equal to the pivot element and each element in the right sub-array is larger than the pivot element.

Conquer: Recursively, sort two subarrays

with Quicksort. Combine: Combine the

already sorted array.

Program:

```
#include
<stdio.h>
#include
<stdlib.h>
#include
<time.h> long
SWAP = 0;
```

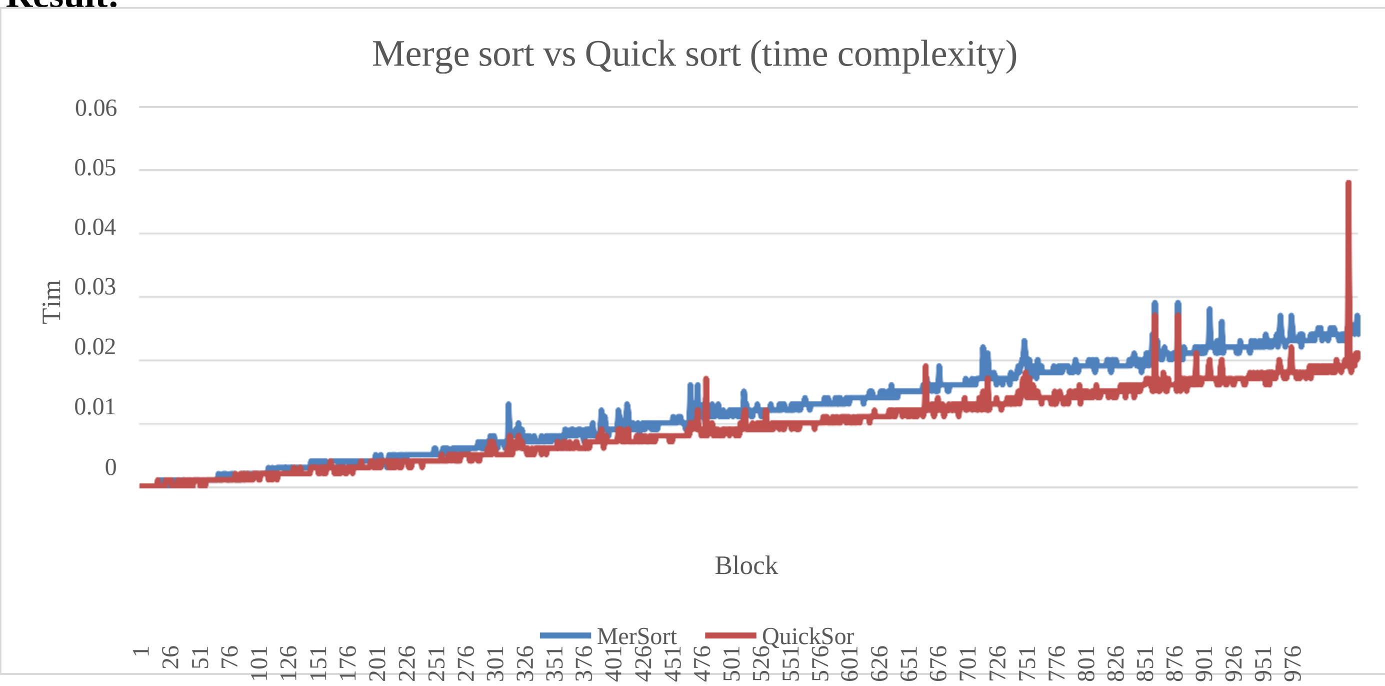
```
void merge(int arr[], int p, int q, int r)
{
  int i, j, k;
  int n1 = q - p
  + 1;int n2 = r
  - q;

  int L[n1], R[n2];

  for (i = 0; i <
    n1; i++)L[i] =
    arr[p + i];
  for (j = 0; j < n2;
    j++) R[j] =
    arr[q + 1 + j];

  i = 0;
  j = 0;

  k = p;
  while (i < n1 && j < n2)
  {
    if (L[i] <= R[j])
    {
      arr[k] =
      L[i];i++;
    }
    else
    {
      arr[k] =
      R[j];j++;
    }
    k++;
  }

  while (i < n1)
  {
    arr[k] =
    L[i];i++;
    k++;
  }

  while (j < n2)
  {
    arr[k] =
    R[j];j++;
```

```
            k++;
          }
        }

        void mergeSort(int arr[], int l, int r)


{if (l < r)
          {

            int m = l + (r - l) / 2;

            mergeSort(arr, l, m);
            mergeSort(arr, m + 1, r);

            merge(arr, l, m, r);
          }
        }

        int quicksort(int a[], int start, int end)
        {
      int pivot = a[end];
    //int pivot = a[start];
        //int random = start + rand() % (end - start);
        //int pivot = a[random];
        //int mid = start + (end - start)/2;
        //int pivot =
          a[mid];int i =
          (start - 1);

          for (int j = start; j <= end - 1; j++)
          {
            if (a[j] < pivot)
            {
              i++;
              int t =
              a[i];a[i]
              = a[j];
              a[j] = t;
              SWAP+
              +;
            }
          }
          int t = a[i +
          1]; a[i + 1] =
          a[end];
          a[end] = t;
```

```
  SWAP++;
  return (i + 1);
}

double quick(int a[], int start, int end)
{
  if (start < end)
  {
    int p = quicksort(a,
    start, end);quick(a,
    start, p - 1);
    quick(a, p + 1, end);
  }
}

int main()
{
  double
  qust,mest;
  srand(time(0));
  FILE *fp,*file;
  fp =
  fopen("random.txt",
  "w");for (int i = 0; i <
  100000; i++)
  {
    fprintf(fp, "%d\n", rand() % 900001 + 100000);
  }
  int upper_limit =
  100;fclose(fp);
  file = fopen("output.txt","w");
  fprintf(file,"Block\tMerSort\tQuickSort\t
  Swaps\n");for (int i = 0; i < 1000; i++)
  {
    fp = fopen("random.txt", "r");
    int arr1[upper_limit], arr2[upper_limit],
    temp_num;for (int j = 0; j < upper_limit;
    j++)
    {
      fscanf(fp, "%d",
      &temp_num);arr1[j] =
      temp_num;
      arr2[j] = temp_num;
    }
    fclose(fp);

    clock_t
```

```
    t; t =
    clock();
    mergeSort(arr2,0,upper_li
    mit-1);t = clock() - t;
    mest = ((double)t) /
    CLOCKS_PER_SEC;clock_t
    t1;
    t1 = clock();
    qust=quick(arr1,0,upper_l
    imit-1);t1 = clock() - t1;
    qust = ((double)t1) / CLOCKS_PER_SEC;
    fprintf(file,"%d\t%lf\t%lf\t%ld\n",i+1, mest,
    qust,SWAP);fflush(stdout);
    upper_limit += 100;
  }
  return 0;
}
```

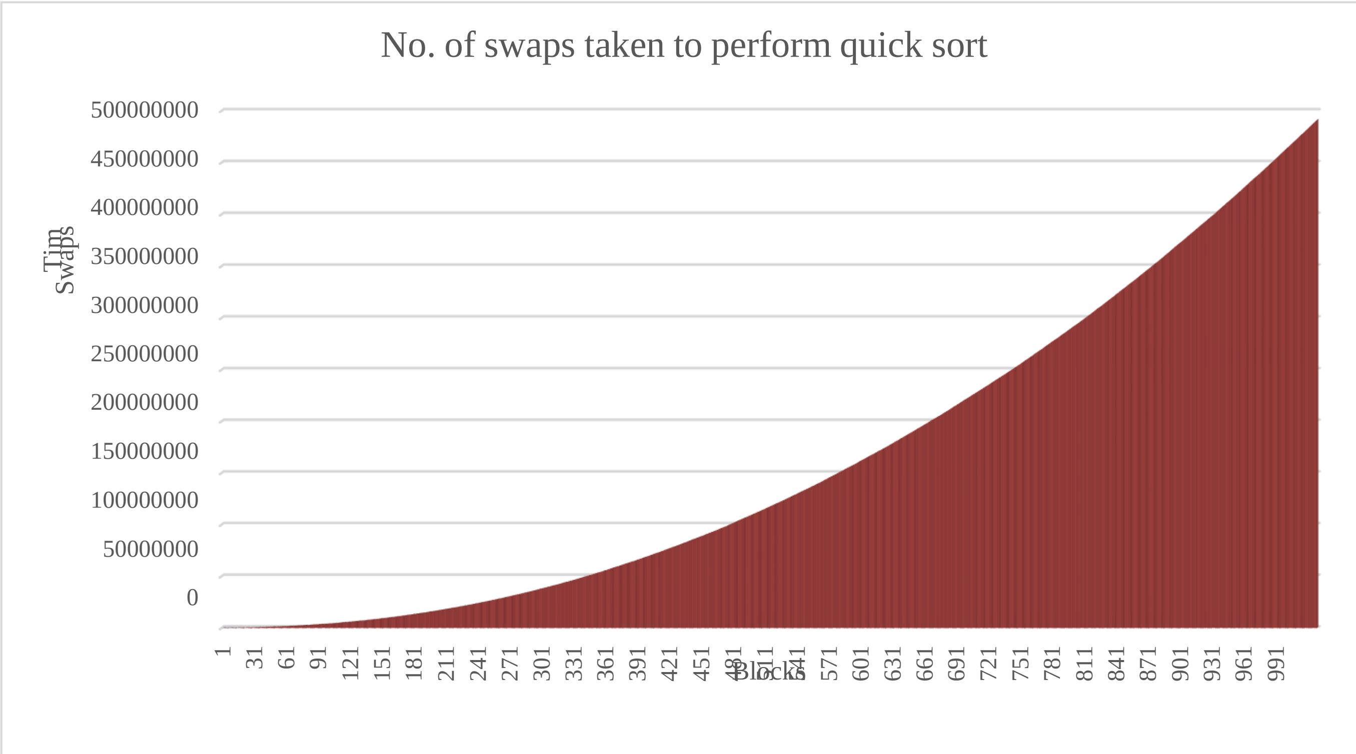
Result:



Inference:

Merge sort: As we can see from the graph, merge sort takes more time at each iteration than quick sort as its always about quick sort in the graph. There are some spikes in at certain movements but overall we can observe a linear increase in the graph.

Quick sort: On the other hand, time taken to perform quick sort is just slightly less than merge sort but on the other hand there are a lot of spikes that can be observed where one rises to as high as 0.05 seconds. It is expected that with some proper work some of these spikes can be overcome. Also, compare with merge sort, which achieves similar results but has much lower round-trip-time.



As we observe as we add more numbers at each iteration to the block the number of swaps required increase significantly reaching hundreds of millions. Linear increase is observed.

Conclusion:

Thus, after performing this experiment I conclude that quick sort performs better than merge sort but it also unstable whereas merge sort takes a little more time but it has a linear increase and doesn't have a lot of ups and downs.
Moreover, when performing quick sort on large data the position of the pivot matter a lot as just changing the pivot yields drastic results. Also, no. of swaps required to sort data is directly proportional to the size of the data.