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SE Comps A
Batch D

DAA EXPERIMENT 2

Aim - Experiment to find the running time of an algorithm.

Details - The understanding of running time of algorithms is explored by implementing two basic sorting algorithms namely Merge and Quick sorts. These algorithms work as follows.

MergeSort - 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.

QuickSort - 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 the median as the pivot.

The key process in quicksort is a partition(). The target of partitions is, given an array and an element x of an array as the pivot, put x at its correct position in a sorted array and put all smaller elements (smaller than x) before x, and put all greater elements (greater than x) after x. All this should be done in linear time.

Code -

```
#include <stdio.h>
#include <stdlib.h>
#include <time.h>

const int limit = 100000;
const int block = 100;

void merge (int arr[], int l, int m, int r) {

        int i = 0, j = 0, k = l;
        int n1 = m - l + 1;
        int n2 = r - m;
        int L[n1], R[n2];
        for (i = 0; i < n1; i++)
        L[i] = arr[l + i];
        for (j = 0; j < n2; j++)
        R[j] = arr[m + 1 + j];
        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);
        }
}

void merge_sort (FILE *f) {
   FILE *fp;
   fp = fopen("daa_2_merge_sort.txt", "w");
        fprintf(fp,"Block Size\tTime Taken\n");
   int size = 0;
   for (int times = 0; times<limit/block; times++) {
        size+=block;
        int arr [size];
        for (int i = 0; i<size; ++i)
                fscanf(f,"%d",&arr[i]);
        // now our array is ready, we perform merge sort
        clock_t t;
        t = clock();
        mergeSort(arr, 0, size-1);
        t = clock()-t;
                double time_taken = ((double)t)/CLOCKS_PER_SEC;
                // storing the result in a file
                fprintf(fp,"%d\t%lf\n",size,time_taken);
        }
   fclose(fp);
}

int partition (int arr[], int low, int high) {
        int pivot = arr[high]; // pivot
        int i = low-1;
        for (int j = low; j <= high - 1; j++) {
        if (arr[j] < pivot) {
```

```
        i++;
        int temp = arr[i];
        arr[i] = arr[j];
        arr[j] = temp;
        }
        }
        int temp = arr[i+1];
        arr[high] = arr[i+1];
        arr[i+1] = temp;
        return i+1;
}

void quickSort (int arr[], int low, int high) {
        if (low < high) {
        int pi = partition(arr, low, high);
        quickSort(arr, low, pi - 1);
        quickSort(arr, pi + 1, high);
        }
}

void quick_sort (FILE *f) {
   FILE *fp;
   fp = fopen("daa_2_quick_sort.txt", "w");
   fprintf(fp,"Block Size\tTime Taken\n");
   int size = 0;
   for (int times = 0; times<limit/block; times++) {
        size+=block;
        int arr [size];
        for (int i = 0; i<size; ++i)
                fscanf(f,"%d",&arr[i]);
        // now our array is ready, we perform quick sort
        clock_t t;
        t = clock();
        quickSort(arr, 0, size-1);
                t = clock()-t;
                double time_taken = ((double)t)/CLOCKS_PER_SEC;
                // storing the result in a file
                fprintf(fp,"%d\t%lf\n",size,time_taken);
   }
```

```
    fclose(fp);
}

int main () {

    // generating 1,00,000 integers and storing them in a file
    FILE *f;
    f = fopen("daa_2_random_integers.txt", "w");
    for (int i = 0; i<limit; ++i)
          fprintf(f,"%d\n",rand());

    // merge sort
    merge_sort(f);

    // quick sort
    quick_sort(f);

    fclose(f);

    return 0;
}
```

1,00,000 randomly generated numbers -

```
    1804289383
846930886
1681692777
1714636915
1957747793
424238335
719885386
1649760492
596516649
1189641421
1025202362
1350490027
783368690
```

1102520059
2044897763
1967513926
1365180540
1540383426
304089172
1303455736
35005211
521595368
294702567
1726956429
336465782
861021530
278722862
233665123
2145174067
468703135
1101513929
1801979802
1315634022
635723058
1369133069
1125898167
1059961393
and so on…

Size of block along with time taken to sort using merge sort -

Block Size	Time Taken
100	0.000007
200	0.000024
300	0.000016
400	0.000020
500	0.000026
600	0.000031
700	0.000037
800	0.000042

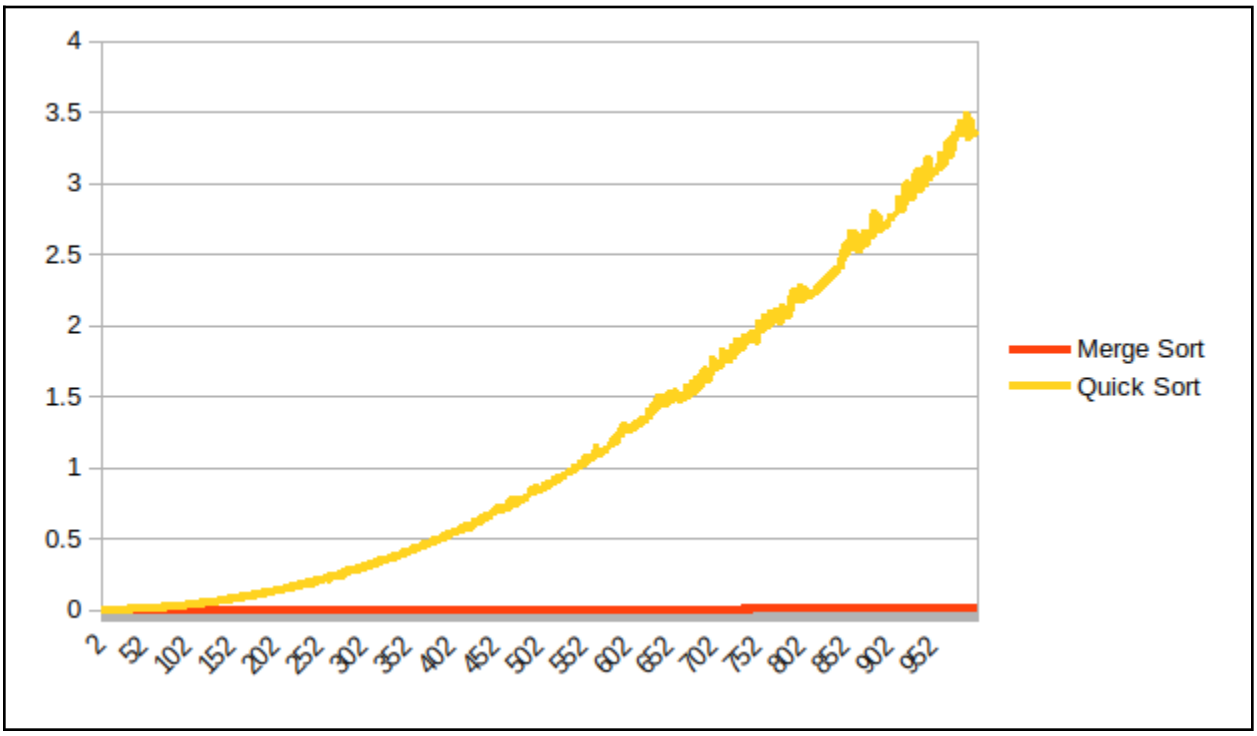
900 0.000082
1000 0.000055
1100 0.000058
1200 0.000064
1300 0.000098
1400 0.000077
1500 0.000099
1600 0.000084
1700 0.000090
1800 0.000095
1900 0.000100
2000 0.000105
2100 0.000113
2200 0.000135
2300 0.000121
2400 0.000127
2500 0.000134
2600 0.000141
2700 0.000180
2800 0.000150
2900 0.000156
3000 0.000196
3100 0.000169
3200 0.000173
3300 0.000179
3400 0.000184
3500 0.000190
3600 0.000216
and so on…

Size of block along with time taken to sort using quick sort -

Block Size	Time Taken
100	0.000009
200	0.000049
300	0.000062
400	0.000093

500 0.000132
600 0.000199
700 0.000216
800 0.000256
900 0.000314
1000 0.000378
1100 0.000451
1200 0.000526
1300 0.000659
1400 0.000711
1500 0.000807
1600 0.000907
1700 0.001015
1800 0.001154
1900 0.001238
2000 0.001367
2100 0.001532
2200 0.001643
2300 0.001941
2400 0.001973
2500 0.002152
2600 0.002292
2700 0.002464
2800 0.002662
2900 0.002817
3000 0.003047
3100 0.003313
3200 0.003636
3300 0.003800
3400 0.004044
3500 0.004228
3600 0.004457
and so on…

Graph of time taken to sort using merge sort and quick sort against size of block to be sorted -



Conclusion - After a hour or two of cumbersome coding, I have finally executed merge sort and quick sort of 1,00,000 integers, taken 100 at a time. It is with clear observation that merge sort is a much more efficient way of sorting your data when it comes in larger sizes, since what took quick sort around 30 minutes, took merge sort mere seconds. We notice that theoretically, the time complexity of both merge sort and quick sort is the same (O(nlogn)), however, in practice merge sort is astonishingly faster. In terms of space complexity, quick sort has higher efficiency (O(logn)) than merge sort (O(n)). Hence we can conclude that merge sort is faster than quick sort in terms of time complexities, however, quick sort is better in terms of space complexity.