Experiment 2

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BATCH : CSE DS D1

AIM : Experiment based on divide and conquer approach

PROBLEM :

You need to implement two sorting algorithms namely Quicksort and Merge sort methods. Compare these algorithms based on time and space complexity. Time required for sorting algorithms can be performed using high_resolution_clock::now() under namespace std::chrono. You have to generate 1,00,000 integer numbers using C/C++ Rand function and save them in a text file. Both the sorting algorithms uses these 1,00,000 integer numbers as input as follows. Each sorting algorithm sorts a block of 100,200,300,...,100000 integer numbers with array indexes numbers A[0..99], A[100..199], A[200..299],…, A[99900..99999]. You need to use high_resolution_clock::now() function to find the time required for 100, 200, 300…. 100000 integer numbers. Finally, compare two algorithms namely Quicksort and Merge sort by plotting the time required to sort integers using LibreOffice Calc/MS Excel. The x-axis of 2-D plot represents the block no. of 1000 blocks. The y-axis of 2-D plot represents the tunning time to sort 1000 blocks of 100,200,300,...,100000 integer numbers.

THEORY:

What is Time complexity?

Time complexity is defined as the amount of time taken by an algorithm to run, as a function of the length of the input. It measures the time taken to execute each statement of code in an algorithm. It is not going to examine the total execution time of an algorithm. Rather, it is going to give information about the variation (increase or decrease) in execution time when the number of operations (increase or decrease) in an algorithm. Yes, as the definition says, the amount of time taken is a function of the length of input only.

What is Quick Sort?

Quicksort is based on a divide and conquer strategy. It works in the following steps:
1. It selects an element from within the array known as the **pivot element**.
2. Then it makes use of the **partition algorithm** to divide the array into two sub-arrays. One sub-array has all the values less than the pivot element. The other sub-array has all the values higher than the pivot element.
3. In the next step, the quicksort algorithm calls itself recursively to sort these two sub-arrays.
4. Once the sorting is done, we can combine both the sub-arrays into a single sorted array. The most important part of quicksort is the partition algorithm. The partition

algorithm puts the element into either of the two subarrays depending on the pivot point. We can choose pivot point in many ways:

- Take the first element as the pivot point
- Take the last element of the array as the pivot point
- Take the middle element of the array as the pivot element.
- Take random element as the pivot element in every recursive call

PARTITION ALGORITHM:-

Step 1: Choose the highest index value i.e. the last element of the array as a pivot point
Step 2: Point to the 1st and last index of the array using two variables.
Step 3: Left points to the low index and Right points to the high
Step 4: while Array[Left] < pivot
Move Right
Step 5: while Array[Right] > pivot
Move Left
Step 6: If no match found in step 5 and step 6, swap Left and Right
Step 7: If Left ≥ Right, their meeting point is the new pivot

What is Merge Sort?

The merge sort algorithm is an implementation of the divide and conquer technique. Thus, it gets completed in three steps:

1. Divide: In this step, the array/list divides itself recursively into sub-arrays until the base case is reached.
2. Recursively solve: Here, the sub-arrays are sorted using recursion.
3. Combine: This step makes use of the **merge(**) **function** to combine the sub-arrays into the final sorted array**.**

ALGORITHM :

QUICKSORT ALGORITHM:-

Step 1 − Array[Right] = pivot
Step 2 − Apply partition algorithm over data items using pivot element
Step 3 − quicksort(left of pivot)
Step 4 − quicksort(right of pivot)

MERGESORT ALGORITHM:-

Step 1: Find the middle index of the array.
Middle = 1 + (last – first)/2
Step 2: Divide the array from the middle.
Step 3: Call merge sort for the first half of the array
MergeSort(array, first, middle)
Step 4: Call merge sort for the second half of the array.
MergeSort(array, middle+1, last)
Step 5: Merge the two sorted halves into a single sorted array

PROGRAM :

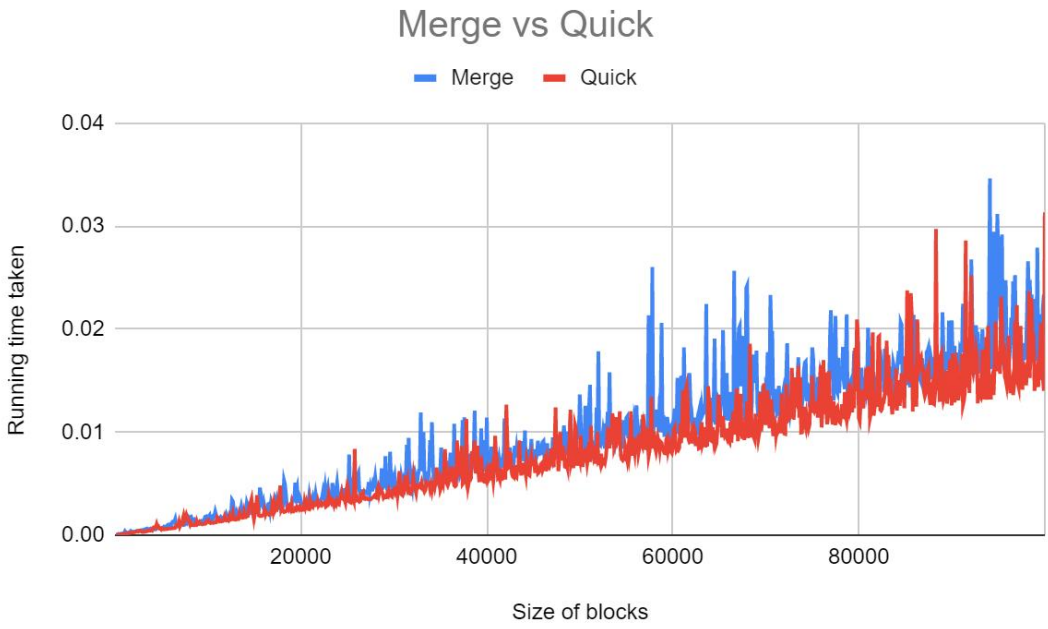
```
#include <stdio.h>
#include <math.h>
#include <conio.h>
#include <stdlib.h>
#include <time.h>
void getInput()
{
FILE *fp;
fp = fopen("inputexp2.text","w");
for(int i=0;i<100000;i++)
fprintf(fp,"%d ",rand()%100000);
fclose(fp);
}
void merge(int arr[], int p, int q, int r) {
// Create L ← A[p..q] and M ← A[q+1..r]
int n1 = q - p + 1;
int n2 = r - q;
int L[n1], M[n2];
for (int i = 0; i < n1; i++)
L[i] = arr[p + i];
for (int j = 0; j < n2; j++)
M[j] = arr[q + 1 + j];// Maintain current index of sub-arrays and main array
int i, j, k;
i = 0;
j = 0;
k = p;
// Until we reach either end of either L or M, pick larger
among
// elements L and M and place them in the correct position at
A[p..r]
while (i < n1 && j < n2) {
if (L[i] <= M[j]) {
arr[k] = L[i];
i++;
} else {
arr[k] = M[j];
j++;
}
k++;
}
// When we run out of elements in either L or M,
// pick up the remaining elements and put in A[p..r]
while (i < n1) {
arr[k] = L[i];
i++;
k++;
}
while (j < n2) {
arr[k] = M[j];
j++;
k++;
}
```

```
}
// Divide the array into two subarrays, sort them and merge
them
void mergeSort(int arr[], int l, int r) {
if (l < r) {
// m is the point where the array is divided into two
subarraysint m = l + (r - l) / 2;
mergeSort(arr, l, m);
mergeSort(arr, m + 1, r);
// Merge the sorted subarrays
merge(arr, l, m, r);
}
}
int partition(int A[], int low, int high)
{
int pivot = A[low];
int i = low + 1;
int j = high;
int temp;
do
{
while (A[i] <= pivot)
{
i++;
}
while (A[j] > pivot)
{
j--;
}
if (i < j)
{
temp = A[i];
A[i] = A[j];
A[j] = temp;
}
} while (i < j);
// Swap A[low] and A[j]
temp = A[low];
A[low] = A[j];
A[j] = temp;
return j;
}void quickSort(int A[], int low, int high)
{
int partitionIndex; // Index of pivot after partition
if (low < high)
{
partitionIndex = partition(A, low, high);
quickSort(A, low, partitionIndex - 1); // sort left
subarray
quickSort(A, partitionIndex + 1, high); // sort right
subarray
}
}
int main(){
```

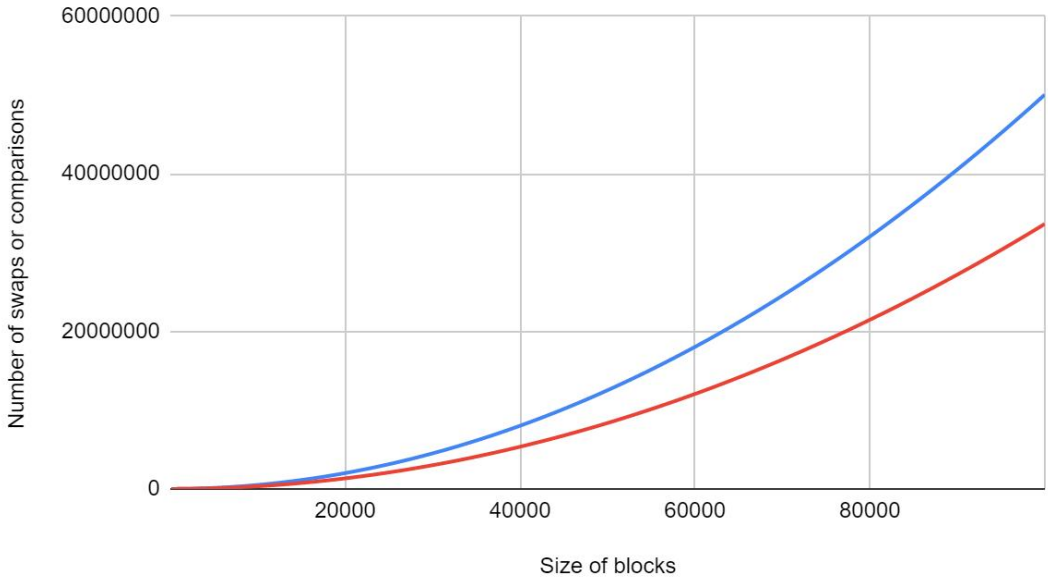
```
getInput();
FILE *rt, *tks;
int a=99;
int arrNums[100000];
clock_t t;
rt = fopen("inputexp2.text", "r");
tks = fopen("mTimes.txt", "w");
for(int i=0; i<1000; i++){
for(int j=0; j<=a; j++){
fscanf(rt, "%d", &arrNums[j]);
}
t = clock();
mergeSort(arrNums,0, a+1);
t = clock() - t;
double time_taken = ((double)t)/CLOCKS_PER_SEC;
fprintf(tks, "time taken for %d iteration is %Lf\n",
(i+1), time_taken);
printf("%d\t%lf\n", (i+1), time_taken);
a = a + 100;
fseek(rt, 0, SEEK_SET);
}
fclose(tks);
tks = fopen("qTimes.txt", "w");
a=99;
for(int i=0; i<1000; i++){
for(int j=0; j<=a; j++){fscanf(rt, "%d", &arrNums[j]);
}
t = clock();
quickSort(arrNums,0, a+1);
t = clock() - t;
double time_taken = ((double)t)/CLOCKS_PER_SEC;
fprintf(tks, "time taken for %d iteration is %Lf\n",
(i+1), time_taken);
printf("%d\t%lf\n", (i+1), time_taken);
a = a + 100;
fseek(rt, 0, SEEK_SET);
}
fclose(tks);
fclose(rt);
return 0;
}
```

GRAPH :

a) Comparison of running time.



b) Comparison of number of swaps. (Here blue indicates quick sort and red indicated merge sort)



RESULT ANALYSIS :

Merge sort generally performs fewer comparisons than quicksort both in the worst-case and on average. If performing a comparison is costly, merge sort will have the upper hand in terms of speed. Quicksort is found to be little faster than the merge sort as the runtime is less in quicksort. Initially both had around same runtimes for blocks but as the nth block increases, as numbers increases in the block, merge sort algorithm takes more time to sort the array.

• Time complexity:

Merge: Best case: O[n log n]
Worst case: O[n log n]
Quick: Best case: O[n log n]
Worst case: O[n^2]
• Space Complexity:
Merge sort: In merge sort, all elements are copied into an auxiliary array of size N, where N is the number of elements present in the unsorted array.
Hence, the space complexity for Merge Sort is O[n] .
Quick Sort: Since quicksort calls itself on the order of log(n) times (in the average case, worst case number of calls is O(n)), at each recursive call a new stack frame of constant size must be allocated. Hence the O(log(n)) space complexity.

CONCLUSION:

In this experiment I understood about two sorting algorithms i.e. merge and quick sort and their implementation in c programming language. Also I learned about a new function which is high_resolution_clock::now() to calculate the running time.