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## PROJECT - 1

## 1 Problem Statement

We are required to analyze the following program/code sample.

## int j = 2 while (j < n) { int k = j while (k < n) { Sum += a[k]\*b[k] k += n^1/3 log n } j = 2\*j }

## 2 Theoretical Analysis

This code has 2 while loops.

* **Outer Loop**

Since j goes from to 2 till n-1, multiplied by 2 at every step.

j = 2 \* (2 \* 2) \* (4 \* 2) \* (8 \* 2) \* (16 \* 2) ……

Therefore, the Big-O of the Outer Loops is O(log(n)).

* **Inner Loop**

K goes from j to n-1 and is incremented by n^ (1/3) log(n) at every step.

n = k\*n^ (1/3) \* log(n).

Therefore, the Big-O for the Inner Loop is O(n^(2/3)/log(n)).

* **Time Complexity of the Complete Code**

Since, they are nested loops, we must multiply the time complexities of both the loops.

O(log(n) \* n^ (2/3) / log(n)) = **O(n2/3).**

## 3 Experimental Analysis

### 3.1 Program Listing

## The values of n that I have taken are 10, 100, 512, 729, 1000, 4913, 10000, 100000, 1000000. I have chosen 512, 729, 1000, 4913 and 1000000 because they are cubes and the time complexity calculated is O(n2/3) Hence, it we be easy to calculate the Adjusted Theoretical Result.

### 3.2 Data Normalization Notes

### Since the experimental values were in nanoseconds and the theoretical results were constants, to compare the data, we need to normalize data using the scaling constant.

The Scaling Constant after the calculations comes out be 608.705836.

### 3.3 Output Numerical Data

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| n | Experimental Result, in ns | Theoretical Result | Scaling Constant | Adjusted Theoretical Result |
| 10 | 7000 | 4.64158883 |  | 2825.36221 |
| 100 | 16000 | 21.5443469 |  | 13114.1697 |
| 512 | 39000 | 64 |  | 38957.1735 |
| 729 | 48000 | 81 |  | 49305.1727 |
| 1000 | 57000 | 100 |  | 60870.5836 |
| 4913 | 166000 | 289 |  | 175915.987 |
| 10000 | 242000 | 464.158883 |  | 282536.221 |
| 100000 | 1141000 | 2154.43469 |  | 1311416.97 |
| 1000000 | 6306000 | 10000 |  | 6087058.36 |
|  | 891333.3333 | 1464.30883 | 608.705836 |  |

**3.4 Graph**

**A graph with a line and a blue line

Description automatically generated**

**3.5 Graph Observations**

From the graph we can observe that the theoretical calculation and the experimental calculations are very close to each other. The theoretical result grows slightly faster than the experimental result.

## 4 Conclusion

## The Time Complexity of the Code is O(n2/3) and based on the observations from the graph, we can conclude that the theoretical and experimental graphs grow very similarly. Hence, we can conclude that our calculations are correct.