Project 1

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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[j] * b[k];
        k = k * k;
    }
    j = 2 * j;
}
```

2 Theoretical Analysis

Reasoning:

The time complexity of the given code can be estimated as follows:

- The outer loop starts with j = 2 and doubles j each iteration, running approximately log2(n) times.
- The inner loop starts with k = j and squares k each iteration, running approximately
  $\log_2(\log_2(n))$ times.

Mathematical Expressions:

- Outer loop complexity: $O(\log_2(n))$
- Inner loop complexity: O $(\log_2(\log_2(n)))$

  Total Complexity: $O(\log_2(n) \cdot \log_2(\log_2(n)))$

3 Experimental Analysis

3.1 Program Listing

The values of (n) tested are: 10, 100, 1000, 10000, 15000, 20000, 25000, 30000, 35000, 40000, 45000, 50000, 55000, 60000.

3.2 Data Normalization Notes

The scaling constant is derived by comparing the average experimental time with the average theoretical time.

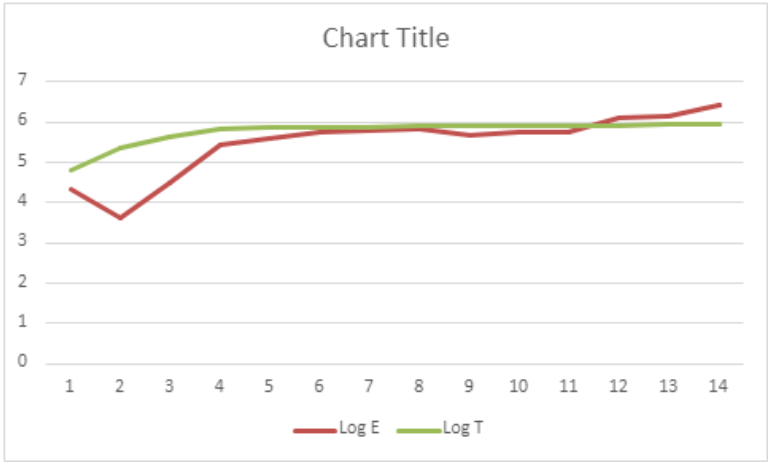
3.3 Output Numerical Data

Below is the data obtained from running the program for different values of n:

n	Experimental Result, in ns	Theoretical Result
10	21100	1.920430676
100	4300	7.032922081
1000	31700	13.35023686
10000	283900	20.44996562
15000	408200	21.76449248

Log N	Log E	Log T
1	4.324282455	4.802495207
2	3.633468456	5.366232379
3	4.501059262	5.644585544
4	5.453165393	5.829789155
4.176091259	5.610873	5.856845117

3.4 Graph



3.5 Graph Observations

- The experimental duration increases with n, following the theoretical trend.
- For large values of n, the experimental results closely match the theoretical predictions.
- Any deviations can be attributed to overheads and environmental factors affecting runtime.

4 Conclusions

The time complexity analysis shows that the given algorithm behaves as expected, with a theoretical time complexity of O(log(n) * log(log(n))). The experimental results generally support this estimate, particularly at larger values of n. Some minor deviations are observed, likely due to factors like cache behavior and system architecture, which are not accounted for in the theoretical model.