Raziel Siegman
9/10/2020
COM 2545; Professor Leff
Estimate Secret Algorithms

Experiment Apparatus: To test the performance of the secret algorithms, each algorithm was first run multiple times with multiple input sizes (N). The lowest input size was N=250. The input size was then doubled continuously until an algorithm would be incapable of processing an input in a reasonable amount of time (about 10 seconds), or, when Java reached its heap limit (in the case of algorithm 2). This was done for all four algorithms, and thus, N was capped differently for each algorithm. Once the caps were determined, each algorithm was run 4 times, with the runtime being tracked in milliseconds. The first run was used to "warm up the machine", and thus its results were ignored, and the three following runs (T1-T3) were then recorded. An example of computer-generated runtimes is included as a screenshot after the results below. Additionally, the results of T1-T3 were averaged (T Average). The ratio of each input to its previous input was calculated once for each N, using T Average. The results of the experiment are recorded below. It should be noted that the results are not listed below when every trial resulted in a runtime of 0, and as such, the first N recorded is different for each algorithm. Additionally, the ratio for the first result recorded in each algorithm is undefined (as the previous result was either 0, or does not exist).

Algorithm 1:

N	T1	T2	T3	T Average	Ratio (of average)
250	16	2	0	6	Undefined
500	72	16	18	35.3333	5.8889
1000	124	93	125	114	3.2264
2000	953	754	802	836.3333	7.3363
4000	7157	7169	7111	7145.6667	8.5440

Algorithm 2:

N	T1	T2	T3	T Average	Ratio (of average)
512,000	0	1	0	0.3333	Undefined
1,024,000	0	1	0	0.3333	1
2,048,000	1	1	1	1	3
4,096,000	2	4	3	3	3
8,192,000	8	5	8	7	2.3333
16,384,000	8	13	10	10.3333	1.4762
32,768,000	17	24	21	20.6667	2
65,536,000	29	44	46	39.6667	1.9194
131,072,000	90	85	89	88	2.2185

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Algorithm 3:

N	T1	T2	T3	T Average	Ratio (of average)
2,000	12	2	4	6	Undefined
4,000	4	6	4	4.6667	0.7778
8,000	24	24	22	23.3333	5
16,000	88	85	103	92	3.9429
32,000	374	353	376	367.6667	3.9964
64,000	1390	1306	1445	1380.3333	3.7543
128,000	5829	5466	5425	5573.3333	4.0377
256,000	23594	21925	17774	21097.6667	3.7855

Algorithm 4:

N	T1	T2	T3	T Average	Ratio (of average)
8,000	0	1	0	0.3333	Undefined
16,000	4	0	0	1.3333	4
32,000	4	8	8	6.6667	5
64,000	12	12	12	12	1.8
128,000	20	21	20	20.3333	1.6944
256,000	41	49	48	46	2.2623
512,000	90	110	104	101.33333	2.2029
1,024,000	184	219	215	206	2.0329
2,048,000	400	457	465	440.6667	2.1392
4,096,000	821	939	930	896.6667	2.0348
8,192,000	1840	1941	2019	1933.3333	2.1561

Results: For the first few values of N, the value of T is small enough that its result is highly variable, and thus produces a ratio that is less conclusive. As N increases though, the data becomes more robust, and the ratios thus become more accurate and consistent. Thus, the ratios for algorithms 1-4 appear to be 8, 2, 4 and 2, respectively. This implies that algorithm 1 is cubic, algorithms 2 and 4 are linear (or linearithmic), and algorithm 3 is quadratic. This is also demonstrated in the log-log graph below, where the results of the above experiment are plotted using the log of N as the x-axis and the log of T Average as the y-axis (using base 2). The log-log graph also has an accompanying chart, which shows the precise slope of each algorithm. The slope was calculated from X_0 to X_f, where X_0

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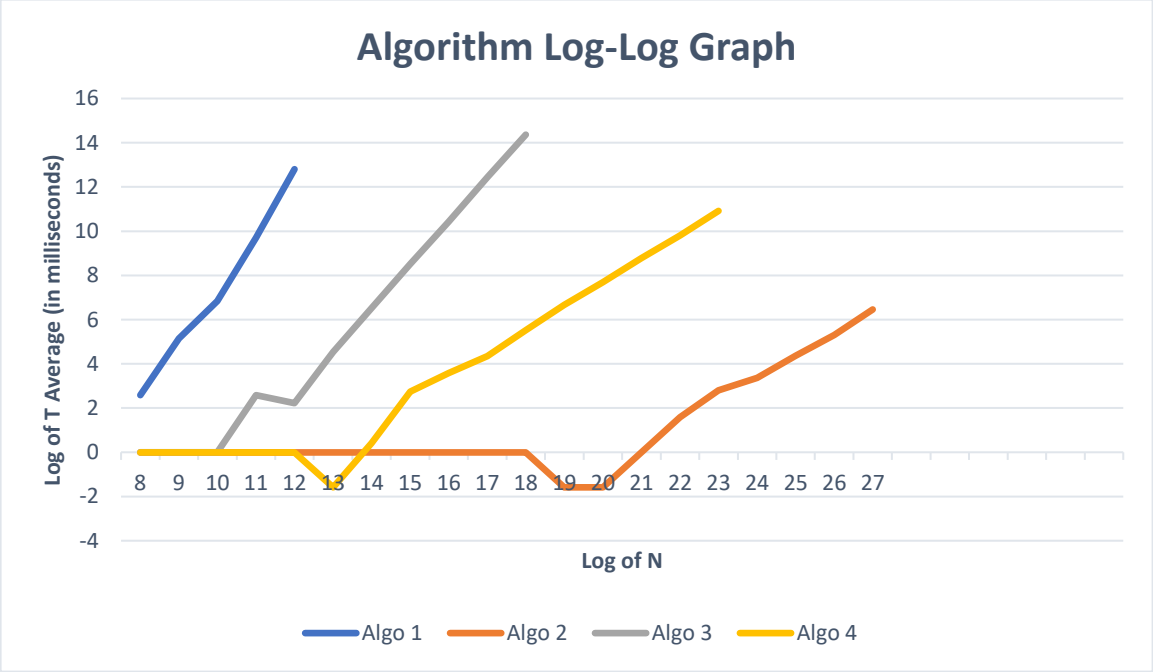
is the first value of N for which the slope is positive, and X_f is the last recorded value of N for the given algorithm. The slopes of algorithms 1-4 are approximately 3, 1, 2, and 1, respectively, supporting the hypothesis in regards to the Big O performance of the algorithms. Note that when T average is below 1 second, the log value is negative. Additionally, note that a relatively large percent of the data, especially for algorithm 1, was taken from smaller data sizes where the results are highly variable, contributing to the error between the expected and actual slopes. As the value of N increases, the instantaneous slope becomes more precise, and aligned with the hypothesis.



	X_0	X_f	Delta X	Y_0	Y_f	Delta Y	Average Slope
Algorithm 1	7.9658	11.9658	4	2.5850	12.8029	10.2179	2.5545
Algorithm 2	19.9658	26.9658	7	-1.5850	6.4594	8.0444	1.1492
Algorithm 3	9.9658	17.9658	8	0	14.3648	14.3648	1.7956
Algorithm 4	12.9658	22.9658	10	-1.5850	10.9169	12.5018	1.2502

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```
"C:\Program Files\JetB
Algo 1
Test 1 Time: 26
Test 2 Time: 25
Test 3 Time: 160
Test 4 Time: 1481
Test 5 Time: 27311
Algo 1
Test 1 Time: 12
Test 2 Time: 46
Test 3 Time: 115
Test 4 Time: 769
Test 5 Time: 6517
Algo 1
Test 1 Time: 2
Test 2 Time: 13
Test 3 Time: 90
Test 4 Time: 828
Test 5 Time: 5887
Algo 1
Test 1 Time: 1
Test 2 Time: 12
Test 3 Time: 84
Test 4 Time: 749
Test 5 Time: 6204
Algo 2
Test 1 Time: 0
Test 2 Time: 0
Test 3 Time: 0
```