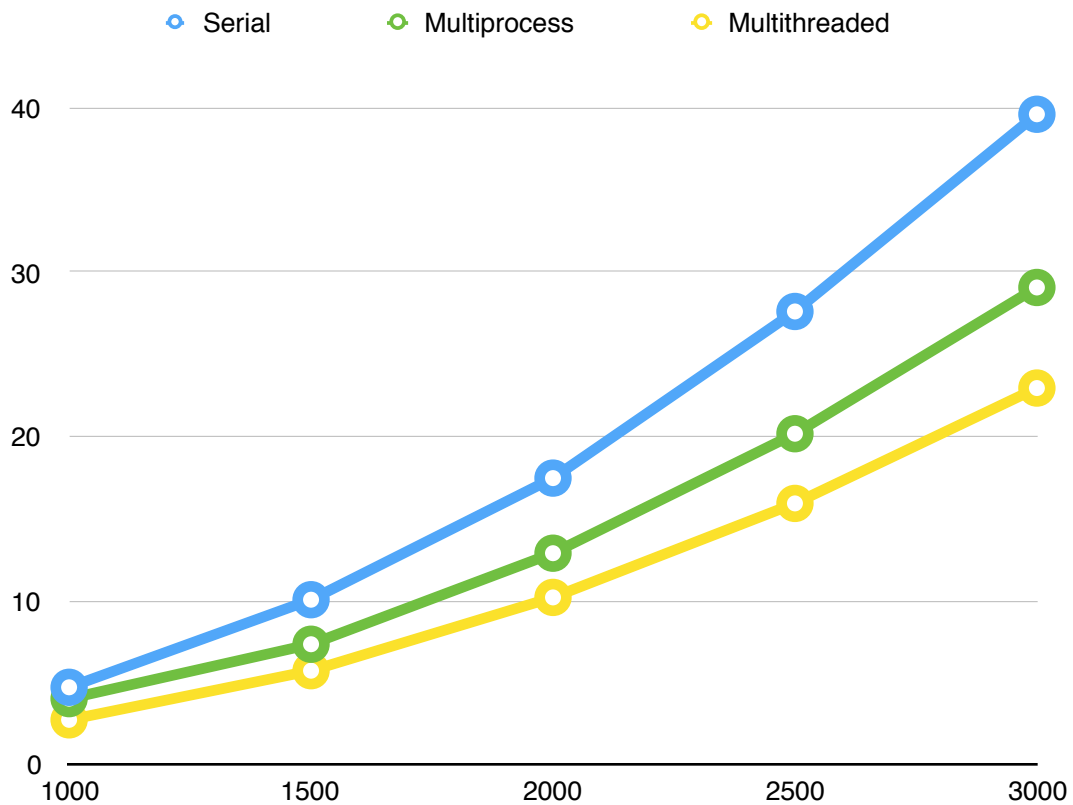


Array Size	Serial	Multithreaded	Multiprocess
1000	4.72	2.74	4.03
1500	10.05	5.73	7.34
2000	17.45	10.19	12.88
2500	27.59	15.91	20.15
3000	39.59	22.93	29.05



Discussion

As we can see from the data above, the Multithreaded program was the fastest overall, with the Multiprocess implementation coming in second, and the Serial being the slowest. The speedup for the Multiprocess version was around 1.36, while for the Multithreaded version it was around 1.73.

One possible explanation for the fact that the Multithreaded version was faster than the Multiprocess version was that threads are more lightweight and thus have less memory overhead. We had to use shared memory for the Multiprocess version and this could be one reason for the difference in times

Raw Data

Serial Heat on Array Size of 1000

4.723668 seconds

Serial Heat on Array Size of 1500

10.058799 seconds

Serial Heat on Array Size of 2000

17.452774 seconds

Serial Heat on Array Size of 2500

27.590396 seconds

Serial Heat on Array Size of 3000

39.593367 seconds

Threaded Heat on Array Size of 1000

2.742217 seconds

Threaded Heat on Array Size of 1500

5.733099 seconds

Threaded Heat on Array Size of 2000

10.188043 seconds

Threaded Heat on Array Size of 2500

15.906216 seconds

Threaded Heat on Array Size of 3000

22.937651 seconds

Forked Heat on Array Size of 1000

4.038062 seconds

Forked Heat on Array Size of 1500

7.345179 seconds

Forked Heat on Array Size of 2000

12.879734 seconds

Forked Heat on Array Size of 2500

20.147404 seconds

Forked Heat on Array Size of 3000

29.049030 seconds

Raw Data from Testing

I tested all the three programs on a 5x5 grid, printing out the initial values, iteration progress and final grid. All three programs returned the same data, which is displayed below.

Initial Grid

```
0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0 20.0
0.0 0.0 0.0 0.0 0.0 0.0 40.0
0.0 0.0 0.0 0.0 0.0 0.0 60.0
0.0 0.0 0.0 0.0 0.0 0.0 80.0
0.0 0.0 0.0 0.0 0.0 0.0 100.0
0.0 20.0 40.0 60.0 80.0 100.0 120.0
----- Iteration number: 10 -----
[2,2]: 5.75 [3,3]: 18.93 [4,4]: 44.29 [5,5]: 80.13
----- Iteration number: 20 -----
[2,2]: 11.38 [3,3]: 27.37 [4,4]: 51.35 [5,5]: 82.67
----- Iteration number: 30 -----
[2,2]: 12.87 [3,3]: 29.38 [4,4]: 52.87 [5,5]: 83.18
----- Iteration number: 40 -----
[2,2]: 13.22 [3,3]: 29.85 [4,4]: 53.22 [5,5]: 83.30
----- Iteration number: 50 -----
[2,2]: 13.31 [3,3]: 29.96 [4,4]: 53.31 [5,5]: 83.32
----- Iteration number: 60 -----
[2,2]: 13.33 [3,3]: 29.99 [4,4]: 53.33 [5,5]: 83.33
----- Iteration number: 70 -----
[2,2]: 13.33 [3,3]: 30.00 [4,4]: 53.33 [5,5]: 83.33
----- Iteration number: 80 -----
[2,2]: 13.33 [3,3]: 30.00 [4,4]: 53.33 [5,5]: 83.33
----- Iteration number: 90 -----
[2,2]: 13.33 [3,3]: 30.00 [4,4]: 53.33 [5,5]: 83.33
----- Iteration number: 100 -----
[2,2]: 13.33 [3,3]: 30.00 [4,4]: 53.33 [5,5]: 83.33
----- Iteration number: 110 -----
[2,2]: 13.33 [3,3]: 30.00 [4,4]: 53.33 [5,5]: 83.33
----- Iteration number: 120 -----
[2,2]: 13.33 [3,3]: 30.00 [4,4]: 53.33 [5,5]: 83.33
----- Iteration number: 130 -----
[2,2]: 13.33 [3,3]: 30.00 [4,4]: 53.33 [5,5]: 83.33
----- Iteration number: 140 -----
[2,2]: 13.33 [3,3]: 30.00 [4,4]: 53.33 [5,5]: 83.33
----- Iteration number: 150 -----
[2,2]: 13.33 [3,3]: 30.00 [4,4]: 53.33 [5,5]: 83.33
----- Iteration number: 160 -----
[2,2]: 13.33 [3,3]: 30.00 [4,4]: 53.33 [5,5]: 83.33
----- Iteration number: 170 -----
[2,2]: 13.33 [3,3]: 30.00 [4,4]: 53.33 [5,5]: 83.33
----- Iteration number: 180 -----
[2,2]: 13.33 [3,3]: 30.00 [4,4]: 53.33 [5,5]: 83.33
----- Iteration number: 190 -----
[2,2]: 13.33 [3,3]: 30.00 [4,4]: 53.33 [5,5]: 83.33
----- Iteration number: 200 -----
[2,2]: 13.33 [3,3]: 30.00 [4,4]: 53.33 [5,5]: 83.33
----- Iteration number: 210 -----
[2,2]: 13.33 [3,3]: 30.00 [4,4]: 53.33 [5,5]: 83.33
----- Iteration number: 220 -----
[2,2]: 13.33 [3,3]: 30.00 [4,4]: 53.33 [5,5]: 83.33
```

```
----- Iteration number: 230 -----  
[2,2]: 13.33 [3,3]: 30.00 [4,4]: 53.33 [5,5]: 83.33  
----- Iteration number: 240 -----  
[2,2]: 13.33 [3,3]: 30.00 [4,4]: 53.33 [5,5]: 83.33  
----- Iteration number: 250 -----  
[2,2]: 13.33 [3,3]: 30.00 [4,4]: 53.33 [5,5]: 83.33  
----- Iteration number: 260 -----  
[2,2]: 13.33 [3,3]: 30.00 [4,4]: 53.33 [5,5]: 83.33  
----- Iteration number: 270 -----  
[2,2]: 13.33 [3,3]: 30.00 [4,4]: 53.33 [5,5]: 83.33  
----- Iteration number: 280 -----  
[2,2]: 13.33 [3,3]: 30.00 [4,4]: 53.33 [5,5]: 83.33  
----- Iteration number: 290 -----  
[2,2]: 13.33 [3,3]: 30.00 [4,4]: 53.33 [5,5]: 83.33  
----- Iteration number: 300 -----  
[2,2]: 13.33 [3,3]: 30.00 [4,4]: 53.33 [5,5]: 83.33
```

0.344577 seconds

Final Grid

```
0.0 0.0 0.0 0.0 0.0 0.0 0.0  
0.0 3.3 6.7 10.0 13.3 16.7 20.0  
0.0 6.7 13.3 20.0 26.7 33.3 40.0  
0.0 10.0 20.0 30.0 40.0 50.0 60.0  
0.0 13.3 26.7 40.0 53.3 66.7 80.0  
0.0 16.7 33.3 50.0 66.7 83.3 100.0  
0.0 20.0 40.0 60.0 80.0 100.0 120.0
```