**Exercise 3:**

Computing each entry of the resulting matrix requires floating point operations ( additions and multiplications). As there are entries, the total number of operations should be at least .

For the matrix of 1000, the minimum number of floating point operations is hence .

Dividing this number by the parallel time (since all the floating point operations happen in the parallel section only), we get a pretty good lower bound for the number of MFLOPS. The best performing value for the Dell Inspiron and Optiplex computers is as follows:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Computer | Threads | Time | IPC | MFLOPS |
| Optiplex | 8 | 2.031 | 1.071 | 492.368 |
| Inspiron | 4 | 2.816666667 | 2.026666667 | 355.0295858 |

(Full data in Appendix A and Appendix B)

Noting that the Optiplex has an 8-core processor, and the Inspiron has a quad-core processor, it would appear that the thread count is optimal when it equals the number of processors, after which the increased threadcount actually results in marginally decreasing performance. This makes sense: with the same number of threads as cores, each thread can run on a separate core without needing to share processing resources, while an increased number of threads will cause contention for each core, and the resulting scheduling and context-switching overhead contribute to the decrease in performance.

**Exercise 4:**

The built-in timer only times the parallel execution time. I added another timer to time the beginning sequential section, and recorded the times in Appendix A. I will be comparing the time for 1 thread (which I take to be -- the best sequential-time program) against the time for 4 threads as follows:

yielding a speedup of approximately 3.05.

**Exercise 5:**

Approach 1: Using Amdahl’s Law and the speedup for calculated in Exercise 3:

The sequential fraction is 0.1038, and so the maximum speedup is

Approach 2:

Using the sequential timing for the single-thread execution, we can observe that

And hence the maximum speedup under Amdahl’s Law is

Appendix A:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Results for Dell Inspiron | |  |  |  | |
| Matrix Size | Threads | Sequential Time | Average Parallel Time | Avg. IPC | MFLOPS | |
| 1000 | 1 | 0.03 | 8.716666667 | 2.07 | 114.7227533 | |
| 1000 | 2 | 0.04 | 7.396666667 | 1.46 | 135.1960342 | |
| 1000 | 4 | 0.05 | 2.816666667 | 2.026666667 | 355.0295858 | |
| 1000 | 8 | 0.04 | 3.446666667 | 1.756666667 | 290.1353965 | |
| 1000 | 16 | 0.05 | 3.04 | 1.903333333 | 328.9473684 | |
| 1000 | 32 | 0.06 | 2.94 | 1.933333333 | 340.1360544 | |
| 1000 | 64 | 0.05 | 2.976666667 | 1.926666667 | 335.9462486 | |
| 1000 | 128 | 0.05 | 2.896666667 | 1.963333333 | 345.2243959 | |
| 1000 | 256 | 0.05 | 2.96 | 1.92 | 337.8378378 | |
| 1000 | 512 | 0.06 | 2.946666667 | 1.926666667 | 339.3665158 | |
| 1000 | 1024 | 0.07 | 2.95 | 1.926666667 | 338.9830508 | |

Appendix B: Results for Dell Optiplex

n | Time(s) | Number of Cycles | Instructions    | MFLOPS  | IPC  
1   7.645     31,163,942,732     59,175,652,625     130.804   1.899  
2   4.264     30,401,372,817      59,173,707,819     234.522   1.946  
4   2.271      31,235,601,254      59,137,437,412     440.335   1.893  
8   2.031     55,310,881,401     59,223,008,193     492.368   1.071  
16  2.106     54,220,393,084      59,170,067,522     474.834   1.093  
32  2.049     55,629,275,423      59,136,495,120     488.043   1.063