Red-Blue Computation

Kyle Rich
Colton Myers
Landon Gilbert-Bland

Motivation

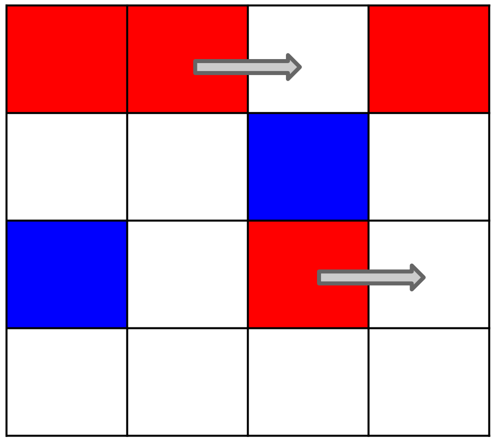
Red/Blue is a fairly simple case study we looked at early in the semester.

- Opportunity to see real speed-up on parallel code
- Apply OpenMP and Pthreads knowledge

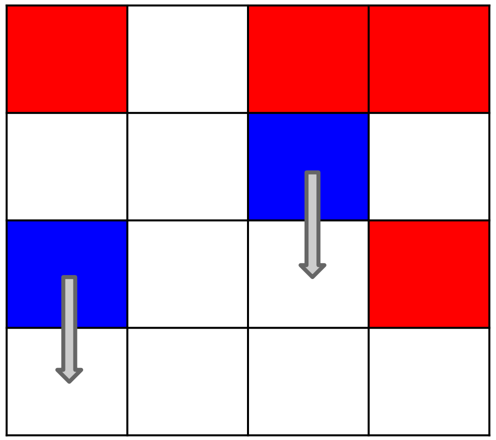
Two-Stage Computation

1. Red squares may move to the right into an empty (white) square
2. Blue squares may move down into an empty (white) square

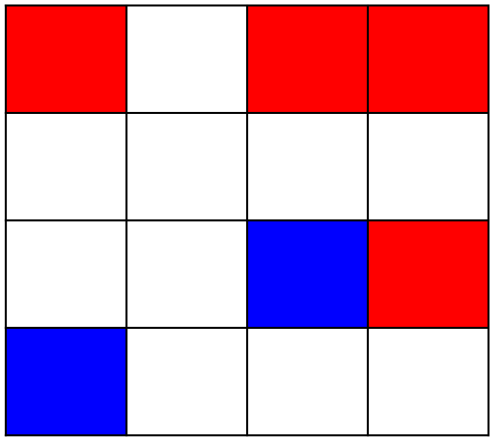
Original



Red Step



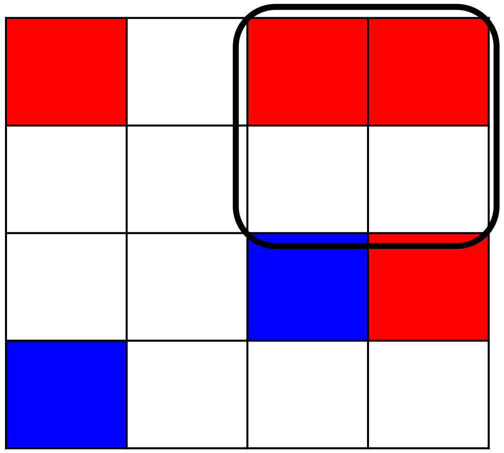
Blue Step



Notice that it does not move recursively -- only one of the reds in the first row moved.

Convergence

1. Split the grid into NxN tiles
2. Compute % for each color in a given tile
3. If that % reaches a threshold, we're done, otherwise, keep stepping



Converges (2x2 tiles and .5 convergence value)

Algorithm Summary (Sequential)

```
read_grid();
while(true) {
  if (converges()) break;
  iterate_red();  // nested for loop
  iterate_blue();  // nested for loop
}
```

Parallelization Difficulties and Strategies

Problems:

- Partition boundaries (blue moves into vacated red square)
- Save previous iteration (all moves work from previous iteration)

Solutions:

- Two different grids, iterate from one to the other
  - Eliminates boundary issues and thread synchronization
- Barrier between each iteration

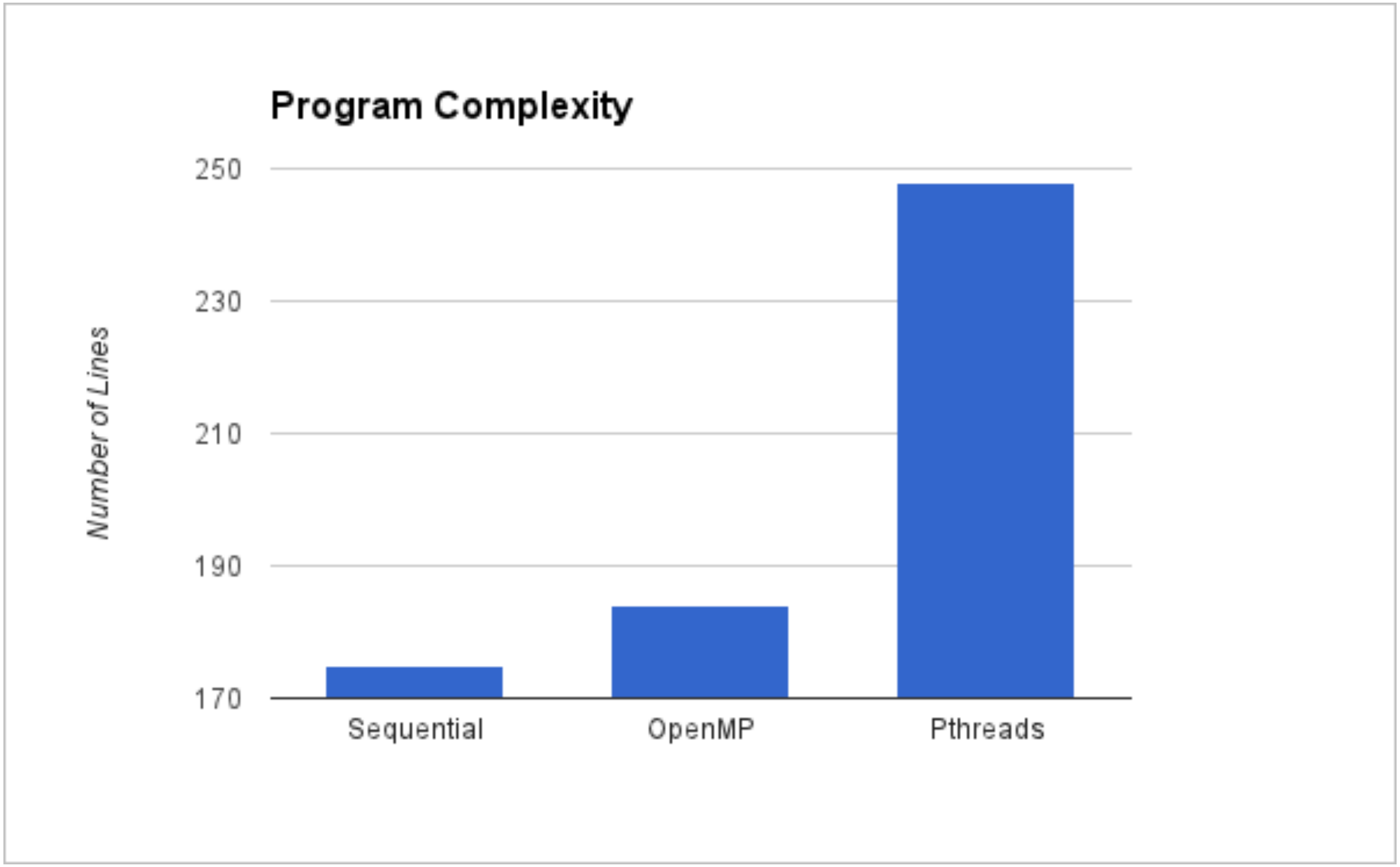
OMP vs Pthreads

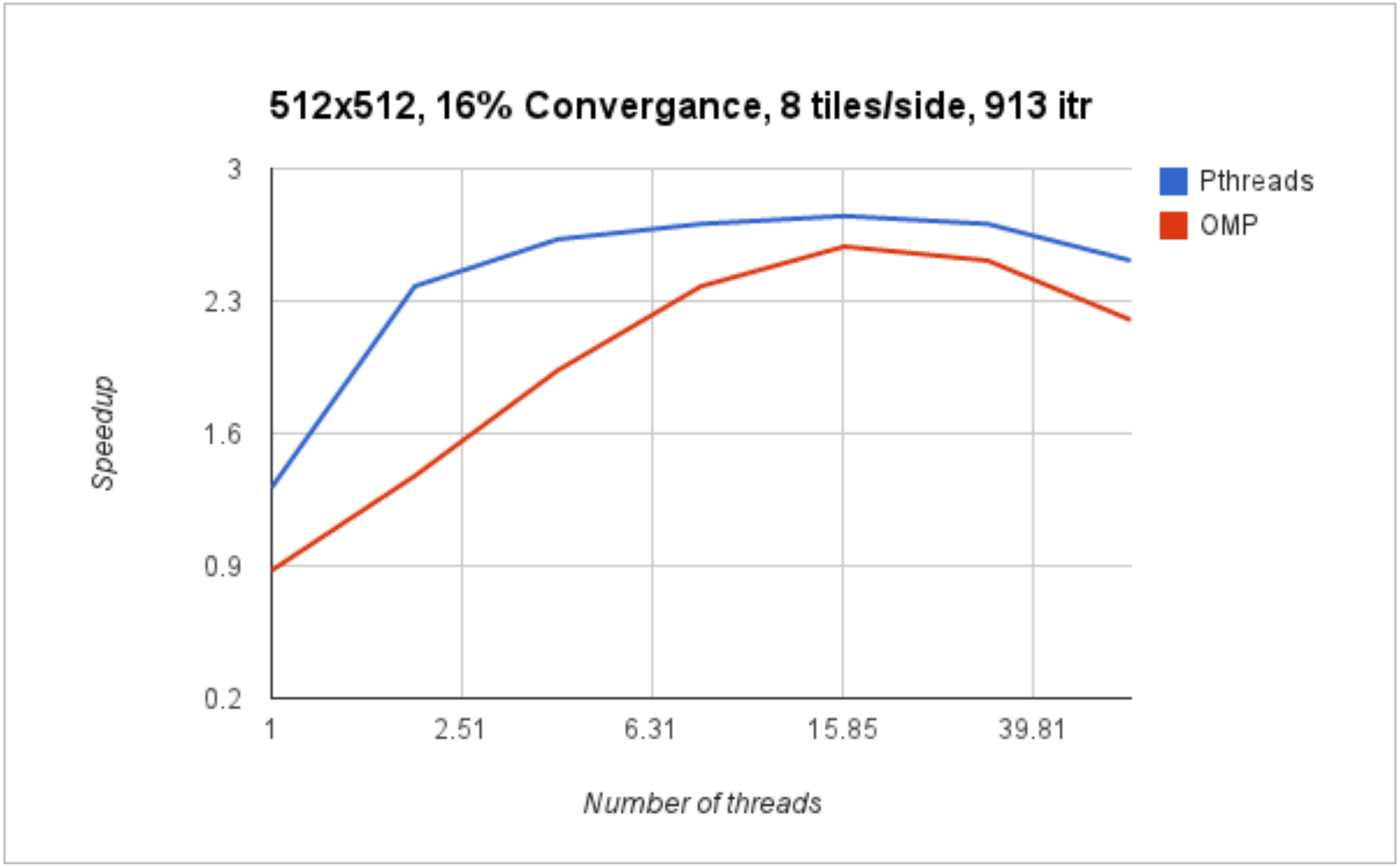
OpenMP does all partitioning for us. Add

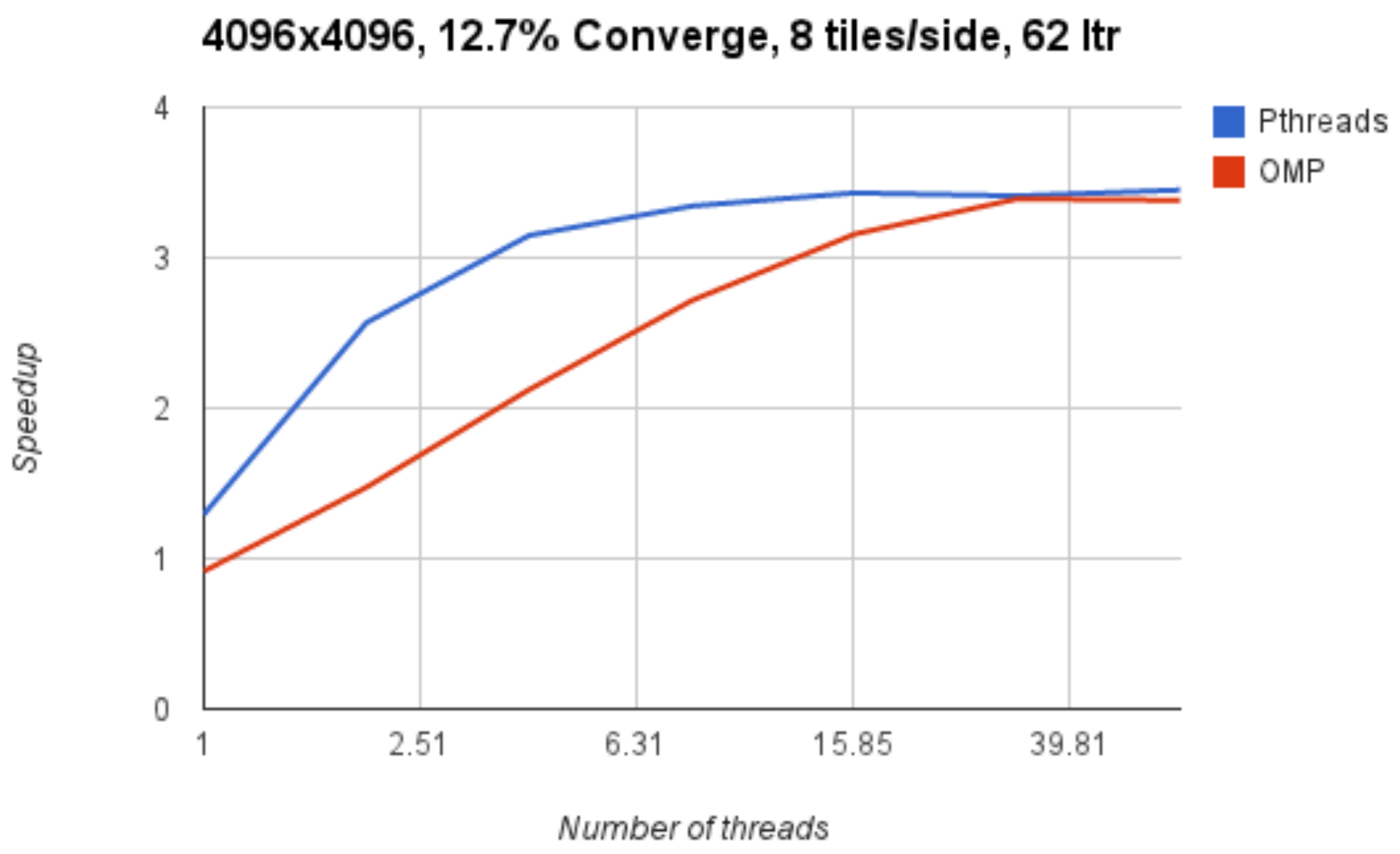
```
#pragma omp parallel for
```

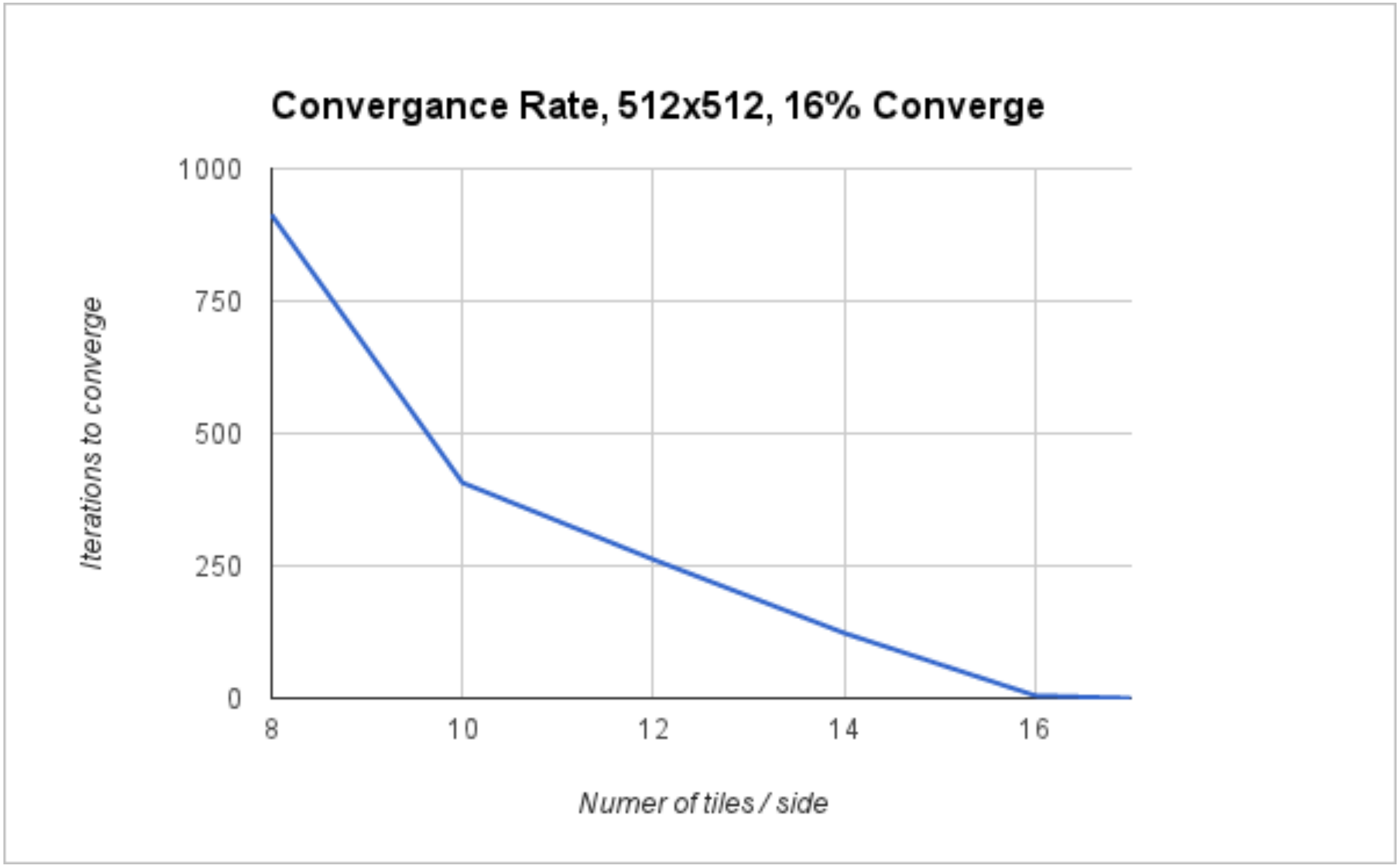
and we're done.

Pthreads requires manual partitioning, but is more optimizable as a result.


Program Complexity
Number of Lines
250
230
210
190
170
Sequential
OpenMP
Pthreads


512x512, 16% Convergance, 8 tiles/side, 913 itr
Pthreads
OMP
Speedup
3
2.3
1.6
0.9
0.2
1
2.51
6.31
15.85
39.81
Number of threads


4096x4096, 12.7% Converge, 8 tiles/side, 62 Itr
Speedup
0
1
2
3
4
1
2.51
6.31
15.85
39.81
Number of threads
Pthreads
OMP


Convergance Rate, 512x512, 16% Converge
Iterations to converge
1000
750
500
250
0
8
10
12
14
16
Numer of tiles / side

Conclusion

- Drastic speedups with both OMP and Pthreads
- Concrete example of drawbacks and advantages of Pthreads vs OMP
    - Complexity for Speedup
- Concrete examples of how one size doesn't fit all
    - Number of threads
    - Size of problem