

CSE 5441: Program 3 Report

Harsh Gupta

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Objective

The objective of this lab is to use OpenMP and analyse how execution of the code differs from the thread version of it. Two different versions of parallel code were implemented and analysed. They are as follows

- a. Disposable
- b. Persistent

This assignment's implementation was simple given the fact similar code was written for thread programming.

Parallelizing the code

Disposable threads - In the disposable program, only one line of code change was required, i.e. adding `"#pragma omp parallel for num_threads(NUM_THREADS)"` before the for loop which calculates new DSV. Though, additional lines were needed to confirm the number of threads created by OpenMP.

Persistent threads - For the persistence program, I defined a parallel region within which the for loop for calculating the computeDSV was moved. This was done to use `"#pragma omp for"` which distributes the load among the thread without creating any additional threads.

Summary of execution time

Persistent and disposable programs were executed for test grid testgrid_400_12206 using different number of threads. Same values for Max DSV, Min DSV and number of iterations was obtained.

Iterations	Max DSV	Min DSV	Affect Rate	Epsilon	File
434142	0.084946	0.082397	0.03	0.03	Testgrid_400_12206

Wall-Clock Time

Number of threads	OpenMP Persistent	OpenMP Disposable	Pthread Persistent	Pthread Disposable
2	2m31s	2m34s	2m46s	3m5s
4	1m58s	2m6s	2m12s	3m9s
8	2m24s	3m15s	2m31s	4m13s
16	3m3s	4m7s	4m1s	7m33s
32	4m8s	4m45s	5m14s	12m13s

Clock

Number of threads	OpenMP Persistent	OpenMP Disposable	Pthread Persistent	Pthread Disposable
2	301250000	305530000	263620000	298400000
4	455980000	478180000	295360000	330330000
8	314860000	481710000	336020000	474230000
16	346790000	416640000	384450000	786870000
32	408200000	387790000	419130000	1225960000

Time

Number of threads	OpenMP Persistent	OpenMP Disposable	Pthread Persistent	Pthread Disposable
2	151	154	166	185
4	118	126	132	189
8	144	195	151	253
16	183	247	241	453
32	248	285	314	733

Chrono

Number of threads	OpenMP Persistent	OpenMP Disposable	Pthread Persistent	Pthread Disposable
2	151317548	153619908	165713763	185776913
4	118234176	125558172	132518803	188703002

8	144056195	194401029	150833459	253590343
16	183565534	246573629	241252126	453177681
32	248211508	284333379	314248981	733276862

Analysis and Observations

Number of threads - The number of threads created by OpenMP was always the same as requested. I didn't find any situation for which the number of threads created were different than the number requested.

Block/Cyclic work distribution - I checked the workload distribution by printing the value of "i" in case of thread 0. Block distribution was automatically used by OpenMP.

Which threading mechanism, pthreads or OpenMP, provided the best results in your case?
OpenMP provided the best results for my program.

Which threading mechanism, pthreads or OpenMP, was the easiest to implement?
OpenMP threading mechanism is the easiest to implement. The serial program can be converted to a multithreaded program by just adding a few lines of code without worrying about a lot of threading concepts.

Which threading mechanism, pthreads or OpenMP, would you be most likely to select for a similar application?

I will use OpenMP threading mechanism for similar application. OpenMP is not only easier to implement but also provides better performance.

Under what circumstances would you speculate that the other mechanism, pthreads or OpenMP, would be preferable?

Pthreads would be preferable when we need to control what each thread is doing and when our program is dependent on the number of threads requested. Pthreads would be useful for creating libraries and in scientific computations where workload distribution is pre-decided.

Were there any surprises you encountered in this exercise?

The running time for disposable OpenMP program was comparable to that of persistent OpenMP program when number of threads are 2 and 4. I was not able to exactly figure out why this was happening. My best guess is that the time taken by barrier synchronizations in the persistent program was greater than the thread creation overhead in the disposable program. When the number of threads increased (8,16,32), the persistent program

performed better as the thread creation overhead in the disposable program would have increased significantly.

To sum, OpenMP is a great tool to quickly parallelize a program. It is fast, efficient and unlike Pthreads, it does not require any major changes in the sequential program. By comparing the runtime of OpenMP and Pthread programs, it can be observed that OpenMP automatically optimizes the program and the workload distribution in a much more efficient way.

Results

PThreads

```
[gupta.749@sl3 cse5441_lab2]$ disposable 0.03 0.03 2 < /class/cse5441/testgrid_400_12206
*****
```

```
Dissipation converged in 434142 iterations
with max DSV = 0.084946 and min DSV = 0.082397
Number of threads: 2, Affect rate = 0.030000 , epsilon = 0.030000
elapsed convergence loop time(clock) : 298400000
elapsed convergence loop time(time) : 185
elapsed convergence loop time (chrono): 185776913.000000
```

```
*****
[gupta.749@sl3 cse5441_lab2]$ disposable 0.03 0.03 4 < /class/cse5441/testgrid_400_12206
*****
```

```
Dissipation converged in 434142 iterations
with max DSV = 0.084946 and min DSV = 0.082397
Number of threads: 4, Affect rate = 0.030000 , epsilon = 0.030000
elapsed convergence loop time(clock) : 330330000
elapsed convergence loop time(time) : 189
elapsed convergence loop time (chrono): 188703002.000000
```

```
*****
[gupta.749@sl3 cse5441_lab2]$ disposable 0.03 0.03 8 < /class/cse5441/testgrid_400_12206
*****
```

```
Dissipation converged in 434142 iterations
with max DSV = 0.084946 and min DSV = 0.082397
Number of threads: 8, Affect rate = 0.030000 , epsilon = 0.030000
elapsed convergence loop time(clock) : 474230000
elapsed convergence loop time(time) : 253
elapsed convergence loop time (chrono): 253590343.000000
```

```
*****
[gupta.749@sl3 cse5441_lab2]$ disposable 0.03 0.03 16 < /class/cse5441/testgrid_400_12206
*****
```

```
Dissipation converged in 434142 iterations
with max DSV = 0.084946 and min DSV = 0.082397
```

Number of threads: 16, Affect rate = 0.030000 , epsilon = 0.030000

elapsed convergence loop time(clock) : 786870000

elapsed convergence loop time(time) : 453

elapsed convergence loop time (chrono): 453177681.000000

[gupta.749@sl3 cse5441_lab2]\$ disposable 0.03 0.03 32 < /class/cse5441/testgrid_400_12206

Dissipation converged in 434142 iterations

with max DSV = 0.084946 and min DSV = 0.082397

Number of threads: 32, Affect rate = 0.030000 , epsilon = 0.030000

elapsed convergence loop time(clock) : 1225960000

elapsed convergence loop time(time) : 733

elapsed convergence loop time (chrono): 733276862.000000

[gupta.749@sl3 cse5441_lab2]\$ persistent 0.03 0.03 2 < /class/cse5441/testgrid_400_12206

Dissipation converged in 434142 iterations

with max DSV = 0.084946 and min DSV = 0.082397

Number of threads: 2, Affect rate = 0.030000 , epsilon = 0.030000

elapsed convergence loop time(clock) : 263620000

elapsed convergence loop time(time) : 166

elapsed convergence loop time (chrono): 165713763.000000

[gupta.749@sl3 cse5441_lab2]\$ persistent 0.03 0.03 4 < /class/cse5441/testgrid_400_12206

Dissipation converged in 434142 iterations

with max DSV = 0.084946 and min DSV = 0.082397

Number of threads: 4, Affect rate = 0.030000 , epsilon = 0.030000

elapsed convergence loop time(clock) : 295360000

elapsed convergence loop time(time) : 132

elapsed convergence loop time (chrono): 132518803.000000

[gupta.749@sl3 cse5441_lab2]\$ persistent 0.03 0.03 8 < /class/cse5441/testgrid_400_12206

Dissipation converged in 434142 iterations

with max DSV = 0.084946 and min DSV = 0.082397

Number of threads: 8, Affect rate = 0.030000 , epsilon = 0.030000

elapsed convergence loop time(clock) : 336020000

elapsed convergence loop time(time) : 151

elapsed convergence loop time (chrono): 150833459.000000

[gupta.749@sl3 cse5441_lab2]\$ persistent 0.03 0.03 16 < /class/cse5441/testgrid_400_12206

Dissipation converged in 434142 iterations

with max DSV = 0.084946 and min DSV = 0.082397

Number of threads: 16, Affect rate = 0.030000 , epsilon = 0.030000

elapsed convergence loop time(clock) : 384450000

elapsed convergence loop time(time) : 241

elapsed convergence loop time (chrono): 241252126.000000

[gupta.749@sl3 cse5441_lab2]\$ persistent 0.03 0.03 32 < /class/cse5441/testgrid_400_12206

Dissipation converged in 434142 iterations

with max DSV = 0.084946 and min DSV = 0.082397

Number of threads: 32, Affect rate = 0.030000 , epsilon = 0.030000

elapsed convergence loop time(clock) : 419130000

elapsed convergence loop time(time) : 314

elapsed convergence loop time (chrono): 314248981.000000

OpenMP

[gupta.749@sl3 Lab2]\$ disposable 0.03 0.03 2 < /class/cse5441/testgrid_400_12206

Dissipation converged in 434142 iterations

with max DSV = 0.084946 and min DSV = 0.082397

Number of OpenMP threads: 2, Affect rate = 0.030000 , epsilon = 0.030000

elapsed convergence loop time(clock) : 305530000

elapsed convergence loop time(time) : 154

elapsed convergence loop time (chrono): 153619908.000000

[gupta.749@sl3 Lab2]\$ disposable 0.03 0.03 4 < /class/cse5441/testgrid_400_12206

Dissipation converged in 434142 iterations

with max DSV = 0.084946 and min DSV = 0.082397

Number of OpenMP threads: 4, Affect rate = 0.030000 , epsilon = 0.030000

elapsed convergence loop time(clock) : 478180000

elapsed convergence loop time(time) : 126

elapsed convergence loop time (chrono): 125558172.000000

*****400_
12206

Dissipation converged in 434142 iterations

with max DSV = 0.084946 and min DSV = 0.082397

Number of OpenMP threads: 8, Affect rate = 0.030000 , epsilon = 0.030000

elapsed convergence loop time(clock) : 481710000

elapsed convergence loop time(time) : 195

elapsed convergence loop time (chrono): 194401029.000000

6gupta.749@sl3 Lab2]\$ disposable 0.03 0.03 16 < /class/cse5441/testgrid_400_12206

Dissipation converged in 434142 iterations

with max DSV = 0.084946 and min DSV = 0.082397

Number of OpenMP threads: 16, Affect rate = 0.030000 , epsilon = 0.030000

elapsed convergence loop time(clock) : 416640000

elapsed convergence loop time(time) : 247

elapsed convergence loop time (chrono): 246573629.000000

[gupta.749@sl3 Lab2]\$ disposable 0.03 0.03 32 < /class/cse5441/testgrid_400_1220 6

Dissipation converged in 434142 iterations

with max DSV = 0.084946 and min DSV = 0.082397

Number of OpenMP threads: 32, Affect rate = 0.030000 , epsilon = 0.030000

elapsed convergence loop time(clock) : 387790000

elapsed convergence loop time(time) : 285

elapsed convergence loop time (chrono): 284333379.000000

[gupta.749@sl3 Lab2]\$ persistent 0.03 0.03 2 < /class/cse5441/testgrid_400_12206

Dissipation converged in 434142 iterations

with max DSV = 0.084946 and min DSV = 0.082397

Number of threads: 2, Affect rate = 0.030000 , epsilon = 0.030000

elapsed convergence loop time(clock) : 301250000

elapsed convergence loop time(time) : 151

elapsed convergence loop time (chrono): 151317548.000000

[gupta.749@sl3 Lab2]\$ persistent 0.03 0.03 4 < /class/cse5441/testgrid_400_12206

Dissipation converged in 434142 iterations

with max DSV = 0.084946 and min DSV = 0.082397

Number of threads: 4, Affect rate = 0.030000 , epsilon = 0.030000

elapsed convergence loop time(clock) : 455980000

elapsed convergence loop time(time) : 118

elapsed convergence loop time (chrono): 118234176.000000

[gupta.749@sl3 Lab2]\$ persistent 0.03 0.03 8 < /class/cse5441/testgrid_400_12206

Dissipation converged in 434142 iterations

with max DSV = 0.084946 and min DSV = 0.082397

Number of threads: 8, Affect rate = 0.030000 , epsilon = 0.030000

elapsed convergence loop time(clock) : 314860000

elapsed convergence loop time(time) : 144

elapsed convergence loop time (chrono): 144056195.000000

[gupta.749@sl3 Lab2]\$ persistent 0.03 0.03 16 < /class/cse5441/testgrid_400_12206

Dissipation converged in 434142 iterations

with max DSV = 0.084946 and min DSV = 0.082397

Number of threads: 16, Affect rate = 0.030000 , epsilon = 0.030000

elapsed convergence loop time(clock) : 346790000

elapsed convergence loop time(time) : 183

elapsed convergence loop time (chrono): 183565534.000000

[gupta.749@sl3 Lab2]\$ persistent 0.03 0.03 32 < /class/cse5441/testgrid_400_12206

Dissipation converged in 434142 iterations

with max DSV = 0.084946 and min DSV = 0.082397

Number of threads: 32, Affect rate = 0.030000 , epsilon = 0.030000

elapsed convergence loop time(clock) : 408200000

elapsed convergence loop time(time) : 248

elapsed convergence loop time (chrono): 248211508.000000
