Programming Assignment 3

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Related questions

(a) Which threading mechanism, pthreads or OpenMP, provided the best results in your case?

OpenMP provided the best results in my case.

(b) Which threading mechanism, ptherads or OpenMP, was the easiest to implement?

I think that OpenMP was easier to implement.

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

I would select OpenMP.

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

When I want to have maximum control of every thread and to know how each thread works, I would choose pthreads.

(e) Were there any surprises you encountered in this exercise?

Yes. Generally the convergence time in OpenMP was much less than the convergence in pthreads. Besides, when the number of threads was less than 16, the performance of disposable threads in OpenMP was better than persistent threads in OpenMP. However, in pthreads, the performance of persistent threads was better than disposable threads.

Supplement

I have reported my parameters of epsilon and affect_rate in my timing result. Besides,

I have also reported my wall-clock run times, actual OpenMP threads created,

requested OpenMP threads and appropriate convergence time, which is real time.

Appendix Timing Result

Input file: testgrid_400_12206
Parameters: epsilon is 0.1, affect_rate is 0.04

OpenMP

(1) Disposable threads：
2 threads：
    The requested number of OpenMP threads: 2
    The actual number of threads created: 2

    ****
    dissipation converged in 111641 iterations,
      with max DSV = 0.085135 and min DSV = 0.081729
      affect rate = 0.100000;   epsilon = 0.040000
    ****

    elapsed convergence loop time (clock): 100780000
    elapsed convergence loop time (time): 51.000000
    elapsed convergence loop time (realtime): 51.000000

    real 0m50.912s
    user 1m40.642s
    sys 0m0.212s
4 threads:
    The requested number of OpenMP threads: 4
    The actual number of threads created: 4

    ****
    dissipation converged in 111641 iterations,
      with max DSV = 0.085135 and min DSV = 0.081729
      affect rate = 0.100000;   epsilon = 0.040000
    ****

    elapsed convergence loop time (clock): 138480000

elapsed convergence loop time (time): 37.000000
elapsed convergence loop time (realtime): 37.000000

real 0m36.791s
user 2m18.153s
sys 0m0.396s

8 threads：
The requested number of OpenMP threads: 8
The actual number of threads created: 8

****
dissipation converged in 111641 iterations,
    with max DSV = 0.085135 and min DSV = 0.081729
    affect rate = 0.100000;   epsilon = 0.040000
****

elapsed convergence loop time (clock): 260450000
elapsed convergence loop time (time): 116.000000
elapsed convergence loop time (realtime): 116.000000

real 1m56.000s
user 3m59.445s
sys 0m21.068s

16 threads：
The requested number of OpenMP threads: 16
The actual number of threads created: 16

****
dissipation converged in 111641 iterations,
    with max DSV = 0.085135 and min DSV = 0.081729
    affect rate = 0.100000;   epsilon = 0.040000
****

elapsed convergence loop time (clock): 267290000
elapsed convergence loop time (time): 161.000000
elapsed convergence loop time (realtime): 161.000000

real 2m40.763s
user 3m57.325s
sys   0m30.030s

24 threads:
The requested number of OpenMP threads: 24
The actual number of threads created: 24

```
**********************************************************
dissipation converged in 111641 iterations,
   with max DSV = 0.085135 and min DSV = 0.081729
   affect rate  = 0.100000;   epsilon = 0.040000
**********************************************************

elapsed convergence loop time  (clock): 280740000
elapsed convergence loop time  (time): 179.000000
elapsed convergence loop time  (realtime): 179.000000

real  2m59.219s
user  4m2.051s
sys   0m38.756s
```
36 threads:
```
The requested number of OpenMP threads: 36
The actual number of threads created: 36

**********************************************************
dissipation converged in 111641 iterations,
   with max DSV = 0.085135 and min DSV = 0.081729
   affect rate  = 0.100000;   epsilon = 0.040000
**********************************************************

elapsed convergence loop time  (clock): 331750000
elapsed convergence loop time  (time): 201.000000
elapsed convergence loop time  (realtime): 201.000000

real  3m20.188s
user  4m33.055s
sys   0m58.760s
```

(2) Persistent threads:
2 threads:
```
The requested number of OpenMP threads: 2
The actual number of OpenMP threads created: 2

**********************************************************
dissipation converged in 111641 iterations,
   with max DSV = 0.085135 and min DSV = 0.081729
   affect rate  = 0.100000;   epsilon = 0.040000
**********************************************************

elapsed convergence loop time  (clock): 103620000
elapsed convergence loop time  (time): 55.000000
```

elapsed convergence loop time (realtime): 55.000000

real 0m54.927s
user 1m42.842s
sys   0m0.860s

4 threads:

The requested number of OpenMP threads: 4
The actual number of OpenMP threads created: 4

****
dissipation converged in 111641 iterations,
    with max DSV = 0.085135 and min DSV = 0.081729
    affect rate = 0.100000;   epsilon = 0.040000
****

elapsed convergence loop time (clock): 262770000
elapsed convergence loop time (time): 95.000000
elapsed convergence loop time (realtime): 95.000000

real 1m34.717s
user 4m21.396s
sys   0m1.449s

8 threads:

The requested number of OpenMP threads: 8
The actual number of OpenMP threads created: 8

****
dissipation converged in 111641 iterations,
    with max DSV = 0.085135 and min DSV = 0.081729
    affect rate = 0.100000;   epsilon = 0.040000
****

elapsed convergence loop time (clock): 271970000
elapsed convergence loop time (time): 138.000000
elapsed convergence loop time (realtime): 138.000000

real 2m18.397s
user 4m20.372s
sys   0m11.666s

16 threads:

The requested number of OpenMP threads: 16
The actual number of OpenMP threads created: 16

****

dissipation converged in 111641 iterations,
    with max DSV = 0.085135 and min DSV = 0.081729
    affect rate = 0.100000;   epsilon = 0.040000
    ****

    elapsed convergence loop time (clock): 298390000
    elapsed convergence loop time (time): 140.000000
    elapsed convergence loop time (realtime): 140.000000

    real 2m19.930s
    user 4m42.952s
    sys   0m15.503s
24 threads:
    The requested number of OpenMP threads: 24
    The actual number of OpenMP threads created: 24

    ****
    dissipation converged in 111641 iterations,
    with max DSV = 0.085135 and min DSV = 0.081729
    affect rate = 0.100000;   epsilon = 0.040000
    ****

    elapsed convergence loop time (clock): 404570000
    elapsed convergence loop time (time): 179.000000
    elapsed convergence loop time (realtime): 179.000000

    real 2m59.545s
    user 6m19.796s
    sys   0m24.837s
36 threads:
    The requested number of OpenMP threads: 36
    The actual number of OpenMP threads created: 36

    ****
    dissipation converged in 111641 iterations,
    with max DSV = 0.085135 and min DSV = 0.081729
    affect rate = 0.100000;   epsilon = 0.040000
    ****

    elapsed convergence loop time (clock): 543490000
    elapsed convergence loop time (time): 198.000000
    elapsed convergence loop time (realtime): 198.000000

    real 3m17.638s

user 8m28.163s
sys 0m35.383s

Pthreads:

(3) Disposable threads：

2 threads：

```
***************************************************************
dissipation converged in 111641 iterations,
    with max DSV = 0.085135 and min DSV = 0.081729
    affect rate  = 0.100000;   epsilon = 0.040000
***************************************************************

elapsed convergence loop time  (clock): 251950000
elapsed convergence loop time  (time): 163.000000
elapsed convergence loop time  (realtime): 163.000000

real  2m43.103s
user 3m51.334s
sys  0m20.681s
```

4 threads:

```
***************************************************************
dissipation converged in 111641 iterations,
    with max DSV = 0.085135 and min DSV = 0.081729
    affect rate  = 0.100000;   epsilon = 0.040000
***************************************************************

elapsed convergence loop time  (clock): 269520000
elapsed convergence loop time  (time): 155.000000
elapsed convergence loop time  (realtime): 155.000000

real  2m34.801s
user 3m52.059s
sys  0m37.541s
```

8 threads：

```
***************************************************************
dissipation converged in 111641 iterations,
    with max DSV = 0.085135 and min DSV = 0.081729
    affect rate  = 0.100000;   epsilon = 0.040000
***************************************************************

elapsed convergence loop time  (clock): 362360000
elapsed convergence loop time  (time): 204.000000
elapsed convergence loop time  (realtime): 204.000000
```

```
    real  3m24.075s
    user  3m32.099s
    sys   2m30.293s
16 threads：
    **************************************************************
    dissipation converged in 111641 iterations,
        with max DSV = 0.085135 and min DSV = 0.081729
        affect rate  = 0.100000;   epsilon = 0.040000
    **************************************************************

    elapsed convergence loop time  (clock): 607360000
    elapsed convergence loop time  (time): 335.000000
    elapsed convergence loop time  (realtime): 335.000000

    real  5m34.695s
    user  5m4.224s
    sys   5m3.203s
24 threads:
    **************************************************************
    dissipation converged in 111641 iterations,
        with max DSV = 0.085135 and min DSV = 0.081729
        affect rate  = 0.100000;   epsilon = 0.040000
    **************************************************************

    elapsed convergence loop time  (clock): 661510000
    elapsed convergence loop time  (time): 398.000000
    elapsed convergence loop time  (realtime): 398.000000

    real  6m38.149s
    user  4m55.539s
    sys   6m6.003s
36 threads:
    **************************************************************
    dissipation converged in 111641 iterations,
        with max DSV = 0.085135 and min DSV = 0.081729
        affect rate  = 0.100000;   epsilon = 0.040000
    **************************************************************

    elapsed convergence loop time  (clock): 949830000
    elapsed convergence loop time  (time): 508.000000
    elapsed convergence loop time  (realtime): 508.000000

    real  8m28.225s
```

```
user  6m58.856s
sys   8m51.034s
```

(4) Persistent threads:

2 threads:
```
    ***************************************************************
    dissipation converged in 111641 iterations,
        with max DSV = 0.085135 and min DSV = 0.081729
        affect rate  = 0.100000;   epsilon = 0.040000
    ***************************************************************

    elapsed convergence loop time  (clock): 102490000
    elapsed convergence loop time  (time): 53.000000
    elapsed convergence loop time  (realtime): 53.000000

    real  0m53.138s
    user  1m40.689s
    sys   0m1.868s
```
4 threads:
```
    ***************************************************************
    dissipation converged in 111641 iterations,
        with max DSV = 0.085135 and min DSV = 0.081729
        affect rate  = 0.100000;   epsilon = 0.040000
    ***************************************************************

    elapsed convergence loop time  (clock): 126310000
    elapsed convergence loop time  (time): 39.000000
    elapsed convergence loop time  (realtime): 39.000000

    real  0m39.450s
    user  2m2.926s
    sys   0m3.444s
```
8 threads:
```
    ***************************************************************
    dissipation converged in 111641 iterations,
        with max DSV = 0.085135 and min DSV = 0.081729
        affect rate  = 0.100000;   epsilon = 0.040000
    ***************************************************************

    elapsed convergence loop time  (clock): 180780000
    elapsed convergence loop time  (time): 57.000000
    elapsed convergence loop time  (realtime): 57.000000

    real  0m57.294s
```

```
        user  2m47.984s
        sys   0m12.850s
16 threads:
    ****************************************************************
    dissipation converged in 111641 iterations,
        with max DSV = 0.085135 and min DSV = 0.081729
        affect rate  = 0.100000;   epsilon = 0.040000
    ****************************************************************

    elapsed convergence loop time  (clock): 561440000
    elapsed convergence loop time  (time): 249.000000
    elapsed convergence loop time  (realtime): 249.000000

    real  4m9.102s
    user  8m11.237s
    sys   1m10.264s
24 threads:
    ****************************************************************
    dissipation converged in 111641 iterations,
        with max DSV = 0.085135 and min DSV = 0.081729
        affect rate  = 0.100000;   epsilon = 0.040000
    ****************************************************************

    elapsed convergence loop time  (clock): 719300000
    elapsed convergence loop time  (time): 367.000000
    elapsed convergence loop time  (realtime): 367.000000

    real  6m7.454s
    user  10m25.984s
    sys   1m33.382s
36 threads:
    ****************************************************************
    dissipation converged in 111641 iterations,
        with max DSV = 0.085135 and min DSV = 0.081729
        affect rate  = 0.100000;   epsilon = 0.040000
    ****************************************************************

    elapsed convergence loop time  (clock): 951130000
    elapsed convergence loop time  (time): 559.000000
    elapsed convergence loop time  (realtime): 559.000000

    real 9m19.153s
    user13m44.177s
    sys  2m7.018s
```