

CS 470 Monte Carlo Pthreads Lab

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1. Copy the lab files from `/shared/cs470/pth-mcpi` to your home folder on the cluster.

2. Examine the program and make sure you understand what it's doing. Compile it and run it a few times with different dart counts and observe how the accuracy and timing results change. Here are some examples (note the “`srun`” command that submits the program as a job on the cluster):

```
srun ./mcpi 100 1
srun ./mcpi 100000 1
srun ./mcpi 100000000 1
```

3. Change the program to enable the use of multiple threads and remove the old error message. Split the total number of darts evenly among all the threads. For now, do not include any synchronization.

HINT: You will need to change both `main()` and `throw_darts()`

HINT: Don't forget to allocate space for multiple thread handles (use an array)

4. Run experiments to see how well it scales. Run experiments with 100 million darts and different thread counts. Use the following table to track your results and generate a graph of the timing results.

| Number of worker threads | Time in seconds | Estimated π |
|--------------------------|-----------------|-----------------|
| 1 | 1.587 | 3.141635e+00 |
| 2 | 0.778 | 1.570694e+00 |
| 4 | .397 | 7.853988e-01 |
| 8 | .194 | 3.926668e-01 |
| 16 (HT) | .098 | 1.963341e-01 |

5. Answer the following questions: How well does the application scale? Are the estimates of π accurate? If not, why not?

Application scales correctly, but pi is not accurately estimated. This is because the threads are stepping on each other

6. Change the program to use a Pthreads mutex to guard the update to `darts_in_circle` in `throw_darts` (do not change anything else).

7. What effect(s) does the change in #4 have? Explain the results and **include some sample output and timing information**—use tables and/or graphs as appropriate.

(Used the same criteria as Q4)

| Number of worker threads | Time in seconds | Estimated π |
|--------------------------|-----------------|-----------------|
| 1 | 2.05 | 3.141623e+00 |
| 2 | 5.239 | 3.141647e+00 |
| 4 | 7.259 | 3.141690e+00 |
| 8 | 7.81 | 3.141459e+00 |
| 16 (HT) | 7.516 | 3.141474e+00 |

Results for pi are now more accurate but tends to run slower with more threads

8. Fix the program so that it is both fast and accurate. Explain your changes and show sample output and timing information. Use the results to argue that your fix is optimal. How well does your final version scale?

Changed throw_darts so a local_darts_in_circle is incremented and then added to global darts_in_circle outside of for loop to reduce calls to shared resources

(Used the same criteria as Q4)

| Number of worker threads | Time in seconds | Estimated π |
|--------------------------|-----------------|-----------------|
| 1 | 1.419 | 3.141590e+00 |
| 2 | .708 | 3.141478e+00 |
| 4 | .354 | 3.141551e+00 |
| 8 | .117 | 3.141411e+00 |
| 16 (HT) | .087 | 3.141560e+00 |

9. Submit this document as a PDF as well as your final `mcp1.c` to the appropriate Canvas assignment by the due date. If you worked in groups, each group should designate ONE PERSON to submit a copy of both files. Make sure the list of names at the top of this document is complete, and that it matches the list of names in the comment at the top of the submitted source code.