CS 475 Parallel Programming: The Mutex Stack Challenge Conner Rhea

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Write-Up:

- 1. I ran this project on my personally built computer at home, which uses an AMD Ryzen 5 5600X 6-Core processor.
- 2. I run windows but used an Übuntu Shell in order to run the bash scripts and compile.
- 3. I used the G++ compiler, word for word the same code provide by Professor Bailey.
- 4. Code snippets of mutex code included:

```
void
Push( int n )
{
    if (USE_MUTEX)
        omp_set_lock( &Lock );

    StackPtr++;
    Stack[StackPtr] = n;

    if (USE_MUTEX)
        omp_unset_lock( &Lock );
}
```

```
int
Pop()
   // if the stack is empty, give the Push() function a chance to put something on the stack:
   while( StackPtr < 0 && t < TIMEOUT )</pre>
       t++;
   // if there is nothing to pop, return;
   if( StackPtr < 0 )</pre>
       return FAILED;
   if (USE MUTEX)
      omp set lock( &Lock );
   int n = Stack[StackPtr];
   StackPtr--;
   if (USE MUTEX)
       omp_unset_lock( &Lock );
   WasPopped[n] = true;
   return n;
main( int argc, char *argv[ ] )
]#ifndef OPENMP
      fprintf( stderr, "OpenMP is not supported here.\n" );
      return 1:
-#endif
      omp init lock( &Lock );
```

- 5. When USE_MUTEX was true, we always got a result with 0 NimPopErrors, however when this variable was false, outside specific rare instances it almost always had a multitude of errors.
 - a. The Non-Mutex version did land successfully twice, once in the 2048 block and once in the 1024 block. With only two instances of this happening, it seems extremely unlikely to occur outside of pure chance.
 - b. Not to an absurd degree, the failure percentage remained fairly constant between 30-50% with the majority of the time landing squarely in the 40% range.
 - c. There does seem to be a time difference as NUMN increases, where the mutex version becomes slower. If I had to guess, juggling the lock becomes more costly as NUMN increases needing to block for a time to run the pushes and pops, whereas letting it run with no locks and fail hard is faster.
- 6. No Tables and graphs are needed, but I included the output of my shell anyway for fun and reference.

```
3$ bash loop1.bash
                USE MUTEX =
                                                          0 =
NUMN =
         1024
                              true
                                      NumPopErrors =
                                                                 0.00%
                                                                          Elapsed time =
                                                                                              83.76 microseconds
NUMN =
                 USE MUTEX =
                                      NumPopErrors =
                                                                 0.00%
         1024
                              true
                                                          A
                                                                          Elapsed time =
                                                                                              77.54 microseconds
                 USE_MUTEX =
NUMN =
         1024
                              true
                                      NumPopErrors =
                                                          a
                                                                 0.00%
                                                                          Elapsed time =
                                                                                             158.44 microseconds
NUMN =
         1024
                 USE_MUTEX =
                              true
                                      NumPopErrors =
                                                          A
                                                                 0.00%
                                                                          Elapsed time =
                                                                                             165.17 microseconds
                 USE_MUTEX =
NUMN =
         1024
                              true
                                      NumPopErrors =
                                                          А
                                                                 0.00%
                                                                          Elapsed time =
                                                                                              70.63 microseconds
NUMN =
         1024
                 USE_MUTEX =
                              false
                                      NumPopErrors =
                                                                51.07%
                                                                          Elapsed time =
                                                                                              63.80 microseconds
NUMN =
         1024
                 USE_MUTEX =
                              false
                                      NumPopErrors =
                                                         507
                                                                49.51%
                                                                          Elapsed time =
                                                                                              69.02 microseconds
NUMN =
         1024
                 USE_MUTEX =
                              false
                                      NumPopErrors =
                                                         288
                                                                28.12%
                                                                          Elapsed time =
                                                                                              90.82 microseconds
                                                                38.96%
NUMN =
         1024
                 USE_MUTEX =
                              false
                                      NumPopErrors
                                                         399
                                                                          Elapsed time
                                                                                             135.67 microseconds
NUMN
                 USE MUTEX
                                      NumPopErrors
                                                                46.19%
                                                                          Elapsed time
                                                                                             206.03 microseconds
         1024
                              false
                                                         473
                                      NumPopErrors
                                                                 0.00%
                                                                                             114.91 microseconds
NUMN =
                 USE_MUTEX
                                                                          Elapsed time
         1024
                              false
                                                          0
                 USE_MUTEX
                                                                18.65%
NUMN
         1024
                              false
                                      NumPopErrors
                                                         191
                                                                          Elapsed time
                                                                                              79.89 microseconds
                 USE_MUTEX
                                      NumPopErrors
                                                                49.61%
IUMN =
         1024
                              false
                                                         508
                                                                          Elapsed time
                                                                                              65.35 microseconds
NUMN
         1024
                 USE MUTEX
                              false
                                      NumPopErrors =
                                                         480
                                                                46.88%
                                                                          Elapsed time
                                                                                              64.95 microseconds
NUMN =
         1024
                 USE_MUTEX
                              false
                                      NumPopErrors
                                                         538
                                                                52.54%
                                                                          Elapsed time
                                                                                              66.26 microseconds
NUMN =
         2048
                 USE MUTEX
                                      NumPopErrors =
                                                          0
                                                                 0.00%
                                                                          Elapsed time
                                                                                              72.30 microseconds
                              true
                 USE MUTEX
NUMN =
         2048
                                      NumPopErrors =
                                                                 0.00%
                                                                          Elapsed time =
                                                                                             190.17 microseconds
                              true
                                                          a
                USE_MUTEX
USE_MUTEX
                                      NumPopErrors =
NUMN =
         2048
                              true
                                                          0
                                                                 0.00%
                                                                          Elapsed time =
                                                                                             294.36 microseconds
         2048
                                      NumPopErrors =
                                                                                             291.57 microseconds
NUMN =
                                                          A
                                                                 0.00%
                                                                          Elapsed time =
                              true
                USE_MUTEX =
NUMN =
         2048
                              true
                                      NumPopErrors =
                                                          0
                                                                 0.00%
                                                                          Elapsed time =
                                                                                             178.85 microseconds
                                      NumPopErrors =
NUMN =
         2048
                              false
                                                        938 =
                                                                45.80%
                                                                          Elapsed time =
                                                                                              92.32 microseconds
                USE_MUTEX =
                                                                          Elapsed time =
         2048
                                      NumPopErrors =
                                                                42.68%
                                                                                             100.97 microseconds
NUMN =
                              false
                                                        874 =
                                      NumPopErrors =
         2048
                                                                45.80%
                                                                          Elapsed time =
                                                                                             102.61 microseconds
NUMN =
                              false
                                                        938
                USE_MUTEX = USE_MUTEX =
                                      NumPopErrors =
                                                                          Elapsed time =
                                                                45.85%
NUMN =
         2048
                             false
                                                        939 =
                                                                                              97.51 microseconds
NUMN =
         2048
                              false
                                      NumPopErrors =
                                                         908
                                                                44.34%
                                                                          Elapsed time =
                                                                                              99.73 microseconds
                 USE_MUTEX =
                                      NumPopErrors =
NUMNI =
         2048
                              false
                                                         923
                                                                45.07%
                                                                          Elapsed time =
                                                                                              95.13 microseconds
NUMN =
         2048
                 USE MUTEX =
                              false
                                      NumPopErrors =
                                                         886
                                                                43.26%
                                                                          Elapsed time =
                                                                                              96.35 microseconds
NUMN =
         2048
                 USE_MUTEX =
                              false
                                      NumPopErrors =
                                                         858
                                                                41.89%
                                                                          Elapsed time =
                                                                                             101.25 microseconds
NUMN =
         2048
                 USE_MUTEX =
                              false
                                      NumPopErrors =
                                                          0
                                                                 0.00%
                                                                          Elapsed time =
                                                                                              87.71 microseconds
NUMN =
         2048
                 USE_MUTEX =
                              false
                                      NumPopErrors =
                                                         982
                                                                44.04%
                                                                          Elapsed time
                                                                                              99.47 microseconds
NUMN =
         4096
                 USE MUTEX =
                                      NumPopErrors =
                                                                 0.00%
                                                                          Elapsed time =
                                                                                             552.92 microseconds
                              true
                                                          0
NUMN =
         4096
                 USE_MUTEX =
                                      NumPopErrors =
                                                                 0.00%
                                                                          Elapsed time =
                                                                                             295.70 microseconds
                               true
                                                           0
                                                                          Elapsed time
                                                                                             529.84 microseconds
NUMN
                 USE_MUTEX =
                                      NumPopErrors =
                                                                 0.00%
         4096
                               true
                                                           0
NUMN =
                 USE_MUTEX
                                      NumPopErrors
                                                                 0.00%
                                                                          Elapsed time
                                                                                             456.25 microseconds
         4096
                               true
                                                           0
                 USE_MUTEX
NUMN
         4096
                              true
                                      NumPopErrors
                                                           0
                                                                 0.00%
                                                                          Elapsed time
                                                                                             476.88 microseconds
IUMN
         4096
                 USE_MUTEX
                              false
                                      NumPopErrors
                                                        1727
                                                                42.16%
                                                                          Elapsed time
                                                                                             159.95 microseconds
                                                                          Elapsed time
NUMN
         4096
                 USE_MUTEX
                              false
                                      NumPopErrors
                                                        1732
                                                                42.29%
                                                                                             161.29 microseconds
                 USE MUTEX
NUMN =
         4096
                              false
                                      NumPopErrors
                                                       2055
                                                                50.17%
                                                                          Elapsed time =
                                                                                             135.26 microseconds
NUMN =
                 USE_MUTEX
                              false
                                      NumPopErrors
                                                                45.43%
                                                                          Elapsed time =
         4096
                                                       1861
                                                                                             172.13 microseconds
                 USE MUTEX
NUMN =
         4096
                              false
                                      NumPopErrors
                                                        1548
                                                                37.79%
                                                                          Elapsed time =
                                                                                             146.43 microseconds
                 USE_MUTEX
                              false
                                      NumPopErrors
                                                                43.14%
NUMN =
         4096
                                                       1767
                                                                          Elapsed time =
                                                                                             156.20 microseconds
                 USE MUTEX
                                      NumPopErrors
NUMN =
         4096
                              false
                                                                39.06%
                                                                          Elapsed time =
                                                                                             161.20 microseconds
                                                        1600
                USE_MUTEX =
                                      NumPopErrors
                                                        997
                                                                24.34%
NUMN =
                              false
                                                                          Elapsed time =
                                                                                             133.12 microseconds
         4096
                                      NumPopErrors =
NUMN =
         4096
                              false
                                                       2155
                                                                52.61%
                                                                          Elapsed time =
                                                                                             133.81 microseconds
                USE_MUTEX = USE_MUTEX =
                                                                                             159.10 microseconds
                              false
                                      NumPopErrors =
                                                       1748 =
                                                                42.68%
                                                                          Elapsed time =
NUMN =
         4096
                                                                                             994.67 microseconds
                                      NumPopErrors =
                                                                 0.00%
                                                                          Elapsed time =
NUMN =
         8192
                              true
                                                          0
                USE_MUTEX =
                                      NumPopErrors =
                                                                 0.00%
NIIMNI =
         8192
                              true
                                                          A
                                                                          Elapsed time =
                                                                                             842.06 microseconds
NUMN =
         8192
                              true
                                      NumPopErrors =
                                                          A
                                                                 0.00%
                                                                          Elapsed time =
                                                                                            1004.59 microseconds
NUMN =
         8192
                 USE_MUTEX =
                              true
                                      NumPopErrors =
                                                          а
                                                                 0.00%
                                                                          Elapsed time =
                                                                                             903.58 microseconds
NUMN =
         8192
                 USE_MUTEX =
                              true
                                      NumPopErrors =
                                                          A
                                                                 0.00%
                                                                          Elapsed time =
                                                                                             599.00 microseconds
                 USE_MUTEX =
NUMN =
         8192
                             false
                                      NumPopErrors =
                                                                45.57%
                                                                          Elapsed time =
                                                                                             267.47 microseconds
NUMN =
         8192
                 USE_MUTEX =
                             false
                                      NumPopErrors =
                                                        3628
                                                                44.29%
                                                                          Elapsed time =
                                                                                             263.60 microseconds
NUMN =
         8192
                 USE_MUTEX =
                             false
                                      NumPopErrors =
                                                        3625
                                                                44.25%
                                                                          Elapsed time =
                                                                                             274.76 microseconds
                                                                          Elapsed time =
NUMN =
         8192
                 USE_MUTEX =
                                      NumPopErrors =
                                                                44.38%
                                                                                             267.35 microseconds
                             false
NUMN =
         8192
                 USE_MUTEX =
                              false
                                      NumPopErrors
                                                        3623
                                                                44.23%
                                                                          Elapsed time
                                                                                             265.80 microseconds
NUMN
         8192
                 USE MUTEX =
                             false
                                      NumPopErrors
                                                        3705
                                                                45.23%
                                                                          Elapsed time
                                                                                             262.46 microseconds
NMU
                 USE_MUTEX =
                                      NumPopErrors
                                                                          Elapsed time
         8192
                              false
                                                        3564
                                                                43.51%
                                                                                             266.16 microseconds
                                                                          Elapsed time
IUMN
         8192
                 USE_MUTEX =
                             false
                                      NumPopErrors
                                                                40.66%
                                                                                             270.86 microseconds
                                                                41.94%
                 USE MUTEX =
IUMN =
         8192
                              false
                                      NumPopErrors
                                                        3436
                                                                          Elapsed time
                                                                                             283.70 microseconds
JUMN
                 USE MUTEX
                             false
                                      NumPopErrors
                                                        3451
                                                                42.13%
                                                                          Elapsed
                                                                                  time
                                                                                             267.28 microseconds
```

```
16384
                  USE_MUTEX =
                                 true , NumPopErrors =
                                                                       0.00%,
                                                                                Elapsed time =
                                                                                                    1820.76 microseconds
                                                                0 =
NUMN =
                  USE_MUTEX = true , NumPopErrors =
                                                                                Elapsed time =
                                                                                                    1401.18 microseconds
         16384
                                                                0 =
                                                                      0.00%
                                                                      0.00%
NUMN =
         16384
                  USE_MUTEX = true , NumPopErrors =
                                                                0 =
                                                                                Elapsed time =
                                                                                                    1832.57 microseconds
                                                                                Elapsed time =
                                                                                                    1643.72 microseconds
NUMN =
         16384
                  USE_MUTEX = true
                                         NumPopErrors =
                                                                0 =
                                                                      0.00%
                                                                      0.00%
NUMN =
         16384
                  USE_MUTEX = true , NumPopErrors =
                                                                                Elapsed time =
                                                                                                    1023.36 microseconds
                  USE_MUTEX = false , NumPopErrors = USE_MUTEX = false , NumPopErrors =
         16384
                                                                                Elapsed time =
                                                                                                     467.27 microseconds
NUMN =
                                                            7662 =
                                                                     46.77%
                                                                                Elapsed time =
NUMN =
         16384
                                                                                                     516.93 microseconds
                                                            6963 =
                                                                     42.50%
                  USE_MUTEX = false ,
NUMN =
         16384
                                         NumPopErrors =
                                                            7280
                                                                     44.43%
                                                                                Elapsed time =
                                                                                                     515.38 microseconds
                  USE_MUTEX = false , NumPopErrors = USE_MUTEX = false , NumPopErrors =
NUMN =
         16384
                                                            8185 =
                                                                     49.96%
                                                                                Elapsed time =
                                                                                                     418.05 microseconds
NUMN =
                                                                                Elapsed time =
                                                                                                     503.48 microseconds
         16384
                                                            6994 =
                                                                     42.69%
NUMN =
         16384
                  USE_MUTEX = false , NumPopErrors =
                                                            7784 =
                                                                     47.51%
                                                                                Elapsed time =
                                                                                                     449.43 microseconds
                  USE_MUTEX = false , NumPopErrors = USE_MUTEX = false , NumPopErrors =
NUMN =
         16384
                                                            7259 =
                                                                     44.31%
                                                                                Elapsed time =
                                                                                                     485.56 microseconds
                                                                                Elapsed time =
NUMN =
         16384
                                                                     42.22%
                                                                                                     494.93 microseconds
                                                            6917 =
                  USE_MUTEX = false ,
                                         NumPopErrors =
NUMN =
         16384
                                                            6623 =
                                                                     40.42%
                                                                                Elapsed time =
                                                                                                     522.28 microseconds
                  USE_MUTEX = false , NumPopErrors = USE_MUTEX = true , NumPopErrors =
NUMN =
         16384
                                                                     43.90%
                                                                                                     378.11 microseconds
                                                            7193 =
                                                                                Elapsed time
NUMN =
         32768
                                                                      0.00%
                                                                                Elapsed time =
                                                                                                    2082.86 microseconds
                                                               0 =
                                                                      0.00%
NUMN =
         32768
                  USE_MUTEX = true , NumPopErrors =
                                                               0 =
                                                                                Elapsed time =
                                                                                                    1996.52 microseconds
NUMN =
         32768
                  USE_MUTEX = true , NumPopErrors =
                                                               0 =
                                                                      0.00%
                                                                                Elapsed time =
                                                                                                    3000.07 microseconds
                  USE_MUTEX = true , NumPopErrors =
NUMN =
         32768
                                                               0 =
                                                                      0.00%
                                                                                Elapsed time =
                                                                                                    3558.01 microseconds
                  USE_MUTEX = true , NumPopErrors =
                                                                      0.00%
                                                                                Elapsed time =
                                                                                                    2404.35 microseconds
NUMN =
         32768
                                                               0 =
                  USE_MUTEX = false ,
NUMN =
         32768
                                         NumPopErrors = 14602 =
                                                                     44.56%
                                                                                Elapsed time =
                                                                                                     945.58 microseconds
NUMN =
         32768
                  USE_MUTEX = false , NumPopErrors = 11052 =
                                                                     33.73%
                                                                                Elapsed time =
                                                                                                     441.26 microseconds
        32768
                  USE_MUTEX = false , NumPopErrors = 14422 = 44.01%
NUMN =
                                                                                Elapsed time =
                                                                                                     993.44 microseconds
                  USE_MUTEX = false , NumPopErrors = 14766 =
                                                                                                    1012.09 microseconds
NUMN =
         32768
                                                                     45.06%
                                                                                Elapsed time =
NUMN =
         32768
                  USE_MUTEX = false , NumPopErrors = 19508 = 59.53%
                                                                                Elapsed time =
                                                                                                     922.67 microseconds
                  USE_MUTEX = false , NumPopErrors = 14229 = 43.42%
USE_MUTEX = false , NumPopErrors = 13234 = 40.39%
                                                                                                    981.06 microseconds
1091.37 microseconds
NUMN =
        32768
                                                                                Elapsed time =
NUMN =
         32768
                                                                                Elapsed time =
         32768
                  USE_MUTEX = false , NumPopErrors = 17967 = 54.83% , Elapsed time =
                                                                                                    1029.16 microseconds
 UMN = 32768 , USE_MUTEX = false , NumPopErrors = 14946 = 45.61% , Elapsed time = 932.88 mic
UMN = 32768 , USE_MUTEX = false , NumPopErrors = 16889 = 51.54% , Elapsed time = 893.05 mic
heac@DESKTOP-NJ3FSKU:/mnt/c/Users/stygi/Desktop/IRL Stuff/OSU Folder/CS 475 Parallel/Project 3$
NUMN = 32768
NUMN = 32768
                                                                                                     932.88 microseconds
                                                                                                     893.05 microseconds
```