CS 475 Parallel Programming: The Mutex Stack Challenge

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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 Ubuntu 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:
    int t = 0;
    while( StackPtr < 0  &&  t < TIMEOUT )
        t++;

    // if there is nothing to pop, return;
    if( StackPtr < 0 )
        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;
}
```

```
int
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.

```
rheac@DESKTOP-NJ3FSKU:/mnt/c/Users/stygi/Desktop/IRL Stuff/OSU Folder/CS 475 Parallel/Project 3$ bash loop1.bash
NUMN =   1024 , USE_MUTEX =  true , NumPopErrors =     0 =   0.00% , Elapsed time =     83.76 microseconds
NUMN =   1024 , USE_MUTEX =  true , NumPopErrors =     0 =   0.00% , Elapsed time =     77.54 microseconds
NUMN =   1024 , USE_MUTEX =  true , NumPopErrors =     0 =   0.00% , Elapsed time =    158.44 microseconds
NUMN =   1024 , USE_MUTEX =  true , NumPopErrors =     0 =   0.00% , Elapsed time =    165.17 microseconds
NUMN =   1024 , USE_MUTEX =  true , NumPopErrors =     0 =   0.00% , Elapsed time =     70.63 microseconds
NUMN =   1024 , USE_MUTEX = false , NumPopErrors =   523 =  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
NUMN =   1024 , USE_MUTEX = false , NumPopErrors =   399 =  38.96% , Elapsed time =    135.67 microseconds
NUMN =   1024 , USE_MUTEX = false , NumPopErrors =   473 =  46.19% , Elapsed time =    206.03 microseconds
NUMN =   1024 , USE_MUTEX = false , NumPopErrors =     0 =   0.00% , Elapsed time =    114.91 microseconds
NUMN =   1024 , USE_MUTEX = false , NumPopErrors =   191 =  18.65% , Elapsed time =     79.89 microseconds
NUMN =   1024 , USE_MUTEX = false , NumPopErrors =   508 =  49.61% , 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 =  true , NumPopErrors =     0 =   0.00% , Elapsed time =     72.30 microseconds
NUMN =   2048 , USE_MUTEX =  true , NumPopErrors =     0 =   0.00% , Elapsed time =    190.17 microseconds
NUMN =   2048 , USE_MUTEX =  true , NumPopErrors =     0 =   0.00% , Elapsed time =    294.36 microseconds
NUMN =   2048 , USE_MUTEX =  true , NumPopErrors =     0 =   0.00% , Elapsed time =    291.57 microseconds
NUMN =   2048 , USE_MUTEX =  true , NumPopErrors =     0 =   0.00% , Elapsed time =    178.85 microseconds
NUMN =   2048 , USE_MUTEX = false , NumPopErrors =   938 =  45.80% , Elapsed time =     92.32 microseconds
NUMN =   2048 , USE_MUTEX = false , NumPopErrors =   874 =  42.68% , Elapsed time =    100.97 microseconds
NUMN =   2048 , USE_MUTEX = false , NumPopErrors =   938 =  45.80% , Elapsed time =    102.61 microseconds
NUMN =   2048 , USE_MUTEX = false , NumPopErrors =   939 =  45.85% , Elapsed time =     97.51 microseconds
NUMN =   2048 , USE_MUTEX = false , NumPopErrors =   908 =  44.34% , Elapsed time =     99.73 microseconds
NUMN =   2048 , USE_MUTEX = false , NumPopErrors =   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 =   902 =  44.04% , Elapsed time =     99.47 microseconds
NUMN =   4096 , USE_MUTEX =  true , NumPopErrors =     0 =   0.00% , Elapsed time =    552.92 microseconds
NUMN =   4096 , USE_MUTEX =  true , NumPopErrors =     0 =   0.00% , Elapsed time =    295.70 microseconds
NUMN =   4096 , USE_MUTEX =  true , NumPopErrors =     0 =   0.00% , Elapsed time =    529.84 microseconds
NUMN =   4096 , USE_MUTEX =  true , NumPopErrors =     0 =   0.00% , Elapsed time =    456.25 microseconds
NUMN =   4096 , USE_MUTEX =  true , NumPopErrors =     0 =   0.00% , Elapsed time =    476.88 microseconds
NUMN =   4096 , USE_MUTEX = false , NumPopErrors =  1727 =  42.16% , Elapsed time =    159.95 microseconds
NUMN =   4096 , USE_MUTEX = false , NumPopErrors =  1732 =  42.29% , Elapsed time =    161.29 microseconds
NUMN =   4096 , USE_MUTEX = false , NumPopErrors =  2055 =  50.17% , Elapsed time =    135.26 microseconds
NUMN =   4096 , USE_MUTEX = false , NumPopErrors =  1861 =  45.43% , Elapsed time =    172.13 microseconds
NUMN =   4096 , USE_MUTEX = false , NumPopErrors =  1548 =  37.79% , Elapsed time =    146.43 microseconds
NUMN =   4096 , USE_MUTEX = false , NumPopErrors =  1767 =  43.14% , Elapsed time =    156.20 microseconds
NUMN =   4096 , USE_MUTEX = false , NumPopErrors =  1600 =  39.06% , Elapsed time =    161.20 microseconds
NUMN =   4096 , USE_MUTEX = false , NumPopErrors =   997 =  24.34% , Elapsed time =    133.12 microseconds
NUMN =   4096 , USE_MUTEX = false , NumPopErrors =  2155 =  52.61% , Elapsed time =    133.81 microseconds
NUMN =   4096 , USE_MUTEX = false , NumPopErrors =  1748 =  42.68% , Elapsed time =    159.10 microseconds
NUMN =   8192 , USE_MUTEX =  true , NumPopErrors =     0 =   0.00% , Elapsed time =    994.67 microseconds
NUMN =   8192 , USE_MUTEX =  true , NumPopErrors =     0 =   0.00% , Elapsed time =    842.06 microseconds
NUMN =   8192 , USE_MUTEX =  true , NumPopErrors =     0 =   0.00% , Elapsed time =   1004.59 microseconds
NUMN =   8192 , USE_MUTEX =  true , NumPopErrors =     0 =   0.00% , Elapsed time =    903.58 microseconds
NUMN =   8192 , USE_MUTEX =  true , NumPopErrors =     0 =   0.00% , Elapsed time =    599.00 microseconds
NUMN =   8192 , USE_MUTEX = false , NumPopErrors =  3733 =  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
NUMN =   8192 , USE_MUTEX = false , NumPopErrors =  3636 =  44.38% , Elapsed time =    267.35 microseconds
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
NUMN =   8192 , USE_MUTEX = false , NumPopErrors =  3564 =  43.51% , Elapsed time =    266.16 microseconds
NUMN =   8192 , USE_MUTEX = false , NumPopErrors =  3331 =  40.66% , Elapsed time =    270.86 microseconds
NUMN =   8192 , USE_MUTEX = false , NumPopErrors =  3436 =  41.94% , Elapsed time =    283.70 microseconds
NUMN =   8192 , USE_MUTEX = false , NumPopErrors =  3451 =  42.13% , Elapsed time =    267.28 microseconds
```

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