POSIX Thread Programming

**Team name: Feel free to be creative**

Name of the VM: 🡨 Centos7VM

Password: 🡨 IloveCS4500

Team members names:

Jaylen McKinney | Worked on half of part 1 and part 3

Brogan Bewley | Worked on half of part 1 and part 2

# Description of Project: 2 – 3 Sentences

Here write a few (2-3) sentences describing the purpose of the program. You may be more specific later in the pseudocode or conclusion section of this report. You should write in complete sentences to describe the purpose.

# Pseudocode: This can be a picture, drawing, sketch, or digitally produced. For example, if you hand-wrote it on a sheet of paper, convert it into and image and paste it here. If you typed it in notepad, copy and paste it here.

**Pseudocode for part 1**

Readfile function

1. Make sure that the file exists
2. Allocate memory for the string and the substring
3. Read the strings from the file
   1. If the strings are empty, return an error message
4. Create two variables to hold the length of the strings

Num\_substring function

1. Create integer to hold the number of matching characters
2. Create integer variable to hold number of substrings
3. Create a variable for the starting position
4. Create a variable for the ending position
5. For loop from value of start to value of end
   1. Reset count to 0
   2. Nested for loop for substring count
      1. If the two characters at position i of string and substring match, increment count by 1
      2. Else if the count equals the length of the substring, a match has been found
         1. Lock thread
         2. Increment total by 1
         3. Unlock thread

Main function

1. Create array of threads of type pthread\_t
2. Create count integer
3. Jump to readfile function to read from file
4. Create array of thread number
5. Initialize lock for threads
6. For loop for threads from 0 to the current number of threads
   1. Split string into 4 separate strings for threads
   2. Create a thread and run num\_substring function
7. For loop to join the threads from 0 to current number of threads
   1. Wait for the thread to terminate
8. Destroy the lock
9. Exit program

**Part 3 pseudocode**

1. Create K data nodes
2. Create a struct to create a node for a linked list
3. Create a lock for the pthread
4. Create a list pointer for the linked list

Bind to CPU function (Sets up the CPU affinity)

1. Create a CPU set mask
2. Clear the mask so that it contains no CPUs
3. Set the mask to the current CPU ID
4. If the CPU affinity is not set
   1. Print out an error
   2. Exit

Generate data node function

1. Create a node pointer
2. Allocate size for the node pointer
3. If the pointer’s memory was allocated
   1. Set next to null
4. Else
   1. Print out error message
5. Return the pointer

Producer thread function

1. Run the bind thread to cpu function
2. Create a node pointer and temp pointer
3. Create an integer counter
4. While the counter is less than K
   1. Jump to generate\_data\_node to create node
   2. If node creation was successful
      1. While true
         1. If the lock is acquired
            1. Set the node pointer’s data to 1
      2. If the linked list is empty
         1. Set the list header and tail equal to the pointer
      3. Else
         1. Put the new node at the end of the list
         2. Update tail to be new node
      4. Unlock the thread
      5. Break from the loop
5. Increment counter

Main function

1. Create integer variables for counter I and number of threads
2. Create an integer variable for the current number of CPUs
3. Create an integer pointer for an empty array of CPUs
4. Create a temporary and next node pointer
5. Create variables for a start and end time
6. If the user did not input anything
   1. Return an error message
   2. Exit
7. Set the number of threads equal to user’s input
8. Create a pthread array with num of elements being the num of threads
9. Get the current number of CPUs
10. If there are CPUs present
    1. Allocate memory for the cpu\_array
    2. If memory for the array was not allocated
       1. Print error message
       2. Exit
    3. Else
       1. For loop from I to the number of CPUs
          1. Set the CPU number I to the current CPU\_array index
11. Initialize a mutex
12. Allocate size for the list
13. If memory for list was not allocated
    1. Print end message
    2. Exit
14. Initialize linked list
15. Get the program’s start time
16. For loop from i to the number of threads
    1. Create a pthread and have that thread run through the producer thread function
17. For loop from i to the number of threads
    1. If the thread does not equal 0
       1. Wait for the thread to terminate
18. Get the finish time
19. If the linked list is not empty
    1. Set next and temporary pointer equal to the head of the list
    2. While temporary pointer is not null
       1. Clear and free every node from the linked list
20. If the cpu\_array is not empty
    1. Free memory from the cpu\_array
21. Calculate total runtime

# Conclusion 1- 2 Paragraphs

Part 1 took a bit of time to figure out. Since we did not fully understand how pthreads worked, we spent some time researching different pthread functions. We also had some trouble separating the string amongst the threads. Brogan figured out how to separate the string so that each thread could find substrings. He also implemented the for loop for the substrings. Jaylen wrote the loops to create the pthreads, the loop to wait for the thread to terminate, and added some comments for better understanding of the code.

Part 3 took a little while to figure out. Reading through all that code and trying to figure out how it all worked was a challenge. Eventually, Jaylen figured out that changing the pthread\_mutex\_trylock function to pthread\_mutex\_lock improved the performance of the program. We also noticed that performance was significantly more improved if ther were more threads involved.

K=200

|  |  |  |
| --- | --- | --- |
| Threads | List avg | My-list avg |
| 2 | (548+445+415+320)/4 = 432 | (572+478+538+310)/4 = 474.5 |
| 4 | (1156+771+885+758)/4 = 892.5 | (685+912+717+654)/4 = 742 |
| 6 | (1500+1094+1134+1382)/4 = 1277.5 | (901+1014+1048+1076)/4 = 1009.75 |
| 8 | (1980+1369+1726+1447)/4 = 1630.5 | (1387+1538+1849+1490)/4 = 1566 |

K=400

|  |  |  |
| --- | --- | --- |
| Threads | List avg | My-list avg |
| 2 | (662+408+447+516)/4 = 508.25 | (572+607+478+589)/4 = 561.5 |
| 4 | (1778+1401+1715+1621)/4 = 1628.75 | (1509+1447+951+884)/4 = 1197.75 |
| 6 | (1501+1380+1923+2387)/4 = 1797.75 | (1303+1726+1173+1289)/4 = 1372.75 |
| 8 | (2088+2474+3526+2510)/4 = 2649.5 | (1572+1638+1592+2161)/4 = 1740.75 |

K=600

|  |  |  |
| --- | --- | --- |
| Threads | List avg | My-list avg |
| 2 | (957+794+1068+1009)/4 = 957 | (633+727+620+645)/4 = 656.25 |
| 4 | (2536+2038+2453+2445)/4 = 2368 | (1271+1370+1065+1207)/4 = 1228.25 |
| 6 | (2898+2989+2645+2736)/4 = 2817 | (1658+1707+1690+1612)/4 = 1666.75 |
| 8 | (3634+2682+3307+3233)/4 = 3214 | (2875+3092+2316+1837)/4= 2530 |

In the modified program, the only thing that was changed was using pthread\_mutex\_lock instead of pthread\_mutex\_trylock. At lower K values and thread counts, using trylock was typically faster than using lock. However, as K and the thread count increased, the performance of lock improved as well. The reason that pthread\_mutex\_lock decreases performance time over pthread\_mutex\_trylock is because pthread\_mutex\_trylock is a nonblocking function. If the mutex is currently locked, it will return immediately. However, if a mutex is currently locked with pthread\_mutex\_lock, the calling thread will be blocked until it becomes available. Since the thread is completely blocked until the lock becomes available instead of running in the background until the lock becomes available, that makes pthread\_mutex\_lock more efficient than pthread\_mutex\_trylock.

Describe in which ways the project could have improved? Do you feel as though you put forth your best efforts? Did your team function well as a group? If not, please share in which ways with the instructor, not in the conclusion of this report. Students who do not participate in group projects may submit a single submission that they created by themselves – it cannot be the same submission the group you are assigned to submitted if you did not participate in the group work.

# Lessons Learned

You are not confined to the following prompts, they are examples of the types of questions you might ponder while determining what your lessons learned were. Each team member can submit a separate “Lessons Learned” section to the dropbox in Canvas, or each student can paste a paragraph response in this document. Were you able to complete the project basically the first time through with little to no errors? Describe how you utilized the hints (if you needed to)? Describe which part of the project you learned the most from, what you learned, and how you feel it could benefit you someday in the future. Can you relate it to a potential career you may choose? How did completing this project contribute to your knowledge of how computing and OS (in general) behave? You may also add general take-aways about the assignment itself, if you would like. You may consider addressing: do you feel the assignment was about the appropriate breadth and depth you would expect from a higher level CS course?

Jaylen

Throughout this project, I learned how threads are applied to programming. I learned how to create a thread, lock a thread, and wait for a thread to terminate in C. I also learned the difference between pthread\_mutex\_trylock and pthread\_mutex\_lock. Lock is faster than trylock because if the mutex object is locked, then the thread will be blocked until the lock is available. This is different from trylock, where if the mutex object is locked, the thread will return immediately. This project was a lot of trial and error. Even if I didn’t do everything perfectly, I still learned a lot from this project. The most difficult part was figuring out how to get the for loop for substrings to work with threads. Brogan really helped me out twith that part. I also realized that I should really start writing pseudocode again. I got so comfortable just writing code that when I needed to think more in-depth, I got stuck. Writing pseudocode a little bit earlier in the project would have saved me a lot of time.