PROGRAMMING ASSIGNMENT 5
DUE: Monday October 26, 11:59 PM

DESCRIPTION

Create a program to sort an array of integers using the Merge Sort algorithm. The program will use several threads for different tasks and semaphores to coordinate these tasks. Please refer to the diagram provided for this assignment for a better understanding of the different components of your program.

Your program MUST include the following:

1. Five threads. The thread ids MUST be “th1”, “th2”, “th3”, “th4”, and “th5”.
2. The function associated with “th1” MUST be named “createArray”. It will use an input parameter (array size n) via a command line argument to create a one-dimensional array to be sorted. The array will consist of n random integers between -1000 to 1000, inclusive. After the array is created, “th1” will print to the console each element separated by a tab ‘\t’. See sample output below.
3. The function associated with “th2” MUST be named “sortFirstHalf”. It will sort the first n/2 elements of the array by calling the “mergeSort” function which will be described below.
4. The function associated with “th3” MUST be named “sortSecondHalf”. It will sort the second n/2 elements of the array by calling the “mergeSort” function.
5. “th2” and “th3” MUST run concurrently. This will provide speed-up of the sorting process. See sample output below.
6. The function associated with “th4” MUST be named “mergeTwoHalves”. It will combine first half of the sorted arrays with second half of the sorted array by calling the “merge” function which will be described below.
7. The function associated with “th5” MUST be named “printSortedArray”. It will print all the elements in the sorted array separated by a tab ‘\t’. See sample output below.

Your program will also include two functions. As the diagram for this assignment shows “th2” and “th3” will first call the function “mergeSort” and then the function “merge”.

8. The function “mergeSort” will divide the array into equal halves repeatedly until there is only one element left and then call the “merge” function to sort the array.

9. Below is a pseudocode for "mergeSort". To confirm that "th2" and "th3" are running concurrently, as soon as you enter the "mergeSort" function and if "th2" is running, you must print "*" followed by the first element of the array that is passed into "mergeSort. If "th3" is running then print "**" followed by the first element of the array that is passed into "mergeSort. Use a tab ("\t") in between prints. See sample output below.

```
1. procedure mergeSort( var a as array )
2.
3.     if ( n == 1 ) return a
4.
5.     var l1 as array = a[0] ... a[n/2]
6.     var l2 as array = a[n/2+1] ... a[n]
7.
8.     l1 = mergeSort( l1 )
9.     l2 = mergeSort( l2 )
10.
11.    return merge( l1, l2 )
12. end procedure
```

```
IF is called by thread 2
      Print ("*"+a[0]+ "\t")
ELSE IF called by thread 3
      Print ("**"+a[0]+ "\t")
```

10. The function "merge" will combine the divided arrays sorting them in ***ascending order***. Below is a pseudocode for "merge".

```
1. procedure merge( var a as array, var b as array )
2.
3.     var c as array
4.     while ( a and b have elements )
5.        if ( a[0] > b[0] )
6.           add b[0] to the end of c
7.           remove b[0] from b
8.        else
9.           add a[0] to the end of c
10.          remove a[0] from a
11.       end if
12.    end while
13.
14.    while ( a has elements )
15.       add a[0] to the end of c
16.       remove a[0] from a
17.    end while
18.
19.    while ( b has elements )
20.       add b[0] to the end of c
21.       remove b[0] from b
22.    end while
23.
24.    return c
25.
26. end procedure
```

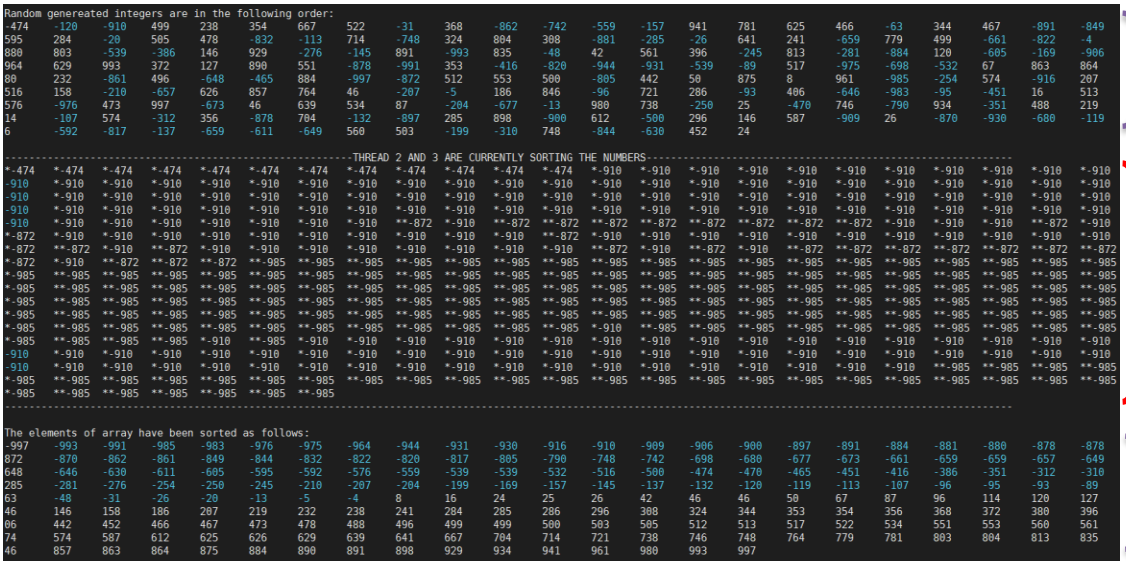
COMPILER COMMAND

Your program must be able to compile with the command **gcc assign5.c -o assign5 -lpthread**

Sample INPUT

./assign5 200 Where 200 is the input size n for the random array.

Sample OUTPUT



This section is printing all the random number generated by th1.

This section is printed by the function "mergeSort" As you can see * and ** are mixed that is because th2 (*) and th3 (**) are run CONCURRENTLY.

Note: you must try a large array size and or run the program couple times to see this pattern.

This section is printing the entire sorted array by th5.

SUBMISSION

Submit assign5.c file through Canvas.

GRADING CRITERIA

- **Early submission (by Oct 24, 11:59pm) will receive a 5% bonus**
- **Late submissions will lose points as stated on the syllabus – 10% for each day late.**
- **A program that does not compile will result in a zero!**
- Functionality:
  - 3% - for your full name in the first line as a comment and code organization
  - 15% - for implementing the merge sort algorithm correctly
    - 8% - for "mergeSort" function
    - 7% - for "merge" function
  - 1% - for every thread and associated function named as requested. 7% total
  - 7% - for every thread and associated function that performs correctly. 35% total
  - 10% - for correctly creating and initializing semaphores.
  - 25% - for placing the semaphores correctly within the program
  - 5% - for correctly releasing semaphores at the appropriate place during execution.

PLAGIARISM!

Your program must be your original work, as stated and described in the syllabus. If you are unsure about whether some open source code can be used, contact the TA.

You are allowed to use any portion of code that is included in the course slides published in canvas.