



# MARMARA UNIVERSITY

## FACULTY OF ENGINEERING

COMPUTER SCIENCE ENGINEERING

---

**CSE3033 – OPERATING SYSTEMS**

**INSTRUCTOR: ALİ HAYDAR ÖZER**

**PROGRAMMING ASSIGNMENT 3 (USING THREADS TO SYNCHRONIZE) - REPORT**

**ÖMERCAN GÖKTAŞ – 150119671**

**BERKAN KORKMAZ – 150119623**

**İPEK KÜLHAN - 150119041**

**DETAILS ABOUT THE PROGRAM**

This program implemented in C language. The main purpose of the program is to synchronize threads. There are 4 types of threads in the program which are read, upper, replace, and write threads. At the beginning of the program number of arguments is checked firstly. If the number of arguments is not 6, an error will be raised. Secondly, given file is checked whether it exists or not, then given numbers of threads are checked if they are integer or not. If any of them is not integer, an error will be raised. Then a mutex is created to synchronize the threads. After that, threads are going to be created accordingly given number of threads. Then read threads are executed. Read threads are executed then they read a line from the given file line by line. When a read thread finds its line, mutex is locked and this line is added to struct pointer, and the mutex is unlocked, and so on. When all the read threads are terminated, write, upper, and replace threads are created accordingly. If a line is processed by upper and replace thread, write threads checks that and modifies the file. If the line is not processed yet, the write threads waits with while loop until the line is processed by these threads. Finally, when all the write, upper, and replace threads are terminated, mutex is destroyed.

**EXAMPLE RUN**

- to compile the C file, this line should be executed:

gcc -o main main.c -lpthread

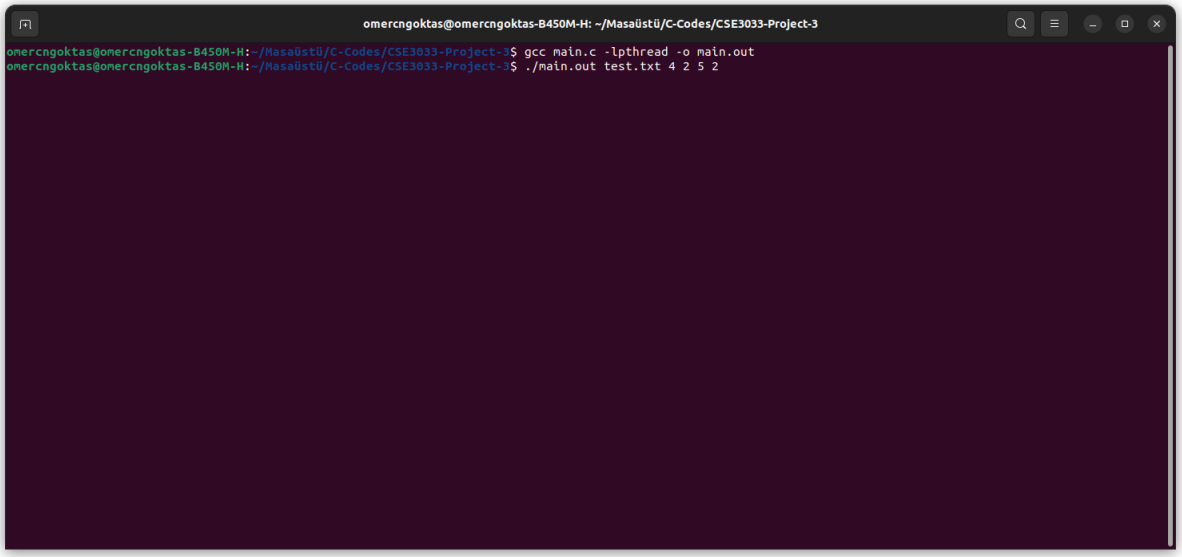
or an out file can be created with the given line below:

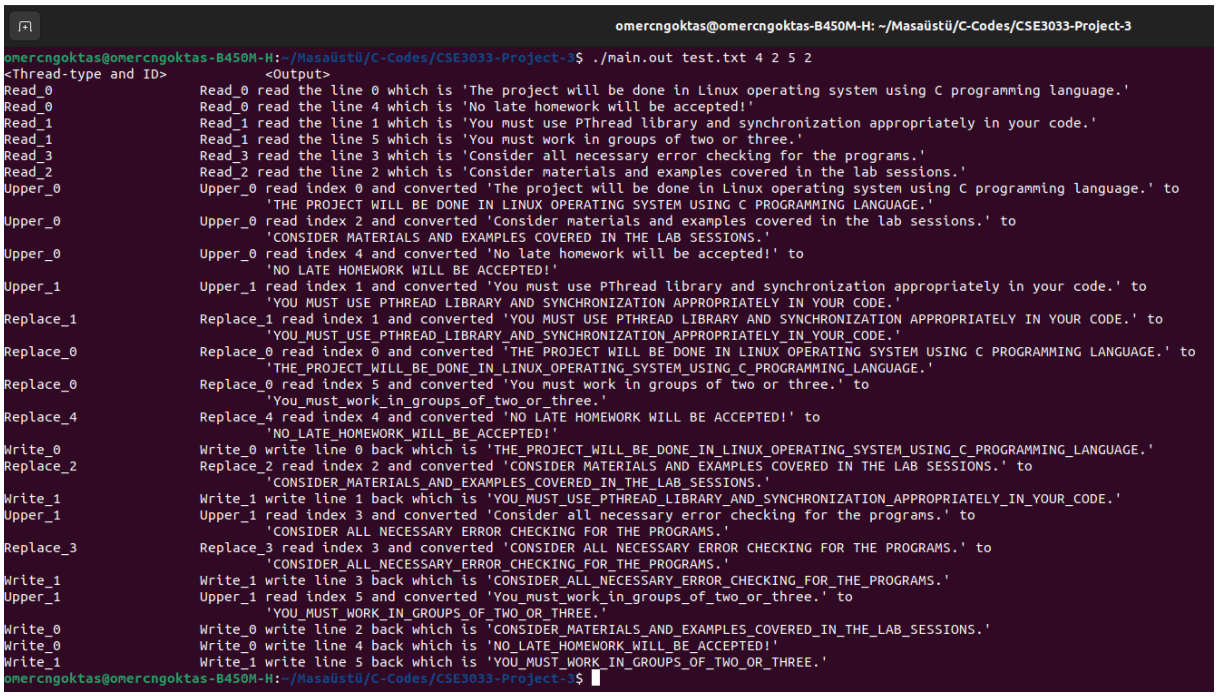
gcc main.c -lpthread -o main.out

- to run the program, this line should be executed:

./main.out fileName noOfReadThreads noOfUpperThreads noOfReplaceThreads noOfWriteThreads

After compiling the main file, an out file is created, and execution of this file can be seen from the picture given below:




As it can be seen from the picture given above, 4 read threads created and they were executed. We can also see that the order of the read line is non-deterministic. After read threads are terminated, we see that 4 upper threads executed, 4 replace threads executed, and then write thread checked a line and found out that it has processed by read and upper threads. So, it modifies the file. After that, rest of the threads continued to execute.

Before the execution, content of the file can be seen:

test.txt

```
1  The project will be done in Linux operating system using C programming language.
2  You must use PThread library and synchronization appropriately in your code.
3  Consider materials and examples covered in the lab sessions.
4  Consider all necessary error checking for the programs.
5  No late homework will be accepted!
6  You must work in groups of two or three.
7
```

After the execution, we see that lower case letters are changed to upper case letters and space characters changed with underscore character:

test.txt

```
1  THE_PROJECT_WILL_BE_DONE_IN_LINUX_OPERATING_SYSTEM_USING_C_PROGRAMMING_LANGUAGE.
2  YOU_MUST_USE_PTHREAD_LIBRARY_AND_SYNCHRONIZATION_APPROPRIATELY_IN_YOUR_CODE.
3  CONSIDER_MATERIALS_AND_EXAMPLES_COVERED_IN_THE_LAB_SESSIONS.
4  CONSIDER_ALL_NECESSARY_ERROR_CHECKING_FOR_THE_PROGRAMS.
5  NO_LATE_HOMEWORK_WILL_BE_ACCEPTED!
6  YOU_MUST_WORK_IN_GROUPS_OF_TWO_OR_THREE.
7
```

And result of an another execution of the program:

```
omercngoktas@omercngoktas-B450M-H:~/MasaüstÜ/C-Codes/CSE3033-Project-3$ ./main.out test.txt 3 5 4 2
<Thread-type and ID>            <Output>
Read_0                  Read_0 read the line 0 which is 'The project will be done in Linux operating system using C programming language.'
Read_0                  Read_0 read the line 3 which is 'Consider all necessary error checking for the programs.'
Read_2                  Read_2 read the line 2 which is 'Consider materials and examples covered in the lab sessions.'
Read_2                  Read_2 read the line 5 which is 'You must work in groups of two or three.'
Read_1                  Read_1 read the line 1 which is 'You must use PThread library and synchronization appropriately in your code.'
Read_1                  Read_1 read the line 4 which is 'No late homework will be accepted!'
Upper_0                 Upper_0 read index 0 and converted 'The project will be done in Linux operating system using C programming language.' to
                                'THE PROJECT WILL BE DONE IN LINUX OPERATING SYSTEM USING C PROGRAMMING LANGUAGE.'
Upper_0                 Upper_0 read index 5 and converted 'You must work in groups of two or three.' to
                                'YOU MUST WORK IN GROUPS OF TWO OR THREE.'
Upper_1                 Upper_1 read index 1 and converted 'You must use PThread library and synchronization appropriately in your code.' to
                                'YOU MUST USE PTHREAD LIBRARY AND SYNCHRONIZATION APPROPRIATELY IN YOUR CODE.'
Upper_2                 Upper_2 read index 2 and converted 'Consider materials and examples covered in the lab sessions.' to
                                'CONSIDER MATERIALS AND EXAMPLES COVERED IN THE LAB SESSIONS.'
Upper_3                 Upper_3 read index 3 and converted 'Consider all necessary error checking for the programs.' to
                                'CONSIDER ALL NECESSARY ERROR CHECKING FOR THE PROGRAMS.'
Upper_4                 Upper_4 read index 4 and converted 'No late homework will be accepted!' to
                                'NO LATE HOMEWORK WILL BE ACCEPTED!'
Replace_0               Replace_0 read index 0 and converted 'THE PROJECT WILL BE DONE IN LINUX OPERATING SYSTEM USING C PROGRAMMING LANGUAGE.' to
                                'THE_PROJECT_WILL_BE_DONE_IN_LINUX_OPERATING_SYSTEM_USING_C_PROGRAMMING_LANGUAGE.'
Replace_0               Replace_0 read index 4 and converted 'NO LATE HOMEWORK WILL BE ACCEPTED!' to
                                'NO_LATE_HOMEWORK_WILL_BE_ACCEPTED!'
Replace_2               Replace_2 read index 2 and converted 'CONSIDER MATERIALS AND EXAMPLES COVERED IN THE LAB SESSIONS.' to
                                'CONSIDER_MATERIALS_AND_EXAMPLES_COVERED_IN_THE_LAB_SESSIONS.'
Write_0                 Write_0 write line 0 back which is 'THE_PROJECT_WILL_BE_DONE_IN_LINUX_OPERATING_SYSTEM_USING_C_PROGRAMMING_LANGUAGE.'
Write_0                 Write_0 write line 2 back which is 'CONSIDER_MATERIALS_AND_EXAMPLES_COVERED_IN_THE_LAB_SESSIONS.'
Write_0                 Write_0 write line 4 back which is 'NO_LATE_HOMEWORK_WILL_BE_ACCEPTED!'
Replace_1               Replace_1 read index 1 and converted 'YOU MUST USE PTHREAD LIBRARY AND SYNCHRONIZATION APPROPRIATELY IN YOUR CODE.' to
                                'YOU_MUST_USE_PTHREAD_LIBRARY_AND_SYNCHRONIZATION_APPROPRIATELY_IN_YOUR_CODE.'
Replace_1               Replace_1 read index 5 and converted 'YOU MUST WORK IN GROUPS OF TWO OR THREE.' to
                                'YOU_MUST_WORK_IN_GROUPS_OF_TWO_OR_THREE.'
Write_1                 Write_1 write line 1 back which is 'YOU_MUST_USE_PTHREAD_LIBRARY_AND_SYNCHRONIZATION_APPROPRIATELY_IN_YOUR_CODE.'
Replace_3               Replace_3 read index 3 and converted 'CONSIDER ALL NECESSARY ERROR CHECKING FOR THE PROGRAMS.' to
                                'CONSIDER_ALL_NECESSARY_ERROR_CHECKING_FOR_THE_PROGRAMS.'
Write_1                 Write_1 write line 3 back which is 'CONSIDER_ALL_NECESSARY_ERROR_CHECKING_FOR_THE_PROGRAMS.'
Write_1                 Write_1 write line 5 back which is 'YOU_MUST_WORK_IN_GROUPS_OF_TWO_OR_THREE.'
omercngoktas@omercngoktas-B450M-H:~/MasaüstÜ/C-Codes/CSE3033-Project-3$
```

We can observe that after 6 lines are processed by read threads and 3 lines are processed by replace threads. These lines are 0, 5, 1, 2, 3, 4 for read threads and 0, 4, 2 for replace threads respectively. And then, write threads are found out that lines 0, 2, and 4 are processed by these threads, so it modifies the file.

And here another result of execution:

```
omercngoktas@omercngoktas-B450M-H:~/Masaüstü/C-Codes/CSE3033-Project-3$ ./main.out test.txt 2 4 3 2
<Thread-type and ID>            <Output>
Read_0                  Read_0 read the line 0 which is 'The global queue must be created the first time a thread needs to use by that thread.'
Read_0                  Read_0 read the line 2 which is 'The user will execute the program specifying the number of threads to be created of each kind.'
Read_1                  Read_1 read the line 1 which is 'Preserving consistency and preventing deadlocks are major issues to be considered.'
Read_1                  Read_1 read the line 3 which is 'You will then create the specified number of threads of each type.'
Upper_0                 Upper_0 read index 0 and converted 'The global queue must be created the first time a thread needs to use by that thread.' to
                                'THE GLOBAL QUEUE MUST BE CREATED THE FIRST TIME A THREAD NEEDS TO USE BY THAT THREAD.'
Upper_1                 Upper_1 read index 1 and converted 'Preserving consistency and preventing deadlocks are major issues to be considered.' to
                                'PRESERVING CONSISTENCY AND PREVENTING DEADLOCKS ARE MAJOR ISSUES TO BE CONSIDERED.'
Upper_2                 Upper_2 read index 2 and converted 'The user will execute the program specifying the number of threads to be created of each kind.' to
                                'THE USER WILL EXECUTE THE PROGRAM SPECIFYING THE NUMBER OF THREADS TO BE CREATED OF EACH KIND.'
Replace_0               Replace_0 read index 0 and converted 'THE GLOBAL QUEUE MUST BE CREATED THE FIRST TIME A THREAD NEEDS TO USE BY THAT THREAD.' to
                                'THE_GLOBAL_QUEUE_MUST_BE_CREATED_THE_FIRST_TIME_A_THREAD_NEEDS_TO_USE_BY_THAT_THREAD.'
Write_0                 Write_0 write line 0 back which is 'THE_GLOBAL_QUEUE_MUST_BE_CREATED_THE_FIRST_TIME_A_THREAD_NEEDS_TO_USE_BY_THAT_THREAD.'
Upper_3                 Upper_3 read index 3 and converted 'You will then create the specified number of threads of each type.' to
                                'YOU WILL THEN CREATE THE SPECIFIED NUMBER OF THREADS OF EACH TYPE.'
Replace_0               Replace_0 read index 3 and converted 'YOU WILL THEN CREATE THE SPECIFIED NUMBER OF THREADS OF EACH TYPE.' to
                                'YOU_WILL_THEN_CREATE_THE_SPECIFIED_NUMBER_OF_THREADS_OF_EACH_TYPE.'
Replace_2               Replace_2 read index 2 and converted 'THE USER WILL EXECUTE THE PROGRAM SPECIFYING THE NUMBER OF THREADS TO BE CREATED OF EACH KIND.' to
                                'THE_USER_WILL_EXECUTE_THE_PROGRAM_SPECIFYING_THE_NUMBER_OF_THREADS_TO_BE_CREATED_OF_EACH_KIND.'
Replace_1               Replace_1 read index 1 and converted 'PRESERVING CONSISTENCY AND PREVENTING DEADLOCKS ARE MAJOR ISSUES TO BE CONSIDERED.' to
                                'PRESERVING_CONSISTENCY_AND_PREVENTING_DEADLOCKS_ARE_MAJOR_ISSUES_TO_BE_CONSIDERED.'
Write_0                 Write_0 write line 2 back which is 'THE_USER_WILL_EXECUTE_THE_PROGRAM_SPECIFYING_THE_NUMBER_OF_THREADS_TO_BE_CREATED_OF_EACH_KIND.'
Write_1                 Write_1 write line 1 back which is 'PRESERVING_CONSISTENCY_AND_PREVENTING_DEADLOCKS_ARE_MAJOR_ISSUES_TO_BE_CONSIDERED.'
Write_1                 Write_1 write line 3 back which is 'YOU_WILL_THEN_CREATE_THE_SPECIFIED_NUMBER_OF_THREADS_OF_EACH_TYPE.'
omercngoktas@omercngoktas-B450M-H:~/Masaüstü/C-Codes/CSE3033-Project-3$
```