

**Gebze Technical University**  
**Computer Engineering**

**System Programing(CSE 344)**

**Midterm**

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## Problem

Two programs need to be written for a server and client. For each client connection request, the server will create a thread and communication will take place over this process. The clients will interact with the server in real time. When starting the server, the number of clients to be connected and the directory in which it will operate will be specified. A log file will be created for each operation. The server will process commands from the client and send them to the client. In summary task is to design and implement a file server that enables multiple clients to connect, access and modify the contents of files in a specific directory

## Solutions

**System Design:** Initially, the high-level architecture of the system should be designed. This involves determining the number of processes on both the server and client side and how they will communicate with each other. You could use a network protocol like FIFO for communication between the client and server. Additionally, you will need to determine which operations will be performed by multiple processes and which processes will be managed by signals.

**File I/O Module:** This module should perform reading and writing operations in various file formats. This includes being able to handle different types of files such as text files and binary files. Also, the management of large files (larger than 10 MB) should be considered.

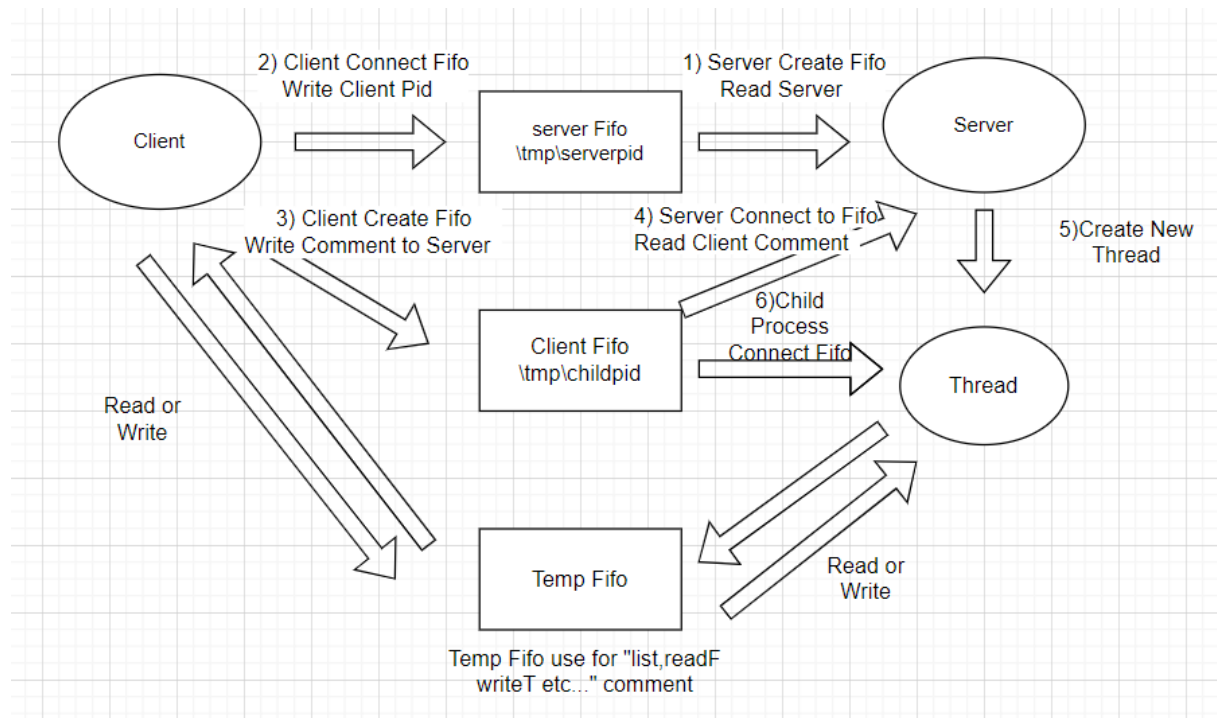
**Synchronization Module:** This module should be designed to prevent race conditions and provide mutual exclusion. When resource sharing is required between processes, one process should wait for others to complete and no changes should be made on the resource during this time. This ensures the preservation of data integrity and consistency of the file system.

**Integration of File I/O and Synchronization Modules:** These two modules should be integrated to form a file access system that can be accessed by multiple processes at the same time.

**Testing:** You should verify the system by testing the simultaneous access to files by multiple processes. This will help confirm that data consistency is maintained and race conditions are prevented.

These general steps should assist in creating a file server designed to meet most of the specified requirements. However, if a specific programming language or framework is being used, the solution might be slightly different. For instance, some languages naturally provide multi-process support, while others require specific libraries or plugins.

## System Design

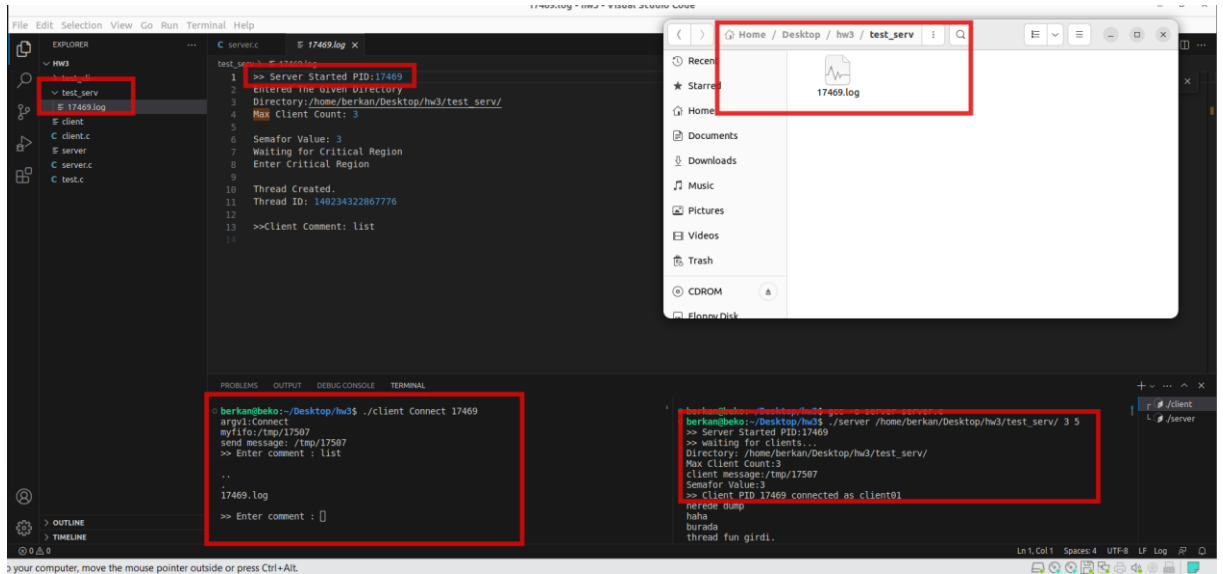


- 1) First, the server creates a FIFO for the clients to connect.
- 2) The client sends the address of the FIFO it created to the server.
- 3) "The client is ready to write commands by opening the FIFO file it created.
- 4) The server starts listening for incoming commands from the client by connecting to the FIFO created by the client.
- 5) After reading the new FIFO address, the server creates a new Thread. The client establishes communication with the thread.
- 6) The thread connects to the FIFO created by the client. The client and server communicate through this FIFO.

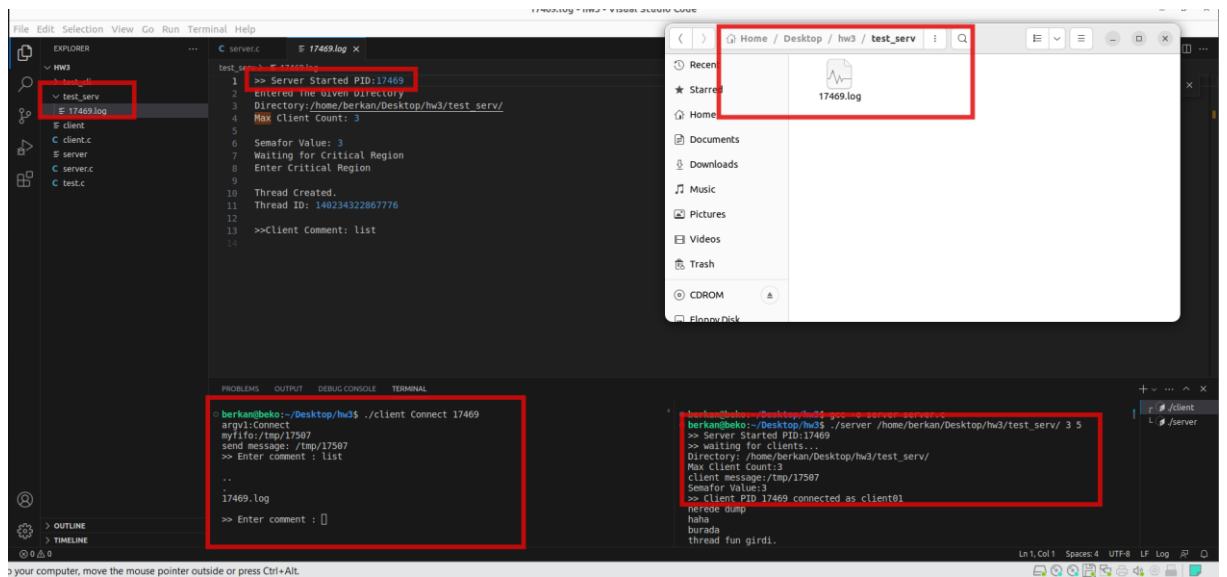
**Temp Fifo:** These are temporary FIFOs created during the execution of commands.(list,readF,upload ...).

## Requirements

- 1) The server will operate in the directory specified at startup.



- ❖ As you can see, entries have been made into the specified directory, and the log file has been created there.



2) The server should be able to accept connections from as many clients as the maximum number of clients specified in the input when starting the server.

- ❖ The maximum number of clients that can connect to the server was given as 3. When 3 clients are connected, it rejects the 4th client's connection. The reason for the server rejecting the connection is because the client input is **'tryConnect'**.

```
berkan@beko: ~/Desktop/hw3
$ ./client tryConnect 18296
argv:tryConnect
try girdl
try message:no
Que is full
berkan@beko: ~/Desktop/hw3

berkan@beko: ~/Desktop/hw3
$ ./client tryConnect 18296
argv:tryConnect
try girdl
try message:yes
myfifo:/tmp/18521
send message: /tmp/18521
>> Enter comment : []

berkan@beko: ~/Desktop/hw3
$ ./client tryConnect 18296
argv:tryConnect
try girdl
try message:yes
myfifo:/tmp/18497
send message: /tmp/18497
>> Enter comment : []

164 printf("Thread Pool Size:%d",threadNum);
165
166 signal(SIGINT, handle_sigint);
167 strcat(myfifo,FIFO_DIRECTORY);
168 sprintf(pidSrt, "%d", getpid());
169 strcat(logFile,pidSrt);
170 strcat(logFile,".log");
171

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL
berkan@beko:~/Desktop/hw3$ ^C
berkan@beko:~/Desktop/hw3$ ./client tryConnect 17911
argv:tryConnect
try girdl
^C
berkan@beko:~/Desktop/hw3$ ^C
berkan@beko:~/Desktop/hw3$ ./client tryConnect 18296
argv:tryConnect
try girdl
try message:yes
myfifo:/tmp/18417
send message: /tmp/18417
>> Enter comment : []

thread fun girdl 1:
Child process PID:18296
Client message:/tmp/18521try
Semafor Value:1
Client message:/tmp/18521
Semafor Value:1
>> Client PID 18296 connected as client03
thread fun girdl:
Child process PID:18296
Client message:/tmp/18538try
Semafor Value:0
```

```
berkan@beko: ~/Desktop/hw3
$ ./client tryConnect 18296
argv:tryConnect
try girdl
try message:no
Que is full
berkan@beko: ~/Desktop/hw3

berkan@beko: ~/Desktop/hw3
$ ./client tryConnect 18296
argv:tryConnect
try girdl
try message:yes
myfifo:/tmp/18521
send message: /tmp/18521
>> Enter comment : []

berkan@beko: ~/Desktop/hw3
$ ./client tryConnect 18296
argv:tryConnect
try girdl
try message:yes
myfifo:/tmp/18497
send message: /tmp/18497
>> Enter comment : []

164 printf("Thread Pool Size:%d",threadNum);
165
166 signal(SIGINT, handle_sigint);
167 strcat(myfifo,FIFO_DIRECTORY);
168 sprintf(pidSrt, "%d", getpid());
169 strcat(logFile,pidSrt);
170 strcat(logFile,".log");
171

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL
berkan@beko:~/Desktop/hw3$ ^C
berkan@beko:~/Desktop/hw3$ ./client tryConnect 17911
argv:tryConnect
try girdl
^C
berkan@beko:~/Desktop/hw3$ ^C
berkan@beko:~/Desktop/hw3$ ./client tryConnect 18296
argv:tryConnect
try girdl
try message:yes
myfifo:/tmp/18417
send message: /tmp/18417
>> Enter comment : []

berkan@beko:~/Desktop/hw3$ ^C
berkan@beko:~/Desktop/hw3$ ./server /home/berkan/Desktop/hw3/test_serv/ 3 5
>> Server Started PID:18296
Directory: /home/berkan/Desktop/hw3/test_serv/
Max Client Count:3
>> waiting for clients...
client message:/tmp/18417try
Semafor Value:3
>> Client PID 18296 connected as client01
thread fun girdl:
Child process PID:18296
Client message:/tmp/18538try
Semafor Value:0
```

- ❖ "When we enter '**connected**' in the client input, the server takes it into the connection queue. When one client's connection drops, the next client in line connects.

The screenshot shows three terminal windows in Visual Studio Code. The left window displays the server code with functions `tryConnect` and `Connect`. The middle window shows the client running `tryConnect 20199`. The right window shows the client running `Connect 20199`. The server terminal shows logs for client 20199 connecting and sending messages.

The screenshot shows three terminal windows in Visual Studio Code. The left window displays the server code with functions `tryConnect` and `Connect`. The middle window shows the client running `tryConnect 23219`. The right window shows the client running `Connect 23219`. The server terminal shows logs for client 23219 connecting and sending messages.

- ❖ In the image below, one client exits and the other is allowed to enter commands.

```

berkan@beka: ~/Desktop/midterm/client
berkan@beka:~/Desktop/midterm/client$ ./client tryConnect 8571
argv:tryConnect
try girdi
try message:yes
myfifo:/tmp/8765
send message: /tmp/8765
>> Enter comment : quit

Sending write request to server log file
waiting for logfile ...
logfile write request granted...
bye..
clkttt
berkan@beka:~/Desktop/midterm/client$

berkan@beka:~/Desktop/midterm/client$ ./client tryConnect 8571
argv:tryConnect
try girdi
try message:yes
myfifo:/tmp/8813
send message: /tmp/8813
>> Enter comment : list

..
tmp.txt
8571.log
di
>> Enter comment :

berkan@beka:~/Desktop/midterm/client$ ./client Connect 8571
argv:Connect
myfifo:/tmp/8909
send message: /tmp/8909
>> Enter comment :

berkan@beka:~/Desktop/midterm/server$ gcc -o server server.c
berkan@beka:~/Desktop/midterm/server$ ./server /home/berkan/Desktop/midterm/test 3
>> waiting for clients...
>> Server Started PID:8571
Directory: /home/berkan/Desktop/midterm/test
Max Client Count:3
client message:/tmp/8701try
Semafor Value:3
client message:/tmp/8701
Semafor Value:3
>> Client PID 8571 connected as client01

```

- ❖ Tread Code Sinnipet  
thread pool

```

int threadNum = atoi(argv[3]);
pthread_t threadpool[threadNum]; // thread num;
printf("Thread Pool Size:%d",threadNum);

```

- ❖ Every client connecto one thread. Below image is Thread fun

```

void *ThreadFunction(void *arguments) {

    arg_struct* args = (arg_struct*)arguments;
    char childFifo[100] ="";
    char tmp[100] ="";

```

- ❖ If the semaphore is available, a thread is created. If not, it waits for the other clients to exit. Then it creates a thread. The thread starts running.

```

write(logfd, waiting for critical region\n",strlen( waiting for critical region\n ));

sem_wait(semaphore);
write(logfd,"Enter Critical Region\n",strlen("Enter Critical Region\n"));
childCount++;

printf(">> Client PID %s connected as client0%d\n",pidSrt,childCount);
close(fd);

pthread_create(&threadpool[threadCounter++], NULL, ThreadFunction, (void*)&args);

//pthread_join(threadpool[threadCounter++], NULL);

```

3) display the list of possible client requests

```
berkan@beko: ~/Desktop/midterm/client
argv:tryConnect
try girdl
try message:yes
myfifo:/tmp/8765
send message: /tmp/8765
>> Enter comment : quit

Sending write request to server log file
waiting for logfile ...
logfile write request granted...
bye..
ciktll
berkan@beko: ~/Desktop/midterm/client$

berkan@beko: ~/Desktop/midterm/client$ ./client tryConnect 8571
argv:tryConnect
try girdl
try message:yes
myfifo:/tmp/8813
send message: /tmp/8813
>> Enter comment : list

..
tmp.txt
..
8571.log
..
>> Enter comment : help

Available comments are :
help, list, readF, writeF, upload, download, quit, killServer
>> Enter comment :

berkan@beko: ~/Desktop/midterm/client$ ./client Connect 8571
argv:Connect
try girdl
try message:no
Que is full
berkan@beko: ~/Desktop/midterm/client$ ./client Connect 8571
argv:Connect
myfifo:/tmp/8909
send message: /tmp/8909
>> Enter comment : list

..
tmp.txt
..
8571.log
>> Enter comment :

berkan@beko: ~/Desktop/midterm/client$
```

❖ The visuals of how the commands work.

```
berkan@beko: ~/Desktop/midterm/client
argv:tryConnect
try girdl
try message:yes
myfifo:/tmp/8701
send message: /tmp/8701
>> Enter comment :

berkan@beko: ~/Desktop/midterm/client$ ./client Connect 8571
argv:Connect
myfifo:/tmp/9617
send message: /tmp/9617
>> Enter comment : help list

list
sends a request to display the list of files in Servers directory.
>> Enter comment : help readF

readF <file> <line #>
display the #th line of the <file>, returns with an
error if <file> does not exists
>> Enter comment : help upload

upload <file>
uploads the file from the current working directory of client to the Servers directory (beware of the cases no file in clients current
working directory and file with the same name on Servers side)
>> Enter comment : help writeF

writeF <file> <line #> <string>
request to write the content of "string" to the #th line the <file>, if the line # is not given writes to the end of file. If the file
es not exists in Servers directory creates and edits the file at the same time
>> Enter comment :

berkan@beko: ~/Desktop/midterm/client$
```



4) Show the files in the directory when the 'list' command is given.

```
berkan@beka: ~/Desktop/midterm/client
argvi:tryConnect
try girdl
try message:yes
myfifo:/tmp/8765
send message: /tmp/8765
>> Enter comment : quit

Sending write request to server log file
waiting for logfile ...
logfile write request granted...
bye...
ciktli
berkan@beka:~/Desktop/midterm/client$

berkan@beka:~/Desktop/midterm/client$ ./client tryConnect 8571
argvi:tryConnect
try girdl
try message:yes
myfifo:/tmp/8813
send message: /tmp/8813
>> Enter comment : list
..
tmp.txt
8571.log
>> Enter comment :

berkan@beka:~/Desktop/midterm/client$ ./client Connect 8571
argvi:Connect
myfifo:/tmp/8909
send message: /tmp/8909
>> Enter comment : list
..
tmp.txt
8571.log
>> Enter comment :

int main(int argc, char *argv[]) {
    int fd;
    // Fifo file path
    char myfifo[100] = "";
    char arr[80] = "";
    char slash[100] = "/";
    int rchildPid;
```

File Explorer:

- 64186.log
- 64471.log
- 64564.log
- 64653.log
- berkan.txt
- deneme.txt
- serv
- server
- server.c
- tmp.txt
- tmp7.txt
- test
- 8571.log
- tmp.txt

Terminal Output:

```
berkan@beka:~/Desktop/midterm/client$ gcc -o client client.c
berkan@beka:~/Desktop/midterm/client$ ./client tryConnect 8571
argvi:tryConnect
try girdl
try message:yes
myfifo:/tmp/8701
send message: /tmp/8701
>> Enter comment :
```

5) Requests to display the # line of the <file>, if no line number is given the whole contents of the file is requested (and displayed on the client side)

**readF <file> <line #>**

❖ The result without giving a number.

```
client.c
test > tmp.txt
1 berkan
2 manisa
3 ahmet
4 123
5 gebze
6 turgutlu

server.c
berkan@beko: ~/Desktop/midterm/client
myfifo:/tmp/8813
send message: /tmp/8813
>> Enter comment : list

..
tmp.txt
..
8571.log

>> Enter comment : help

Available comments are :
help, list, readF, writeT, upload, download, quit, killServer
>> Enter comment : readF tmp.txt

readf girdt
berkan
manisa
ahmet
123
gebze
turgutlu

>> Enter comment :

41 char arr[80] = "";
42 char slash[100] = "/";
43 int childPid;
```

**Note:** Data cannot be fetched by giving a line number.

6) Request to write the content of “string” to the #th line the <file>, if the line # is not given writes to the end of file. If the file does not exists in Servers directory creates and edits the file at the same time.

writeT <file> <line #> <string>

❖ The word 'ahmet' in the 3rd line has been replaced with the word 'gtu'.

```
client.c
test > tmp.txt
1 berkan
2 manisa
3 gtu
4 123
5 gebze
6 turgutlu

server.c
berkan@beko: ~/Desktop/midterm/client
>> Enter comment : readF tmp.txt

readf girdt
berkan
manisa
ahmet
123
gebze
turgutlu

>> Enter comment : readF tmp.txt 3

readf girdt
berkan
manisa
ahmet
123
gebze
turgutlu
ahmet

>> Enter comment : writeT tmp.txt 3 gtu

Printed file>> Enter comment :

41 char arr[80] = "";
42 char slash[100] = "/";
43 int childPid;
```

❖ When there is no file, a file is created. "When a file is opened, another process cannot perform operations on the same file. The file has been locked with a **File Lock**.

```

// if file does not exist, create it and write to it
file = fopen(filename, "w");
fprintf(file, "%s\n", newLine);
} else {
    lock.l_type = F_WRLCK; /* Yazma kilidi */
    lock.l_whence = SEEK_SET; /* Başlangıçtan itibaren */
    lock.l_start = 0; /* Başlangıç offset */
    lock.l_len = 0;
    if (fcntl(fd, F_SETLK, &lock) == -1) {
        perror("fcntl");
    }

    while (fgets(line, sizeof(line), file) != NULL) {
        if (count == lineNumber) {
            // change line
            strcat(temp, newLine);
            strcat(temp, "\n");
        } else {
            // keep line
            strcat(temp, line);
        }
        count++;
    }
    if (lineNumber < 0 || lineNumber >= count) {
        // add line to the end
        strcat(temp, newLine);
        strcat(temp, "\n");
    }
}

```

**Not:** When no number is given, it doesn't write to the end of the file.

7) Uploads the file from the current working directory of client to the Servers directory (beware of the cases no file in clients current working directory and file with the same name on Servers side)  
upload <file>

❖ As seen in the first situation, the test directory is empty.

```
File Edit Selection View Go Run Terminal Help
EXPLORER
  MIDTERM
    launch.json
    client
    client.c
    client.c
    deneme.txt
    tmp.txt
    tmp2.txt
    server
    log
    berkan.txt
    deneme.txt
    serv
    server
    server.c
    server.c
    tmp.txt
    tmp2.txt
    8571.log
    berkan.txt
  OUTLINE
  TIMELINE

client.c
client.c
1 berkan
2 manisa
3 ahmet
4 123
5 gebze
6 turgutlu
7

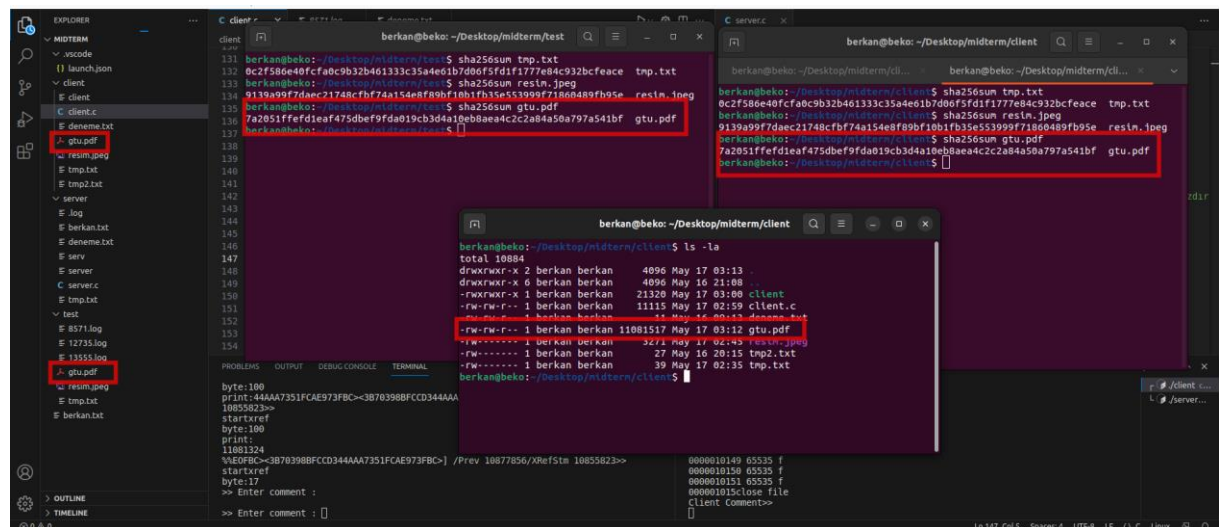
server.c
server.c
291
292 write(readfd, fileStr, strlen(fileStr) + 1);
293 fclose(file);
294
295 void writef(char* filename, int lineNumber, char* newLine) {
296 FILE* file;
297 int fd;
298 char line[256];
299 int count = 1;
300 struct flock lock;
301 file = fopen(filename, "r+");
302 fd = fileno(file);
303 if (file == NULL) {
304 // if file does not exist, create it and write to it
305 fprintf(file, "%s\n", newLine);
306 } else {
307 lock.l_type = F_WRLCK; /* Yazma kilidi */
308 lock.l_whence = SEEK_SET; /* Başlangıçtan itibaren */
309 lock.l_start = 0; /* Başlangıç offset */
310 lock.l_len = 0;
311 if (fcntl(fd, F_SETLK, &lock) == -1) {
312 perror("fcntl");
313 }
314 }
```

❖ When looked at with the 'list' command in the command line, the tmp.txt file does not appear at first. After running the 'upload tmp.txt' command and then running the 'list' command, it can be seen that the tmp.txt file has been created under the test directory.

```
client.c
client.c
1 berkan
2 manisa
3 ahmet
4 123
5 gebze
6 turgutlu
7

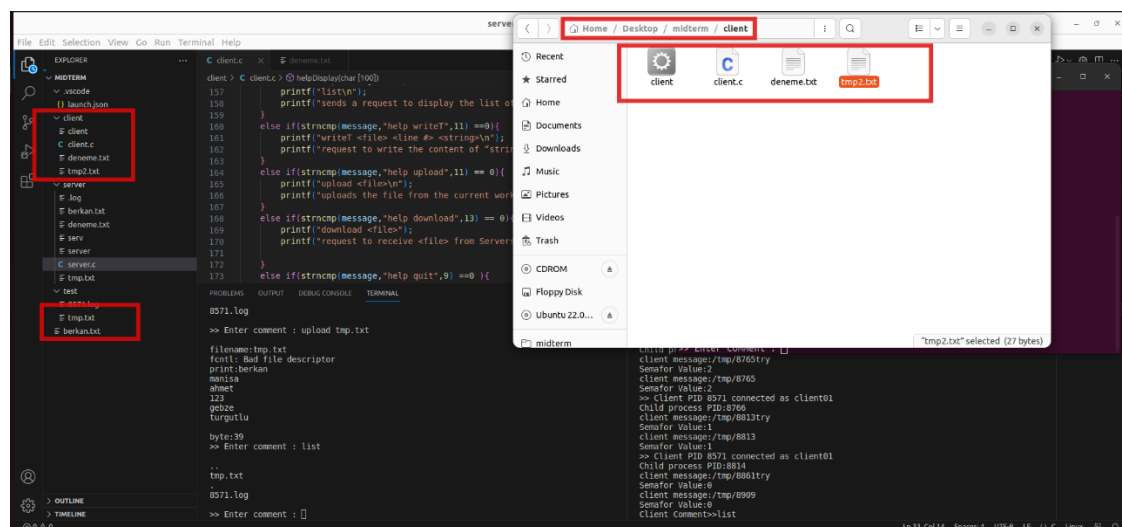
server.c
server.c
291
292 write(readfd, fileStr, strlen(fileStr) + 1);
293 fclose(file);
294
295 void writef(char* filename, int lineNumber, char* newLine) {
296 FILE* file;
297 int fd;
298 char line[256];
299 int count = 1;
300 struct flock lock;
301 file = fopen(filename, "r+");
302 fd = fileno(file);
303 if (file == NULL) {
304 // if file does not exist, create it and write to it
305 fprintf(file, "%s\n", newLine);
306 } else {
307 lock.l_type = F_WRLCK; /* Yazma kilidi */
308 lock.l_whence = SEEK_SET; /* Başlangıçtan itibaren */
309 lock.l_start = 0; /* Başlangıç offset */
310 lock.l_len = 0;
311 if (fcntl(fd, F_SETLK, &lock) == -1) {
312 perror("fcntl");
313 }
314 }
```

- ❖ We were able to copy a 10MB file with 'upload', and after conducting a hash check, we confirmed it's the same file.



## 7) Request to receive <file> from Servers directory to client side. **download <file>**

- ❖ It appears that there is a tmp.txt in the directory where the client is running. In the next image, we will copy the tmp.txt file from the test directory to the client directory with the 'download' command.

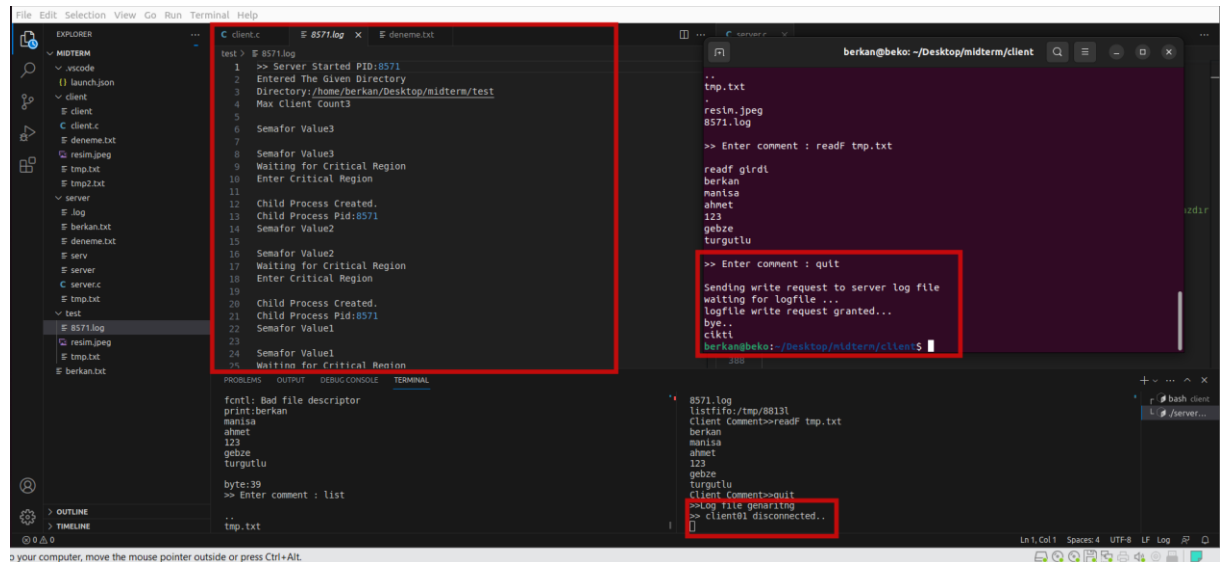


- ❖ The download was successfully received. The tmp.txt file was created in the client directory.



8) Send write request to Server side log file and quits.  
quit

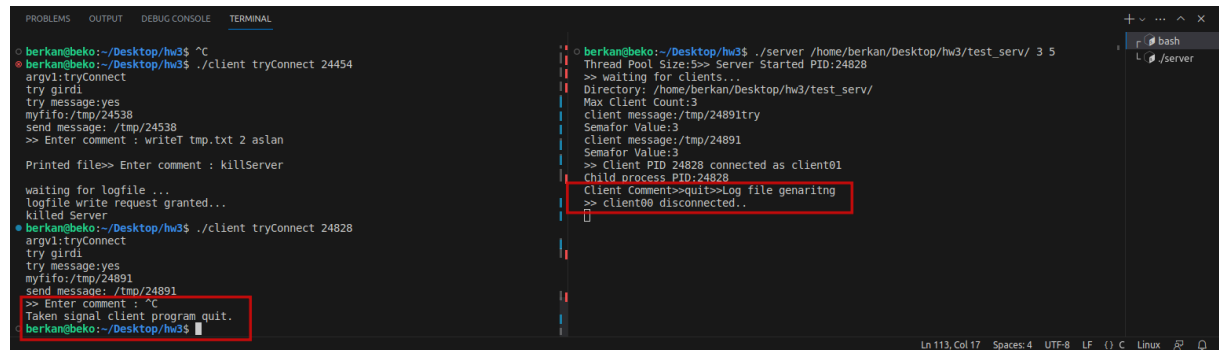
- ❖ The 'quit' command was given to the client and the connection with the server was terminated. After the connection was severed, the semaphore was incremented by one.



```
client.c
1 >> Server Started PID:8571
2 Entered The Given Directory
3 Directory:/home/berkan/Desktop/midterm/test
4 Max Client Count3
5
6 Semaphore Value3
7
8 Semaphore Value3
9 Waiting for Critical Region
10 Enter Critical Region
11
12 Child Process Created.
13 Child Process Pid:8571
14 Semaphore Value2
15
16 Semaphore Value2
17 Waiting for Critical Region
18 Enter Critical Region
19
20 Child Process Created.
21 Child Process Pid:8571
22 Semaphore Value1
23
24 Semaphore Value1
25 Waiting for Critical Region

server.c
1 listfifo:/tmp/8571
2 Client Comment>readf tmp.txt
3
4
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6
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```

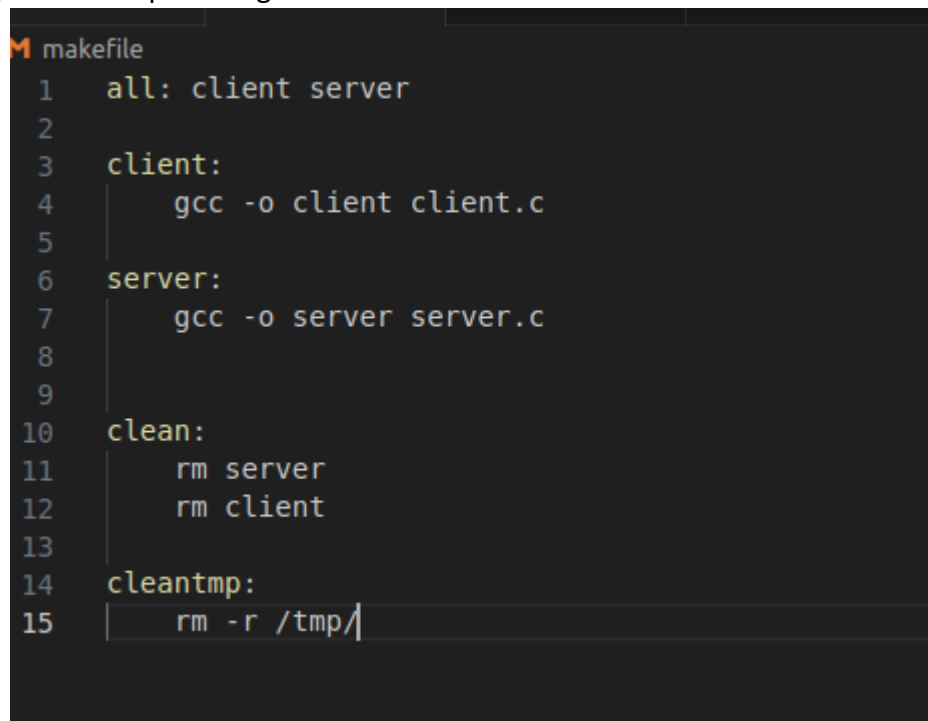
- ❖ The client stopped itself when it received the Ctrl+C signal. The server, on the other hand, disconnected its connection.



```
berkan@beko:~/Desktop/hw3$ ^C
berkan@beko:~/Desktop/hw3$ ./client tryConnect 24454
argv1:tryConnect
try girdi
try message:yes
myifo:/tmp/24538
send message: /tmp/24538
>> Enter comment : writeT tmp.txt 2 aslan
Printed file>> Enter comment : killServer
waiting for logfile ...
logfile write request granted...
Killed Server
berkan@beko:~/Desktop/hw3$ ./client tryConnect 24828
argv1:tryConnect
try girdi
try message:yes
myifo:/tmp/24891
send message: /tmp/24891
>> Enter comment : ^C
Taken signal client program quit.
berkan@beko:~/Desktop/hw3$

berkan@beko:~/Desktop/hw3$ ./server /home/berkan/Desktop/hw3/test_serv/ 3 5
Thread Pool Size:5>> Server Started PID:24828
>> waiting for clients...
Directory: /home/berkan/Desktop/hw3/test_serv/
Max Client Count:3
client message:/tmp/24891try
Semafor Value:3
client message:/tmp/24891
Semafor Value:3
>> Client PID 24828 connected as client01
Child process PID:24828
Client Comment->quit>>Log file genaritng
>> client00 disconnected..
```

10) File cleanup is being done with the makefile.



```
makefile
1 all: client server
2
3 client:
4     gcc -o client client.c
5
6 server:
7     gcc -o server server.c
8
9
10 clean:
11     rm server
12     rm client
13
14 cleantmp:
15     rm -r /tmp/
```

11)

## Summary

Unfulfilled requirements are noted under the respective items. File transfers with a 10MB file have been successfully performed using 'download' and 'upload'. Files have been examined through their hash values. Using semaphores, clients have been put in a queue. After one client closes, the next client in the queue starts working. The functioning of the program is demonstrated in the images above.



**Not:** You need to press enter twice after each input. (If the client cannot connect to the server, try again. Buffurı temizlemek için her input sonrası 2 kere enterı tıklayın. Client servera bağlanmazsa tekrar deneyince bağlanıyor.)