# System Programming
# Homework 4 Report
# Spring 2023

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# Client Side

## Functions

The main function accepts two arguments: the first argument specifies whether the client wants to connect or try to connect to the server, and the second argument is the process ID of the server.

**void generateRequest(char* buffer)**: This function is used to generate a Request structure based on the user's input. It creates a Request structure using malloc() and sets the pid, payloadSize, payload, and type fields based on the user's input. It uses strtok() to tokenize the user's input and extract the necessary information.

**int createFifo(int pid)**: This function is used to create a named pipe (FIFO) for inter-process communication. It takes the process ID as input and generates a FIFO path based on the ID. It then creates the FIFO using mkfifo() and sets the appropriate permissions.

**int isValidRequest(Request *req)**: This function checks whether a Request structure is valid or not. It returns 0 if the type field of the Request is empty and 1 otherwise.

**void sigint_handler(int signum)**: This function is very similar to the sigint_handler function on the server side. It is used to handle SIGINT signals. When the user presses Ctrl+C on the terminal it sends a message to the server, the server disconnects the client and the client process gets terminated.

The main function first checks whether the arguments are valid or not. If they are, it creates a named pipe for the client and sends a Connect or tryConnect request to the server, depending on the first argument. It then waits for a response from the server and prints the result. If the response is **CONNECTION_ESTABLISHED**, it means that the client has successfully connected to the server. If the response is anything else, it means that the server was unable to establish a connection with the client.

Finally, the main function reads commands from the user and sends them to the server using named pipes. It then waits for a response from the server and prints it. If the response is **ERROR**, it means that the server was unable to process the command. If the response is anything else, it means that the server has successfully processed the command.

# Server Side

## Global Variables

**parent_pid**: A global variable of type pid_t that stores the process ID of the parent process.
**rootAddress**: A character array of size 256 that stores the path to the server directory.
**requestQueue**: An array of requests sent by the clients.
**requestQueueCounter**: Size of the requestQueue
**clients**: An array of clients. Servers saves the connected clients into this array
**clientsCounter**: Size of the clients array
**totalCounter**: Number of clients connected to user since the server's initialization
**clientsQueue**: An array of clients. If a client wants to connect to the server but if the capacity is full, they are saved in this array
**clientsQueueCounter**: Size of the clientsQueue

## Functions

**void writeLog(char* message)**: This function is used to write log messages to a log file named "logfile.txt". It takes a string message as input and writes it to the log file. The function also implements file locking using the flock() function to prevent concurrent writes to the log file.

**void sigint_handler(int signum)**: This function is a signal handler for the SIGINT signal, which is sent to the process when the user presses Ctrl+C. The function sends the SIGTERM signal to all child processes and exits the parent process.

**void server_send(int pid, char* message)**: This function is used to send a response message to a client through a FIFO (named pipe). It takes a process id and a string message as input. It creates a FIFO with a name that includes the process ID of the client and writes the message to the FIFO.

**char* getManualText(Request req)**: This function returns a help message based on the client's request. It takes a Request structure as input and returns a string message. If the payloadSize is 0, it returns a list of available commands. Otherwise, it returns a description of the specified command.

**void printManual(Request req)**: This function is used to print the help message to the client. It takes a Request structure as input, retrieves the help message using the getManualText() function, and sends it to the client using server_send() function.

**void printListOfFiles(Request req)**: This function is used to retrieve the list of files in the server directory and send it to the client. It takes a Request structure as input and retrieves the list of files using the "ls" command. It then sends the list to the client using server_send() function.

**bool isNumber(char *number)**: This function returns true if the given input is numeric else returns false

**void readFileLine(Request req, int target)**: This function reads a file from the server's file system and sends its contents back to the client through a named pipe (FIFO). It creates a child process to execute the cat command and redirects its output to the named pipe. It waits for the child process to finish executing before returning. The function also uses file locking to ensure only one process writes to the named pipe at a time.

**void writeFileEOF(Request req)**: This function appends the text specified in the req.payload[1] argument to the end of the file specified in req.payload[0]. It also uses a named pipe to send a response to the client. The function uses file locking to prevent multiple processes from writing to the same file simultaneously.

**void writeFileLine(Request req)**: This function is used to write data to a specific line in a file. The function takes in a Request object that contains information about the file path, the line number, and the data to be written. The function opens the file, reads each line, and writes the data to the specified line number. The function also uses file locking to ensure that no other process can access the file while it is being modified. Finally, the original file is deleted, and the temporary file is renamed to the original file name.

**void downloadFile(Request req)**: This function is used to download a file from the server. First client sends a download request, the server accepts this request and starts sending packages to the client in 1kb of chunks. Client takes these packages and writes them to the requested file.

**void uploadFile(Request req)**: This function is used to upload a file to the server. It's basically the opposite of upload. In this case the client sends those packages and the server writes them to the server's directory.

**char* getProcessName(int pid)**: This function is used to retrieve the name of a process given its process ID (pid). The function takes in an integer pid, an array of client processes clients, the number of clients clientsCounter, and two semaphores clients_sem and clientsCounter_sem. The function searches through the clients array to find the client process with the given pid and returns its name.

**void clientQuit(Request req)**: This function is used to handle a client quitting the server. The function takes in a Request object that contains information about the quitting client. The function removes the quitting client from the clients array and sends a success message to the client. The function also logs the client's quitting event and updates the number of clients in the clientsCounter variable. The function uses three semaphores to ensure that the critical section of code is executed atomically and avoids race conditions.

**void handleRequest(Request req)**: This function is used to handle a client request. The function takes in a Request object, the number of clients clientsCounter, an array of client processes clients, and three semaphores clients_sem, clientsCounter_sem, and isAvailable_sem. The function first checks the type of the request and calls the appropriate function to handle the request. If the request is not recognized, the function sends an error message to the client. The function uses semaphores to ensure that the critical section of code is executed atomically and avoids race conditions.

In the main function **fd, fdClient, and fdLog** variables are file descriptors for the server, client, and log files, respectively. The clients variable is a two-dimensional integer array that stores information about the connected clients.

The **rootAddress** variable is a string that represents the root directory of the server. If the first command-line argument is **"Here" or "."**, then the root directory is set to an empty string. Otherwise, the root directory is set to the value of the first command-line argument with a forward slash appended to it.

mkdir function creates a directory with the name specified in rootAddress with read, write, and execute permissions. Also a file called **logfile.txt** is created here. It holds the information of connected and disconnected clients.

**MAX_NUMBER_OF_CLIENTS** is an integer variable that represents the maximum number of clients that can be connected to the server. The value is obtained from the second command-line argument and is converted from a string to an integer using the atoi function.

The **clientsCounter**, **clients**, and **totalCounter** variables are initialized.. clientsCounter is used to keep track of the number of connected clients, clients is an array that stores information about the connected clients id and a counter value, and totalCounter keeps track of the total number of requests processed by the server. This is used to generate a label for the client.

The mutexClients, mutexClientsCounter, mutexClientsQueue and mutexClientsQueueCounter mutexes are initialized. These mutexes are used to prevent race conditions between threads.

It takes the POOL_SIZE as a user input and creates POOL_SIZE number of threads. The pthread_create function uses start_threads as an input.

**start_threads** function:

```
void* startThread(void* arg){
  int t_id = *(int*)arg;
  while(1){
    Request req;
    // ============== CRITICAL REGION ==================== //
    pthread_mutex_lock(&mutexQueue);
    while(requestCounter == 0){
      pthread_cond_wait(&condQueue, &mutexQueue);
    }
    req = requestQueue[0];
    for(int i=0; i<requestCounter-1; i++){
      requestQueue[i] = requestQueue[i+1];
    }
    requestCounter--;
    pthread_mutex_unlock(&mutexQueue);
    // ============== CRITICAL REGION ==================== //
    handleRequest(req);
  }
}
```

It checks if there are some requests in the queue. If not, it starts to wait until a function sends a signal to it. When it finds an available request in the queue it takes it and calls the handleRequest function with this request.

We also have another function for threading and it is called submitRequest.

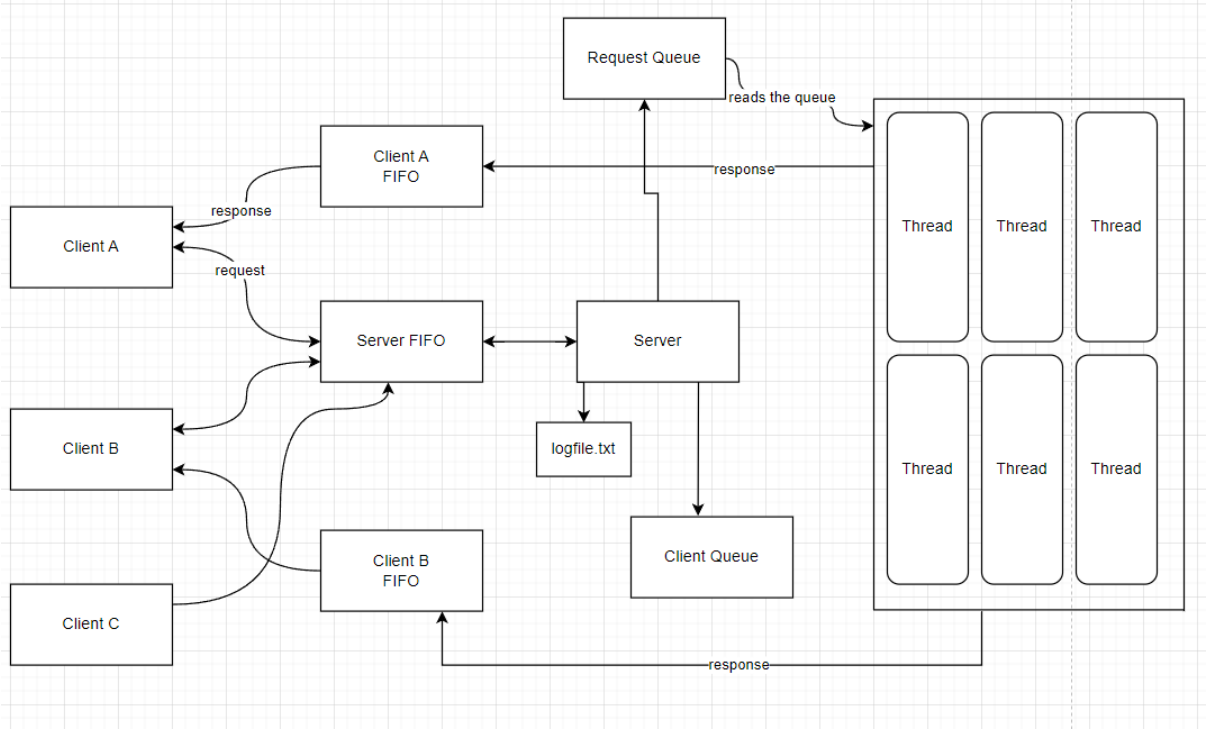
**submitRequest** function:

```
void submitRequest(Request req){
  pthread_mutex_lock(&mutexQueue);
  requestQueue[requestCounter++] = req;
  pthread_mutex_unlock(&mutexQueue);
  pthread_cond_signal(&condQueue);
}
```

It basically takes a request struct and appends it to requestQueue array and signals the **condQueue** conditional variable.

And in the main function of the server, we have a while loop and it reads the server's fifo to get user requests. After that it calls submitRequest function, with this way a thread handles the user request in the meantime the main process can read another process in the main function. **In this way, the system will run multithread**.

# Architecture of my System




This is my system design. A client sends a **Connect** or **tryConnect** request to the server using Server FIFO. Server accepts the requests if it is not out of capacity. If it is out and the request is Connect then servers save the client's process id on clientQueue and when a client quits it takes the first process in the queue and connects it to the system. If the request is tryConnect and the system is out of capacity again, the client simply terminates by prompting the server is out of capacity.

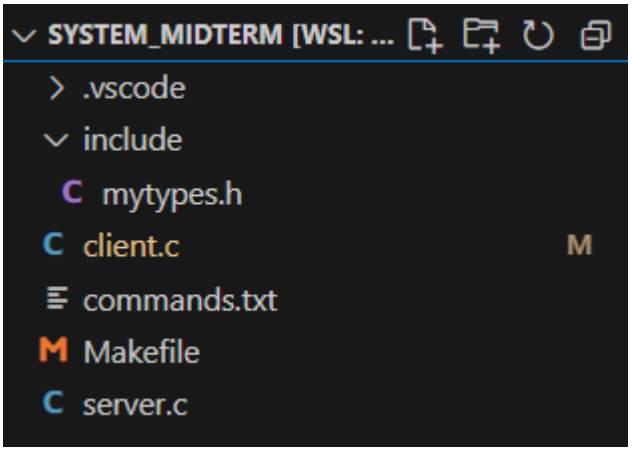
If there is room for the client in the server, the server saves the request to request queue. After that an available thread takes the request, handles it and sends the message back to the clients. But this time it uses the client's fifo.

When a user wants to quit, it sends a quit message to its fifo. Child process takes it and kills itself. When a child process dies, the server decrements the counter by one. When the server gets a killServer, it kills all of its child processes and itself with **raise(SIGINT)** and this code calls **sigint_handler** function.

Server also writes all the Connect, tryConnect and quit requests and the logfile.txt. When the server needs to write that file it first locks it with **flock** function, so no other process can write it at that moment, and unlocks it when it's finished.

# Test Cases

This is the folder structure of my project. mytypes.h contains some macros an a struct named Request and Block




```c
typedef struct Request {
  int pid;
  char type[BUF_SIZE];
  char payload[3][BUF_SIZE];
  int payloadSize;
} Request;
```

Request struct has this shape. pid keeps the process id, type is the type of the request. It can be **Connect, tryConnect, help, list, readF, writeT, upload or download**. payload is the extra parameters. For example if the input is **“help writeT”**, payload becomes **{writeT}** and in that case **payloadSize** becomes 1.

Now I will call **make server** to compile server.c and call **make client** to compile client.c.

```
barisayyildiz@DESKTOP-2V8A48Q:~/system_midterm$ make server
gcc server.c -o biboServer
barisayyildiz@DESKTOP-2V8A48Q:~/system_midterm$
```

```
barisayyildiz@DESKTOP-2V8A48Q:~/system_midterm$ make client
gcc client.c -o biboClient
barisayyildiz@DESKTOP-2V8A48Q:~/system_midterm$
```

I will run the server with the capacity of 2 and with the dirname dir.

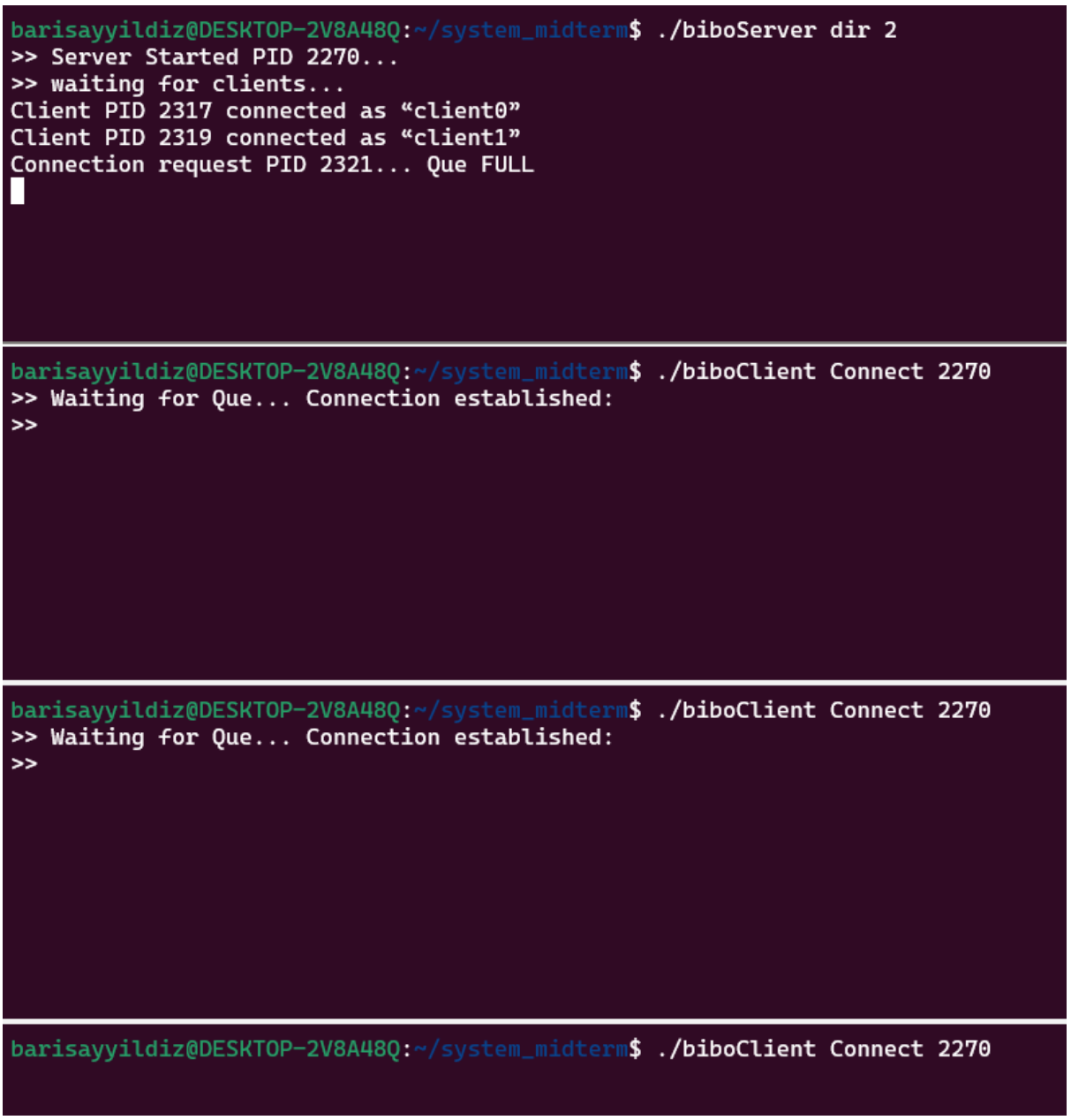
```
barisayyildiz@DESKTOP-2V8A48Q:~/system_midterm$ ./biboServer dir 2
>> Server Started PID 2270...
>> waiting for clients...
```

As you can see server created a directory named dir, its process id is 2270 and it created a fifo file for the server with the format **"biboServer_{PROCESS_ID}"**

```
barisayyildiz@DESKTOP-2V8A48Q:/tmp$ ls -d bibo*
biboServer_2270
barisayyildiz@DESKTOP-2V8A48Q:/tmp$
```

```
barisayyildiz@DESKTOP-2V8A48Q:/tmp$ ps -C biboServer
  PID TTY          TIME CMD
 2270 tty1     00:00:00 biboServer
barisayyildiz@DESKTOP-2V8A48Q:/tmp$
```

Now I will try to create 3 processes:




As you can see two of them successfully connected with the names “**client0**” and “**client1**”. And the third client couldn’t connect because there was no room for it.

And you can see that there are 3 biboServer processes, 1 for the main process and 2 for the children processes. And again we have 2 child processes.

```
barisayyildiz@DESKTOP-2V8A48Q:/tmp$ ps -C biboServer
  PID TTY          TIME CMD
 3070 tty1     00:00:00 biboServer
 3072 tty1     00:00:00 biboServer
 3074 tty1     00:00:00 biboServer
barisayyildiz@DESKTOP-2V8A48Q:/tmp$ ps -C biboClient
  PID TTY          TIME CMD
 3071 tty6     00:00:00 biboClient
 3073 tty2     00:00:00 biboClient
barisayyildiz@DESKTOP-2V8A48Q:/tmp$
```

After that I quit client0

```
barisayyildiz@DESKTOP-2V8A48Q:~/system_midterm$ ./biboServer dir 2
>> Server Started PID 2270...
>> waiting for clients...
Client PID 2317 connected as “client0”
Client PID 2319 connected as “client1”
Connection request PID 2321... Que FULL
client0 disconnected...
Client PID 2321 connected as “client2”
```

```
barisayyildiz@DESKTOP-2V8A48Q:~/system_midterm$ ./biboClient Connect 2270
>> Waiting for Que... Connection established:
>> quit
barisayyildiz@DESKTOP-2V8A48Q:~/system_midterm$
```

```
barisayyildiz@DESKTOP-2V8A48Q:~/system_midterm$ ./biboClient Connect 2270
>> Waiting for Que... Connection established:
>>
```

```
barisayyildiz@DESKTOP-2V8A48Q:~/system_midterm$ ./biboClient Connect 2270
>> Waiting for Que... Connection established:
>>
```

And client2 is connected to the server.

```
barisayyildiz@DESKTOP-2V8A48Q:~/system_midterm$ ./biboServer dir 2
>> Server Started PID 2270...
>> waiting for clients...
Client PID 2317 connected as “client0”
Client PID 2319 connected as “client1”
Connection request PID 2321... Que FULL
client0 disconnected...
Client PID 2321 connected as “client2”
Try Connect request PID 2323... Que FULL... exiting
```

```
barisayyildiz@DESKTOP-2V8A48Q:~/system_midterm$ ./biboClient Connect 2270
>> Waiting for Que... Connection established:
>> quit
barisayyildiz@DESKTOP-2V8A48Q:~/system_midterm$ ./biboClient tryConnect 2270
>> Waiting for Que... server is out of capacity, closing....
barisayyildiz@DESKTOP-2V8A48Q:~/system_midterm$
```

A client used tryConnect but since the server was out of capacity it couldn’t connect and got terminated.

Now let’s test some of the commands

# Commands:

## help

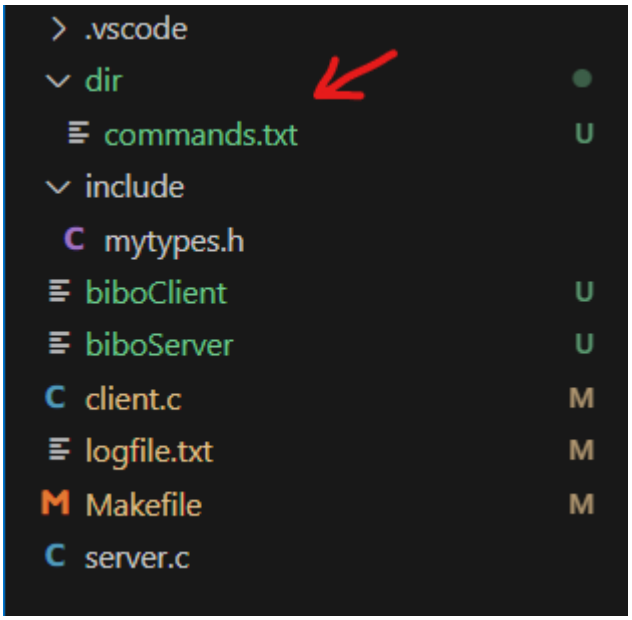
```
>> help

        Available comments are :
                help, list, readF, writeT, upload, download, quit, killServer

>>
```

```
>> help writeT

       writeT <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 does not exists in Servers directory creates and edits the
file at the same time
```

## upload

commands.txt from root directory moved to folder dir

```
>> upload commands.txt

file uploaded successfully

>>
```

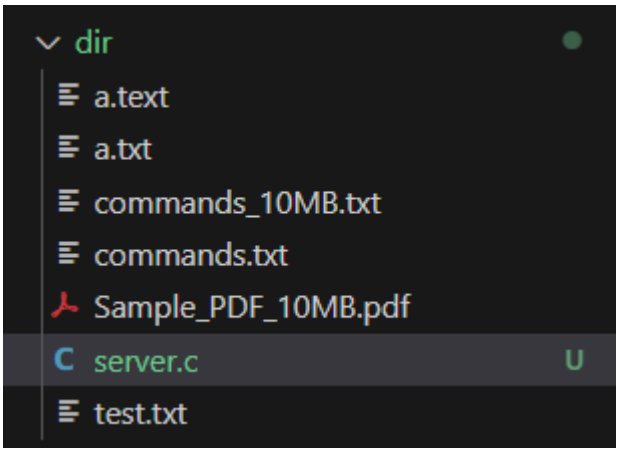



As you can see commands.txt is in directory dir

But for large files, uploaded files get a little corrupted. For example

```
>> upload server.c

file uploaded successfully
>>
```

Server.c under dir directory




And for files that is larger than 10MB

```
-rw-r--r-- 1 barisayyildiz barisayyildiz 11919600 May 16 20:45 commands_10MB.txt
```

```
>> upload commands_10MB.txt

file uploaded successfully
>>
```

You can see that there is no difference

```
barisayyildiz@DESKTOP-2V8A48Q:~/system_hw4$ diff commands_10MB.txt dir/commands_10MB.txt
barisayyildiz@DESKTOP-2V8A48Q:~/system_hw4$
```

readF

```
>> readF commands.txt

help
list
readF <file> <line #>
writeT <file> <line #> <string>
upload <file>
download <file>
quit
killServer
```

```
>> readF commands.txt 3

readF <file> <line #>
```

```
>> readF commands.txt 1000

requested file is smaller than the target size...
>>
```

writeF

```
>> writeT commands.txt helllooooooooo

text appended...
>>
```

dir > commands.txt

```
1  help
2  list
3  readF <file> <line #>
4  writeT <file> <line #> <string>
5  upload <file>
6  download <file>
7  quit
8  killServer
9  hellllooooooooo
```

```
>> writeT commands.txt 3 hellloo_woorrrllddd

text appended...
>>
```

dir > commands.txt

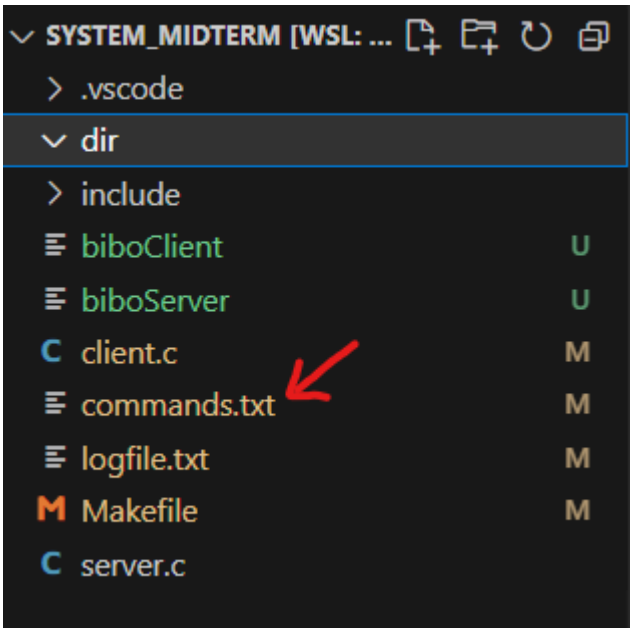
```
1  help
2  list
3  hellloo_woorrrllddd
4  writeT <file> <line #> <string>
5  upload <file>
6  download <file>
7  quit
8  killServer
9  hellllooooooooo
```

list

```
>> list

commands.txt
...
>>
```

download

```
>> download commands.txt

file downloaded successfully

>>
```




commands.txt is back to the root directory.

Now let’s download commands_10MB.txt

```
barisayyildiz@DESKTOP-2V8A48Q:~/system_midterm$ ./biboServer dir 2
>> Server Started PID 18860...
>> waiting for clients...
Client PID 18861 connected as “client0”
Client PID 18863 connected as “client1”
File copied successfully.
File copied successfully.
```

```
>> ^C
barisayyildiz@DESKTOP-2V8A48Q:~/system_midterm$ make client
gcc client.c -o biboClient
barisayyildiz@DESKTOP-2V8A48Q:~/system_midterm$ ./biboClient Connect 18860
>> Waiting for Que... Connection established:
>> download commands2_10MB.txt

file downloaded successfully..

>>
```

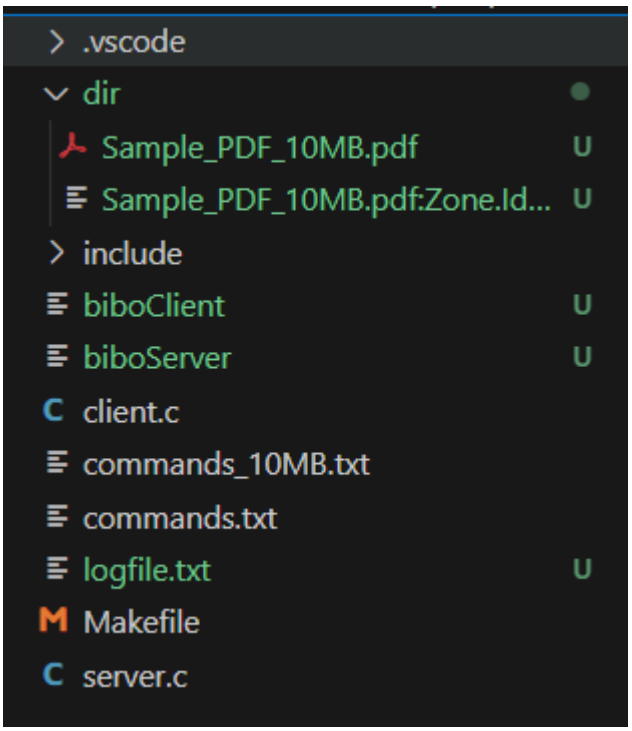
```
file downloaded successfully..

>> ^C
barisayyildiz@DESKTOP-2V8A48Q:~/system_midterm$ ./biboClient Connect 18860
>> Waiting for Que... Connection established:
>> download commands2_10MB.txt

file downloaded successfully..

>>
```

I have downloaded the same file at the same time but since I use file locks, there was no race condition and I was able to download the file without any corruption

Downloaded:

```
barisayyildiz@DESKTOP-2V8A48Q:~/system_hw4$ diff commands_10MB.txt dir/commands_10MB.txt
barisayyildiz@DESKTOP-2V8A48Q:~/system_hw4$
```

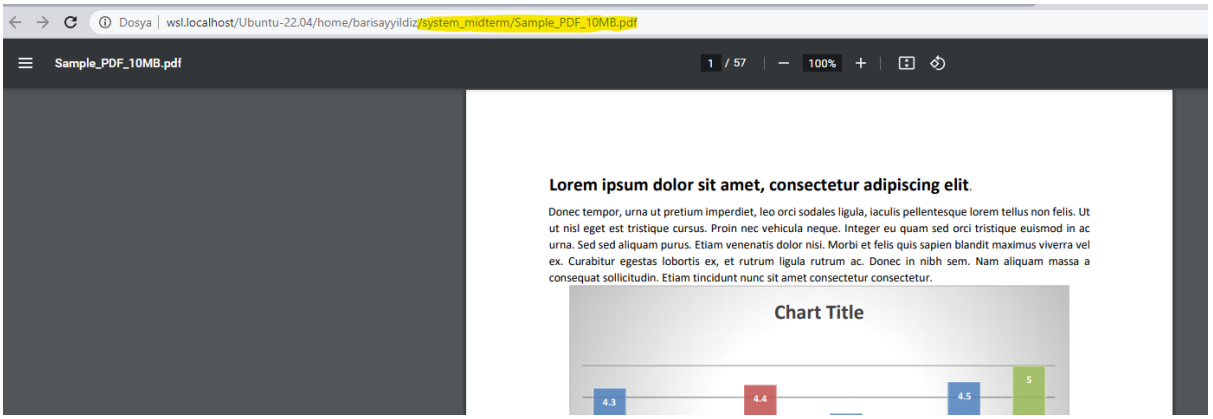
Now let’s download this pdf file




```
barisayyildiz@DESKTOP-2V8A48Q:~/system_midterm$ make server
gcc server.c -o biboServer
barisayyildiz@DESKTOP-2V8A48Q:~/system_midterm$ ./biboServer dir 2
>> Server Started PID 22785...
>> waiting for clients...
Client PID 22793 connected as “client0”
File copied successfully.
```

```
barisayyildiz@DESKTOP-2V8A48Q:~/system_midterm$ make client
gcc client.c -o biboClient
barisayyildiz@DESKTOP-2V8A48Q:~/system_midterm$ ./biboClient Connect 22785
>> Waiting for Que... Connection established:
>> download Sample_PDF_10MB.pdf

file downloaded successfully..

>>
```

As you can see we are able to open the pdf file from the root directory

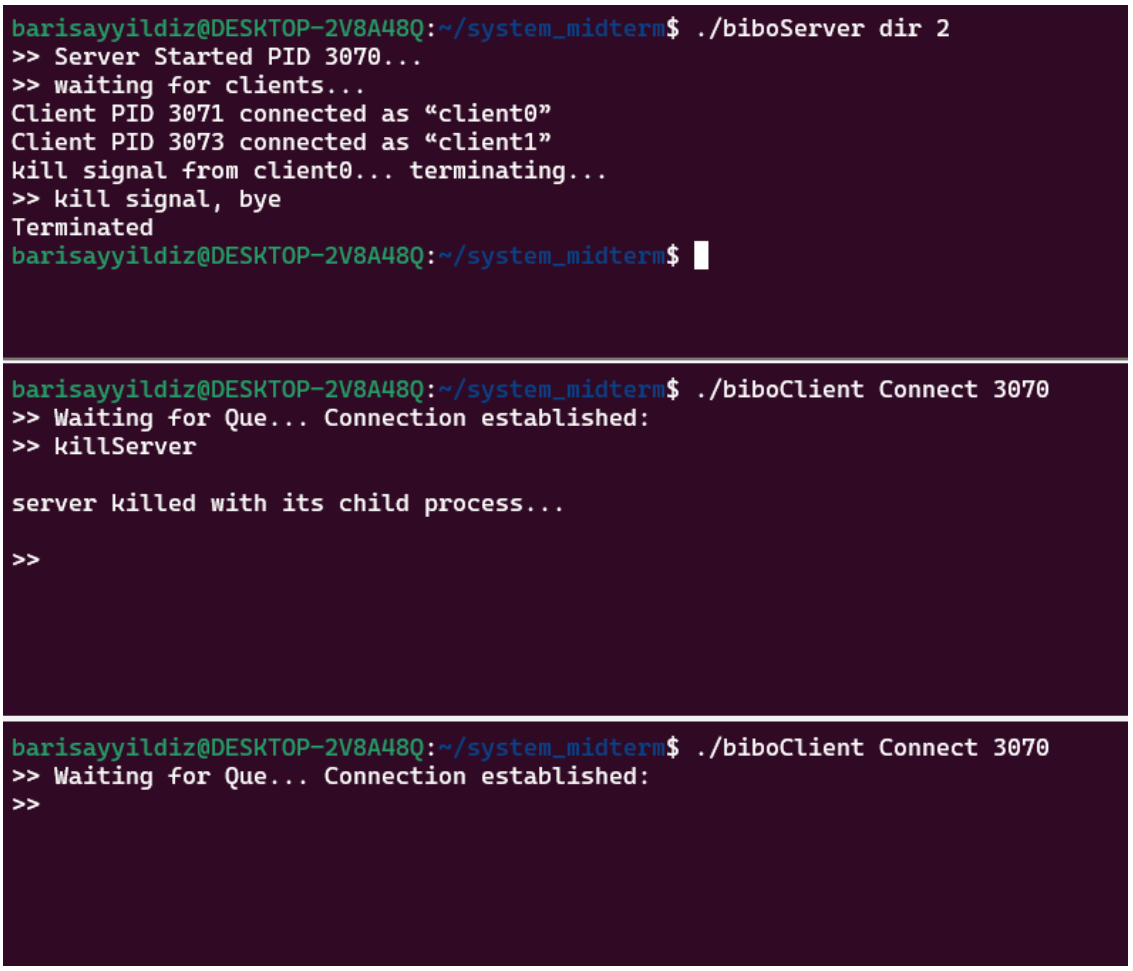



quit

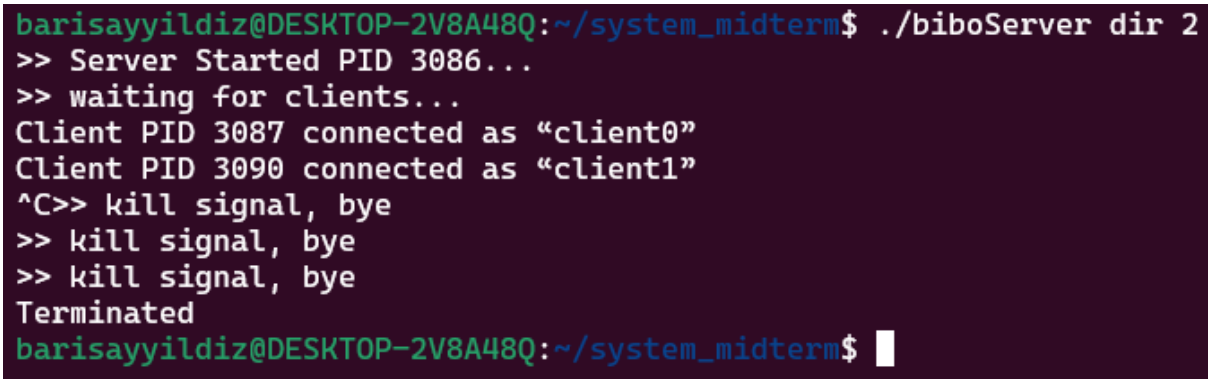
```
barisayyildiz@DESKTOP-2V8A48Q:~/system_midterm$ ./biboServer dir 2
>> Server Started PID 3018...
>> waiting for clients...
Client PID 3019 connected as “client0”
Client PID 3045 connected as “client1”
client1 disconnected...
Client PID 3047 connected as “client2”
client0 disconnected...
```

```
        Available comments are :
                help, list, readF, writeT, upload, download, quit, killServer

>> help

        Available comments are :
                help, list, readF, writeT, upload, download, quit, killServer

>> quit
barisayyildiz@DESKTOP-2V8A48Q:~/system_midterm$
```

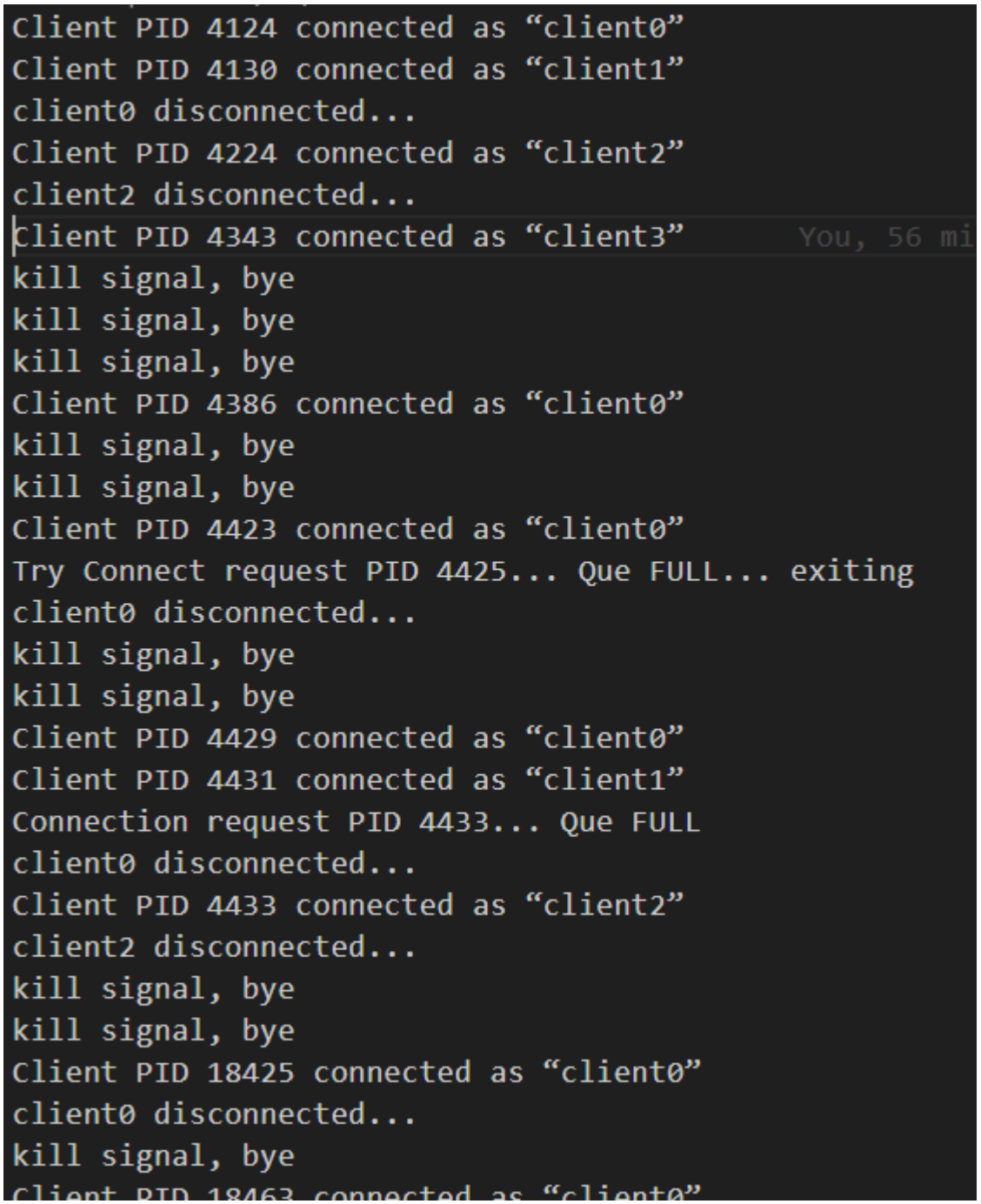
killServer




ctrl+c in server



Logfile




I tried download command with different thread numbers

## With 5 threads:

```
file uploaded successfully
>> upload commands_10MB.txt

file uploaded successfully
>> upload commands_10MB.txt

file uploaded successfully
>> upload commands_10MB.txt

file uploaded successfully
>> upload commands_10MB.txt
```

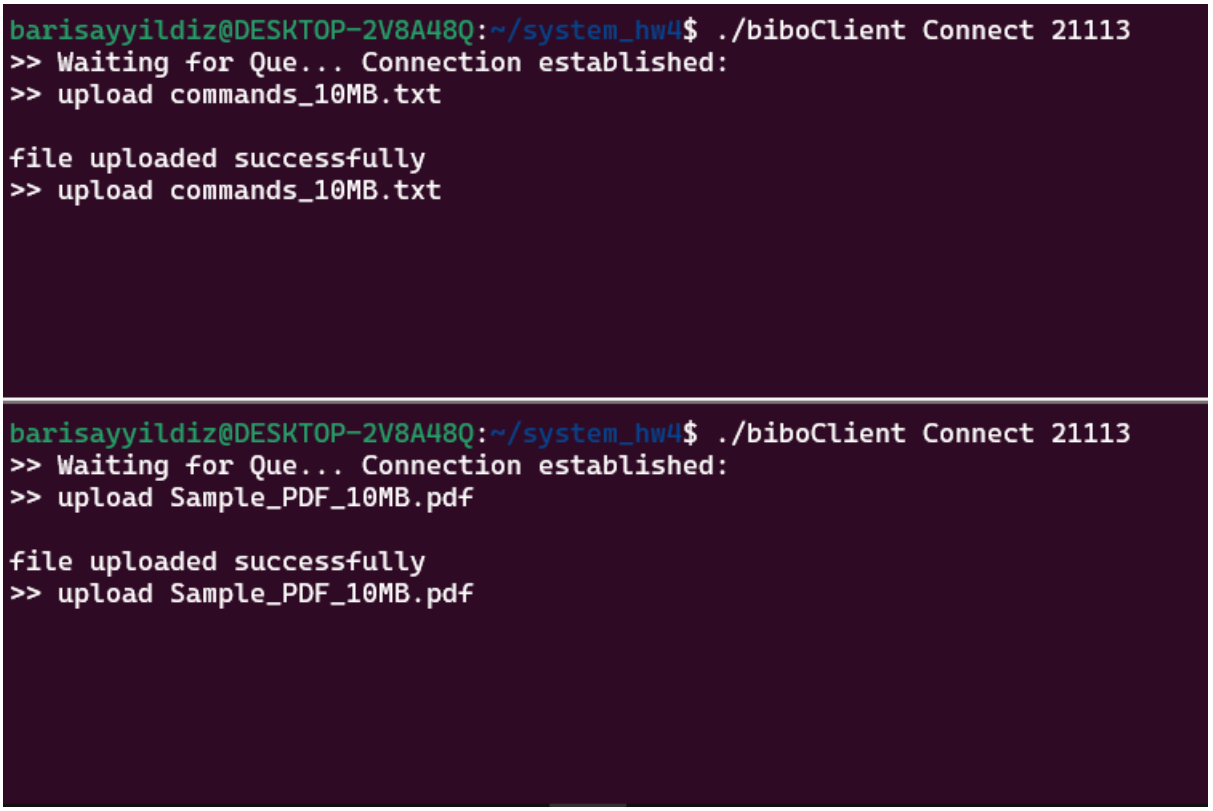
```
barisayyildiz@DESKTOP-2V8A48Q:~/system_hw4$ ./biboClient Connect 20551
>> Waiting for Que... Connection established:
>> upload commands_10MB.txt

file uploaded successfully
>> upload Sample_PDF_10MB.pdf

file uploaded successfully
>> upload Sample_PDF_10MB.pdf
```

With 10 threads:

```
barisayyildiz@DESKTOP-2V8A48Q:~/system_hw4$ ./biboClient Connect 21113
>> Waiting for Que... Connection established:
>> upload commands_10MB.txt
```

```
barisayyildiz@DESKTOP-2V8A48Q:~/system_hw4$ ./biboClient Connect 21113
>> Waiting for Que... Connection established:
>> upload Sample_PDF_10MB.pdf
```

With 20 threads:



# How to run:

make server
	This will create executable biboServer
make client
	This will create executable biboClient
make clear
	This will remove biboServer, biboClient and logfile.txt

./biboServer  <dirname> <max #of client> <poolSize>
./biboClient ServerPID

Example:

./biboServer dir 2 5
./biboServer Here 5 10
./biboServer . 4 20

Here and . will not create a directory for server

./biboClient Connect <PID>
./biboClient tryConnect <PID>