A Secure Person2Person (P2P) Micropayment System w/ OpenSSL User Manual

IM 3010 Programming Assignment: Phase 03 Implementation

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Contents

Introduction

In **Phase 02**, we are asked to implement a server-side program to handle requests sent by clients in the Micropayment System. Functions for a server-side program include *registering*, *login*, *listing*, *transacting*, and *exiting*. Simply start running the program by `./server <SERVER_PORT> <CONCURRENT_USER_LIMIT>` after compilation (which can be done by `make server`).

`CONCURRENT_USER_LIMIT` is completely optional. The maximum is set to the number of concurrent threads supported by the implementation.

The user manual will cover the running environment used when developing the program, the environment that this code could be used in, the usage of the server-side program, the compilation, and the references when doing this assignment.

Environment

macOS

The environment used to develop this project is:

> Operating System: macOS 12.0.1
> CPP Standard: C++17

It means that **you can run this program in a macOS environment** if the program is also compiled in the exact environment.

`C++17` is used to serve the standard library header `filesystem` used when creating/deleting a database file.

I am using `sqlite3` to handle user profiles on *the backend*. By default, `sqlite3` is pre-installed in all versions of macOS[1].

Ubuntu

For the given `server` binary, you can run it on:

> Operating System: Ubuntu 20.04
> CPP Standard: C++17

To compile, **you may need to install some extra dependencies/packages** on your system:

1. Install `sqlite3` (you can see why in the References section)

```
sudo apt install sqlite3
sudo apt-get install libsqlite3-dev
```

2. Install `openssl`

```
sudo apt-get install openssl
```

3. Make sure your GCC version is up-to-date (GCC 9-ish) to support `C++17` (**please ignore this if you did not mess up with your environment**)

```
sudo add-apt-repository ppa:ubuntu-toolchain-r/test
sudo apt update
sudo apt install gcc-9 g++-9
sudo update-alternatives --install /usr/bin/gcc gcc /usr/bin/gcc-9
    60 --slave /usr/bin/g++ g++ /usr/bin/g++-9 # to make sure gcc
   is using the latest version of GCC
```

I am testing out the Linux-formatted `server` binary on Karton from my MacBook. Karton is developed based on Docker containers. The code is also tested on Ubuntu 20.04 virtual box.

Notice that the user interface requires Nerd Fonts to render.

[1] How to install SQLite on macOS

Usage

TL;DR:

```
./server <SERVER_PORT> <[OPTIONAL] CONCURRENT_USER_LIMIT>
```

```
./client <SERVER_IP> <SERVER_PORT>
```

Running Server Program

Before running the `client` program, you have to make sure that the `server` is running. You can start the server on port 8888 and limited to a maximum of three concurrent connected clients by running:

```
./server 8888 3
```

Here is a look of the above command:

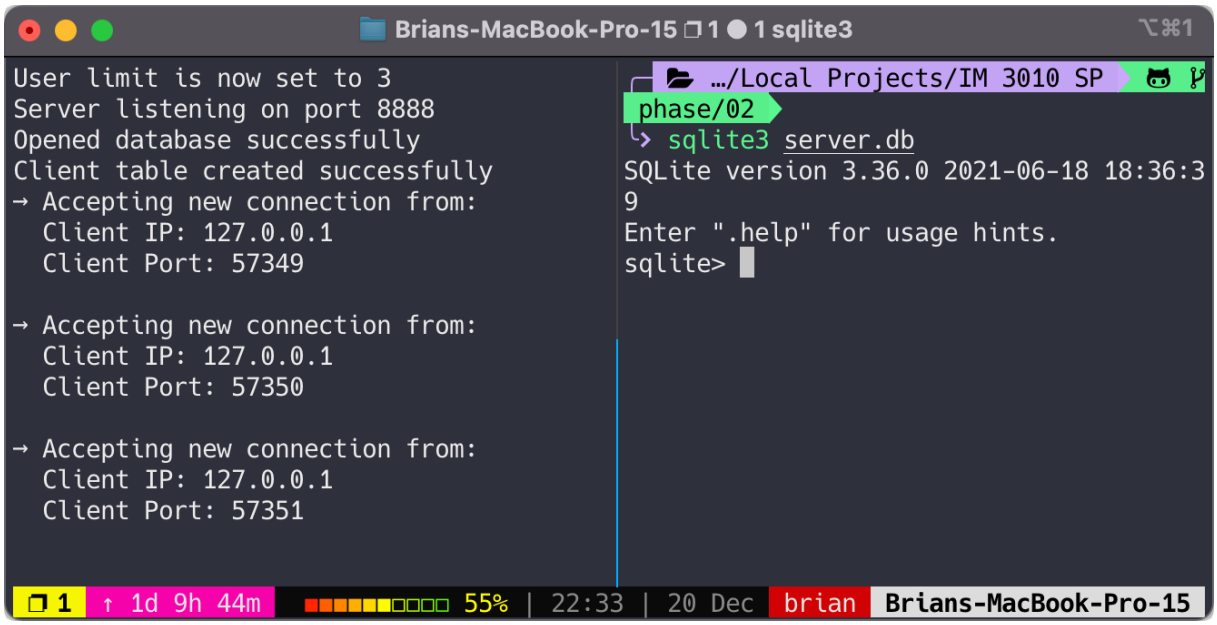
The basic usage is: `./server <SERVER_PORT> <CONCURRENT_USER_LIMIT>`.

And that is simply it. You can have a glimpse of what is going on in the server by peeking into the `server.db` file via `sqlite3` simply by typing in:

```
sqlite3 server.db
```

and you shall get access to the database with a table named `client` that stores all user data, including users' connection states.

So together with `sqlite3`, you will be able to gain access to the database and keep the server running at the same time:

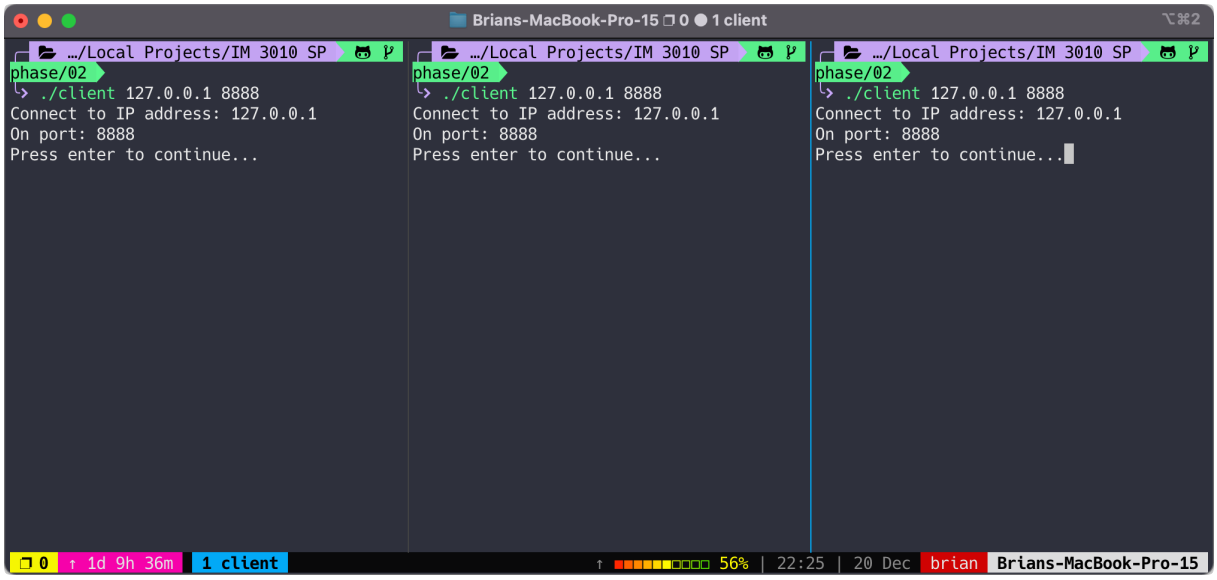


Working Server

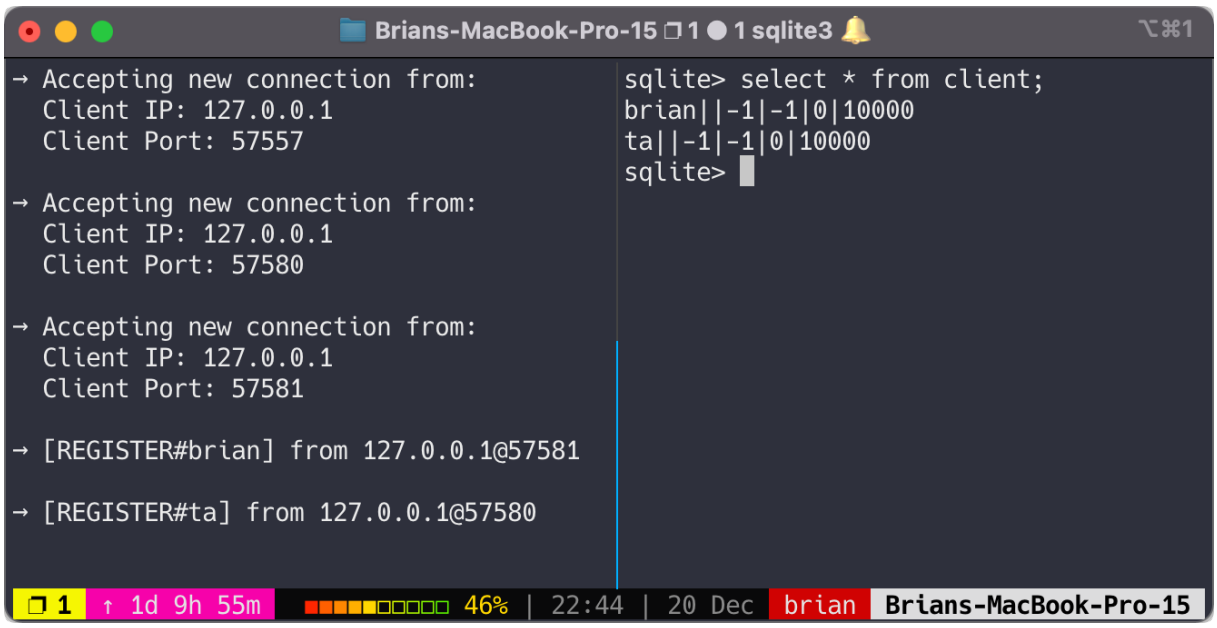
The server will always throw out `[<CLIENT_MSG>] from <CLIENT_PORT>@<CLIENT_PUBLIC_PORT>` when a message is received from a client.

When Clients Connect to Server When a client connects to the server, it will show IP address and port of that client.

The following screenshots show how three clients connect to the server listening on port 8888:

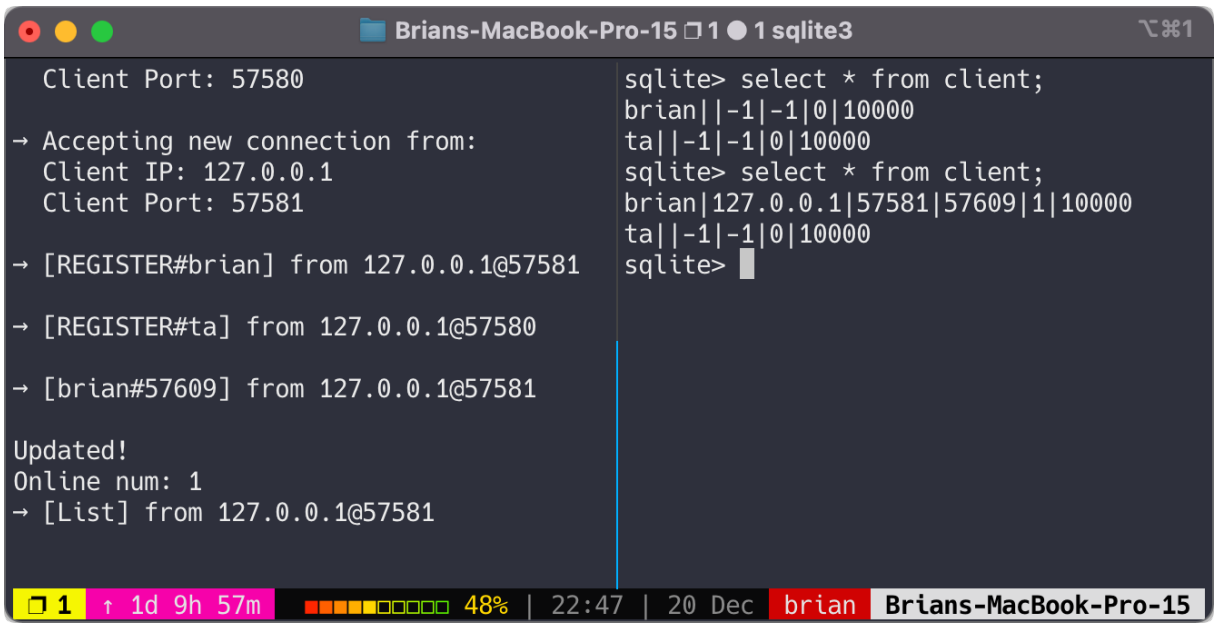


User Registration When a user registers, you shall also see an update directly within the database.



If a user already registered, the server will return `210 FAIL` to the client.

User Login You see that the server recorded IP address, public port, private port (the port specified by the logged in client as shown in `[brian#57609]`).

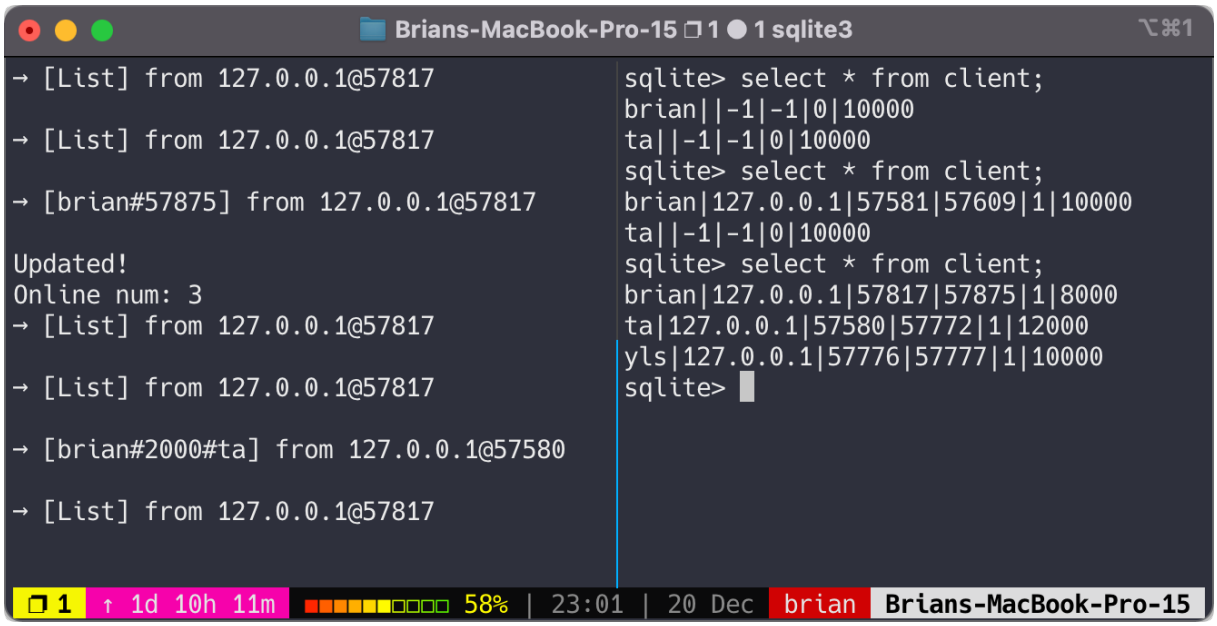


I will log in with three users on three clients in the rest of the demonstration.

Information Listing A user must log in before requesting for system information. A message `Please login first` will be sent to the client if the session is not logged in.

Otherwise, it will show the system information to the user as specified in the assignment specification.

P2P Transaction As can be seen below, the `[brian#2000#ta]` message indicates that user `brian` transfers 2000 dollars to `ta`.

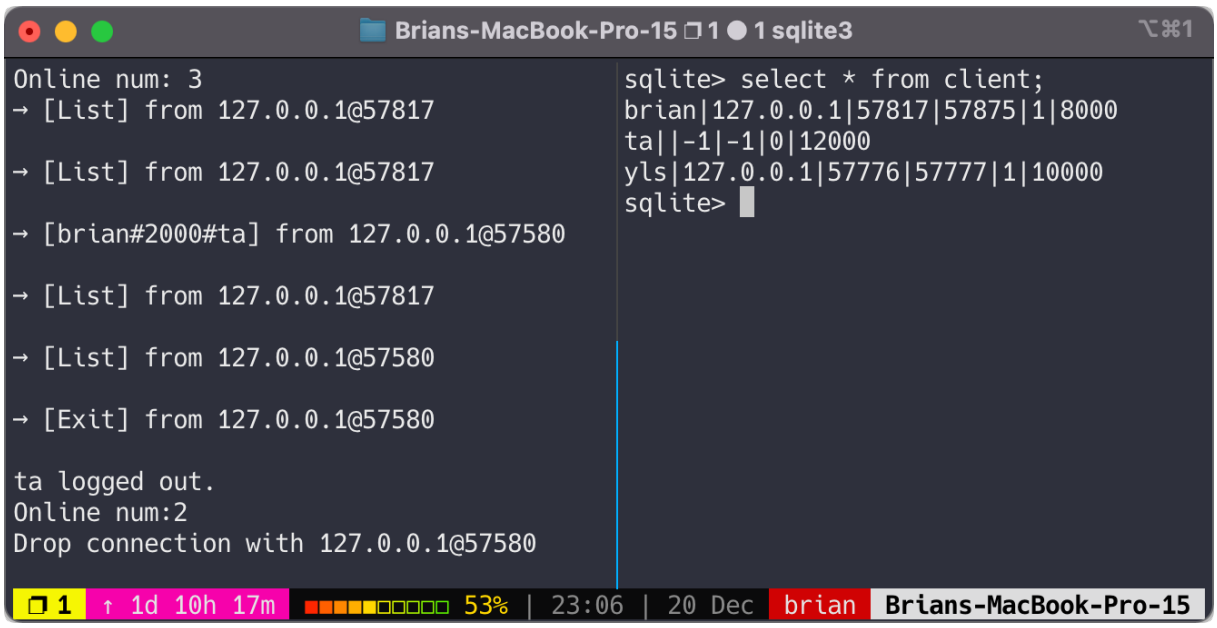


You can also see that the database is updated accordingly.

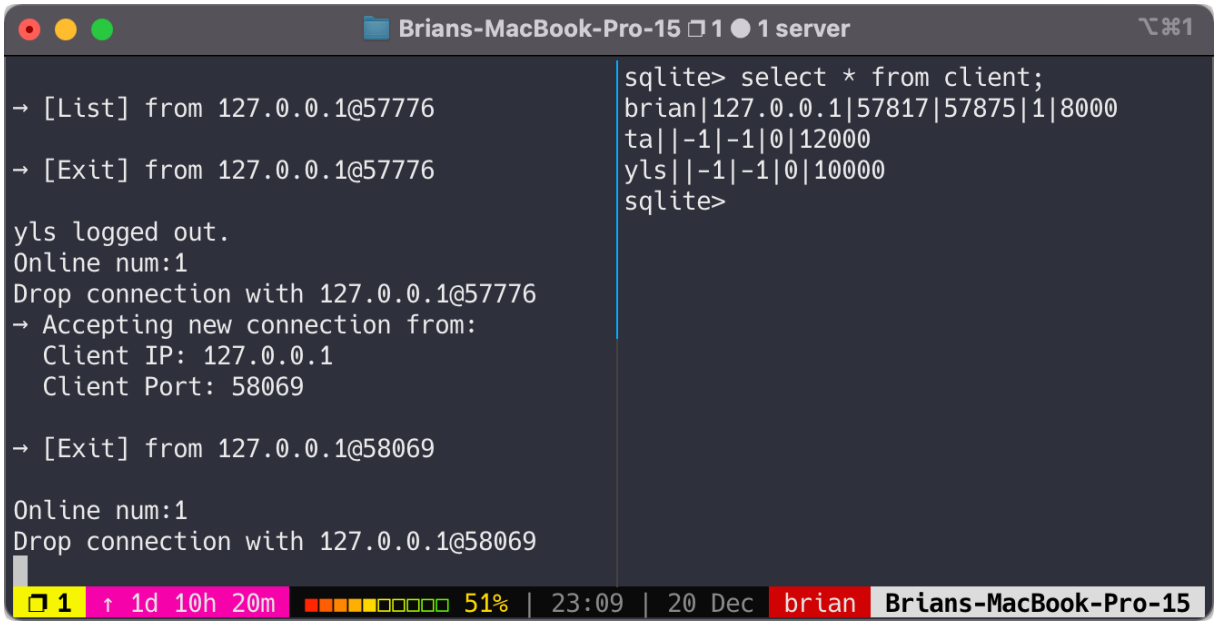
User Logout There might be three cases:

When a user logs out:

The server will prompt *who* logs out.

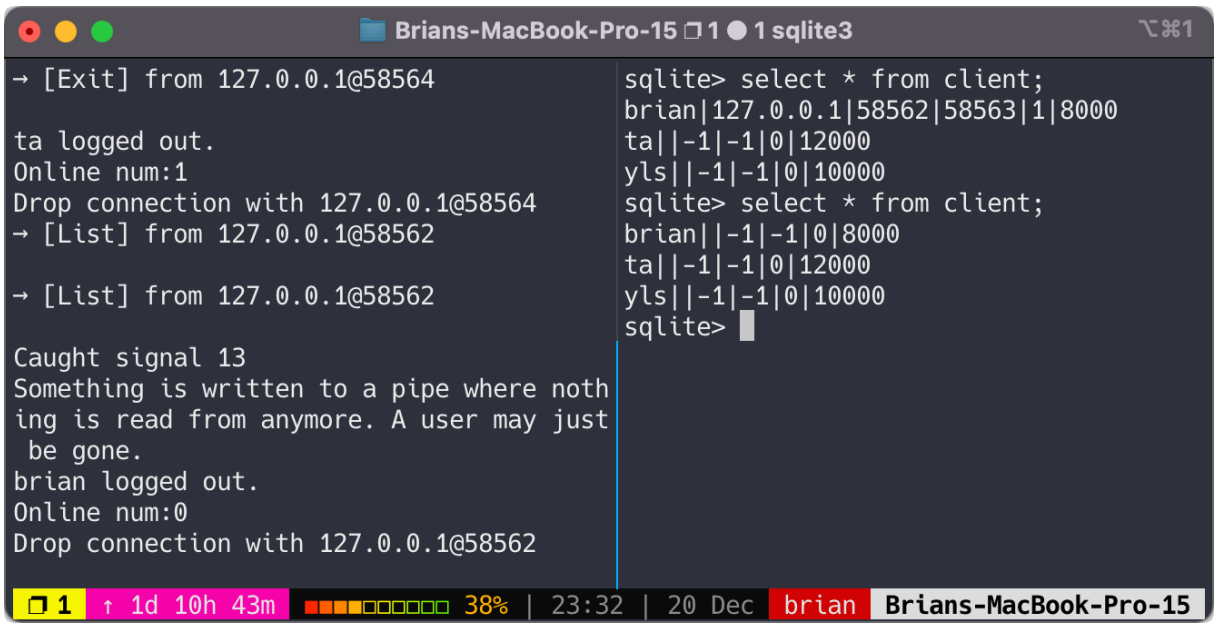


When a client exits properly:



When a client terminates suddenly (and returns a `SIGPIPE`):

This is not really possible since the client is well implemented. But if it does, server will handle:



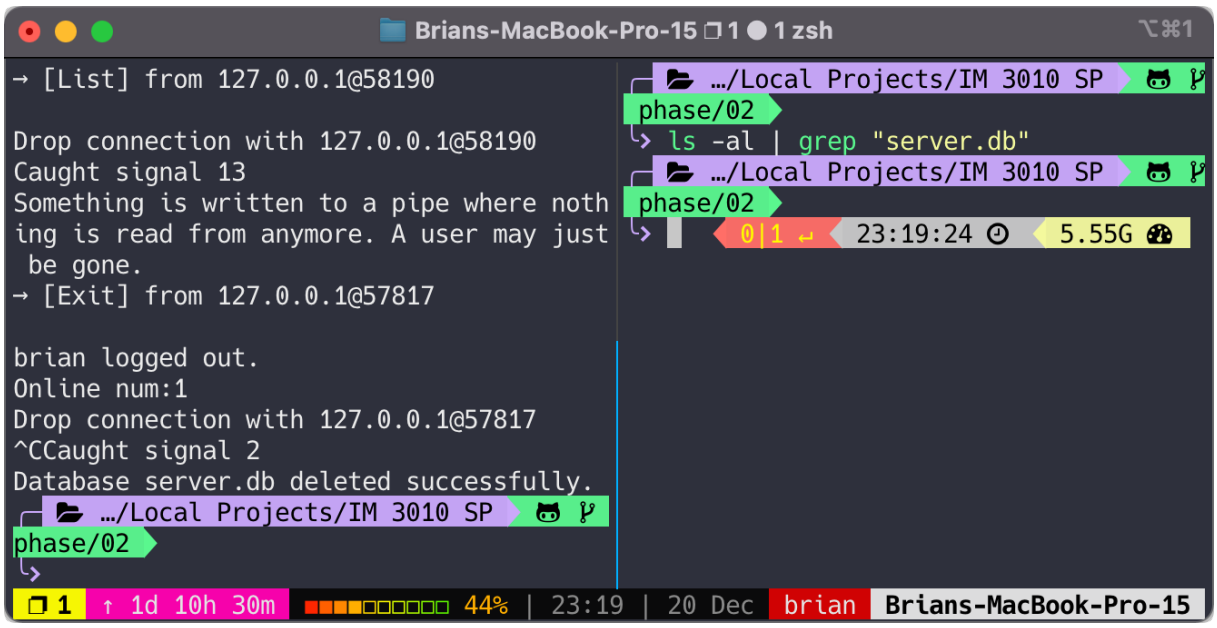
When Clients Exceed Thread Limit The server will notice and soon prompt that it has now detected more clients that it can handle. The client that triggers this action will have to wait until some other online users exit the server. The client will expect to see some "waiting".

This part has been properly shown in the demo session.

Terminating Server Program

To terminate the server, you will have to `CTRL + C` while the server is running. Signal handling is implemented so that you can do it safely.

The termination of the server will also cause the deletion of the db file `server.db`. The settings for not deleting the database can only be modified from the source code at `src/Database.cpp`.



Running Client Program

For the client part, I won't show the screenshot in this documentation again; you can see the demos/screenshots in *Phase 01 User Manual*.

If you are testing out the client program on your localhost:

```
./client 127.0.0.1 8888
```

Otherwise, you will have to figure out the right server IP address and the port the server is listening on.

The basic usage is: `./client <SERVER_IP> <SERVER_PORT>`.

Exiting Client Program

You can exit a client using two methods:

1. Typing in `5` to *properly tell the server you are to exit* and quit the session peacefully, or
2. Hitting `CTRL + C` to forcefully terminate the session; `server` will handle the error accordingly.

How to Compile

Notice that you will need to have the dependencies installed first if you are using Linux. Please click here if you miss the part.

Compiling Server Only

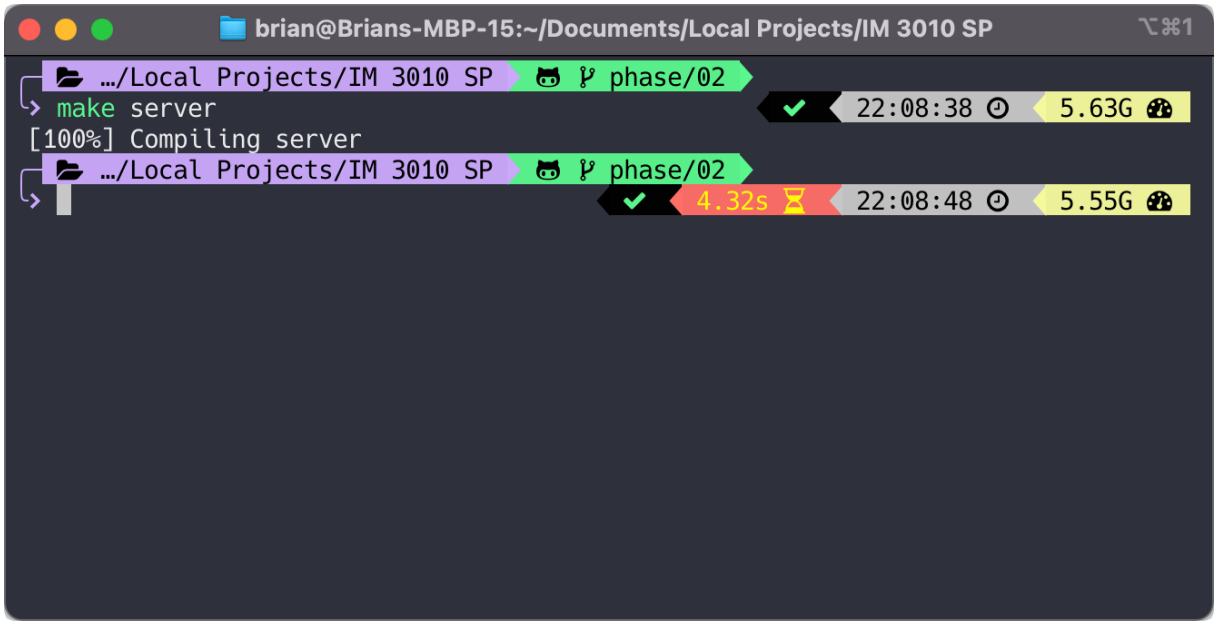
You can start the program already by typing `./server <SERVER_PORT> <CONCURRENT_USER_LIMIT>` into your terminal if you are on a Linux distribution (*Ubuntu* is used for testing) or on a macOS.

To rebuild the program, on either **macOS** or a **Linux** system, make sure to install the dependencies first before you run `make server` in the terminal app.

It will take a bit longer to compile `server` as compared to `client` since it is linking much more powerful and bigger libraries (`-lsqlite3` for using database).

If `server` binary already exists, you may want to run `make clean` first to remove the file.

If done properly, you should see the following output:

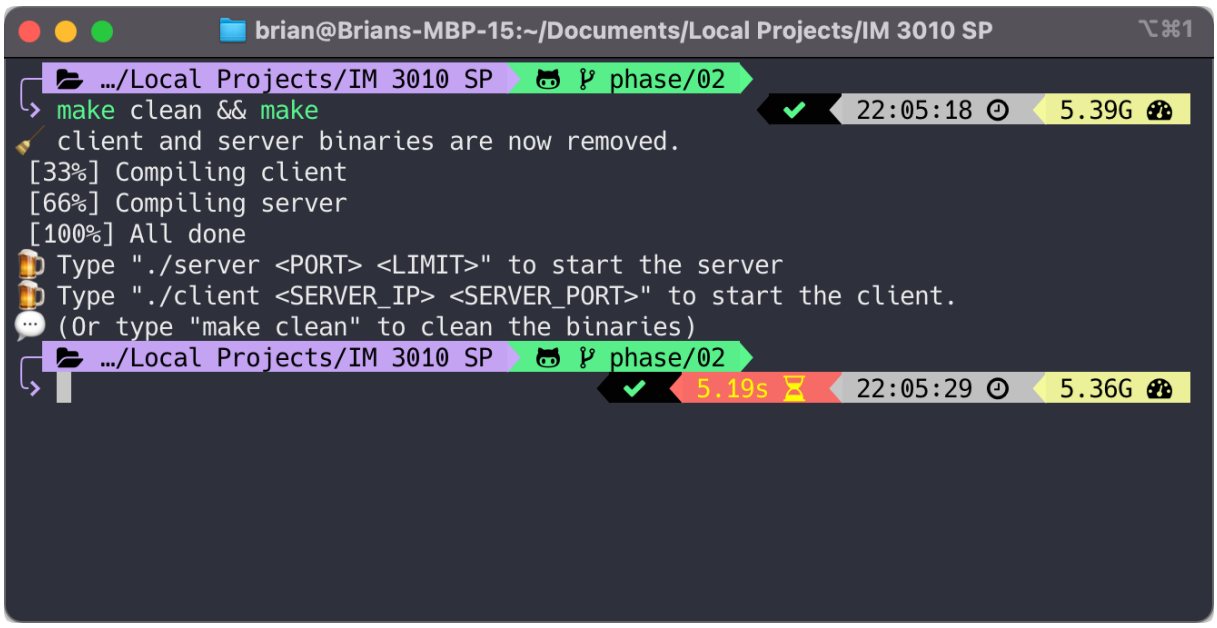


Compiling Client and Server

You can simply start off by doing:

```
1  make clean && make
```

If no errors occur, you shall see the following output on your terminal:



References

Server-side Implementation

- ☒ Creation of a **database** for handling multiple input and querying

  Background: As far as I know, handling simultaneous reads and writes can be a hassle when implemented manually. I consulted to my friends studying CSIE, and they also believe using a database could be a more practical and reasonable way to implement such querying function.

  I looked it up and find out that `sqlite` integrates so well with C/C++. `sqlite` can drive a db of up to 140TB, allows multiple simultaneous reads and, like other databases stores data in files on disk.

  Though for our use case, the need for a database is unnecessary due to the fact that we are only opening to **few users** (3) at a time, I still feel this urge to learn how to implement one for this project.

- ☒ Deletion of the database (`*.db`)
  - Filesystem Library in `C++17` at https://stackoverflow.com/a/59424074/10871988
- ☒ More on sqlite C++
  - https://github.com/fnc12/sqlite_orm → I am using this
  - https://www.runoob.com/sqlite/sqlite-c-cpp.html

- ☒ Thread and Worker Pool
  - https://ncona.com/2019/05/using-thread-pools-in-cpp/ - a very good article explaining how to use thread pools
  - https://stackoverflow.com/questions/15752659/thread-pooling-in-c11
  - https://stackoverflow.com/questions/48943929/killing-thread-from-another-thread-c
  - ☒ https://github.com/vit-vit/ctpl → I am using this
- ☒ Handling `SIGINT`
  - https://stackoverflow.com/questions/1641182/how-can-i-catch-a-ctrl-c-event
- ☒ `TIME WAIT`

  Background: `server` could not close connection after the socket is closed:

  ```
  sudo netstat -tanl | grep 8888
  ```

  ```
  tcp4       0       0       127.0.0.1.64480       127.0.0.1.8888
             TIME_WAIT
  ```

  https://stackoverflow.com/questions/23915304/how-to-avoid-time-wait-for-server-sockets
- ☒ Catch SIGPIPE from sudden death of a client
  - https://stackoverflow.com/questions/61688091/catching-client-exit-from-server-on-socket-programing
  - https://stackoverflow.com/questions/26752649/so-nosigpipe-was-not-declared
  - https://stackoverflow.com/questions/18935446/program-received-signal-sigpipe-broken-pipe/18963142

Client-side Implementation

(from phase01)

- Repositories
  - Learn Network Protocol and Programming Using C at https://github.com/apsrcreatix/Socket-Programming-With-C
  - Peer to peer program in C at https://github.com/um4ng-tiw/Peer-to-Peer-Socket-C
  - C Multithreaded Client-Server at https://github.com/RedAndBlueEraser/c-multithreaded-client-server
  - Socket programming examples in C++ at https://github.com/zappala/socket-programming-examples-c

- Others
  - Parse (split) a string in C++ using string delimiter (standard C++) at https://stackoverflow.com/a/14266139/10871988
  - Finding Unused Port in C++ at https://stackoverflow.com/a/1107242/10871988
  - Unix Specification (link to `bind()`) at https://pubs.opengroup.org/onlinepubs/007908799/xns/bind.html, but of course many more functions are looked up
  - Port Forwarding for a Docker Container at https://docs.docker.com/config/containers/container-networking/
  - Karton for not running on virtual machine at https://karton.github.io

User Manual

(from phase01)

- Eisvogel at https://github.com/Wandmalfarbe/pandoc-latex-template