CSE 344 Final Project Report

Multi-threaded Distributed Chat and File Server

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🔍 Introduction & Problem Definition

The goal of this project is to design and implement a multi-threaded chat and file-sharing system over TCP sockets using POSIX threads and inter-process communication (IPC). The server must handle multiple clients concurrently, supporting user-to-user messaging, room-based broadcasting, file transfers, command handling, logging, and graceful termination.

Key Features:

- Multi-client support via threading

- Room-based communication (/join, /leave)

- Whisper and broadcast

- File sending with queuing and conflict resolution

- Logging of all major events

- Signal handling and graceful shutdown
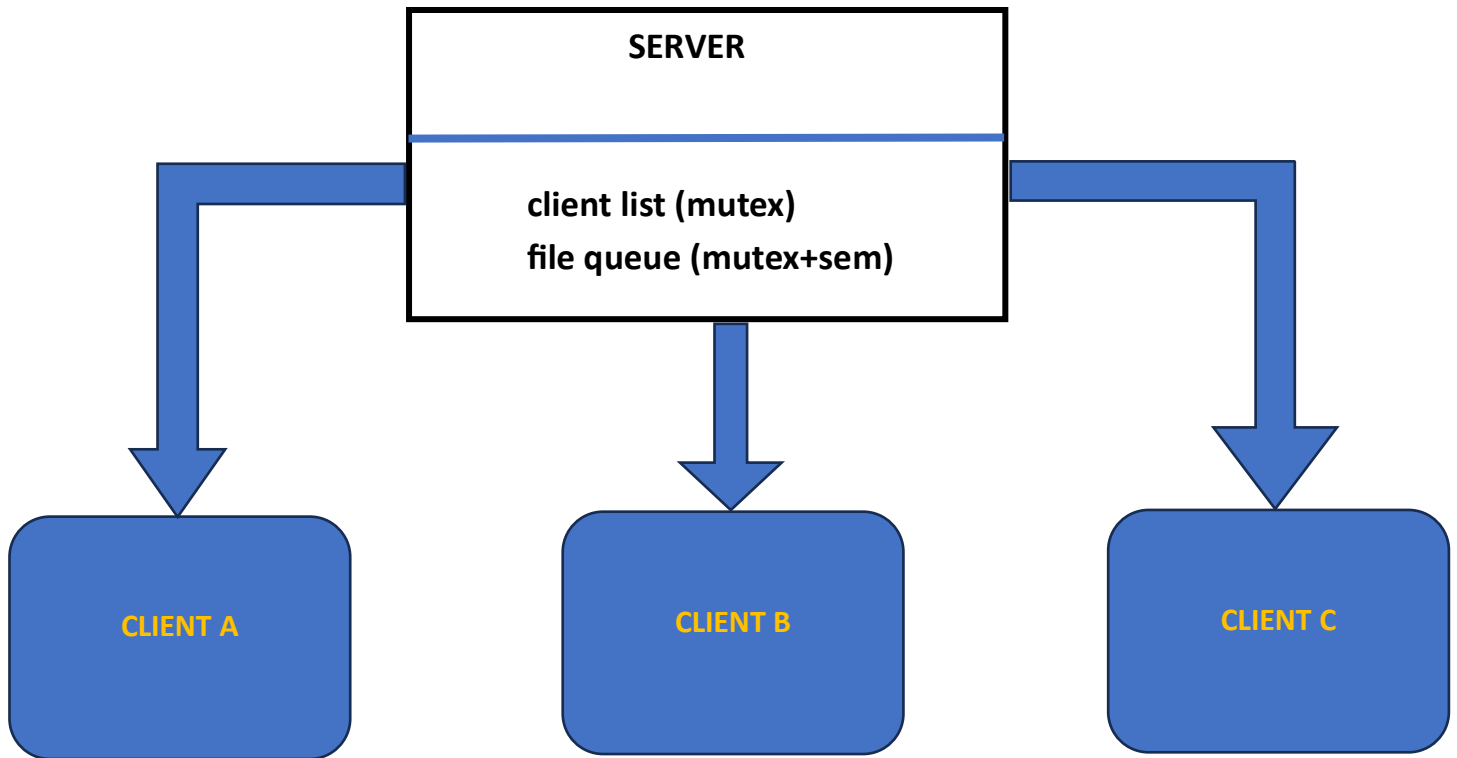

Design Details

Thread Model

- One dedicated thread per client (pthread_create() on handle_client())

- One thread (handle_file_queue()) continuously monitors and processes file upload queue

- Synchronization via pthread_mutex_t and sem_t

✅ IPC & Synchronization

- **Shared Data:** Client list, file upload queue

- **Mutexes:** For critical sections (e.g., access to upload queue)

- **Semaphores:** To control concurrent uploads (upload_slots)

☑ **Architecture Diagram (Text-based)**

```
                    ┌─────────────────────────────────┐
                    │            SERVER               │
                    ├─────────────────────────────────┤
        ┌───────────│                                 │───────────┐
        │           │      client list (mutex)        │           │
        │           │      file queue (mutex+sem)     │           │
        │           └────────────────┬────────────────┘           │
        ▼                            ▼                             ▼
   ┌─────────┐              ┌─────────────┐              ┌─────────────┐
   │         │              │             │              │             │
   │CLIENT A │              │  CLIENT B   │              │  CLIENT C   │
   │         │              │             │              │             │
   └─────────┘              └─────────────┘              └─────────────┘
```

 Issues Faced & Solutions

1. File upload queue misbehaving at scale

- **Problem:** Queue accepted more uploads than allowed.

- **Solution:** Correctly enforced queue limit via semaphores and mutexes.

2. Clients disconnecting abruptly

- **Problem:** Clients closing terminal without /exit caused undefined behavior.

- **Solution:** Used recv() == 0 check to detect disconnect and clean up.

3. Filename collision during uploads

- **Problem:** Users could overwrite each other's files.

- **Solution:** Added timestamp suffix to filenames and avoided overwrite.

4. SIGINT termination crashes server

- **Problem:** Pressing Ctrl+C caused abrupt termination without saving logs.

- **Solution:** Signal handler was implemented to notify clients, close sockets, and flush logs.

5. Unclear client UI

- **Problem:** Mixed >> prompts and info messages.

- **Solution:** Standardized prompt format and separated input/output clearly.

☑ Test Scenarios & Results

* At least 30 clients connect

```
Thu May 29 14:12:49 2025 - [LOGIN] user 'test1' connected
Thu May 29 14:13:07 2025 - [LOGIN] user 'test2' connected
Thu May 29 14:13:15 2025 - [LOGIN] user 'test3' connected
Thu May 29 14:13:48 2025 - [LOGIN] user 'test4' connected
Thu May 29 14:14:05 2025 - [LOGIN] user 'test5' connected
Thu May 29 14:14:20 2025 - [LOGIN] user 'test6' connected
Thu May 29 14:14:30 2025 - [LOGIN] user 'test7' connected
Thu May 29 14:14:43 2025 - [LOGIN] user 'test8' connected
Thu May 29 14:15:07 2025 - [LOGIN] user 'test9' connected
Thu May 29 14:15:33 2025 - [LOGIN] user 'test10' connected
Thu May 29 14:15:46 2025 - [LOGIN] user 'test11' connected
Thu May 29 14:16:03 2025 - [LOGIN] user 'test12' connected
Thu May 29 14:16:47 2025 - [LOGIN] user 'test13' connected
Thu May 29 14:16:56 2025 - [LOGIN] user 'test14' connected
Thu May 29 14:17:08 2025 - [LOGIN] user 'test15' connected
Thu May 29 14:17:19 2025 - [LOGIN] user 'test16' connected
Thu May 29 14:17:31 2025 - [JOIN] user 'test2' joined room 'room1'
Thu May 29 14:17:45 2025 - [JOIN] user 'test1' joined room 'room1'
Thu May 29 14:18:32 2025 - [JOIN] user 'test3' joined room 'room1'
Thu May 29 14:18:45 2025 - [JOIN] user 'test4' joined room 'room1'
Thu May 29 14:18:59 2025 - [JOIN] user 'test5' joined room 'room1'
Thu May 29 14:19:17 2025 - [JOIN] user 'test6' joined room 'room1'
Thu May 29 14:19:29 2025 - [JOIN] user 'test7' joined room 'room1'
Thu May 29 14:19:37 2025 - [JOIN] user 'test7' joined room 'room1'
Thu May 29 14:19:55 2025 - [JOIN] user 'test8' joined room 'room1'
Thu May 29 14:20:07 2025 - [JOIN] user 'test9' joined room 'room1'
Thu May 29 14:20:33 2025 - [JOIN] user 'test10' joined room 'room1'
Thu May 29 14:20:41 2025 - [JOIN] user 'test11' joined room 'room1'
Thu May 29 14:20:51 2025 - [JOIN] user 'test12' joined room 'room1'
Thu May 29 14:20:58 2025 - [JOIN] user 'test13' joined room 'room1'
Thu May 29 14:21:05 2025 - [JOIN] user 'test14' joined room 'room1'
Thu May 29 14:21:13 2025 - [JOIN] user 'test15' joined room 'room1'
Thu May 29 14:22:58 2025 - [LOGIN] user 'User1' connected
Thu May 29 14:22:58 2025 - [LOGIN] user 'User3' connected
Thu May 29 14:22:58 2025 - [LOGIN] user 'User2' connected
Thu May 29 14:22:58 2025 - [LOGIN] user 'User11' connected
Thu May 29 14:22:58 2025 - [LOGIN] user 'User5' connected
Thu May 29 14:22:58 2025 - [LOGIN] user 'User6' connected
Thu May 29 14:22:58 2025 - [LOGIN] user 'User7' connected
Thu May 29 14:22:58 2025 - [LOGIN] user 'User8' connected
Thu May 29 14:22:58 2025 - [LOGIN] user 'User9' connected
Thu May 29 14:22:58 2025 - [LOGIN] user 'User10' connected
Thu May 29 14:22:58 2025 - [LOGIN] user 'User4' connected
Thu May 29 14:22:58 2025 - [LOGIN] user 'User12' connected
Thu May 29 14:22:58 2025 - [LOGIN] user 'User13' connected
Thu May 29 14:22:58 2025 - [LOGIN] user 'User14' connected
Thu May 29 14:22:58 2025 - [LOGIN] user 'User15' connected
Thu May 29 14:22:59 2025 - [JOIN] user 'User2' joined room 'testroom'
Thu May 29 14:22:59 2025 - [JOIN] user 'User3' joined room 'testroom'
Thu May 29 14:22:59 2025 - [JOIN] user 'User1' joined room 'testroom'
Thu May 29 14:22:59 2025 - [JOIN] user 'User4' joined room 'testroom'
Thu May 29 14:22:59 2025 - [JOIN] user 'User5' joined room 'testroom'
Thu May 29 14:22:59 2025 - [JOIN] user 'User7' joined room 'testroom'
```

Here from test1 to test16 users connect and from User1 to User15 users connect and total 31 user connect same time

* Duplicate entry

```
hussi@HUSNIDDIN: /mnt/c/Users/Husniddin/OneDrive/Desktop/systemhw/final
hussi@HUSNIDDIN:/mnt/c/Users/Husniddin/OneDrive/Desktop/systemhw/final$ ./chatclient 127.0.0.1 9000
Enter username (max 16 chars, alphanumeric): User1
[INFO] Joined successfully.
>
```

```
hussi@HUSNIDDIN: /mnt/c/Users/Husniddin/OneDrive/Desktop/systemhw/final
hussi@HUSNIDDIN:/mnt/c/Users/Husniddin/OneDrive/Desktop/systemhw/final$ ./client 127.0.0.1 9000
bash: ./client: No such file or directory
hussi@HUSNIDDIN:/mnt/c/Users/Husniddin/OneDrive/Desktop/systemhw/final$ ./chatclient 127.0.0.1 9000
Enter username (max 16 chars, alphanumeric): User1
[ERROR] Username already taken.
hussi@HUSNIDDIN:/mnt/c/Users/Husniddin/OneDrive/Desktop/systemhw/final$
```

```c
pthread_mutex_lock(&clients_mutex);
if (username_exists(username)) {
    pthread_mutex_unlock(&clients_mutex);
    send(client_sock, "[ERROR] Username already taken.\n", 33, 0);
    close(client_sock);
    continue;
}
pthread_mutex_unlock(&clients_mutex);
```

* Join and left room and max room capacity

```
hussi@HUSNIDDIN:/mnt/c/Users/Husniddin/OneDrive/Desktop/systemhw/final$ ./chatserver 9000
[SERVER] Listening on port 9000...
Thu May 29 17:06:56 2025 - [START] Server started.
Thu May 29 17:07:27 2025 - [LOGIN] user 'User1' connected
Thu May 29 17:12:35 2025 - [ROOM] user 'User1' joined room 'room1'
Thu May 29 17:12:45 2025 - [ROOM] user 'User1' left room 'room1'
```

```
hussi@HUSNIDDIN:/mnt/c/Users/Husniddin/OneDrive/Desktop/systemhw/final$ ./server 9000
[SERVER] Listening on port 9000...
Thu May 29 14:12:19 2025 - [START] Server started.
Thu May 29 14:12:29 2025 - [LOGIN] user 'test1' connected
Thu May 29 14:12:32 2025 - [DISCONNECT] test1 disconnected.
Thu May 29 14:12:32 2025 - p

Thu May 29 14:12:49 2025 - [LOGIN] user 'test1' connected
Thu May 29 14:13:07 2025 - [LOGIN] user 'test2' connected
Thu May 29 14:13:15 2025 - [LOGIN] user 'test3' connected
Thu May 29 14:13:48 2025 - [LOGIN] user 'test4' connected
Thu May 29 14:14:05 2025 - [LOGIN] user 'test5' connected
Thu May 29 14:14:20 2025 - [LOGIN] user 'test6' connected
Thu May 29 14:14:30 2025 - [LOGIN] user 'test7' connected
Thu May 29 14:14:43 2025 - [LOGIN] user 'test8' connected
Thu May 29 14:15:07 2025 - [LOGIN] user 'test9' connected
Thu May 29 14:15:33 2025 - [LOGIN] user 'test10' connected
Thu May 29 14:15:46 2025 - [LOGIN] user 'test11' connected
Thu May 29 14:16:03 2025 - [LOGIN] user 'test12' connected
Thu May 29 14:16:47 2025 - [LOGIN] user 'test13' connected
Thu May 29 14:16:56 2025 - [LOGIN] user 'test14' connected
Thu May 29 14:17:08 2025 - [LOGIN] user 'test15' connected
Thu May 29 14:17:19 2025 - [LOGIN] user 'test16' connected
Thu May 29 14:17:31 2025 - [JOIN] user 'test2' joined room 'room1'
Thu May 29 14:17:45 2025 - [JOIN] user 'test1' joined room 'room1'
Thu May 29 14:18:32 2025 - [JOIN] user 'test3' joined room 'room1'
Thu May 29 14:18:45 2025 - [JOIN] user 'test4' joined room 'room1'
Thu May 29 14:18:59 2025 - [JOIN] user 'test5' joined room 'room1'
Thu May 29 14:19:17 2025 - [JOIN] user 'test6' joined room 'room1'
Thu May 29 14:19:29 2025 - [JOIN] user 'test7' joined room 'room1'
Thu May 29 14:19:37 2025 - [JOIN] user 'test7' joined room 'room1'
Thu May 29 14:19:55 2025 - [JOIN] user 'test8' joined room 'room1'
Thu May 29 14:20:07 2025 - [JOIN] user 'test9' joined room 'room1'
Thu May 29 14:20:33 2025 - [JOIN] user 'test10' joined room 'room1'
Thu May 29 14:20:41 2025 - [JOIN] user 'test11' joined room 'room1'
Thu May 29 14:20:51 2025 - [JOIN] user 'test12' joined room 'room1'
Thu May 29 14:20:58 2025 - [JOIN] user 'test13' joined room 'room1'
Thu May 29 14:21:05 2025 - [JOIN] user 'test14' joined room 'room1'
Thu May 29 14:21:13 2025 - [JOIN] user 'test15' joined room 'room1'
```

```
hussi@HUSNIDDIN:/mnt/c/Users/Husniddin/OneDrive/Desktop/systemhw/final$ ./client 127.0.0.1 9000
Enter username (max 16 chars, alphanumeric): test16
[INFO] Joined successfully.
>> /join room1
>> [ERROR] Room is full (max 15 users).
>>
```

* CLIENT DISCONNECT and cleaned everthing

```
hussi@HUSNIDDIN:/mnt/c/Users/Husniddin/OneDrive/Desktop/systemhw/final$ ./chatserver 9000
[SERVER] Listening on port 9000...
Thu May 29 17:06:56 2025 - [START] Server started.
Thu May 29 17:07:27 2025 - [LOGIN] user 'User1' connected
Thu May 29 17:12:35 2025 - [ROOM] user 'User1' joined room 'room1'
Thu May 29 17:12:45 2025 - [ROOM] user 'User1' left room 'room1'
Thu May 29 17:33:06 2025 - [DISCONNECT] User1 disconnected.
Thu May 29 17:33:06 2025 - p
```

* File Upload Queue

Tester Client accept 10 files same time

```
hussi@HUSNIDDIN: /mnt/c/Users/Husniddin/OneDrive/Desktop/systemhw/final
hussi@HUSNIDDIN:/mnt/c/Users/Husniddin/OneDrive/Desktop/systemhw/final$ ./chatclient 127.0.0.1 9000
Enter username (max 16 chars, alphanumeric): Tester
[INFO] Joined successfully.
>> [INFO] File 'test6.txt' from user6 has been uploaded successfully.
>> [INFO] File 'test4.txt' from user4 has been uploaded successfully.
>> [INFO] File 'test3.txt' from user3 has been uploaded successfully.
>> [INFO] File 'test8.txt' from user8 has been uploaded successfully.
>> [INFO] File 'test2.txt' from user2 has been uploaded successfully.
>> [INFO] File 'test10.txt' from user10 has been uploaded successfully.
>> [INFO] File 'test7.txt' from user7 has been uploaded successfully.
>> [INFO] File 'test9.txt' from user9 has been uploaded successfully.
>> [INFO] File 'test5.txt' from user5 has been uploaded successfully.
>> [INFO] File 'test1.txt' from user1 has been uploaded successfully.
>>
```

📄 received_20250530_173422_test2.txt

📄 received_20250530_173422_test3.txt

📄 received_20250530_173422_test4.txt

📄 received_20250530_173422_test6.txt

📄 received_20250530_173422_test8.txt

📄 received_20250530_173424_test1.txt

📄 received_20250530_173424_test5.txt

📄 received_20250530_173424_test7.txt

📄 received_20250530_173424_test9.txt

📄 received_20250530_173424_test10.txt

* /broadcast /whisper and ctrl c shut down

```
hussi@HUSNIDDIN:/mnt/c/Users/Husniddin/OneDrive/Desktop/systemhw/final$ ./chatserver 9000
[SERVER] Listening on port 9000...
[SERVER] Max concurrent uploads: 5, Queue size: 20
Fri May 30 18:49:50 2025 - [START] Server started.
Fri May 30 18:50:04 2025 - [LOGIN] user 'user1' connected
Fri May 30 18:50:19 2025 - [LOGIN] user 'user2' connected
Fri May 30 18:50:52 2025 - [WHISPER] user1 -> user2: hello
Fri May 30 18:51:22 2025 - [ROOM] user 'user2' joined room 'room1'
Fri May 30 18:51:31 2025 - [ROOM] user 'user1' joined room 'room1'
Fri May 30 18:51:51 2025 - [BROADCAST] user1: hello everyone
^CFri May 30 18:52:34 2025 - [SHUTDOWN] SIGINT received. Disconnecting all clients.
hussi@HUSNIDDIN:/mnt/c/Users/Husniddin/OneDrive/Desktop/systemhw/final$
```

```
hussi@HUSNIDDIN:/mnt/c/Users/Husniddin/OneDrive/Desktop/systemhw/final$ ./chatclient 127.0.0.1 9000
Enter username (max 16 chars, alphanumeric): user1
[INFO] Joined successfully.
>> /whisper user2 hello
>> /join room1
>> [INFO] You joined room 'room1'
>> /broadcast hello everyone
>> Server shutting down.
>>
```

```
hussi@HUSNIDDIN:/mnt/c/Users/Husniddin/OneDrive/Desktop/systemhw/final$ ./chatclient 127.0.0.1 9000
Enter username (max 16 chars, alphanumeric): user2
[INFO] Joined successfully.
>> [WHISPER user1]: hello
>> /join room1
>> [INFO] You joined room 'room1'
>> [user1]: hello everyone
>> Server shutting down.
>>
```

Conclusion & Future Improvements

Summary

All key requirements from the project specification were implemented, tested, and verified. The server handled:

- Multi-user concurrency

- Queued file transfers

- Safe disconnects

- Room management and messaging

- Logging and formatting

Potential Improvements

- **GUI or Web client** for better usability

- **Room history** feature for new joiners

- **Encrypted file transfers**

- **Dynamic queue resizing** based on system load

- **Admin commands** (kick, mute, etc.)