

## Introduction:

For this project, I created an intricate server-client architecture that uses both TCP and UDP to complete tasks. I read the Internet Relay Chat (IRC) documentation before starting this project and referred back to this documentation consistently during the development of my client-server application. At the end of this project, I had created a real-time chat application, similar to Discord, which allows messaging between clients directly and through channels. This application also saves specific attributes for both the clients and channels, and depending on these attributes will handle communication differently. Furthermore, this application can handle multiple clients concurrently who can send and receive chat messages relayed through the server with efficiency and quickness.

## Design:

For the design of my project, I made sure to include all commands required with error-handling for each. I made sure to include all the reply codes listed, as well as incorporate some of my own or ones that were included in the IRC that I felt needed to be included. To show my design, I will explain each of the commands functionality, their required reply codes, and the reply codes I implemented myself with reasoning for each. For what each channel/user mode represents for my server, refer to MODE command below

NOTE: all my replies will start with the prefix of the server hostname, as stated in the IRC(see screenshot below from given Chicago Project article from project instructions)

Assuming you've chosen a nick that is not already taken, the IRC server will send back a `RPL_WELCOME` reply (which is assigned code `001`). This reply has the following components:

- `:bar.example.com`: The prefix. Remember that prefixes are used to indicate the origin of a message. Since this reply originates in server `bar.example.com`, the prefix simply includes that hostname. This may seem redundant, given that the client presumably already knows it is connected to that server; however, in IRC networks, a reply could originate in a server other than the one the client is connected to.

## TCP Commands:

### NICK-

Command format: Nick <nickname>

### Required Replies Implemented:

431- If <nickname> is empty

432- if <nickname> does not start with an alphabetical character, and all other characters are not digits/alphabetical

433- if <nickname> is taken by another user, however once users disconnects nickname is freed

### My Replies Implemented:

Nickname changed- replied when nickname is successfully set

## USER-

Command format: User <username> <mode> <unused> <realname>

### Notes on the command:

As stated in IRC, mode is a bitwise, so 0 bits (0 digit) no mode will be set, 2 bits (4 digit) user mode 'w' will be set, 3 bits (8 digit) user mode 'i' will be set (see screenshot below)

#### 3.1.3 User message

Command: USER  
Parameters: <user> <mode> <unused> <realname>

The USER command is used at the beginning of connection to specify the username, hostname and realname of a new user.

The <mode> parameter should be a numeric, and can be used to automatically set user modes when registering with the server. This parameter is a bitmask, with only 2 bits having any signification: if the bit 2 is set, the user mode 'w' will be set and if the bit 3 is set, the user mode 'i' will be set. (See [Section 3.1.5 "User Modes"](#)).

### Required Replies Implemented:

001- Sent when user registered successfully

002- also sent when user registered successfully

004- also sent when user registered successfully

NOTE: IN IRC it states all 3 must be issued when user registered successfully (see last line in screenshot below)

#### 5.1 Command responses

Numerics in the range from 001 to 099 are used for client-server connections only and should never travel between servers. Replies generated in the response to commands are found in the range from 200 to 399.

```
001 RPL_WELCOME
    "Welcome to the Internet Relay Network
    <nick>!<user>@<host>"
002 RPL_YOUREHOST
    "Your host is <servername>, running version <ver>"
003 RPL_CREATED
    "This server was created <date>"
004 RPL_MYINFO
    "<servername> <version> <available user modes>
    <available channel modes>"
```

- The server sends Replies 001 to 004 to a user upon successful registration.

501- unknown error flag when digit is not 0,4, or 8

461-Not enough parameters

### My Replies Implemented:

462- When user is already registered

Error in realname- when realname given doesn't start with a ':' like in the examples of the IRC(see below screenshot)

Example:

```
USER guest 0 * :Ronnie Reagan ; User registering themselves with :
                               username of "guest" and real name
                               "Ronnie Reagan".
```

Use NICK command before user- given if user doesn't have set nickname

## MODE-

Command format: MODE <Nickname/Channel Name> <(+/-) mode character>

### Notes on the command:

- Default user mode is 'w' after NICK command, so that they can receive wallops commands(UDP notifications)
- User mode can only be changed by that specific user
- Channels available: #general, #anonymous, #secret, #private
- General has no initial mode, anonymous has 'a', secret has 's', private has 'p'
- All of these channel modes can be changed by any user, and any channel can be changed.

### My modes implementation:

User-

'w'- initial mode set on user after NICK command, wallops allows for UDP broadcast messages to be sent to it(heartbeat, statistics, real time notifications)

'a'- away mode, when set doesn't allow user to receive any messages at all

'i'- invisible user, won't show up in channels or as an active user in general, but will still receive all messages sent to it or the channel it is a part of. If invisible is set for the user and they're in a channel, they will be hidden from all commands that will show who is in the channel(IE: list, names, join, UDP statistics, etc.). Also will not be shown as an active user on UDP heartbeat messages(shows all active users).

Channel-

no mode- #general channel, can be PRIVMSGed from users inside and outside of channel and is visible

'a'- #anonymous channel can be PRIVMSGed from users inside and outside of the channel, but all users in channel and messaging channel will be shown as anonymous. Visible channel

'p'- #private channel, cannot be PRIVMSGed unless user is apart of that channel, is a visible channel

's'- #secret channel, cannot be PRIVMSGed unless user is apart of that channel, is not a visible channel(won't show up for LIST)

### **Required Replies Implemented:**

501- unknown error flag

502- Cannot change mode for other users

461- not enough parameters

### **My Replies Implemented:**

221- if command is just MODE <nickname>, it will return the user mode

324- if command is just MODE <channel>, it will return the channel mode

User changed mode successfully- reply after successfully changing(using +) a user mode

User mode removed successfully- reply after successfully removing(using -) a user mode

Channel changed mode successfully- reply after successfully changing(using +) a channel mode

Channel mode removed successfully- reply after successfully removing(using -) a channel mode

Mode must begin with +/- - given if command doesn't include +/- before mode

Channel doesn't exist- if given a channel that doesn't exist

## **QUIT:**

Command format: QUIT <exit message>

### **Notes on command**

-Exit message is not required

-Exit message is displayed for user

-This command closes the socket and removes the user from the socket list

-This command also sends a UDP message(real time notification) to all users with wallops attribute, informing them the user has left

### **My Replies Implemented:**

Will display to users they have quit the IRC server as well as send a UDP alert to all users with wallops attribute.

## **JOIN-**

Command format: JOIN <channelname>

### **Notes on the command:**

- Need to at least have NICK set before joining channel
- Will alert other users in channel that you joined
- If users are not in channel and have wallops attribute, they are sent a UDP alert that you joined the channel
  - This UDP alert will not happen if you join a channel with "s" attribute or will hide the your name if you join a channel with the "a" attribute

### **Required Replies Implemented:**

- 332- issued to user when channel is successfully joined, shows channelname, topic, connected users (assuming they don't have 'i' attribute or channel with 'a' attribute)
- 403-no such channel exists
- 461- needs more parameters

### **My Replies Implemented:**

Need to use NICK command before joining channel- reply given so that users at least have a nickname before joining, allows for LIST, NAMES, and other commands to work.

## **PART-**

Command format: PART <channelname>

### **Notes on the command:**

- Need to be part of the channel you are leaving
- Will alert other users in channel that you left
- If users are not in channel and have wallops attribute, they are sent a UDP alert that you left the channel
  - This UDP alert will not happen if you leave a channel with "s" attribute or will hide the your name if you leave a channel with the "a" attribute

### **Required Replies Implemented:**

- 461- needs more parameters

### **My Replies Implemented:**

You have left the channel- reply made so it confirms to user specifically that they left  
You are not apart of this channel- reply made if you try to leave channel you aren't apart of

## **TOPIC-**

Command format: TOPIC <channelname> <topic>

#### Notes on the command:

-<topic> is not required in command, if putting just channelname it will show channels topic, if you include <topic> it will change that channel's topic

#### Required Replies Implemented:

332- returns topic of channel

403- no such channel

461- needs more parameters

#### My Replies Implemented:

Topic changed to: - confirms you have changed topic and shows what you've changed it to

Topic must start with ':' - Like in IRC, you must include ':' in command before the topic you want to change it to(see screenshot below)

```
TOPIC #test :another topic ; Command to set the topic on #test  
to "another topic".
```

## LIST-

Command format: LIST <channelname>

#### Notes on the command:

-Shows a list of all channels available, or if <channelname> is included just shows the one specified.

-Shows number of users(excluding invisible users) in each channel and does not show secret channels

#### Required Replies Implemented:

403- No such channel

322/323- List and list end, with channels in middle

## NAMES-

Command format: NAMES <channelname>

#### Notes on the command:

-shows a list of names in a channel, doesn't show invisible users, but does show indicators of channels (see screenshot below)

-@ shown for secret channels, \* for private, = for others

```

353      RPL_NAMREPLY
        "( "=" / "*" / "@" ) <channel>
          :[ "@" / "+" ] <nick> *( " " [ "@" / "+" ] <nick> )
- "@" is used for secret channels, "*" for private
  channels, and "=" for others (public channels).

```

### Required Replies Implemented:

353- reply of names  
 366- end of names  
 403- no such channel  
 461- need more parameters

## PRIVMSG-

Command format: PRIVMSG <nickname/channelname> <intendedmsg>

### Notes on the command:

- Can privmsg any user after nickname is set
- Can privmsg general and anonymous channels if outside/inside of them, can privmsg secret and private channels only if inside of them
- Cannot privmsg away users

### Required Replies Implemented:

401- no such nickname  
 403- no such channel  
 404- cannot send message to channel (private or secret in this case)  
 461- need more parameters

### My Replies Implemented:

No message given- if <intendedmsg> is empty  
 Client you are trying to message is currently away- if nickname entered has away attribute

## UDP Design-

**Note:** for my UDP portion of the project, I could not get the timer working. I got the UDP messages and timed messages working separately, but could not get the UDP messages to send to the client on the given heartbeat/statistic timer. However, I have the UDP correctly setup and sending messages correctly to all users with 'w' attribute. The real time notifications work as intended, but for the heartbeat and statistics messages, I made these work through client commands. I will describe each of these below

## Heartbeat-

Command format: Heartbeat

This command returns the required heartbeat command to the user who issued it, as well as any user who has the 'w' attribute and is an active user(has issued at least one command)

This heartbeat command says hello to the active user and returns a list of all current active users(excluding invisible and away users).

Example:

```
Client: Connecting to 192.168.0.10
Nick Jake
> camccclu-0: Nickname changed
heartbeat
> (UDP): Hello active user! This is your heartbeat message:
Connected Users List: Ben Jake
```

Client who issues heartbeat

```
Client: Connecting to 192.168.0.10
nick Ben
> camccclu-0: Nickname changed
(UDP): Hello active user! This is your heartbeat message:
Connected Users List: Ben Jake
```

Active user who receives heartbeat as well

## Statistics-

Command format: Statistics

Similar to heartbeat above, the command returns the required statistics (number of active users, active channels, CPU usage) to the user who issued it as well as any user with 'w' attribute that is an active user(has issued at least one command)

Example:

```
Client: Connecting to 192.168.0.10
nick Ben
> camccclu-0: Nickname changed
join #general
> camccclu-0: 332 RPL_TOPIC
Ben #general: An open channel with no flags
You are connected!
Connected Users: Ben
(UDP): Hello active user! This is your server statistics message:
Number of Active Users:
2
Number of Active Channels(Have users in them):
#general: 1 users
CPU Usage: 0.708008%
```

Client sets nickname, joins channel, and gets sent UDP statistics message



```

Client: Connecting to 192.168.0.10
Nick Jake
> camcclu-0: Nickname changed
Statistics
> (UDP): Hello active user! This is your server statistics message:
Number of Active Users:
2
Number of Active Channels(Have users in them):
#general: 1 users
CPU Usage: 0.708008%

```

Client sets nickname, initiates statistics command

NOTE: statistics will not return an active channel if an invisible user is in it, or secret channels in general

## Real-Time Notifications

No command required, real time UDP notifications are set up for the JOIN, PART, and QUIT commands. For any user that has 'w' attribute, they will get alerted whenever a user joins/leaves a channel(excluding secret channels) or quits.

Example:

```

Client: Connecting to 192.168.0.10
nick ben
> camcclu-0: Nickname changed
Join #general
> camcclu-0: 332 RPL_TOPIC
ben #general: An open channel with no flags
You are connected!
Connected Users: ben
Part #general
> (UDP): Hello active user! The user ben has left the channel: #general
camcclu-0: You have left the channel
quit
> (UDP): Hello active user! The user ben has left the IRC server
camcclu-0: ben has quit IRC server
Server closed the connection.

```

Client joins channel, parts with channel, then quits

```

Client: Connecting to 192.168.0.10
Nick jake
> camcclu-0: Nickname changed
(UDP): Hello active user! The user ben has joined the channel: #general
(UDP): Hello active user! The user ben has left the channel: #general
(UDP): Hello active user! The user ben has left the IRC server

```

Client with wallops attribute, receives notifications for each of these

## Sample Runs:

```
Client: Connecting to 192.168.0.10
Nick Jake
> camcclu-0: Nickname changed
USER Jake2003 * * :Jake Moore
> camcclu-0: 001 RPL_WELCOME
Welcome to the Internet Relay Network
Jake!Jake2003@camcclu-0
002 RPL_YOURHOST
Your host is camcclu-0
004 RPL_MYINFO
Available User Modes: a, i, w
Available Channel Modes: p, s, a
JOIN #general
> camcclu-0: 332 RPL_TOPIC
Jake #general: An open channel with no flags
You are connected!
Connected Users: Jake
part #general
> (UDP): Hello active user! The user Jake has left the channel: #general
camcclu-0: You have left the channel
```

## Setting Nickname(Jake), Registering, Joining/Leaving Channel

```
Client: Connecting to 192.168.0.10
NICK Ben
> camcclu-0: Nickname changed
USER BenW * * :Ben White
> camcclu-0: 001 RPL_WELCOME
Welcome to the Internet Relay Network
Ben!BenW@camcclu-0
002 RPL_YOURHOST
Your host is camcclu-0
004 RPL_MYINFO
Available User Modes: a, i, w
Available Channel Modes: p, s, a
PRIVMSG Jake Hello!
> (UDP): Hello active user! The user Jake has left the channel
camcclu-0: You have left the channel
camcclu-0: :Ben!camcclu-0
PRIVMSG Jake Hello!
```

## New User "Ben" registers and PRIVMSGs Jake

```
> JOIN #general
> camcclu-0: 332 RPL_TOPIC
Ben #general: An open channel with no flags
You are connected!
Connected Users: Ben
camcclu-0: Jake!camcclu-0
JOIN #general
(UDP): Hello active user! The user Ben has joined the channel: #general
JOIN #general
> camcclu-0: 332 RPL_TOPIC
Jake #general: An open channel with no flags
You are connected!
Connected Users: Jake Ben
LIST
> camcclu-0: 322 RPL_LIST
#anonymous 0 users :An open channel with anonymous flag
#general 2 users :An open channel with no flags
#private 0 users :A private channel
323 RPL_LISTEND :End of LIST
```

Ben(top picture) joins #general, UDP is sent to Jake(bottom picture), Jake joins too, Ben is alerted in the channel (Jake!camcclu-0 message on top). Then Jake issues LIST.

```

NAMES #general
> camcclu-0: 353 RPL_NAMREPLY
= #general
@Jake @Ben
366 RPL_ENDOFNAMES
#general :End of names list

```

NAMES #general shows both of them in channel

```

client: connecting to 192.168.0.10
TOPIC #general
> camcclu-0: 332 RPL_TOPIC
#general: An open channel with no flags
TOPIC #general :newtopic
> camcclu-0: Topic changed to: newtopic
TOPIC #general
> camcclu-0: 332 RPL_TOPIC
#general: newtopic

```

Issuing TOPIC and changing TOPIC

```

/ camcclu-0: Nickname changed
JOIN #general
> camcclu-0: 332 RPL_TOPIC
ben #general: newtopic
You are connected!
Connected Users: Jake ben
MODE ben +i
> camcclu-0: User mode changed successfully
NAMES #general
> camcclu-0: 353 RPL_NAMREPLY
= #general
@Jake
366 RPL_ENDOFNAMES
#general :End of names list

```

Client using MODE on user to become invisible

```

LIST
> camcclu-0: 322 RPL_LIST
#anonymous 0 users :An open channel with anonymous flag
#general 1 users :newtopic
#private 0 users :A private channel
323 RPL_LISTEND :End of LIST
MODE #general +s
> camcclu-0: Channel mode changed successfully
LIST
> camcclu-0: 322 RPL_LIST
#anonymous 0 users :An open channel with anonymous flag
#private 0 users :A private channel
323 RPL_LISTEND :End of LIST
MODE #general -s
> camcclu-0: Channel mode removed successfully
LIST
> camcclu-0: 322 RPL_LIST
#anonymous 0 users :An open channel with anonymous flag
#general 1 users :newtopic
#private 0 users :A private channel
323 RPL_LISTEND :End of LIST

```

Client using MODE on channel (adding 's' to #general, then removing it)

```

JOIN #anonymous
> camcclu-0: 332 RPL_TOPIC
jake #anonymous: An open channel with anonymous flag
You are connected!
Connected Users: (Anonymous User)
camcclu-0: :Anonymous!camcclu-0
PRIVMSG #anonymous hello

```

```

PRIVMSG #anonymous hello

```

One client issues PRIVMSG to a channel(anonymous in this case), client in channel receives it

```

JOIN #secret
> camcclu-0: 332 RPL_TOPIC
jake #secret: A secret channel
You are connected!
Connected Users: jake
camcclu-0: ben!camcclu-0
JOIN #secret
camcclu-0: :ben!camcclu-0
PRIVMSG #secret hello

```

```

> PRIVMSG #secret hello
> camcclu-0: 404 ERR_CANNOTSENDOCHAN
#secret :Cannot send to channel
JOIN #secret
> camcclu-0: 332 RPL_TOPIC
ben #secret: A secret channel
You are connected!
Connected Users: jake
PRIVMSG #secret hello

```

Bottom client tries to message #secret, cannot since he is not in channel, joins channel(top screen is in channel and notified), then sends message (received on top screen)

**NOTE: UDP Sample Runs are included above in UDP Design section**

**Summary:**

In summary, I have completed everything required of the project according to IRC guidelines and the project instructions. In my design section above each command and their replies are explained. In my sample runs you can see these commands in action.