CS-436 DHCP Protocol Case Study

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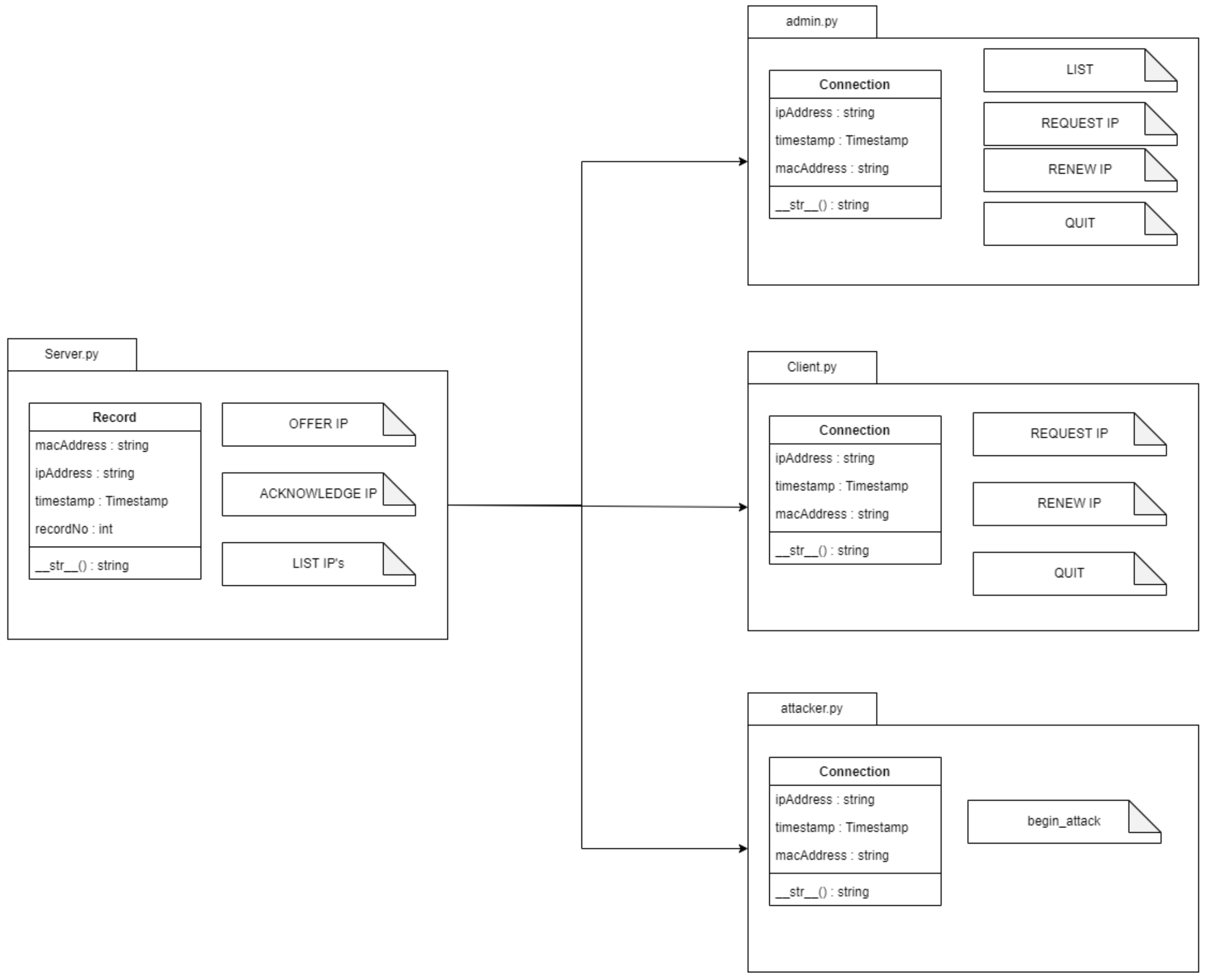
Abstract

In this case study a simplified implementation of the Dynamic Host Configuration Protocol (DHCP) will be described. The system consists of four programs written in Python: server.py, client.py, admin.py, and attacker.py. These programs and their roles will be described in more detail.

Program Design and Implementation



DHCP is a protocol in which IP addresses are allocated to clients that request an address. This protocol is used to dynamically manage the hosts on a network subnet in a manner which allows for an appropriate distribution and use of IP addresses. This includes managing lease times, checking for addresses that have fallen out of use, and may be reallocated, and fundamentally assigning addresses to new requesters. The process of successfully allocating an IP address involves a four step process, a client DISCOVER message, a server OFFER response, a client REQUEST response, and finally a server ACKNOWLEDGE response.

server.py

The server program serves IP addresses to requesting clients. When the server receives a message from a client it comes in the form of a byte array. This array is decoded, and the resulting string is then split along the spacing. Due to Python's dynamic n-tuple nature, this tuple may range from 2 to 4 sections, so much care must be taken to ensure that the message parsed through later is accessed using the correct indices. The first element of the n-tuple, assuming the server has in fact received a message in the correct format (incorrect formats will result in a safe "DECLINE" message returned to the client and no server crash), will be the type of request. These possibilities are DISCOVER, REQUEST, RENEW, RELEASE, and LIST. The server will then act accordingly to that message type; based on the message type we can also determine the n of the n-tuple, i.e., DISCOVER -> 2, REQUEST -> 4, LIST -> 1, etc. The information pertaining to an available IP address is stored in a Record class, seen in the above diagram. When the program is offering a new IP address it first checks to see if the requesting MAC address already has an address allocated, then it simply updates the expiration, and sends the OFFER to the client. If the server receives a REQUEST, it checks to see if the IP address has already been taken, or that the client has not taken longer that the allocated lease time to accept. If both are false, then the server once again updates the timestamp in the record to reflect a new lease and sends and ACKNOWLEDGE message. The RENEW message protocol is to check for an address that has already been allocated to the MAC address and simply update the expiration lease on the record. The RELEASE operation is to simply mark the record's MAC address as empty and the timestamp to "now" so as to always be expired when checked. Finally, upon receiving a LIST request the server will form a formatted string of the information contained in all records owned by the server and send that to the requesting client.

client.py

The client program emulates a host attempting to request a new IP address. It provides a number value input menu for a user to select actions regarding IP allocation. The initial four way request is done automatically when the program starts. The client broadcasts a DISCOVER message containing its MAC address to the DHCP server. The client, after it receives the corresponding OFFER message, then immediately sends a REQUEST message. Upon receiving an ACKNOWLEDGE message, the client then stores the connection to memory to reference the expiration later. The client also can send a RENEW message, requesting the server to extend or reallocate an already existing connection record. Finally the client may also send a RELEASE message to responsibly deallocate its reserved IP address record.

admin.py

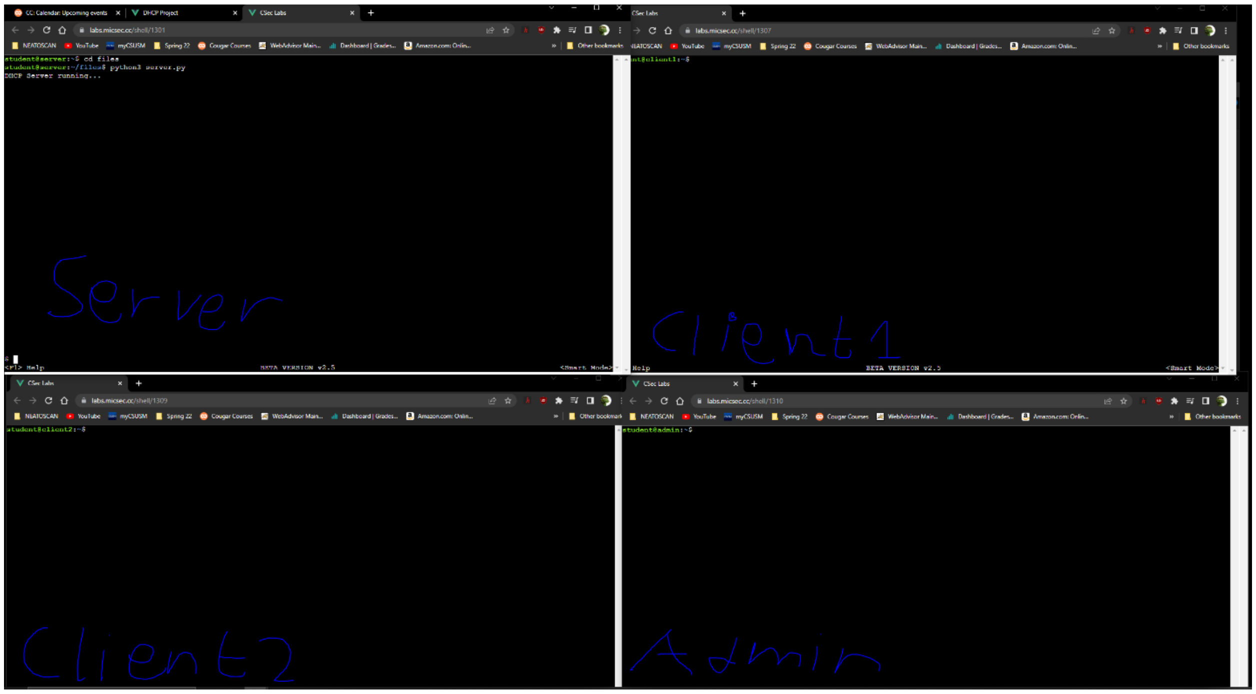
The admin program works identically to the client program, except it has the ability to make a LIST request to the DHCP server. This requests a detailed list of records maintained by the server of each connected client. This would be used in certain networking management situations.

attacker.py

The attacker program will generate many falsified MAC addresses and make a DISCOVER request for each one. The server will then continuously OFFER IP addresses to this false client for each DISCOVER. This effectively reserves every single IP address, making them all unavailable to true clients. This is attacker program conducts a Denial of Service (DoS) attack.

Testing

The following are thirteen steps outlined in the project specification. The images are captures from a live run of the four programs, and the descriptions of them are taken from the project specification.



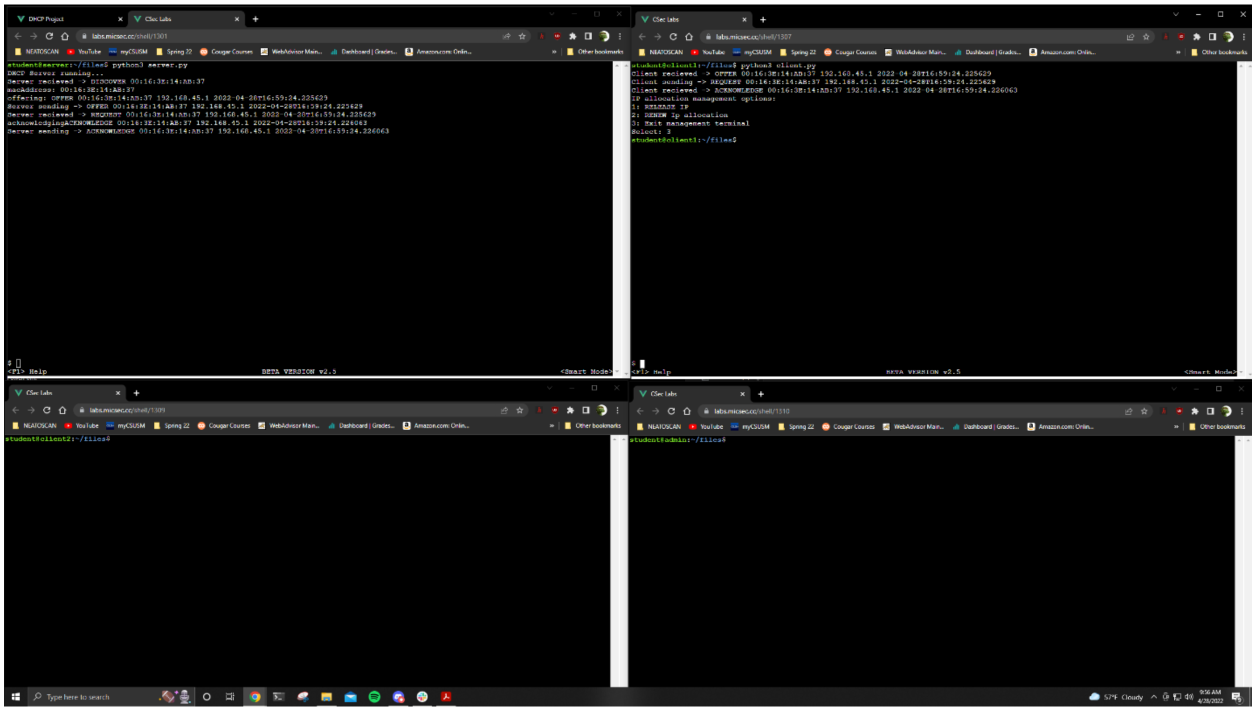
```
student@server:~$ cd files
student@server:~/files$ python3 server.py
DHCP Server running...
```

```
nt@client1:~$
```

```
student@client2:~$
```

```
student@admin:~$
```

1. Run the server on `server`



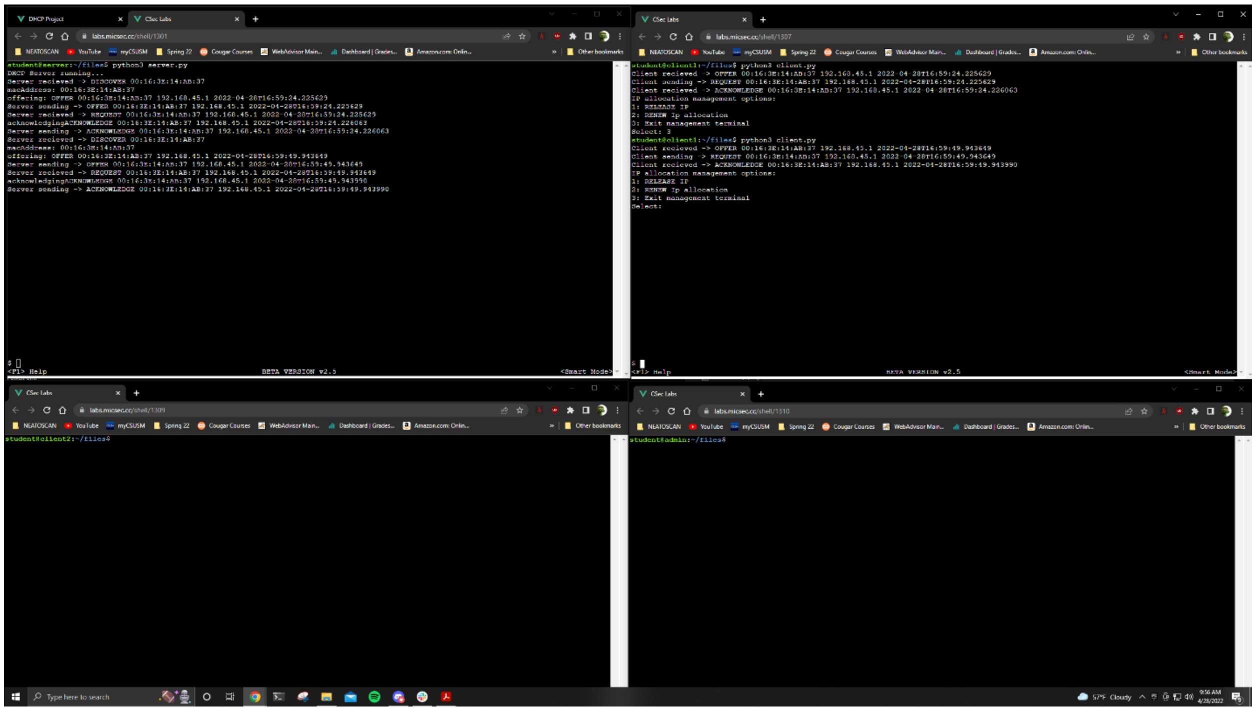
```
student@server:~/files$ python3 server.py
DHCP Server running...
Server recieved -> DISCOVER 00:16:3E:14:AB:37
macAddress: 00:16:3E:14:AB:37
offering: OFFER 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:24.225629
Server sending -> OFFER 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:24.225629
Server recieved -> REQUEST 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:24.225629
acknowledgingACKNOWLEDGE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:24.226063
Server sending -> ACKNOWLEDGE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:24.226063
```

```
student@client1:~/files$ python3 client.py
Client recieved -> OFFER 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:24.225629
Client sending -> REQUEST 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:24.225629
Client recieved -> ACKNOWLEDGE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:24.226063
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select: 3
student@client1:~/files$
```

```
student@client2:~/files$
```

```
student@admin:~/files$
```

2. Run the client on `client1`. Make sure that the client receives the first available IP address. The menu will be displayed for the client. Choose **quit**.



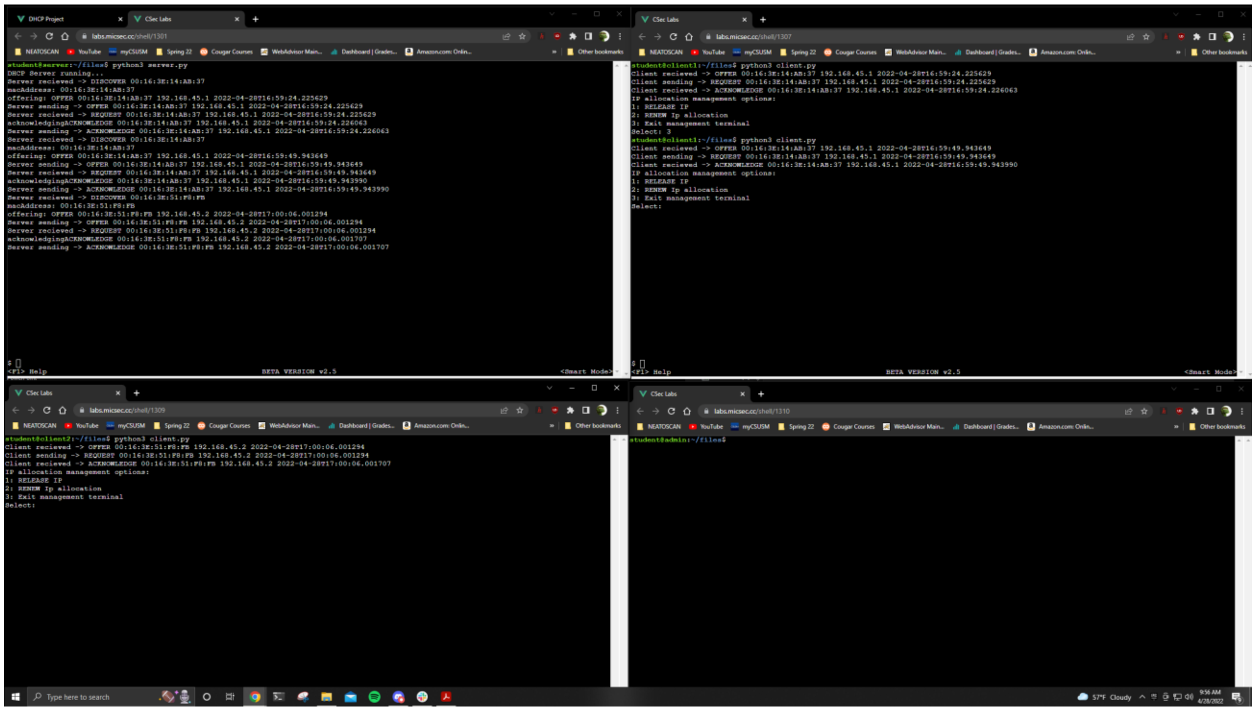
```
student@server:~/files$ python3 server.py
DHCP Server running...
Server recieved -> DISCOVER 00:16:3E:14:AB:37
macAddress: 00:16:3E:14:AB:37
offering: OFFER 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:24.225629
Server sending -> OFFER 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:24.225629
Server recieved -> REQUEST 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:24.225629
acknowledgingACKNOWLEDGE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:24.226063
Server sending -> ACKNOWLEDGE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:24.226063
Server recieved -> DISCOVER 00:16:3E:14:AB:37
macAddress: 00:16:3E:14:AB:37
offering: OFFER 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:49.943649
Server sending -> OFFER 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:49.943649
Server recieved -> REQUEST 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:49.943649
acknowledgingACKNOWLEDGE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:49.943990
Server sending -> ACKNOWLEDGE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:49.943990
```

```
student@client1:~/files$ python3 client.py
Client recieved -> OFFER 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:24.225629
Client sending -> REQUEST 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:24.225629
Client recieved -> ACKNOWLEDGE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:24.226063
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select: 3
student@client1:~/files$ python3 client.py
Client recieved -> OFFER 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:49.943649
Client sending -> REQUEST 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:49.943649
Client recieved -> ACKNOWLEDGE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:49.943990
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select:
```

```
student@client2:~/files$
```

```
student@admin:~/files$
```

3. Now we want to make sure that the same client cannot receive a new IP address from another terminal. Run the client on `client1` again. Make sure that the server verifies that the client already has an IP address `x.x.x.x`. The menu will be displayed for the client.



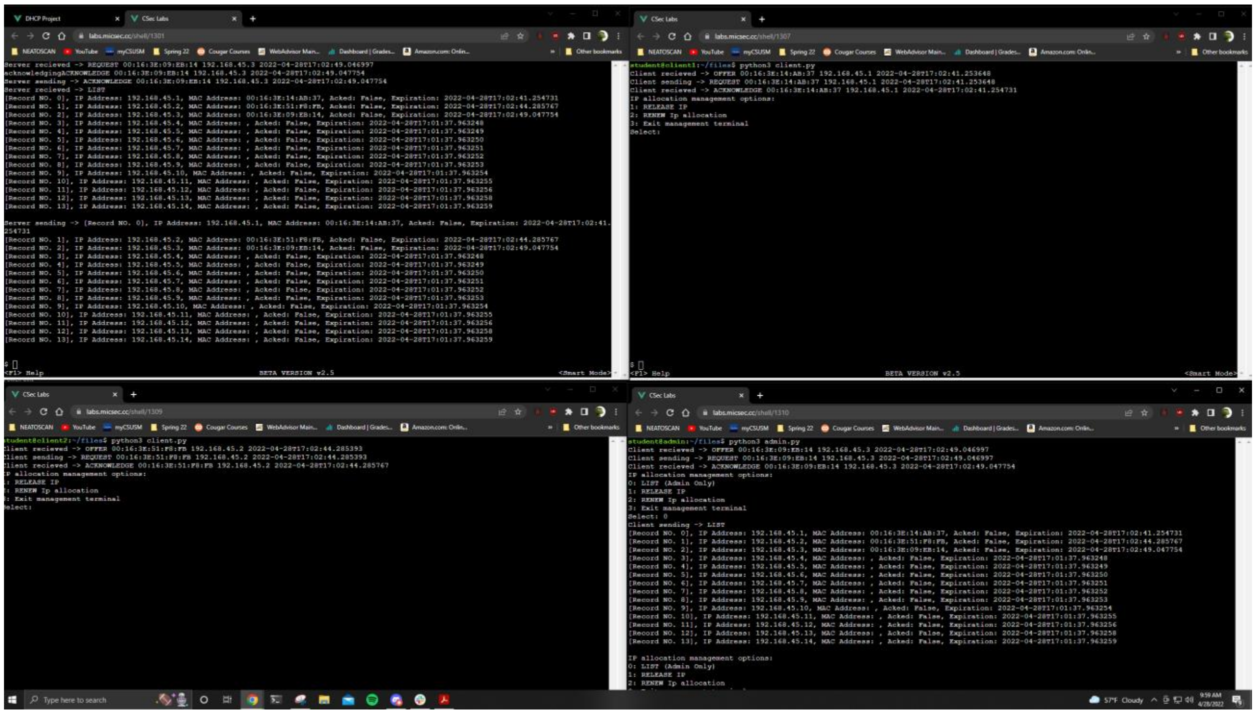
```
student@server:~/files$ python3 server.py
DHCP Server running...
Server recieved -> DISCOVER 00:16:3E:14:AB:37
macAddress: 00:16:3E:14:AB:37
offering: OFFER 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:24.225629
Server sending -> OFFER 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:24.225629
Server recieved -> REQUEST 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:24.225629
acknowledgingACKNOWLEDGE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:24.226063
Server sending -> ACKNOWLEDGE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:24.226063
Server recieved -> DISCOVER 00:16:3E:14:AB:37
macAddress: 00:16:3E:14:AB:37
offering: OFFER 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:49.943649
Server sending -> OFFER 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:49.943649
Server recieved -> REQUEST 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:49.943649
acknowledgingACKNOWLEDGE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:49.943990
Server sending -> ACKNOWLEDGE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:49.943990
Server recieved -> DISCOVER 00:16:3E:51:F8:FB
macAddress: 00:16:3E:51:F8:FB
offering: OFFER 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:00:06.001294
Server sending -> OFFER 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:00:06.001294
Server recieved -> REQUEST 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:00:06.001294
acknowledgingACKNOWLEDGE 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:00:06.001707
Server sending -> ACKNOWLEDGE 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:00:06.001707
```

```
student@client1:~/files$ python3 client.py
Client recieved -> OFFER 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:24.225629
Client sending -> REQUEST 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:24.225629
Client recieved -> ACKNOWLEDGE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:24.226063
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select: 3
student@client1:~/files$ python3 client.py
Client recieved -> OFFER 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:49.943649
Client sending -> REQUEST 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:49.943649
Client recieved -> ACKNOWLEDGE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T16:59:49.943990
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select:
```

```
student@client2:~/files$ python3 client.py
Client recieved -> OFFER 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:00:06.001294
Client sending -> REQUEST 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:00:06.001294
Client recieved -> ACKNOWLEDGE 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:00:06.001707
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select:
```

```
student@admin:~/files$
```

4. Run the client on `client2`. Now make sure that `client2` receives the next available IP address. The menu will be displayed for the client. Wait for 10 seconds and then choose renew. Make sure the server immediately sends an `ACKNOWLEDGE` and renews the timestamp. Then, the menu will be displayed again. Wait for 1 minute and then choose renew. Make sure that you go over `DISCOVER` - `OFFER` - `REQUEST` - `ACKNOWLEDGE`, get the same IP address and a new lease time. Then, the menu will be displayed again. Now, choose quit.



```
Server recieved -> REQUEST 00:16:3E:09:EB:14 192.168.45.3 2022-04-28T17:02:49.046997
acknowledgingACKNOWLEDGE 00:16:3E:09:EB:14 192.168.45.3 2022-04-28T17:02:49.047754
Server sending -> ACKNOWLEDGE 00:16:3E:09:EB:14 192.168.45.3 2022-04-28T17:02:49.047754
Server recieved -> LIST
[Record NO. 0], IP Address: 192.168.45.1, MAC Address: 00:16:3E:14:AB:37, Acked: False, Expiration: 2022-04-28T17:02:41.254731
[Record NO. 1], IP Address: 192.168.45.2, MAC Address: 00:16:3E:51:F8:FB, Acked: False, Expiration: 2022-04-28T17:02:44.285767
[Record NO. 2], IP Address: 192.168.45.3, MAC Address: 00:16:3E:09:EB:14, Acked: False, Expiration: 2022-04-28T17:02:49.047754
[Record NO. 3], IP Address: 192.168.45.4, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963248
[Record NO. 4], IP Address: 192.168.45.5, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963249
[Record NO. 5], IP Address: 192.168.45.6, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963250
[Record NO. 6], IP Address: 192.168.45.7, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963251
[Record NO. 7], IP Address: 192.168.45.8, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963252
[Record NO. 8], IP Address: 192.168.45.9, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963253
[Record NO. 9], IP Address: 192.168.45.10, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963254
[Record NO. 10], IP Address: 192.168.45.11, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963255
[Record NO. 11], IP Address: 192.168.45.12, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963256
[Record NO. 12], IP Address: 192.168.45.13, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963258
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259

Server sending -> [Record NO. 0], IP Address: 192.168.45.1, MAC Address: 00:16:3E:14:AB:37, Acked: False, Expiration: 2022-04-28T17:02:41.
254731
[Record NO. 1], IP Address: 192.168.45.2, MAC Address: 00:16:3E:51:F8:FB, Acked: False, Expiration: 2022-04-28T17:02:44.285767
[Record NO. 2], IP Address: 192.168.45.3, MAC Address: 00:16:3E:09:EB:14, Acked: False, Expiration: 2022-04-28T17:02:49.047754
[Record NO. 3], IP Address: 192.168.45.4, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963248
[Record NO. 4], IP Address: 192.168.45.5, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963249
[Record NO. 5], IP Address: 192.168.45.6, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963250
[Record NO. 6], IP Address: 192.168.45.7, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963251
[Record NO. 7], IP Address: 192.168.45.8, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963252
[Record NO. 8], IP Address: 192.168.45.9, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963253
[Record NO. 9], IP Address: 192.168.45.10, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963254
[Record NO. 10], IP Address: 192.168.45.11, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963255
[Record NO. 11], IP Address: 192.168.45.12, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963256
[Record NO. 12], IP Address: 192.168.45.13, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963258
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259

$
<F1> Help                         BETA VERSION v2.5                         <Smart Mode>
```

```
student@client1:~/files$ python3 client.py
Client recieved -> OFFER 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.253648
Client sending -> REQUEST 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.253648
Client recieved -> ACKNOWLEDGE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.254731
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select:

$
<F1> Help                         BETA VERSION v2.5                         <Smart Mode>
```

```
student@client2:~/files$ python3 client.py
Client recieved -> OFFER 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:02:44.285393
Client sending -> REQUEST 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:02:44.285393
Client recieved -> ACKNOWLEDGE 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:02:44.285767
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select:
```

```
student@admin:~/files$ python3 admin.py
Client recieved -> OFFER 00:16:3E:09:EB:14 192.168.45.3 2022-04-28T17:02:49.046997
Client sending -> REQUEST 00:16:3E:09:EB:14 192.168.45.3 2022-04-28T17:02:49.046997
Client recieved -> ACKNOWLEDGE 00:16:3E:09:EB:14 192.168.45.3 2022-04-28T17:02:49.047754
IP allocation management options:
0: LIST (Admin Only)
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select: 0
Client sending -> LIST
[Record NO. 0], IP Address: 192.168.45.1, MAC Address: 00:16:3E:14:AB:37, Acked: False, Expiration: 2022-04-28T17:02:41.254731
[Record NO. 1], IP Address: 192.168.45.2, MAC Address: 00:16:3E:51:F8:FB, Acked: False, Expiration: 2022-04-28T17:02:44.285767
[Record NO. 2], IP Address: 192.168.45.3, MAC Address: 00:16:3E:09:EB:14, Acked: False, Expiration: 2022-04-28T17:02:49.047754
[Record NO. 3], IP Address: 192.168.45.4, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963248
[Record NO. 4], IP Address: 192.168.45.5, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963249
[Record NO. 5], IP Address: 192.168.45.6, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963250
[Record NO. 6], IP Address: 192.168.45.7, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963251
[Record NO. 7], IP Address: 192.168.45.8, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963252
[Record NO. 8], IP Address: 192.168.45.9, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963253
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[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259

IP allocation management options:
0: LIST (Admin Only)
1: RELEASE IP
2: RENEW Ip allocation
```
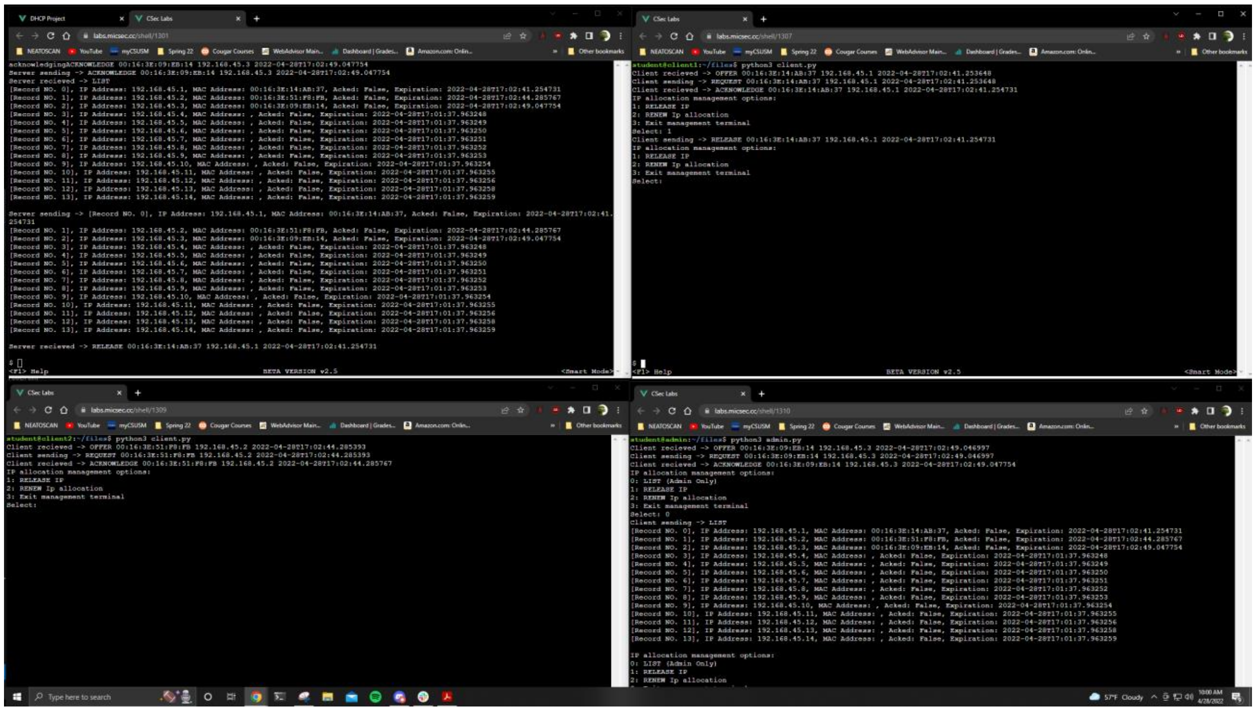

5. Run the admin client on `admin` to display the list of current clients. Make sure that the list contains the 2 current clients.



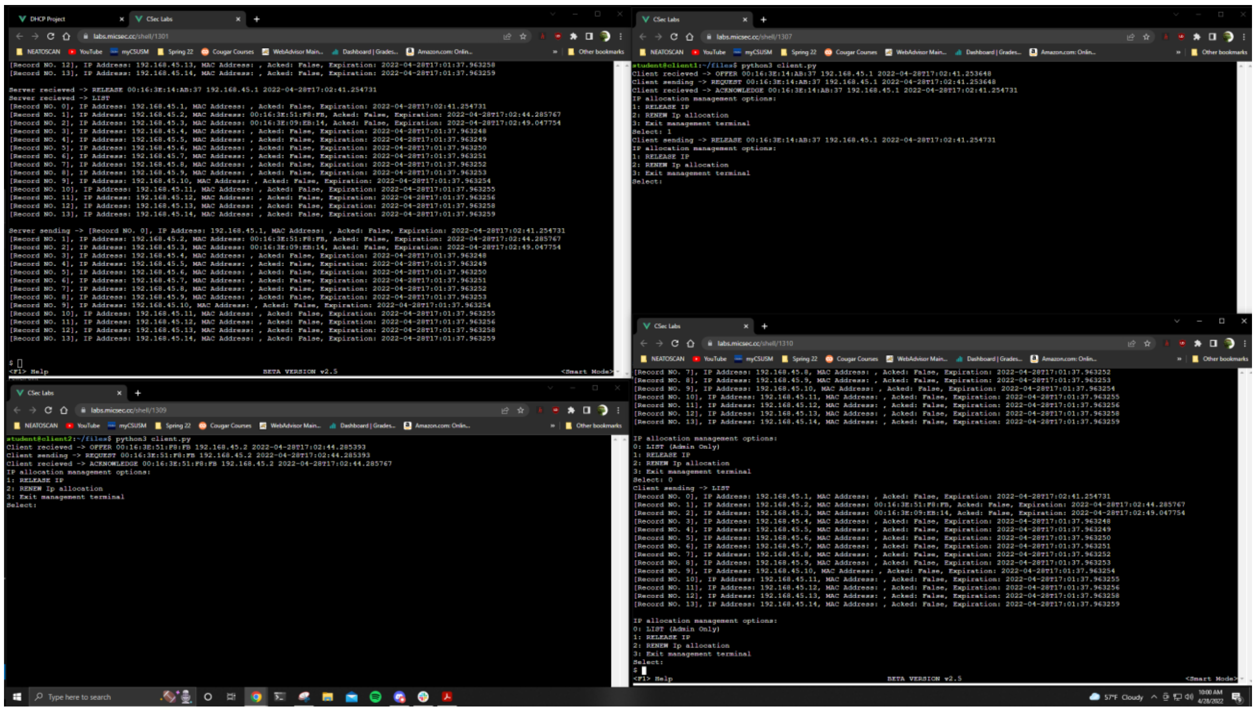
```
acknowledgingACKNOWLEDGE 00:16:3E:09:EB:14 192.168.45.3 2022-04-28T17:02:49.047754
Server sending -> ACKNOWLEDGE 00:16:3E:09:EB:14 192.168.45.3 2022-04-28T17:02:49.047754
Server recieved -> LIST
[Record NO. 0], IP Address: 192.168.45.1, MAC Address: 00:16:3E:14:AB:37, Acked: False, Expiration: 2022-04-28T17:02:41.254731
[Record NO. 1], IP Address: 192.168.45.2, MAC Address: 00:16:3E:51:F8:FB, Acked: False, Expiration: 2022-04-28T17:02:44.285767
[Record NO. 2], IP Address: 192.168.45.3, MAC Address: 00:16:3E:09:EB:14, Acked: False, Expiration: 2022-04-28T17:02:49.047754
[Record NO. 3], IP Address: 192.168.45.4, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963248
[Record NO. 4], IP Address: 192.168.45.5, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963249
[Record NO. 5], IP Address: 192.168.45.6, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963250
[Record NO. 6], IP Address: 192.168.45.7, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963251
[Record NO. 7], IP Address: 192.168.45.8, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963252
[Record NO. 8], IP Address: 192.168.45.9, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963253
[Record NO. 9], IP Address: 192.168.45.10, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963254
[Record NO. 10], IP Address: 192.168.45.11, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963255
[Record NO. 11], IP Address: 192.168.45.12, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963256
[Record NO. 12], IP Address: 192.168.45.13, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963258
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259

Server sending -> [Record NO. 0], IP Address: 192.168.45.1, MAC Address: 00:16:3E:14:AB:37, Acked: False, Expiration: 2022-04-28T17:02:41.
254731
[Record NO. 1], IP Address: 192.168.45.2, MAC Address: 00:16:3E:51:F8:FB, Acked: False, Expiration: 2022-04-28T17:02:44.285767
[Record NO. 2], IP Address: 192.168.45.3, MAC Address: 00:16:3E:09:EB:14, Acked: False, Expiration: 2022-04-28T17:02:49.047754
[Record NO. 3], IP Address: 192.168.45.4, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963248
[Record NO. 4], IP Address: 192.168.45.5, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963249
[Record NO. 5], IP Address: 192.168.45.6, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963250
[Record NO. 6], IP Address: 192.168.45.7, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963251
[Record NO. 7], IP Address: 192.168.45.8, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963252
[Record NO. 8], IP Address: 192.168.45.9, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963253
[Record NO. 9], IP Address: 192.168.45.10, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963254
[Record NO. 10], IP Address: 192.168.45.11, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963255
[Record NO. 11], IP Address: 192.168.45.12, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963256
[Record NO. 12], IP Address: 192.168.45.13, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963258
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259

Server recieved -> RELEASE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.254731

$ 
<F1> Help                                BETA VERSION v2.5                              <Smart Mode>
```

```
student@client1:~/files$ python3 client.py
Client recieved -> OFFER 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.253648
Client sending -> REQUEST 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.253648
Client recieved -> ACKNOWLEDGE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.254731
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select: 1
Client sending -> RELEASE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.254731
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select:

$ 
<F1> Help                                BETA VERSION v2.5                              <Smart Mode>
```

```
student@client2:~/files$ python3 client.py
Client recieved -> OFFER 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:02:44.285393
Client sending -> REQUEST 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:02:44.285393
Client recieved -> ACKNOWLEDGE 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:02:44.285767
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select:
```

```
student@admin:~/files$ python3 admin.py
Client recieved -> OFFER 00:16:3E:09:EB:14 192.168.45.3 2022-04-28T17:02:49.046997
Client sending -> REQUEST 00:16:3E:09:EB:14 192.168.45.3 2022-04-28T17:02:49.046997
Client recieved -> ACKNOWLEDGE 00:16:3E:09:EB:14 192.168.45.3 2022-04-28T17:02:49.047754
IP allocation management options:
0: LIST (Admin Only)
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select: 0
Client sending -> LIST
[Record NO. 0], IP Address: 192.168.45.1, MAC Address: 00:16:3E:14:AB:37, Acked: False, Expiration: 2022-04-28T17:02:41.254731
[Record NO. 1], IP Address: 192.168.45.2, MAC Address: 00:16:3E:51:F8:FB, Acked: False, Expiration: 2022-04-28T17:02:44.285767
[Record NO. 2], IP Address: 192.168.45.3, MAC Address: 00:16:3E:09:EB:14, Acked: False, Expiration: 2022-04-28T17:02:49.047754
[Record NO. 3], IP Address: 192.168.45.4, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963248
[Record NO. 4], IP Address: 192.168.45.5, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963249
[Record NO. 5], IP Address: 192.168.45.6, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963250
[Record NO. 6], IP Address: 192.168.45.7, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963251
[Record NO. 7], IP Address: 192.168.45.8, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963252
[Record NO. 8], IP Address: 192.168.45.9, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963253
[Record NO. 9], IP Address: 192.168.45.10, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963254
[Record NO. 10], IP Address: 192.168.45.11, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963255
[Record NO. 11], IP Address: 192.168.45.12, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963256
[Record NO. 12], IP Address: 192.168.45.13, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963258
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259

IP allocation management options:
0: LIST (Admin Only)
1: RELEASE IP
2: RENEW Ip allocation
```

6. On `client1`, choose **release**. `client1` will display a proper message and the menu. Make sure that the server has released the client's IP address. The server should display a message on the screen indicating that.



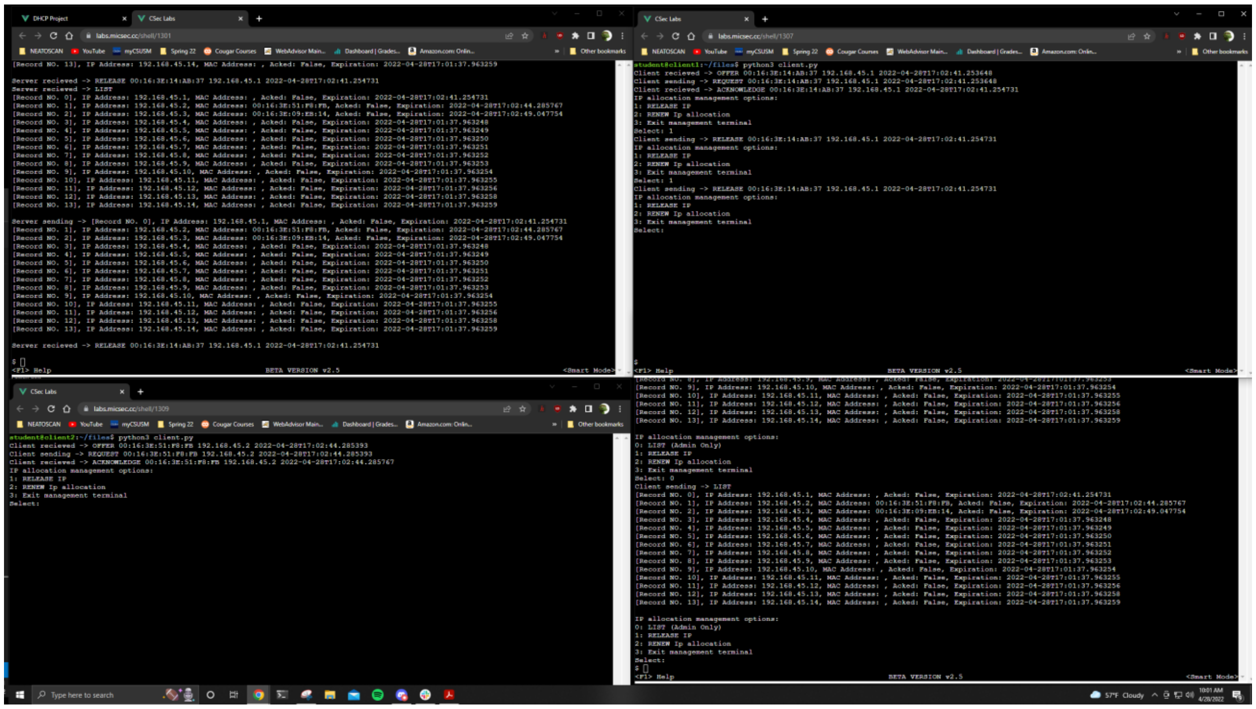
```
[Record NO. 12], IP Address: 192.168.45.13, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963258
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259

Server recieved -> RELEASE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.254731
Server recieved -> LIST
[Record NO. 0], IP Address: 192.168.45.1, MAC Address: , Acked: False, Expiration: 2022-04-28T17:02:41.254731
[Record NO. 1], IP Address: 192.168.45.2, MAC Address: 00:16:3E:51:F8:FB, Acked: False, Expiration: 2022-04-28T17:02:44.285767
[Record NO. 2], IP Address: 192.168.45.3, MAC Address: 00:16:3E:09:EB:14, Acked: False, Expiration: 2022-04-28T17:02:49.047754
[Record NO. 3], IP Address: 192.168.45.4, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963248
[Record NO. 4], IP Address: 192.168.45.5, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963249
[Record NO. 5], IP Address: 192.168.45.6, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963250
[Record NO. 6], IP Address: 192.168.45.7, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963251
[Record NO. 7], IP Address: 192.168.45.8, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963252
[Record NO. 8], IP Address: 192.168.45.9, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963253
[Record NO. 9], IP Address: 192.168.45.10, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963254
[Record NO. 10], IP Address: 192.168.45.11, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963255
[Record NO. 11], IP Address: 192.168.45.12, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963256
[Record NO. 12], IP Address: 192.168.45.13, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963258
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259

Server sending -> [Record NO. 0], IP Address: 192.168.45.1, MAC Address: , Acked: False, Expiration: 2022-04-28T17:02:41.254731
[Record NO. 1], IP Address: 192.168.45.2, MAC Address: 00:16:3E:51:F8:FB, Acked: False, Expiration: 2022-04-28T17:02:44.285767
[Record NO. 2], IP Address: 192.168.45.3, MAC Address: 00:16:3E:09:EB:14, Acked: False, Expiration: 2022-04-28T17:02:49.047754
[Record NO. 3], IP Address: 192.168.45.4, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963248
[Record NO. 4], IP Address: 192.168.45.5, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963249
[Record NO. 5], IP Address: 192.168.45.6, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963250
[Record NO. 6], IP Address: 192.168.45.7, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963251
[Record NO. 7], IP Address: 192.168.45.8, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963252
[Record NO. 8], IP Address: 192.168.45.9, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963253
[Record NO. 9], IP Address: 192.168.45.10, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963254
[Record NO. 10], IP Address: 192.168.45.11, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963255
[Record NO. 11], IP Address: 192.168.45.12, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963256
[Record NO. 12], IP Address: 192.168.45.13, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963258
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259


$ 
<F1> Help                                   BETA VERSION v2.5                                   <Smart Mode>
```

```
student@client1:~/files$ python3 client.py
Client recieved -> OFFER 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.253648
Client sending -> REQUEST 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.253648
Client recieved -> ACKNOWLEDGE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.254731
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select: 1
Client sending -> RELEASE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.254731
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select:
```

```
student@client2:~/files$ python3 client.py
Client recieved -> OFFER 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:02:44.285393
Client sending -> REQUEST 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:02:44.285393
Client recieved -> ACKNOWLEDGE 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:02:44.285767
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select:
```

```
[Record NO. 7], IP Address: 192.168.45.8, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963252
[Record NO. 8], IP Address: 192.168.45.9, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963253
[Record NO. 9], IP Address: 192.168.45.10, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963254
[Record NO. 10], IP Address: 192.168.45.11, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963255
[Record NO. 11], IP Address: 192.168.45.12, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963256
[Record NO. 12], IP Address: 192.168.45.13, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963258
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259

IP allocation management options:
0: LIST (Admin Only)
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select: 0
Client sending -> LIST
[Record NO. 0], IP Address: 192.168.45.1, MAC Address: , Acked: False, Expiration: 2022-04-28T17:02:41.254731
[Record NO. 1], IP Address: 192.168.45.2, MAC Address: 00:16:3E:51:F8:FB, Acked: False, Expiration: 2022-04-28T17:02:44.285767
[Record NO. 2], IP Address: 192.168.45.3, MAC Address: 00:16:3E:09:EB:14, Acked: False, Expiration: 2022-04-28T17:02:49.047754
[Record NO. 3], IP Address: 192.168.45.4, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963248
[Record NO. 4], IP Address: 192.168.45.5, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963249
[Record NO. 5], IP Address: 192.168.45.6, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963250
[Record NO. 6], IP Address: 192.168.45.7, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963251
[Record NO. 7], IP Address: 192.168.45.8, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963252
[Record NO. 8], IP Address: 192.168.45.9, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963253
[Record NO. 9], IP Address: 192.168.45.10, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963254
[Record NO. 10], IP Address: 192.168.45.11, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963255
[Record NO. 11], IP Address: 192.168.45.12, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963256
[Record NO. 12], IP Address: 192.168.45.13, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963258
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259

IP allocation management options:
0: LIST (Admin Only)
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select:
$ 
<F1> Help                                   BETA VERSION v2.5                                   <Smart Mode>
```

7. Run the admin client on `admin` to display the list of current clients. Make sure that the list contains only `client2`.



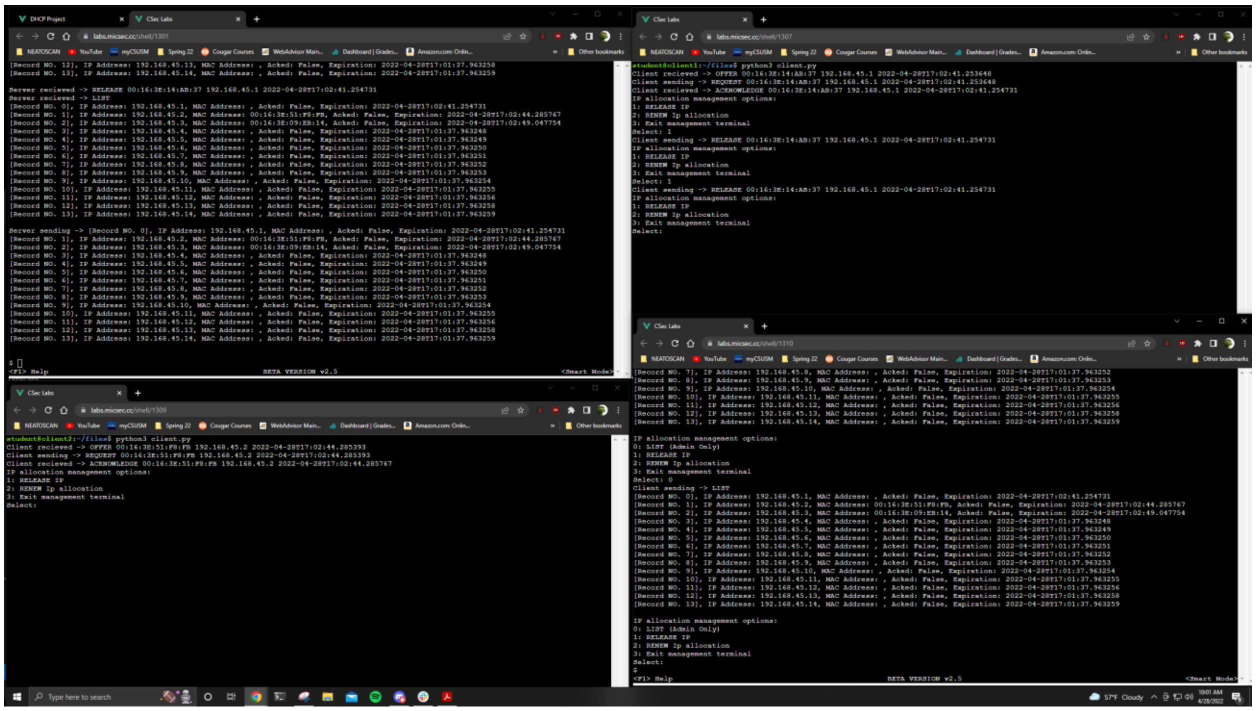
```
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259

Server recieved -> RELEASE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.254731
Server recieved -> LIST
[Record NO. 0], IP Address: 192.168.45.1, MAC Address: , Acked: False, Expiration: 2022-04-28T17:02:41.254731
[Record NO. 1], IP Address: 192.168.45.2, MAC Address: 00:16:3E:51:F8:FB, Acked: False, Expiration: 2022-04-28T17:02:44.285767
[Record NO. 2], IP Address: 192.168.45.3, MAC Address: 00:16:3E:09:EB:14, Acked: False, Expiration: 2022-04-28T17:02:49.047754
[Record NO. 3], IP Address: 192.168.45.4, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963248
[Record NO. 4], IP Address: 192.168.45.5, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963249
[Record NO. 5], IP Address: 192.168.45.6, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963250
[Record NO. 6], IP Address: 192.168.45.7, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963251
[Record NO. 7], IP Address: 192.168.45.8, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963252
[Record NO. 8], IP Address: 192.168.45.9, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963253
[Record NO. 9], IP Address: 192.168.45.10, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963254
[Record NO. 10], IP Address: 192.168.45.11, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963255
[Record NO. 11], IP Address: 192.168.45.12, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963256
[Record NO. 12], IP Address: 192.168.45.13, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963258
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259

Server sending -> [Record NO. 0], IP Address: 192.168.45.1, MAC Address: , Acked: False, Expiration: 2022-04-28T17:02:41.254731
[Record NO. 1], IP Address: 192.168.45.2, MAC Address: 00:16:3E:51:F8:FB, Acked: False, Expiration: 2022-04-28T17:02:44.285767
[Record NO. 2], IP Address: 192.168.45.3, MAC Address: 00:16:3E:09:EB:14, Acked: False, Expiration: 2022-04-28T17:02:49.047754
[Record NO. 3], IP Address: 192.168.45.4, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963248
[Record NO. 4], IP Address: 192.168.45.5, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963249
[Record NO. 5], IP Address: 192.168.45.6, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963250
[Record NO. 6], IP Address: 192.168.45.7, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963251
[Record NO. 7], IP Address: 192.168.45.8, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963252
[Record NO. 8], IP Address: 192.168.45.9, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963253
[Record NO. 9], IP Address: 192.168.45.10, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963254
[Record NO. 10], IP Address: 192.168.45.11, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963255
[Record NO. 11], IP Address: 192.168.45.12, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963256
[Record NO. 12], IP Address: 192.168.45.13, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963258
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259

Server recieved -> RELEASE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.254731

$
<F1> Help                         BETA VERSION v2.5                         <Smart Mode>
```

```
student@client1:~/files$ python3 client.py
Client recieved -> OFFER 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.253648
Client sending -> REQUEST 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.253648
Client recieved -> ACKNOWLEDGE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.254731
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select: 1
Client sending -> RELEASE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.254731
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select: 1
Client sending -> RELEASE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.254731
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select:

$
<F1> Help                         BETA VERSION v2.5                         <Smart Mode>
```

```
student@client2:~/files$ python3 client.py
Client recieved -> OFFER 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:02:44.285393
Client sending -> REQUEST 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:02:44.285393
Client recieved -> ACKNOWLEDGE 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:02:44.285767
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select:
```

```
[Record NO. 8], IP Address: 192.168.45.9, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963253
[Record NO. 9], IP Address: 192.168.45.10, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963254
[Record NO. 10], IP Address: 192.168.45.11, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963255
[Record NO. 11], IP Address: 192.168.45.12, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963256
[Record NO. 12], IP Address: 192.168.45.13, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963258
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259

IP allocation management options:
0: LIST (Admin Only)
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select: 0
Client sending -> LIST
[Record NO. 0], IP Address: 192.168.45.1, MAC Address: , Acked: False, Expiration: 2022-04-28T17:02:41.254731
[Record NO. 1], IP Address: 192.168.45.2, MAC Address: 00:16:3E:51:F8:FB, Acked: False, Expiration: 2022-04-28T17:02:44.285767
[Record NO. 2], IP Address: 192.168.45.3, MAC Address: 00:16:3E:09:EB:14, Acked: False, Expiration: 2022-04-28T17:02:49.047754
[Record NO. 3], IP Address: 192.168.45.4, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963248
[Record NO. 4], IP Address: 192.168.45.5, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963249
[Record NO. 5], IP Address: 192.168.45.6, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963250
[Record NO. 6], IP Address: 192.168.45.7, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963251
[Record NO. 7], IP Address: 192.168.45.8, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963252
[Record NO. 8], IP Address: 192.168.45.9, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963253
[Record NO. 9], IP Address: 192.168.45.10, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963254
[Record NO. 10], IP Address: 192.168.45.11, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963255
[Record NO. 11], IP Address: 192.168.45.12, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963256
[Record NO. 12], IP Address: 192.168.45.13, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963258
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259

IP allocation management options:
0: LIST (Admin Only)
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select:
$
<F1> Help                         BETA VERSION v2.5                         <Smart Mode>
```

8. On `client1` , again choose release. `Client1` will display a proper message and the menu. Make sure that the server verifies that the IP address has already been released. The server should display a message on the screen indicating that.



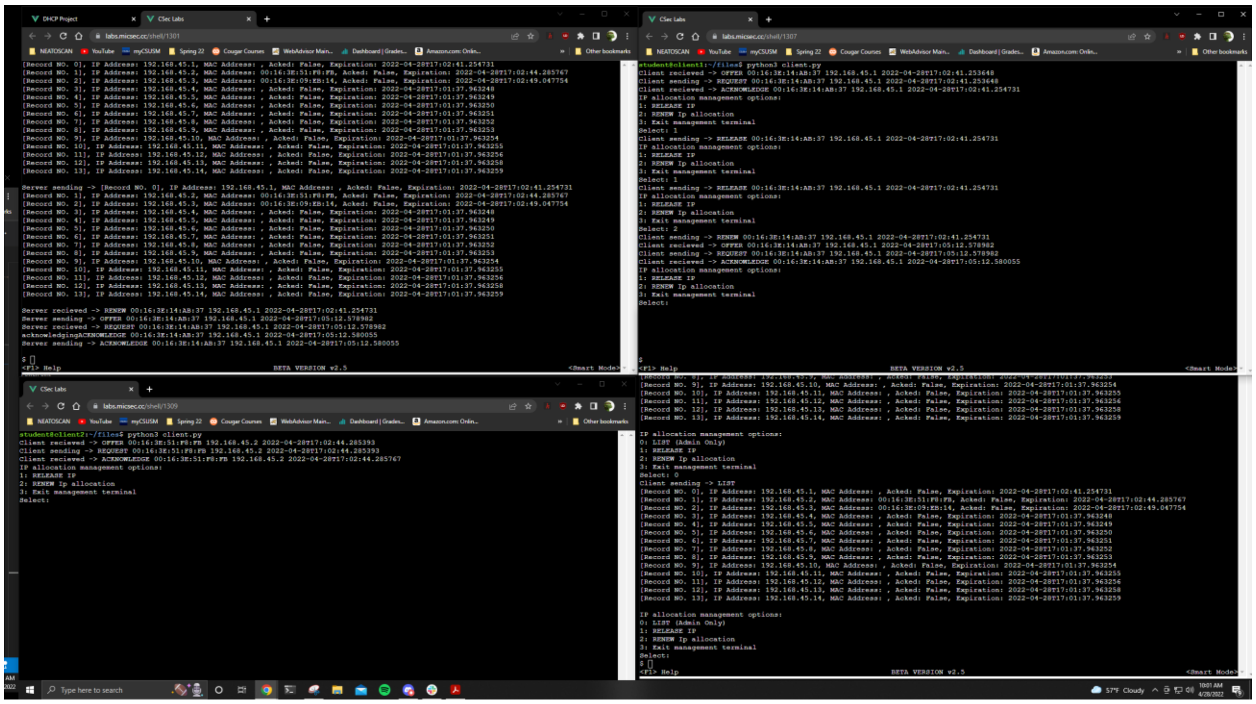
```
[Record NO. 12], IP Address: 192.168.45.13, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963258
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259

Server recieved -> RELEASE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.254731
Server recieved -> LIST
[Record NO. 0], IP Address: 192.168.45.1, MAC Address: , Acked: False, Expiration: 2022-04-28T17:02:41.254731
[Record NO. 1], IP Address: 192.168.45.2, MAC Address: 00:16:3E:51:F8:FB, Acked: False, Expiration: 2022-04-28T17:02:44.285767
[Record NO. 2], IP Address: 192.168.45.3, MAC Address: 00:16:3E:09:EB:14, Acked: False, Expiration: 2022-04-28T17:02:49.047754
[Record NO. 3], IP Address: 192.168.45.4, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963248
[Record NO. 4], IP Address: 192.168.45.5, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963249
[Record NO. 5], IP Address: 192.168.45.6, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963250
[Record NO. 6], IP Address: 192.168.45.7, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963251
[Record NO. 7], IP Address: 192.168.45.8, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963252
[Record NO. 8], IP Address: 192.168.45.9, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963253
[Record NO. 9], IP Address: 192.168.45.10, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963254
[Record NO. 10], IP Address: 192.168.45.11, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963255
[Record NO. 11], IP Address: 192.168.45.12, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963256
[Record NO. 12], IP Address: 192.168.45.13, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963258
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259

Server sending -> [Record NO. 0], IP Address: 192.168.45.1, MAC Address: , Acked: False, Expiration: 2022-04-28T17:02:41.254731
[Record NO. 1], IP Address: 192.168.45.2, MAC Address: 00:16:3E:51:F8:FB, Acked: False, Expiration: 2022-04-28T17:02:44.285767
[Record NO. 2], IP Address: 192.168.45.3, MAC Address: 00:16:3E:09:EB:14, Acked: False, Expiration: 2022-04-28T17:02:49.047754
[Record NO. 3], IP Address: 192.168.45.4, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963248
[Record NO. 4], IP Address: 192.168.45.5, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963249
[Record NO. 5], IP Address: 192.168.45.6, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963250
[Record NO. 6], IP Address: 192.168.45.7, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963251
[Record NO. 7], IP Address: 192.168.45.8, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963252
[Record NO. 8], IP Address: 192.168.45.9, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963253
[Record NO. 9], IP Address: 192.168.45.10, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963254
[Record NO. 10], IP Address: 192.168.45.11, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963255
[Record NO. 11], IP Address: 192.168.45.12, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963256
[Record NO. 12], IP Address: 192.168.45.13, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963258
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259


$
<F1> Help                                BETA VERSION v2.5                                <Smart Mode>
```

```
student@client1:~/files$ python3 client.py
Client recieved -> OFFER 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.253648
Client sending -> REQUEST 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.253648
Client recieved -> ACKNOWLEDGE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.254731
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select: 1
Client sending -> RELEASE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.254731
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select: 1
Client sending -> RELEASE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.254731
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select:
```

```
student@client2:~/files$ python3 client.py
Client recieved -> OFFER 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:02:44.285393
Client sending -> REQUEST 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:02:44.285393
Client recieved -> ACKNOWLEDGE 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:02:44.285767
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select:
```

```
[Record NO. 7], IP Address: 192.168.45.8, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963252
[Record NO. 8], IP Address: 192.168.45.9, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963253
[Record NO. 9], IP Address: 192.168.45.10, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963254
[Record NO. 10], IP Address: 192.168.45.11, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963255
[Record NO. 11], IP Address: 192.168.45.12, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963256
[Record NO. 12], IP Address: 192.168.45.13, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963258
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259

IP allocation management options:
0: LIST (Admin Only)
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select: 0
Client sending -> LIST
[Record NO. 0], IP Address: 192.168.45.1, MAC Address: , Acked: False, Expiration: 2022-04-28T17:02:41.254731
[Record NO. 1], IP Address: 192.168.45.2, MAC Address: 00:16:3E:51:F8:FB, Acked: False, Expiration: 2022-04-28T17:02:44.285767
[Record NO. 2], IP Address: 192.168.45.3, MAC Address: 00:16:3E:09:EB:14, Acked: False, Expiration: 2022-04-28T17:02:49.047754
[Record NO. 3], IP Address: 192.168.45.4, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963248
[Record NO. 4], IP Address: 192.168.45.5, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963249
[Record NO. 5], IP Address: 192.168.45.6, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963250
[Record NO. 6], IP Address: 192.168.45.7, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963251
[Record NO. 7], IP Address: 192.168.45.8, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963252
[Record NO. 8], IP Address: 192.168.45.9, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963253
[Record NO. 9], IP Address: 192.168.45.10, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963254
[Record NO. 10], IP Address: 192.168.45.11, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963255
[Record NO. 11], IP Address: 192.168.45.12, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963256
[Record NO. 12], IP Address: 192.168.45.13, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963258
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259

IP allocation management options:
0: LIST (Admin Only)
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select:
$
<F1> Help                                BETA VERSION v2.5                                <Smart Mode>
```

9. Run the admin client on `admin` to display the list of current clients. Make sure that the list contains only the client on `client2`.



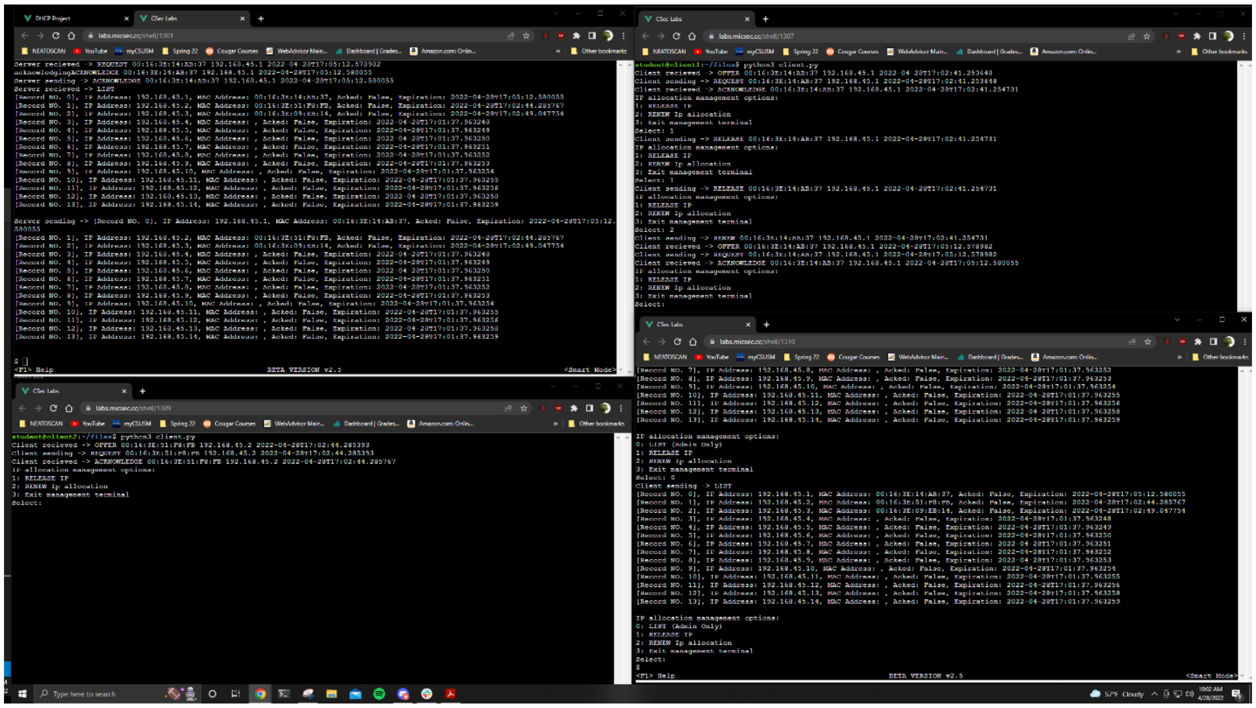
```
[Record NO. 0], IP Address: 192.168.45.1, MAC Address: , Acked: False, Expiration: 2022-04-28T17:02:41.254731
[Record NO. 1], IP Address: 192.168.45.2, MAC Address: 00:16:3E:51:F8:FB, Acked: False, Expiration: 2022-04-28T17:02:44.285767
[Record NO. 2], IP Address: 192.168.45.3, MAC Address: 00:16:3E:09:EB:14, Acked: False, Expiration: 2022-04-28T17:02:49.047754
[Record NO. 3], IP Address: 192.168.45.4, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963248
[Record NO. 4], IP Address: 192.168.45.5, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963249
[Record NO. 5], IP Address: 192.168.45.6, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963250
[Record NO. 6], IP Address: 192.168.45.7, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963251
[Record NO. 7], IP Address: 192.168.45.8, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963252
[Record NO. 8], IP Address: 192.168.45.9, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963253
[Record NO. 9], IP Address: 192.168.45.10, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963254
[Record NO. 10], IP Address: 192.168.45.11, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963255
[Record NO. 11], IP Address: 192.168.45.12, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963256
[Record NO. 12], IP Address: 192.168.45.13, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963258
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259

Server sending -> [Record NO. 0], IP Address: 192.168.45.1, MAC Address: , Acked: False, Expiration: 2022-04-28T17:02:41.254731
[Record NO. 1], IP Address: 192.168.45.2, MAC Address: 00:16:3E:51:F8:FB, Acked: False, Expiration: 2022-04-28T17:02:44.285767
[Record NO. 2], IP Address: 192.168.45.3, MAC Address: 00:16:3E:09:EB:14, Acked: False, Expiration: 2022-04-28T17:02:49.047754
[Record NO. 3], IP Address: 192.168.45.4, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963248
[Record NO. 4], IP Address: 192.168.45.5, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963249
[Record NO. 5], IP Address: 192.168.45.6, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963250
[Record NO. 6], IP Address: 192.168.45.7, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963251
[Record NO. 7], IP Address: 192.168.45.8, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963252
[Record NO. 8], IP Address: 192.168.45.9, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963253
[Record NO. 9], IP Address: 192.168.45.10, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963254
[Record NO. 10], IP Address: 192.168.45.11, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963255
[Record NO. 11], IP Address: 192.168.45.12, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963256
[Record NO. 12], IP Address: 192.168.45.13, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963258
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259

Server recieved -> RENEW 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.254731
Server sending -> OFFER 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:05:12.578982
Server recieved -> REQUEST 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:05:12.578982
acknowledgingACKNOWLEDGE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:05:12.580055
Server sending -> ACKNOWLEDGE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:05:12.580055

$ 
<F1> Help                                   BETA VERSION v2.5                                   <Smart Mode>
```

```
student@client1:~/files$ python3 client.py
Client recieved -> OFFER 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.253648
Client sending -> REQUEST 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.253648
Client recieved -> ACKNOWLEDGE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.254731
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select: 1
Client sending -> RELEASE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.254731
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select: 1
Client sending -> RELEASE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.254731
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select: 2
Client sending -> RENEW 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.254731
Client recieved -> OFFER 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:05:12.578982
Client sending -> REQUEST 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:05:12.578982
Client recieved -> ACKNOWLEDGE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:05:12.580055
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select:

$
<F1> Help                                   BETA VERSION v2.5                                   <Smart Mode>
```

```
student@client2:~/files$ python3 client.py
Client recieved -> OFFER 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:02:44.285393
Client sending -> REQUEST 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:02:44.285393
Client recieved -> ACKNOWLEDGE 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:02:44.285767
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select:
```

```
[Record NO. 9], IP Address: 192.168.45.10, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963254
[Record NO. 10], IP Address: 192.168.45.11, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963255
[Record NO. 11], IP Address: 192.168.45.12, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963256
[Record NO. 12], IP Address: 192.168.45.13, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963258
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259

IP allocation management options:
0: LIST (Admin Only)
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select: 0
Client sending -> LIST
[Record NO. 0], IP Address: 192.168.45.1, MAC Address: , Acked: False, Expiration: 2022-04-28T17:02:41.254731
[Record NO. 1], IP Address: 192.168.45.2, MAC Address: 00:16:3E:51:F8:FB, Acked: False, Expiration: 2022-04-28T17:02:44.285767
[Record NO. 2], IP Address: 192.168.45.3, MAC Address: 00:16:3E:09:EB:14, Acked: False, Expiration: 2022-04-28T17:02:49.047754
[Record NO. 3], IP Address: 192.168.45.4, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963248
[Record NO. 4], IP Address: 192.168.45.5, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963249
[Record NO. 5], IP Address: 192.168.45.6, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963250
[Record NO. 6], IP Address: 192.168.45.7, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963251
[Record NO. 7], IP Address: 192.168.45.8, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963252
[Record NO. 8], IP Address: 192.168.45.9, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963253
[Record NO. 9], IP Address: 192.168.45.10, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963254
[Record NO. 10], IP Address: 192.168.45.11, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963255
[Record NO. 11], IP Address: 192.168.45.12, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963256
[Record NO. 12], IP Address: 192.168.45.13, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963258
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259

IP allocation management options:
0: LIST (Admin Only)
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select:
$ 
<F1> Help                                   BETA VERSION v2.5                                   <Smart Mode>
```

10. On `client1` , choose renew. Make sure that the server assigns the same IP address as before to `client1` and replies to the client. The server should display a message on the screen indicating that. Then `client1` displays a proper message and the menu. Choose quit.



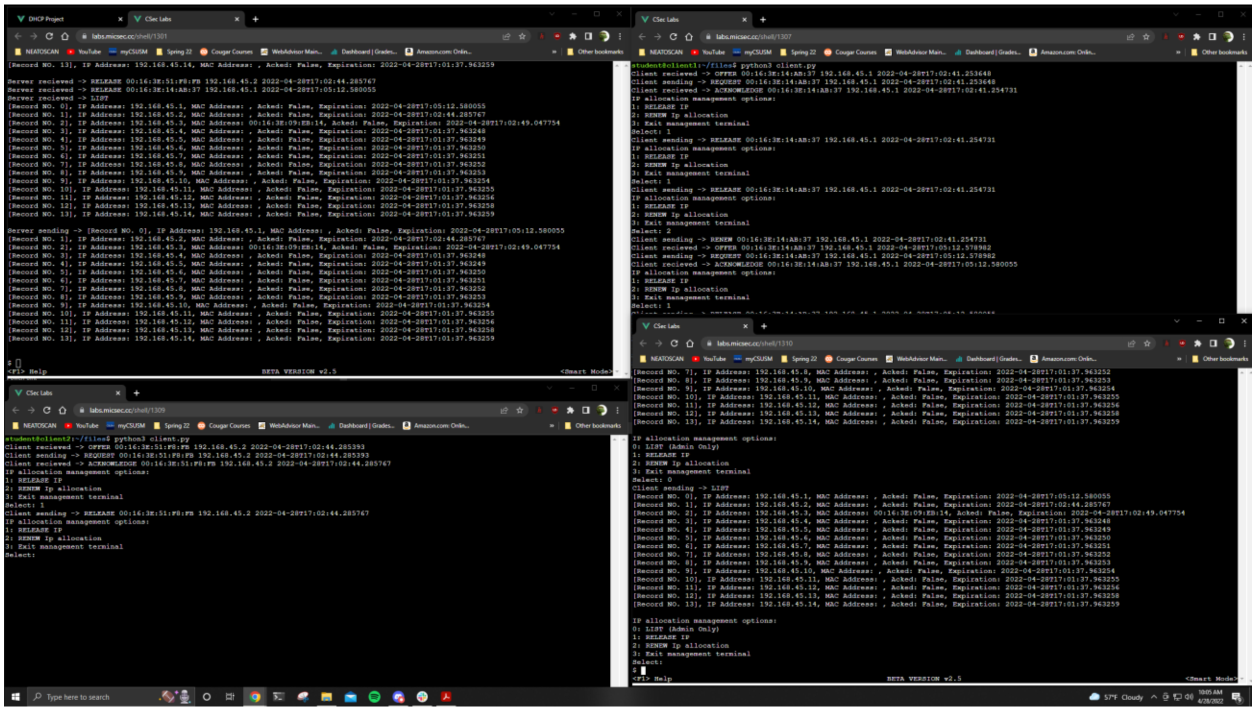
```
Server recieved -> REQUEST 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:05:12.578982
acknowledgingACKNOWLEDGE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:05:12.580055
Server sending -> ACKNOWLEDGE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:05:12.580055
Server recieved -> LIST
[Record NO. 0], IP Address: 192.168.45.1, MAC Address: 00:16:3E:14:AB:37, Acked: False, Expiration: 2022-04-28T17:05:12.580055
[Record NO. 1], IP Address: 192.168.45.2, MAC Address: 00:16:3E:51:F8:FB, Acked: False, Expiration: 2022-04-28T17:02:44.285767
[Record NO. 2], IP Address: 192.168.45.3, MAC Address: 00:16:3E:09:EB:14, Acked: False, Expiration: 2022-04-28T17:02:49.047754
[Record NO. 3], IP Address: 192.168.45.4, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963248
[Record NO. 4], IP Address: 192.168.45.5, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963249
[Record NO. 5], IP Address: 192.168.45.6, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963250
[Record NO. 6], IP Address: 192.168.45.7, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963251
[Record NO. 7], IP Address: 192.168.45.8, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963252
[Record NO. 8], IP Address: 192.168.45.9, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963253
[Record NO. 9], IP Address: 192.168.45.10, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963254
[Record NO. 10], IP Address: 192.168.45.11, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963255
[Record NO. 11], IP Address: 192.168.45.12, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963256
[Record NO. 12], IP Address: 192.168.45.13, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963258
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259

Server sending -> [Record NO. 0], IP Address: 192.168.45.1, MAC Address: 00:16:3E:14:AB:37, Acked: False, Expiration: 2022-04-28T17:05:12.
580055
[Record NO. 1], IP Address: 192.168.45.2, MAC Address: 00:16:3E:51:F8:FB, Acked: False, Expiration: 2022-04-28T17:02:44.285767
[Record NO. 2], IP Address: 192.168.45.3, MAC Address: 00:16:3E:09:EB:14, Acked: False, Expiration: 2022-04-28T17:02:49.047754
[Record NO. 3], IP Address: 192.168.45.4, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963248
[Record NO. 4], IP Address: 192.168.45.5, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963249
[Record NO. 5], IP Address: 192.168.45.6, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963250
[Record NO. 6], IP Address: 192.168.45.7, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963251
[Record NO. 7], IP Address: 192.168.45.8, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963252
[Record NO. 8], IP Address: 192.168.45.9, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963253
[Record NO. 9], IP Address: 192.168.45.10, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963254
[Record NO. 10], IP Address: 192.168.45.11, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963255
[Record NO. 11], IP Address: 192.168.45.12, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963256
[Record NO. 12], IP Address: 192.168.45.13, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963258
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259


$ 
<F1> Help                                   BETA VERSION v2.5                                   <Smart Mode>
```

```
student@client1:~/files$ python3 client.py
Client recieved -> OFFER 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.253648
Client sending -> REQUEST 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.253648
Client recieved -> ACKNOWLEDGE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.254731
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select: 1
Client sending -> RELEASE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.254731
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select: 1
Client sending -> RELEASE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.254731
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select: 2
Client sending -> RENEW 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.254731
Client recieved -> OFFER 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:05:12.578982
Client sending -> REQUEST 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:05:12.578982
Client recieved -> ACKNOWLEDGE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:05:12.580055
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select:
```

```
student@client2:~/files$ python3 client.py
Client recieved -> OFFER 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:02:44.285393
Client sending -> REQUEST 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:02:44.285393
Client recieved -> ACKNOWLEDGE 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:02:44.285767
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select:
```

```
[Record NO. 7], IP Address: 192.168.45.8, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963252
[Record NO. 8], IP Address: 192.168.45.9, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963253
[Record NO. 9], IP Address: 192.168.45.10, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963254
[Record NO. 10], IP Address: 192.168.45.11, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963255
[Record NO. 11], IP Address: 192.168.45.12, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963256
[Record NO. 12], IP Address: 192.168.45.13, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963258
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259

IP allocation management options:
0: LIST (Admin Only)
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select: 0
Client sending -> LIST
[Record NO. 0], IP Address: 192.168.45.1, MAC Address: 00:16:3E:14:AB:37, Acked: False, Expiration: 2022-04-28T17:05:12.580055
[Record NO. 1], IP Address: 192.168.45.2, MAC Address: 00:16:3E:51:F8:FB, Acked: False, Expiration: 2022-04-28T17:02:44.285767
[Record NO. 2], IP Address: 192.168.45.3, MAC Address: 00:16:3E:09:EB:14, Acked: False, Expiration: 2022-04-28T17:02:49.047754
[Record NO. 3], IP Address: 192.168.45.4, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963248
[Record NO. 4], IP Address: 192.168.45.5, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963249
[Record NO. 5], IP Address: 192.168.45.6, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963250
[Record NO. 6], IP Address: 192.168.45.7, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963251
[Record NO. 7], IP Address: 192.168.45.8, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963252
[Record NO. 8], IP Address: 192.168.45.9, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963253
[Record NO. 9], IP Address: 192.168.45.10, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963254
[Record NO. 10], IP Address: 192.168.45.11, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963255
[Record NO. 11], IP Address: 192.168.45.12, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963256
[Record NO. 12], IP Address: 192.168.45.13, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963258
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259

IP allocation management options:
0: LIST (Admin Only)
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select:
$
<F1> Help                                   BETA VERSION v2.5                                   <Smart Mode>
```

11. Run the admin client on `admin` to display the list of current clients. Make sure that the list contains the 2 current clients.



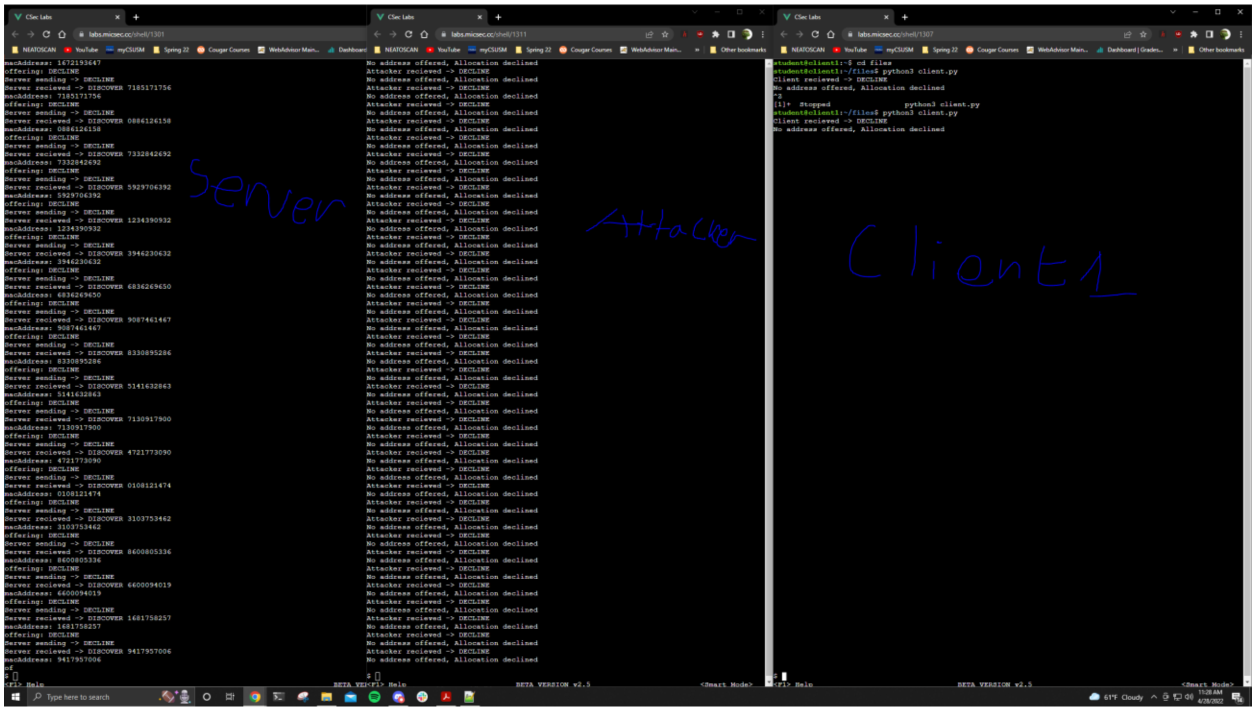
```
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259

Server recieved -> RELEASE 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:02:44.285767
Server recieved -> RELEASE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:05:12.580055
Server recieved -> LIST
[Record NO. 0], IP Address: 192.168.45.1, MAC Address: , Acked: False, Expiration: 2022-04-28T17:05:12.580055
[Record NO. 1], IP Address: 192.168.45.2, MAC Address: , Acked: False, Expiration: 2022-04-28T17:02:44.285767
[Record NO. 2], IP Address: 192.168.45.3, MAC Address: 00:16:3E:09:EB:14, Acked: False, Expiration: 2022-04-28T17:02:49.047754
[Record NO. 3], IP Address: 192.168.45.4, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963248
[Record NO. 4], IP Address: 192.168.45.5, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963249
[Record NO. 5], IP Address: 192.168.45.6, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963250
[Record NO. 6], IP Address: 192.168.45.7, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963251
[Record NO. 7], IP Address: 192.168.45.8, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963252
[Record NO. 8], IP Address: 192.168.45.9, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963253
[Record NO. 9], IP Address: 192.168.45.10, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963254
[Record NO. 10], IP Address: 192.168.45.11, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963255
[Record NO. 11], IP Address: 192.168.45.12, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963256
[Record NO. 12], IP Address: 192.168.45.13, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963258
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259

Server sending -> [Record NO. 0], IP Address: 192.168.45.1, MAC Address: , Acked: False, Expiration: 2022-04-28T17:05:12.580055
[Record NO. 1], IP Address: 192.168.45.2, MAC Address: , Acked: False, Expiration: 2022-04-28T17:02:44.285767
[Record NO. 2], IP Address: 192.168.45.3, MAC Address: 00:16:3E:09:EB:14, Acked: False, Expiration: 2022-04-28T17:02:49.047754
[Record NO. 3], IP Address: 192.168.45.4, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963248
[Record NO. 4], IP Address: 192.168.45.5, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963249
[Record NO. 5], IP Address: 192.168.45.6, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963250
[Record NO. 6], IP Address: 192.168.45.7, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963251
[Record NO. 7], IP Address: 192.168.45.8, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963252
[Record NO. 8], IP Address: 192.168.45.9, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963253
[Record NO. 9], IP Address: 192.168.45.10, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963254
[Record NO. 10], IP Address: 192.168.45.11, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963255
[Record NO. 11], IP Address: 192.168.45.12, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963256
[Record NO. 12], IP Address: 192.168.45.13, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963258
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259


$
<F1> Help                                   BETA VERSION v2.5                                   <Smart Mode>
```

```
student@client1:~/files$ python3 client.py
Client recieved -> OFFER 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.253648
Client sending -> REQUEST 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.253648
Client recieved -> ACKNOWLEDGE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.254731
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select: 1
Client sending -> RELEASE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.254731
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select: 1
Client sending -> RELEASE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.254731
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select: 2
Client sending -> RENEW 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:02:41.254731
Client recieved -> OFFER 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:05:12.578982
Client sending -> REQUEST 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:05:12.578982
Client recieved -> ACKNOWLEDGE 00:16:3E:14:AB:37 192.168.45.1 2022-04-28T17:05:12.580055
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select: 1
```

```
student@client2:~/files$ python3 client.py
Client recieved -> OFFER 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:02:44.285393
Client sending -> REQUEST 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:02:44.285393
Client recieved -> ACKNOWLEDGE 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:02:44.285767
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select: 1
Client sending -> RELEASE 00:16:3E:51:F8:FB 192.168.45.2 2022-04-28T17:02:44.285767
IP allocation management options:
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select:
```

```
[Record NO. 7], IP Address: 192.168.45.8, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963252
[Record NO. 8], IP Address: 192.168.45.9, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963253
[Record NO. 9], IP Address: 192.168.45.10, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963254
[Record NO. 10], IP Address: 192.168.45.11, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963255
[Record NO. 11], IP Address: 192.168.45.12, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963256
[Record NO. 12], IP Address: 192.168.45.13, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963258
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259

IP allocation management options:
0: LIST (Admin Only)
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select: 0
Client sending -> LIST
[Record NO. 0], IP Address: 192.168.45.1, MAC Address: , Acked: False, Expiration: 2022-04-28T17:05:12.580055
[Record NO. 1], IP Address: 192.168.45.2, MAC Address: , Acked: False, Expiration: 2022-04-28T17:02:44.285767
[Record NO. 2], IP Address: 192.168.45.3, MAC Address: 00:16:3E:09:EB:14, Acked: False, Expiration: 2022-04-28T17:02:49.047754
[Record NO. 3], IP Address: 192.168.45.4, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963248
[Record NO. 4], IP Address: 192.168.45.5, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963249
[Record NO. 5], IP Address: 192.168.45.6, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963250
[Record NO. 6], IP Address: 192.168.45.7, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963251
[Record NO. 7], IP Address: 192.168.45.8, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963252
[Record NO. 8], IP Address: 192.168.45.9, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963253
[Record NO. 9], IP Address: 192.168.45.10, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963254
[Record NO. 10], IP Address: 192.168.45.11, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963255
[Record NO. 11], IP Address: 192.168.45.12, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963256
[Record NO. 12], IP Address: 192.168.45.13, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963258
[Record NO. 13], IP Address: 192.168.45.14, MAC Address: , Acked: False, Expiration: 2022-04-28T17:01:37.963259

IP allocation management options:
0: LIST (Admin Only)
1: RELEASE IP
2: RENEW Ip allocation
3: Exit management terminal
Select:
$
<F1> Help                                   BETA VERSION v2.5                                   <Smart Mode>
```

12. Release IP addresses of both `client1` and `client2` . Then, run the admin client on `admin`. Make sure that the list replied by the server indicates that both clients have released their IP addresses.



```
macAddress: 1672193647
offering: DECLINE
Server sending -> DECLINE
Server recieved -> DISCOVER 7185171756
macAddress: 7185171756
offering: DECLINE
Server sending -> DECLINE
Server recieved -> DISCOVER 0886126158
macAddress: 0886126158
offering: DECLINE
Server sending -> DECLINE
Server recieved -> DISCOVER 7332842692
macAddress: 7332842692
offering: DECLINE
Server sending -> DECLINE
Server recieved -> DISCOVER 5929706392
macAddress: 5929706392
offering: DECLINE
Server sending -> DECLINE
Server recieved -> DISCOVER 1234390932
macAddress: 1234390932
offering: DECLINE
Server sending -> DECLINE
Server recieved -> DISCOVER 3946230632
macAddress: 3946230632
offering: DECLINE
Server sending -> DECLINE
Server recieved -> DISCOVER 6836269650
macAddress: 6836269650
offering: DECLINE
Server sending -> DECLINE
Server recieved -> DISCOVER 9087461467
macAddress: 9087461467
offering: DECLINE
Server sending -> DECLINE
Server recieved -> DISCOVER 8330895286
macAddress: 8330895286
offering: DECLINE
Server sending -> DECLINE
Server recieved -> DISCOVER 5141632863
macAddress: 5141632863
offering: DECLINE
Server sending -> DECLINE
Server recieved -> DISCOVER 7130917900
macAddress: 7130917900
offering: DECLINE
Server sending -> DECLINE
Server recieved -> DISCOVER 4721773090
macAddress: 4721773090
offering: DECLINE
Server sending -> DECLINE
Server recieved -> DISCOVER 0108121474
macAddress: 0108121474
offering: DECLINE
Server sending -> DECLINE
Server recieved -> DISCOVER 3103753462
macAddress: 3103753462
offering: DECLINE
Server sending -> DECLINE
Server recieved -> DISCOVER 8600805336
macAddress: 8600805336
offering: DECLINE
Server sending -> DECLINE
Server recieved -> DISCOVER 6600094019
macAddress: 6600094019
offering: DECLINE
Server sending -> DECLINE
Server recieved -> DISCOVER 1681758257
macAddress: 1681758257
offering: DECLINE
Server sending -> DECLINE
Server recieved -> DISCOVER 9417957006
macAddress: 9417957006
of
$ 
<F1> Help
```

```
No address offered, Allocation declined
Attacker recieved -> DECLINE
No address offered, Allocation declined
Attacker recieved -> DECLINE
No address offered, Allocation declined
Attacker recieved -> DECLINE
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Attacker recieved -> DECLINE
No address offered, Allocation declined

$ 
<F1> Help                       BETA VERSION v2.5
```

```
student@client1:~$ cd files
student@client1:~/files$ python3 client.py
Client recieved -> DECLINE
No address offered, Allocation declined
^Z
[1]+  Stopped                 python3 client.py
student@client1:~/files$ python3 client.py
Client recieved -> DECLINE
No address offered, Allocation declined
```

13. **Extra credit test**: Run the attacker client on `attacker`. Then on `client1`, run the client. Make sure that the server declines the `DISCOVER` message from `client1`. Then, run the admin client. Make sure that 14 IP addresses have been offered to the fraudulent MAC addresses that have been created by the attacker.
    - Note the large amount of DECLINE messages on the server and attacker terminals. It is difficult to capture an image of the correctly allocated IP addresses before the server fills up.
    - The client also has a declined allocation request; having its service denied.