

# Assignment 4

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## - Environment

```
mininet@mininet-VirtualBox:~$ python --version
Python 2.7.17
mininet@mininet-VirtualBox:~$ python3 --version
Python 3.6.9
```

```
mininet@mininet-VirtualBox:~$ cat /etc/issue
Ubuntu 18.04.5 LTS \n \l
```

사용한 라이브러리 : socket, struct, threading

## - Explanation

### ■ Client

ID 를 입력 받고 클라이언트는 소켓 두개를 엽니다. 하나는 서버 통신, NAT 를 통한 네트워크 연결을 위한 소켓이고, 나머지 하나는 NAT 를 통해 통신하지 않는 private ip 와 port 로 통신하는 소켓을 동시에 thread 를 통해서 열어둡니다. 그 이후 서버에 packet 을 보내 등록을 요청하고, 현재 등록되어있는 클라이언트 정보를 받습니다. 그 후 client 함수에서는 input 을 통해서 입력받는 명령인 @chat, @show\_list 를 입력 받아 해당 명령을 수행합니다. @chat 수행 중, 같은 public ip 를 가지고 있는 클라이언트에게는 저장되어있는 private ip 를 통해서 패킷을 전송합니다. Public ip 로 연결하는 소켓은 서버로부터 새로운 클라이언트 등록/disappear/deregister 에 대한 broadcast 패킷이나 NAT 를 통한 chat 데이터를 수신합니다. (=recv\_side 함수) Extended Goal 을 구현하기 위해 private ip 로 수신 받는 소켓을 열어서 입력 받는 함수 chat\_recv 를 정의하였습니다. 그 소켓을 통해 패킷을 넘겨주는 상대방은 같은 NAT 상의 있는 클라이언트뿐 입니다.

Message format 을 이렇습니다.

보내는 패킷 : #num\_instr + clientID + \nWr + data

수신받는 패킷 : #num\_instr + serverID + \nWr + data

#num_instr	1	2	3	5	6
정보	register_response	broadcast_data	chat_data	broadcast_deregister	im_alive

Data 에는 clientID|chat\_data 형태이고, 서버를 통해 오는 패킷은 ID|address|private\_ip + \n 형태를 띄고 있습니다.

### ■ server

서버는 실행되자마자 소켓을 열어 클라이언트로 새로운 등록정보를 받을 준비를 합니다. 서버에서는 3 개의 패킷 정보를 처리합니다. 새로운 등록을 요청하는 패킷, 클라이언트로부터 10 초마다 받는 'keep alive' purpose 패킷, deregister 를 요청하는 패킷입니다.

새로운 등록을 요청하는 패킷은 수신 받고 등록되어있는 다른 클라이언트에게 새로운 클라이언트 등록을 알리는 broadcast packet 을 보냅니다. 그 이후 패킷으로부터 받는 clientID, public address, private address 를 받아 dictionary

자료구조에 저장합니다.

```
client_list = dict() # ID 와 public addr 저장하는 dictionary
```

```
client_pri_ip = dict() # ID 와 private addr 저장하는 dictionary
```

client\_time = dict() # ID : recent\_access time – disappear action 을 구현하기 위해 Thread timer 객체를 저장하고 있는 dictionary 입니다. keep alive packet 에 의해 매번 초기화됩니다. 30 초동안 초기화되지 않을 시, disappear action 을 수행합니다.

저장한 이후 해당 클라이언트에게 현재 등록되어있는 클라이언트 정보를 넘겨줍니다.

#num\_instr + serverID + \nWr + ID|address|private\_ip + \n + ID|address|private\_ip + \n + ... 형태입니다.

'keep alive' purpose 패킷은 client\_time 에서 해당 요청을 하는 ID 의 timer 객체를 초기화한 이후 다시 timer 을 시작합니다.

deregister 를 요청하는 패킷은 클라이언트에서 @exit 을 실행하는 받는 패킷입니다. 서버에서는 요청한 클라이언트의 데이터를 3 개의 dictionary 에서 모두 없앤 이후 남은 클라이언트에게 등록 취소를 알리기 위해 broadcast 합니다.

Disappear action : timeout 함수에서 해당 action 을 수행합니다. 해당 clientID 정보를 삭제한 이후 클라이언트들에게 클라이언트정보를 삭제하라는 패킷을 broadcast 합니다.

## - Evaluation

- The client registers to the registration server.
- The client and server can handle other client's registration and deregistration.

The image displays five terminal windows illustrating the registration and login process of clients to a server. Each window shows the execution of a Python script that interacts with a registration server.

- Host: pri.1.2**: Shows the registration of client '1234567890'. The terminal output includes the client's ID and IP address, and a confirmation message from the server.
- Host: pri.2.2**: Shows the registration of client 'hwbae0326'. The terminal output includes the client's ID and IP address, and a confirmation message from the server.
- Host: public1**: Shows the registration of client 'hey yo'. The terminal output includes the client's ID and IP address, and a confirmation message from the server.
- Host: pri.1.3**: Shows the registration of client 'baehyunwoong'. The terminal output includes the client's ID and IP address, and a confirmation message from the server.
- Host: pri.2.3**: Shows the registration of client 'c1'. The terminal output includes the client's ID and IP address, and a confirmation message from the server.

Below the registration screenshots, there are three additional terminal windows showing the login process:

- Host: server**: Shows the login of client 'hwbae0326'. The terminal output includes the client's ID and IP address, and a confirmation message from the server.
- Host: server**: Shows the login of client 'c1'. The terminal output includes the client's ID and IP address, and a confirmation message from the server.
- Host: server**: Shows the login of client 'baehyunwoong'. The terminal output includes the client's ID and IP address, and a confirmation message from the server.

- The client can send, receive, and display a chat message.

host: pri.1.2

```
root@mininet-VirtualBox:~/prac_4# make client
python3 client.py
Enter ID: c1.2
192.168.2.2
c1.2 ('10.0.0.1', 59526)
nat2.2 10.0.0.2:58090 is added
c1.3 10.0.0.1:53160 is added
public123 10.0.0.4:52764 is added
From public123 [hi]
@show_list
=====registered ID info=====
c1.2 10.0.0.1:59526
nat2.2 10.0.0.2:58090
c1.3 10.0.0.1:53160
nat2.3 10.0.0.2:51727
public123 10.0.0.4:52764
@chat c1.3 hi the the no way to go
From nat2.3 [hi]
@chat public123 hey public
From public123 [hi]
```

host: pri.2.2

```
root@mininet-VirtualBox:~/prac_4# make client
python3 client.py
Enter ID: nat2.2
192.168.2.2
c1.2 ('10.0.0.1', 59526)
nat2.2 ('10.0.0.2', 58090)
c1.3 ('10.0.0.1', 53160)
nat2.3 10.0.0.2:51727 is added
public123 10.0.0.4:52764 is added
From nat2.2 [is there anyone here]
@show_list
=====registered ID info=====
c1.2 10.0.0.1:59526
nat2.2 10.0.0.2:58090
c1.3 10.0.0.1:53160
nat2.3 10.0.0.2:51727
public123 10.0.0.4:52764
@chat c1.2 hi
From nat2.2 [hi]
1
2
```

host: server

```
root@mininet-VirtualBox:~/prac_4# make client
python3 client.py
Enter ID: public123
10.0.0.4
c1.2 ('10.0.0.1', 59526)
nat2.2 ('10.0.0.2', 58090)
c1.3 ('10.0.0.1', 53160)
nat2.3 ('10.0.0.2', 51727)
public123 ('10.0.0.4', 52764)
@show_list
=====registered ID info=====
c1.2 10.0.0.1:59526
nat2.2 10.0.0.2:58090
c1.3 10.0.0.1:53160
nat2.3 10.0.0.2:51727
public123 10.0.0.4:52764
@chat c1.2 hi
From c1.2 [hey public]
```

host: pri.1.3

```
root@mininet-VirtualBox:~/prac_4# make client
python3 client.py
Enter ID: c1.3
192.168.1.3
c1.2 ('10.0.0.1', 59526)
nat2.2 ('10.0.0.2', 58090)
c1.3 ('10.0.0.1', 53160)
nat2.3 10.0.0.2:51727 is added
public123 10.0.0.4:52764 is added
From c1.2 [hi the the no way to go]
```

host: pri.2.3

```
root@mininet-VirtualBox:~/prac_4# make client
python3 client.py
Enter ID: nat2.3
192.168.2.3
c1.2 ('10.0.0.1', 59526)
nat2.2 ('10.0.0.2', 58090)
c1.3 ('10.0.0.1', 53160)
nat2.3 ('10.0.0.2', 51727)
public123 10.0.0.4:52764 is added
From nat2.2 [is there anyone here]
@show_list
=====registered ID info=====
c1.2 10.0.0.1:59526
nat2.2 10.0.0.2:58090
c1.3 10.0.0.1:53160
nat2.3 10.0.0.2:51727
public123 10.0.0.4:52764
@chat c1.2 hi
From nat2.2 [hi]
1
2
```

host: public1

```
root@mininet-VirtualBox:~/prac_4# make client
python3 client.py
Enter ID: public123
10.0.0.4
c1.2 ('10.0.0.1', 59526)
nat2.2 ('10.0.0.2', 58090)
c1.3 ('10.0.0.1', 53160)
nat2.3 ('10.0.0.2', 51727)
public123 ('10.0.0.4', 52764)
@show_list
=====registered ID info=====
c1.2 10.0.0.1:59526
nat2.2 10.0.0.2:58090
c1.3 10.0.0.1:53160
nat2.3 10.0.0.2:51727
public123 10.0.0.4:52764
@chat c1.2 hi
From c1.2 [hey public]
```

- Enable clients under the same NAT can communicate using the same private network prefix  
( without NAT assistance )

host: pri.2.2

```
root@mininet-VirtualBox:~/prac_4# make client
python3 client.py
Enter ID: nat2.2
192.168.2.2
c1.2 ('10.0.0.1', 59526)
nat2.2 ('10.0.0.2', 58090)
c1.3 ('10.0.0.1', 53160)
nat2.3 10.0.0.2:51727 is added
public123 10.0.0.4:52764 is added
From nat2.2 [is there anyone here]
@show_list
=====registered ID info=====
c1.2 10.0.0.1:59526
nat2.2 10.0.0.2:58090
c1.3 10.0.0.1:53160
nat2.3 10.0.0.2:51727
public123 10.0.0.4:52764
@chat nat2.2 hi
From nat2.2 [hi]
1
2
```

host: pri.2.3

```
root@mininet-VirtualBox:~/prac_4# make client
python3 client.py
Enter ID: nat2.3
192.168.2.3
c1.2 ('10.0.0.1', 59526)
nat2.2 ('10.0.0.2', 58090)
c1.3 ('10.0.0.1', 53160)
nat2.3 ('10.0.0.2', 51727)
public123 10.0.0.4:52764 is added
From nat2.2 [is there anyone here]
@show_list
=====registered ID info=====
c1.2 10.0.0.1:59526
nat2.2 10.0.0.2:58090
c1.3 10.0.0.1:53160
nat2.3 10.0.0.2:51727
public123 10.0.0.4:52764
@chat c1.2 hi
From nat2.2 [hi]
1
2
```

host: public1

```
root@mininet-VirtualBox:~/prac_4# make client
python3 client.py
Enter ID: public123
10.0.0.4
c1.2 ('10.0.0.1', 59526)
nat2.2 ('10.0.0.2', 58090)
c1.3 ('10.0.0.1', 53160)
nat2.3 ('10.0.0.2', 51727)
public123 ('10.0.0.4', 52764)
@show_list
=====registered ID info=====
c1.2 10.0.0.1:59526
nat2.2 10.0.0.2:58090
c1.3 10.0.0.1:53160
nat2.3 10.0.0.2:51727
public123 10.0.0.4:52764
@chat c1.2 hi
From c1.2 [hey public]
```

Capturing from nat2-eth2

No.	Time	Source	Destination	Protocol	Length	Info
16	59.769482074	192.168.2.2	192.168.2.3	UDP	61	48983 → 10081 Len=19
17	59.769482074	192.168.2.2	192.168.2.3	ICMPv6	79	Router Solicitation from 0a:dd:0e:fa:f1:e0
18	55.130146178	ea:9d:d7:4c:a0:53	00:00:00:00:00:02	ARP	42	Who has 192.168.2.1? Tell 192.168.2.2
19	55.136751640	00:00:00:00:00:02	ea:9d:d7:4c:a0:53	ARP	60	192.168.2.1 is at 00:00:00:00:00:02
20	55.897263970	ea:9d:d7:4c:a0:53	6a:ae:ce:6b:ec:1c	ARP	42	Who has 192.168.2.3? Tell 192.168.2.2
21	55.898162890	6a:ae:ce:6b:ec:1c	ea:9d:d7:4c:a0:53	ARP	42	192.168.2.3 is at 6a:ae:ce:6b:ec:1c
22	58.675626421	fe80::8dd:eff:fefa::	ff02::fb	MDNS	107	Standard query 0x0000 PTR _ipps._tcp.local.
23	59.152492447	fe80::a8d3:18ff:fe5::	ff02::fb	MDNS	107	Standard query 0x0000 PTR _ipps._tcp.local.
24	59.253397896	fe80::5c7c:78ff:fe1::	ff02::fb	MDNS	107	Standard query 0x0000 PTR _ipps._tcp.local.
25	60.020744785	192.168.2.2	10.0.0.3	UDP	52	48983 → 10080 Len=10
26	66.903836255	fe80::a8d3:18ff:fe5::	ff02::2	ICMPv6	79	Router Solicitation from aa:d3:18:53:99:19
27	70.023041934	192.168.2.2	10.0.0.3	UDP	52	48983 → 10080 Len=10

Frame 16: 61 bytes on wire (488 bits), 61 bytes captured (488 bits) on interface 0  
 Ethernet II, Src: ea:9d:d7:4c:a0:53 (ea:9d:d7:4c:a0:53), Dst: 6a:ae:ce:6b:ec:1c (6a:ae:ce:6b:ec:1c)  
 Internet Protocol Version 4, Src: 192.168.2.2, Dst: 192.168.2.3  
 User Datagram Protocol, Src Port: 48983, Dst Port: 10081  
 Data (19 bytes)

0000 6a ae ce 6b ec 1c ea 9d d7 4c a0 53 00 00 45 00 j . k . . . . L S . . . E .  
 0010 00 2f 7c 23 40 00 40 11 39 45 c0 a8 02 02 c0 a8 / # 0 0 9 E . . . . .  
 0020 02 03 bf 57 27 61 00 1b 85 82 00 03 6e 61 74 32 . W a . . . . nat2  
 0030 2e 32 0a 0d 6e 61 74 32 2e 32 7c 68 69 . 2 . nat2 . 2 hi

nat2.2 + | + "hi"  
 clientID + | + chat\_data

## ■ For '@exit' command

The following code blocks represent the terminal output from the six windows shown in the image:

```

"host: pri.1.2"
root@mininet-VirtualBox:~/prac_4# make client
python3 client.py
Enter ID: 1234567890
192.168.1.2
hey yo ('10.0.0.4', 58164)
1234567890 ('10.0.0.1', 50211)
hwbae0326 10.0.0.2:59094 is added
c1 10.0.0.2:58519 is added
baehyunwoong 10.0.0.1:53873 is added
@show_list
=====registered ID info=====
hey yo 10.0.0.4:58164
1234567890 10.0.0.1:50211
hwbae0326 10.0.0.2:59094
c1 10.0.0.2:58519
baehyunwoong 10.0.0.1:53873
hwbae0326 ('10.0.0.2', 59094) is deleted

"host: pri.2.2"
root@mininet-VirtualBox:~/prac_4# make client
python3 client.py
Enter ID: hwbae0326
192.168.2.2
hey yo ('10.0.0.4', 58164)
1234567890 ('10.0.0.1', 50211)
hwbae0326 ('10.0.0.2', 59094)
c1 10.0.0.2:58519 is added
baehyunwoong 10.0.0.1:53873 is added
@show_list
=====registered ID info=====
hey yo 10.0.0.4:58164
1234567890 10.0.0.1:50211
hwbae0326 10.0.0.2:59094
c1 10.0.0.2:58519
baehyunwoong 10.0.0.1:53873
hwbae0326 ('10.0.0.2', 59094) is deleted
#exit
include command @ !
@exit
client close.. waiting for timer...
recv side end
stop sending alive message
local recv end
root@mininet-VirtualBox:~/prac_4# [ successfully exit

"host: public1"
root@mininet-VirtualBox:~/prac_4# make client
python3 client.py
Enter ID: hey yo
10.0.0.4
hey yo ('10.0.0.4', 58164)
1234567890 10.0.0.1:50211 is added
hwbae0326 10.0.0.2:59094 is added
c1 10.0.0.2:58519 is added
baehyunwoong 10.0.0.1:53873 is added
@show_list
=====registered ID info=====
hey yo 10.0.0.4:58164
1234567890 10.0.0.1:50211
hwbae0326 10.0.0.2:59094
c1 10.0.0.2:58519
baehyunwoong 10.0.0.1:53873
hwbae0326 ('10.0.0.2', 59094) is deleted

"host: pri.1.3"
root@mininet-VirtualBox:~/prac_4# make client
python3 client.py
Enter ID: baehyunwoong
192.168.1.3
hey yo ('10.0.0.4', 58164)
1234567890 ('10.0.0.1', 50211)
hwbae0326 ('10.0.0.2', 59094)
c1 ('10.0.0.2', 58519)
baehyunwoong ('10.0.0.1', 53873)
@show_list
=====registered ID info=====
hey yo 10.0.0.4:58164
1234567890 10.0.0.1:50211
hwbae0326 10.0.0.2:59094
c1 10.0.0.2:58519
baehyunwoong 10.0.0.1:53873
hwbae0326 ('10.0.0.2', 59094) is deleted

"host: pri.2.3"
root@mininet-VirtualBox:~/prac_4# make client
python3 client.py
Enter ID: c1
192.168.2.3
hey yo ('10.0.0.4', 58164)
1234567890 ('10.0.0.1', 50211)
hwbae0326 ('10.0.0.2', 59094)
c1 ('10.0.0.2', 58519)
baehyunwoong 10.0.0.1:53873 is added
@show_list
=====registered ID info=====
hey yo 10.0.0.4:58164
1234567890 10.0.0.1:50211
hwbae0326 10.0.0.2:59094
c1 10.0.0.2:58519
baehyunwoong 10.0.0.1:53873
hwbae0326 ('10.0.0.2', 59094) is deleted

"host: server"
1234567890 ('10.0.0.1', 50211)
=====log in ID=====
hwbae0326 ('10.0.0.2', 59094)
=====registered ID=====
hey yo ('10.0.0.4', 58164)
1234567890 ('10.0.0.1', 50211)
hwbae0326 ('10.0.0.2', 59094)
c1 ('10.0.0.2', 58519)
=====log in ID=====
c1 ('10.0.0.2', 58519)
=====registered ID=====
baehyunwoong ('10.0.0.1', 53873)
=====log in ID=====
hey yo ('10.0.0.4', 58164)
1234567890 ('10.0.0.1', 50211)
hwbae0326 ('10.0.0.2', 59094)
c1 ('10.0.0.2', 58519)
baehyunwoong ('10.0.0.1', 53873)
hwbae0326 is deregister 10.0.0.2:59094

```

## ■ For client disappearance without sending a deregistration request.

The following code blocks represent the terminal output from the six windows shown in the image:

```

"host: pri.1.2"
root@mininet-VirtualBox:~/prac_4# make client
python3 client.py
Enter ID: 1234567890
192.168.1.2
hey yo ('10.0.0.4', 58164)
1234567890 ('10.0.0.1', 50211)
hwbae0326 10.0.0.2:59094 is added
c1 10.0.0.2:58519 is added
baehyunwoong 10.0.0.1:53873 is added
@show_list
=====registered ID info=====
hey yo 10.0.0.4:58164
1234567890 10.0.0.1:50211
hwbae0326 10.0.0.2:59094
c1 10.0.0.2:58519
baehyunwoong 10.0.0.1:53873
hwbae0326 ('10.0.0.2', 59094) is deleted
c1 ('10.0.0.2', 58519) is deleted

"host: pri.2.2"
root@mininet-VirtualBox:~/prac_4# make client
python3 client.py
Enter ID: hwbae0326
192.168.2.2
hey yo ('10.0.0.4', 58164)
1234567890 ('10.0.0.1', 50211)
hwbae0326 ('10.0.0.2', 59094)
c1 10.0.0.2:58519 is added
baehyunwoong 10.0.0.1:53873 is added
@show_list
=====registered ID info=====
hey yo 10.0.0.4:58164
1234567890 10.0.0.1:50211
hwbae0326 10.0.0.2:59094
c1 10.0.0.2:58519
baehyunwoong 10.0.0.1:53873
hwbae0326 ('10.0.0.2', 59094) is deleted
#exit
include command @ !
@exit
client close.. waiting for timer...
recv side end
stop sending alive message
local recv end
root@mininet-VirtualBox:~/prac_4# [ @exit case

"host: public1"
root@mininet-VirtualBox:~/prac_4# make client
python3 client.py
Enter ID: hey yo
10.0.0.4
hey yo ('10.0.0.4', 58164)
1234567890 10.0.0.1:50211 is added
hwbae0326 10.0.0.2:59094 is added
c1 10.0.0.2:58519 is added
baehyunwoong 10.0.0.1:53873 is added
@show_list
=====registered ID info=====
hey yo 10.0.0.4:58164
1234567890 10.0.0.1:50211
hwbae0326 10.0.0.2:59094
c1 10.0.0.2:58519
baehyunwoong 10.0.0.1:53873
hwbae0326 ('10.0.0.2', 59094) is deleted
c1 ('10.0.0.2', 58519) is deleted

"host: pri.1.3"
root@mininet-VirtualBox:~/prac_4# make client
python3 client.py
Enter ID: baehyunwoong
192.168.1.3
hey yo ('10.0.0.4', 58164)
1234567890 ('10.0.0.1', 50211)
hwbae0326 ('10.0.0.2', 59094)
c1 ('10.0.0.2', 58519)
baehyunwoong ('10.0.0.1', 53873)
@show_list
=====registered ID info=====
hey yo 10.0.0.4:58164
1234567890 10.0.0.1:50211
hwbae0326 10.0.0.2:59094
c1 10.0.0.2:58519
baehyunwoong 10.0.0.1:53873
hwbae0326 ('10.0.0.2', 59094) is deleted
c1 ('10.0.0.2', 58519) is deleted

"host: pri.2.3"
hwbae0326 10.0.0.2:59094
c1 10.0.0.2:58519
baehyunwoong 10.0.0.1:53873
hwbae0326 ('10.0.0.2', 59094) is deleted
"Client (most recent call last):
File "client.py", line 201, in <module>
client(serverIP, serverPort, clientID)
File "client.py", line 142, in client
data = input("")
KeyboardInterrupt
Traceback (most recent call last):
File "/usr/lib/python3.6/threading.py", line 1294, in _shutdown
t.join()
File "/usr/lib/python3.6/threading.py", line 1056, in join
self._wait_for_tstate_lock()
File "/usr/lib/python3.6/threading.py", line 1072, in _wait_for_tstate_lock
elif lock.acquire(block, timeout):
KeyboardInterrupt
Makefile:4: recipe for target 'client' failed
make: *** [client] Error 1
root@mininet-VirtualBox:~/prac_4# [ ID: c1 disappear case

"host: server"
1234567890 ('10.0.0.1', 50211)
=====log in ID=====
hwbae0326 ('10.0.0.2', 59094)
=====registered ID=====
hey yo ('10.0.0.4', 58164)
1234567890 ('10.0.0.1', 50211)
hwbae0326 ('10.0.0.2', 59094)
c1 ('10.0.0.2', 58519)
=====log in ID=====
c1 ('10.0.0.2', 58519)
=====registered ID=====
baehyunwoong ('10.0.0.1', 53873)
=====log in ID=====
hey yo ('10.0.0.4', 58164)
1234567890 ('10.0.0.1', 50211)
hwbae0326 ('10.0.0.2', 59094)
c1 ('10.0.0.2', 58519)
baehyunwoong ('10.0.0.1', 53873)
hwbae0326 is deregister 10.0.0.2:59094
c1 is disappear 10.0.0.2:58519

```