Lab 6.1 Firewall VPN

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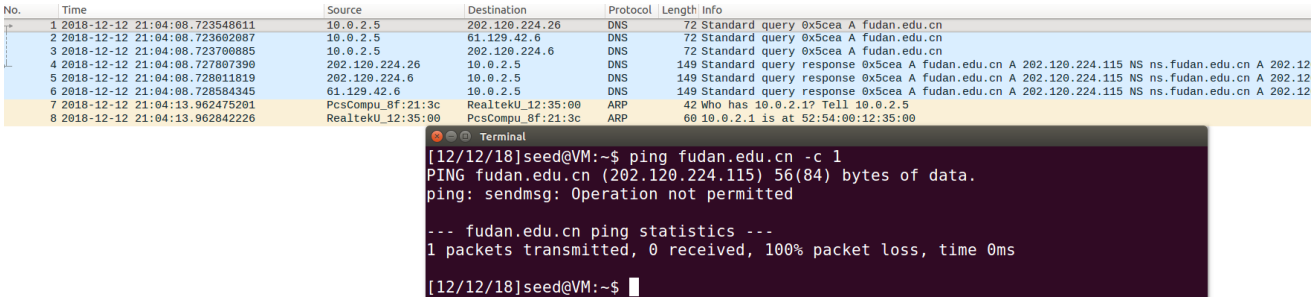
Task 1: VM Setup

> VM1: 10.0.2.5 as the client
>
> VM2: 10.0.2.6 as the server

Task 2: Set up Firewall

```
sudo ufw deny out on enp0s3 from 10.0.2.5 to 202.120.224.115
```



No.	Time	Source	Destination	Protocol	Length	Info
1	2018-12-12 21:04:08.723548611	10.0.2.5	202.120.224.26	DNS	72	Standard query 0x5cea A fudan.edu.cn
2	2018-12-12 21:04:08.723602087	10.0.2.5	61.129.42.6	DNS	72	Standard query 0x5cea A fudan.edu.cn
3	2018-12-12 21:04:08.723700885	10.0.2.5	202.120.224.6	DNS	72	Standard query 0x5cea A fudan.edu.cn
4	2018-12-12 21:04:08.727807390	202.120.224.26	10.0.2.5	DNS	149	Standard query response 0x5cea A fudan.edu.cn A 202.120.224.115 NS ns.fudan.edu.cn A 202.12
5	2018-12-12 21:04:08.728011819	202.120.224.6	10.0.2.5	DNS	149	Standard query response 0x5cea A fudan.edu.cn A 202.120.224.115 NS ns.fudan.edu.cn A 202.12
6	2018-12-12 21:04:08.728584345	61.129.42.6	10.0.2.5	DNS	149	Standard query response 0x5cea A fudan.edu.cn A 202.120.224.115 NS ns.fudan.edu.cn A 202.12
7	2018-12-12 21:04:13.962475201	PcsCompu_8f:21:3c	RealtekU_12:35:00	ARP	42	Who has 10.0.2.1? Tell 10.0.2.5
8	2018-12-12 21:04:13.962842226	RealtekU_12:35:00	PcsCompu_8f:21:3c	ARP	60	10.0.2.1 is at 52:54:00:12:35:00

Task 3: Bypassing Firewall using VPN

Step 1: Run VPN Server

```
$ make
$ sudo ./vpnserver
```

In another terminal

```
$ sudo ifconfig tun0 192.168.53.1/24 up
$ sudo sysctl net.ipv4.ip_forward=1
```

Step 2: Run VPN Client

I changed the server ip, and then start the client program.

```
$ sudo ./vpnclient
```

Configure the interface

```
sudo ifconfig tun0 192.168.53.5/24 up
```

Step 3: Set Up Routing on Client and Server VMs.

Client

```
$ sudo route add -net 202.120.224.0/24 tun0
# fudan.edu.cn
$ sudo route add -net 192.168.53.0/24 tun0
# tunnel subnet
```

Server

```
$ sudo route add -net 192.168.53.0/24 tun0
# tunnel subnet
```

Step 4: Set Up NAT on Server VM

```
$ sudo iptables -F
# Flush the selected chain (all the chains in the table if none is given). This
is equivalent to deleting all the rules one by one.
$ sudo iptables -t nat -F
# Flush nat chain
$ sudo iptables -t nat -A POSTROUTING -j MASQUERADE -o enp0s3
# Append postrouting chain and jump to masquerade
```

Then try to ping fudan.edu.cn. There was a query from fudan.edu.cn. The firewall was bypassed.

```
[12/13/18]seed@VM:~$ ping fudan.edu.cn -c 1
PING fudan.edu.cn (202.120.224.115) 56(84) bytes of data.
64 bytes from 224.fudan.edu.cn (202.120.224.115): icmp_seq=1 ttl=58 time=15.4 ms

--- fudan.edu.cn ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 15.499/15.499/15.499/0.000 ms
[12/13/18]seed@VM:~$
```

The query from 10.0.2.6 was indicated by tunnel

```
[12/13/18]seed@VM:~/.../Atask2$ sudo ./vpnclient 10.0.2.6
[sudo] password for seed:
Got a packet from TUN
Got a packet from TUN
Got a packet from TUN
Got a packet from TUN
Got a packet from the tunnel
Got a packet from the tunnel
Got a packet from the tunnel
Got a packet from TUN
Got a packet from the tunnel
```

> client, any

1	2018-12-13 20:56:49.944992539	127.0.0.1	127.0.1.1	DNS	74	Standard query 0x6fd2 A fudan.edu.cn
2	2018-12-13 20:56:49.945038500	10.0.2.5	202.120.224.26	DNS	74	Standard query 0x1008 A fudan.edu.cn
3	2018-12-13 20:56:49.945089926	10.0.2.5	61.129.42.6	DNS	74	Standard query 0x1008 A fudan.edu.cn
4	2018-12-13 20:56:49.945112333	10.0.2.5	202.120.224.6	DNS	74	Standard query 0x1008 A fudan.edu.cn
5	2018-12-13 20:56:49.956938304	202.120.224.26	10.0.2.5	DNS	151	Standard query response 0x1008 A fudan.edu.cn A 202.120.224.115 NS ns.fudan.edu.cn A 202.
6	2018-12-13 20:56:49.956952290	202.120.224.6	10.0.2.5	DNS	151	Standard query response 0x1008 A fudan.edu.cn A 202.120.224.115 NS ns.fudan.edu.cn A 202.
7	2018-12-13 20:56:49.956954699	61.129.42.6	10.0.2.5	DNS	151	Standard query response 0x1008 A fudan.edu.cn A 202.120.224.115 NS ns.fudan.edu.cn A 202.
8	2018-12-13 20:56:49.957056065	127.0.1.1	127.0.0.1	DNS	151	Standard query response 0x6fd2 A fudan.edu.cn A 202.120.224.115 NS ns.fudan.edu.cn A 202.
9	2018-12-13 20:56:49.957234947	192.168.53.5	202.120.224.115	ICMP	100	Echo (ping) request id=0x1b06, seq=1/256, ttl=64 (reply in 12)
10	2018-12-13 20:56:49.957367061	10.0.2.5	10.0.2.6	UDP	128	37892 → 55555 Len=84
11	2018-12-13 20:56:49.962346939	10.0.2.6	10.0.2.5	UDP	128	55555 → 37892 Len=84
12	2018-12-13 20:56:49.962637539	202.120.224.115	192.168.53.5	ICMP	100	Echo (ping) reply id=0x1b06, seq=1/256, ttl=58 (request in 9)
13	2018-12-13 20:56:49.962819680	127.0.0.1	127.0.1.1	DNS	90	Standard query 0x2b35 PTR 115.224.120.202.in-addr.arpa
14	2018-12-13 20:56:49.962858545	10.0.2.5	61.129.42.6	DNS	90	Standard query 0x80e6 PTR 115.224.120.202.in-addr.arpa
15	2018-12-13 20:56:49.969852362	61.129.42.6	10.0.2.5	DNS	181	Standard query response 0x80e6 PTR 115.224.120.202.in-addr.arpa PTR 224.fudan.edu.cn NS n
16	2018-12-13 20:56:49.970007041	127.0.1.1	127.0.0.1	DNS	181	Standard query response 0x2b35 PTR 115.224.120.202.in-addr.arpa PTR 224.fudan.edu.cn NS n
17	2018-12-13 20:56:50.788678228	10.0.2.5	10.0.2.3	DHCP	344	DHCP Request - Transaction ID 0xf5b29a71
18	2018-12-13 20:56:50.795451642	10.0.2.3	255.255.255.255	DHCP	592	DHCP ACK - Transaction ID 0xf5b29a71
19	2018-12-13 20:56:55.124448088	PcsCompu_33:6c:48		ARP	62	Who has 10.0.2.5? Tell 10.0.2.6
20	2018-12-13 20:56:55.124464916	PcsCompu_8f:21:3c		ARP	44	10.0.2.5 is at 08:00:27:8f:21:3c
21	2018-12-13 20:56:56.037059420	PcsCompu_8f:21:3c		ARP	44	Who has 10.0.2.3? Tell 10.0.2.5

> client, tun0

From user's perspecitve, tun0 was doing the whole thing

```
    1 2018-12-13 21:03:47.506292545 192.168.53.5    202.120.224.115 ICMP      84 Echo (ping) request  id=0x1b33, seq=1/256, ttl=64 (reply in 2)
    2 2018-12-13 21:03:47.531981517 202.120.224.115 192.168.53.5    ICMP      84 Echo (ping) reply    id=0x1b33, seq=1/256, ttl=58 (request in 1)
```

> client, enp0s3

In fact, 10.0.2.5 works as a middle man and it is 10.0.2.6 that interacts with fudan.edu.cn

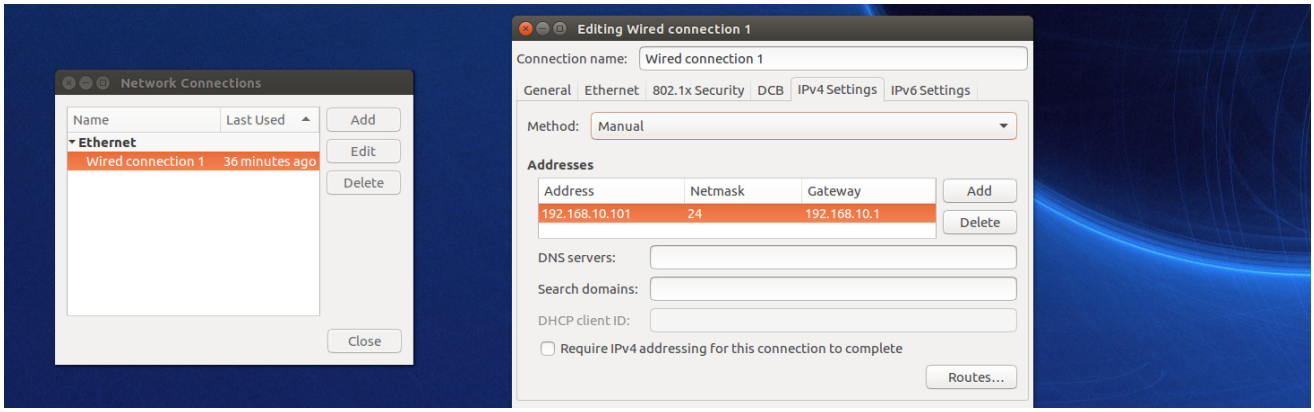
```
    1 2018-12-13 21:04:44.693494997 10.0.2.5        202.120.224.26  DNS       72 Standard query 0x4e4a A fudan.edu.cn
    2 2018-12-13 21:04:44.693547207 10.0.2.5        61.129.42.6     DNS       72 Standard query 0x4e4a A fudan.edu.cn
    3 2018-12-13 21:04:44.693566069 10.0.2.5        202.120.224.6   DNS       72 Standard query 0x4e4a A fudan.edu.cn
    4 2018-12-13 21:04:44.698121157 202.120.224.26  10.0.2.5        DNS      149 Standard query response 0x4e4a A fudan.edu.cn A 202.120.224.115 NS ns.fudan.edu.cn A 202.120.224.
    5 2018-12-13 21:04:44.698973319 61.129.42.6     10.0.2.5        DNS      149 Standard query response 0x4e4a A fudan.edu.cn A 202.120.224.115 NS ns.fudan.edu.cn A 202.120.224.
    6 2018-12-13 21:04:44.699379917 10.0.2.5        10.0.2.6        UDP      126 37892 → 55555 Len=84
    7 2018-12-13 21:04:44.699702653 202.120.224.6   10.0.2.5        DNS      149 Standard query response 0x4e4a A fudan.edu.cn A 202.120.224.115 NS ns.fudan.edu.cn A 202.120.224.
    8 2018-12-13 21:04:44.700043155 10.0.2.6        202.120.224.115 ICMP      98 Echo (ping) request  id=0x1b3b, seq=1/256, ttl=63 (reply in 9)
    9 2018-12-13 21:04:44.704535479 202.120.224.115 10.0.2.6        ICMP      98 Echo (ping) reply    id=0x1b3b, seq=1/256, ttl=59 (request in 8)
   10 2018-12-13 21:04:44.704933908 10.0.2.6        10.0.2.5        UDP      126 55555 → 37892 Len=84
   11 2018-12-13 21:04:44.705799819 10.0.2.5        61.129.42.6     DNS       88 Standard query 0x9ae5 PTR 115.224.120.202.in-addr.arpa
   12 2018-12-13 21:04:44.710756449 61.129.42.6     10.0.2.5        DNS      179 Standard query response 0x9ae5 PTR 115.224.120.202.in-addr.arpa PTR 224.fudan.edu.cn NS ns.fudan.
   13 2018-12-13 21:04:49.749067684 PcsCompu_33:6c:48 PcsCompu_8f:21:3c ARP      60 Who has 10.0.2.5? Tell 10.0.2.6
```

Lab 6.2 VPN

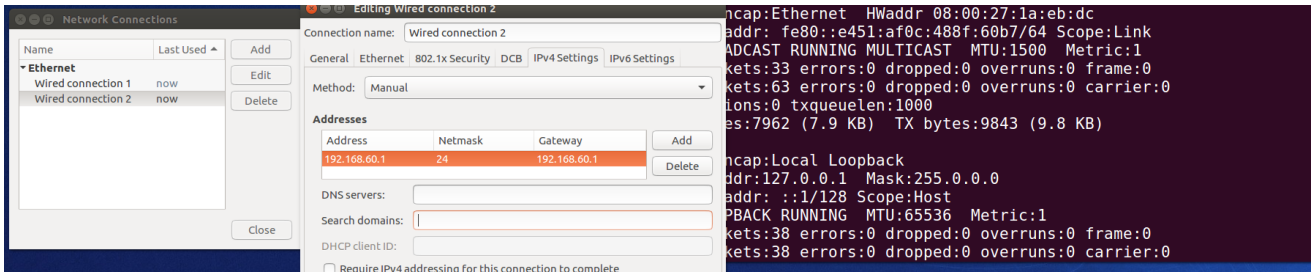
Task 1: VM Setup

	Host U	Server	Host V
NAT	10.0.2.5	10.0.2.6	
Internal		192.169.60.1	192.169.60.101

On Host V



On Server



Task 2: Creating a VPN Tunnel using TUN/TAP

Step 1: Run VPN Server

```
$ make
$ sudo ./vpnserver
```

In another terminal

```
$ sudo ifconfig tun0 192.168.53.1/24 up
sudo sysctl net.ipv4.ip_forward=1
```

Step 2: Run VPN Client

I modified the source code to make it read the arguments, and then start the client program.

```
$ sudo ./vpnclient 10.0.2.6
```

Configure the interface

```
sudo ifconfig tun0 192.168.53.5/24 up
```

Step 3: Set Up Routing on Client and Server VMs.

Client

```
$ sudo route add -net 192.168.60.0/24 tun0
# to the internal
```

Server

```
$ sudo route add -net 192.168.60.0/24 enp0s8
# internal
```

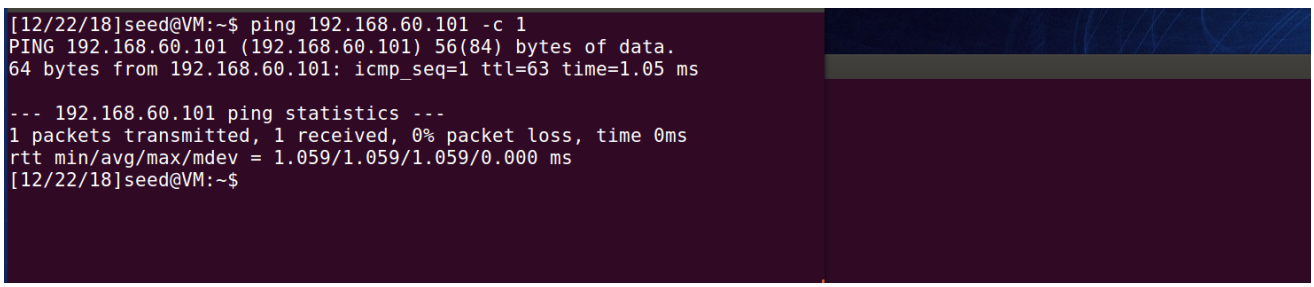
Step 4: Set Up Routing on Host V

The packet will be sent to default gateway in default NIC since it has only one. So no special configuration is needed.

Step 5: Test the VPN Tunnel

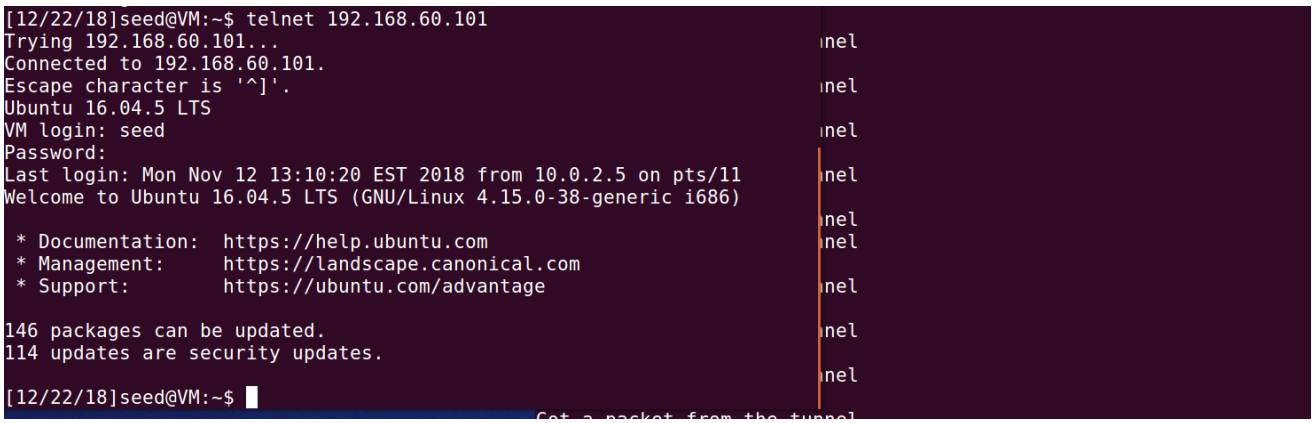
Ping

```
ping 192.168.60.101 -c 1
```



Telnet

```
telnet 192.168.60.101
```



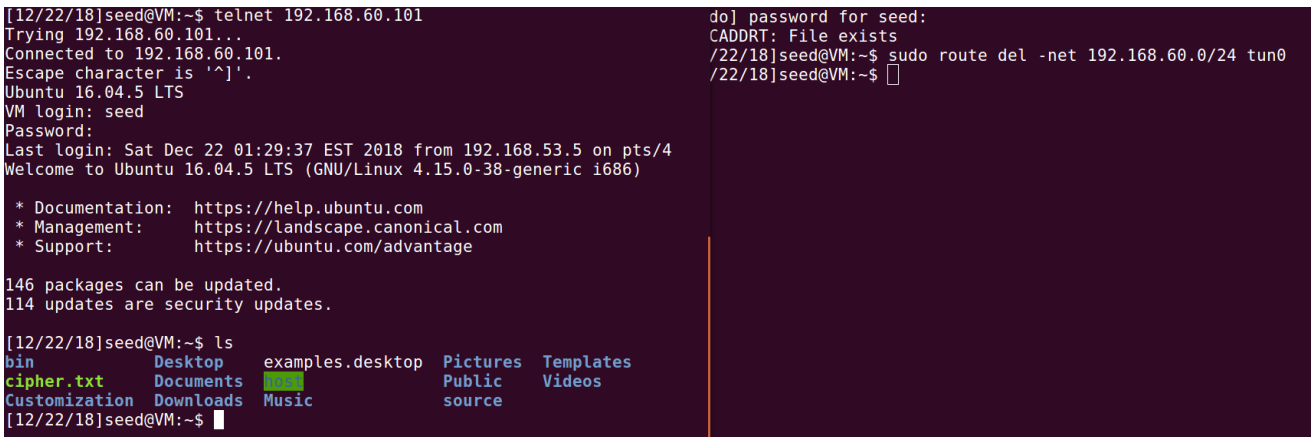
Step 6: Tunnel-Breaking Test

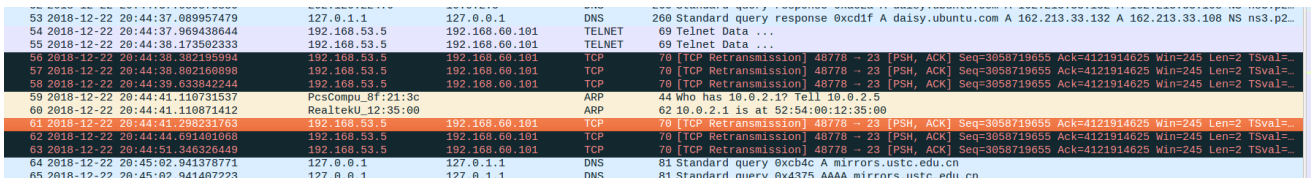
Keep the connection alive and break the tunnel

I break the tunnel by redirect the route table

```
$ sudo route del -net 192.168.60.0/24 tun0
```

Then my input would get no response. That is because Host V will not receive any packet from Host U, so neither will Host V send any echo to Host U

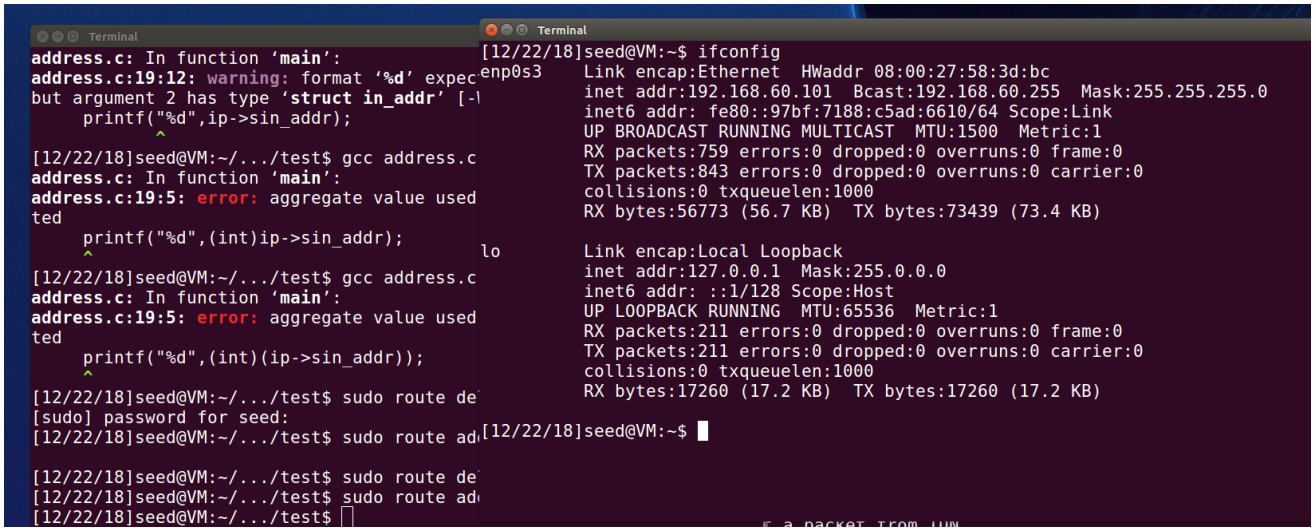




Then resume the tunnel by direct the route table back.

```
$ sudo route add -net 192.168.60.0/24 tun0
```

The connection will still work. Since Host V can receive packets now. The interrupt before is transparent to Host V.



Task 3: Encrypting the Tunnel

run the server

```
$ make 3
$ sudo ./server3
$ sudo ifconfig tun0 192.168.53.1/24 up
$ sudo sysctl net.ipv4.ip_forward=1
```

```
[12/29/18]seed@VM:~/.../lab6$ sudo ./server3
[sudo] password for seed:
TUN setup
TCP Setup
13771: Start
13771: Handshake
13771: Working
```

run the client

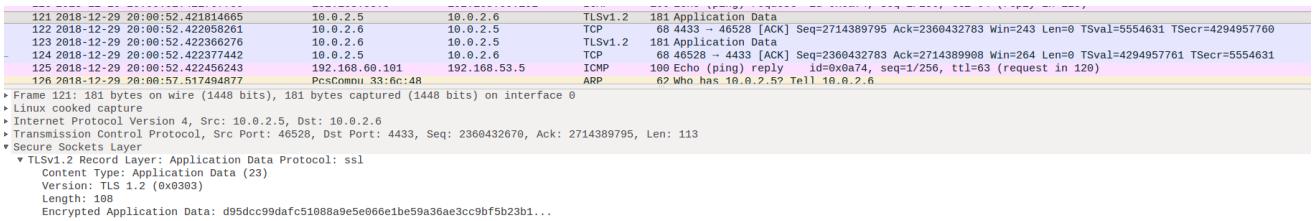
```
$ sudo ./client3
# default argument is "serverguan.com", 4433
$ sudo ifconfig tun0 192.168.53.5/24 up
$ sudo route add -net 192.168.60.0/24 tun0
$ ping 192.168.60.101 -c 1
```

```
[12/29/18]seed@VM:~/.../lab6$ sudo ./client3
[sudo] password for seed:
TLS Initialized
TCP Connected
Verification passed.
Verification passed.
SSL connection is successful
SSL connection using AES256-GCM-SHA384
^[^A
```

```
[12/29/18]seed@VM:~$ ping 192.168.60.101 -c 1
PING 192.168.60.101 (192.168.60.101) 56(84) bytes of data.
64 bytes from 192.168.60.101: icmp_seq=1 ttl=63 time=0.772 ms

--- 192.168.60.101 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 0.772/0.772/0.772/0.000 ms
```

Check the wireshark



It is indeed encrypted.

Task 4: Authenticating the VPN Server

Subtask 1: Generate my own certificate

```
# generate ca
$ openssl req -new -x509 -keyout ca.key -out ca.crt -config openssl.cnf
# generate server certificate
$ openssl genrsa -out serverguan.key 1024
$ openssl req -new -key serverguan.key -out serverguan.csr -config openssl.cnf
# sign
$ openssl ca -in serverguan.csr -out serverguan.crt -cert ca.crt -keyfile ca.key -
config openssl.cnf
```

Distribution

```
$ openssl x509 -in serverguan.pem -noout -subject_hash
40b51be0
# I'm working on shared folder, soft linking would not work
$ mv serverguan.pem 40b51be0.0
# ca
$ openssl x509 -in ca.pem -noout -subject_hash
$ mv ca.pem bdf70d7e.0
```

Subtask 2: Code demonstration

- Verifying that the server certificate is valid

Here, it stipulates that both client and server's certificates should be checked

```
    // sets the verification flags for ctx to be mode and specifies the verify_callback
function to be used
    // SSL_VERIFY_PEER means to examine the certificate of both sides.
    SSL_CTX_set_verify(ctx, SSL_VERIFY_PEER, NULL);
```

Then check the certificate of the server

```
    // get and set verification parameters
    X509_VERIFY_PARAM *vpm = SSL_get0_param(ssl);
    X509_VERIFY_PARAM_set1_host(vpm, hostname, 0);
```

- Verifying that the server is the owner of the certificate

```
// Whenever a certificate is verified during a SSL/TLS handshake
// a verification function is called
int verify_callback(int preverify_ok, X509_STORE_CTX *x509_ctx)
{
   char buf[300];

   // returns the certificate in ctx which caused the error or NULL
   // if no certificate is relevant
   X509 *cert = X509_STORE_CTX_get_current_cert(x509_ctx);
   X509_NAME_oneline(X509_get_subject_name(cert), buf, 300);
   printf("subject= %s\n", buf);
   if (preverify_ok == 1)
   {
      printf("Verification passed.\n");
   }
   else
   {
      int err = X509_STORE_CTX_get_error(x509_ctx);
      printf("Verification failed: %s.\n",
             X509_verify_cert_error_string(err));
   }
}
```

- Verifying that the server is the intended server

```
#define CHK_SSL(err)               \
   if ((err) < 1)                  \
   {                               \
      ERR_print_errors_fp(stderr); \
      exit(2);                     \
   }
    int err = SSL_connect(ssl);
    // During the connection
    CHK_SSL(err);
```

Subtask 3: Failed authentication

I edit the host file to change the intend server

```
$ sudo vi /etc/hosts
10.0.2.6    fudan.edu.cn
```

run the client again

```
$ sudo ./client3 fudan.edu.cn
```

```
[----------------------------------------------------------------------------]
Legend: code, data, rodata, value
167       int err = SSL_connect(ssl);
gdb-peda$ n
Verification failed: Hostname mismatch.
[Inferior 1 (process 3386) exited normally]
Warning: not running or target is remote
gdb-peda$
```

During the handshake, it would report the hostname do not match since the server don't hold the key for fudan.edu.cn

Task 5: Authenticating the VPN Client

The login funtion of client

```
void login(SSL *ssl) {
  char username[NAME_LENGTH];
  char password[PASSWORD_LENGTH];
  char request[BUFF_SIZE];
  char reply[BUFF_SIZE];
  int len;

  printf("Your username:\n");
  scanf("%s", username);
  getchar();
  printf("Your password:\n");
  scanf("%s", password);

#ifdef DEBUG
  printf("Username: %s\nPassword: %s\n", username, password);
#endif

  // request
  bzero(request, BUFF_SIZE);
  strcpy(request, username);
  strcat(request, " ");
  strcat(request, password);
  len = strlen(username) + strlen(password) + 1;
  request[len] = '\0';

#ifdef DEBUG
  printf("Request: %s\tLen: %d\n", request, len);
#endif

  SSL_write(ssl, request, len);

  // check reply
  bzero(reply, BUFF_SIZE);
  len = SSL_read(ssl, reply, BUFF_SIZE - 1);
  reply[len] = '\0';

  // fail
  if (strcmp(reply, "success")) {
    printf("Login Failed\n");
    endRequest();
  }
  // success
}
```

The checkLogin function of server

```
int checkLogin(SSL *ssl, int conn) {
  char *pch;
  char username[100];
  char password[1000];
  char request[BUFF_SIZE];

  // if not clear, the string would be weird
  memset(&username, 0, sizeof(username));
  memset(&password, 0, sizeof(password));
  memset(&request, 0, BUFF_SIZE);

  int len = SSL_read(ssl, request, BUFF_SIZE - 1);
  request[len] = '\0';

#ifdef DEBUG
  printf("Logging in:%s\n", request);
#endif

  // username
  pch = strtok(request, " ");
  if (!pch) {
    printf("Invalid username\n");
    return -1;
  }
  strcpy(username, pch);
#ifdef DEBUG
  printf("Username:%s\n", username);
#endif

  // password
  pch = strtok(NULL, " ");
  if (!pch) {
    printf("Invalid password\n");
    return -1;
  }
  strcpy(password, pch);
#ifdef DEBUG
  printf("Password:%s\n", password);
#endif

  // check the shadow
  struct spwd *pw;
  char *epasswd;
  pw = getspnam(username);
  if (pw == NULL) {
    printf("Invalid account\n");
    return -1;
  }

  // return the result
  epasswd = crypt(password, pw->sp_pwdp);
  char *fail = "fail";
  char *success = "success";
```

```
    if (strcmp(epasswd, pw->sp_pwdp)) {
      printf("Username and password do not match\n");
      SSL_write(ssl, fail, strlen(fail));
      return -1;
    }
    SSL_write(ssl, success, strlen(success));
    return 1;
  }
```

Run the server

```
$ make 5
$ sudo ./server5
$ sudo ifconfig tun0 192.168.53.1/24 up
$ sudo sysctl net.ipv4.ip_forward=1
```

```
[12/29/18]seed@VM:~/.../lab6$ sudo ./server5
TUN setup
TCP Setup
14931: Start
14931: Handshake
14931: Working
```

Run the client

```
$ sudo ./client5
$ sudo ifconfig tun0 192.168.53.5/24 up
$ sudo route add -net 192.168.60.0/24 tun0
```

```
[12/29/18]seed@VM:~/.../lab6$ sudo ./client5
TLS Initialized
TCP Connected
Verification passed.
Verification passed.
SSL connection is successful
SSL connection using AES256-GCM-SHA384
Your username:
seed
Your password:
dees
```

A failed login demostration

```
[12/29/18]seed@VM:~/.../lab6$ sudo ./client5
TLS Initialized
TCP Connected
Verification passed.
Verification passed.
SSL connection is successful
SSL connection using AES256-GCM-SHA384
Your username:
seed
Your password:
notdees
Login Failed
[12/29/18]seed@VM:~/.../lab6$
```

```
14934: Start
14934: Handshake
Username and password do not match
14934: Login Fail
```

Task 6: Supporting Multiple Clients

```
+-------------------------------------------+
+-socket1<-----pipe 1-------+                |
|                           |                v
+-socket2<-----pipe 2-------+<--main proc <---tun0
|                           |
+-socket3<-----pipe 3-------+
```

At first, I think there would be 2 pipes for every connection, one for upstream and one for downstream.

But in the upstream, the datagram from socket could be transported to tun0 directly.

```
// 父进程监听 tun0，一旦听到就写进 pipe
void tun2pipe(int tunfd, int pipefd) {
  int len;
  char buff[BUFF_SIZE];

  bzero(buff, BUFF_SIZE);
  len = read(tunfd, buff, BUFF_SIZE);
  buff[len] = '\0';
  // normal write, no ssl
  write(pipefd, buff, len);
}

// 子进程监听 pipe，一旦听到就写到 socket
void pipe2socket(int pipefd, int sockfd, SSL *ssl) {
  int len;
  char buff[BUFF_SIZE];

  bzero(buff, BUFF_SIZE);
  len = read(pipefd, buff, BUFF_SIZE);
  buff[len] = '\0';
  write(ssl, buff, len);
}

// 子进程监听 socket，一旦听到就写到 tun0
void socket2tun(int tunfd, int sockfd, SSL *ssl) {
  int len;
  char buff[BUFF_SIZE];

  bzero(buff, BUFF_SIZE);
  len = SSL_read(ssl, buff, BUFF_SIZE);
  buff[len] = '\0';
  SSL_write(tunfd, buff, len);
}`
```