CS751 - Network Engineering Assignment Report

On

Emulate TLS Fingerprinting on Network Namespaces

Submitted by

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Aim

This project aims at use of JA3/JA3S library to emulate TLS fingerprinting in network namespaces.

Installation

Step 1: Install iperf using following command sudo apt-get install iperf3

Step 2: Install openssl. Following are the steps to install OpenSSL

1. Download the latest stable version of OpenSSL using following wget command and unpack it using tar command.

```
$ wget -c https://www.openssl.org/source/openssl-1.0.2p.tar.gz
$ tar -xzvf openssl-1.0.2p.tar.gz
```

2. Move into the extracted directory, configure, build, after a successful build, test the libraries and install OpenSSL in the default location, which is /usr/local/ssl, by running the following commands.

```
$ cd openssl-1.0.2p/
$ ./config
$ make
$ make test
$ sudo make install
```

3. Move into the installation directory and view the various sub-directories and files using ls command.

```
$ cd /usr/local/ssl/
$ ls -l

drwxr-xr-x. 2 root root  4096 Aug 22 06:37 bin
drwxr-xr-x. 2 root root  4096 Aug 22 06:37 certs
drwxr-xr-x. 3 root root  4096 Aug 22 06:37 include
drwxr-xr-x. 4 root root  4096 Aug 22 06:37 lib
drwxr-xr-x. 6 root root  4096 Aug 22 06:36 man
drwxr-xr-x. 2 root root  4096 Aug 22 06:37 misc
-rw-r--r--. 1 root root 10835 Aug 22 06:37 openssl.cnf
drwxr-xr-x. 2 root root  4096 Aug 22 06:37 private
```

The following are important directories you need to take note of:

- bin – contains the openssl binary and some utility scripts.
- include/openssl – contains the header files needed for building your own programs that use libcrypto or libssl.
- lib – contains the OpenSSL library files.
- lib/engines – contains the OpenSSL dynamically loadable engines.
- man – contains the OpenSSL man-pages.
- share/doc/openssl/html – contains HTML rendition of the man-pages.
- certs – the default location for certificate files.
- private – the default location for private key files.

4. To check the version of OpenSSL you have just installed, run the following command.

```
$ /usr/local/ssl/bin/openssl version

OpenSSL 1.0.2p  14 Aug 2018
```

5. To use the newly installed OpenSSL version on your system, you need to add the directory /usr/local/ssl/bin/ to your PATH, in the file /.bashrc (or the equivalent for your shell).

```
$ vim ~/.bashrc
```

Add this line at the bottom of the file.

```
export PATH="/usr/local/ssl/bin:${PATH}"
```

Save and close the file and reload the configuration using the command below.

```
$ source .bashrc
```

6. Now open a new terminal window and run the following commands to confirm that the new OpenSSL binary is located in your PATH and that you can run it without typing its full path.

```
$ openssl version

OpenSSL 1.0.2p  14 Aug 2018
```

In case of any doubt regarding openssl installation please refer following given link: LINK:openssl

Step 3: Install JA3 To install JA3, first install pyja3 module using following command

pip install pyja3

Step 4: Inorder to run JA3S we need JA3S.py file. Inorder to get it clone the below given repository

https://github.com/salesforce/ja3

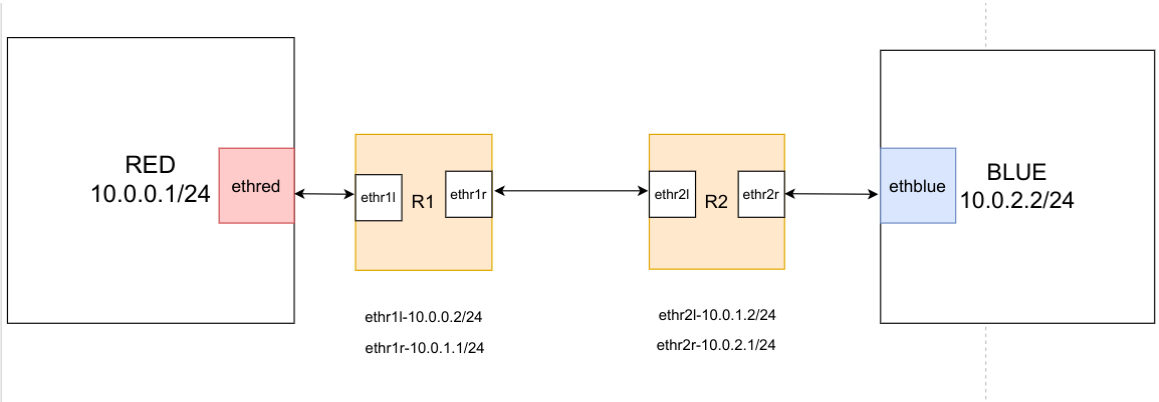
Step 5: Install WireShark. To install wireshark use following command

sudo apt install wireshark

Creating Network Namespaces

We emulate TLS fingerprinting on a topology which consist of two host and two routers. Below diagram shows the topology that we created. Note: Before creating namespace you should be in sudo mode. Use following command to get into sudo mode

sudo su



Here RED and BLUE are the two host and R1 and R2 are the two routers between RED and BLUE host. Below given script is used to create the topology.

```
#!/bin/bash
ip netns add red                                        #for adding new host red
ip netns add blue                                       #for adding new host blue
ip netns add r1                                         #for adding router r1
ip netns add r2                                         #for adding router r2
ip link add ethred type veth peer name ethr1l           #for adding virtual ethernet  having endpoints names as ethred ethr1l
ip link add ethr1r type veth peer name ethr2l           #for adding virtual ethernet  having endpoints names as ethr1r ethr2l
ip link add ethr2r type veth peer name ethblue          #for adding virtual ethernet  having endpoint names as ethr2r ethblue
ip link set  ethred netns red                           #for connecting ethred interface of virtual ethernet to host red
ip link set  ethr1l netns r1                            #for connecting ethr1l interface of virtual ethernet to router r1
ip link set  ethr1r netns r1                            #for connecting ethr1r interface of virtual ethernet to router r1
ip link set  ethr2l netns r2                            #for connecting ethr2l interface of virtual ethernet to router r2
ip link set  ethr2r netns r2                            #for connecting ethr2r interface of virtual ethernet to router r2
ip link set  ethblue netns blue                         #for connecting ethblue interface of virtual ethernet to host blue
ip netns exec red ip link set lo up                     #for setting loopback  interface  up mode  in red host
ip netns exec blue ip link set lo up                    #for setting loopback  interface  up mode  in blue host
ip netns exec r1 ip link set lo up                      #for setting loopback  interface  up mode  in r1 router
ip netns exec r2 ip link set lo up                      #for setting loopback  interface  up mode  in r2 router
ip netns exec red ip link set ethred up                 #for setting ethred    interface  up mode  in red host
ip netns exec blue ip link set ethblue up               #for setting ethblue   interface  up mode  in blue host
ip netns exec r1 ip link set ethr1l up                  #for setting ethr1l   interface  up mode  in r1 router
ip netns exec r1 ip link set ethr1r up                  #for setting ethr1r  interface  up mode  in r1 router
ip netns exec r2 ip link set ethr2l up                  #for setting ethr2l   interface  up mode  in r2 router
ip netns exec r2 ip link set ethr2r up                  #for setting ethr2r   interface  up mode  in r2 router
ip netns exec red ip address add 10.0.0.1/24 dev ethred         #allocation of ip address ethred
ip netns exec r1 ip address add 10.0.0.2/24 dev ethr1l          #allocation of ip address ethr1r
ip netns exec r1 ip address add 10.0.1.1/24 dev ethr1r          #allocation of ip address ethr1r
ip netns exec r2 ip address add 10.0.1.2/24 dev ethr2l          #allocation of ip address ethr2l
ip netns exec r2 ip address add 10.0.2.1/24 dev ethr2r          #allocation of ip address ethr2r
ip netns exec blue ip address add 10.0.2.2/24 dev ethblue       #allocation of ip address ethblue
ip netns exec red ip route add default via 10.0.0.2 dev ethred  #setting default route for ethred interface
ip netns exec blue ip route add default via 10.0.2.1 dev ethblue #setting default route for ethblue interface
ip netns exec r1 ip route add default via 10.0.1.2 dev ethr1r    #setting default route for ethr1r interface
ip netns exec r2 ip route add default via 10.0.1.1 dev ethr2l    #setting default route for ethr2l interface
ip netns exec r1 sysctl -w net.ipv4.ip_forward=1                #enable ip forwarding at router r1
ip netns exec r2 sysctl -w net.ipv4.ip_forward=1                #enable ip forwarding at router r2
```

Copy the code in a file with extension .sh and run it using terminal with following command

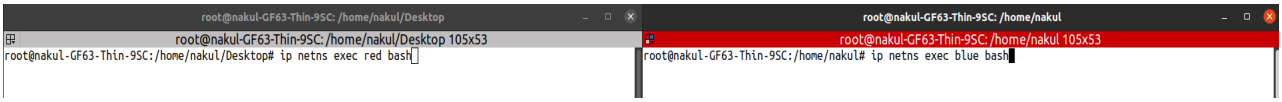
$ ./filename

(Note that here filename is written without the extension .sh)

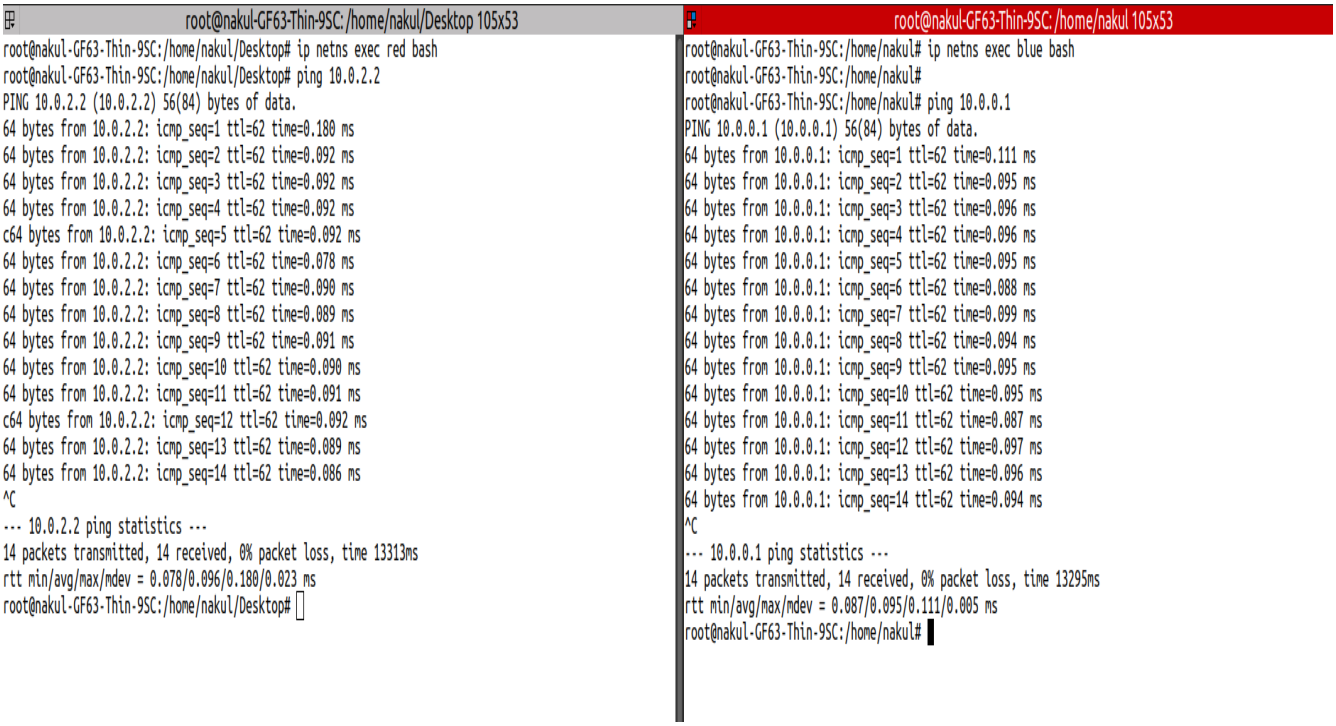
Emulation of TLS Fingerprinting

Step1: Open two terminals. In one terminal open RED bash instance and in one terminal open BLUE bash instance using following

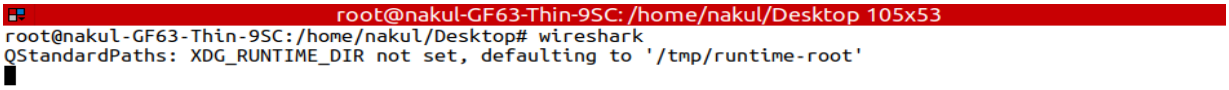
$ *ip netns exec red bash*
$ *ip netns exec blue bash*



Step 2: Now we will ping BLUE from RED and RED from BLUE as shown below.

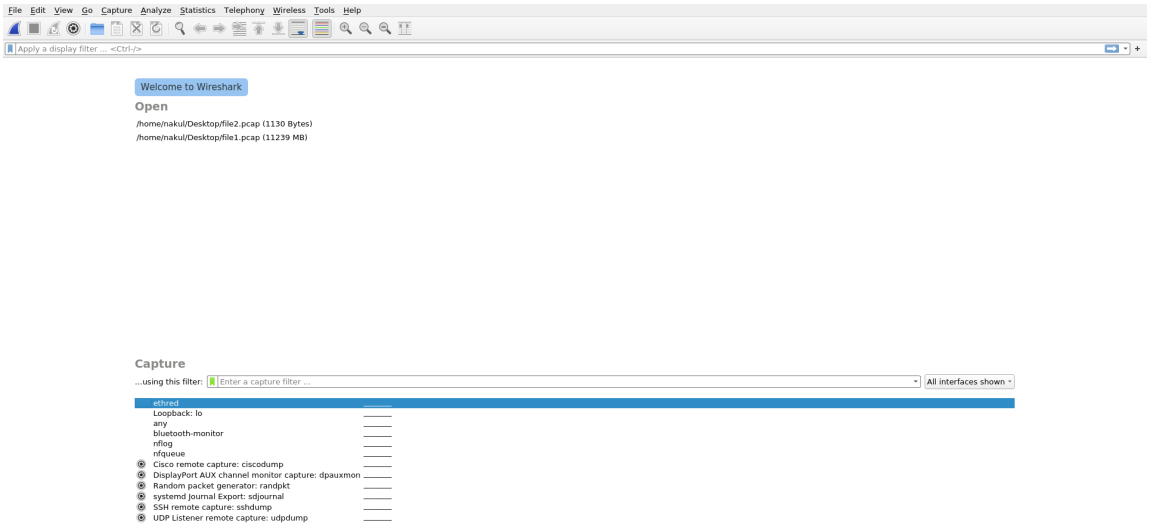


Step 3: We open wireshark on RED Bash instance.



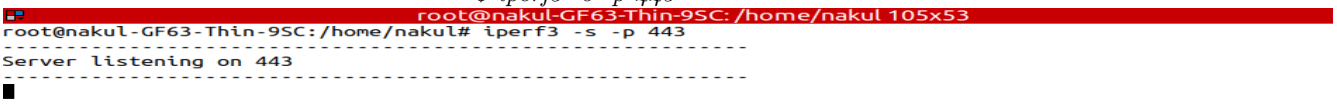
Step 4: In wireshark, choose RED interface(ethred) so that we can capture packets that are coming

to RED bash instance and going to BLUE bash instance.



Step 5: We created server on BLUE BASH instance on port 443 using following command

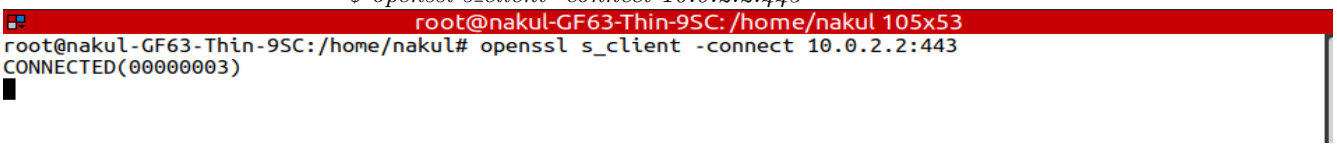
$ iperf3 -s -p 443



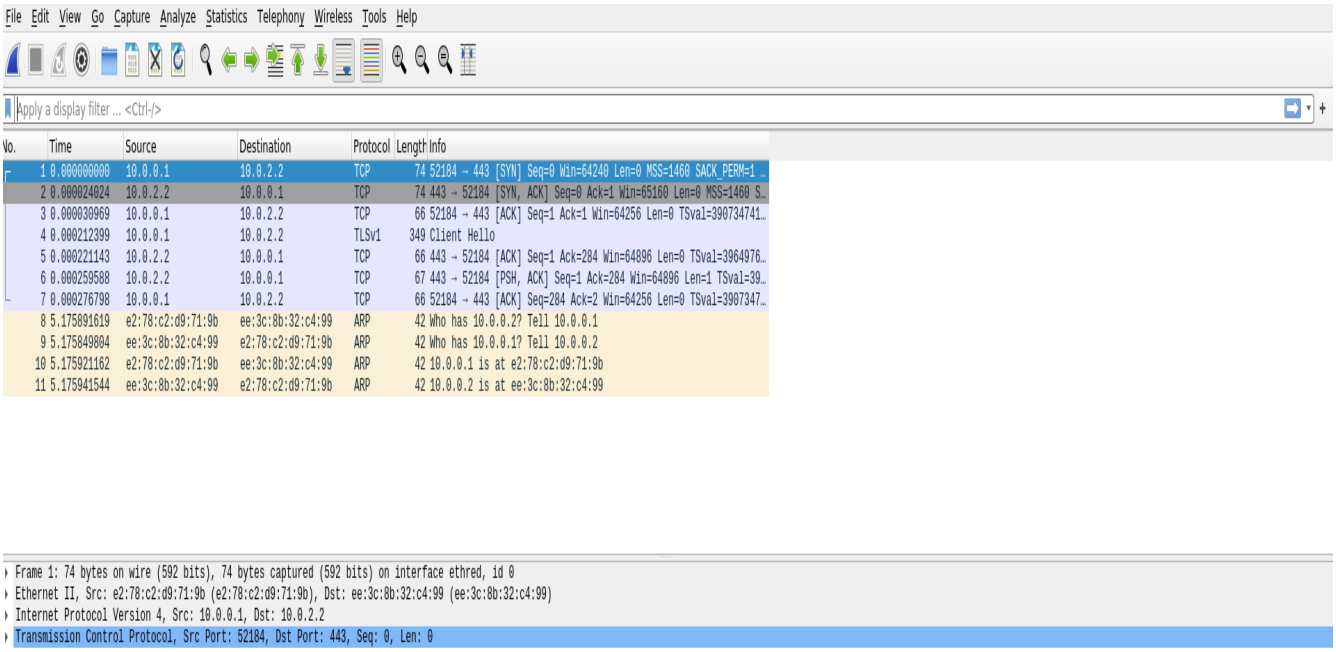
Note: We created server on port 443 because it is standard port of SSL.

Step 6: Now From RED Bash we are connecting to BLUE bash (which is our server) using OpenSSL. Below is the command

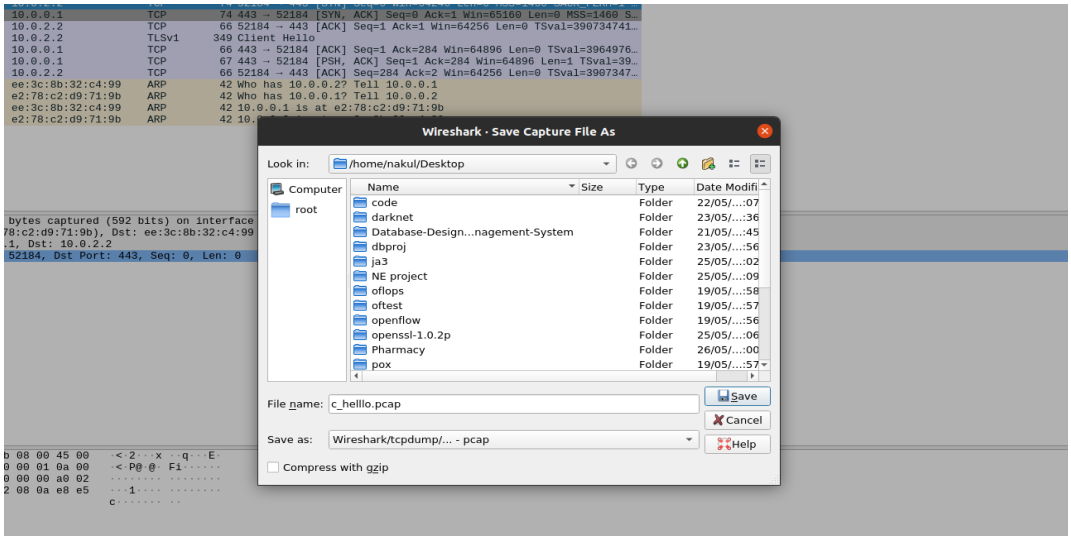
$ openssl s_client -connect 10.0.2.2:443



Step 7: Now as both RED and BLUE bash are connected via TCP handshake. After that TLS handshake will be done and during this period client hello packet will be transferred from client to server. We will capture this packet in wireshark on ethred namespace.



Step 8: Save the captured packet in a .pcap file.



JA3 is a fingerprinting mechanism performed on a Client that uses TLS to connect with the Server. This is done by performing a series of operations on the ClientHello packet received in the first step of the TLS Negotiation processes.

If you want to see how JA3 is calculated please refer the link: LINK:JA3

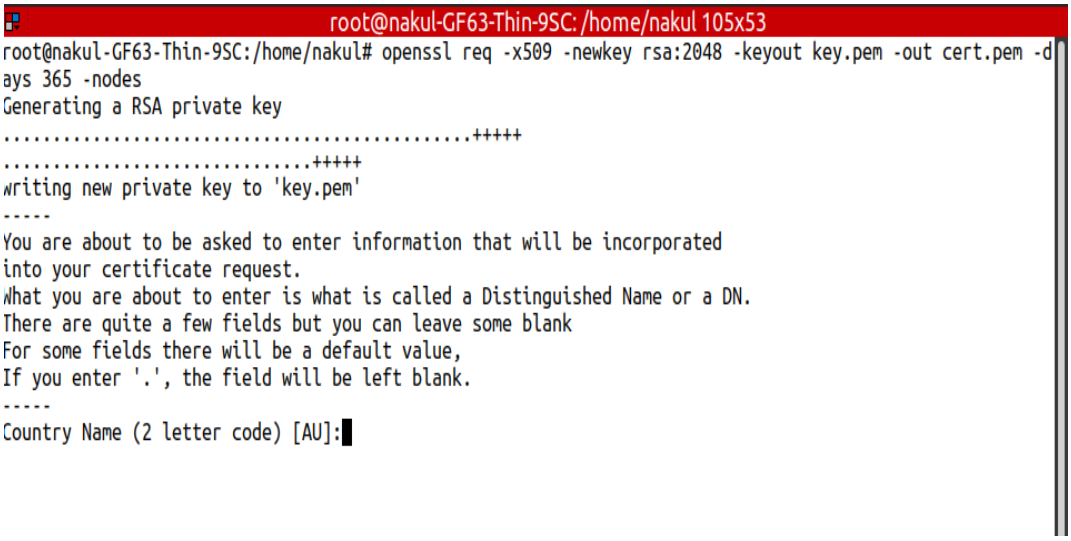
Step 9: Now using JA3 we calculate TLS fingerprint. Below is the command for running ja3 on .pcap file.

$ ja3 filename.pcap

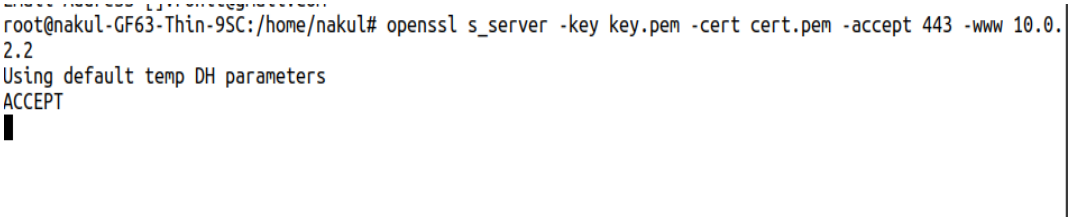
Note: We can give only .pcap file to ja3.

Step 10: Inorder to Calculate JA3S we are going to start simple https server on BLUE bash. We need to create two certificates which will be used by the OpenSSL s_server command.

$ openssl req -x509 -newkey rsa:2048 -keyout key.pem -out cert.pem -days 365 -nodes

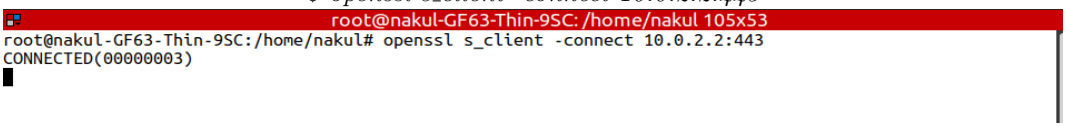


Step 11: Starting the openssl s_server.



Step 12: Now we connected OpenSSL s_server via RED Bash.

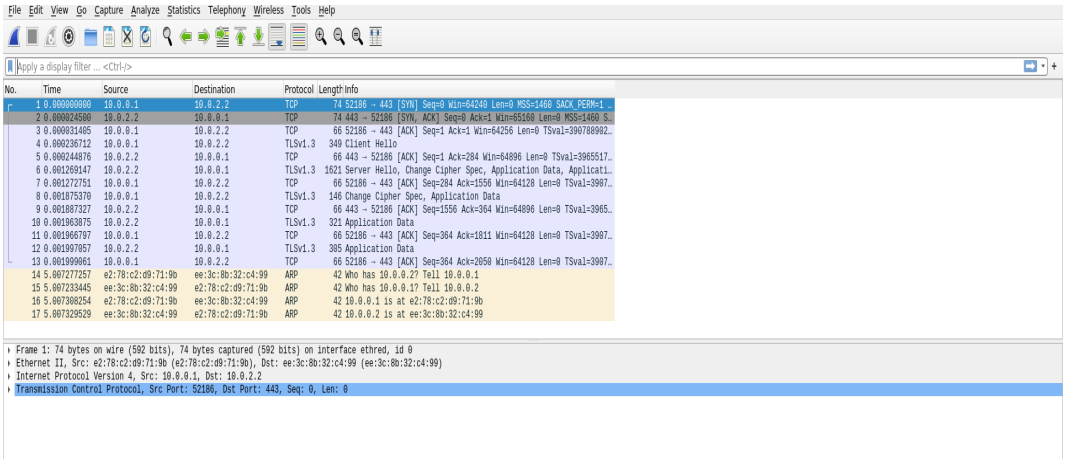
$ openssl s_client -connect 10.0.2.2:443



Step 13: These are the server details that we got on BLUE bash.

```
root@nakul-GF63-Thin-9SC:/home/nakul# openssl req -x509 -newkey rsa:2048 -keyout key.pem -out cert.pem -d
ays 365 -nodes
Generating a RSA private key
.....................................+++++
.............................+++++
writing new private key to 'key.pem'
-----
You are about to be asked to enter information that will be incorporated
into your certificate request.
What you are about to enter is what is called a Distinguished Name or a DN.
There are quite a few fields but you can leave some blank
For some fields there will be a default value,
If you enter '.', the field will be left blank.
-----
Country Name (2 letter code) [AU]:IN
State or Province Name (full name) [Some-State]:KARNATAKA
Locality Name (eg, city) []:MANGALORE
Organization Name (eg, company) [Internet Widgits Pty Ltd]:NITK
Organizational Unit Name (eg, section) []:EDU
Common Name (e.g. server FQDN or YOUR name) []:NIT
Email Address []:rohit@gmail.com
```

Step 14: By using wireshark we are able to capture client hello and server hello.save it as a .pcap file.



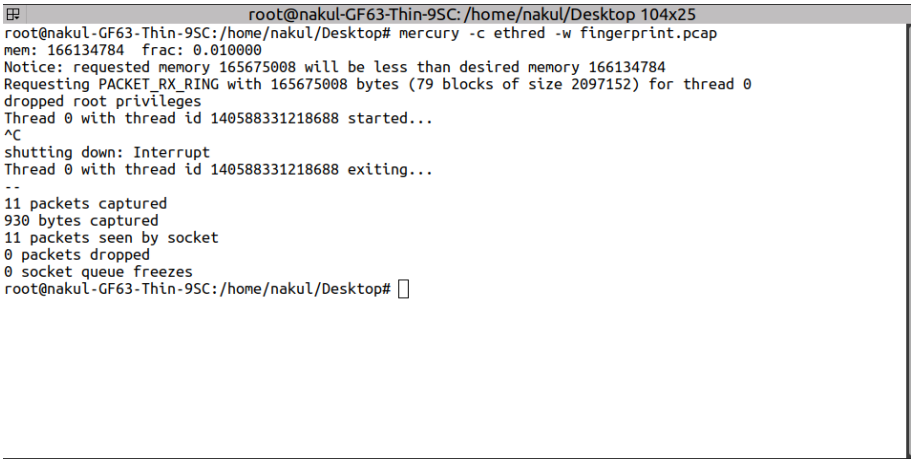
Step 15:First we have to go inside the ja3 folder which we clone from git https://github.com/salesforce/ja3.git Now by using ja3.py python script we calculate client hello fingerprint and using ja33s.py python script we calculate server hello fingerprint from same .pcap file.

1 TLS Fingerprinting using Mercury

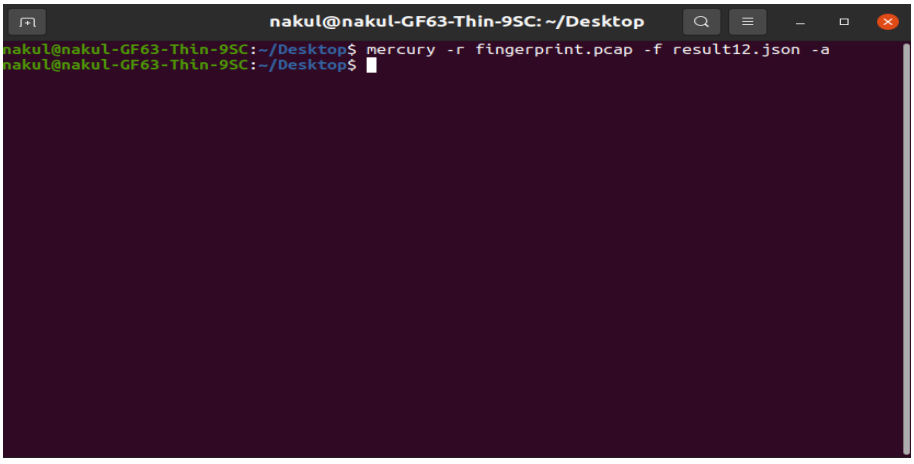
step 1:For Installing Mercury first we have to clone git link https://github.com/cisco/mercury.git
step 2:Building and installing mercury .In the root directory, run

```
./configure
make
```

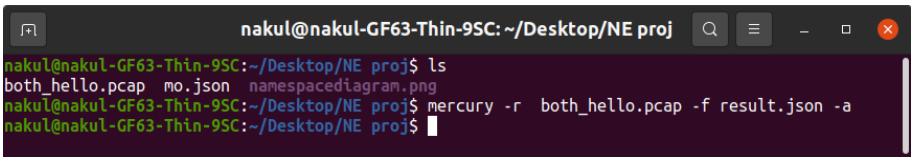
step 3:We will use the same steps as mentioned in TLS method to create a openssl server in blue host and connecting to it from red host and for capturing packets at red interface we used inbuilt packet capture of mercury.



step 4:By using these command we calculate tls fingerprint using mercury



step 5: By using these command we can calculate fingerprint in .json file using mercury.



step 6: These is result of tls client hello and tls server hello fingerprint using mercury

these are few command useful for fingerprinting

```
mercury -c eth0 -w foo.pcap           # capture from eth0, write to foo.pcap
mercury -c eth0 -w foo.pcap -t cpu    # as above, with one thread per CPU
mercury -c eth0 -w foo.mcap -t cpu -s # as above, selecting packet metadata
mercury -r foo.mcap -f foo.json       # read foo.mcap, write fingerprints
mercury -r foo.mcap -f foo.json -a    # as above, with fingerprint analysis
mercury -c eth0 -t cpu -f foo.json -a # capture and analyze fingerprints
```

Reference Links

1. https://infosecwriteups.com/demystifying-ja3-one-handshake-at-a-time-c80b04ccb393
2. https://github.com/salesforce/ja3.git
3. https://hackernoon.com/ja3-and-ja3s-in-security-monitoring-of-ssl-communication-6e1w348s
4. https://www.tecmint.com/install-openssl-from-source-in-centos-ubuntu/
5. https://superhero.ninja/2015/07/22/create-a-simple-https-server-with-openssl-s_server/
5. https://github.com/cisco/mercury.git/