Network Security – CSCI_6541_80

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Homework Assignment – 5

IPSec Assignment

Setup:

- Download this file from within Ubuntu:
  http://archive.ubuntu.com/ubuntu/pool/universe/i/ipsec-tools/ipsec-tools_0.8.2+20140711-10build1_amd64.deb

- You can use the command: wget
  http://archive.ubuntu.com/ubuntu/pool/universe/i/ipsec-tools/ipsec-tools_0.8.2+20140711-10build1_amd64.deb

- Install it
  You can use the command: dpkg -i ipsec-tools_0.8.2+20140711-10build1_amd64.deb

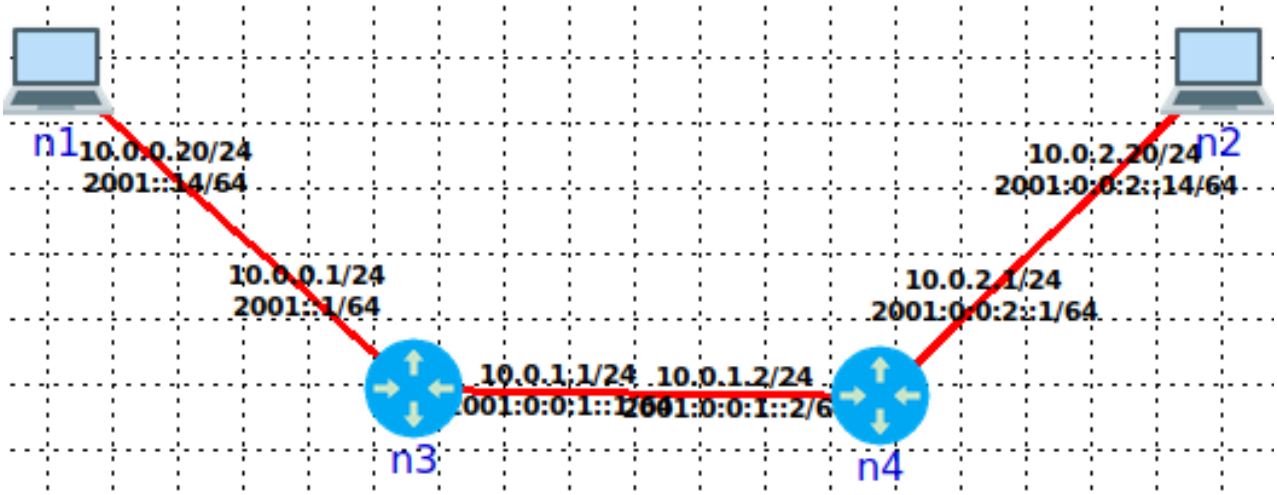
- Make sure it is installed
  You can run the command: setkey -DP. It should return "No SPD entries"

- You can read about setkey here:
  - https://manpages.debian.org/testing/ipsec-tools/setkey.8.en.html
  - https://www.kame.net/newsletter/19991007/
  - http://www.ipsec-howto.org/x304.html

- Useful commands:
  - setkey -F: flushes SAD database
  - setkey -FP: flushes SPD database
  - setkey -D: dumps SAD database
  - setkey -DP: dumps SPD database
  - setkey -h: displays help menu

Assignment (10 points)

Create the topology shown below in CORE:



The setkey command takes a config file. You can run it as follows to have it read and apply the configuration in the config file:

- setkey -f my_config.file

You will create the file "my_config.file " for some of the nodes in each the questions below. The content of the config file will be different for each of the questions below and for each node. I recommend having a "n1_config.file" for node n1, n2_config.file for n2, etc.

Using the "setkey" command, create the following configurations:

1. (4 points) Your will create two configs: n1_config.file to use on n1, and n2_config.file to use on n2. The configurations will create a transport association in AH mode between nodes n1 and n2.

   1.1. (1 point) Show the content of both config files

Content of n1_config.file in AH mode:

```
core@core-VM: ~/HW5
  GNU nano 4.8                    n1_config.file
#!/usr/sbin/setkey -f

# Configuration for 192.168.1.100

# Flush the SAD and SPD
flush;
spdflush;

# Attention: Use this keys only for testing purposes!
# Generate your own keys!

# AH SAs using 128 bit long keys
add 10.0.0.20 10.0.2.20 ah 0x200 -A hmac-md5
0xc0291ff014dccdd03874d9e8e4cdf3e6;
add 10.0.2.20 10.0.0.20 ah 0x300 -A hmac-md5
0x96358c90783bbfa3d7b196ceabe0536b;

# ESP SAs using 192 bit long keys (168 + 24 parity)
# add 192.168.1.100 192.168.2.100 esp 0x201 -E 3des-cbc
# 0x7aeaca3f87d060a12f4a4487d5a5c3355920fae69a96c831;
# add 192.168.2.100 192.168.1.100 esp 0x301 -E 3des-cbc
# 0xf6ddb555acfd9d77b03ea3843f2653255afe8eb5573965df;

# Security policies
spdadd 10.0.0.20 10.0.2.20 any -P out ipsec
           ah/transport//require;

spdadd 10.0.2.20 10.0.0.20 any -P in ipsec
           ah/transport//require;

^G Get Help    ^O Write Out   ^W Where Is    ^K Cut Text    ^J Justify
^X Exit        ^R Read File   ^\ Replace     ^U Paste Text  ^T To Spell
```

Content of n2_config.file in AH mode:

```
core@core-VM: ~/HW5
  GNU nano 4.8                    n2_config.file
#!/usr/sbin/setkey -f

# Configuration for 192.168.1.100

# Flush the SAD and SPD
flush;
spdflush;

# Attention: Use this keys only for testing purposes!
# Generate your own keys!

# AH SAs using 128 bit long keys
add 10.0.0.20 10.0.2.20 ah 0x200 -A hmac-md5
0xc0291ff014dccdd03874d9e8e4cdf3e6;
add 10.0.2.20 10.0.0.20 ah 0x300 -A hmac-md5
0x96358c90783bbfa3d7b196ceabe0536b;

# ESP SAs using 192 bit long keys (168 + 24 parity)
# add 192.168.1.100 192.168.2.100 esp 0x201 -E 3des-cbc
# 0x7aeaca3f87d060a12f4a4487d5a5c3355920fae69a96c831;
# add 192.168.2.100 192.168.1.100 esp 0x301 -E 3des-cbc
# 0xf6ddb555acfd9d77b03ea3843f2653255afe8eb5573965df;

# Security policies
spdadd 10.0.0.20 10.0.2.20 any -P in ipsec
           ah/transport//require;

spdadd 10.0.2.20 10.0.0.20 any -P out ipsec
           ah/transport//require;

                          [ Read 29 lines ]
^G Get Help    ^O Write Out   ^W Where Is    ^K Cut Text    ^J Justify
^X Exit        ^R Read File   ^\ Replace     ^U Paste Text  ^T To Spell
```

Running n1_config.file with setkey command and pinging n2 (IP: 10.0.2.20) from n1:

```
root@n1:/tmp/pycore.1/n1.conf# cd /home/core/HW5
root@n1:/home/core/HW5# ls
HW5.xml  n1_config.file  n2_config.file
root@n1:/home/core/HW5# setkey -f n1_config.file
root@n1:/home/core/HW5# ping 10.0.2.20
PING 10.0.2.20 (10.0.2.20) 56(84) bytes of data.
64 bytes from 10.0.2.20: icmp_seq=1 ttl=62 time=0.115 ms
64 bytes from 10.0.2.20: icmp_seq=2 ttl=62 time=0.164 ms
64 bytes from 10.0.2.20: icmp_seq=3 ttl=62 time=0.281 ms
64 bytes from 10.0.2.20: icmp_seq=4 ttl=62 time=0.167 ms
64 bytes from 10.0.2.20: icmp_seq=5 ttl=62 time=0.188 ms
64 bytes from 10.0.2.20: icmp_seq=6 ttl=62 time=0.082 ms
64 bytes from 10.0.2.20: icmp_seq=7 ttl=62 time=0.311 ms
64 bytes from 10.0.2.20: icmp_seq=8 ttl=62 time=0.108 ms
64 bytes from 10.0.2.20: icmp_seq=9 ttl=62 time=0.127 ms
64 bytes from 10.0.2.20: icmp_seq=10 ttl=62 time=0.197 ms
64 bytes from 10.0.2.20: icmp_seq=11 ttl=62 time=0.147 ms
```

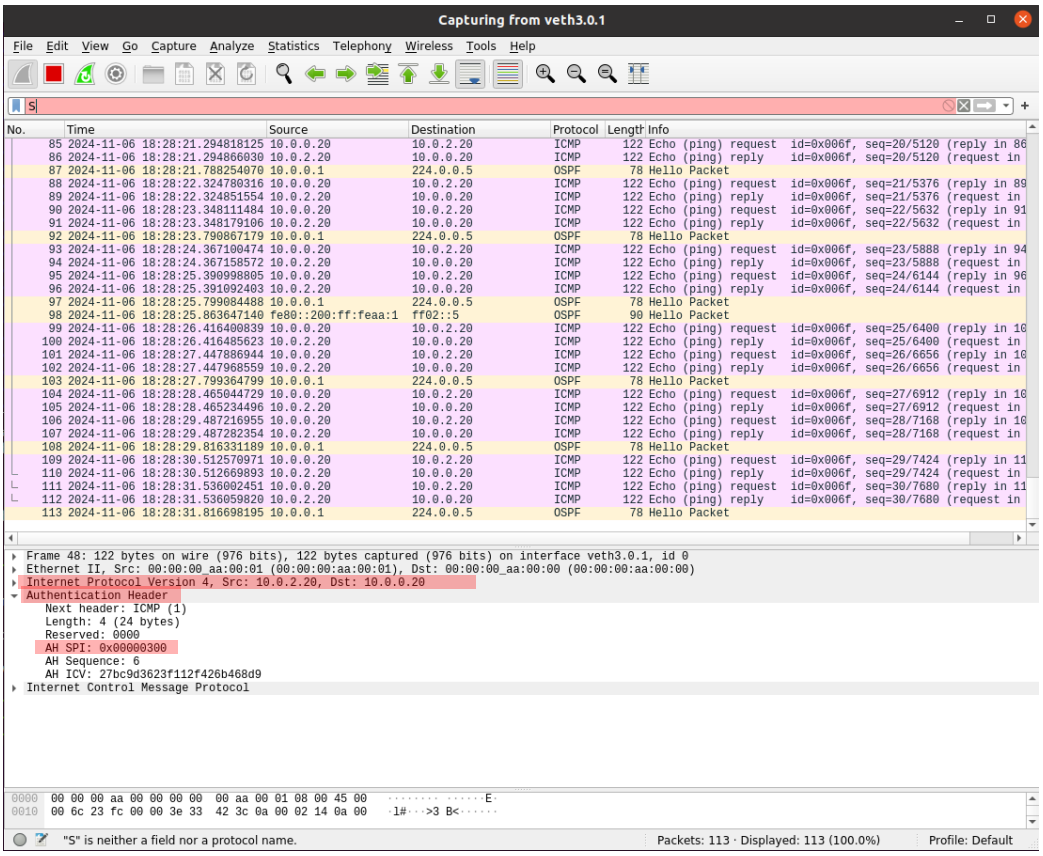
Running the n2_config.file using setkey command:

```
root@n2:/tmp/pycore.1/n2.conf# cd /home/core/HW5
root@n2:/home/core/HW5# ls
HW5.xml  n1_config.file  n2_config.file
root@n2:/home/core/HW5# setkey -f n2_config.file
root@n2:/home/core/HW5# S
```

1.2. (1 points) Show ping command from n1 to n2 successfully sending and receiving

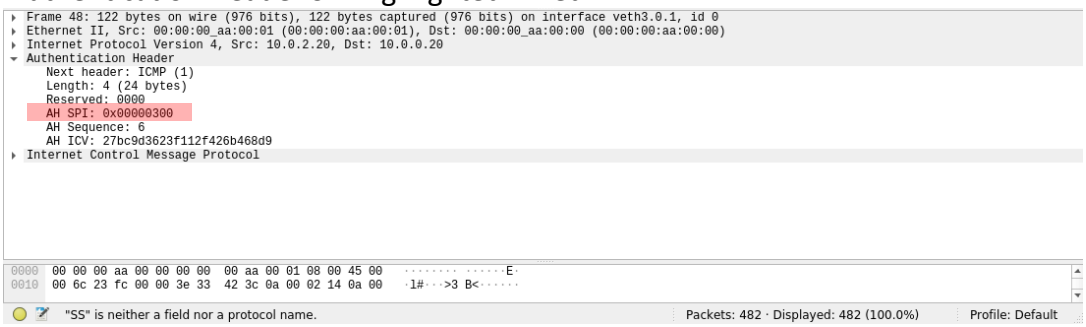
1.2.1. Show a Wireshark screenshot of ICMP echo request and echo response authenticated at the 10.0.0.1 interface on n3.

ICMP echo request and reply with authentication header:



1.2.2. Highlight the SPI value in the header in red.

Authentication Header SPI highlighted in red:



1.3. Redo 1.2 but using ESP mode

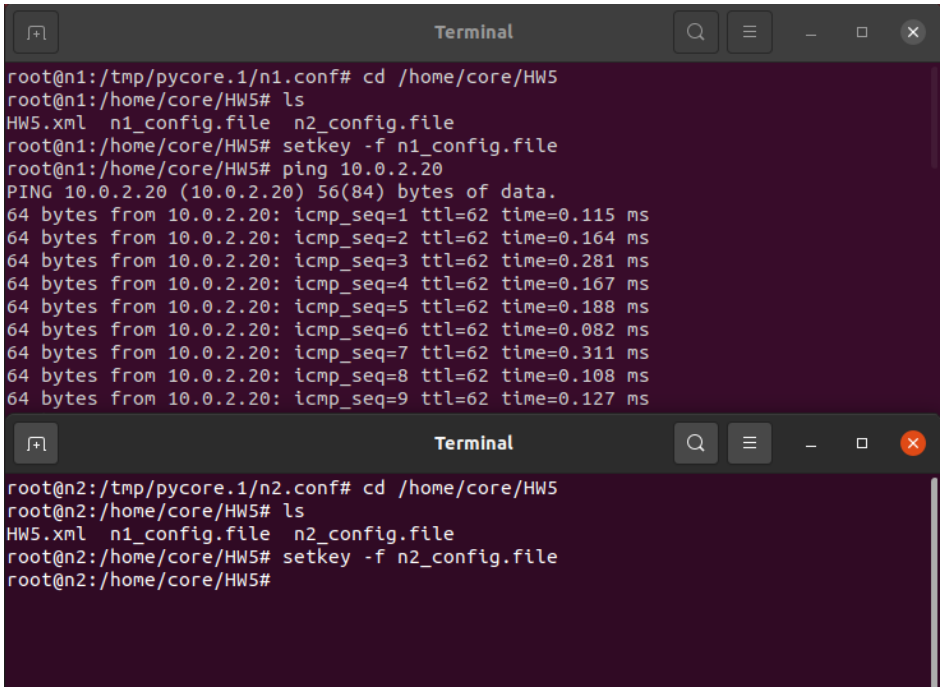
Content of n1_config.file in ESP mode:

```
core@core-VM: ~/HW5
  GNU nano 4.8                    n1_config.file
#!/usr/sbin/setkey -f

# Configuration for 192.168.1.100

# Flush the SAD and SPD
flush;
spdflush;

# Attention: Use this keys only for testing purposes!
# Generate your own keys!

# AH SAs using 128 bit long keys
#add 10.0.0.20 10.0.2.20 ah 0x200 -A hmac-md5
#0xc0291ff014dccdd03874d9e8e4cdf3e6;
#add 10.0.2.20 10.0.0.20 ah 0x300 -A hmac-md5
#0x96358c90783bbfa3d7b196ceabe0536b;

# ESP SAs using 192 bit long keys (168 + 24 parity)
add 10.0.0.20 10.0.2.20 esp 0x201 -E 3des-cbc
0x7aeaca3f87d060a12f4a4487d5a5c3355920fae69a96c831;
add 10.0.2.20 10.0.0.20 esp 0x301 -E 3des-cbc
0xf6ddb555acfd9d77b03ea3843f2653255afe8eb5573965df;

# Security policies
spdadd 10.0.0.20 10.0.2.20 any -P out ipsec
           esp/transport//require;

spdadd 10.0.2.20 10.0.0.20 any -P in ipsec
           esp/transport//require;

                              [ Wrote 29 lines ]
^G Get Help    ^O Write Out   ^W Where Is    ^K Cut Text    ^J Justify
^X Exit        ^R Read File   ^\ Replace     ^U Paste Text  ^T To Spell
```

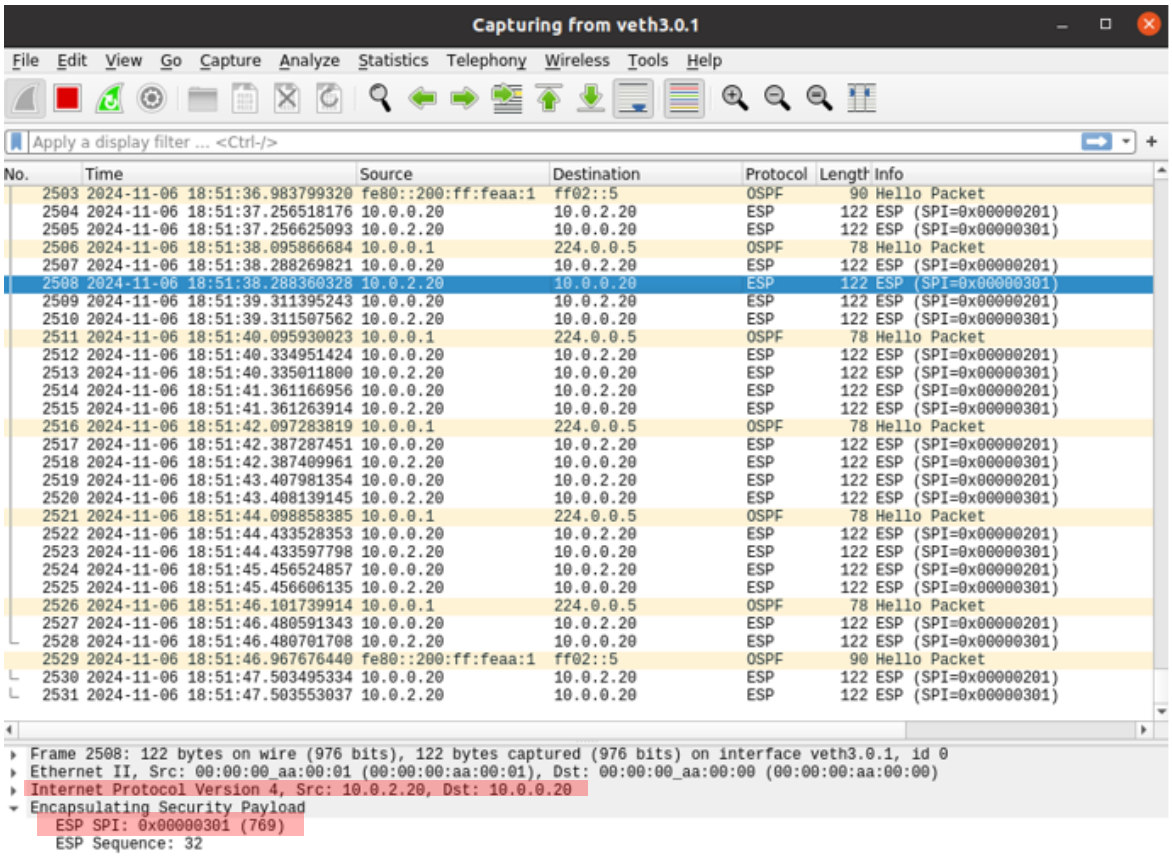
Content of n2_config.file in ESP mode:

```
core@core-VM: ~/HW5
  GNU nano 4.8                    n2_config.file                  Modified
#!/usr/sbin/setkey -f

# Configuration for 192.168.1.100

# Flush the SAD and SPD
flush;
spdflush;

# Attention: Use this keys only for testing purposes!
# Generate your own keys!

# AH SAs using 128 bit long keys
#add 10.0.0.20 10.0.2.20 ah 0x200 -A hmac-md5
#0xc0291ff014dccdd03874d9e8e4cdf3e6;
#add 10.0.2.20 10.0.0.20 ah 0x300 -A hmac-md5
#0x96358c90783bbfa3d7b196ceabe0536b;

# ESP SAs using 192 bit long keys (168 + 24 parity)
add 10.0.0.20 10.0.2.20 esp 0x201 -E 3des-cbc
0x7aeaca3f87d060a12f4a4487d5a5c3355920fae69a96c831;
add 10.0.2.20 10.0.0.20 esp 0x301 -E 3des-cbc
0xf6ddb555acfd9d77b03ea3843f2653255afe8eb5573965df;

# Security policies
spdadd 10.0.0.20 10.0.2.20 any -P in ipsec
           esp/transport//require;

spdadd 10.0.2.20 10.0.0.20 any -P out ipsec
           esp/transport//require;

File Name to Write: n2_config.file
^G Get Help      M-D DOS Format    M-A Append        M-B Backup File
^C Cancel        M-M Mac Format    M-P Prepend       ^T To Files
```

Running n1_config.file and n2_config.file using the setkey command and pinging n2 (IP: 10.0.2.20) from n1:



ESP with ESP header is captured in Wireshark as shown below:



ESP SPI Header value highlighted in red:

```
▸ Frame 2508: 122 bytes on wire (976 bits), 122 bytes captured (976 bits) on interface veth3.0.1, id 0
▸ Ethernet II, Src: 00:00:00_aa:00:01 (00:00:00:aa:00:01), Dst: 00:00:00_aa:00:00 (00:00:00:aa:00:00)
▸ Internet Protocol Version 4, Src: 10.0.2.20, Dst: 10.0.0.20
▾ Encapsulating Security Payload
    ESP SPI: 0x00000301 (769)
    ESP Sequence: 32
```

1.4. Flush the SPD and SAD at nodes n1 and n2 (look at useful commands above)

Commands for flushing SPD and SAD from both n1 and n2 nodes:
Flushing SPD: **setkey -FP**
Checking SPD entries: **setkey -DP**
Flushing SAD: **setkey -Fp**
Checking SAD entries: **setkey -Dp**

```
Terminal
root@n1:/tmp/pycore.1/n1.conf# setkey -FP
root@n1:/tmp/pycore.1/n1.conf# setkey -DP
No SPD entries.
root@n1:/tmp/pycore.1/n1.conf# setkey -Fp
root@n1:/tmp/pycore.1/n1.conf# setkey -Dp
No SAD entries.
root@n1:/tmp/pycore.1/n1.conf#
```

```
Terminal
root@n2:/tmp/pycore.1/n2.conf# setkey -FP
root@n2:/tmp/pycore.1/n2.conf# setkey -DP
No SPD entries.
root@n2:/tmp/pycore.1/n2.conf# setkey -Fp
root@n2:/tmp/pycore.1/n2.conf# setkey -Dp
No SAD entries.
root@n2:/tmp/pycore.1/n2.conf#
```

2. (4 points) You will create two configs: n3_config.file to use on n3, and n4_config.file to use on n4. The config files will create a tunnel association in AH mode between nodes n3 and n4. At n3, tunnel UDP traffic in 10.0.0.0/24 subnet. At n4, tunnel UDP traffic in 10.0.2.0/24 subnet.

2.1. (1 points) Show the content of both config files

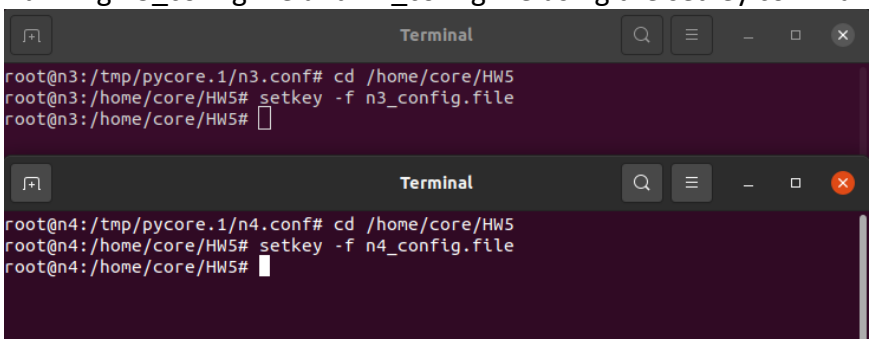
Content of n3_config.file in AH mode with UDP traffic:

```
core@core-VM: ~/HW5
  GNU nano 4.8                    n3_config.file
#!/usr/sbin/setkey -f

# Flush the SAD and SPD
flush;
spdflush;

# AH SAs doing encryption using 192 bit long keys (168 + 24 parity)
# and authentication using 128 bit long keys
add 10.0.1.1 10.0.1.2 ah 0x201 -m tunnel
-A hmac-md5 0xc0291ff014dccdd03874d9e8e4cdf3e6;

add 10.0.1.2 10.0.1.1 ah 0x301 -m tunnel
-A hmac-md5 0x96358c90783bbfa3d7b196ceabe0536b;

# Security policies
spdadd 10.0.0.0/24 10.0.2.0/24 UDP -P out ipsec
           ah/tunnel/10.0.1.1-10.0.1.2/require;

spdadd 10.0.2.0/24 10.0.0.0/24 UDP -P in ipsec
           ah/tunnel/10.0.1.2-10.0.1.1/require;

                              [ Read 20 lines ]
^G Get Help    ^O Write Out   ^W Where Is    ^K Cut Text    ^J Justify
^X Exit        ^R Read File   ^\ Replace     ^U Paste Text  ^T To Spell
```

Content of n4_config.file in AH mode with UDP traffic:

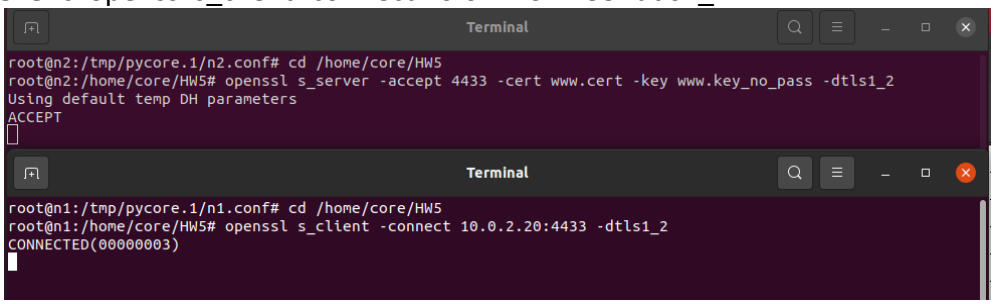
```
core@core-VM: ~/HW5
  GNU nano 4.8                    n4_config.file
#!/usr/sbin/setkey -f

# Flush the SAD and SPD
flush;
spdflush;

# AH SAs doing encryption using 192 bit long keys (168 + 24 parity)
# and authentication using 128 bit long keys
add 10.0.1.1 10.0.1.2 ah 0x201 -m tunnel
-A hmac-md5 0xc0291ff014dccdd03874d9e8e4cdf3e6;

add 10.0.1.2 10.0.1.1 ah 0x301 -m tunnel
-A hmac-md5 0x96358c90783bbfa3d7b196ceabe0536b;

# Security policies
spdadd 10.0.0.0/24 10.0.2.0/24 UDP -P in ipsec
           ah/tunnel/10.0.1.1-10.0.1.2/require;

spdadd 10.0.2.0/24 10.0.0.0/24 UDP -P out ipsec
           ah/tunnel/10.0.1.2-10.0.1.1/require;

                              [ Read 20 lines ]
^G Get Help    ^O Write Out   ^W Where Is    ^K Cut Text    ^J Justify
^X Exit        ^R Read File   ^\ Replace     ^U Paste Text  ^T To Spell
```

Running n3_config.file and n4_config.file using the setkey command:



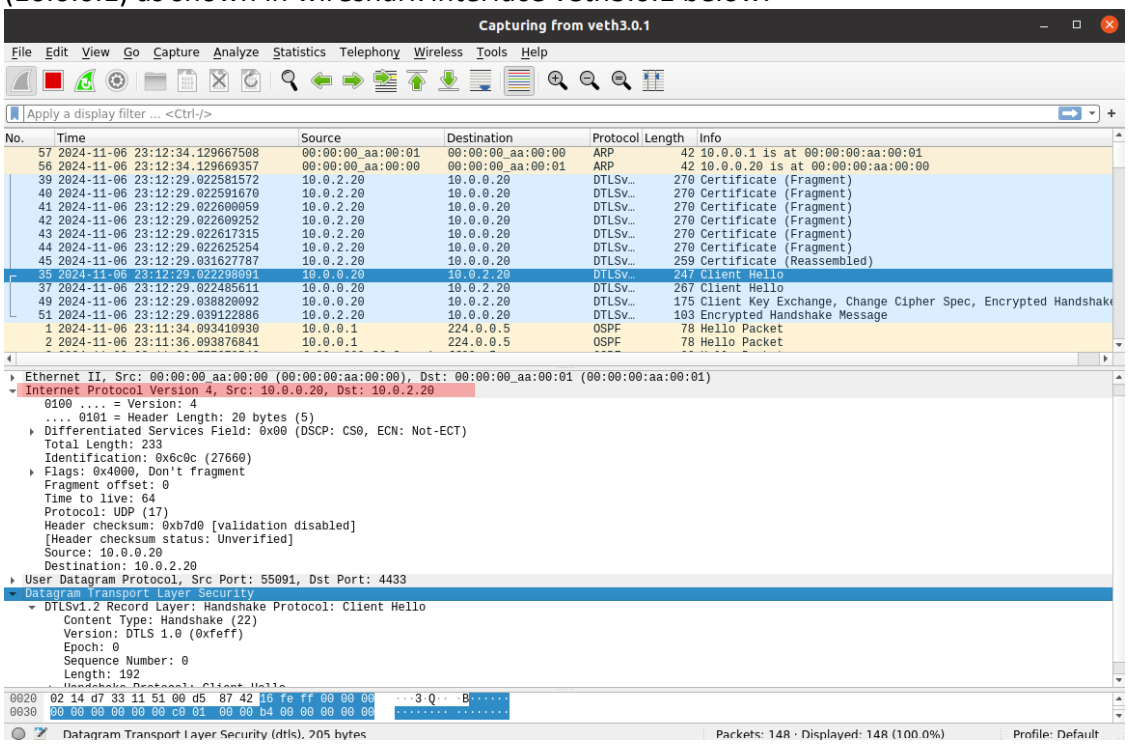
2.2. (1 points) Do a DTLS session from n1 to n2 successfully

Running a DTLS session from n1 (client) to n2 (server) using the following commands:
Server: openssl s_server -accept 4433 cert www.cert -key www.key.no_pass -dtls1_2
Client: openssl s_client -connect 10.0.2.20:4433 -dtls1_2



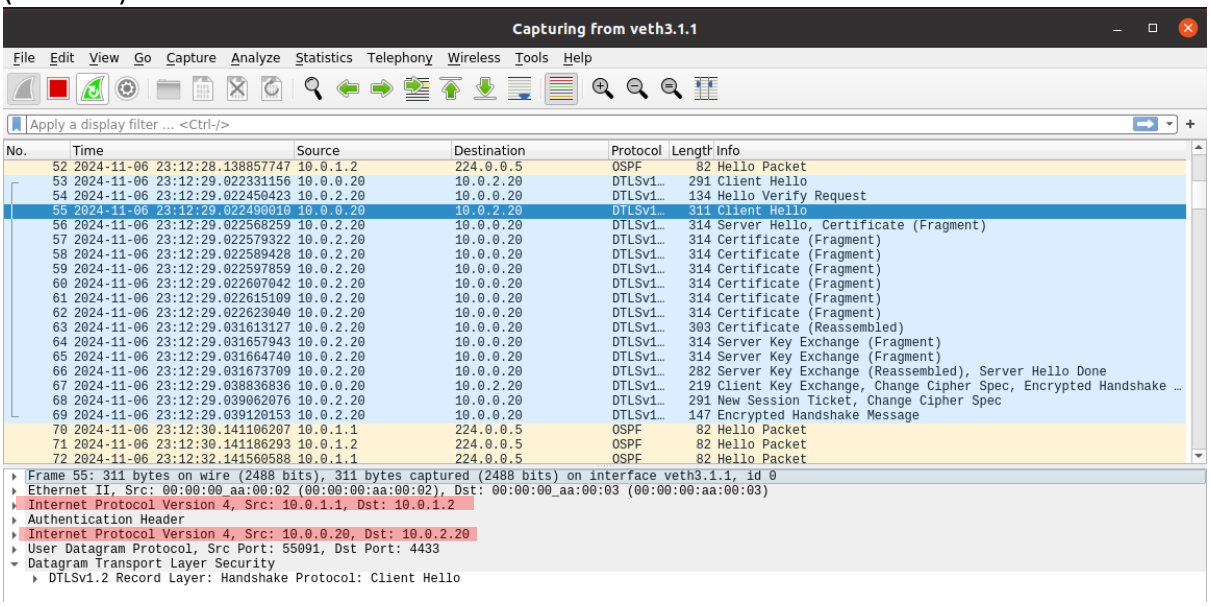
2.2.1. Show a Wireshark screenshot of Client Hello packets entering the 10.0.0.1 interface on n3.

DTLS Client Hello packets moving from n1 (10.0.0.20) to n2 (10.0.2.20) via n3 (10.0.0.1) as shown in wireshark interface veth3.0.1 below:



2.2.2. Show a Wireshark screenshot of Client Hello packets leaving the 10.0.1.1 interface on n3.

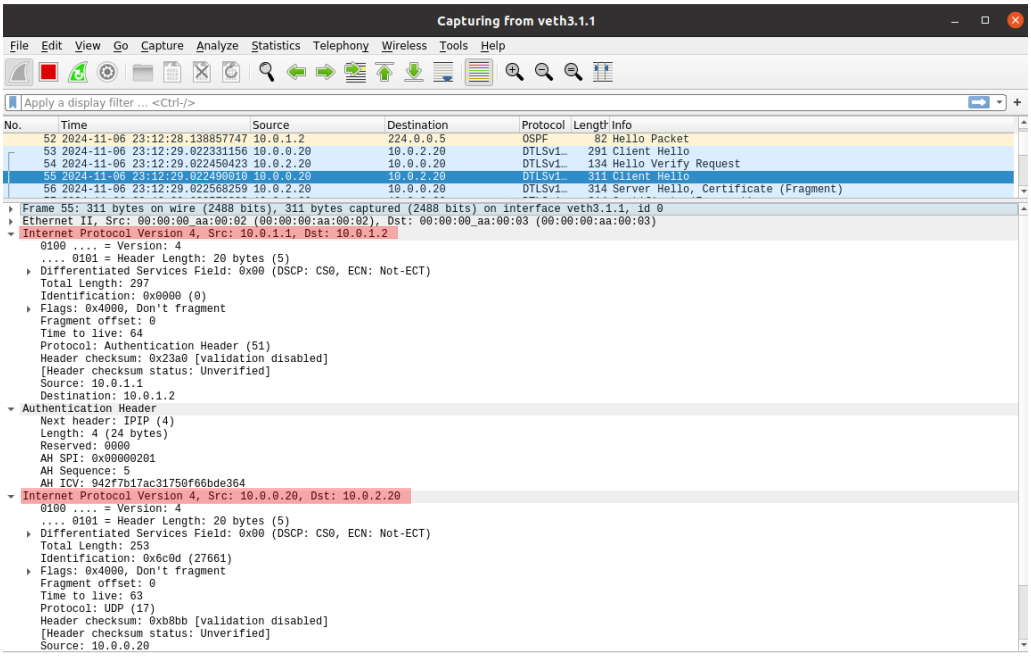
DTLS Client Hello packets moving from n1 (10.0.0.20) to n2 (10.0.2.20) via n3 (10.0.1.1) as shown in wireshark interface veth3.1.1 below:



2.2.2.1. Show inner and outer IP headers addresses

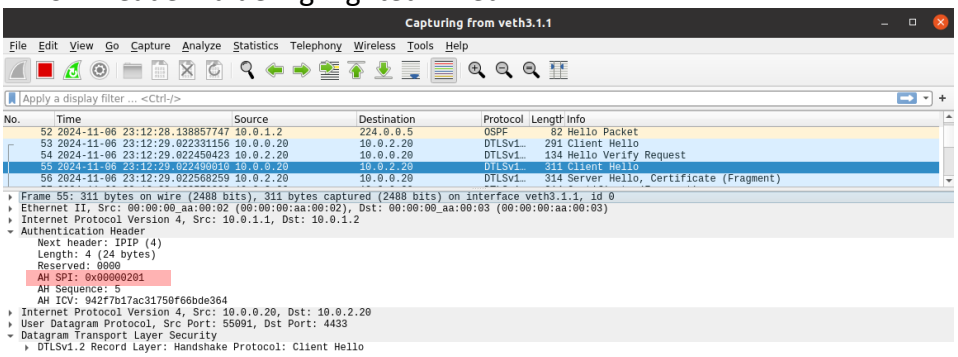
Outer IP header address:
Source: 10.0.1.1
Destination: 10.0.1.2

Inner IP header address:
Source: 10.0.0.20
Destination: 10.0.2.20



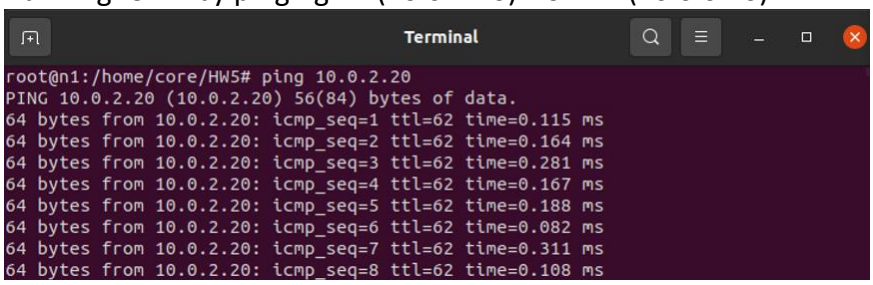
2.2.2.2. Highlight the SPI value in the header in red.

AH SPI Header value highlighted in red:

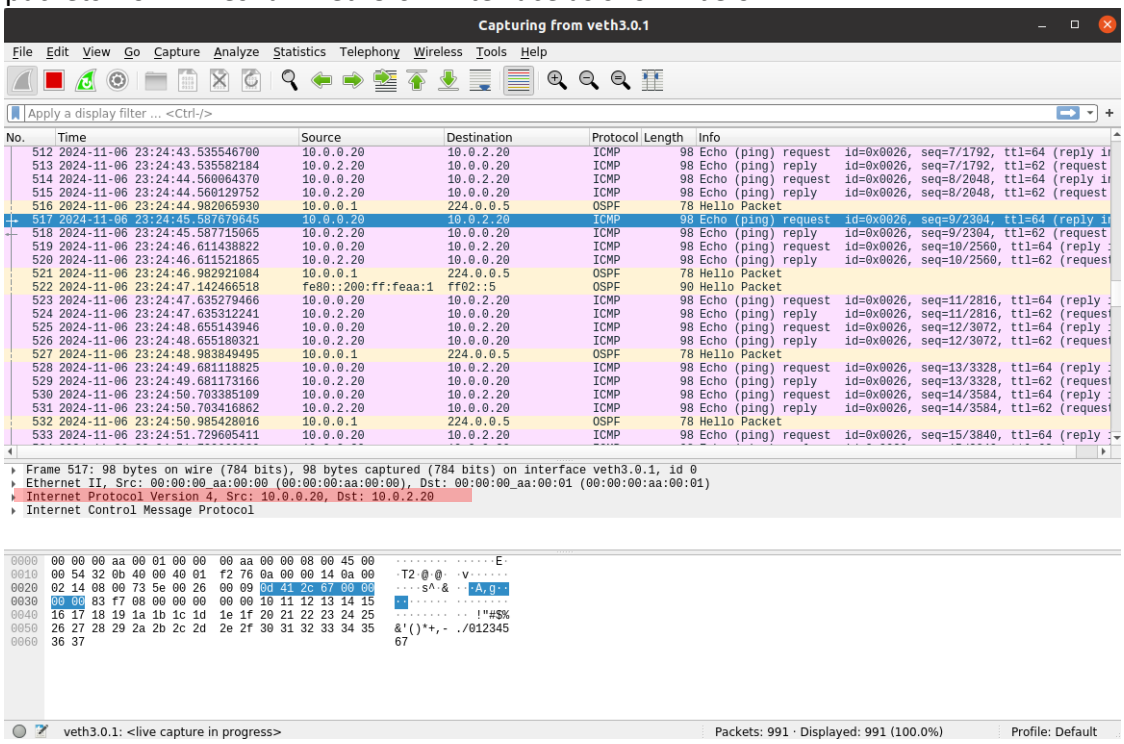


2.3. Repeat 2.2 using ICMP, you should not see any AH headers

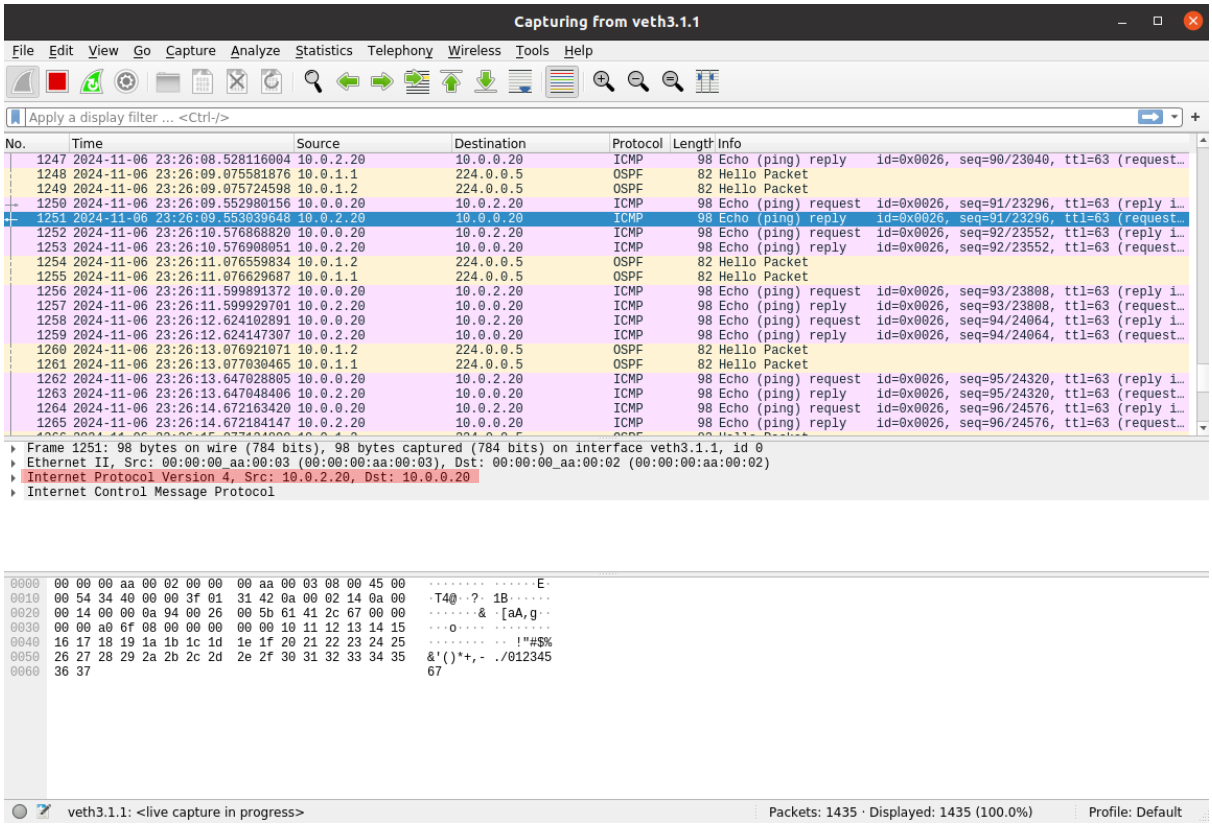
Running ICMP by pinging n2 (10.0.2.20) from n1(10.0.0.20):



You can see that there are no authentication headers (AH) in the ICMP echo request packets from wireshark veth3.0.1 interface as shown below:

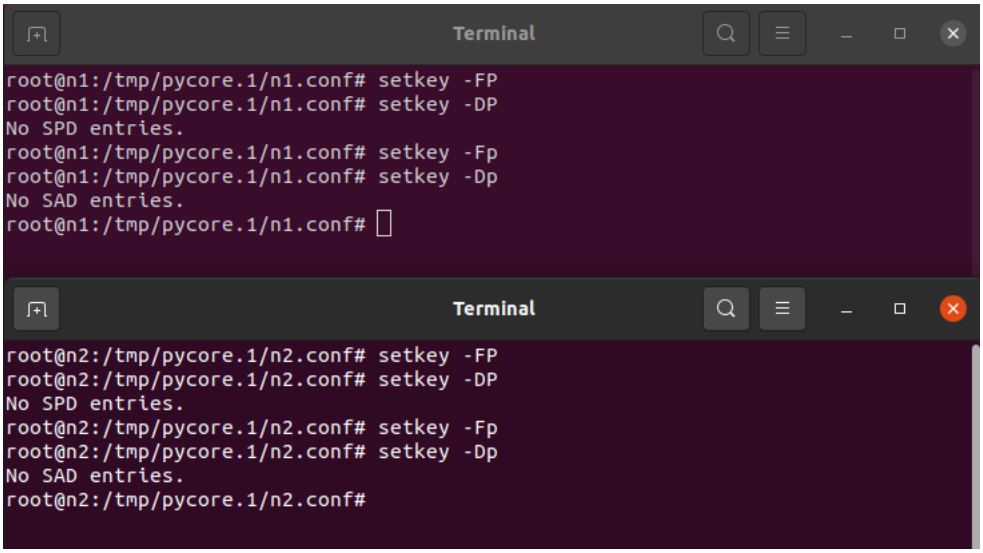


You can see that there are no authentication headers (AH) in the ICMP echo reply packets from wireshark veth 3.1.1 interface as shown below:



2.4. Flush the SPD and SAD at nodes n1 and n2 (look at useful commands above)

Commands for flushing SPD and SAD from both n1 and n2 nodes:
Flushing SPD: **setkey -FP**
Checking SPD entries: **setkey -DP**
Flushing SAD: **setkey -Fp**
Checking SAD entries: **setkey -Dp**

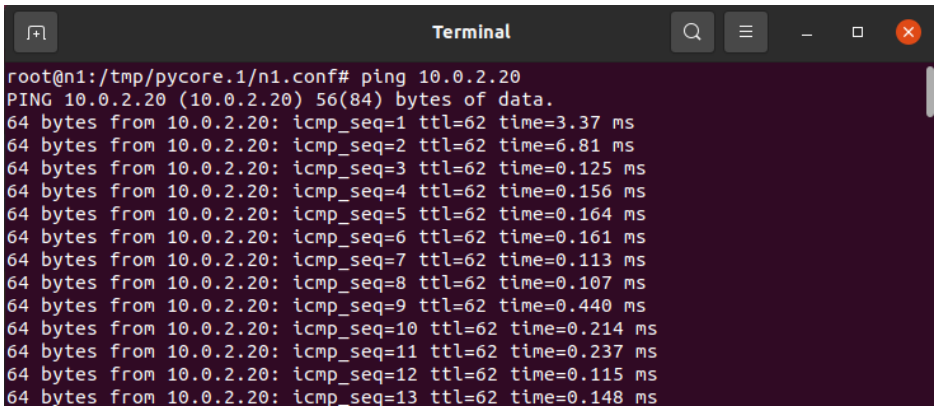


3. (2 points) Combine (1.2) in AH mode and (2.2) in AH mode but apply for any protocol instead of just UDP.

In n1_config.file and n2_config.file, change the content back into AH Security Association and Security policies as shown in step 1.1 above. In n3_config.file and n4_config.file, change the security policies traffic from **UDP to any** as shown in step 1.1

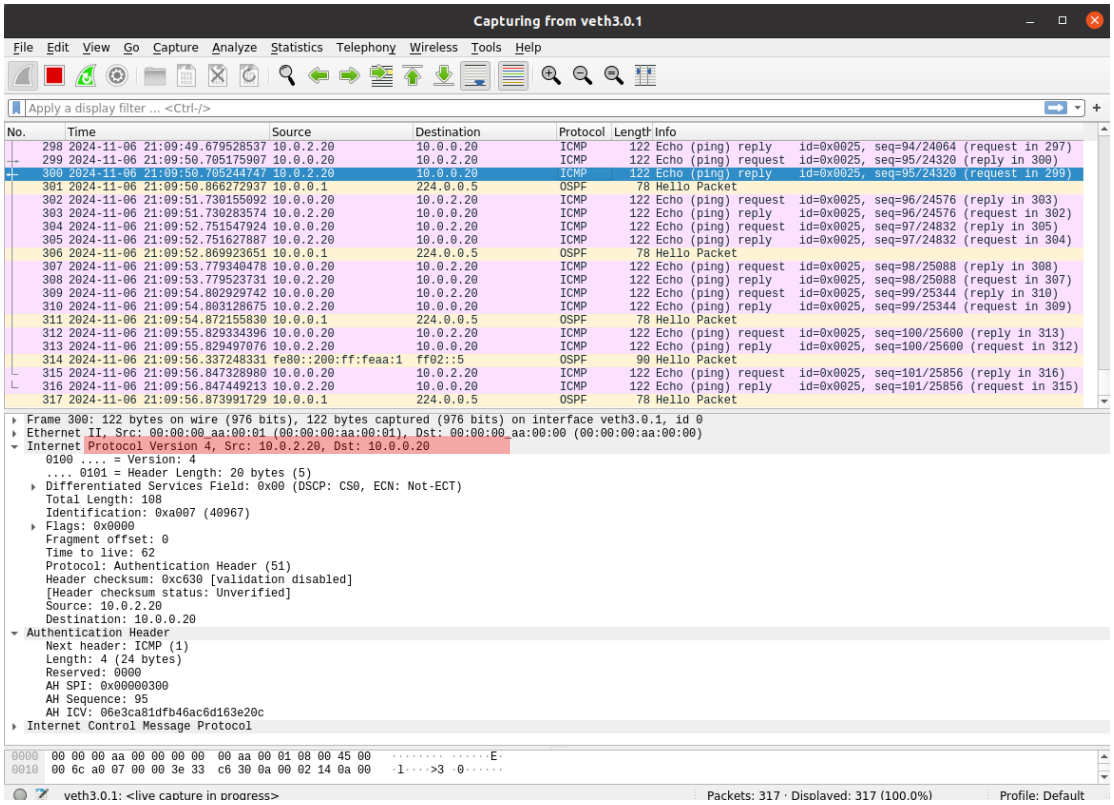
3.1. Ping from n1 to n2

Pinging n2 (10.0.2.20) from n1(10.0.0.20) as shown:

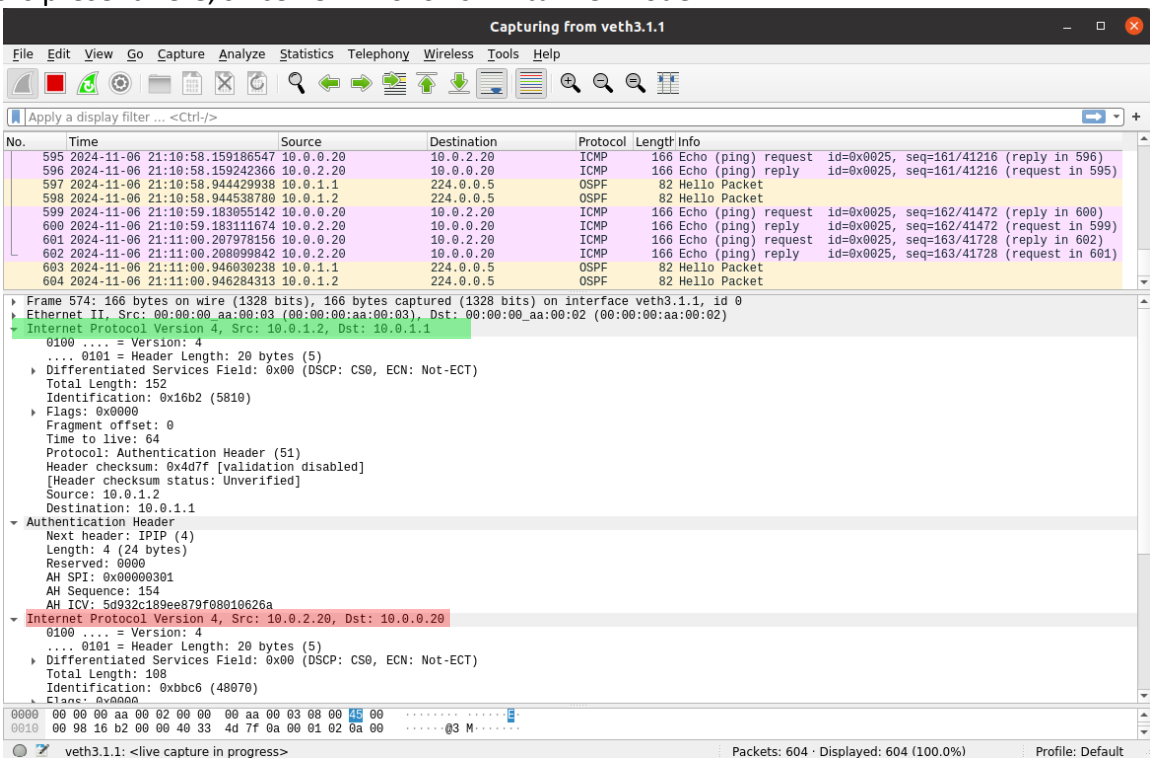


3.1.1. Show a Wireshark screenshot of ICMP packets on interfaces between n1-n3, n3-n4, and n4-n2 in that order. Highlight the inner and outer IP headers addresses on each.

ICMP packets on veth3.0.1 interface of wireshark between n1-n3 is shown below. For n1-n3, Inner IP address is highlighted in red, and no outer IP address is present since it follows AH transport mode.



ICMP packets on veth3.1.1 interface of wireshark between n3-n4 is shown below. For n3-n4, Inner IP address is highlighted in red, and outer IP address is highlighted in green. Outer IP address is present here, since n3-n4 follows AH tunnel mode.



ICMP packets on veth4.1.1 interface of wireshark between n4-n2 is shown below. For n4-n2, Inner IP address is highlighted in red, and no outer IP address is present since it follows AH transport mode.