

Otto-Friedrich-University Bamberg  
Professorship for Computer Science,  
Communication Services, Telecommunication,  
Systems and Computer Networks



## Foundation of Internet Communication

### Assignement1

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# Chapter 1

## Wireshark Handling

Explain what we are going to do in this section here

### 1.1 Provide a short documentation that explained its actions

Wireshark is a network protocol analyzer. Using wireshark, we can monitor what's happening on the network.

#### Who use Wireshark?

- Network administrators use it to troubleshoot network problems
- Network security engineers use it to examine security problems
- QA engineers use it to verify network applications
- Developers use it to debug protocol implementations
- People use it to learn network protocol internals

#### Features

- Available for UNIX and Windows.
- it is an open source software project, and is released under the GNU General Public License (GPL)
- Capture live packet data from a network interface including Ethernet, Wireless LAN,...

- Open files containing packet data captured with tcpdump/WinDump, Wireshark, and many other packet capture programs.
- Import packets from text files containing hex dumps of packet data.
- Display packets with very detailed protocol information.
- Save packet data captured.
- Export some or all packets in a number of capture file formats.
- Filter packets on many criteria.
- Search for packets on many criteria.
- Colorize packet display based on filters.
- Create various statistics.

#### **Wireshark is not**

- It isn't an intrusion detection system. It will not warn you when someone does strange things on your network . However, if it happens, Wireshark can help you figure out what is really going on.
- Wireshark will not manipulate things on the network.. Wireshark doesn't send packets on the network.

#### **Supported platforms**

Wireshark runs on most UNIX and UNIX-like platforms including Linux and most BSD variants. It also runs on various Windows platforms

## **1.2 How long was the period between the sending of the HTTP GET message until the receipt of the HTTP OK reply? Provide screenshots**

183 ms.

No.	Time	Source	Destination	Protocol	Length	Info
61	5.584473	192.168.0.12	184.168.47.225	HTTP	705	GET /2015/01/21/calculate-http-response-time-in-wireshark/ HTTP/1.1
74	5.777487	184.168.47.225	192.168.0.12	HTTP	1315	HTTP/1.1 200 OK (text/html)
92	6.017920	2a02:810d:82bf:dc60::2a04:fa87:ffff::c00	2a02:810d:82bf:dc60::2a04:fa87:ffff::c00	HTTP	613	GET /avatar/d30536da380a1a9cc4053a25783261ea?s=50&d=mm&r=g HTTP/1.1
94	6.038248	2a04:fa87:ffff::c00	2a02:810d:82bf:dc60::2a02:810d:82bf:dc60	HTTP	561	HTTP/1.1 304 Not Modified
129	6.399352	192.168.0.12	184.168.47.225	HTTP	636	GET /favicon.ico HTTP/1.1
130	6.585002	184.168.47.225	192.168.0.12	HTTP	509	HTTP/1.1 302 Moved Temporarily (text/html) (text/html)
131	"REF"	192.168.0.12	184.168.47.225	HTTP	656	GET wp-admin/images/w-logo-blue.png HTTP/1.1
135	0.181093	184.168.47.225	192.168.0.12	HTTP	460	HTTP/1.1 200 OK (PNG)
140	4.282353	192.168.0.12	184.168.47.225	HTTP	879	GET /2015/01/21/calculate-http-response-time-in-wireshark/ HTTP/1.1
159	4.472561	184.168.47.225	192.168.0.12	HTTP	1315	HTTP/1.1 200 OK (text/html)

▸ Frame 131: 656 bytes on wire (5248 bits), 656 bytes captured (5248 bits) on interface 0  
 ▸ Ethernet II, Src: HonHaiPr\_61:db:37 (78:e4:00:61:db:37), Dst: HitronTe\_76:ee:72 (f0:f2:49:76:ee:72)  
 ▸ Internet Protocol Version 4, Src: 192.168.0.12, Dst: 184.168.47.225  
 ▸ Transmission Control Protocol, Src Port: 58362, Dst Port: 80, Seq: 1234, Ack: 11209, Len: 602

Figure 1.1: Http Response Time

# Chapter 2

## Wireshark Packet Filtering

### 2.1 Ping tool

- Ping tool is utility used for troubleshooting, testing and diagnosing issues related to network connectivity
- When we use Wireshark for capturing live packets in the background we parallelly use terminal and ping [www.google.com](http://www.google.com)
- We let Wireshark to capture the packets for few seconds

```
PING www.google.com (172.217.163.132): 56 data bytes
64 bytes from 172.217.163.132: icmp_seq=0 ttl=52 time=73.983 ms
64 bytes from 172.217.163.132: icmp_seq=1 ttl=52 time=85.190 ms
64 bytes from 172.217.163.132: icmp_seq=2 ttl=52 time=87.461 ms
64 bytes from 172.217.163.132: icmp_seq=3 ttl=52 time=58.847 ms
64 bytes from 172.217.163.132: icmp_seq=4 ttl=52 time=49.609 ms
^C
--- www.google.com ping statistics ---
5 packets transmitted, 5 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 49.609/71.018/87.461/14.741 ms
```

Figure 2.1: Pinging [www.google.com](http://www.google.com)

- Using wireshark packet filter `ip.addr == host/destination address`.  
eg:- `ip.addr == 172.217.163.132`

ip.addr == 172.217.163.100						
No.	Time	Source	Destination	Protocol	Length	Info
5118	43.474709	172.20.10.2	172.217.163.100	ICMP	98	Echo (ping) request id=0xa304, seq=0/0, ttl=64 (reply in 51...
5126	43.583242	172.217.163.100	172.20.10.2	ICMP	98	Echo (ping) reply id=0xa304, seq=0/0, ttl=52 (request in ...
5189	44.479044	172.20.10.2	172.217.163.100	ICMP	98	Echo (ping) request id=0xa304, seq=1/256, ttl=64 (reply in ...
5196	44.559059	172.217.163.100	172.20.10.2	ICMP	98	Echo (ping) reply id=0xa304, seq=1/256, ttl=52 (request in ...
5243	45.481205	172.20.10.2	172.217.163.100	ICMP	98	Echo (ping) request id=0xa304, seq=2/512, ttl=64 (reply in ...
5247	45.559178	172.217.163.100	172.20.10.2	ICMP	98	Echo (ping) reply id=0xa304, seq=2/512, ttl=52 (request in ...
5399	46.486006	172.20.10.2	172.217.163.100	ICMP	98	Echo (ping) request id=0xa304, seq=3/768, ttl=64 (reply in ...
▶ Frame 5118: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface en0, id 0						
▶ Ethernet II, Src: Apple_9a:6a:10 (98:46:0a:9a:6a:10), Dst: 46:00:10:16:40:64 (46:00:10:16:40:64)						
▶ Internet Protocol Version 4, Src: 172.20.10.2, Dst: 172.217.163.100						
▶ Internet Control Message Protocol						

Figure 2.2: Display filter

## 2.2 Packets sent by the host IP Address

- The Packets sent by the host when we visit the URL <http://www.caid.a.org/tools/visualization/mapnet> can be displayed with the help of the display filter `ip.dst == ip address of the url`.  
eg:- `ip.addr == 192.168.43.82`.

Wireshark File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help									
Wi-Fi: en0									
dns									
No.	Time	Source	Destination	Protocol	Length	Info			
5	3.648605	192.168.43.180	192.168.43.251	DNS	73	Standard query 0x90a0 A www.caida.org			
6	3.649258	192.168.43.180	192.168.43.251	DNS	73	Standard query 0xab75 AAAA www.caida.org			
8	3.711584	2405:204:5019:196d...	2405:204:5019:196d...	DNS	103	Standard query 0xf3b1 A mmx-ds.cdn.whatsapp.net			
9	3.711766	2405:204:5019:196d...	2405:204:5019:196d...	DNS	103	Standard query 0xf7574 AAAA mmx-ds.cdn.whatsapp.net			
10	3.713231	2405:204:5019:196d...	2405:204:5019:196d...	DNS	103	Standard query 0xf3b1 A mmx-ds.cdn.whatsapp.net			
13	3.752310	2405:204:5019:196d...	2405:204:5019:196d...	DNS	119	Standard query response 0xf3b1 A mmx-ds.cdn.whatsapp.net A 1...			
14	3.753022	2405:204:5019:196d...	2405:204:5019:196d...	DNS	131	Standard query response 0xf7574 AAAA mmx-ds.cdn.whatsapp.net ...			
35	4.505171	192.168.43.251	192.168.43.180	DNS	109	Standard query response 0x90a0 A www.caida.org CNAME cider.c...			
36	4.506897	192.168.43.251	192.168.43.180	DNS	121	Standard query response 0xab75 AAAA www.caida.org CNAME cide...			

▶ Frame 5: 73 bytes on wire (584 bits), 73 bytes captured (584 bits) on interface en0, id 0 ▶ Ethernet II, Src: Apple_98:64:d0 (98:46:0a:98:64:d0), Dst: ca:bf:2f:3f:e5:71 (ca:bf:2f:3f:e5:71) ▶ Internet Protocol Version 4, Src: 192.168.43.180, Dst: 192.168.43.251 ▶ User Datagram Protocol, Src Port: 12687, Dst Port: 53 ▶ Domain Name System (query)									
---	--	--	--	--	--	--	--	--	--

0000	ca bf 2f 3f e5 71 98 46	0a 98 64 d0 00 00 45 00	..../? q F ..d...E.
0010	00 3b ff fd 00 00 40 11	a1 b4 c0 a8 2b b4 c0 a8	.;...@ ....+...
0020	2b fb 31 8f 00 35 00 27	a5 47 90 a0 01 00 00 01	+1...S...G.....
0030	00 00 00 00 00 00 03 77	77 77 05 63 61 69 64 61	.....w ww.caida
0040	03 6f 72 67 00 00 01 00	01	.org.....

Figure 2.3: Destination ip Address with DNS filter

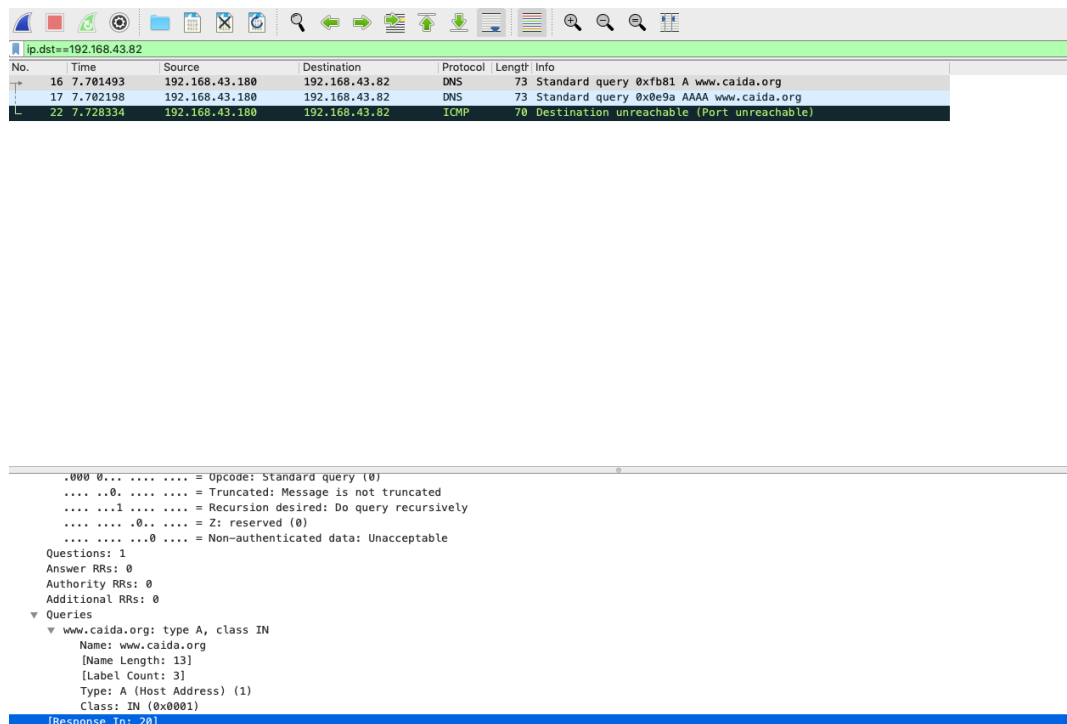


Figure 2.4: IP address display filter

## 2.3 Packets sent by the host MAC Address

- The Mac address of my system is 98:46:0a:98:64:d0.
- The packets sent by the host MAC address, if we visit the URL <http://www.caida.org/tools/visualization/mapnet> can be displayed with the filter `eth.addr==mac address`  
eg:- `eth.addr== 98:46:0a:98:64:d0`



No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.43.180	239.255.255.250	SSDP	217	M-SEARCH * HTTP/1.1
2	0.000813	192.168.43.180	239.255.255.250	SSDP	217	M-SEARCH * HTTP/1.1
3	0.001128	192.168.43.180	239.255.255.250	SSDP	217	M-SEARCH * HTTP/1.1
4	0.001251	192.168.43.180	239.255.255.250	SSDP	217	M-SEARCH * HTTP/1.1
5	4.681125	192.168.43.180	17.134.127.250	TCP	78	49365 → 443 [SYN, ECN, CWR] Seq=0 Win=65535 Len=0 MSS=1460 W...
6	5.041818	17.134.127.250	192.168.43.180	TCP	74	443 → 49365 [SYN, ACK, ECN] Seq=0 Ack=1 Win=43440 Len=0 MSS=...
7	5.041951	192.168.43.180	17.134.127.250	TCP	66	49365 → 443 [ACK] Seq=1 Ack=1 Win=131712 Len=0 TSval=6470375...
8	5.044981	192.168.43.180	17.134.127.250	TLSv1	583	Client Hello
9	5.210257	17.134.127.250	192.168.43.180	TCP	66	443 → 49365 [ACK] Seq=1 Ack=518 Win=45056 Len=0 TSval=337701...
10	5.867853	17.134.127.250	192.168.43.180	TLSv1	1396	Server Hello
11	5.867960	17.134.127.250	192.168.43.180	TCP	1424	443 → 49365 [ACK] Seq=1331 Ack=518 Win=45056 Len=1350 TSval=...
12	5.867150	192.168.43.180	17.134.127.250	TCP	66	49365 → 443 [ACK] Seq=518 Ack=1331 Win=130368 Len=0 TSval=64...
13	5.872963	17.134.127.250	192.168.43.180	TLSv1	305	Certificate, Server Key Exchange, Server Hello Done
14	5.873057	192.168.43.180	17.134.127.250	TCP	66	49365 → 443 [ACK] Seq=518 Ack=2928 Win=130816 Len=0 TSval=64...
15	5.878791	17.134.127.250	192.168.43.180	TCP	305	[TCP Spurious Retransmission] 443 → 49365 [PSH, ACK] Seq=268...
16	5.878873	192.168.43.180	17.134.127.250	TCP	78	[TCP Window Update] 49365 → 443 [ACK] Seq=518 Ack=2928 Win=1...
17	5.885500	192.168.43.180	17.134.127.250	TLSv1	159	Client Key Exchange, Change Cipher Spec, Encrypted Handshake...
18	6.176722	17.134.127.250	192.168.43.180	TCP	66	443 → 49365 [ACK] Seq=2928 Ack=611 Win=45056 Len=0 TSval=337...
19	6.346651	17.134.127.250	192.168.43.180	TLSv1	117	Change Cipher Spec, Encrypted Handshake Message
20	6.353008	192.168.43.180	17.134.127.250	TCP	66	49365 → 443 [ACK] Seq=611 Ack=2979 Win=131008 Len=0 TSval=64...
21	6.353009	192.168.43.180	17.134.127.250	TLSv1	384	Application Data
22	6.353010	192.168.43.180	17.134.127.250	TLSv1	198	Application Data
23	6.639609	17.134.127.250	192.168.43.180	TCP	66	443 → 49365 [ACK] Seq=2979 Ack=929 Win=49152 Len=0 TSval=337...
24	6.639614	17.134.127.250	192.168.43.180	TCP	66	443 → 49365 [ACK] Seq=2979 Ack=1061 Win=49152 Len=0 TSval=33...
25	7.146670	17.134.127.250	192.168.43.180	TLSv1	306	Application Data
26	7.146780	192.168.43.180	17.134.127.250	TCP	66	49365 → 443 [ACK] Seq=1061 Ack=3210 Win=130816 Len=0 TSval=6...

```

Frame 1: 217 bytes on wire (1736 bits), 217 bytes captured (1736 bits) on interface en0, id 0
  Ethernet II, Src: Apple_98:64:d0 (98:46:0a:98:64:d0), Dst: IPv4mcast_7f:ff:fa (01:00:5e:7f:ff:fa)
    Destination: IPv4mcast_7f:ff:fa (01:00:5e:7f:ff:fa)
    Source: Apple_98:64:d0 (98:46:0a:98:64:d0)
    Type: IPv4 (0x0800)
  Internet Protocol Version 4, Src: 192.168.43.180, Dst: 239.255.255.250
  User Datagram Protocol, Src Port: 55646, Dst Port: 1900
  Simple Service Discovery Protocol
    M-SEARCH * HTTP/1.1\r\n
      HOST: 239.255.255.250:1900\r\n
      MAN: "ssdp:discover"\r\n
      MX: 1\r\n
      ST: urn:dial-multiscreen-org:service:dial:1\r\n
      USER-AGENT: Google Chrome/81.0.4044.129 Mac OS X\r\n
      \r\n
      [Full request URI: http://239.255.255.250:1900/]
      [HTTP request 1/4]

```

Figure 2.5: Mac address display filter

## 2.4 Difference between MAC and IP address

- MAC stands for Media Access Control where as IP stands for Internet Protocol address.
- The main difference between MAC and IP address is that, MAC Address indicates the physical address of computer. It uniquely identifies the devices on a network. Where as IP Address is the logical address of the computer is used to uniquely identifies the connection of network with that device in a network.
- Mac address is a six byte hexa decimal address while ip address is either four(IPV4) byte or six (IPV6)byte address.
- Mac address operates in the data link layer and ip address operates in the network layer

## 2.5 MAC address usage

- Yes, our system need MAC address for many reasons as below,
- MAC address is needed for to make a connection to local Ethernet (or wifi) network function.
- For a device to communicate with a machine on the LAN (Local Area Network) MAC address is mandatory.
- Its a low level unique ID for network device.
- The routers and switches use MAC address tables to find out what devices lie on what ports. This is used to intelligently move packets to the right port.
- It's easier to use MAC address than IP address as a network card can have more then one IP address assigned to it at once, hence it's more efficient to store the MAC instead.

## 2.6 Packets recieved by the host

- The packets recieved by the host can be displayed with the display filter: ip.dst=host ip address  
eg:- ip.dst=92.168.43.180

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	13.33.151.14	192.168.43.180	TLSv1...	1424	Ignored Unknown Record
2	0.000006	13.33.151.14	192.168.43.180	TLSv1...	1424	Ignored Unknown Record
4	0.006040	13.33.151.14	192.168.43.180	TLSv1...	1424	Ignored Unknown Record
5	0.014984	13.33.151.14	192.168.43.180	TLSv1...	1424	Ignored Unknown Record
6	0.014988	13.33.151.14	192.168.43.180	TCP	1424	[TCP segment of a reassembled PDU]
7	0.020921	13.33.151.14	192.168.43.180	TLSv1...	1424	Ignored Unknown Record
8	0.020927	13.33.151.14	192.168.43.180	TLSv1...	1424	Ignored Unknown Record
9	0.028928	13.33.151.14	192.168.43.180	TLSv1...	1424	Ignored Unknown Record
10	0.034998	13.33.151.14	192.168.43.180	TLSv1...	1424	Ignored Unknown Record
11	0.035004	13.33.151.14	192.168.43.180	TLSv1...	1424	Ignored Unknown Record
12	0.035005	13.33.151.14	192.168.43.180	TLSv1...	1424	Ignored Unknown Record
14	0.043346	13.33.151.14	192.168.43.180	TLSv1...	1424	Ignored Unknown Record
15	0.043352	13.33.151.14	192.168.43.180	TLSv1...	1424	Ignored Unknown Record
18	0.057171	13.33.151.14	192.168.43.180	TLSv1...	1424	Ignored Unknown Record
19	0.057178	13.33.151.14	192.168.43.180	TLSv1...	1424	Ignored Unknown Record
20	0.057179	13.33.151.14	192.168.43.180	TLSv1...	1424	Ignored Unknown Record
23	0.069139	13.33.151.14	192.168.43.180	TLSv1...	1424	Ignored Unknown Record
24	0.069147	13.33.151.14	192.168.43.180	TLSv1...	1424	Ignored Unknown Record
25	0.069149	13.33.151.14	192.168.43.180	TLSv1...	1424	Ignored Unknown Record
28	0.083647	13.33.151.14	192.168.43.180	TLSv1...	1424	Ignored Unknown Record
29	0.083656	13.33.151.14	192.168.43.180	TLSv1...	1424	Ignored Unknown Record
30	0.083657	13.33.151.14	192.168.43.180	TLSv1...	1424	Ignored Unknown Record
31	0.097182	13.33.151.14	192.168.43.180	TLSv1...	1424	Ignored Unknown Record
32	0.097190	13.33.151.14	192.168.43.180	TLSv1...	1424	Ignored Unknown Record
33	0.103407	13.33.151.14	192.168.43.180	TLSv1...	1424	Ignored Unknown Record
34	0.103414	13.33.151.14	192.168.43.180	TLSv1...	1424	Ignored Unknown Record

▶ Frame 1: 1424 bytes on wire (11392 bits), 1424 bytes captured (11392 bits) on interface en0, id 0  
 ▶ Ethernet II, Src: d6:18:2a:86:c8:0f (d6:18:2a:86:c8:0f), Dst: Apple\_98:64:d0 (98:46:0a:98:64:d0)  
 ▼ Internet Protocol Version 4, Src: 13.33.151.14, Dst: 192.168.43.180  
   0100 ... = Version: 4  
   ... 0101 = Header Length: 20 bytes (5)  
   ▶ Differentiated Services Field: 0x28 (DSCP: AF11, ECN: Not-ECT)  
   Total Length: 1410  
   Identification: 0xfce3 (64739)  
   ▶ Flags: 0x4000, Don't fragment  
   Fragment offset: 0  
   Time to live: 62  
   Protocol: TCP (6)  
   Header checksum: 0xa9de [validation disabled]  
   [Header checksum status: Unverified]  
   Source: 13.33.151.14  
   Destination: 192.168.43.180

Figure 2.6: Packets recieved by the host

## 2.7 Tcp filter to capture packets

- Tcp expression that captures packets containing IP datagrams with a source or destination IP address equal to your IP address is as follows:

1)host 192.168.43.180.

## 2.8 Tcp filter to capture packets between 2 hosts

- Capture filter expression that captures packets containing IP datagrams between two hosts with IP addresses 10.0.0.3 and 10.0.0.12 both on interface eth0 is as follows  
1)host 10.0.0.3 and host 10.0.0.12

## 2.9 TCP Packet Capture

- Tcpdump expression that captures TCP packets using port number 22.
  - 1) `tcp dst port 22`
  - 2) `tcp src port 22`

## 2.10 Display Packets with defined frame size

- Syntax for a display filter that shows only IP datagrams with a destination IP address equal to 192.168.178.1 and frame size greater than 350 bytes  
`ip.dst == 192.168.178.1 and frame.len > 350`

# Chapter 3

## Basic Linux network administration

In this section we are going to set up a small emulated LAN of the topology in figure 3.1 using basic Linux network functionality and Kathará.

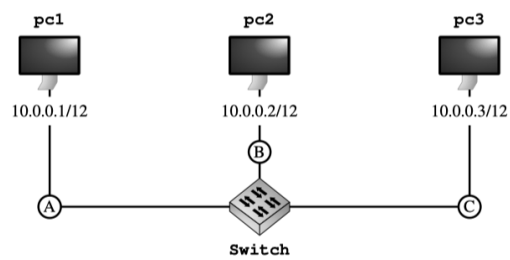


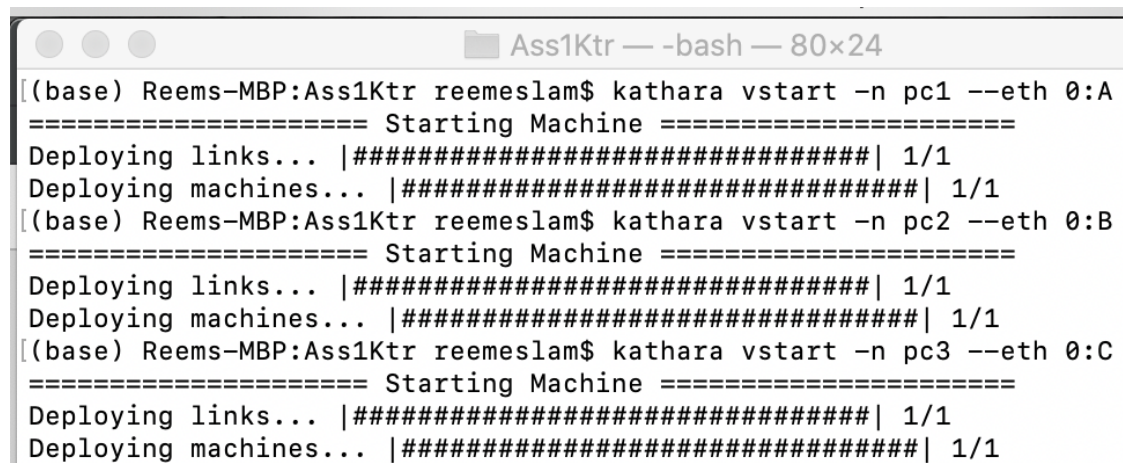
Figure 1: LAN setup

Linux PC	IP Address	Interface	CD
pc1	10.0.0.1/12	eth0	A
pc2	10.0.0.2/12	eth0	B
pc3	10.0.0.3/12	eth0	C
switch		eth0	A
		eth1	B
		eth2	C

Figure 3.1: LAN switching configuration

## 3.1 Creating the four devices

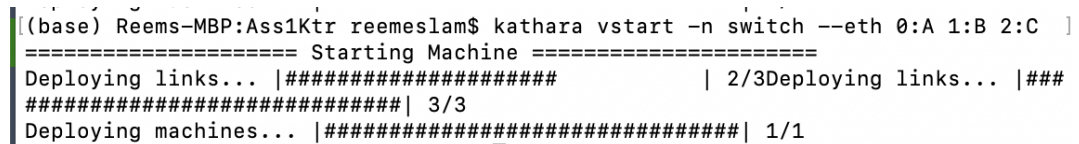
### 3.1.1 Creating Three PCs each assigned a network interface and unique collision domain



```
Ass1Ktr — -bash — 80x24
[(base) Reems-MBP:Ass1Ktr reemeslam$ kathara vstart -n pc1 --eth 0:A
===== Starting Machine =====
Deploying links... |#####| 1/1
Deploying machines... |#####| 1/1
[(base) Reems-MBP:Ass1Ktr reemeslam$ kathara vstart -n pc2 --eth 0:B
===== Starting Machine =====
Deploying links... |#####| 1/1
Deploying machines... |#####| 1/1
[(base) Reems-MBP:Ass1Ktr reemeslam$ kathara vstart -n pc3 --eth 0:C
===== Starting Machine =====
Deploying links... |#####| 1/1
Deploying machines... |#####| 1/1
```

Figure 3.2: Created three PCs each assigned a network interface with unique collision domain

### 3.1.2 Creating a switch that has three network interfaces attached, where each interface is connected to a different collision domain



```
[(base) Reems-MBP:Ass1Ktr reemeslam$ kathara vstart -n switch --eth 0:A 1:B 2:C ]
===== Starting Machine =====
Deploying links... |#####| 2/3Deploying links... |###
#####| 3/3
Deploying machines... |#####| 1/1
```

Figure 3.3: Created a Switch with three network interfaces, where each interface is connected to a different collision domain

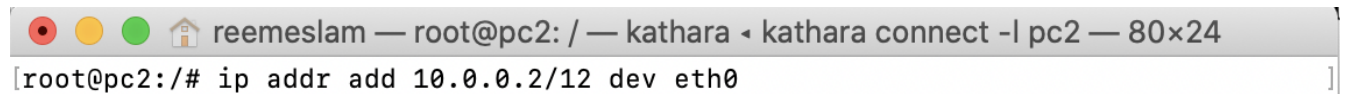
## 3.2 Configuring the four devices

### 3.2.1 Configuring an IP address for PC1, PC2 and PC2

A terminal window titled 'reemeslam — root@pc1: / — kathara • kathara connect -l pc1 — 80x24'. The command prompt is '[root@pc1:/# ip addr add 10.0.0.1/12 dev eth0'. The IP address '10.0.0.1' is highlighted in blue.

```
[root@pc1:/# ip addr add 10.0.0.1/12 dev eth0
```

Figure 3.4: configured IP address for PC1

A terminal window titled 'reemeslam — root@pc2: / — kathara • kathara connect -l pc2 — 80x24'. The command prompt is '[root@pc2:/# ip addr add 10.0.0.2/12 dev eth0'.

```
[root@pc2:/# ip addr add 10.0.0.2/12 dev eth0
```

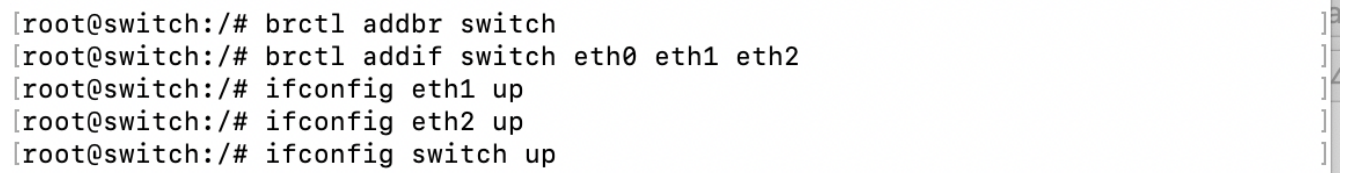
Figure 3.5: configured IP address for PC2

A terminal window titled 'reemeslam — root@pc3: / — kathara • kathara connect -l pc3 — 80x24'. The command prompt is '[root@pc3:/# ip addr add 10.0.0.3/12 dev eth0'.

```
[root@pc3:/# ip addr add 10.0.0.3/12 dev eth0
```

Figure 3.6: configured IP address for PC3

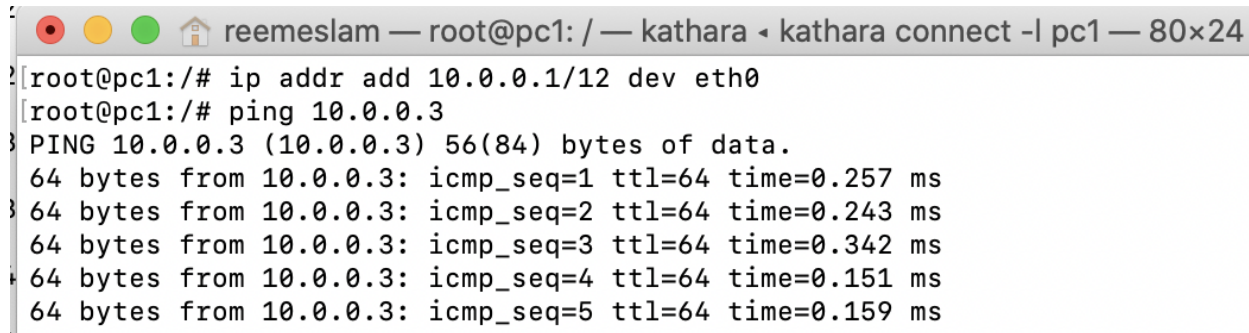
### 3.2.2 Configuring a bridge for the switch, set-up the environment and turning on the bridge

A terminal window showing the configuration of a bridge named 'switch'. The commands are: 'brctl addbr switch', 'brctl addif switch eth0 eth1 eth2', 'ifconfig eth1 up', 'ifconfig eth2 up', and 'ifconfig switch up'.

```
[root@switch:/# brctl addbr switch
[root@switch:/# brctl addif switch eth0 eth1 eth2
[root@switch:/# ifconfig eth1 up
[root@switch:/# ifconfig eth2 up
[root@switch:/# ifconfig switch up
```

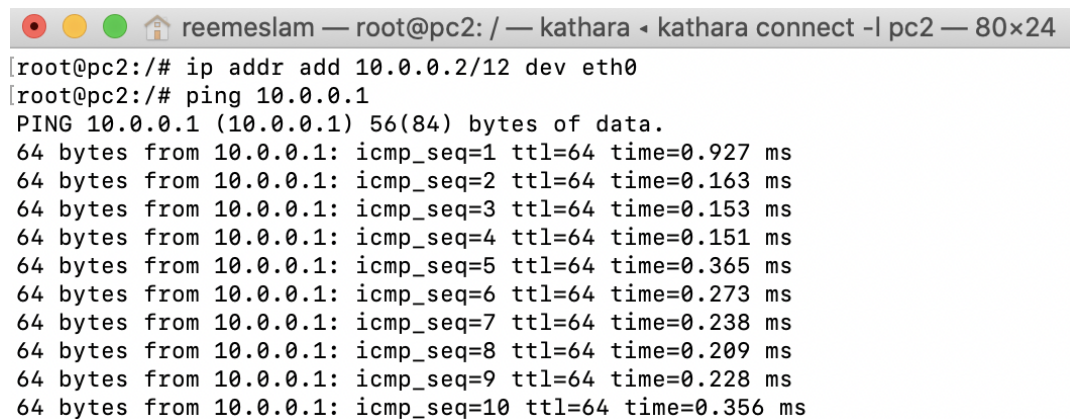
Figure 3.7: Created a bridge with name switch, Added the three interfaces to the switch, turned on eth1 & eth2 and Turned the bridge on

### 3.2.3 Testing the network by sending pings between PCs



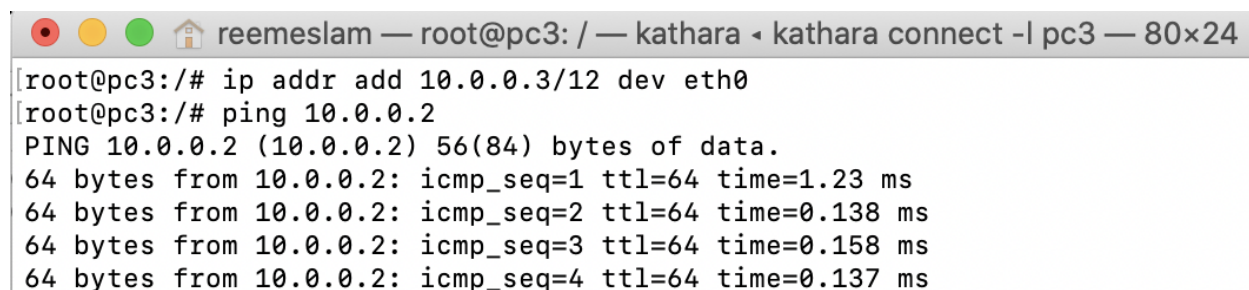
```
reemeslam — root@pc1: / — kathara ◀ kathara connect -l pc1 — 80×24
[root@pc1:/# ip addr add 10.0.0.1/12 dev eth0
[root@pc1:/# ping 10.0.0.3
PING 10.0.0.3 (10.0.0.3) 56(84) bytes of data.
 64 bytes from 10.0.0.3: icmp_seq=1 ttl=64 time=0.257 ms
 64 bytes from 10.0.0.3: icmp_seq=2 ttl=64 time=0.243 ms
 64 bytes from 10.0.0.3: icmp_seq=3 ttl=64 time=0.342 ms
 64 bytes from 10.0.0.3: icmp_seq=4 ttl=64 time=0.151 ms
 64 bytes from 10.0.0.3: icmp_seq=5 ttl=64 time=0.159 ms
...
```

Figure 3.8: Sending ping from PC-1 to PC-3 to check connectivity



```
reemeslam — root@pc2: / — kathara ◀ kathara connect -l pc2 — 80×24
[root@pc2:/# ip addr add 10.0.0.2/12 dev eth0
[root@pc2:/# ping 10.0.0.1
PING 10.0.0.1 (10.0.0.1) 56(84) bytes of data.
 64 bytes from 10.0.0.1: icmp_seq=1 ttl=64 time=0.927 ms
 64 bytes from 10.0.0.1: icmp_seq=2 ttl=64 time=0.163 ms
 64 bytes from 10.0.0.1: icmp_seq=3 ttl=64 time=0.153 ms
 64 bytes from 10.0.0.1: icmp_seq=4 ttl=64 time=0.151 ms
 64 bytes from 10.0.0.1: icmp_seq=5 ttl=64 time=0.365 ms
 64 bytes from 10.0.0.1: icmp_seq=6 ttl=64 time=0.273 ms
 64 bytes from 10.0.0.1: icmp_seq=7 ttl=64 time=0.238 ms
 64 bytes from 10.0.0.1: icmp_seq=8 ttl=64 time=0.209 ms
 64 bytes from 10.0.0.1: icmp_seq=9 ttl=64 time=0.228 ms
 64 bytes from 10.0.0.1: icmp_seq=10 ttl=64 time=0.356 ms
```

Figure 3.9: Sending ping from PC-2 to PC-1 to check connectivity

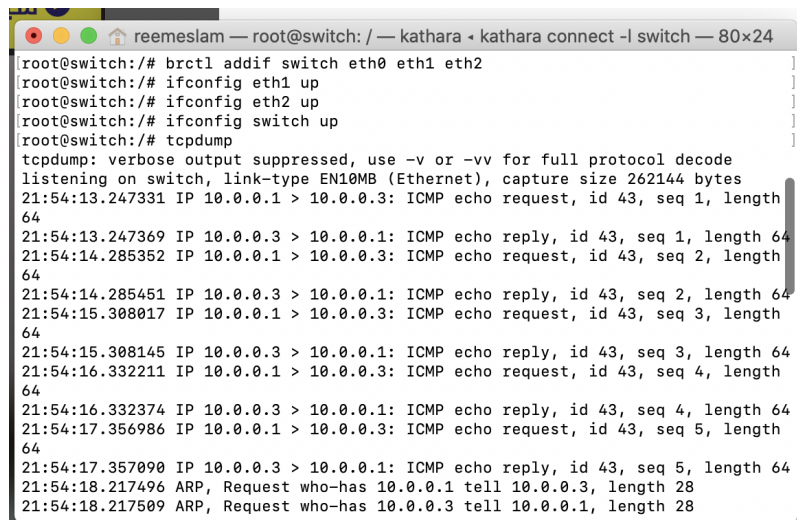


```
reemeslam — root@pc3: / — kathara ◀ kathara connect -l pc3 — 80×24
[root@pc3:/# ip addr add 10.0.0.3/12 dev eth0
[root@pc3:/# ping 10.0.0.2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
 64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=1.23 ms
 64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.138 ms
 64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.158 ms
 64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0.137 ms
```

Figure 3.10: Sending ping from PC-3 to PC-2 to check connectivity



### 3.3 Checking connectivity by Capturing the ICMP messages exchanged by devices on sending ping from Pc-1 to PC-3.

A screenshot of a terminal window titled 'reemeslam — root@switch: / — kathara • kathara connect -l switch — 80x24'. The terminal shows the following commands and output:

```
root@switch:/# brctl addif switch eth0 eth1 eth2
root@switch:/# ifconfig eth1 up
root@switch:/# ifconfig eth2 up
root@switch:/# ifconfig switch up
root@switch:/# tcpdump
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on switch, link-type EN10MB (Ethernet), capture size 262144 bytes
21:54:13.247331 IP 10.0.0.1 > 10.0.0.3: ICMP echo request, id 43, seq 1, length 64
21:54:13.247369 IP 10.0.0.3 > 10.0.0.1: ICMP echo reply, id 43, seq 1, length 64
21:54:14.285352 IP 10.0.0.1 > 10.0.0.3: ICMP echo request, id 43, seq 2, length 64
21:54:14.285451 IP 10.0.0.3 > 10.0.0.1: ICMP echo reply, id 43, seq 2, length 64
21:54:15.308017 IP 10.0.0.1 > 10.0.0.3: ICMP echo request, id 43, seq 3, length 64
21:54:15.308145 IP 10.0.0.3 > 10.0.0.1: ICMP echo reply, id 43, seq 3, length 64
21:54:16.332211 IP 10.0.0.1 > 10.0.0.3: ICMP echo request, id 43, seq 4, length 64
21:54:16.332374 IP 10.0.0.3 > 10.0.0.1: ICMP echo reply, id 43, seq 4, length 64
21:54:17.356986 IP 10.0.0.1 > 10.0.0.3: ICMP echo request, id 43, seq 5, length 64
21:54:17.357090 IP 10.0.0.3 > 10.0.0.1: ICMP echo reply, id 43, seq 5, length 64
21:54:18.217496 ARP, Request who-has 10.0.0.1 tell 10.0.0.3, length 28
21:54:18.217509 ARP, Request who-has 10.0.0.3 tell 10.0.0.1, length 28
```

Figure 3.11: Capturing the ICMP messages between PC-1 and PC-3

### 3.4 .Conf and .startup files

For bigger complex networks using just terminals will not be the best approach, also each time you want to re-run the network you will need to configure everything again in the terminal. Better approach is to configure the environment in files and then run this files in the terminal.

#### 3.4.1 .Conf file

The lab.conf will help us to setup the base infrastructure when the lab is initialized. The syntax is direct and easy as we can see in 3.12

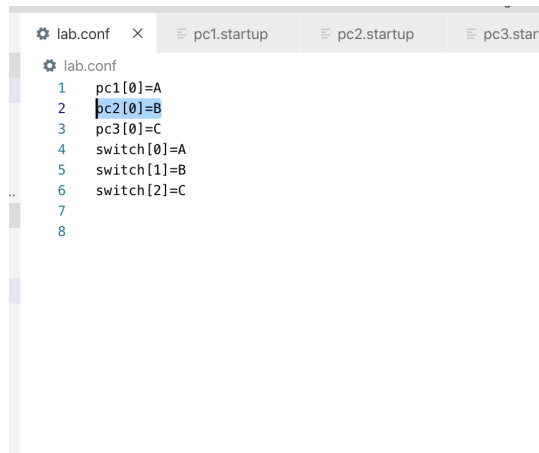


Figure 3.12: The .Conf file for the network

### 3.4.2 .Startup

In .startup file we add all of the commands we want to run in each device like, configuring IP address, configuring the bridge in switch.. etc. As you can see in 3.13 the commands are the same as we used in the terminal.

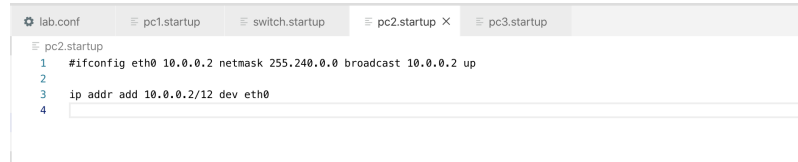


Figure 3.13: .Startup file for PC-2 device

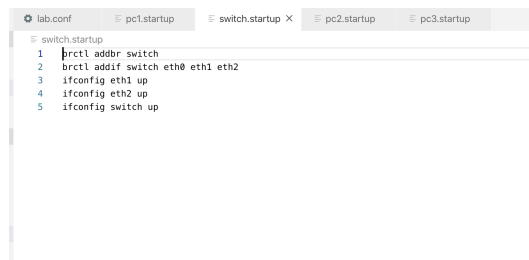


Figure 3.14: .Startup file for Switch device

After saving the files open the terminal in the same directory that has the files and run "Kathara lstart", The devices will open. Start testing the network by sending pings and capturing ICMP messages.

```

root@pc1:/# ping 10.0.0.2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=0.133 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.188 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.201 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0.219 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=0.165 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=0.143 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=0.122 ms
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=0.242 ms
64 bytes from 10.0.0.2: icmp_seq=9 ttl=64 time=0.084 ms
64 bytes from 10.0.0.2: icmp_seq=10 ttl=64 time=0.125 ms
64 bytes from 10.0.0.2: icmp_seq=11 ttl=64 time=0.127 ms
64 bytes from 10.0.0.2: icmp_seq=12 ttl=64 time=0.162 ms
^C
--- 10.0.0.2 ping statistics ---
12 packets transmitted, 12 received, 0% packet loss, time 11256ms
rtt min/avg/max/mdev = 0.084/0.159/0.242/0.044 ms
root@pc1:/#

root@pc3:/# ping 10.0.0.2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=0.241 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.136 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.135 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0.135 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=0.099 ms
^C
--- 10.0.0.2 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4133ms
rtt min/avg/max/mdev = 0.099/0.149/0.241/0.048 ms
root@pc3:/#

root@pc2:/#
--- Startup Commands Log
++ ip addr add 10.0.0.2/12 dev eth0
--- End Startup Commands Log

root@pc2:/# ping 10.0.0.1
PING 10.0.0.1 (10.0.0.1) 56(84) bytes of data.
64 bytes from 10.0.0.1: icmp_seq=1 ttl=64 time=0.178 ms
64 bytes from 10.0.0.1: icmp_seq=2 ttl=64 time=0.178 ms
64 bytes from 10.0.0.1: icmp_seq=3 ttl=64 time=0.156 ms
64 bytes from 10.0.0.1: icmp_seq=4 ttl=64 time=0.252 ms
64 bytes from 10.0.0.1: icmp_seq=5 ttl=64 time=0.135 ms
64 bytes from 10.0.0.1: icmp_seq=6 ttl=64 time=0.444 ms
64 bytes from 10.0.0.1: icmp_seq=7 ttl=64 time=0.123 ms
^C
root@pc2:/#

root@switch:/#
--- Startup Commands Log
++ brctl addbr switch
++ brctl addif switch eth0 eth1 eth2
++ ifconfig eth1 up
++ ifconfig eth2 up
--- End Startup Commands Log

root@switch:/# tcpdump
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on switch, link-type EN10MB (Ethernet), capture size 262144 bytes
12:22:20.481974 IP 10.0.0.2 > 10.0.0.1: ICMP echo request, id 44, seq 20, length 64
12:22:20.482915 IP 10.0.0.1 > 10.0.0.2: ICMP echo reply, id 44, seq 20, length 64
12:22:21.586275 IP 10.0.0.2 > 10.0.0.1: ICMP echo request, id 44, seq 21, length 64
12:22:21.586357 IP 10.0.0.1 > 10.0.0.2: ICMP echo reply, id 44, seq 21, length 64
12:22:22.530122 IP 10.0.0.2 > 10.0.0.1: ICMP echo request, id 44, seq 22, length 64
12:22:22.530167 IP 10.0.0.1 > 10.0.0.2: ICMP echo reply, id 44, seq 22, length 64
12:22:23.555981 IP 10.0.0.2 > 10.0.0.1: ICMP echo request, id 44, seq 23, length 64
12:22:23.556109 IP 10.0.0.1 > 10.0.0.2: ICMP echo reply, id 44, seq 23, length 64
12:22:24.578371 IP 10.0.0.2 > 10.0.0.1: ICMP echo request, id 44, seq 24, length 64
12:22:24.578455 IP 10.0.0.1 > 10.0.0.2: ICMP echo reply, id 44, seq 24, length 64
^X12:22:25.602486 IP 10.0.0.2 > 10.0.0.1: ICMP echo request, id 44, seq 25, length 64
12:22:25.602576 IP 10.0.0.1 > 10.0.0.2: ICMP echo reply, id 44, seq 25, length 64
12:22:26.627222 IP 10.0.0.2 > 10.0.0.1: ICMP echo request, id 44, seq 26, length 64
12:22:26.627400 IP 10.0.0.1 > 10.0.0.2: ICMP echo reply, id 44, seq 26, length 64
^C
14 packets captured
14 packets received by filter
0 packets dropped by kernel
root@switch:/#

```

Figure 3.15: Overview for the whole network