



**San José State**  
UNIVERSITY

**EE- 284**

**CONVERGENT VOICE AND DATA NETWORKS**

**SPRING 2018**

**COURSE PROJECT- 1**

**A HANDS-ON SIP-BASED VOIP EXPERIMENTS ON: CALL ESTABLISHMENT, BUSY LINES,  
CALL ON HOLD, AND CONFERENCE CALLING**

**GROUP- 4**

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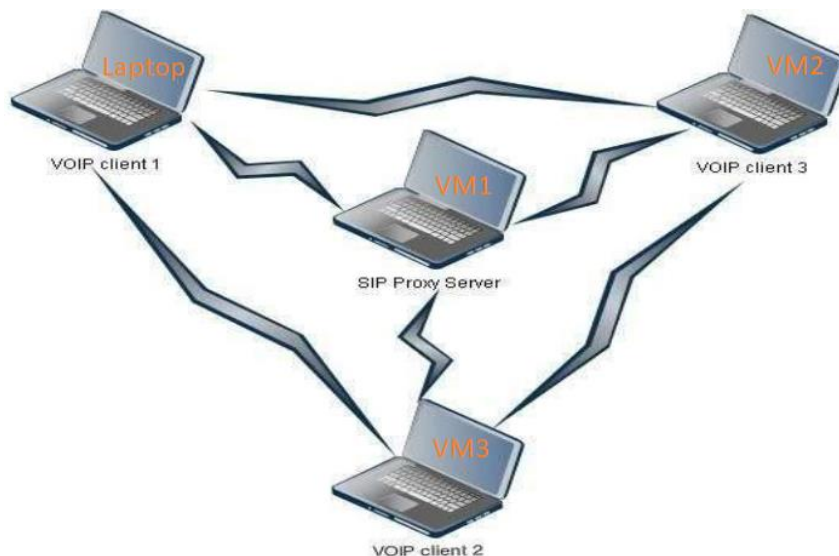
# PART-1

## Abstract

The aim of the project is to understand the implementation of SIP [Session Initiation Protocol] to enable media transfer or voice communication. The project comprises of one server and three clients to implement the four phases. The server software used is Asterisk Software and the clients use X-Lite soft phones to implement voice calls. Client registers with the server and calls are then established. Four different call scenarios are observed and implemented. The call scenario packets are screen captured using Wireshark and call flows are also observed.

## HARDWARE SETUP AND TOOL DOWNLOADS:

### 1. Call Scenarios



Phase 1 and 2 of this project only need 2 clients. Phase 1 includes a simple call. Phase 2 comprises of a call invite from one request but busy tone sent from the other client. Phase 3 and 4 require a third client. Phase 3 includes a call between two clients, with third client calling and existing call put on hold and third client's call picked up. Phase 4 is a conference call where a call is already established between 2 clients and then the third client calls and the calls are merged.

### 2. Network Setup

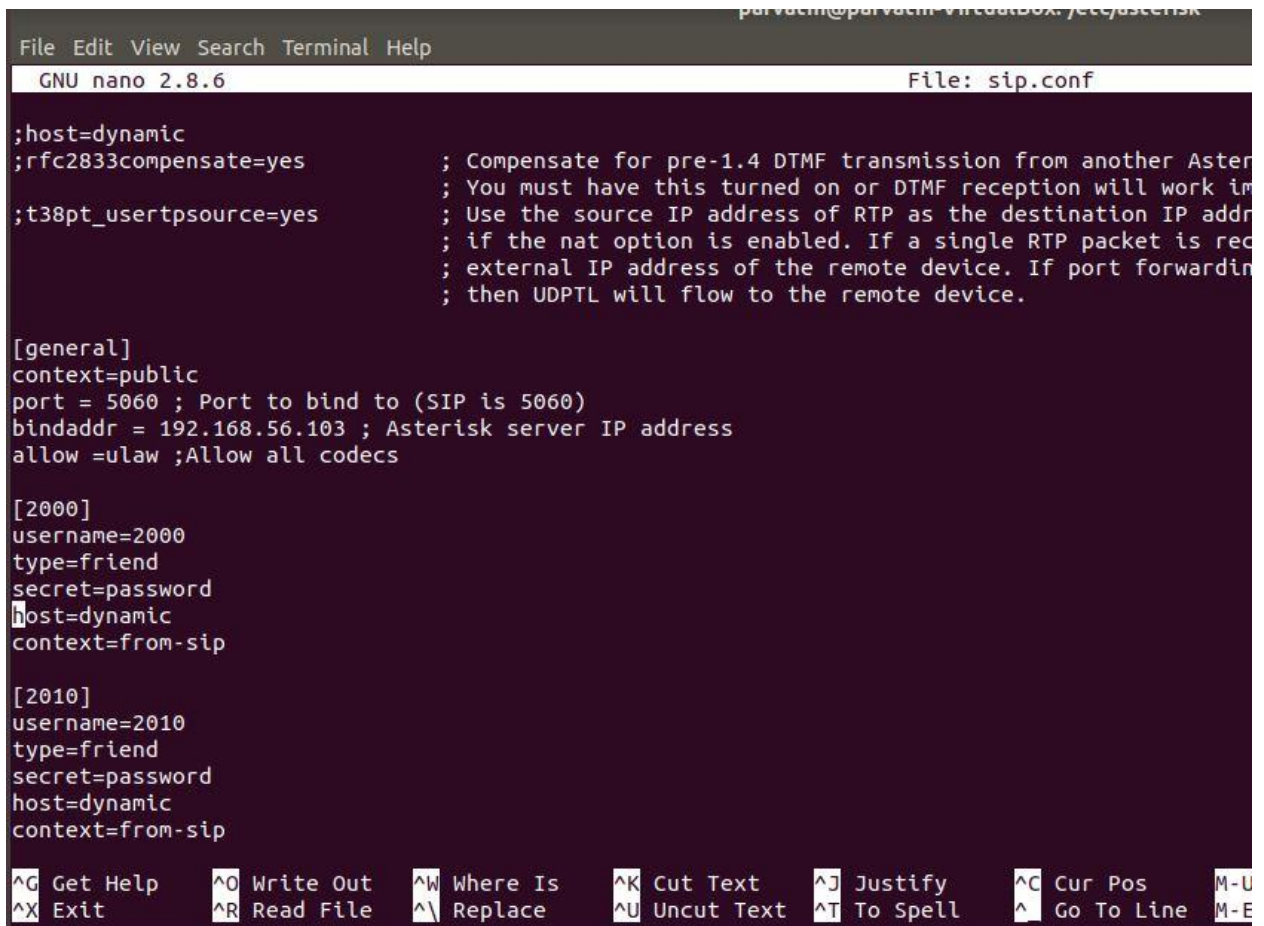
This project comprises of one Ubuntu server and three Windows 7 clients. We used VirtualBox to implement the virtual machines, and set the network adapters of each as a Host

only network to connect them together in one LAN. The network can also be established through a native Ubuntu OS and three clients in different laptops connected through an ad hoc network.

### 3. Server Setup

We create the first VM which is the server. We then installed the Asterisk software and all the necessary dependencies for it to work. We modified the sip.conf and extensions.conf file according to the requirements of Phase 1.

We added this to the end of the sip.conf file:



```
File Edit View Search Terminal Help
GNU nano 2.8.6 File: sip.conf

;host=dynamic
;rfc2833compensate=yes           ; Compensate for pre-1.4 DTMF transmission from another Asterisk
;                                ; You must have this turned on or DTMF reception will work im
;                                ; Use the source IP address of RTP as the destination IP address
;t38pt_ustpsrc=yes               ; if the nat option is enabled. If a single RTP packet is received
;                                ; external IP address of the remote device. If port forwarding
;                                ; then UDPTL will flow to the remote device.

[general]
context=public
port = 5060 ; Port to bind to (SIP is 5060)
bindaddr = 192.168.56.103 ; Asterisk server IP address
allow =ulaw ;Allow all codecs

[2000]
username=2000
type=friend
secret=password
host=dynamic
context=from-sip

[2010]
username=2010
type=friend
secret=password
host=dynamic
context=from-sip

^G Get Help      ^O Write Out    ^W Where Is     ^K Cut Text     ^J Justify     ^C Cur Pos     M-U
^X Exit          ^R Read File    ^\ Replace      ^U Uncut Text   ^T To Spell    ^_ Go To Line   M-E
```

```
parvathi@parvathi-VirtualBox: /etc/asterisk
File Edit View Search Terminal Help
GNU nano 2.8.6 File: extensions.conf Modified

; friendly Asterisk CLI prompt.
;
; "core show application <command>" will show details of how you
; use that particular application in this file, the dial plan.
; "core show functions" will list all dialplan functions
; "core show function <COMMAND>" will show you more information about
; one function. Remember that function names are UPPER CASE.
;
[from-sip]
exten => 2000, 1, Dial(SIP/2000,20)
exten =. 2000, 2, Answer()

exten => 2010, 1, Dial(SIP/2010,20)
exten => 2010, 2, Answer()

^G Get Help ^O Write Out ^W Where Is ^K Cut Text ^J Justify ^C Cur Pos
^X Exit ^R Read File ^\ Replace ^U Uncut Text ^T To Spell ^_ Go To Line
```

```
Ubuntu [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Fri 16:05
You have the Auto capture keyboard option turned on. This will cause the Virtual Machine to automatically capture the keyboard every time the VM window is activated and make it unavailable to other applications running on your host machine: when the keyboard is
parvathi@parvathi-VirtualBox: /etc/asterisk
File Edit View Search Terminal Help
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI> sip show peers
parvathi-VirtualBox*CLI>
Name/username Host Dyn Forcerport Comedia ACL Port Status Description
2000/2000 192.168.56.1 D Auto (No) No 54057 Unmonitored
2010/2010 192.168.56.104 D Auto (No) No 49261 Unmonitored
2020/2020 192.168.56.105 D Auto (No) No 53497 Unmonitored
3 sip peers [Monitored: 0 online, 0 offline Unmonitored: 3 online, 0 offline]
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
```

The server and client respective IP addresses are as follows:

Server or Client	IP Address of S/C
Server	192.168.56.103
Client - I	192.168.56.1
Client - II	192.168.56.104
Client - III	192.168.56.105

The client setup screenshots:

2000 =>

SIP Account

Account Voicemail Topology Presence Transport Advanced

Account name:

Protocol:

Allow this account for:

☒ Call

☒ IM / Presence

User Details

\* User ID:

\* Domain:

Password:

Display name:

Authorization name:

Domain Proxy

☒ Register with domain and receive calls

Send outbound via:

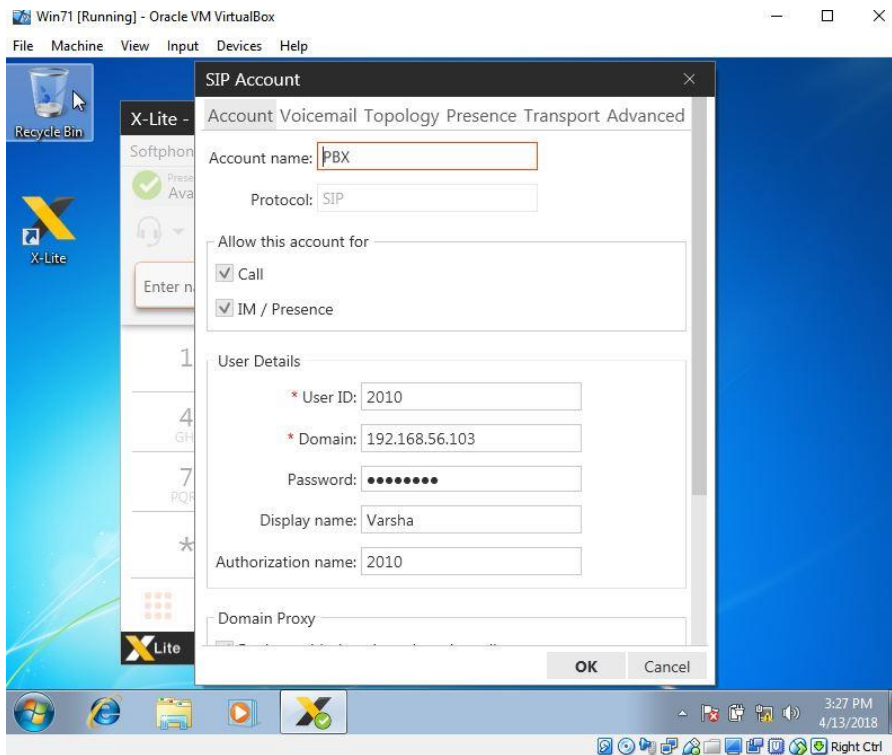
☒ Domain

☐ Proxy Address:

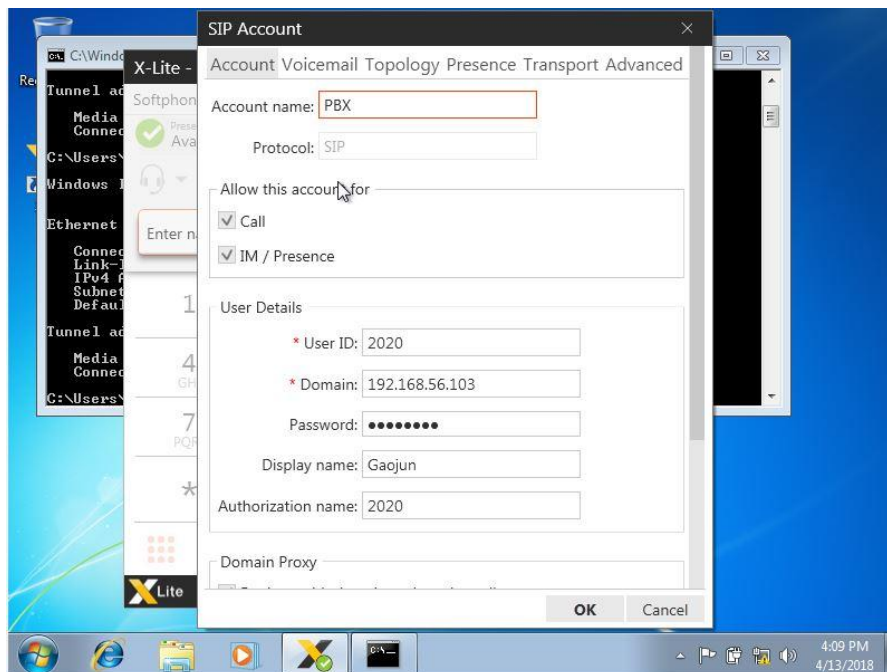
Dial plan:

OK Cancel

2010 =>



2020 =>



#### 4. Clients Setup



We created 2 more VM's, Client 1 and 2. X-Lite phone were installed next into them and configured according to the instructions given.

## 5. Connect the clients to the Host-only network.

Connect all the clients with the Proxy Server with the Host-Only Adapter. Assign IP address manually to the Host-Only Adapter in the range "169.254.X.X" with subnet mask "255.255.255.0"

# EXPERIMENT:

## PHASE 1- ESTABLISH AND ANALYZE A SUCCESSFUL CALL BETWEEN 2 SIP CLIENTS:

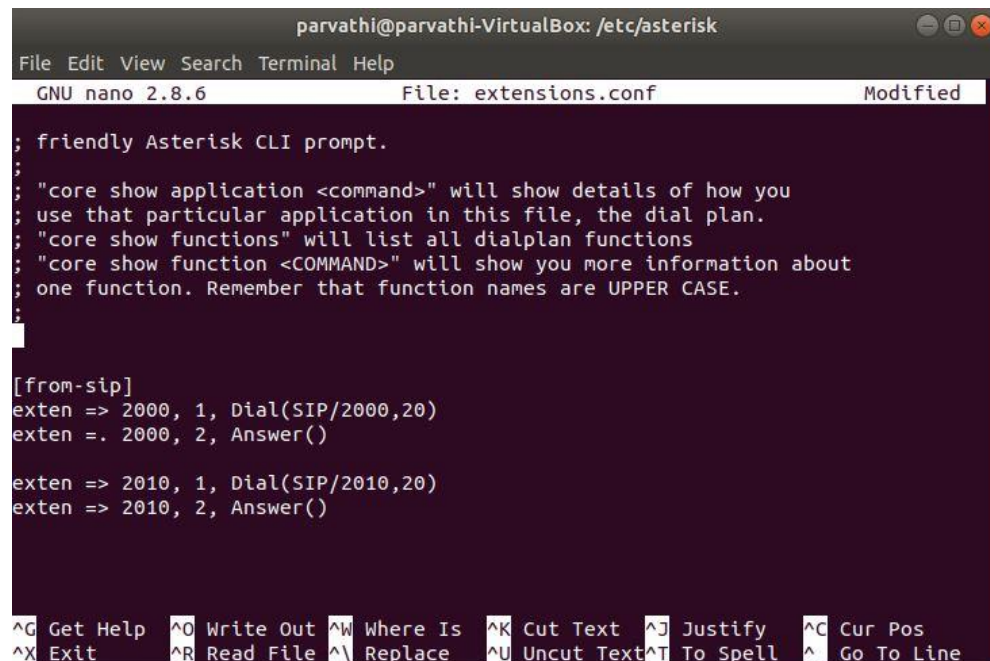
We establish a call between client 1 and 2 after registering both of them to the server.

### 1. Call establishment.

Call is established between Client 1 and 2. [2000 calls 2010]

The extensions are set as follows:

[from-sip]



```
parvathi@parvathi-VirtualBox: /etc/asterisk
File Edit View Search Terminal Help
GNU nano 2.8.6 File: extensions.conf Modified

; friendly Asterisk CLI prompt.
;
; "core show application <command>" will show details of how you
; use that particular application in this file, the dial plan.
; "core show functions" will list all dialplan functions
; "core show function <COMMAND>" will show you more information about
; one function. Remember that function names are UPPER CASE.
;

[from-sip]
exten => 2000, 1, Dial(SIP/2000,20)
exten =. 2000, 2, Answer()

exten => 2010, 1, Dial(SIP/2010,20)
exten => 2010, 2, Answer()

^G Get Help ^O Write Out ^W Where Is ^K Cut Text ^J Justify ^C Cur Pos
^X Exit ^R Read File ^\ Replace ^U Uncut Text ^T To Spell ^_ Go To Line
```

We now type “reload for everything to take effect.

Name on X-Lite Phone	ID
Client I	2000
Client II	2010
Client III	2020



## 2. Capture of results

Below figure shows the Wireshark capture during the calling between the two clients.

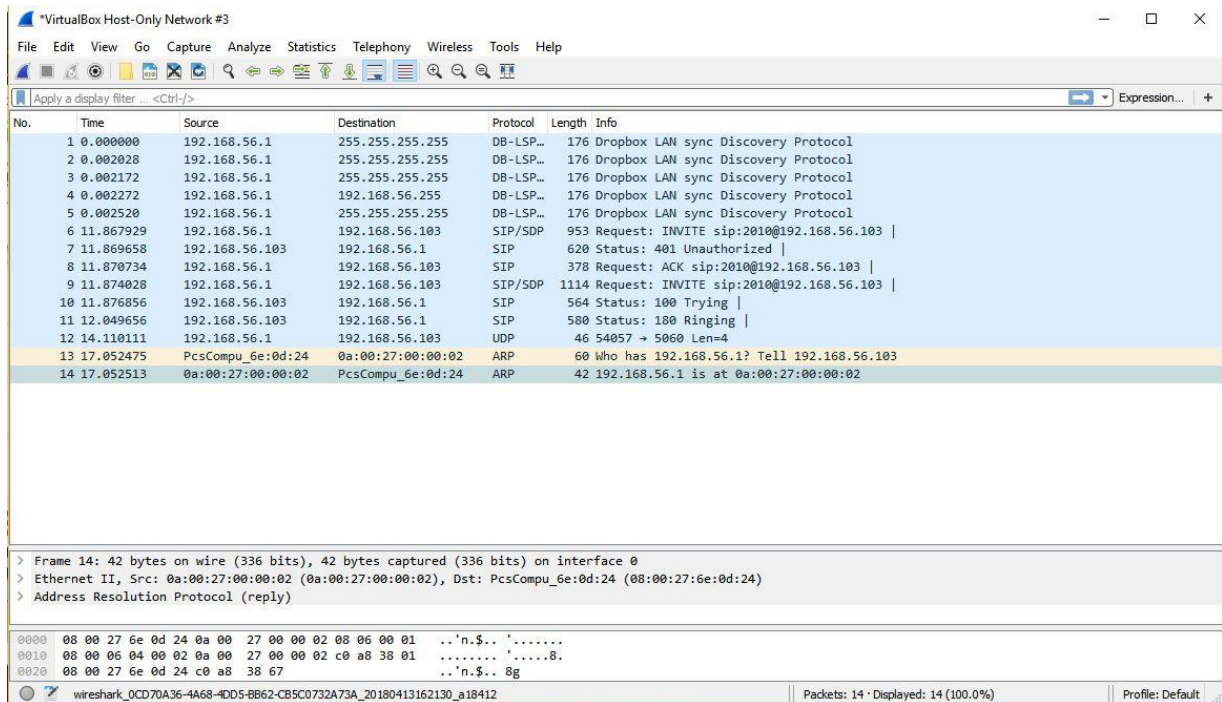


Fig > Calling from one side

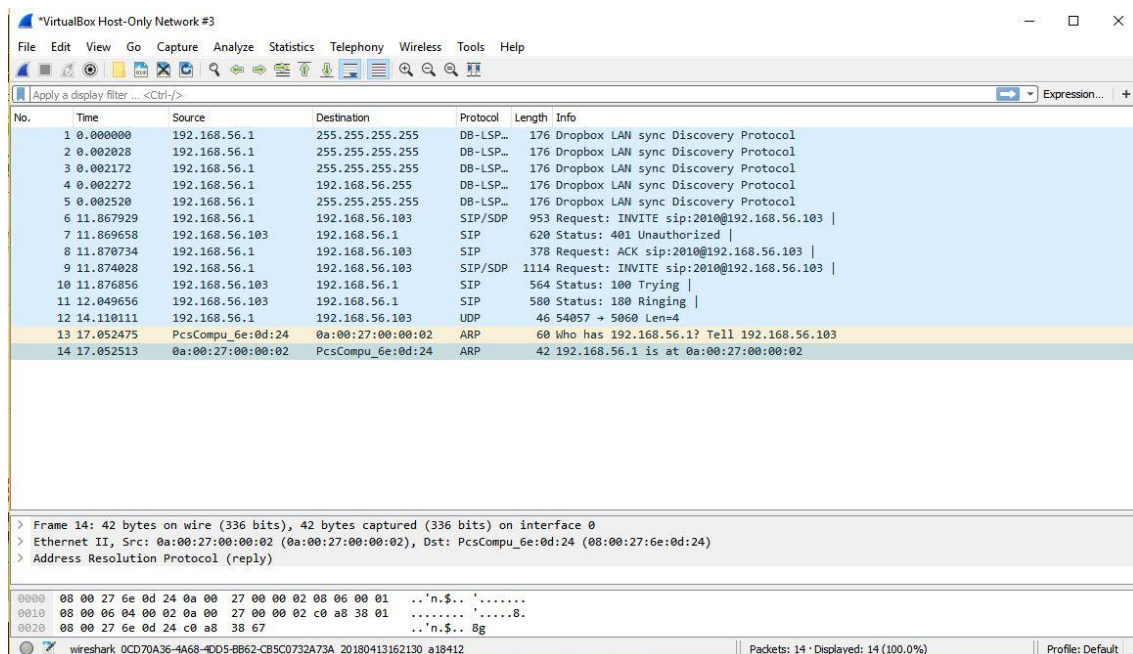


Figure > Call Accepted by the other side

Above Wireshark capture shows the scenario when the call is accepted by the called user.

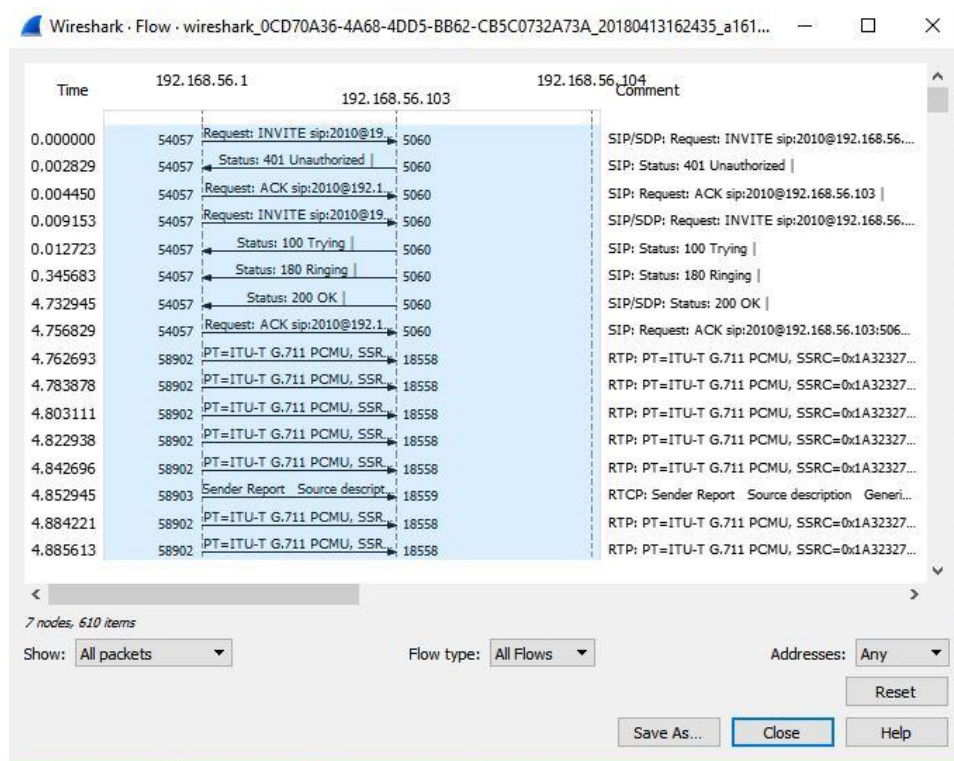


Figure > Call Flow between 2000 and 2010

Above figure shows the capture of message sequences between the 2010 and 2000.

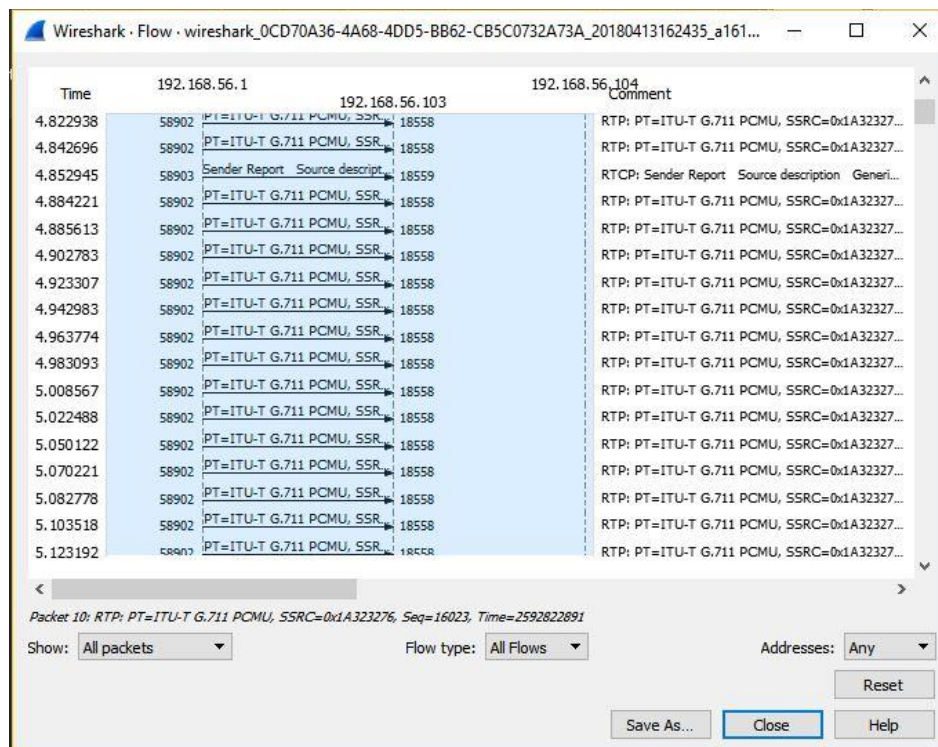




Figure > RTP packets call flow between 2000 and 2010

No.	Time	Source	Destination	Protocol	Length	Info
545	10.004931	192.168.56.1	192.168.56.104	RTP	214	PT=ITU-T G.711 PCMU, SSR...
546	10.022699	192.168.56.104	192.168.56.1	RTP	214	PT=ITU-T G.711 PCMU, SSR...
547	10.022719	192.168.56.1	192.168.56.104	RTP	214	PT=ITU-T G.711 PCMU, SSR...
548	10.042714	192.168.56.104	192.168.56.1	RTP	214	PT=ITU-T G.711 PCMU, SSR...
549	10.042894	192.168.56.1	192.168.56.104	RTP	214	PT=ITU-T G.711 PCMU, SSR...
550	10.062962	192.168.56.1	192.168.56.104	RTP	214	PT=ITU-T G.711 PCMU, SSR...
551	10.064001	192.168.56.104	192.168.56.1	RTP	214	PT=ITU-T G.711 PCMU, SSR...
552	10.066076	192.168.56.1	239.255.255.250	SSDP	216	M-SEARCH * HTTP/1.1
553	10.083097	192.168.56.1	192.168.56.104	RTP	214	PT=ITU-T G.711 PCMU, SSR...
554	10.084709	192.168.56.104	192.168.56.1	RTP	214	PT=ITU-T G.711 PCMU, SSR...
555	10.103117	192.168.56.1	192.168.56.104	RTP	214	PT=ITU-T G.711 PCMU, SSR...
556	10.104211	192.168.56.104	192.168.56.1	RTP	214	PT=ITU-T G.711 PCMU, SSR...
557	10.122419	192.168.56.1	192.168.56.104	RTP	214	PT=ITU-T G.711 PCMU, SSR...
558	10.125761	192.168.56.104	192.168.56.1	RTP	214	PT=ITU-T G.711 PCMU, SSR...
559	10.142438	192.168.56.1	192.168.56.104	RTP	214	PT=ITU-T G.711 PCMU, SSR...
560	10.145959	192.168.56.104	192.168.56.1	RTP	214	PT=ITU-T G.711 PCMU, SSR...
561	10.162501	192.168.56.1	192.168.56.104	RTP	214	PT=ITU-T G.711 PCMU, SSR...
562	10.164925	192.168.56.104	192.168.56.1	RTP	214	PT=ITU-T G.711 PCMU, SSR...
563	10.182441	192.168.56.1	192.168.56.104	RTP	214	PT=ITU-T G.711 PCMU, SSR...
564	10.187126	192.168.56.104	192.168.56.1	RTP	214	PT=ITU-T G.711 PCMU, SSR...
565	10.201600	192.168.56.104	192.168.56.1	RTCP	82	Receiver Report Goodby...
566	10.202364	192.168.56.1	192.168.56.104	RTP	214	PT=ITU-T G.711 PCMU, SSR...
567	10.222793	192.168.56.1	192.168.56.104	RTP	214	PT=ITU-T G.711 PCMU, SSR...

> Frame 30: 214 bytes on wire (1712 bits), 214 bytes captured (1712 bits) on interface 0

> Ethernet II, Src: 0a:00:27:00:00:02 (0a:00:27:00:00:02), Dst: PcsCompu\_6e:0d:24 (08:00:27:6e:0d:24)

> Internet Protocol Version 4, Src: 192.168.56.1, Dst: 192.168.56.103

> User Datagram Protocol, Src Port: 58902, Dst Port: 18558

```

0000  08 00 27 6e 0d 24 0a 00 27 00 00 02 08 00 45 00  ..'n.$.. '.....E.
0010  00 c8 02 d4 00 00 80 11 45 98 c0 a8 38 01 c0 a8  .....E...8...
0020  38 67 e6 16 48 7e 00 b4 d6 0d 80 00 3e aa 9a 8b  8g..H~.. ....>...

```

wireshark\_OCD70A36-4A68-4...73A\_20180413162435\_a16192 | Packets: 610 · Displayed: 610 (100.0%) · Dropped: 0 (0.0%) | Profile: Default

Figure > RTP Packets in the call

### 3. Phase-1 Summary:

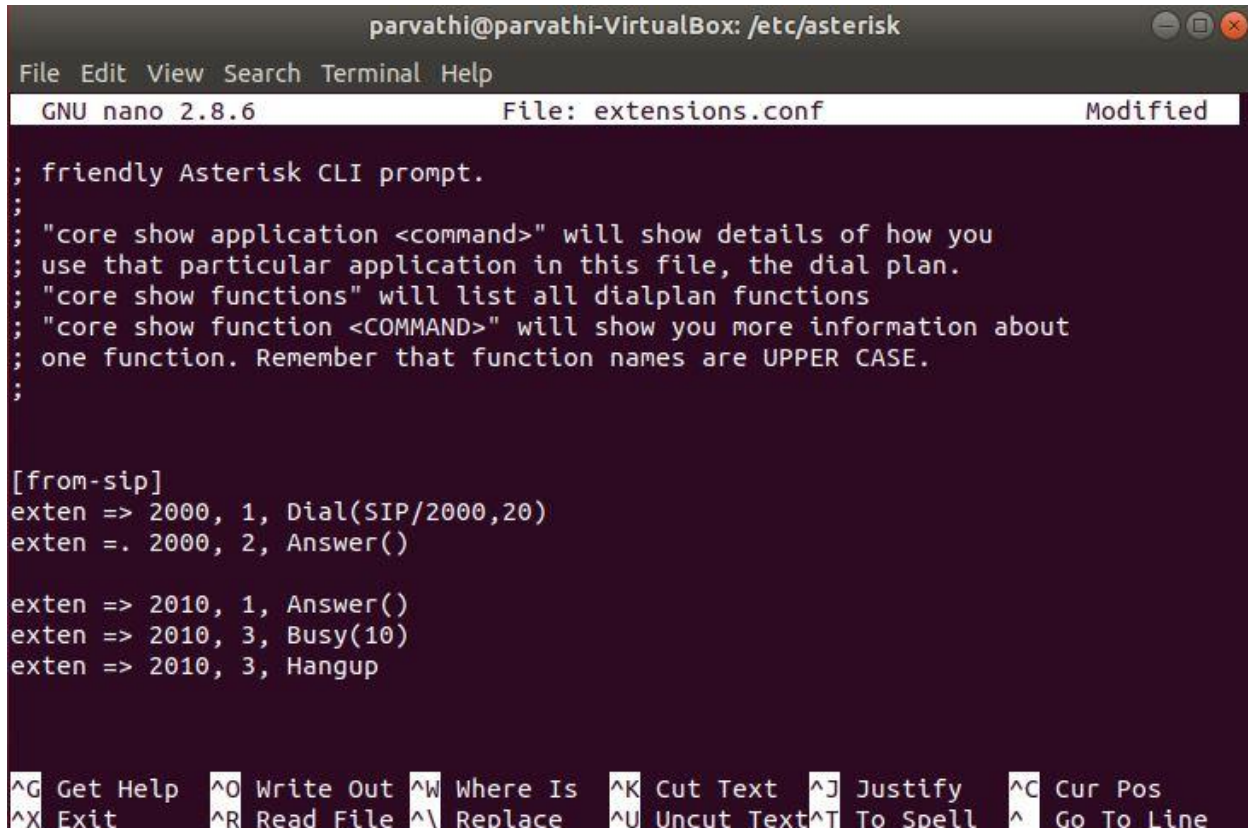
Call established between 2000 and 2010 after invite from 2000.

## PHASE 2- BUSY USER:

We set 2010 as a busy user so 2000 would only hear a busy tone when 2010 accepts the call from 2000 user.

## 1. Call establishment.

The sip.conf file is the same as Phase 1. Some changes are made to the extension.conf file for Client 1 and 2. We then give the reload command.



```
parvathi@parvathi-VirtualBox: /etc/asterisk
File Edit View Search Terminal Help
GNU nano 2.8.6 File: extensions.conf Modified

; friendly Asterisk CLI prompt.
;
; "core show application <command>" will show details of how you
; use that particular application in this file, the dial plan.
; "core show functions" will list all dialplan functions
; "core show function <COMMAND>" will show you more information about
; one function. Remember that function names are UPPER CASE.
;

[from-sip]
exten => 2000, 1, Dial(SIP/2000,20)
exten =. 2000, 2, Answer()

exten => 2010, 1, Answer()
exten => 2010, 3, Busy(10)
exten => 2010, 3, Hangup

^G Get Help ^O Write Out ^W Where Is ^K Cut Text ^J Justify ^C Cur Pos
^X Exit ^R Read File ^\ Replace ^U Uncut Text ^T To Spell ^_ Go To Line
```

## 2. Capture of results

The Wireshark screenshots are attached below:

\*VirtualBox Host-Only Network #3

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Filter: sip

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.56.1	192.168.56.103	SIP/SDP	953	Request: INVITE sip:2...
2	0.002751	192.168.56.103	192.168.56.1	SIP	620	Status: 401 Unauthori...
3	0.004429	192.168.56.1	192.168.56.103	SIP	378	Request: ACK sip:2010...
4	0.009357	192.168.56.1	192.168.56.103	SIP/SDP	1114	Request: INVITE sip:2...
5	0.011993	192.168.56.103	192.168.56.1	SIP	564	Status: 100 Trying
6	0.013893	192.168.56.103	192.168.56.1	SIP/SDP	890	Status: 200 OK
7	0.034086	192.168.56.1	192.168.56.103	SIP	496	Request: ACK sip:2010...
392	3.829432	192.168.56.1	192.168.56.103	SIP	662	Request: BYE sip:2010...
393	3.831212	192.168.56.103	192.168.56.1	SIP	531	Status: 200 OK

> Frame 1: 953 bytes on wire (7624 bits), 953 bytes captured (7624 bits) on interface 0

> Ethernet II, Src: 0a:00:27:00:00:02 (0a:00:27:00:00:02), Dst: PcsCompu\_6e:0d:24 (08:00:27:6e:0d:24)

> Internet Protocol Version 4, Src: 192.168.56.1, Dst: 192.168.56.103

<

0000	08 00 27 6e 0d 24 0a 00 27 00 00 02 08 00 45 00	.. 'n.\$.. '.....E.
0010	03 ab 06 f5 00 00 80 11 3e 94 c0 a8 38 01 c0 a8	..... >...8...
0020	38 67 d3 29 13 c4 03 97 1c 43 49 4e 56 49 54 45	8g.).... .CINVITE

Session Initiation Protocol: Protocol

Packets: 393 · Displayed: 9 (2.3%) · Dropped: 0 (0.0%) | Profile: Default

Figure > Call establishment between 2 clients

Above Wireshark capture shows the flow for SIP messages exchanged between the clients.

\*VirtualBox Host-Only Network #3

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Filter: Apply a display filter ... <Ctrl-/>

No.	Time	Source	Destination	Protocol	Length	Info
337	3.283435	192.168.56.103	192.168.56.1	RTP	214	PT=ITU-T G.711 ...
338	3.299613	192.168.56.1	192.168.56.103	RTP	214	PT=ITU-T G.711 ...
339	3.302839	192.168.56.103	192.168.56.1	RTP	214	PT=ITU-T G.711 ...
340	3.320083	192.168.56.1	192.168.56.103	RTP	214	PT=ITU-T G.711 ...
341	3.323721	192.168.56.103	192.168.56.1	RTP	214	PT=ITU-T G.711 ...
342	3.340194	192.168.56.1	192.168.56.103	RTP	214	PT=ITU-T G.711 ...
343	3.343535	192.168.56.103	192.168.56.1	RTP	214	PT=ITU-T G.711 ...
344	3.359584	192.168.56.1	192.168.56.103	RTP	214	PT=ITU-T G.711 ...
345	3.362909	192.168.56.103	192.168.56.1	RTP	214	PT=ITU-T G.711 ...
346	3.380381	192.168.56.1	192.168.56.103	RTP	214	PT=ITU-T G.711 ...
347	3.384385	192.168.56.103	192.168.56.1	RTP	214	PT=ITU-T G.711 ...
348	3.400422	192.168.56.1	192.168.56.103	RTP	214	PT=ITU-T G.711 ...
349	3.403553	192.168.56.103	192.168.56.1	RTP	214	PT=ITU-T G.711 ...
350	3.420133	192.168.56.1	192.168.56.103	RTP	214	PT=ITU-T G.711 ...
351	3.423116	192.168.56.103	192.168.56.1	RTP	214	PT=ITU-T G.711 ...
352	3.440176	192.168.56.1	192.168.56.103	RTP	214	PT=ITU-T G.711 ...
353	3.443515	192.168.56.103	192.168.56.1	RTP	214	PT=ITU-T G.711 ...
354	3.460108	192.168.56.1	192.168.56.103	RTP	214	PT=ITU-T G.711 ...
355	3.463517	192.168.56.103	192.168.56.1	RTP	214	PT=ITU-T G.711 ...
356	3.480019	192.168.56.1	192.168.56.103	RTP	214	PT=ITU-T G.711 ...
357	3.483708	192.168.56.103	192.168.56.1	RTP	214	PT=ITU-T G.711 ...
358	3.500403	192.168.56.1	192.168.56.103	RTP	214	PT=ITU-T G.711 ...

> Frame 349: 214 bytes on wire (1712 bits), 214 bytes captured (1712 bits) on interface 0

> Ethernet II, Src: PcsCompu\_6e:0d:24 (08:00:27:6e:0d:24), Dst: 0a:00:27:00:00:02 (0a:00:27:00:00:02)

> Internet Protocol Version 4, Src: 192.168.56.103, Dst: 192.168.56.1

<

0000	0a 00 27 00 00 02 08 00 27 6e 0d 24 08 00 45 00	.. '..... 'n.\$..E.
0010	00 c8 df 11 40 00 40 11 69 5a c0 a8 38 67 c0 a8	....@.@. iZ..8g..
0020	38 01 37 50 cb a8 00 b4 5d d9 80 00 0d c5 00 00	8.7P.... l.....



Figure > RTP packets

Above wireshark capture shows the RTP packets exchanged after the call is established between the users.

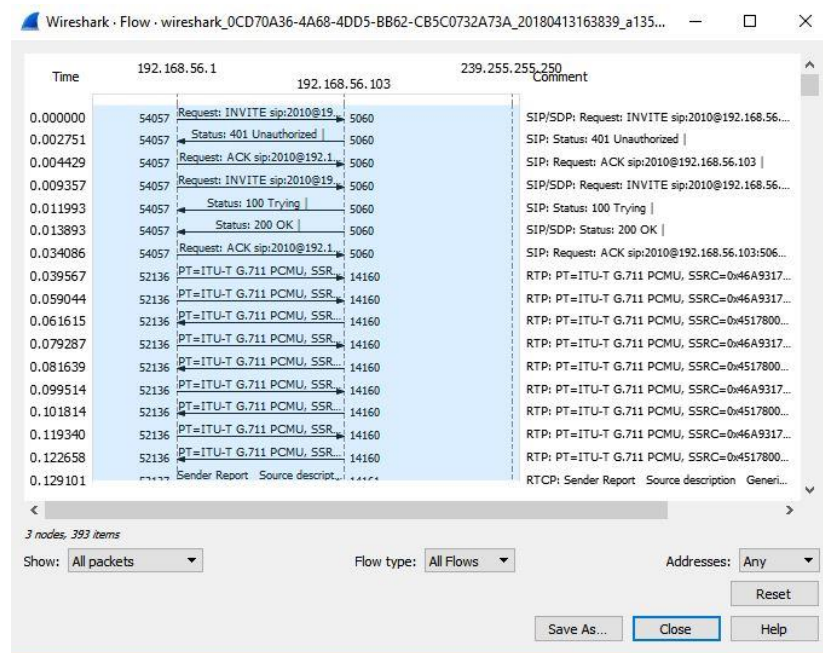


Figure > Packet Flow

Above capture shows the messages exchanged between the clients.

### 3. Phase-2 Summary:

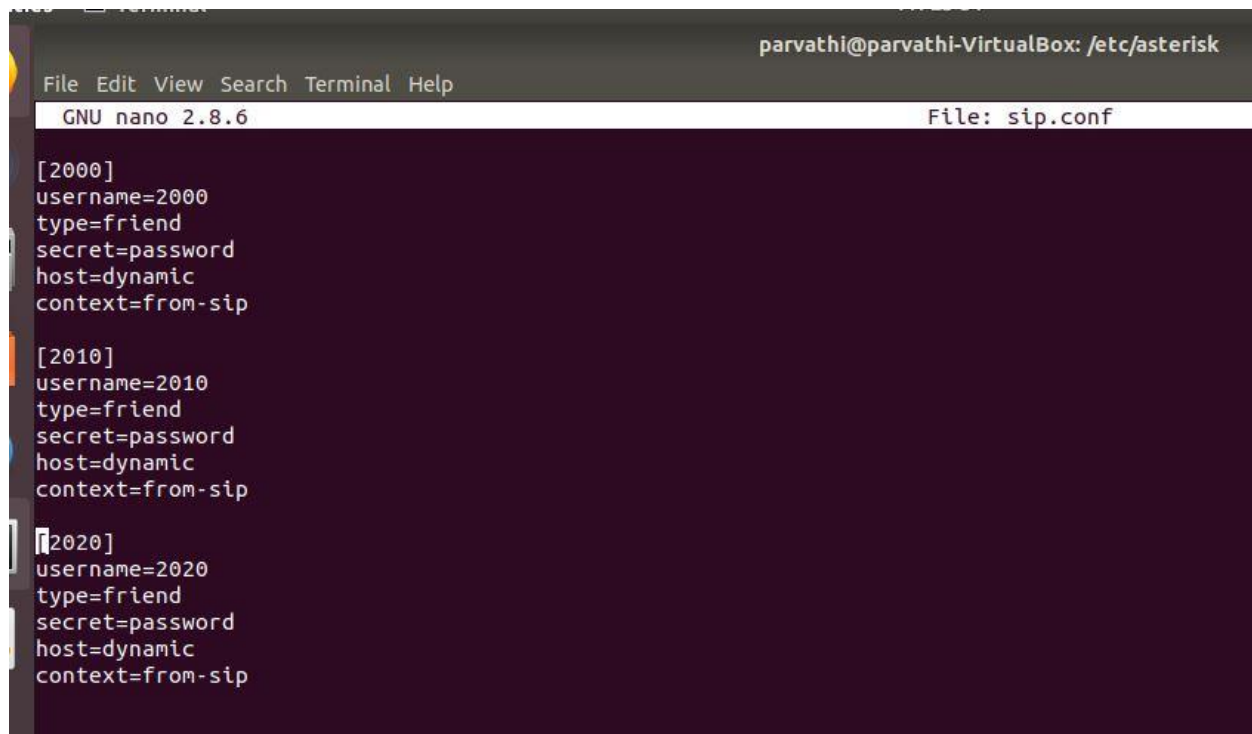
In this phase, 2000 calls 2010 but gets a busy tone.

## PHASE 3 - CALL ON HOLD:

Here, 2000 calls 2010 and establishes a call. 2020 tries to call 2000. Therefore, 2000 user puts 2010 on hold and accepts 2020.

### 1. Call establishment.

The experiments need three clients. The third client can be included as user 2020 in sip.conf file from Phase I, as follows:



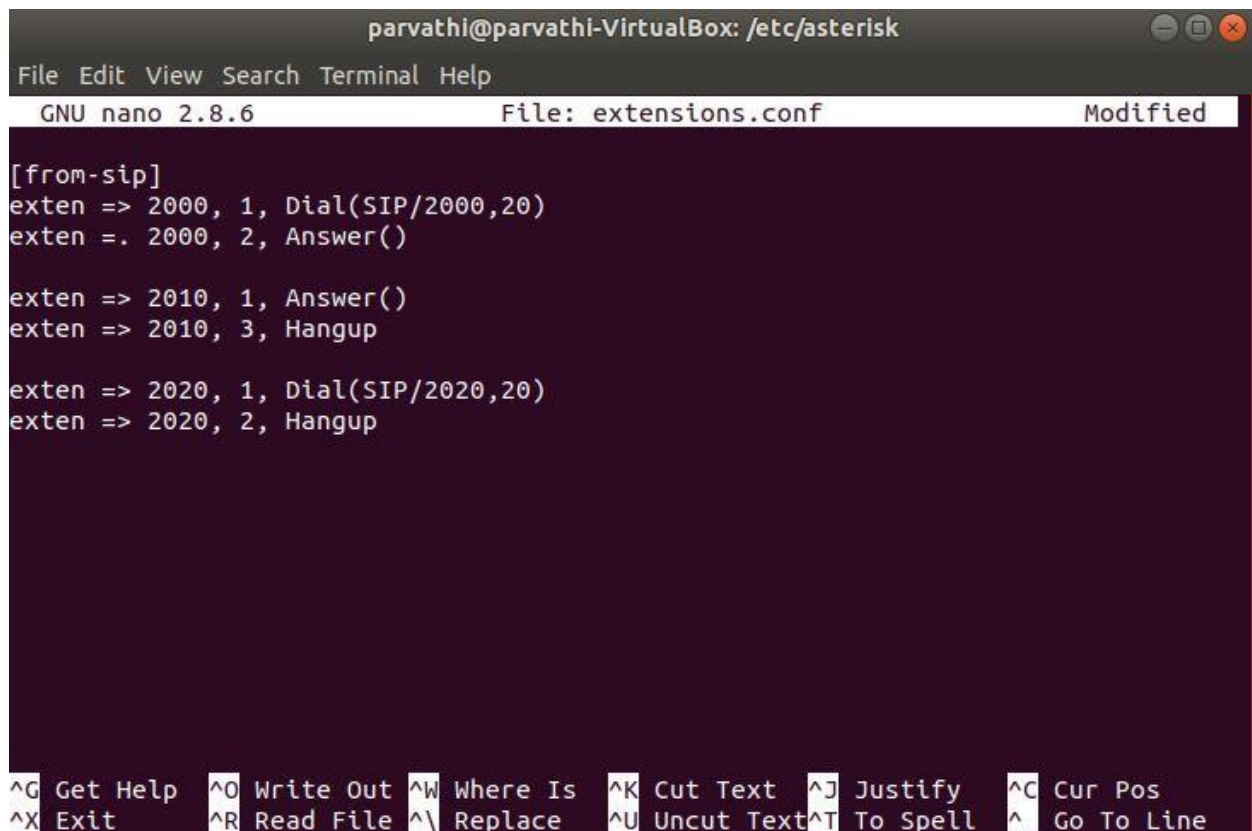
```
parvathi@parvathi-VirtualBox: /etc/asterisk
File Edit View Search Terminal Help
GNU nano 2.8.6 File: sip.conf

[2000]
username=2000
type=friend
secret=password
host=dynamic
context=from-sip

[2010]
username=2010
type=friend
secret=password
host=dynamic
context=from-sip

[2020]
username=2020
type=friend
secret=password
host=dynamic
context=from-sip
```

The extensions.conf file is modified and added to the existing values.



```
parvathi@parvathi-VirtualBox: /etc/asterisk
File Edit View Search Terminal Help
GNU nano 2.8.6 File: extensions.conf Modified

[from-sip]
exten => 2000, 1, Dial(SIP/2000,20)
exten =. 2000, 2, Answer()

exten => 2010, 1, Answer()
exten => 2010, 3, Hangup

exten => 2020, 1, Dial(SIP/2020,20)
exten => 2020, 2, Hangup

^G Get Help ^O Write Out ^W Where Is ^K Cut Text ^J Justify ^C Cur Pos
^X Exit ^R Read File ^\ Replace ^U Uncut Text ^T To Spell ^_ Go To Line
```

## 2. Capture of results



VirtualBox Host-Only Network #3

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/> Expression...

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.56.1	255.255.255.255	DB-LSP...	176	Dropbox LAN syn...
2	0.005340	192.168.56.1	255.255.255.255	DB-LSP...	176	Dropbox LAN syn...
3	0.005573	192.168.56.1	255.255.255.255	DB-LSP...	176	Dropbox LAN syn...
4	0.005787	192.168.56.1	192.168.56.255	DB-LSP...	176	Dropbox LAN syn...
5	0.006349	192.168.56.1	255.255.255.255	DB-LSP...	176	Dropbox LAN syn...
6	3.942047	192.168.56.1	192.168.56.103	SIP/SDP	953	Request: INVITE...
7	3.944660	192.168.56.103	192.168.56.1	SIP	620	Status: 401 Una...
8	3.945910	192.168.56.1	192.168.56.103	SIP	378	Request: ACK si...
9	3.950887	192.168.56.1	192.168.56.103	SIP/SDP	1114	Request: INVITE...
10	3.954129	192.168.56.103	192.168.56.1	SIP	564	Status: 100 Try...
11	4.164195	192.168.56.103	192.168.56.1	SIP	580	Status: 180 Rin...
12	9.097650	PcsCompu_6e:0d:24	0a:00:27:00:00:02	ARP	60	Who has 192.168...
13	9.097678	0a:00:27:00:00:02	PcsCompu_6e:0d:24	ARP	42	192.168.56.1 is...
14	9.433448	192.168.56.103	192.168.56.1	SIP/SDP	890	Status: 200 OK ...
15	9.451719	192.168.56.1	192.168.56.103	SIP	496	Request: ACK si...
16	9.467090	192.168.56.1	192.168.56.103	RTP	214	PT=ITU-T G.711 ...
17	9.482005	192.168.56.103	192.168.56.1	SIP/SDP	898	Request: INVITE...
18	9.486306	192.168.56.1	192.168.56.103	RTP	214	PT=ITU-T G.711 ...
19	9.491732	192.168.56.103	192.168.56.1	RTP	214	PT=ITU-T G.711 ...
20	9.493043	192.168.56.103	192.168.56.1	RTP	214	PT=ITU-T G.711 ...
21	9.494290	192.168.56.103	192.168.56.1	RTP	214	PT=ITU-T G.711 ...
22	9.495381	192.168.56.103	192.168.56.1	RTP	214	PT=ITU-T G.711 ...

> Frame 6: 953 bytes on wire (7624 bits), 953 bytes captured (7624 bits) on interface 0

> Ethernet II, Src: 0a:00:27:00:00:02 (0a:00:27:00:00:02), Dst: PcsCompu\_6e:0d:24 (08:00:27:6e:0d:24)

> Internet Protocol Version 4, Src: 192.168.56.1, Dst: 192.168.56.103

<

```

0000 08 00 27 6e 0d 24 0a 00 27 00 00 02 08 00 45 00  ..'n.$.. '.....E.
0010 03 ab 07 d7 00 00 80 11 3d b2 c0 a8 38 01 c0 a8  .....=...8...
0020 38 67 d3 29 13 c4 03 97 86 e9 49 4e 56 49 54 45  8g.).... ..INVITE

```

Figure > Calling between two clients

Above Wireshark capture shows the SIP messages between the user 2000 and 2010.

VirtualBox Host-Only Network #3

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/> Expression...

No.	Time	Source	Destination	Protocol	Length	Info
2626	35.693816	192.168.56.103	192.168.56.1	SIP	579	Status: 100 Tryin...
2627	35.695378	192.168.56.103	192.168.56.1	SIP/SDP	866	Status: 200 OK
2628	35.696529	192.168.56.104	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
2629	35.707403	192.168.56.1	192.168.56.103	SIP	496	Request: ACK sip:...
2630	35.717356	192.168.56.104	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
2631	35.740244	192.168.56.104	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
2632	35.754485	192.168.56.104	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
2633	35.777050	192.168.56.104	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
2634	35.788593	192.168.56.104	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
2635	35.807733	192.168.56.104	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
2636	38.009315	0a:00:27:00:00:02	PcsCompu_6e:0d:24	ARP	42	Who has 192.168.5...
2637	38.010696	PcsCompu_6e:0d:24	0a:00:27:00:00:02	ARP	60	192.168.56.103 is...
2638	38.024293	PcsCompu_6e:0d:24	0a:00:27:00:00:02	ARP	60	Who has 192.168.5...
2639	38.024318	0a:00:27:00:00:02	PcsCompu_6e:0d:24	ARP	42	192.168.56.1 is a...
2640	38.541692	192.168.56.1	192.168.56.103	SIP/SDP	807	Status: 200 OK
2641	38.543767	192.168.56.103	192.168.56.1	SIP	509	Request: ACK sip:...
2642	38.550417	192.168.56.1	192.168.56.103	RTP	214	PT=ITU-T G.711 PC...
2643	38.553182	192.168.56.103	192.168.56.1	SIP/SDP	973	Request: INVITE s...
2644	38.567063	192.168.56.1	192.168.56.103	RTP	214	PT=ITU-T G.711 PC...
2645	38.586209	192.168.56.1	192.168.56.103	RTP	214	PT=ITU-T G.711 PC...
2646	38.606491	192.168.56.1	192.168.56.103	RTP	214	PT=ITU-T G.711 PC...
2647	38.626518	192.168.56.1	192.168.56.103	RTP	214	PT=ITU-T G.711 PC...

> Frame 17: 898 bytes on wire (7184 bits), 898 bytes captured (7184 bits) on interface 0

> Ethernet II, Src: PcsCompu\_6e:0d:24 (08:00:27:6e:0d:24), Dst: 0a:00:27:00:00:02 (0a:00:27:00:00:02)

> Internet Protocol Version 4, Src: 192.168.56.103, Dst: 192.168.56.1

> User Datagram Protocol, Src Port: 5060, Dst Port: 54057

```

0000  0a 00 27 00 00 02 08 00 27 6e 0d 24 08 00 45 00  ..'.... 'n$.E.
0010  03 74 f7 ed 00 00 40 11 8d d2 c0 a8 38 67 c0 a8  .t....@. ....8g..
0020  38 01 13 c4 d3 29 03 60 4d 3d 49 4e 56 49 54 45  8....)`M=INVITE

```

wireshark\_OCD70A36-4...0180413164532\_a06312 | Packets: 3259 · Displayed: 3259 (100.0%) · Dropped: 0 (0.0%) | Profile: Default

Figure > A Call on HOLD by first user

Above Wireshark screenshot shows the different messages when the 2000 puts the call of 2010 on hold to accept the call of 2020.

VirtualBox Host-Only Network #3

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/> Expression...

No.	Time	Source	Destination	Protocol	Length	Info
2868	41.247765	192.168.56.1	192.168.56.105	RTP	214	PT=ITU-T G.711 PC...
2869	41.248510	192.168.56.105	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
2870	41.267673	192.168.56.1	192.168.56.105	RTP	214	PT=ITU-T G.711 PC...
2871	41.268630	192.168.56.105	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
2872	41.288103	192.168.56.1	192.168.56.105	RTP	214	PT=ITU-T G.711 PC...
2873	41.290029	192.168.56.105	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
2874	41.307065	192.168.56.1	192.168.56.105	RTP	214	PT=ITU-T G.711 PC...
2875	41.309752	192.168.56.105	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
2876	41.326603	192.168.56.1	192.168.56.105	RTP	214	PT=ITU-T G.711 PC...
2877	41.328311	192.168.56.105	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
2878	41.346750	192.168.56.1	192.168.56.105	RTP	214	PT=ITU-T G.711 PC...
2879	41.349350	192.168.56.105	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
2880	41.366823	192.168.56.1	192.168.56.105	RTP	214	PT=ITU-T G.711 PC...
2881	41.370877	192.168.56.105	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
2882	41.386550	192.168.56.1	192.168.56.105	RTP	214	PT=ITU-T G.711 PC...
2883	41.390321	192.168.56.105	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
2884	41.406789	192.168.56.1	192.168.56.105	RTP	214	PT=ITU-T G.711 PC...
2885	41.412002	192.168.56.105	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
2886	41.427179	192.168.56.1	192.168.56.105	RTP	214	PT=ITU-T G.711 PC...
2887	41.441352	192.168.56.105	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
2888	41.446618	192.168.56.1	192.168.56.105	RTP	214	PT=ITU-T G.711 PC...
2889	41.450803	192.168.56.105	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...

> Frame 17: 898 bytes on wire (7184 bits), 898 bytes captured (7184 bits) on interface 0

> Ethernet II, Src: PcsCompu\_6e:0d:24 (08:00:27:6e:0d:24), Dst: 0a:00:27:00:00:02 (0a:00:27:00:00:02)

> Internet Protocol Version 4, Src: 192.168.56.103, Dst: 192.168.56.1

> User Datagram Protocol, Src Port: 5060, Dst Port: 54057

```

0000  0a 00 27 00 00 02 08 00 27 6e 0d 24 08 00 45 00  ..'.... 'n$.E.
0010  03 74 f7 ed 00 00 40 11 8d d2 c0 a8 38 67 c0 a8  .t....@. ....8g..
0020  38 01 13 c4 d3 29 03 60 4d 3d 49 4e 56 49 54 45  8....)`M=INVITE

```

wireshark\_OCD70A36-4...0180413164532\_a06312 | Packets: 3259 · Displayed: 3259 (100.0%) · Dropped: 0 (0.0%) | Profile: Default

Figure > 2000 accepts 2020 and transmission begins

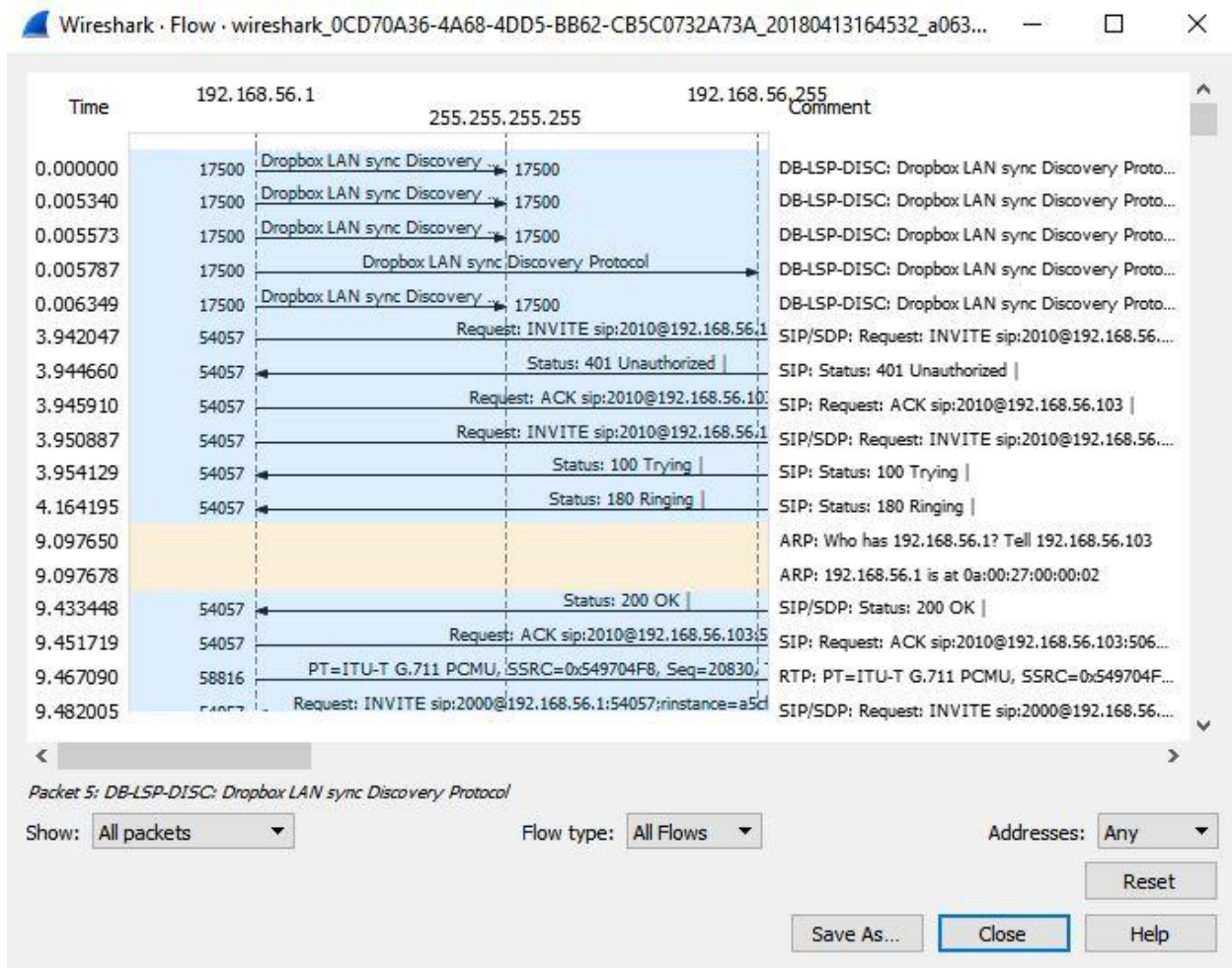


Figure > Call Flow

### 3. Phase – 3 Summary:

Here, call is already in progress between 2000 and 2010 when 2020 calls. 2000 puts 2010 on hold and accepts 2020. 2010 would hear a hold tone.

## PHASE 4 - CALL CONFERENCING:

### 1. Call establishment.

Here, 2000 and 2010 have an established call. 2020 calls user 2000. 2000 puts 2010 on hold, and accepts the call from 2020. 2000 then merges both the calls together to form a conference call.

### 2. Capture of results



\*VirtualBox Host-Only Network #3

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/> Expression...

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.56.1	192.168.56.103	SIP/SDP	953	Request: INVITE s...
2	0.002600	192.168.56.103	192.168.56.1	SIP	620	Status: 401 Unaut...
3	0.004115	192.168.56.1	192.168.56.103	SIP	378	Request: ACK sip:...
4	0.008620	192.168.56.1	192.168.56.103	SIP/SDP	1114	Request: INVITE s...
5	0.012470	192.168.56.103	192.168.56.1	SIP	564	Status: 100 Tryin...
6	0.114256	192.168.56.103	192.168.56.1	SIP	580	Status: 180 Ringi...
7	4.243594	192.168.56.1	192.168.56.103	UDP	46	54057 → 5060 Len=4
8	4.939761	0a:00:27:00:00:02	PcsCompu_6e:0d:24	ARP	42	Who has 192.168.5...
9	4.941266	PcsCompu_6e:0d:24	0a:00:27:00:00:02	ARP	60	192.168.56.103 is...
10	5.061525	PcsCompu_6e:0d:24	0a:00:27:00:00:02	ARP	60	Who has 192.168.5...
11	5.061575	0a:00:27:00:00:02	PcsCompu_6e:0d:24	ARP	42	192.168.56.1 is a...
12	6.219725	192.168.56.103	192.168.56.1	SIP/SDP	888	Status: 200 OK
13	6.240145	192.168.56.1	192.168.56.103	SIP	496	Request: ACK sip:...
14	6.241750	192.168.56.103	192.168.56.1	SIP/SDP	896	Request: INVITE s...
15	6.251330	192.168.56.1	192.168.56.103	RTP	214	PT=ITU-T G.711 PC...
16	6.254763	192.168.56.103	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
17	6.271209	192.168.56.103	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
18	6.271480	192.168.56.1	192.168.56.103	RTP	214	PT=ITU-T G.711 PC...
19	6.291064	192.168.56.1	192.168.56.103	RTP	214	PT=ITU-T G.711 PC...
20	6.292000	192.168.56.103	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
21	6.311125	192.168.56.1	192.168.56.103	RTP	214	PT=ITU-T G.711 PC...
22	6.312013	PcsCompu_85:e0:d1	Broadcast	ARP	42	Who has 192.168.5...

> Frame 1: 953 bytes on wire (7624 bits), 953 bytes captured (7624 bits) on interface 0

> Ethernet II, Src: 0a:00:27:00:00:02 (0a:00:27:00:00:02), Dst: PcsCompu\_6e:0d:24 (08:00:27:6e:0d:24)

> Internet Protocol Version 4, Src: 192.168.56.1, Dst: 192.168.56.103

> User Datagram Protocol, Src Port: 54057, Dst Port: 5060

0000 08 00 27 6e 0d 24 0a 00 27 00 00 02 08 00 45 00 ..'n\$. '.....E.

0010 03 ab 0f 29 00 00 80 11 36 60 c0 a8 38 01 c0 a8 ...). .... 6'.8...

0020 38 67 d3 29 13 c4 03 97 bc 45 49 4e 56 49 54 45 8g.).... .EINVITE

wireshark\_OCD70A36-4..0180413165937\_a16232 | Packets: 3035 · Displayed: 3035 (100.0%) · Dropped: 0 (0.0%) | Profile: Default

Figure > Call in progress between 2000 and 2010

\*VirtualBox Host-Only Network #3

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Filter: sip Expression...

No.	Time	Source	Destination	Protocol	Length	Info
28	6.339435	192.168.56.1	192.168.56.103	SIP	334	Status: 100 Tryin...
29	6.340284	192.168.56.1	192.168.56.103	SIP/SDP	789	Status: 200 OK
30	6.341762	192.168.56.103	192.168.56.1	SIP	481	Request: ACK sip:...
848	14.495568	192.168.56.103	192.168.56.1	SIP/SDP	997	Request: INVITE s...
857	14.580212	192.168.56.1	192.168.56.103	SIP	344	Status: 100 Tryin...
876	14.754918	192.168.56.1	192.168.56.103	SIP	507	Status: 180 Ringi...
1227	18.387951	192.168.56.1	192.168.56.103	SIP/SDP	1139	Request: INVITE s...
1228	18.391006	192.168.56.103	192.168.56.1	SIP	579	Status: 100 Tryin...
1229	18.395819	192.168.56.103	192.168.56.1	SIP/SDP	864	Status: 200 OK
1231	18.403607	192.168.56.1	192.168.56.103	SIP	496	Request: ACK sip:...
1242	23.254096	192.168.56.1	192.168.56.103	SIP/SDP	807	Status: 200 OK
1243	23.258457	192.168.56.103	192.168.56.1	SIP	509	Request: ACK sip:...
1244	23.265872	192.168.56.103	192.168.56.1	SIP/SDP	973	Request: INVITE s...
1254	23.377130	192.168.56.1	192.168.56.103	SIP	357	Status: 100 Tryin...
1255	23.377969	192.168.56.1	192.168.56.103	SIP/SDP	807	Status: 200 OK
1256	23.379859	192.168.56.103	192.168.56.1	SIP	509	Request: ACK sip:...
1532	26.165458	192.168.56.1	192.168.56.103	SIP/SDP	1139	Request: INVITE s...
1533	26.168185	192.168.56.103	192.168.56.1	SIP	579	Status: 100 Tryin...
1534	26.169785	192.168.56.103	192.168.56.1	SIP/SDP	864	Status: 200 OK
1539	26.183896	192.168.56.1	192.168.56.103	SIP	496	Request: ACK sip:...
3022	33.595014	192.168.56.1	192.168.56.103	SIP	530	Request: BYE sip:...
3023	33.595139	192.168.56.1	192.168.56.103	SIP	662	Request: BYE sip:...

> Frame 30: 481 bytes on wire (3848 bits), 481 bytes captured (3848 bits) on interface 0

> Ethernet II, Src: PcsCompu\_6e:0d:24 (08:00:27:6e:0d:24), Dst: 0a:00:27:00:00:02 (0a:00:27:00:00:02)

> Internet Protocol Version 4, Src: 192.168.56.103, Dst: 192.168.56.1

> User Datagram Protocol, Src Port: 5060, Dst Port: 54057

0000 0a 00 27 00 00 02 08 00 27 6e 0d 24 08 00 45 00 ..'.....'n\$.E.

0010 01 d3 10 78 00 00 40 11 76 e9 c0 a8 38 67 c0 a8 ...x. @. v...8g..

0020 38 01 13 c4 d3 29 01 bf 76 6b 41 43 4b 20 73 69 8....).. vkACK si

Session Initiation Protocol: Protocol | Packets: 3035 · Displayed: 33 (1.1%) · Dropped: 0 (0.0%) | Profile: Default

Figure > Invite from 2020

\*VirtualBox Host-Only Network #3

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/> Expression...

No.	Time	Source	Destination	Protocol	Length	Info
1809	27.517208	192.168.56.104	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
1810	27.531047	192.168.56.1	192.168.56.104	RTP	214	PT=ITU-T G.711 PC...
1811	27.531102	192.168.56.1	192.168.56.105	RTP	214	PT=ITU-T G.711 PC...
1812	27.534305	192.168.56.105	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
1813	27.538212	192.168.56.104	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
1814	27.551450	192.168.56.1	192.168.56.104	RTP	214	PT=ITU-T G.711 PC...
1815	27.551503	192.168.56.1	192.168.56.105	RTP	214	PT=ITU-T G.711 PC...
1816	27.554751	192.168.56.105	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
1817	27.555779	192.168.56.104	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
1818	27.571616	192.168.56.1	192.168.56.104	RTP	214	PT=ITU-T G.711 PC...
1819	27.571663	192.168.56.1	192.168.56.105	RTP	214	PT=ITU-T G.711 PC...
1820	27.574721	192.168.56.105	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
1821	27.578150	192.168.56.104	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
1822	27.591125	192.168.56.1	192.168.56.104	RTP	214	PT=ITU-T G.711 PC...
1823	27.591182	192.168.56.1	192.168.56.105	RTP	214	PT=ITU-T G.711 PC...
1824	27.595249	192.168.56.105	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
1825	27.597925	192.168.56.104	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
1826	27.611707	192.168.56.1	192.168.56.104	RTP	214	PT=ITU-T G.711 PC...
1827	27.611763	192.168.56.1	192.168.56.105	RTP	214	PT=ITU-T G.711 PC...
1828	27.615100	192.168.56.105	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
1829	27.619230	192.168.56.104	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
1830	27.631477	192.168.56.1	192.168.56.104	RTP	214	PT=ITU-T G.711 PC...

> Frame 30: 481 bytes on wire (3848 bits), 481 bytes captured (3848 bits) on interface 0

> Ethernet II, Src: PcsCompu\_6e:0d:24 (08:00:27:6e:0d:24), Dst: 0a:00:27:00:00:02 (0a:00:27:00:00:02)

> Internet Protocol Version 4, Src: 192.168.56.103, Dst: 192.168.56.1

> User Datagram Protocol, Src Port: 5060, Dst Port: 54057

```

0000  0a 00 27 00 00 02 08 00  27 6e 0d 24 08 00 45 00  ..'....'n$.E.
0010  01 d3 10 78 00 00 40 11  76 e9 c0 a8 38 67 c0 a8  ...x.@.v...8g..
0020  38 01 13 c4 d3 29 01 bf  76 6b 41 43 4b 20 73 69  8....)..vkACK si

```

wireshark\_OCD70A36-4...0180413165937\_a16232 | Packets: 3035 · Displayed: 3035 (100.0%) · Dropped: 0 (0.0%) | Profile: Default

Figure > Call From 2020

\*VirtualBox Host-Only Network #3

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/> Expression...

No.	Time	Source	Destination	Protocol	Length	Info
2155	27.856107	192.168.56.105	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
2156	27.863668	192.168.56.104	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
2157	27.866471	192.168.56.1	192.168.56.104	RTP	214	PT=ITU-T G.711 PC...
2158	27.866556	192.168.56.1	192.168.56.105	RTP	214	PT=ITU-T G.711 PC...
2159	27.876657	192.168.56.105	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
2160	27.884827	192.168.56.104	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
2161	27.886581	192.168.56.1	192.168.56.104	RTP	214	PT=ITU-T G.711 PC...
2162	27.886632	192.168.56.1	192.168.56.105	RTP	214	PT=ITU-T G.711 PC...
2163	27.897375	192.168.56.105	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
2164	27.904073	192.168.56.104	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
2165	27.906565	192.168.56.1	192.168.56.104	RTP	214	PT=ITU-T G.711 PC...
2166	27.906621	192.168.56.1	192.168.56.105	RTP	214	PT=ITU-T G.711 PC...
2167	27.918241	192.168.56.105	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
2168	27.925486	192.168.56.104	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
2169	27.926514	192.168.56.1	192.168.56.104	RTP	214	PT=ITU-T G.711 PC...
2170	27.926562	192.168.56.1	192.168.56.105	RTP	214	PT=ITU-T G.711 PC...
2171	27.939336	192.168.56.105	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
2172	27.947427	192.168.56.1	192.168.56.104	RTP	214	PT=ITU-T G.711 PC...
2173	27.947436	192.168.56.104	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
2174	27.947483	192.168.56.1	192.168.56.105	RTP	214	PT=ITU-T G.711 PC...
2175	27.958716	192.168.56.105	192.168.56.1	RTP	214	PT=ITU-T G.711 PC...
2176	27.963349	PcsCompu_55:65:4e	0a:00:27:00:00:02	ARP	42	Who has 192.168.5...

> Frame 1: 176 bytes on wire (1408 bits), 176 bytes captured (1408 bits) on interface 0

> Ethernet II, Src: 0a:00:27:00:00:02 (0a:00:27:00:00:02), Dst: Broadcast (ff:ff:ff:ff:ff:ff)

> Internet Protocol Version 4, Src: 192.168.56.1, Dst: 255.255.255.255

> User Datagram Protocol, Src Port: 17500, Dst Port: 17500

```

0000  ff ff ff ff ff ff 0a 00  27 00 00 02 08 00 45 00  .....E.
0010  00 a2 33 8d 00 00 80 11  0e 15 c0 a8 38 01 ff ff  ..3.....8...
0020  ff ff 44 5c 44 5c 00 8e  d8 78 7b 22 68 6f 73 74  ..D\D\...x{"host

```

wireshark\_OCD70A36-4A68-4DD5...732A73A\_20180413170602\_a1608 | Packets: 2655 · Displayed: 2655 (100.0%) | Profile: Default

Figure > Merged Calls



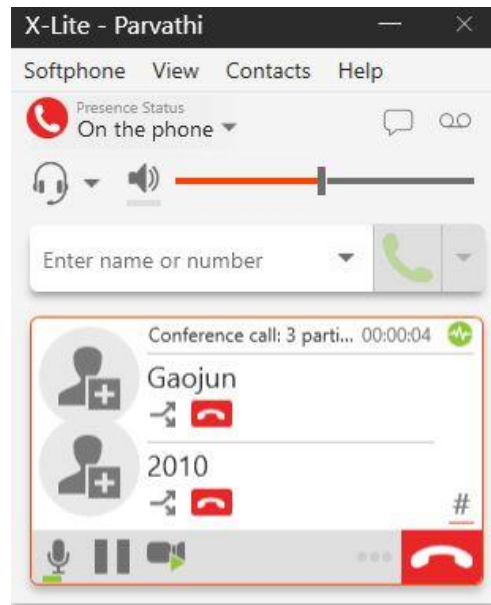


Figure > Merge Calls by client 2000

\*VirtualBox Host-Only Network #3

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Apply a display filter ... <Ctrl-/> Expression...

No.	Time	Source	Destination	Protocol	Length	Info
7	1.381815	192.168.56.103	192.168.56.1	SIP	620	Status: 401 Unaut...
8	1.384309	192.168.56.1	192.168.56.103	SIP	378	Request: ACK sip:...
9	1.391177	192.168.56.1	192.168.56.103	SIP/SDP	1114	Request: INVITE s...
10	1.394890	192.168.56.103	192.168.56.1	SIP	564	Status: 100 Tryin...
11	1.640740	192.168.56.103	192.168.56.1	SIP	580	Status: 180 Ringi...
12	5.966579	0a:00:27:00:00:02	PcsCompu_6e:0d:24	ARP	42	Who has 192.168.5...

> Frame 8: 378 bytes on wire (3024 bits), 378 bytes captured (3024 bits) on interface 0

▼ Ethernet II, Src: 0a:00:27:00:00:02 (0a:00:27:00:00:02), Dst: PcsCompu\_6e:0d:24 (08:00:27:6e:0d:24)

- > Destination: PcsCompu\_6e:0d:24 (08:00:27:6e:0d:24)
- > Source: 0a:00:27:00:00:02 (0a:00:27:00:00:02)
- Type: IPv4 (0x0800)
- > Internet Protocol Version 4, Src: 192.168.56.1, Dst: 192.168.56.103
- > User Datagram Protocol, Src Port: 54057, Dst Port: 5060
- > Session Initiation Protocol (ACK)

Figure > Media Access Control address of the Server

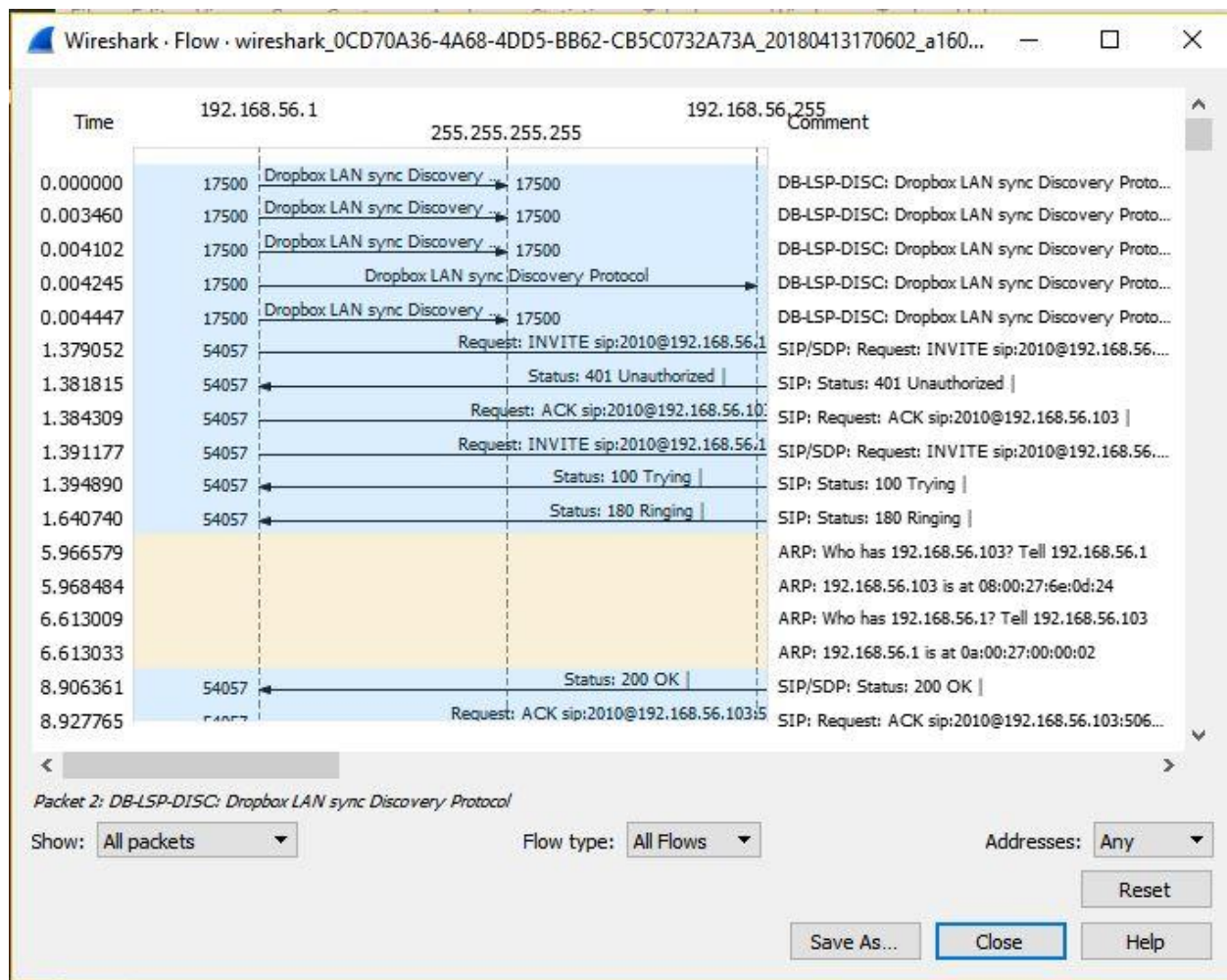


Figure > Call Flow

### 3. Phase – 4 Summary

Here 2000 and 2010 have a call in progress. 2020 sends a call request connection to 2000. 2000 puts 2010 on hold and accepts 2020. 2000 then invites 2020 to be part of the three user call.

## PART-2

### Abstract

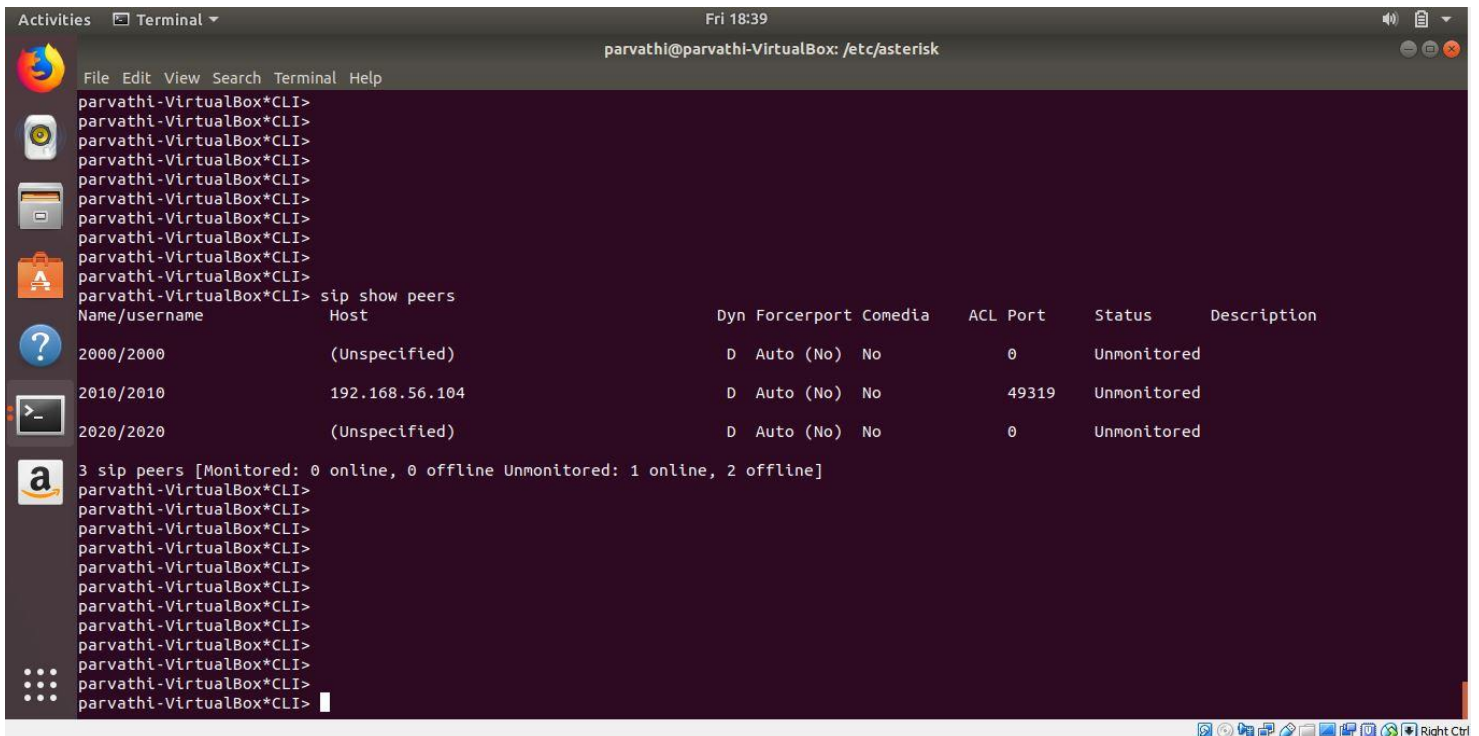
Part 2 states to create a client using code, with SIP functionalities.



In this part we created a SIP client script using python. The client can successfully register, unregister and send call invite to another client. The working of the client is shown in below figures.

### 1. Registering Client:

This screenshot from the server shows that the client is not registered at the beginning. As seen at the bottom, there is only one client is registered to the server. The registered client is with IP 192.168.56.104 and having user ID 2010.



```
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI> sip show peers
Name/username      Host                Dyn Forcerport Comedia  ACL Port  Status      Description
2000/2000          (Unspecified)      D   Auto (No)  No           0      Unmonitored
2010/2010          192.168.56.104    D   Auto (No)  No        49319  Unmonitored
2020/2020          (Unspecified)      D   Auto (No)  No           0      Unmonitored

3 sip peers [Monitored: 0 online, 0 offline Unmonitored: 1 online, 2 offline]
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
```

Figure > Only 2010 registered

The client script is now run on an Ubuntu client virtual machine. It requires the client IP [192.168.56.106], Server IP [192.168.56.103], Username [we have specified 2000], Password [which is just password for us].

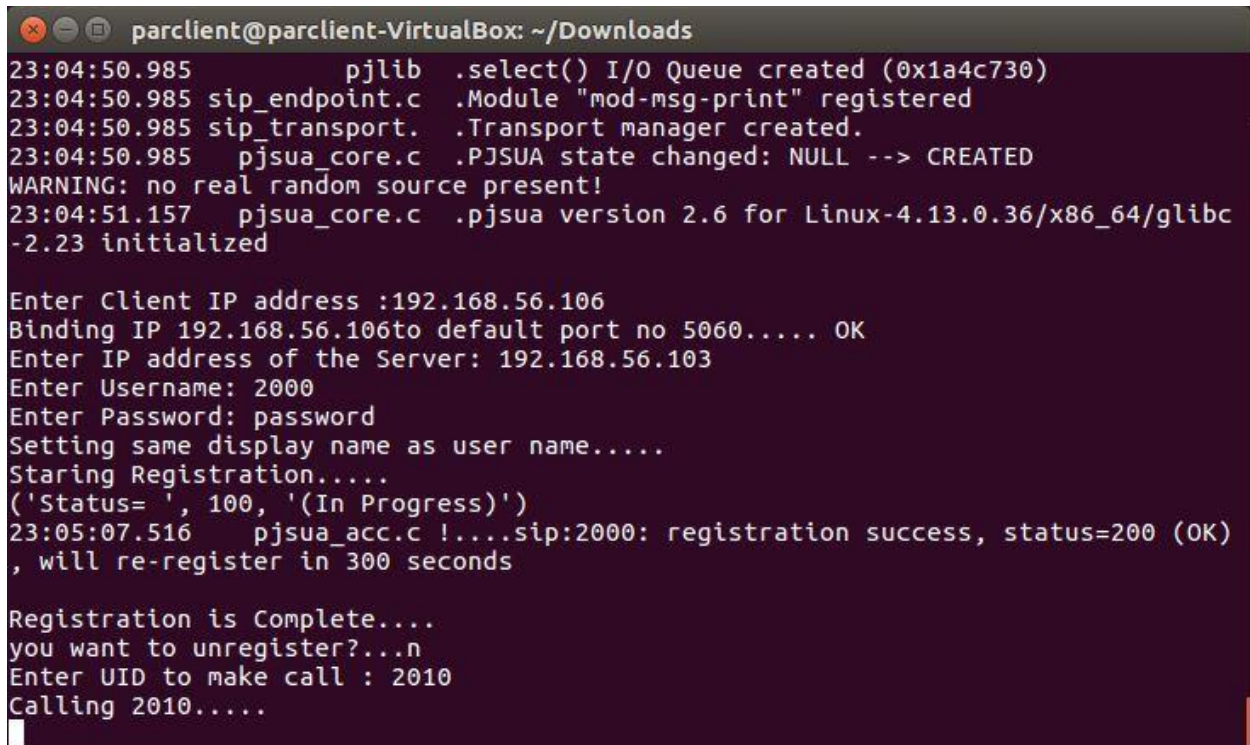


Figure > Registered screenshot from server side

Hence, the registration of client has been completed.

## 2. Calling:

One the registration process is complete, calling will begin to the user mentioned earlier. [2010].

A terminal window titled 'parclient@parclient-VirtualBox: ~/Downloads' displays the output of a SIP client script. The log shows the initialization of pjsua, including the creation of an I/O queue, registration of modules, and state changes. It then shows the user entering the client IP (192.168.56.106), server IP (192.168.56.103), username (2000), and password (password). The registration process is initiated and successful, with a status of 200 (OK). The user is prompted to enter a UID to make a call, and they enter 2010. The script then attempts to call 2010.

```
parclient@parclient-VirtualBox: ~/Downloads
23:04:50.985      pjljb  .select() I/O Queue created (0x1a4c730)
23:04:50.985 sip_endpoint.c .Module "mod-msg-print" registered
23:04:50.985 sip_transport. .Transport manager created.
23:04:50.985  pjsua_core.c .PJSUA state changed: NULL --> CREATED
WARNING: no real random source present!
23:04:51.157  pjsua_core.c .pjsua version 2.6 for Linux-4.13.0.36/x86_64/glibc
-2.23 initialized

Enter Client IP address :192.168.56.106
Binding IP 192.168.56.106to default port no 5060..... OK
Enter IP address of the Server: 192.168.56.103
Enter Username: 2000
Enter Password: password
Setting same display name as user name.....
Starting Registration.....
('Status= ', 100, '(In Progress)')
23:05:07.516  pjsua_acc.c !....sip:2000: registration success, status=200 (OK)
, will re-register in 300 seconds

Registration is Complete....
you want to unregister?...n
Enter UID to make call : 2010
Calling 2010.....
```

Figure > Calling from client script to 2010

With this, the opposite client's X-Lite starts ringing and the other client can answer or decline.

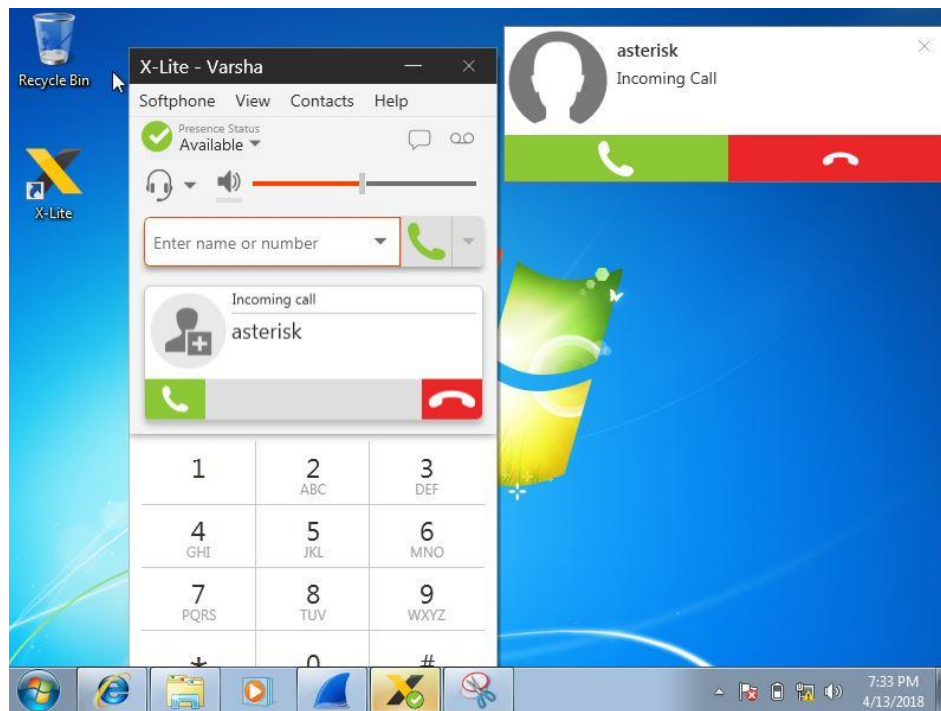


Figure > Incoming call

### 3. Unregistering Client:

Once the user gives command the script starts unregistering the client from the SIP server. The following figure shows the unregistering process.

```

parclient@parclient-VirtualBox: ~/Downloads
23:00:05.564      pjlib .select() I/O Queue created (0x16ae730)
23:00:05.564 sip_endpoint.c .Module "mod-msg-print" registered
23:00:05.564 sip_transport. .Transport manager created.
23:00:05.564 pjsua_core.c .PJSUA state changed: NULL --> CREATED
WARNING: no real random source present!
23:00:05.755 pjsua_core.c .pjsua version 2.6 for Linux-4.13.0.36/x86_64/glibc
-2.23 initialized

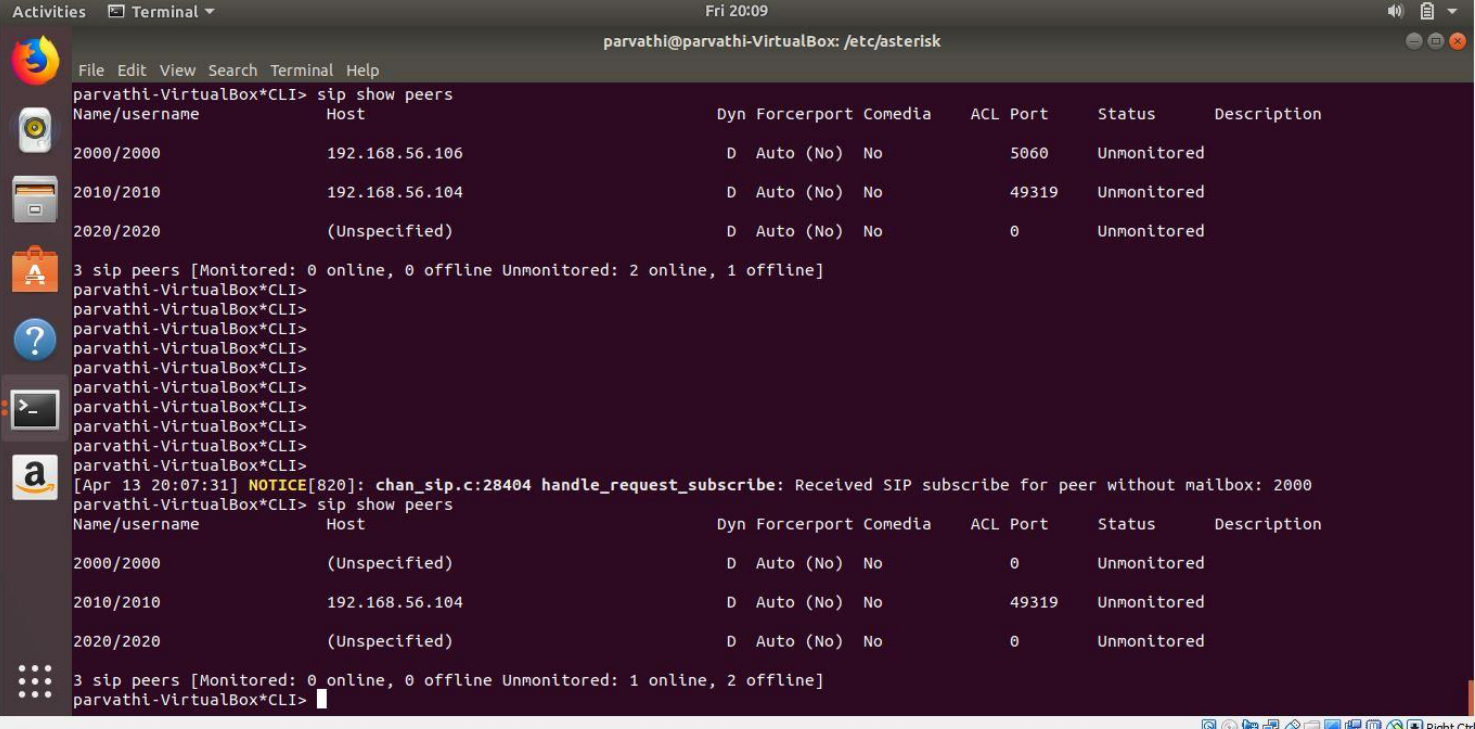
Enter Client IP address :192.168.56.106
Binding IP 192.168.56.106to default port no 5060..... OK
Enter IP address of the Server: 192.168.56.103
Enter Username: 2000
Enter Password: password
Setting same display name as user name.....
Starting Registration.....
('Status= ', 100, '(In Progress)')
23:00:28.543 pjsua_acc.c !....sip:2000: registration success, status=200 (OK)
, will re-register in 300 seconds

Registration is Complete....
you want to unregister?...y
23:00:35.874 pjsua_acc.c ....sip:2000: unregistration success
  
```



Figure > Unregistration by client script

The above figure shows that the client has successfully been unregistered from the SIP server. The following figure proves the successful registration from the SIP server.



The screenshot shows a terminal window titled 'parvathi@parvathi-VirtualBox: /etc/asterisk'. It displays two 'sip show peers' commands. The first command shows three peers: 2000/2000 (192.168.56.106), 2010/2010 (192.168.56.104), and 2020/2020 (Unspecified). The second command, after unregistration, shows the same three peers, but the status for 2000/2000 is now 'Unmonitored' and its port is '0'. A notice message indicates that a SIP subscribe request was received for peer 2000 without a mailbox.

```
parvathi-VirtualBox*CLI> sip show peers
Name/username      Host                Dyn Forcerport Conedia  ACL Port    Status    Description
2000/2000           192.168.56.106     D  Auto (No)  No      5060      Unmonitored
2010/2010           192.168.56.104     D  Auto (No)  No      49319     Unmonitored
2020/2020           (Unspecified)      D  Auto (No)  No      0         Unmonitored

3 sip peers [Monitored: 0 online, 0 offline Unmonitored: 2 online, 1 offline]
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
parvathi-VirtualBox*CLI>
[Apr 13 20:07:31] NOTICE[820]: chan_sip.c:28404 handle_request_subscribe: Received SIP subscribe for peer without mailbox: 2000
parvathi-VirtualBox*CLI> sip show peers
Name/username      Host                Dyn Forcerport Conedia  ACL Port    Status    Description
2000/2000           (Unspecified)      D  Auto (No)  No      0         Unmonitored
2010/2010           192.168.56.104     D  Auto (No)  No      49319     Unmonitored
2020/2020           (Unspecified)      D  Auto (No)  No      0         Unmonitored

3 sip peers [Monitored: 0 online, 0 offline Unmonitored: 1 online, 2 offline]
parvathi-VirtualBox*CLI>
```

Figure > Shows unregistered client script

Therefore, the client script has successfully unregistered from the Asterisk server.

#### 4. Wireshark Capture:

Below are the Wireshark screenshots showing the SIP invite, register packets from the Python client script. The register packet is intended for the server and the invite packet for the client on the other end.

The SIP registration packet is from the Python script client 192.168.56.106.

\*Local Area Connection

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Expression...

No.	Time	Source	Destination	Protocol	Length	Info
19	36.098125	192.168.56.106	192.168.56.103	SIP	567	Request: REGISTER sip...
20	36.099176	192.168.56.103	192.168.56.106	SIP	602	Status: 401 Unauthori...
22	36.114364	192.168.56.106	192.168.56.103	SIP	733	Request: REGISTER sip...
27	36.118034	192.168.56.103	192.168.56.106	SIP	618	Status: 200 OK (1 bi...
32	42.795116	192.168.56.106	192.168.56.103	SIP/SDP	1160	Request: INVITE sip:2...
33	42.797841	192.168.56.103	192.168.56.106	SIP	610	Status: 401 Unauthori...
34	42.823176	192.168.56.106	192.168.56.103	SIP	410	Request: ACK sip:2010...
35	42.823177	192.168.56.106	192.168.56.103	SIP/SDP	1331	Request: INVITE sip:2...
36	42.827363	192.168.56.103	192.168.56.106	SIP	591	Status: 100 Trying
37	42.829257	192.168.56.103	192.168.56.104	SIP/SDP	1008	Request: INVITE sip:2...
39	43.332694	192.168.56.103	192.168.56.104	SIP/SDP	1008	Request: INVITE sip:2...
40	44.334247	192.168.56.103	192.168.56.104	SIP/SDP	1008	Request: INVITE sip:2...
41	45.068303	192.168.56.104	192.168.56.103	SIP	352	Status: 100 Trying
42	45.069273	192.168.56.104	192.168.56.103	SIP	352	Status: 100 Trying
43	45.069994	192.168.56.104	192.168.56.103	SIP	352	Status: 100 Trying
51	54.123905	192.168.56.104	192.168.56.103	SIP	515	Status: 180 Ringing
52	54.126118	192.168.56.103	192.168.56.106	SIP	607	Status: 180 Ringing
54	62.837013	192.168.56.103	192.168.56.104	SIP	471	Request: CANCEL sip:2...

▶ Frame 19: 567 bytes on wire (4536 bits), 567 bytes captured (4536 bits) on interface 0  
 ▶ Ethernet II, Src: PcsCompu\_17:73:da (08:00:27:17:73:da), Dst: PcsCompu\_6e:0d:24 (08:00:27:6e:0d:24)  
 ▶ Internet Protocol Version 4, Src: 192.168.56.106, Dst: 192.168.56.103  
 ▶ User Datagram Protocol, Src Port: 5060, Dst Port: 5060

```

0000  08 00 27 6e 0d 24 08 00 27 17 73 da 08 00 45 00  ..'n$. 's...E.
0010  02 29 07 22 40 00 00 11 3f 80 c0 a8 38 6a c0 a8  .).X@.@. ?...8j..
0020  38 67 13 c4 13 c4 02 15 77 36 52 45 47 49 53 54  8g..... n&REGIST
  
```

Figure > Call from client script

The ack shows successful call establishment. Below is the screenshot.

\*Local Area Connection

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Expression...

No.	Time	Source	Destination	Protocol	Length	Info
23	21.164894	192.168.56.103	192.168.56.104	SIP/SDP	1008	Request: INVITE sip...
24	21.256386	192.168.56.104	192.168.56.103	SIP	352	Status: 100 Trying ...
25	21.441105	192.168.56.104	192.168.56.103	SIP	515	Status: 180 Ringing...
26	21.444561	192.168.56.103	192.168.56.106	SIP	608	Status: 180 Ringing...
35	27.908435	192.168.56.104	192.168.56.103	SIP/SDP	818	Status: 200 OK
36	27.910781	192.168.56.103	192.168.56.104	SIP	523	Request: ACK sip:20...
37	27.912937	192.168.56.103	192.168.56.106	SIP/SDP	954	Status: 200 OK
38	27.917808	192.168.56.103	192.168.56.104	SIP/SDP	983	Request: INVITE sip...
41	27.917809	192.168.56.106	192.168.56.103	SIP	374	Request: ACK sip:20...
44	27.919427	192.168.56.103	192.168.56.106	SIP/SDP	895	Request: INVITE sip...
50	27.971896	192.168.56.106	192.168.56.103	SIP/SDP	925	Request: INVITE sip...
51	27.971897	192.168.56.106	192.168.56.103	SIP	374	Status: 491 Another...
52	27.971897	192.168.56.103	192.168.56.106	SIP	648	Status: 491 Request...
53	27.972288	192.168.56.103	192.168.56.106	SIP	432	Request: ACK sip:19...
59	28.021998	192.168.56.106	192.168.56.103	SIP	374	Request: ACK sip:20...
112	28.420032	192.168.56.103	192.168.56.104	SIP/SDP	983	Request: INVITE sip...
164	28.791296	192.168.56.103	192.168.56.106	SIP/SDP	895	Request: INVITE sip...
173	28.816317	192.168.56.106	192.168.56.103	SIP/SDP	887	Status: 200 OK

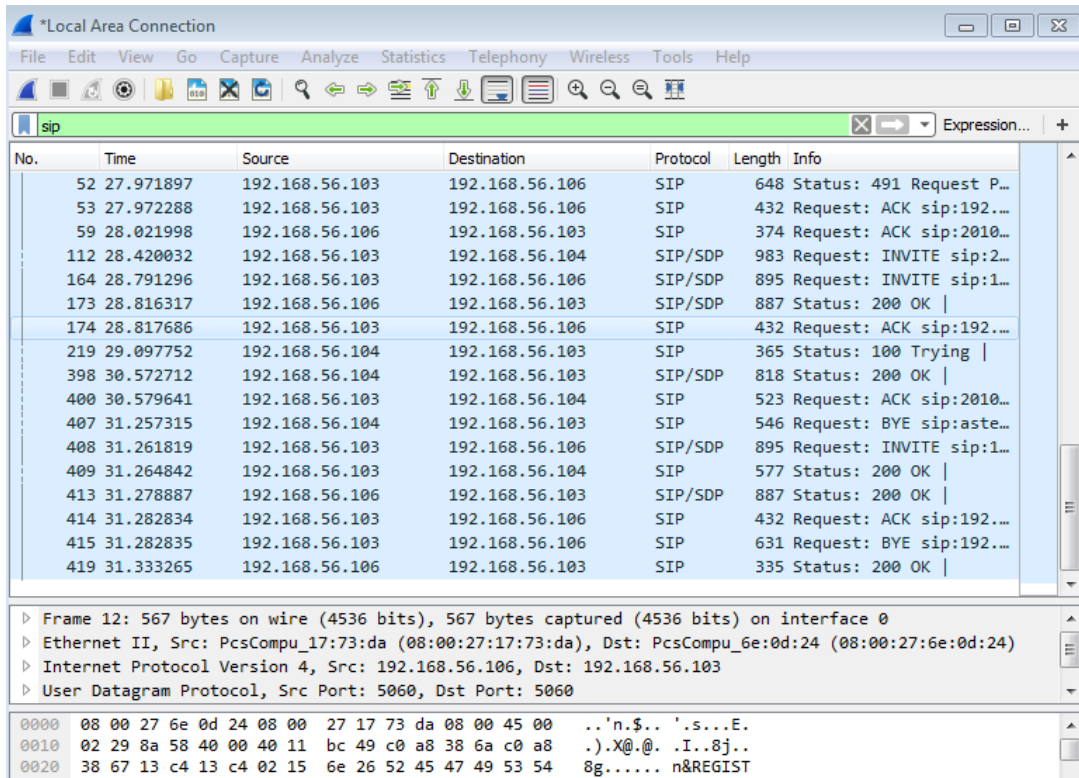
▶ Frame 12: 567 bytes on wire (4536 bits), 567 bytes captured (4536 bits) on interface 0  
 ▶ Ethernet II, Src: PcsCompu\_17:73:da (08:00:27:17:73:da), Dst: PcsCompu\_6e:0d:24 (08:00:27:6e:0d:24)  
 ▶ Internet Protocol Version 4, Src: 192.168.56.106, Dst: 192.168.56.103  
 ▶ User Datagram Protocol, Src Port: 5060, Dst Port: 5060

```

0000  08 00 27 6e 0d 24 08 00 27 17 73 da 08 00 45 00  ..'n$. 's...E.
0010  02 29 8a 58 40 00 00 11 bc 49 c0 a8 38 6a c0 a8  .).X@.@. .I..8j..
0020  38 67 13 c4 13 c4 02 15 6e 26 52 45 47 49 53 54  8g..... n&REGIST
  
```

Figure > Call established

The figure below shows the end of the call.



The image shows a Wireshark packet capture window titled '\*Local Area Connection'. The filter bar is set to 'sip'. The packet list pane shows 20 packets, with the last packet (No. 419) selected. The packet details pane shows the structure of the selected packet: Frame 12, Ethernet II, Internet Protocol Version 4, and User Datagram Protocol. The packet bytes pane shows the raw data in hexadecimal and ASCII.

No.	Time	Source	Destination	Protocol	Length	Info
52	27.971897	192.168.56.103	192.168.56.106	SIP	648	Status: 491 Request P...
53	27.972288	192.168.56.103	192.168.56.106	SIP	432	Request: ACK sip:192...
59	28.021998	192.168.56.106	192.168.56.103	SIP	374	Request: ACK sip:2010...
112	28.420032	192.168.56.103	192.168.56.104	SIP/SDP	983	Request: INVITE sip:2...
164	28.791296	192.168.56.103	192.168.56.106	SIP/SDP	895	Request: INVITE sip:1...
173	28.816317	192.168.56.106	192.168.56.103	SIP/SDP	887	Status: 200 OK
174	28.817686	192.168.56.103	192.168.56.106	SIP	432	Request: ACK sip:192...
219	29.097752	192.168.56.104	192.168.56.103	SIP	365	Status: 100 Trying
398	30.572712	192.168.56.104	192.168.56.103	SIP/SDP	818	Status: 200 OK
400	30.579641	192.168.56.103	192.168.56.104	SIP	523	Request: ACK sip:2010...
407	31.257315	192.168.56.104	192.168.56.103	SIP	546	Request: BYE sip:aste...
408	31.261819	192.168.56.103	192.168.56.106	SIP/SDP	895	Request: INVITE sip:1...
409	31.264842	192.168.56.103	192.168.56.104	SIP	577	Status: 200 OK
413	31.278887	192.168.56.106	192.168.56.103	SIP/SDP	887	Status: 200 OK
414	31.282834	192.168.56.103	192.168.56.106	SIP	432	Request: ACK sip:192...
415	31.282835	192.168.56.103	192.168.56.106	SIP	631	Request: BYE sip:192...
419	31.333265	192.168.56.106	192.168.56.103	SIP	335	Status: 200 OK

Frame 12: 567 bytes on wire (4536 bits), 567 bytes captured (4536 bits) on interface 0  
Ethernet II, Src: PcsCompu\_17:73:da (08:00:27:17:73:da), Dst: PcsCompu\_6e:0d:24 (08:00:27:6e:0d:24)  
Internet Protocol Version 4, Src: 192.168.56.106, Dst: 192.168.56.103  
User Datagram Protocol, Src Port: 5060, Dst Port: 5060

0000 08 00 27 6e 0d 24 08 00 27 17 73 da 08 00 45 00 ..'n.\$..'.s...E.  
0010 02 29 8a 58 40 00 40 11 bc 49 c0 a8 38 6a c0 a8 .).X@.@. .I..8j..  
0020 38 67 13 c4 13 c4 02 15 6e 26 52 45 47 49 53 54 8g..... n&REGIST



## SOURCE CODE:

```
import pjsua as sip
import sys
import time

def log_cb(level, str, len):
    print(str)

#Cll back instance

class Calling_back_account(sip.AccountCallback):
    def __init__(self,account):
        sip.AccountCallback.__init__(self, account)

    #Clling to URI

class SRCallCallback(sip.CallCallback):
    def __init__(self, call):
        sip.CallCallback.__init__(self, call)

    def Active_state(self):
        print("Call is :", self.call.info().state_text),
        print("last code :", self.call.info().last_code),
        print("(" + self.call.info().last_reason + ")")

    #Disconnection

    if (self.call.info().state_text == 'DISCONNCTD'):
        print 'Press anykey to Unregister.....'
        return

try:
    #Instance creation
    sip_lib = sip.Lib()
    sip_lib.init(log_cfg = sip.LogConfig(level=3, callback=log_cb))
    #creating Transport Object Instance...
```

```

client_IP_address = raw_input('Enter Client IP address :')

transport_socket = sip.TransportConfig()

transport_socket.port = 5060

transport_socket.bound_addr = client_IP_address

print('Binding IP ' + client_IP_address + 'to default port no 5060.....'),

transport_bind=sip_lib.create_transport(sip.TransportType.UDP,transport_socket)

print('OK')

#Starting SIP libraries

sip_lib.start()

sip_lib.set_null_snd_dev()

#Starting Registering Process

r_IP=raw_input("Enter IP address of the Server: ")

r_name=raw_input("Enter Username: ")

r_pwd=raw_input("Enter Password: ")

print 'Setting same display name as user name.....'

r_Dname=r_name

print 'Staring Registration.....'

conf_of_account = sip.AccountConfig(domain = r_IP, username = r_name, password=r_pwd, display =
r_Dname, proxy = 'sip:%s:5060' % r_IP)

conf_of_account.id ="sip:%s" % (r_name)

conf_of_account.reg_uri ='sip:%s:%s' % (r_IP,transport_socket.port)

account_callback = Calling_back_account(conf_of_account)

acc = sip_lib.create_account(conf_of_account,cb=account_callback)

#Setting value to Calling_back_account class

acc.set_callback(account_callback)

print('Status= ',acc.info().reg_status,'(' + acc.info().reg_reason + ')')

time.sleep(5)

print 'Registration is Complete....'

Reg_unreg=raw_input("you want to unregister?...")

if (Reg_unreg=="y"):

```

```
acc.set_registration(False)
```

```
else:
```

```
#CLI
```

```
c_ID = raw_input('Enter UID to make call : ')
```

```
print 'Calling %s.....' % (c_ID)
```

```
s_URI = 'sip:%s@%s:%s' % (c_ID,r_IP,transport_socket.port)
```

```
call = acc.make_call(s_URI, SRCallCallback(acc))
```

```
#Unreg
```

```
input = sys.stdin.readline().rstrip('\r\n')
```

```
print 'Unregistering.....'
```

```
time.sleep(2)
```

```
sip_lib.destroy()
```

```
time.sleep(2)
```

```
sip_lib= None
```

```
sys.exit(1)
```

```
#Excpt
```

```
except sip.Error, err:
```

```
print 'Initializations Error', err
```

```
sip_lib.destroy()
```

## Conclusion:

In the project we gained practical experience for configuration of the server and clients. We also observed the signaling messages in SIP. The first part included different call scenarios between X-Lite clients registered to Asterisk server. In Part-2, we installed PJSIP library to create a client using a Python script.

We implemented four different call scenarios while observing the SIP messages sent by capturing screenshots of packets in Wireshark. We also studied the RTP messages transmitted. This project is very helpful for us in understanding how IP-telephony works using SIP and RTP protocol.

## References:

[1] <http://www.asteriskguru.com/tutorials/>

[2] <http://www.pjsip.org/>

[3] RFC 3261, *SIP: Session Initiation Protocol*

[4] <http://www.voip-info.org/wiki/view/PJSIP>