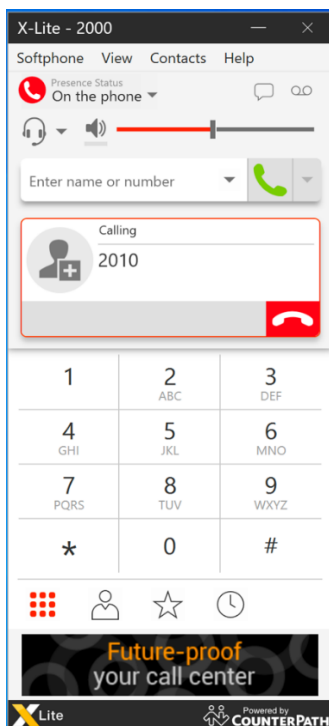


## “Voice Call Establishment and Conference Call over IP, a Hands-on SIP-Based Experiment”

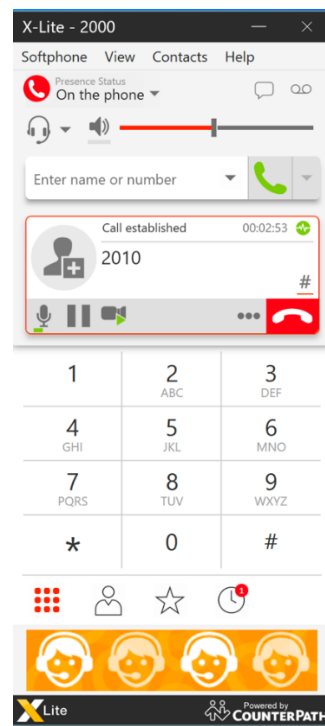
### Part I. Establish and analyze a successful call between 2 SIP clients:



Client 2000 dialing  
2010



Incoming call on 2010  
from 2000



Call established between  
2000 and 2010.

**Part A) Client 2000 and Client 2010 register with the PBX server whose destination IP address is 192.168.1.35 and is shown below:**

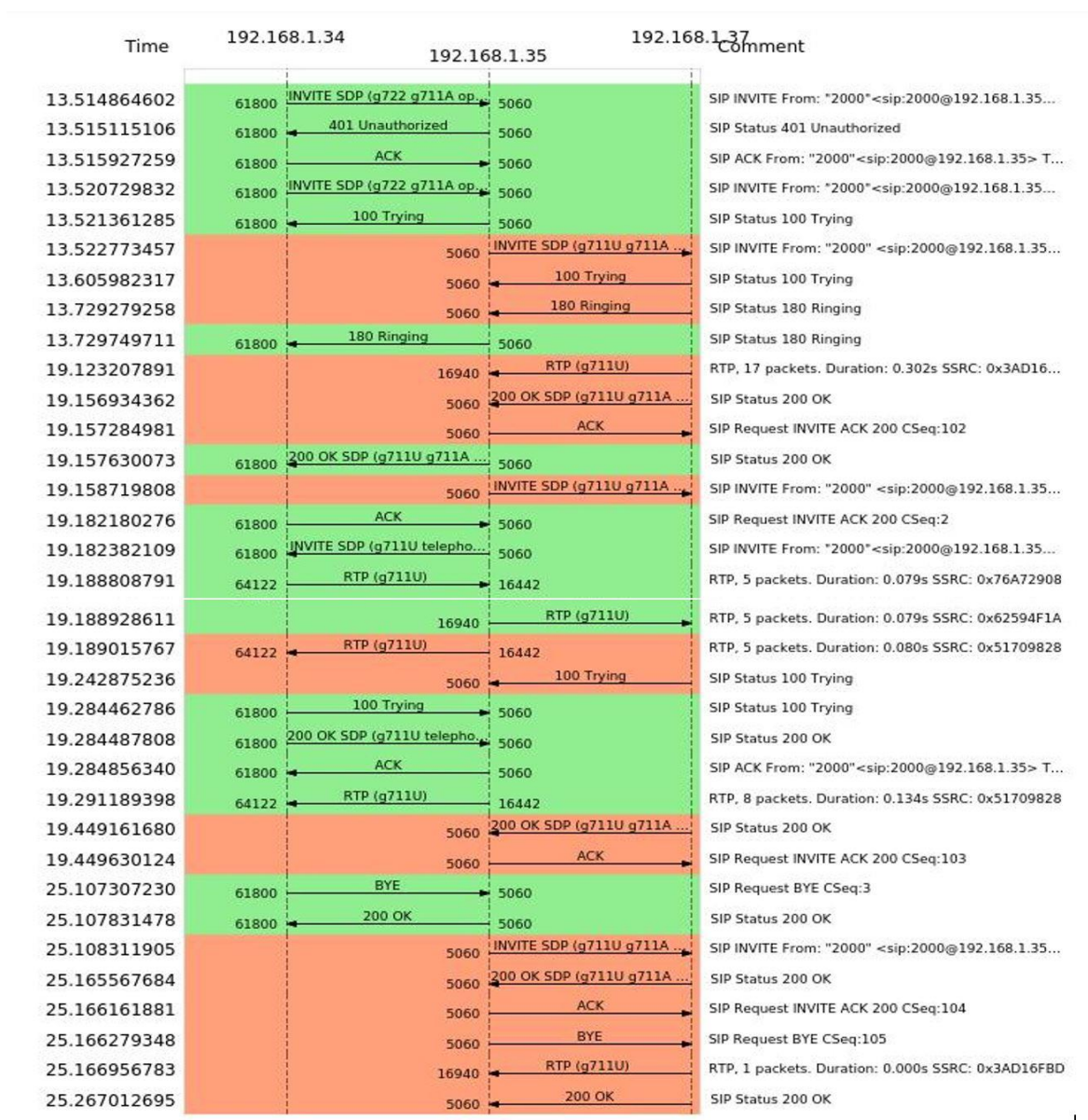
Time	192.168.1.34	192.168.1.35	192.168.1.37	Comment
9.527846307	61800	Request: REGISTER sip:192...	5060	SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
9.528153156	61800	Status: 401 Unauthorized	5060	SIP: Status: 401 Unauthorized
9.534838760	61800	Request: REGISTER sip:192...	5060	SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
9.535216419	61800	Status: 200 OK (1 binding)	5060	SIP: Status: 200 OK (1 binding)
9.541623205	61800	Request: REGISTER sip:192...	5060	SIP: Request: REGISTER sip:192.168.1.35 (remove...
9.541798048	61800	Status: 401 Unauthorized	5060	SIP: Status: 401 Unauthorized
9.547144378	61800	Request: REGISTER sip:192...	5060	SIP: Request: REGISTER sip:192.168.1.35 (remove...
9.547516586	61800	Status: 200 OK (0 bindings)	5060	SIP: Status: 200 OK (0 bindings)
9.553056080	61800	Request: REGISTER sip:192...	5060	SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
9.553223245	61800	Status: 401 Unauthorized	5060	SIP: Status: 401 Unauthorized
9.558470595	61800	Request: REGISTER sip:192...	5060	SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
9.558713717	61800	Status: 200 OK (1 binding)	5060	SIP: Status: 200 OK (1 binding)
11.134389256	61800	Request: SUBSCRIBE sip:20...	5060	SIP: Request: SUBSCRIBE sip:2000@192.168.1.35
11.134636637	61800	Status: 401 Unauthorized	5060	SIP: Status: 401 Unauthorized
11.163258088	61800	Request: SUBSCRIBE sip:20...	5060	SIP: Request: SUBSCRIBE sip:2000@192.168.1.35
11.163488073	61800	Status: 404 Not found (no ...	5060	SIP: Status: 404 Not found (no mailbox)
37.295588474		5060 Request: REGISTER sip:192...		SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
37.295827444		5060 Status: 401 Unauthorized		SIP: Status: 401 Unauthorized
37.315723285		5060 Request: REGISTER sip:192...		SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
37.316180828		5060 Status: 200 OK (1 binding)		SIP: Status: 200 OK (1 binding)
37.325080953		5060 Request: REGISTER sip:192...		SIP: Request: REGISTER sip:192.168.1.35 (remove...
37.325248479		5060 Status: 401 Unauthorized		SIP: Status: 401 Unauthorized
37.333485657		5060 Request: REGISTER sip:192...		SIP: Request: REGISTER sip:192.168.1.35 (remove...
37.333791316		5060 Status: 200 OK (0 bindings)		SIP: Status: 200 OK (0 bindings)
37.352069533		5060 Request: REGISTER sip:192...		SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
37.352252871		5060 Status: 401 Unauthorized		SIP: Status: 401 Unauthorized
37.358841638		5060 Request: REGISTER sip:192...		SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
37.359215288		5060 Status: 200 OK (1 binding)		SIP: Status: 200 OK (1 binding)
40.770708810		5060 Request: SUBSCRIBE sip:20...		SIP: Request: SUBSCRIBE sip:2010@192.168.1.35
40.771145594		5060 Status: 401 Unauthorized		SIP: Status: 401 Unauthorized
41.866324698		5060 Request: SUBSCRIBE sip:20...	59713	SIP: Request: SUBSCRIBE sip:2010@192.168.1.35
41.866441290		5060 Request: SUBSCRIBE sip:20...	59713	SIP: Request: SUBSCRIBE sip:2010@192.168.1.35
41.866600877		5060 Status: 404 Not found (no ...	59713	SIP: Status: 404 Not found (no mailbox)
41.866803808		5060 Status: 401 Unauthorized	59713	SIP: Status: 401 Unauthorized

Process of call establishment and call termination is as follows below:

Time	192.168.1.34	192.168.1.35	192.168.1.37	Comment
13.514864602	61800	Request: INVITE sip:2010@...	5060	SIP/SDP: Request: INVITE sip:2010@192.168.1.35
13.515115106	61800	Status: 401 Unauthorized	5060	SIP: Status: 401 Unauthorized
13.515927259	61800	Request: ACK sip:2010@19...	5060	SIP: Request: ACK sip:2010@192.168.1.35
13.520729832	61800	Request: INVITE sip:2010@...	5060	SIP/SDP: Request: INVITE sip:2010@192.168.1.35
13.521361285	61800	Status: 100 Trying	5060	SIP: Status: 100 Trying
13.522773457		5060	Request: INVITE sip:2010@...	SIP/SDP: Request: INVITE sip:2010@192.168.1.37:...
13.605982317		5060	Status: 100 Trying	SIP: Status: 100 Trying
13.729279258		5060	Status: 180 Ringing	SIP: Status: 180 Ringing
13.729749711	61800	Status: 180 Ringing	5060	SIP: Status: 180 Ringing
19.156934362		5060	Status: 200 OK	SIP/SDP: Status: 200 OK
19.157284981		5060	Request: ACK sip:2010@19...	SIP: Request: ACK sip:2010@192.168.1.37:59713;r...
19.157630073	61800	Status: 200 OK	5060	SIP/SDP: Status: 200 OK
19.158719808		5060	Request: INVITE sip:2010@...	SIP/SDP: Request: INVITE sip:2010@192.168.1.37:...
19.182180276	61800	Request: ACK sip:2010@19...	5060	SIP: Request: ACK sip:2010@192.168.1.35:5060
19.182382109	61800	Request: INVITE sip:2000@...	5060	SIP/SDP: Request: INVITE sip:2000@192.168.1.34:...
19.242875236		5060	Status: 100 Trying	SIP: Status: 100 Trying
19.284462786	61800	Status: 100 Trying	5060	SIP: Status: 100 Trying
19.284487808	61800	Status: 200 OK	5060	SIP/SDP: Status: 200 OK
19.284856340	61800	Request: ACK sip:2000@19...	5060	SIP: Request: ACK sip:2000@192.168.1.34:61800;r...
19.449161680		5060	Status: 200 OK	SIP/SDP: Status: 200 OK
19.449630124		5060	Request: ACK sip:2010@19...	SIP: Request: ACK sip:2010@192.168.1.37:59713;r...
25.107307230	61800	Request: BYE sip:2010@19...	5060	SIP: Request: BYE sip:2010@192.168.1.35:5060
25.107831478	61800	Status: 200 OK	5060	SIP: Status: 200 OK
25.108311905		5060	Request: INVITE sip:2010@...	SIP/SDP: Request: INVITE sip:2010@192.168.1.37:...
25.165567684		5060	Status: 200 OK	SIP/SDP: Status: 200 OK
25.166161881		5060	Request: ACK sip:2010@19...	SIP: Request: ACK sip:2010@192.168.1.37:59713;r...
25.166279348		5060	Request: BYE sip:2010@19...	SIP: Request: BYE sip:2010@192.168.1.37:59713;r...
25.267012695		5060	Status: 200 OK	SIP: Status: 200 OK



**Part B) Logical Flow-chart of call establishment and call termination between Client 2000 and 2010 is as follows below:**



### Logical Flow-chart of Call Establishment and Call Termination

Summary:

- Client 2000 and 2010 send Register packet to register with the proxy server with their IP address. The server responds back with an OK message.
- Once the registration process is complete, call establishment process starts with Client 2000 sending an Invite message to the proxy server.
- The proxy server then sends an invite to the callee client 2010 and send a Trying message to 2000. If the client 2010 is available, it sends a Trying message to 2000 and then an OK message followed by a Ringing Message.
- Client 2000 requests a connection by sending an ACK message to connect the call and start the media exchange. Once the media exchange is complete, any one of the clients sends a call termination message i.e. BYE which is acknowledged by all parties with an OK message.

```

▼ Session Initiation Protocol (100)
  ▼ Status-Line: SIP/2.0 100 Trying
    Status-Code: 100
    [Resent Packet: False]
    [Request Frame: 37]
    [Response Time (ms): 161]
  ▼ Message Header
    ▶ Via: SIP/2.0/UDP 192.168.1.35:5060;branch=z9hG4bK26db9cc8
    ▼ To: <sip:2010@192.168.1.37:64201;rinstance=2da60827ea55b9f7>
      ▶ SIP to address: sip:2010@192.168.1.37:64201;rinstance=2da60827ea55b9f7
    ▼ From: "2000" <sip:2000@192.168.1.35>;tag=as2d67d2d2
      SIP Display info: "2000"
      ▶ SIP from address: sip:2000@192.168.1.35
      SIP from tag: as2d67d2d2
      Call-ID: 6c01db684033133656ff026452232f18@192.168.1.35:5060
    ▶ CSeq: 102 INVITE
    Content-Length: 0

```

SIP Trying packet

- SIP Packet: Trying packet being sent from client 2000 requesting to connect a call with Client 2010 with IP address 192.168.1.37. The call ID of this packet is as seen in the image.

### Part C)

**IP Address of Client 2000: 192.168.1.34**

```

▶ Internet Protocol Version 4, Src: 192.168.1.34, Dst: 192.168.1.35
▶ User Datagram Protocol, Src Port: 55414, Dst Port: 5060
▼ Session Initiation Protocol (INVITE)
  ▶ Request-Line: INVITE sip:2010@192.168.1.35 SIP/2.0
  ▼ Message Header
    ▶ Via: SIP/2.0/UDP 192.168.1.34:55414;branch=z9hG4bK-524287-1---60
    Max-Forwards: 70
    ▶ Contact: <sip:2000@192.168.1.34:55414;rinstance=90f6c38a272976db>
    ▶ To: <sip:2010@192.168.1.35>
    ▶ From: "2000"<sip:2000@192.168.1.35>;tag=d6f7fe25
      Call-ID: 99142MDBhZGU5Mjc3Nzg4ZDc0Yjk4MDg2NzFlZjZiYTU0ZjM
    ▶ CSeq: 1 INVITE

```

**IP Address of Client 2010: 192.168.1.37**

```

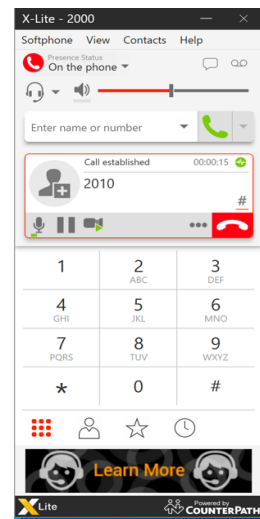
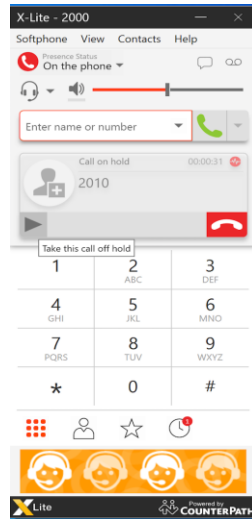
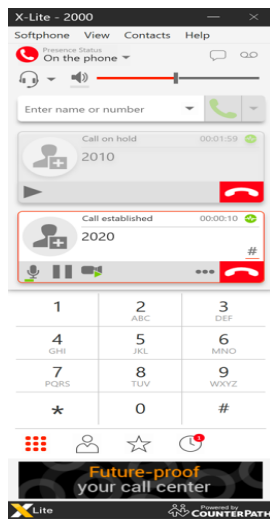
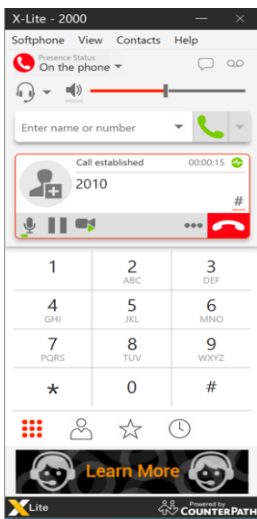
▶ Internet Protocol Version 4, Src: 192.168.1.37, Dst: 192.168.1.35
▶ User Datagram Protocol, Src Port: 64201, Dst Port: 5060
▼ Session Initiation Protocol (INVITE)
  ▶ Request-Line: INVITE sip:2000@192.168.1.35 SIP/2.0
  ▼ Message Header
    ▶ Via: SIP/2.0/UDP 192.168.1.37:64201;branch=z9hG4bK-524287-1---11
    Max-Forwards: 70
    ▶ Contact: <sip:2010@192.168.1.37:64201;rinstance=2da60827ea55b9f7>
    ▶ To: <sip:2000@192.168.1.35>
    ▶ From: "2010"<sip:2010@192.168.1.35>;tag=c296202c
      Call-ID: 99142Mmm50DVkZDE5ZjFkOWRiYzFjNjA4YTMxMzRkN2I1NWU

```

MAC address of PBX server: 08:00:27:09:01:5c

```
▼ Ethernet II, Src: IntelCor_a2:f4:a4 (c0:b6:f9:a2:f4:a4), Dst: PcsCo
  ► Destination: PcsCompu_09:01:5c (08:00:27:09:01:5c)
  ► Source: IntelCor_a2:f4:a4 (c0:b6:f9:a2:f4:a4)
  Type: IPv4 (0x0800)
  ► Internet Protocol Version 4, Src: 192.168.1.34, Dst: 192.168.1.35
  ► User Datagram Protocol, Src Port: 55414, Dst Port: 5060
  ▼ Session Initiation Protocol (INVITE)
    ► Request-Line: INVITE sip:2010@192.168.1.35 SIP/2.0
    ▼ Message Header
      ► Via: SIP/2.0/UDP 192.168.1.34:55414;branch=z9hG4bK-524287-1--
      Max-Forwards: 70
      ► Contact: <sip:2000@192.168.1.34:55414;rinstance=90f6c38a27297
      ► To: <sip:2010@192.168.1.35>
      ► From: "2000"<sip:2000@192.168.1.35>;tag=c65aad2a
      Call-ID: 9914206NjNTE5NjlmZDMzYTFiNjQzOTY2MDBjN2ZiMDUwYjY
```

## Part II.1: Call on Hold:



Call established  
between 2000  
and 2010

Call established between  
2000 and 2020 while  
2010 is put on hold

Call ended between  
2000 and 2020 and  
taking 2010 off hold

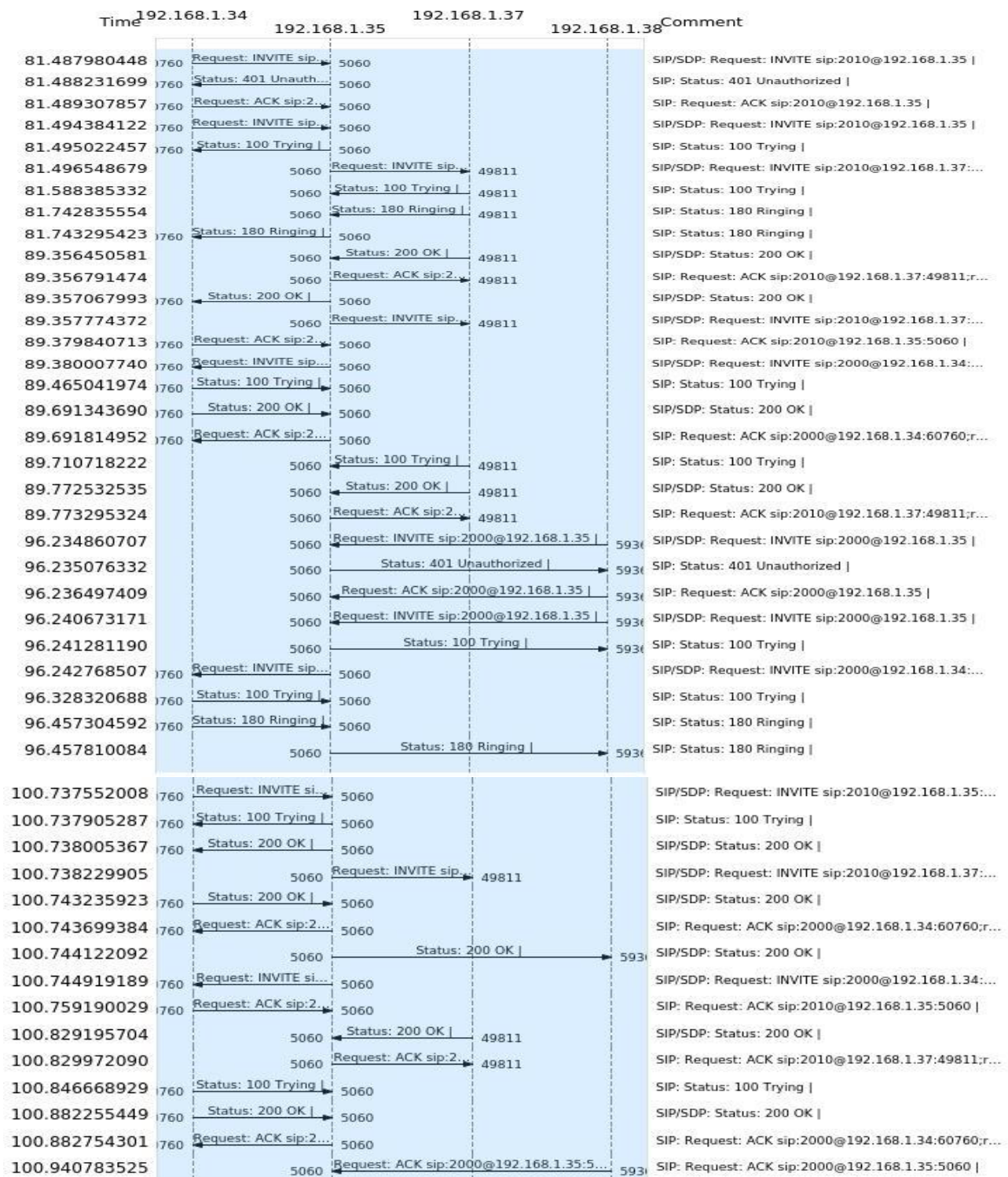
Call resumed  
between 2000  
and 2010



**Part A) Devices 2000, 2010 and 2020 registering with the PBX server is as shown below:**

Time	192.168.1.34	192.168.1.35	192.168.1.37	192.168.1.38	Comment
41.126905497	60	Request: REGISTER...	5060		SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
41.127116750	60	Status: 401 Unauth...	5060		SIP: Status: 401 Unauthorized
41.134687825	60	Request: REGISTER...	5060		SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
41.135037614	60	Status: 200 OK (1 ...	5060		SIP: Status: 200 OK (1 binding)
41.142850292	60	Request: REGISTER...	5060		SIP: Request: REGISTER sip:192.168.1.35 (remove...
41.143030430	60	Status: 401 Unauth...	5060		SIP: Status: 401 Unauthorized
41.150098452	60	Request: REGISTER...	5060		SIP: Request: REGISTER sip:192.168.1.35 (remove...
41.150444914	60	Status: 200 OK (0 ...	5060		SIP: Status: 200 OK (0 bindings)
41.156863784	60	Request: REGISTER...	5060		SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
41.157042951	60	Status: 401 Unauth...	5060		SIP: Status: 401 Unauthorized
41.163306442	60	Request: REGISTER...	5060		SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
41.163592116	60	Status: 200 OK (1 ...	5060		SIP: Status: 200 OK (1 binding)
42.680763560	60	Request: SUBSCRIB...	5060		SIP: Request: SUBSCRIBE sip:2000@192.168.1.35
42.681052330	60	Status: 401 Unauth...	5060		SIP: Status: 401 Unauthorized
42.703697887	60	Request: SUBSCRIB...	5060		SIP: Request: SUBSCRIBE sip:2000@192.168.1.35
42.704044930	60	Status: 404 Not fou...	5060		SIP: Status: 404 Not found (no mailbox)
84.915772984		5060 Request: REGISTER...	49811		SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
84.916032665		5060 Status: 401 Unauth...	49811		SIP: Status: 401 Unauthorized
84.916094232		5060 Request: REGISTER...	49811		SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
84.916257840		5060 Status: 401 Unauth...	49811		SIP: Status: 401 Unauthorized
84.947480475		5060 Request: REGISTER...	49811		SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
84.947910749		5060 Status: 200 OK (1 ...	49811		SIP: Status: 200 OK (1 binding)
85.742387039		5060 Request: REGISTER...	49811		SIP: Request: REGISTER sip:192.168.1.35 (remove...
85.742418317		5060 Request: REGISTER...	49811		SIP: Request: REGISTER sip:192.168.1.35 (remove...
85.742620618		5060 Status: 401 Unauth...	49811		SIP: Status: 401 Unauthorized
85.742792000		5060 Status: 200 OK (1 ...	49811		SIP: Status: 200 OK (1 binding)
85.749659613		5060 Request: REGISTER...	49811		SIP: Request: REGISTER sip:192.168.1.35 (remove...
85.750027355		5060 Status: 200 OK (0 ...	49811		SIP: Status: 200 OK (0 bindings)
86.120351290		5060 Request: REGISTER...	49811		SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
86.120505184		5060 Status: 401 Unauth...	49811		SIP: Status: 401 Unauthorized
86.125555895		5060 Request: REGISTE...	49811		SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
86.125959872		5060 Status: 200 OK (1 ...	49811		SIP: Status: 200 OK (1 binding)
86.423358444		5060 Request: SUBSCRI...	49811		SIP: Request: SUBSCRIBE sip:2010@192.168.1.35
86.423698166		5060 Status: 401 Unaut...	49811		SIP: Status: 401 Unauthorized
86.428851362		5060 Request: SUBSCRI...	49811		SIP: Request: SUBSCRIBE sip:2010@192.168.1.35
86.429106179		5060 Status: 404 Not fo...	49811		SIP: Status: 404 Not found (no mailbox)
129.284344079		5060 Request: REGISTER sip:192.168.1.35 (1...	59369		SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
129.284589923		5060 Status: 401 Unauthorized	59369		SIP: Status: 401 Unauthorized
129.313859506		5060 Request: REGISTER sip:192.168.1.35 (1...	59369		SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
129.314267917		5060 Status: 200 OK (1 binding)	59369		SIP: Status: 200 OK (1 binding)
129.410000214		5060 Request: REGISTER sip:192.168.1.35 (r...	59369		SIP: Request: REGISTER sip:192.168.1.35 (remove...
129.410193569		5060 Status: 401 Unauthorized	59369		SIP: Status: 401 Unauthorized
129.442784918		5060 Request: REGISTER sip:192.168.1.35 (r...	59369		SIP: Request: REGISTER sip:192.168.1.35 (remove...
129.443192735		5060 Status: 200 OK (0 bindings)	59369		SIP: Status: 200 OK (0 bindings)
129.502196421		5060 Request: REGISTER sip:192.168.1.35 (1...	59369		SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
129.502396344		5060 Status: 401 Unauthorized	59369		SIP: Status: 401 Unauthorized
129.636802274		5060 Request: REGISTER sip:192.168.1.35 (1...	59369		SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
129.637113691		5060 Status: 200 OK (1 binding)	59369		SIP: Status: 200 OK (1 binding)
132.842438755		5060 Request: SUBSCRIBE sip:2020@192.168...	59369		SIP: Request: SUBSCRIBE sip:2020@192.168.1.35
132.842725062		5060 Status: 401 Unauthorized	59369		SIP: Status: 401 Unauthorized
132.852168483		5060 Request: SUBSCRIBE sip:2020@192.168...	59369		SIP: Request: SUBSCRIBE sip:2020@192.168.1.35
132.852389552		5060 Status: 404 Not found (no mailbox)	59369		SIP: Status: 404 Not found (no mailbox)

Process of call establishment between 2000 and 2010, and the process of putting 2010 on hold while establishing a call between 2000 and 2020. Process of resuming the call with 2010 is also shown below:



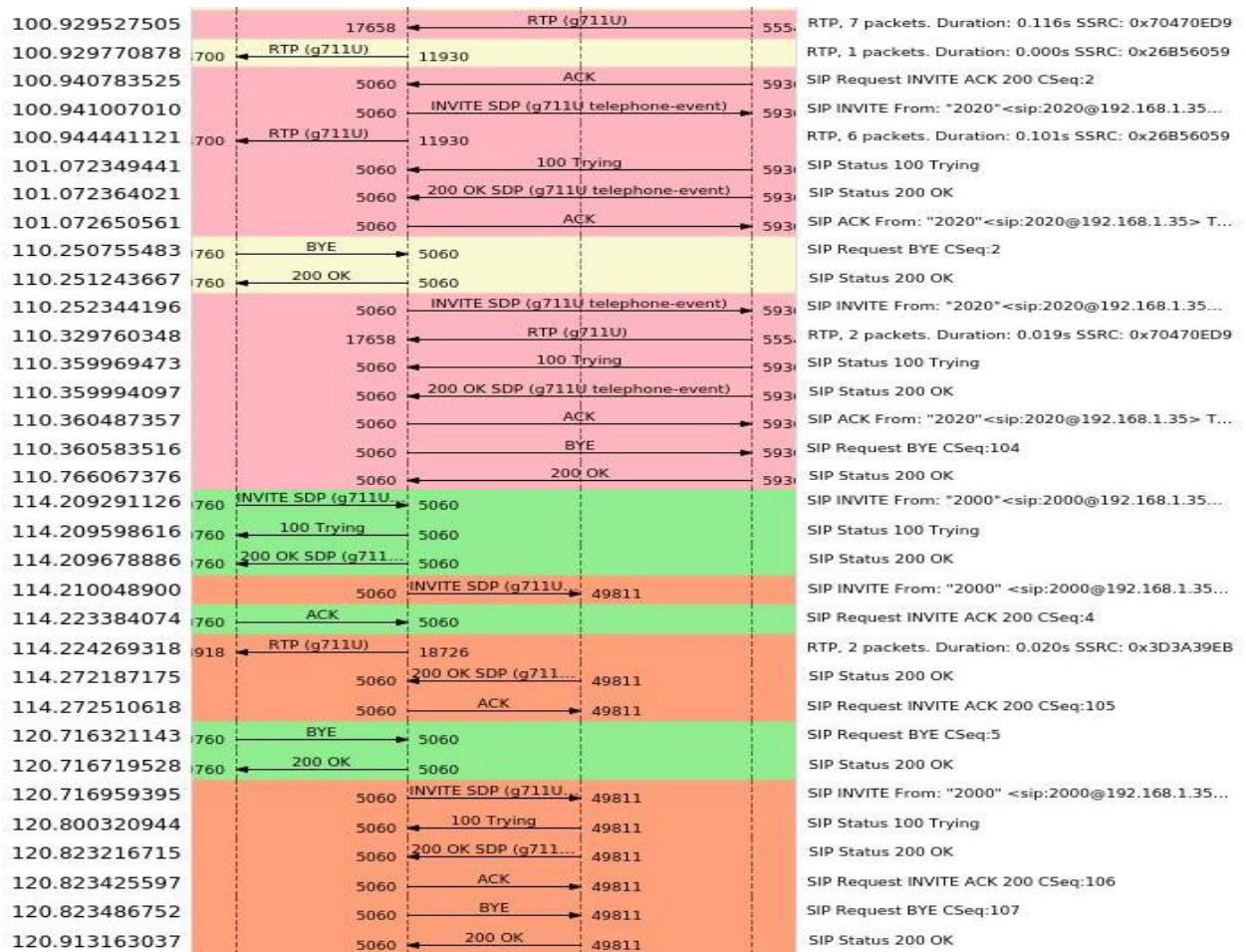


100.941007010		5060	Request: INVITE sip:2020@192.168.1.38	593	SIP/SDP: Request: INVITE sip:2020@192.168.1.38:...
101.072349441		5060	Status: 100 Trying	593	SIP: Status: 100 Trying
101.072364021		5060	Status: 200 OK	593	SIP/SDP: Status: 200 OK
101.072650561		5060	Request: ACK sip:2020@192.168.1.38:5	593	SIP: Request: ACK sip:2020@192.168.1.38:59369;r...
110.250755483	760	5060	Request: BYE sip:2020@192.168.1.35:5060		SIP: Request: BYE sip:2020@192.168.1.35:5060
110.251243667	760	5060	Status: 200 OK		SIP: Status: 200 OK
110.252344196		5060	Request: INVITE sip:2020@192.168.1.38	593	SIP/SDP: Request: INVITE sip:2020@192.168.1.38:...
110.359969473		5060	Status: 100 Trying	593	SIP: Status: 100 Trying
110.359994097		5060	Status: 200 OK	593	SIP/SDP: Status: 200 OK
110.360487357		5060	Request: ACK sip:2020@192.168.1.38:5	593	SIP: Request: ACK sip:2020@192.168.1.38:59369;r...
110.360583516		5060	Request: BYE sip:2020@192.168.1.38:5	593	SIP: Request: BYE sip:2020@192.168.1.38:59369;r...
110.766067376		5060	Status: 200 OK	593	SIP: Status: 200 OK
114.209291126	760	5060	Request: INVITE sip:2010@192.168.1.35		SIP/SDP: Request: INVITE sip:2010@192.168.1.35:...
114.209598616	760	5060	Status: 100 Trying		SIP: Status: 100 Trying
114.209678886	760	5060	Status: 200 OK		SIP/SDP: Status: 200 OK
114.210048900		5060	Request: INVITE sip:2010@192.168.1.37	49811	SIP/SDP: Request: INVITE sip:2010@192.168.1.37:...
114.223384074	760	5060	Request: ACK sip:2010@192.168.1.35:5060		SIP: Request: ACK sip:2010@192.168.1.35:5060
114.272187175		5060	Status: 200 OK	49811	SIP/SDP: Status: 200 OK
114.272510618		5060	Request: ACK sip:2010@192.168.1.37:49811	49811	SIP: Request: ACK sip:2010@192.168.1.37:49811;r...
120.716321143	760	5060	Request: BYE sip:2010@192.168.1.35:5060		SIP: Request: BYE sip:2010@192.168.1.35:5060
120.716719528	760	5060	Status: 200 OK		SIP: Status: 200 OK
120.716959395		5060	Request: INVITE sip:2010@192.168.1.37	49811	SIP/SDP: Request: INVITE sip:2010@192.168.1.37:...
120.800320944		5060	Status: 100 Trying	49811	SIP: Status: 100 Trying
120.823216715		5060	Status: 200 OK	49811	SIP/SDP: Status: 200 OK
120.823425597		5060	Request: ACK sip:2010@192.168.1.37:49811	49811	SIP: Request: ACK sip:2010@192.168.1.37:49811;r...
120.823486752		5060	Request: BYE sip:2010@192.168.1.37:49811	49811	SIP: Request: BYE sip:2010@192.168.1.37:49811;r...
120.913163037		5060	Status: 200 OK	49811	SIP: Status: 200 OK

**Part B)** Logical Flow-chart of call establishment and putting 2010 on hold while establishing call between 2000 and 2020. Resuming call with 2010 is also shown below:

Time	192.168.1.34	192.168.1.35	192.168.1.37	192.168.1.38	Comment
81.487980448	1760	INVITE SDP (g722 g...	5060		SIP INVITE From: "2000" <sip:2000@192.168.1.35...
81.488231699	1760	401 Unauthorized	5060		SIP Status 401 Unauthorized
81.489307857	1760	ACK	5060		SIP ACK From: "2000" <sip:2000@192.168.1.35> T...
81.494384122	1760	INVITE SDP (g722 g...	5060		SIP INVITE From: "2000" <sip:2000@192.168.1.35...
81.495022457	1760	100 Trying	5060		SIP Status 100 Trying
81.496548679		5060	INVITE SDP (g711U...	49811	SIP INVITE From: "2000" <sip:2000@192.168.1.35...
81.588385332		5060	100 Trying	49811	SIP Status 100 Trying
81.742835554		5060	180 Ringing	49811	SIP Status 180 Ringing
81.743295423	1760	180 Ringing	5060		SIP Status 180 Ringing
89.336743760		14532	RTP (RTPTType-126)	62906	RTP, 12 packets. Duration: 0.000s SSRC: 0x1E184...
89.349228913		14532	RTP (g711U)	62906	RTP, 14 packets. Duration: 0.254s SSRC: 0x1E184...
89.356450581		5060	200 OK SDP (g711U...	49811	SIP Status 200 OK
89.356791474		5060	ACK	49811	SIP Request INVITE ACK 200 CSeq:102
89.357067993	1760	200 OK SDP (g711...	5060		SIP Status 200 OK
89.357774372		5060	INVITE SDP (g711U...	49811	SIP INVITE From: "2000" <sip:2000@192.168.1.35...
89.379840713	1760	ACK	5060		SIP Request INVITE ACK 200 CSeq:2
89.380007740	1760	INVITE SDP (g711U...	5060		SIP INVITE From: "2000" <sip:2000@192.168.1.35...
89.390991761	1918	RTP (g711U)	18726		RTP, 15 packets. Duration: 0.278s SSRC: 0x3D5B1...
89.391117105		14532	RTP (g711U)	62906	RTP, 15 packets. Duration: 0.279s SSRC: 0x38456...
89.400184219	1918	RTP (g711U)	18726		RTP, 11 packets. Duration: 0.207s SSRC: 0x3D3A3...
89.465041974	1760	100 Trying	5060		SIP Status 100 Trying
89.691343690	1760	200 OK SDP (g711...	5060		SIP Status 200 OK
89.691814952	1760	ACK	5060		SIP ACK From: "2000" <sip:2000@192.168.1.35> T...
89.710718222		5060	100 Trying	49811	SIP Status 100 Trying
89.772532535		5060	200 OK SDP (g711...	49811	SIP Status 200 OK
89.773295324		5060	ACK	49811	SIP Request INVITE ACK 200 CSeq:103
96.234860707		5060	INVITE SDP (g722 g711A opus g711U Un...	5931	SIP INVITE From: "2020" <sip:2020@192.168.1.35...
96.235076332		5060	401 Unauthorized	5931	SIP Status 401 Unauthorized
96.236497409		5060	ACK	5931	SIP ACK From: "2020" <sip:2020@192.168.1.35> T...
96.240673171		5060	INVITE SDP (g722 g711A opus g711U Un...	5931	SIP INVITE From: "2020" <sip:2020@192.168.1.35...
96.241281190		5060	100 Trying	5931	SIP Status 100 Trying
96.242768507	1760	INVITE SDP (g711U...	5060		SIP INVITE From: "2020" <sip:2020@192.168.1.35...
96.328320688	1760	100 Trying	5060		SIP Status 100 Trying
96.457304592	1760	180 Ringing	5060		SIP Status 180 Ringing
96.457810084		5060	180 Ringing	5931	SIP Status 180 Ringing
100.737552008	1760	INVITE SDP (g711U...	5060		SIP INVITE From: "2000" <sip:2000@192.168.1.35...
100.737905287	1760	100 Trying	5060		SIP Status 100 Trying
100.738005367	1760	200 OK SDP (g711...	5060		SIP Status 200 OK
100.738229905		5060	INVITE SDP (g711U...	49811	SIP INVITE From: "2000" <sip:2000@192.168.1.35...
100.743235923	1760	200 OK SDP (g711...	5060		SIP Status 200 OK
100.743699384	1760	ACK	5060		SIP Request INVITE ACK 200 CSeq:102
100.744122092		5060	200 OK SDP (g711U g711A telephone-ev...	5931	SIP Status 200 OK
100.744919189	1760	INVITE SDP (g711U...	5060		SIP INVITE From: "2020" <sip:2020@192.168.1.35...
100.751852412	1700	RTP (g711U)	11930		RTP, 7 packets. Duration: 0.117s SSRC: 0x33E80EF5
100.759190029	1760	ACK	5060		SIP Request INVITE ACK 200 CSeq:3





### Summary:

- Client 2000, 2010 and 2020 send Register packet to register with the proxy server with their IP address. The server responds with OK message.
- Once the registration process is complete, call establishment process starts with Client 2000 sending an Invite message to the proxy server.
- The proxy server then sends an invite to the callee client 2010 and send a Trying message to 2000. If the client 2010 is available, it sends a Trying message to 2000 and then an OK message followed by a Ringing Message.
- Client 2000 requests a connection by sending an ACK message to connect the call and start the media exchange.
- Now client 2020 wants to call 2000 and sends an Invite packet to proxy server. The same process of call establishment follows and once client 2000 picks the call, media exchange starts between 2000 and 2020. Whilst this call is being established, client 2010 is put on hold by sending an Update message. After media exchange is complete between 2000 and 2020, call is terminated between them.
- Client 2000 then sends an Update message to client 2010 to resume the call. Once the media exchange is complete, any one of the clients sends a call termination message i.e. BYE which is acknowledged by all parties with an OK message.



```

▼ Session Initiation Protocol (180)
▼ Status-Line: SIP/2.0 180 Ringing
  Status-Code: 180
  [Resent Packet: False]
  [Request Frame: 37]
  [Response Time (ms): 161]
▼ Message Header
  ▶ Via: SIP/2.0/UDP 192.168.1.35:5060;branch=z9hG4bK26db9cc8
  ▼ Contact: <sip:2010@192.168.1.37:64201;rinstance=2da60827ea55b9f7>
    ▶ Contact URI: sip:2010@192.168.1.37:64201;rinstance=2da60827ea55b9f7
  ▼ To: "2010"<sip:2010@192.168.1.37:64201;rinstance=2da60827ea55b9f7>;tag=21126f78
    SIP Display info: "2010"
    ▶ SIP to address: sip:2010@192.168.1.37:64201;rinstance=2da60827ea55b9f7
    SIP to tag: 21126f78
  ▼ From: "2000" <sip:2000@192.168.1.35>;tag=as2d67d2d2
    SIP Display info: "2000"
    ▶ SIP from address: sip:2000@192.168.1.35
    SIP from tag: as2d67d2d2
  Call-ID: 6c01db684033133656ff026452232f18@192.168.1.35:5060
  CSeq: 102 INVITE
  User-Agent: X-Lite release 5.6.1 stamp 99142
  Allow-Events: talk, hold
  Content-Length: 0

```

### SIP Ringing packet

- We can see a Ringing packet sent from client 2000 to Client 2010 via the server with IP address 192.168.1.37 to respond to a call setup request. The call ID of the packet is as seen in the image.

## Part C)

IP Address of Client 2000: 192.168.1.34

```

▶ Internet Protocol Version 4, Src: 192.168.1.34, Dst: 192.168.1.35
▶ User Datagram Protocol, Src Port: 55414, Dst Port: 5060
▼ Session Initiation Protocol (INVITE)
  ▶ Request-Line: INVITE sip:2010@192.168.1.35 SIP/2.0
  ▼ Message Header
    ▶ Via: SIP/2.0/UDP 192.168.1.34:55414;branch=z9hG4bK-524287-1---60
    Max-Forwards: 70
    ▶ Contact: <sip:2000@192.168.1.34:55414;rinstance=90f6c38a272976db>
    ▶ To: <sip:2010@192.168.1.35>
    ▶ From: "2000"<sip:2000@192.168.1.35>;tag=d6f7fe25
    Call-ID: 99142MDBhZGU5Mjc3Nzg4ZDc0Yjk4MDg2NzF1ZjZiYTU0ZjM
    ▶ CSeq: 1 INVITE

```

IP Address of Client 2010: 192.168.1.37

```

▶ Internet Protocol Version 4, Src: 192.168.1.37, Dst: 192.168.1.35
▶ User Datagram Protocol, Src Port: 64201, Dst Port: 5060
▼ Session Initiation Protocol (INVITE)
  ▶ Request-Line: INVITE sip:2000@192.168.1.35 SIP/2.0
  ▼ Message Header
    ▶ Via: SIP/2.0/UDP 192.168.1.37:64201;branch=z9hG4bK-524287-1---11
    Max-Forwards: 70
    ▶ Contact: <sip:2010@192.168.1.37:64201;rinstance=2da60827ea55b9f7>
    ▶ To: <sip:2000@192.168.1.35>
    ▶ From: "2010"<sip:2010@192.168.1.35>;tag=c296202c
    Call-ID: 99142MmM50DVkZDE5ZjFkOWRiYzFjNjA4YTMxMzRkN2I1NWU

```

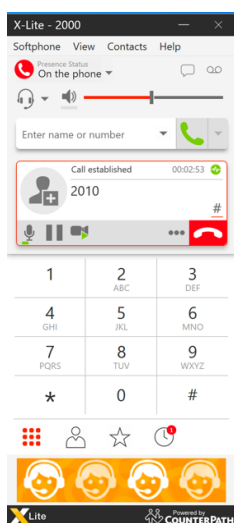
IP Address of Client 2020: 192.168.1.38

```
▼ Ethernet II, Src: PcsCompu_19:45:60 (08:00:27:19:45:60), Dst: PcsCor
  ▶ Destination: PcsCompu_09:01:5c (08:00:27:09:01:5c)
  ▶ Source: PcsCompu_19:45:60 (08:00:27:19:45:60)
  Type: IPv4 (0x0800)
  ▶ Internet Protocol Version 4, Src: 192.168.1.38, Dst: 192.168.1.35
  ▶ User Datagram Protocol, Src Port: 61844, Dst Port: 5060
  ▼ Session Initiation Protocol (INVITE)
    ▼ Request-Line: INVITE sip:2000@192.168.1.35 SIP/2.0
      Method: INVITE
      ▶ Request-URI: sip:2000@192.168.1.35
      [Resent Packet: False]
    ▼ Message Header
      ▶ Via: SIP/2.0/UDP 192.168.1.38:61844;branch=z9hG4bK-524287-1---
      Max-Forwards: 70
      ▶ Contact: <sip:2020@192.168.1.38:61844;rinstance=803eef23e66840>
      ▶ Contact URI: sip:2020@192.168.1.38:61844;rinstance=803eef23
      ▶ To: <sip:2000@192.168.1.35>
      ▶ SIP to address: sip:2000@192.168.1.35
      ▶ From: "2020"<sip:2020@192.168.1.35>;tag=6831a828
      SIP Display info: "2020"
```

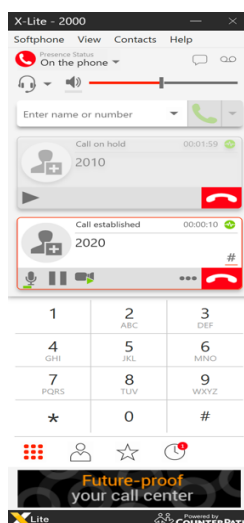
MAC address of PBX server: 08:00:27:09:01:5c

```
▼ Ethernet II, Src: IntelCor_a2:f4:a4 (c0:b6:f9:a2:f4:a4), Dst: PcsCo
  ▶ Destination: PcsCompu_09:01:5c (08:00:27:09:01:5c)
  ▶ Source: IntelCor_a2:f4:a4 (c0:b6:f9:a2:f4:a4)
  Type: IPv4 (0x0800)
  ▶ Internet Protocol Version 4, Src: 192.168.1.34, Dst: 192.168.1.35
  ▶ User Datagram Protocol, Src Port: 55414, Dst Port: 5060
  ▼ Session Initiation Protocol (INVITE)
    ▼ Request-Line: INVITE sip:2010@192.168.1.35 SIP/2.0
      Method: INVITE
      ▶ Request-URI: sip:2010@192.168.1.35
      [Resent Packet: False]
    ▼ Message Header
      ▶ Via: SIP/2.0/UDP 192.168.1.34:55414;branch=z9hG4bK-524287-1--
      Max-Forwards: 70
      ▶ Contact: <sip:2000@192.168.1.34:55414;rinstance=90f6c38a27297>
      ▶ Contact URI: sip:2010@192.168.1.35
      ▶ To: <sip:2010@192.168.1.35>
      ▶ From: "2000"<sip:2000@192.168.1.35>;tag=c65aad2a
      Call-ID: 991420GNjNTE5NjlmZDMzYTfInjQzOTY2MDBjN2ZiMDUwYjY
```

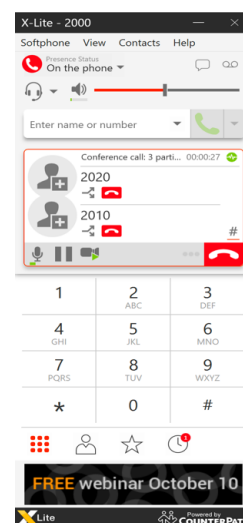
## Part II.2: Call Conferencing



Call established  
between 2000  
and 2010



Call established between  
2000 and 2020 while 2010  
is put on hold



Call conferenced  
between 2000,  
2010 and 2020.

**Part A) Devices 2000, 2010 and 2020 registering with the PBX server is as shown below:**

Time	192.168.1.34	192.168.1.35	192.168.1.37	192.168.1.38	Comment
41.126905497	50	Request: REGISTER	5060		SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
41.127116750	50	Status: 401 Unauth...	5060		SIP: Status: 401 Unauthorized
41.134687825	50	Request: REGISTER	5060		SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
41.135037614	50	Status: 200 OK (1 ...	5060		SIP: Status: 200 OK (1 binding)
41.142850292	50	Request: REGISTER	5060		SIP: Request: REGISTER sip:192.168.1.35 (remove...
41.143030430	50	Status: 401 Unauth...	5060		SIP: Status: 401 Unauthorized
41.150098452	50	Request: REGISTER	5060		SIP: Request: REGISTER sip:192.168.1.35 (remove...
41.150444914	50	Status: 200 OK (0 ...	5060		SIP: Status: 200 OK (0 bindings)
41.156863784	50	Request: REGISTER	5060		SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
41.157042951	50	Status: 401 Unauth...	5060		SIP: Status: 401 Unauthorized
41.163306442	50	Request: REGISTER	5060		SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
41.163592116	50	Status: 200 OK (1 ...	5060		SIP: Status: 200 OK (1 binding)
42.680763560	50	Request: SUBSCRIB	5060		SIP: Request: SUBSCRIBE sip:2000@192.168.1.35
42.681052330	50	Status: 401 Unauth...	5060		SIP: Status: 401 Unauthorized
42.703697887	50	Request: SUBSCRIB	5060		SIP: Request: SUBSCRIBE sip:2000@192.168.1.35
42.704044930	50	Status: 404 Not fou...	5060		SIP: Status: 404 Not found (no mailbox)
84.915772984		5060 Request: REGISTER...	49811		SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
84.916032665		5060 Status: 401 Unauth...	49811		SIP: Status: 401 Unauthorized
84.916094232		5060 Request: REGISTER...	49811		SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
84.916257840		5060 Status: 401 Unauth...	49811		SIP: Status: 401 Unauthorized
84.947480475		5060 Request: REGISTER...	49811		SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
84.947910749		5060 Status: 200 OK (1 ...	49811		SIP: Status: 200 OK (1 binding)
85.742387039		5060 Request: REGISTER...	49811		SIP: Request: REGISTER sip:192.168.1.35 (remove...
85.742418317		5060 Request: REGISTER...	49811		SIP: Request: REGISTER sip:192.168.1.35 (remove...
85.742620618		5060 Status: 401 Unauth...	49811		SIP: Status: 401 Unauthorized
85.742792000		5060 Status: 200 OK (1 ...	49811		SIP: Status: 200 OK (1 binding)
85.749659613		5060 Request: REGISTER...	49811		SIP: Request: REGISTER sip:192.168.1.35 (remove...
85.750027355		5060 Status: 200 OK (0 ...	49811		SIP: Status: 200 OK (0 bindings)
86.120351290		5060 Request: REGISTER...	49811		SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
86.120505184		5060 Status: 401 Unauth...	49811		SIP: Status: 401 Unauthorized
86.125555895		5060 Request: REGISTE...	49811		SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
86.125959872		5060 Status: 200 OK (1 ...	49811		SIP: Status: 200 OK (1 binding)
86.423358444		5060 Request: SUBSCRI...	49811		SIP: Request: SUBSCRIBE sip:2010@192.168.1.35
86.423698166		5060 Status: 401 Unaut...	49811		SIP: Status: 401 Unauthorized
86.428851362		5060 Request: SUBSCRI...	49811		SIP: Request: SUBSCRIBE sip:2010@192.168.1.35
86.429106179		5060 Status: 404 Not fo...	49811		SIP: Status: 404 Not found (no mailbox)
129.284344079		5060 Request: REGISTER sip:192.168.1.35 (1...	59369		SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
129.284589923		5060 Status: 401 Unauthorized	59369		SIP: Status: 401 Unauthorized
129.313859506		5060 Request: REGISTER sip:192.168.1.35 (1...	59369		SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
129.314267917		5060 Status: 200 OK (1 binding)	59369		SIP: Status: 200 OK (1 binding)
129.410000214		5060 Request: REGISTER sip:192.168.1.35 (r...	59369		SIP: Request: REGISTER sip:192.168.1.35 (remove...
129.410193569		5060 Status: 401 Unauthorized	59369		SIP: Status: 401 Unauthorized
129.442784918		5060 Request: REGISTER sip:192.168.1.35 (r...	59369		SIP: Request: REGISTER sip:192.168.1.35 (remove...
129.443192735		5060 Status: 200 OK (0 bindings)	59369		SIP: Status: 200 OK (0 bindings)
129.502196421		5060 Request: REGISTER sip:192.168.1.35 (1...	59369		SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
129.502396344		5060 Status: 401 Unauthorized	59369		SIP: Status: 401 Unauthorized
129.636802274		5060 Request: REGISTER sip:192.168.1.35 (1...	59369		SIP: Request: REGISTER sip:192.168.1.35 (1 bindi...
129.637113691		5060 Status: 200 OK (1 binding)	59369		SIP: Status: 200 OK (1 binding)
132.842438755		5060 Request: SUBSCRIBE sip:2020@192.168...	59369		SIP: Request: SUBSCRIBE sip:2020@192.168.1.35
132.842725062		5060 Status: 401 Unauthorized	59369		SIP: Status: 401 Unauthorized
132.852168483		5060 Request: SUBSCRIBE sip:2020@192.168...	59369		SIP: Request: SUBSCRIBE sip:2020@192.168.1.35
132.852389552		5060 Status: 404 Not found (no mailbox)	59369		SIP: Status: 404 Not found (no mailbox)



Process of call establishment between 2000 and 2010, and the process of putting 2010 on hold while establishing a call between 2000 and 2020. Process of call conferencing between 2000, 2010 and 2020 is shown below:

Time	192.168.1.34	192.168.1.35	192.168.1.37	192.168.1.38	Comment
9.107583232	414	Request: INVITE sip:2010@192.168.1.35	5060		SIP/SDP: Request: INVITE sip:2010@192.168.1.35
9.107838802	414	Status: 401 Unauth...	5060		SIP: Status: 401 Unauthorized
9.108691069	414	Request: ACK sip:2...	5060		SIP: Request: ACK sip:2010@192.168.1.35
9.112983366	414	Request: INVITE sip:2010@192.168.1.35	5060		SIP/SDP: Request: INVITE sip:2010@192.168.1.35
9.113541656	414	Status: 100 Trying	5060		SIP: Status: 100 Trying
9.123474669		5060	Request: INVITE sip:2010@192.168.1.37:...	64201	SIP/SDP: Request: INVITE sip:2010@192.168.1.37:...
9.264926523		5060	Status: 100 Trying	64201	SIP: Status: 100 Trying
9.268234891		5060	Status: 180 Ringing	64201	SIP: Status: 180 Ringing
9.268796131	414	Status: 180 Ringing	5060		SIP: Status: 180 Ringing
15.149770361		5060	Status: 200 OK	64201	SIP/SDP: Status: 200 OK
15.150066899		5060	Request: ACK sip:2...	64201	SIP: Request: ACK sip:2010@192.168.1.37:64201;r...
15.150326818	414	Status: 200 OK	5060		SIP/SDP: Status: 200 OK
15.151191554		5060	Request: INVITE sip:2010@192.168.1.37:...	64201	SIP/SDP: Request: INVITE sip:2010@192.168.1.37:...
15.176301863	414	Request: ACK sip:2...	5060		SIP: Request: ACK sip:2010@192.168.1.35:5060
15.176560061	414	Request: INVITE sip:2000@192.168.1.34:...	5060		SIP/SDP: Request: INVITE sip:2000@192.168.1.34:...
15.235157200		5060	Status: 100 Trying	64201	SIP: Status: 100 Trying
15.299156115	414	Status: 100 Trying	5060		SIP: Status: 100 Trying
15.299197300	414	Status: 200 OK	5060		SIP/SDP: Status: 200 OK
15.299847517	414	Request: ACK sip:2...	5060		SIP: Request: ACK sip:2000@192.168.1.34:55414;r...
15.469625562		5060	Status: 200 OK	64201	SIP/SDP: Status: 200 OK
15.469900740		5060	Request: ACK sip:2...	64201	SIP: Request: ACK sip:2010@192.168.1.37:64201;r...
27.879411068		5060	Request: INVITE sip:2000@192.168.1.35	6184	SIP/SDP: Request: INVITE sip:2000@192.168.1.35
27.879864811		5060	Status: 401 Unauthorized	6184	SIP: Status: 401 Unauthorized
27.882506767		5060	Request: ACK sip:2000@192.168.1.35	6184	SIP: Request: ACK sip:2000@192.168.1.35
27.891391309		5060	Request: INVITE sip:2000@192.168.1.35	6184	SIP/SDP: Request: INVITE sip:2000@192.168.1.35
27.892833109		5060	Status: 100 Trying	6184	SIP: Status: 100 Trying
27.894934420	414	Request: INVITE sip:2000@192.168.1.34:...	5060		SIP/SDP: Request: INVITE sip:2000@192.168.1.34:...
27.982229040	414	Status: 100 Trying	5060		SIP: Status: 100 Trying
28.110218122	414	Status: 180 Ringing	5060		SIP: Status: 180 Ringing
28.111021336		5060	Status: 180 Ringing	6184	SIP: Status: 180 Ringing

33.304173603	414	Request: INVITE sip:2010@192.168.1.35:5060	5060		SIP/SDP: Request: INVITE sip:2010@192.168.1.35:5060
33.304583830	414	Status: 100 Trying	5060		SIP: Status: 100 Trying
33.304671954	414	Status: 200 OK	5060		SIP/SDP: Status: 200 OK
33.304874069		5060 Request: INVITE sip:2010@192.168.1.37:5060	64201		SIP/SDP: Request: INVITE sip:2010@192.168.1.37:5060
33.310555823	414	Status: 200 OK	5060		SIP/SDP: Status: 200 OK
33.311145208	414	Request: ACK sip:2000@192.168.1.34:55414;r...	5060		SIP: Request: ACK sip:2000@192.168.1.34:55414;r...
33.311792449		5060 Status: 200 OK	6184		SIP/SDP: Status: 200 OK
33.313132021	414	Request: INVITE sip:2000@192.168.1.34:5060	5060		SIP/SDP: Request: INVITE sip:2000@192.168.1.34:5060
33.324857254	414	Request: ACK sip:2010@192.168.1.35:5060	5060		SIP: Request: ACK sip:2010@192.168.1.35:5060
33.403648095	414	Status: 200 OK	5060		SIP/SDP: Status: 200 OK
33.404246218	414	Request: ACK sip:2000@192.168.1.34:55414;r...	5060		SIP: Request: ACK sip:2000@192.168.1.34:55414;r...
33.481828782		5060 Status: 100 Trying	64201		SIP: Status: 100 Trying
33.481940757		5060 Status: 200 OK	64201		SIP/SDP: Status: 200 OK
33.482265843		5060 Request: ACK sip:2010@192.168.1.37:64201;r...	64201		SIP: Request: ACK sip:2010@192.168.1.37:64201;r...
33.533623424		5060 Request: ACK sip:2000@192.168.1.35:5060	6184		SIP: Request: ACK sip:2000@192.168.1.35:5060
33.533950942		5060 Request: INVITE sip:2020@192.168.1.38:5060	6184		SIP/SDP: Request: INVITE sip:2020@192.168.1.38:5060
33.625595711		5060 Status: 100 Trying	6184		SIP: Status: 100 Trying
33.760292110		5060 Status: 200 OK	6184		SIP/SDP: Status: 200 OK
33.760616343		5060 Request: ACK sip:2020@192.168.1.38:6184;r...	6184		SIP: Request: ACK sip:2020@192.168.1.38:6184;r...
55.528849751	414	Request: INVITE sip:2010@192.168.1.35:5060	5060		SIP/SDP: Request: INVITE sip:2010@192.168.1.35:5060
55.529162105	414	Status: 100 Trying	5060		SIP: Status: 100 Trying
55.529267971	414	Status: 200 OK	5060		SIP/SDP: Status: 200 OK
55.529551793		5060 Request: INVITE sip:2010@192.168.1.37:5060	64201		SIP/SDP: Request: INVITE sip:2010@192.168.1.37:5060
55.538215661	414	Request: ACK sip:2010@192.168.1.35:5060	5060		SIP: Request: ACK sip:2010@192.168.1.35:5060
55.579375167		5060 Status: 200 OK	64201		SIP/SDP: Status: 200 OK
55.580037455		5060 Request: ACK sip:2010@192.168.1.37:64201;r...	64201		SIP: Request: ACK sip:2010@192.168.1.37:64201;r...
72.242691228	414	Request: BYE sip:2020@192.168.1.35:5060	5060		SIP: Request: BYE sip:2020@192.168.1.35:5060
72.242775026	414	Request: BYE sip:2010@192.168.1.35:5060	5060		SIP: Request: BYE sip:2010@192.168.1.35:5060
72.243302214	414	Status: 200 OK	5060		SIP: Status: 200 OK
72.243715259	414	Status: 200 OK	5060		SIP: Status: 200 OK
72.244205663		5060 Request: INVITE sip:2020@192.168.1.38:5060	6184		SIP/SDP: Request: INVITE sip:2020@192.168.1.38:5060
72.244482971		5060 Request: INVITE sip:2010@192.168.1.37:5060	64201		SIP/SDP: Request: INVITE sip:2010@192.168.1.37:5060
72.289773089		5060 Status: 200 OK	6184		SIP/SDP: Status: 200 OK
72.290199334		5060 Request: ACK sip:2020@192.168.1.38:6184;r...	6184		SIP: Request: ACK sip:2020@192.168.1.38:6184;r...
72.290279160		5060 Request: BYE sip:2020@192.168.1.38:6184;r...	6184		SIP: Request: BYE sip:2020@192.168.1.38:6184;r...
72.313276749		5060 Status: 200 OK	64201		SIP/SDP: Status: 200 OK
72.313603570		5060 Request: ACK sip:2010@192.168.1.37:64201;r...	64201		SIP: Request: ACK sip:2010@192.168.1.37:64201;r...
72.313722708		5060 Request: BYE sip:2010@192.168.1.37:64201;r...	64201		SIP: Request: BYE sip:2010@192.168.1.37:64201;r...
72.386671439		5060 Status: 200 OK	6184		SIP: Status: 200 OK
72.813201086		5060 Request: BYE sip:2010@192.168.1.37:64201;r...	64201		SIP: Request: BYE sip:2010@192.168.1.37:64201;r...
72.819985991		5060 Status: 200 OK	64201		SIP: Status: 200 OK
72.820180438		5060 Status: 200 OK	64201		SIP: Status: 200 OK



**Part B) Logical Flow-chart of call establishment and putting 2010 on hold while establishing call between 2000 and 2020. Call conferencing between 2000, 2010 and 2020 is also shown below:**

Time	192.168.1.34	192.168.1.35	192.168.1.37	192.168.1.38	Comment
28.549750840	57488	401 Unauthorized	5060		SIP Status 401 Unauthorized
28.551140177	57488	ACK	5060		SIP ACK From: "2000"<sip:2000@192.168.1.35> T...
28.558450000	57488	INVITE SDP (g72...	5060		SIP INVITE From: "2000"<sip:2000@192.168.1.35>...
28.559594732	57488	100 Trying	5060		SIP Status 100 Trying
28.561799344		5060	INVITE SDP (g71...	50985	SIP INVITE From: "2000" <sip:2000@192.168.1.35>...
28.711312460		5060	100 Trying	50985	SIP Status 100 Trying
28.744838544		5060	180 Ringing	50985	SIP Status 180 Ringing
28.745247562	57488	180 Ringing	5060		SIP Status 180 Ringing
37.342491428		14522	RTP (g711U)	52364	RTP, 31 packets. Duration: 0.641s SSRC: 0x2EC00...
37.461807197		5060	200 OK SDP (g7...	50985	SIP Status 200 OK
37.462103342		5060	ACK	50985	SIP Request INVITE ACK 200 CSeq:102
37.462438598	57488	200 OK SDP (g7...	5060		SIP Status 200 OK
37.463308733		5060	INVITE SDP (g71...	50985	SIP INVITE From: "2000" <sip:2000@192.168.1.35>...
37.485823111	57488	ACK	5060		SIP Request INVITE ACK 200 CSeq:2
37.486054953	57488	INVITE SDP (g71...	5060		SIP INVITE From: "2000"<sip:2000@192.168.1.35>...
37.490869460	56882	RTP (g711U)	13512		RTP, 4 packets. Duration: 0.060s SSRC: 0x3C896910
37.491007262		14522	RTP (g711U)	52364	RTP, 4 packets. Duration: 0.060s SSRC: 0x1A03AB...
37.500317009	56882	RTP (g711U)	13512		RTP, 4 packets. Duration: 0.063s SSRC: 0x258D462D
37.573000237	57488	200 OK SDP (g7...	5060		SIP Status 200 OK
37.573400362	57488	ACK	5060		SIP ACK From: "2000"<sip:2000@192.168.1.35> T...
37.583841126	56882	RTP (g711U)	13512		RTP, 21 packets. Duration: 0.400s SSRC: 0x258D4...
37.962848484		5060	INVITE SDP (g71...	50985	SIP INVITE From: "2000" <sip:2000@192.168.1.35>...
38.002366351		5060	100 Trying	50985	SIP Status 100 Trying
38.182183213		5060	200 OK SDP (g7...	50985	SIP Status 200 OK
38.182540657		5060	ACK	50985	SIP Request INVITE ACK 200 CSeq:103
50.055018173		5060	INVITE SDP (g722 g711A opus g71...	64820	SIP INVITE From: "2020"<sip:2020@192.168.1.35>...
50.055261908		5060	401 Unauthorized	64820	SIP Status 401 Unauthorized
50.057145997		5060	ACK	64820	SIP ACK From: "2020"<sip:2020@192.168.1.35> T...
50.098144226		5060	INVITE SDP (g722 g711A opus g71...	64820	SIP INVITE From: "2020"<sip:2020@192.168.1.35>...
50.098881170		5060	100 Trying	64820	SIP Status 100 Trying
50.100612297	57488	INVITE SDP (g71...	5060		SIP INVITE From: "2020" <sip:2020@192.168.1.35>...
50.187627183	57488	100 Trying	5060		SIP Status 100 Trying
50.335038358	57488	180 Ringing	5060		SIP Status 180 Ringing
50.335777785		5060	180 Ringing	64820	SIP Status 180 Ringing
54.386602616	57488	INVITE SDP (g71...	5060		SIP INVITE From: "2000"<sip:2000@192.168.1.35>...
54.387004267	57488	100 Trying	5060		SIP Status 100 Trying
54.387218846	57488	200 OK SDP (g7...	5060		SIP Status 200 OK
54.387567738		5060	INVITE SDP (g71...	50985	SIP INVITE From: "2000" <sip:2000@192.168.1.35>...
54.393833372	54700	RTP (g711U)	11860		RTP, 7 packets. Duration: 0.117s SSRC: 0x74A7716
54.394803429	57488	200 OK SDP (g7...	5060		SIP Status 200 OK
54.395186712	57488	ACK	5060		SIP Request INVITE ACK 200 CSeq:102
54.395659012		5060	200 OK SDP (g711U g711A telepho...	64820	SIP Status 200 OK
54.396886280	57488	INVITE SDP (g71...	5060		SIP INVITE From: "2020" <sip:2020@192.168.1.35>...
54.408390775		14522	RTP (g711U)	52364	RTP, 7 packets. Duration: 0.120s SSRC: 0x1A03AB...
54.408589233	57488	ACK	5060		SIP Request INVITE ACK 200 CSeq:3
54.472130933		14522	RTP (g711U)	52364	RTP, 396 packets. Duration: 7.901s SSRC: 0x2EC00...
54.498117045	57488	100 Trying	5060		SIP Status 100 Trying
54.524812856	57488	200 OK SDP (g7...	5060		SIP Status 200 OK
54.525116960	57488	ACK	5060		SIP Request INVITE ACK 200 CSeq:103
54.532393367		5060	100 Trying	50985	SIP Status 100 Trying
54.532550085		5060	200 OK SDP (g7...	50985	SIP Status 200 OK
54.532853885		5060	ACK	50985	SIP Request INVITE ACK 200 CSeq:104
54.548614008		14522	RTP (g711U)	52364	RTP, 390 packets. Duration: 7.779s SSRC: 0x1A03...



54.616019397		15118	RTP (g711U)	65032	RTP, 11 packets. Duration: 0.186s SSRC: 0x450D7...
54.616257235	54700		RTP (g711U)	11860	RTP, 2 packets. Duration: 0.010s SSRC: 0x4594845F
54.628424577		5060	ACK	64820	SIP Request INVITE ACK 200 CSeq:2
54.628679461		5060	INVITE SDP (g711U telephone-event)	64820	SIP INVITE From: "2020"<sip:2020@192.168.1.35>
54.643300900	54700		RTP (g711U)	11860	RTP, 9 packets. Duration: 0.159s SSRC: 0x4594845F
54.805329029		5060	100 Trying	64820	SIP Status 100 Trying
54.826840733		5060	200 OK SDP (g711U telephone-eve...	64820	SIP Status 200 OK
54.827215231		5060	ACK	64820	SIP ACK From: "2020"<sip:2020@192.168.1.35> T...
62.333057668	57488		INVITE SDP (g711U telephone-event)	5060	SIP INVITE From: "2000"<sip:2000@192.168.1.35>
62.333489302	57488		100 Trying	5060	SIP Status 100 Trying
62.333659725	57488		200 OK SDP (g711U telephone-eve...	5060	SIP Status 200 OK
62.334112757		5060	INVITE SDP (g711U telephone-event)	50985	SIP INVITE From: "2000"<sip:2000@192.168.1.35>
62.345829324	57488		ACK	5060	SIP Request INVITE ACK 200 CSeq:4
62.352955861	56882		RTP (g711U)	13512	RTP, 2 packets. Duration: 0.020s SSRC: 0x258D462D
62.490676161		5060	200 OK SDP (g711U telephone-eve...	50985	SIP Status 200 OK
62.491044889		5060	ACK	50985	SIP Request INVITE ACK 200 CSeq:105
70.148763001	57488		BYE	5060	SIP Request BYE CSeq:2
70.148786150	57488		BYE	5060	SIP Request BYE CSeq:5
70.149258668	57488		200 OK	5060	SIP Status 200 OK
70.149693374	57488		200 OK	5060	SIP Status 200 OK
70.150245995		5060	INVITE SDP (g711U telephone-event)	64820	SIP INVITE From: "2020"<sip:2020@192.168.1.35>
70.150929917		5060	INVITE SDP (g711U telephone-event)	50985	SIP INVITE From: "2000"<sip:2000@192.168.1.35>
70.240166553		5060	100 Trying	64820	SIP Status 100 Trying
70.296010694		15118	RTP (g711U)	65032	RTP, 1 packets. Duration: 0.000s SSRC: 0x450D7251
70.307229082		5060	200 OK SDP (g711U telephone-eve...	64820	SIP Status 200 OK
70.307525063		5060	ACK	64820	SIP ACK From: "2020"<sip:2020@192.168.1.35> T...
70.307672659		5060	BYE	64820	SIP Request BYE CSeq:104
70.619962481		5060	100 Trying	50985	SIP Status 100 Trying
70.661219861		14522	RTP (g711U)	52364	RTP, 1 packets. Duration: 0.000s SSRC: 0x2EC001B5
70.673128936		5060	200 OK SDP (g711U telephone-eve...	50985	SIP Status 200 OK
70.673468890		5060	ACK	50985	SIP Request INVITE ACK 200 CSeq:106
70.673567524		5060	BYE	50985	SIP Request BYE CSeq:107
70.808353215		5060	BYE	64820	SIP Request BYE CSeq:104
70.945952903		5060	200 OK	64820	SIP Status 200 OK
70.946742091		5060	200 OK	64820	SIP Status 200 OK
71.173666220		5060	BYE	50985	SIP Request BYE CSeq:107
71.364370886		5060	200 OK	50985	SIP Status 200 OK
71.364566840		5060	200 OK	50985	SIP Status 200 OK

### Summary:

- Client 2000, 2010 and 2020 send Register packet to register with the proxy server with their IP address. The server responds with OK message.
- Once the registration process is complete, call establishment process starts with Client 2000 sending an Invite message to the proxy server.
- The proxy server then sends an invite to the callee client 2010 and send a Trying message to 2000. If the client 2010 is available, it sends a Trying message to 2000 and then an OK message followed by a Ringing Message.
- Client 2000 requests a connection by sending an ACK message to connect the call and start the media exchange.
- Now client 2020 wants to call 2000 and sends an Invite packet to proxy server. The same process of call establishment follows and once client 2000 picks the call, media exchange starts between 2000 and 2020.

- In order to add client 2010 to the ongoing call, proxy server merges the call by sending an INVITE message to 2010. Media exchange takes place between 2000, 2010 and 2020.
- Once the media exchange is complete, any one of the clients sends a call termination message i.e. BYE which is acknowledged by all parties with an OK message and the call is terminated.

```

▼ Session Initiation Protocol (INVITE)
  ▶ Request-Line: INVITE sip:2010@192.168.1.35 SIP/2.0
  ▼ Message Header
    ▶ Via: SIP/2.0/UDP 192.168.1.34:55414;branch=z9hG4bK-524287-1---60d9a9058b8
      Max-Forwards: 70
    ▶ Contact: <sip:2000@192.168.1.34:55414;rinstance=90f6c38a272976db>
    ▶ To: <sip:2010@192.168.1.35>
    ▶ From: "2000"<sip:2000@192.168.1.35>;tag=d6f7fe25
      Call-ID: 99142MDBhZGU5Mjc3Nzg4ZDc0Yjk4MDg2NzF1ZjZiYTU0ZjM
    ▶ CSeq: 1 INVITE
      Allow: OPTIONS, SUBSCRIBE, NOTIFY, INVITE, ACK, CANCEL, BYE, REFER, INFO,
      Content-Type: application/sdp
      Supported: replaces
      User-Agent: X-Lite release 5.6.1 stamp 99142
      Content-Length: 334
  ▶ Message Body

```

#### SIP Invite packet

- We can see an Invite packet sent from client 2000 to server with IP address 192.168.1.35 requesting to connect a call with Client 2010. The call ID is as seen in the image. There are two parts to a SIP packet: message header and message body.

### Part C)

**IP Address of Client 2000: 192.168.1.34**

```

▶ Internet Protocol Version 4, Src: 192.168.1.34, Dst: 192.168.1.35
▶ User Datagram Protocol, Src Port: 55414, Dst Port: 5060
▼ Session Initiation Protocol (INVITE)
  ▶ Request-Line: INVITE sip:2010@192.168.1.35 SIP/2.0
  ▼ Message Header
    ▶ Via: SIP/2.0/UDP 192.168.1.34:55414;branch=z9hG4bK-524287-1---60
      Max-Forwards: 70
    ▶ Contact: <sip:2000@192.168.1.34:55414;rinstance=90f6c38a272976db>
    ▶ To: <sip:2010@192.168.1.35>
    ▶ From: "2000"<sip:2000@192.168.1.35>;tag=d6f7fe25
      Call-ID: 99142MDBhZGU5Mjc3Nzg4ZDc0Yjk4MDg2NzF1ZjZiYTU0ZjM
    ▶ CSeq: 1 INVITE

```



IP Address of Client 2010: 192.168.1.37

```
▶ Internet Protocol Version 4, Src: 192.168.1.37, Dst: 192.168.1.35
▶ User Datagram Protocol, Src Port: 64201, Dst Port: 5060
▼ Session Initiation Protocol (INVITE)
  ▶ Request-Line: INVITE sip:2000@192.168.1.35 SIP/2.0
  ▼ Message Header
    ▶ Via: SIP/2.0/UDP 192.168.1.37:64201;branch=z9hG4bK-524287-1---11
      Max-Forwards: 70
    ▶ Contact: <sip:2010@192.168.1.37:64201;rinstance=2da60827ea55b9f7>
    ▶ To: <sip:2000@192.168.1.35>
    ▶ From: "2010"<sip:2010@192.168.1.35>;tag=c296202c
    Call-ID: 99142Mmm50DVkZDE5ZjFkOWRiYzFjNjA4YTMxMzRkN2I1NWU
```

IP Address of Client 2020: 192.168.1.38

```
▼ Ethernet II, Src: PcsCompu_19:45:60 (08:00:27:19:45:60), Dst: PcsCor
  ▶ Destination: PcsCompu_09:01:5c (08:00:27:09:01:5c)
  ▶ Source: PcsCompu_19:45:60 (08:00:27:19:45:60)
  Type: IPv4 (0x0800)
▶ Internet Protocol Version 4, Src: 192.168.1.38, Dst: 192.168.1.35
▶ User Datagram Protocol, Src Port: 61844, Dst Port: 5060
▼ Session Initiation Protocol (INVITE)
  ▶ Request-Line: INVITE sip:2000@192.168.1.35 SIP/2.0
    Method: INVITE
    ▶ Request-URI: sip:2000@192.168.1.35
    [Resent Packet: False]
  ▼ Message Header
    ▶ Via: SIP/2.0/UDP 192.168.1.38:61844;branch=z9hG4bK-524287-1---
      Max-Forwards: 70
    ▶ Contact: <sip:2020@192.168.1.38:61844;rinstance=803eef23e66840>
    ▶ Contact URI: sip:2020@192.168.1.38:61844;rinstance=803eef23
    ▶ To: <sip:2000@192.168.1.35>
      ▶ SIP to address: sip:2000@192.168.1.35
    ▶ From: "2020"<sip:2020@192.168.1.35>;tag=6831a828
      SIP Display info: "2020"
```

MAC address of PBX server: 08:00:27:09:01:5c

```
▼ Ethernet II, Src: IntelCor_a2:f4:a4 (c0:b6:f9:a2:f4:a4), Dst: PcsCo
  ▶ Destination: PcsCompu_09:01:5c (08:00:27:09:01:5c)
  ▶ Source: IntelCor_a2:f4:a4 (c0:b6:f9:a2:f4:a4)
  Type: IPv4 (0x0800)
▶ Internet Protocol Version 4, Src: 192.168.1.34, Dst: 192.168.1.35
▶ User Datagram Protocol, Src Port: 55414, Dst Port: 5060
▼ Session Initiation Protocol (INVITE)
  ▶ Request-Line: INVITE sip:2010@192.168.1.35 SIP/2.0
  ▼ Message Header
    ▶ Via: SIP/2.0/UDP 192.168.1.34:55414;branch=z9hG4bK-524287-1--
      Max-Forwards: 70
    ▶ Contact: <sip:2000@192.168.1.34:55414;rinstance=90f6c38a27297>
    ▶ To: <sip:2010@192.168.1.35>
    ▶ From: "2000"<sip:2000@192.168.1.35>;tag=c65aad2a
    Call-ID: 991420GNjNTE5NjlmZDMzYTFiNjQzOTY2MDBjN2ZiMDUwYjY
```

Thank You!