Slovenská technická univerzita v Bratislave

Fakulta informatiky a informačných technológií

Mobilné technológie a aplikácie

Zadanie č.1 – SIP Proxy (telefónna ústredňa)

Vypracoval: Lukáš Rucek

ID: 103109

Rok: 2021

Prednášajúci: prof. Ing. Ivan Kotuliak, PhD.

Ing. Marek Galinski, PhD.

Cvičiaci: Ing. Adam Ševčík

Čas cvičení: Štvrtok 10:00 – 11:50

Zadanie:

Hlavná myšlienka zadania:

Na vašom počítači (alebo virtuálnom počítači) sprevádzkujte SIP Proxy, ktorá umožní prepájanie a realizáciu hovorov medzi štandardnými SIP klientami.

Doplňujúce informácie k zadaniu:

Na implementáciu vašej SIP Proxy si môžete zvoliť akýkoľvek programovací jazyk a použiť akúkoľvek SIP knižnicu, ktorá pre daný programovací jazyk existuje. Vo výsledku však musíte spúšťať "váš kód", v ktorom sú zakomponované knižnice, ktoré poskytujú funkcionalitu SIP Proxy. To znamená, že nemôžete zobrať existujúcu SIP Proxy ako napr. Asterisk, kde len skompilujete alebo priamo spustíte cudziu binárku… Hovor musí byť realizovaný medzi dvomi fyzickými zariadeniami v rámci LAN siete.

Rozsah povinných funkcionalít:

- Registrácia účastníka (bez nutnosti autentifikácie)

- Vytočenie hovoru a zvonenie na druhej strane

- Prijatie hovoru druhou stranou, fungujúci hlasový hovor

- Ukončenie hlasového hovoru (prijatého aj neprijatého)

Ak sú splnené všetky tieto podmienky, študent získava 5 bodov, ktoré sú minimom na absolvovanie tohoto zadania.

Doplnkové funkcionality (ktoré môžete, ale nemusíte urobiť):

- Možnosť zrealizovať konferenčný hovor (aspoň 3 účastníci)

- Možnosť presmerovať hovor

- Možnosť realizovať videohovor

- Logovanie "denníka hovorov" – kto kedy komu volal, kedy bol ktorý hovor prijatý, kedy bol ktorý hovor ukončený, do ľubovoľného textového súboru v ľubovoľnom formáte

- Úprava SIP stavových kódov z zdrojovom kóde proxy, napr. "486 Busy Here" zmeníte na "486 Obsadené"

Každá doplnková funkcionalita predstavuje plus 1 bod.

Počas prezentácie zadania musíte byť schopní na zariadení, kde beží ústredňa urobiť SIP trace a otvoriť ho pomocou tcpdump alebo Wireshark, a v primeranom rozsahu vysvetliť cvičiacemu, ako daná signalizácia prebieha.

Základne informácie:

Zadanie je implementované v jazyku Python (Python 3.9) a ako prostredie som využil PyCharm 2021.2.2. Rozhranie programu som riešíl pomocou konzole. Ako SIP klient som využil Linphone.

Z githubu som prevzal python modul sypfullproxy.py: https://github.com/tirfil/PySipFullProxy

Môj github zo všetkými pcapmi: https://github.com/LukasRucek/MTAA_Zadanie1

Upráva modulu:

- Upravenie syntaxe ,pretože daný modul bol naprogramovaný na staršiu verziu Pythonu
  napr. registrar.has_key(destination) => destination in registrar
  string.join(data, "\r\n")   => "\r\n".join(data)
- Zmena výstupov (z anglického názvu na slovenský)

  Napr. `self.sendResponse("406 Not Acceptable")` => `self.sendResponse("406 Neprijatie")`

- Zabalenie knižnice do mainu

Implementované veci zo zadania:

- Registráca účastníka (bez nutnosti autentifikácie)
- Vytočenie hovoru a zvonenie na druhej strane
- Prijatie hovoru druhou stranou, fungujúci hlasový hovor
- Ukončenie hlasového hovoru (prijatého aj neprijatého)
- Možnosť zrealizovať konferečný hovor (aspoň 3 účastníci)
- Možnosť presmerovať hovor
- Možnost realizovať videohovor
- Úprava SIP stavových kódov z zdojovom kóde proxy, napr. „486 Busy Here" zmenenie na „486 Obsadené"

Úprava SIP stavových kódov robím vo vlastnej funkcii translate(code), ktorá sa nachádza v python súbore main.py.

```python
def translate(code):
    help_code = code.split(" ")
    if help_code[1] == "400":
        help_code[2] = "Zly Request"
    elif help_code[1] == "406":
        help_code[2] = "Neprijatie"
    elif help_code[1] == "408":
        help_code[2] = "Nedostupny"
    elif help_code[1] == "486":
        help_code[2] = "Obsadene"
        help_code[3] = ""
    elif help_code[1] == "487":
        help_code[2] = "Zrusene"
    elif help_code[1] == "603":
        help_code[2] = "Odmietnutie"
    elif help_code[1] == "100":
        help_code[2] = "Skusanie"
    elif help_code[1] == "180":
        help_code[2] = "Zvonenie"

    print(help_code)
    help_code = " ".join(help_code)

    return help_code
```

Jednotlivé scénare pcapov:

1. **Scénar: Hovor medzi dvomi mobilmi**

   - V tomto scénari boli použité 2 mobily a jeden PC, ktorý slúžil iba ako server.
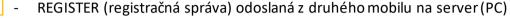
   1.1 Scénar: Kompletný hovor

   - pcap: Kompletny_hovor_wifi.pcapng

15 6.242673	192.168.43.1	192.168.43.241	SIP	671		Request: REGISTER sip:192.168.43.241 (1 binding)	
16 6.242673	192.168.43.1	192.168.43.241	SIP	665		Request: REGISTER sip:192.168.43.241 (1 binding)	
17 6.243946	192.168.43.241	192.168.43.1	SIP	689		Status: 200 OK (1 binding)	
18 6.245131	192.168.43.241	192.168.43.1	SIP	683		Status: 200 OK (1 binding)	
38 17.198722	192.168.43.1	192.168.43.241	SIP/SDP	1228		Request: INVITE sip:lukas@192.168.43.241	
40 17.710598	192.168.43.1	192.168.43.241	SIP/SDP	1228		Request: INVITE sip:lukas@192.168.43.241	
45 18.735051	192.168.43.1	192.168.43.241	SIP/SDP	1228		Request: INVITE sip:lukas@192.168.43.241	
48 19.350090	192.168.43.241	192.168.43.1	SIP	278		Status: 100 Skusanie	
52 19.452627	192.168.43.241	192.168.43.1	SIP	464		Status: 180 Zvonenie	
53 19.453491	192.168.43.241	192.168.43.1	SIP	464		Status: 180 Zvonenie	
54 19.454288	192.168.43.241	192.168.43.1	SIP	464		Status: 180 Zvonenie	
58 20.783784	192.168.43.241	192.168.43.1	SIP/SDP	1279		Status: 200 Ok	
61 21.041409	192.168.43.1	192.168.43.241	SIP	443		Request: ACK sip:lukas@192.168.43.238:45300:transport=udp	
78 28.872990	192.168.43.241	192.168.43.1	SIP	546		Request: BYE sip:lenka@192.168.43.1:58209;transport=udp	
79 28.975110	192.168.43.1	192.168.43.241	SIP	524		Status: 200 Ok	
87 35.323330	192.168.43.1	192.168.43.241	SIP	668		Request: REGISTER sip:192.168.43.241 (remove 1 binding)	
88 35.323822	192.168.43.241	192.168.43.1	SIP	686		Status: 200 OK (removed 1 binding)	
89 35.426040	192.168.43.1	192.168.43.241	SIP	662		Request: REGISTER sip:192.168.43.241 (remove 1 binding)	
90 35.426534	192.168.43.241	192.168.43.1	SIP	680		Status: 200 OK (removed 1 binding)	

- REGISTER (registračná správa) odoslaná z prvého mobilu na server (PC)
- 200 OK (potvrdzovacia správa) odoslaná serverom (PC) na prvý mobil
- INVITE (prvý mobil chce zavolať druhému) odoslaná prvým mobilom na server (PC)
- 100 Skusanie a 180 Zvonenie tieto správy boli odoslaté druhým mobilom na server a zo servera na prvý mobil, 200 OK (potvrdzovacia správa) hovor sa úspešne prijal a odošle sa ACK (Skusanie a Zvonenie sú moje vlastné upravené SIP kódy)
- Prebieha komunikácia medzi volajúcimi
- BYE (správa ,ktorá ukončuje hovor) druhý mobil ukončil hovor tak poslal BYE správu serveru a server poslal túto správu prvému mobilu, 200 OK prvý mobil posiela potvrdzovacia správa serveru
- Ukončenie spojenia prvého mobilu a servera, mobil dostane od servera ešte potvrdzovaciu správu

26 11.151833	192.168.43.238	192.168.43.241	SIP	669	Request: REGISTER sip:192.168.43.241 (1 binding)	
27 11.153010	192.168.43.241	192.168.43.238	SIP	689	Status: 200 OK (1 binding)	
39 17.199606	192.168.43.241	192.168.43.238	SIP	1365	Request: INVITE sip:lukas@192.168.43.241	
43 17.711746	192.168.43.241	192.168.43.238	SIP	1365	Request: INVITE sip:lukas@192.168.43.241	
46 18.736036	192.168.43.241	192.168.43.238	SIP	1365	Request: INVITE sip:lukas@192.168.43.241	
47 19.349542	192.168.43.238	192.168.43.241	SIP	340	Status: 100 Trying	
49 19.451843	192.168.43.238	192.168.43.241	SIP	527	Status: 180 Ringing	
50 19.451843	192.168.43.238	192.168.43.241	SIP	527	Status: 180 Ringing	
51 19.452504	192.168.43.238	192.168.43.241	SIP	527	Status: 180 Ringing	
57 20.782977	192.168.43.238	192.168.43.241	SIP/SDP	1343	Status: 200 Ok	
62 21.042025	192.168.43.241	192.168.43.238	SIP	543	Request: ACK sip:lukas@192.168.43.238:45300;transport=udp	
77 28.872346	192.168.43.238	192.168.43.241	SIP	444	Request: BYE sip:lenka@192.168.43.1:58209;transport=udp	
80 28.975821	192.168.43.241	192.168.43.238	SIP	460	Status: 200 Ok	
93 37.181343	192.168.43.238	192.168.43.241	SIP	666	Request: REGISTER sip:192.168.43.241 (remove 1 binding)	
94 37.181879	192.168.43.241	192.168.43.238	SIP	686	Status: 200 0K (removed 1 binding)	

- REGISTER (registračná správa) odoslaná z druhého mobilu na server (PC)
- 200 OK (potvrdzovacia správa) odoslaná serverom (PC) na druhý mobil
- INVITE (prvý mobil chce zavolať druhému) odoslaná serverom (PC) na druhý mobil
- 100 Trying a 180 Ringing sú posielané na server a server ich pošle druhému mobilu, 200 OK (potvrdzovacia správa) druhy mobil dostáva ACK od serveru
- Prebieha komunikácia medzi volajúcimi
- BYE (správa ,ktorá ukončuje hovor) druhý mobil ukončil hovor tak poslal BYE správu serveru a server poslal túto správu prvému mobilu, 200 OK potvrdzovacia správa (môže sa ukončiť hovor)
- Ukončenie spojenia druhého mobilu a servera, mobil dostane od servera ešte potvrdzovaciu správu

46 18.736036	192.168.43.241	192.168.43.238	SIP	1365	Request: INVITE sip:lukas@192.168.43.241	

```
> Frame 46: 1365 bytes on wire (10920 bits), 1365 bytes captured (10920 bits) on interface \Device\NPF_{5AF9D89C-C452-404F-A52D-9752C898CB9F}, id 0
> Ethernet II, Src: CloudNet_b2:3c:a1 (48:5f:99:b2:3c:a1), Dst: HuaweiTe_52:1c:2e (e4:19:c1:52:1c:2e)
> Internet Protocol Version 4, Src: 192.168.43.241, Dst: 192.168.43.238
> User Datagram Protocol, Src Port: 5060, Dst Port: 45300
∨ Session Initiation Protocol (INVITE)
  > Request-Line: INVITE sip:lukas@192.168.43.241 SIP/2.0
  > Message Header
  ∨ Message Body
      Via: SIP/2.0/UDP 192.168.43.241:5060;branch=z9hG4bK.0-RTB4~uQm\r\n
      Via: SIP/2.0/UDP 192.168.43.1:58209;branch=z9hG4bK.0-RTB4~uQ;received=192.168.43.1;rport=58209\r\n
      From: <sip:lenka@192.168.43.241>;tag=wccbt7BOR\r\n
      To: sip:lukas@192.168.43.241\r\n
      CSeq: 20 INVITE\r\n
      Call-ID: A8-EbpnAP~\r\n
      Max-Forwards: 70\r\n
      Supported: replaces, outbound, gruu\r\n
      Allow: INVITE, ACK, CANCEL, OPTIONS, BYE, REFER, NOTIFY, MESSAGE, SUBSCRIBE, INFO, PRACK, UPDATE\r\n
      Content-Type: application/sdp\r\n
      Content-Length: 517\r\n
      Contact: <sip:lenka@192.168.43.1:58209;transport=udp>;+sip.instance="<urn:uuid:5c6f43dd-e759-0079-b09a-af2700a474f3>";+org.linphone.specs="lime"\r\n
      User-Agent: LinphoneAndroid/4.6.1 (PPA-LX2) LinphoneSDK/5.1.1-pre.9+4a71c4e (release/5.1)\r\n
      \r\n
      v=0\r\n
      o=lenka 422 308 IN IP4 192.168.43.1\r\n
      s=Talk\r\n
      c=IN IP4 192.168.43.1\r\n
      t=0 0\r\n
      a=rtcp-xr:rcvr-rtt=all:10000_stat-summary=loss,dup,jitt,TTL voip-metrics\r\n
      m=audio 7078 RTP/AVP 96 97 98 0 8 18 99 100 101\r\n
      a=rtpmap:96 opus/48000/2\r\n
      a=fmtp:96 useinbandfec=1\r\n
      a=rtpmap:97 speex/16000\r\n
      a=fmtp:97 vbr=on\r\n
      a=rtpmap:98 speex/8000\r\n
      a=fmtp:98 vbr=on\r\n
      a=fmtp:18 annexb=yes\r\n
      a=rtpmap:99 telephone-event/48000\r\n
      a=rtpmap:100 telephone-event/16000\r\n
      a=rtpmap:101 telephone-event/8000\r\n
      a=rtcp-fb:* trr-int 1000\r\n
      a=rtcp-fb:* ccm tmmbr\r\n
```

- Pri obyčajnom hovore sa prenáša audio (pri videohovore aj video).

SIP Proxy (telefónna ústredňa)

1.2 Scénar: Príjemca nestihol príjmuť/nepríjmuť hovor:
- pcap: Nestihol_odpovedat_WIFI.pcapng

72 32.051574	192.168.43.238	192.168.43.241	SIP	340	Status: 100 Trying |
74 32.153951	192.168.43.238	192.168.43.241	SIP	527	Status: 180 Ringing |
75 32.153951	192.168.43.238	192.168.43.241	SIP	527	Status: 180 Ringing |
78 32.165388	192.168.43.238	192.168.43.241	SIP	527	Status: 180 Ringing |
81 32.201543	192.168.43.238	192.168.43.241	SIP	527	Status: 180 Ringing |
120 37.785878	192.168.43.238	192.168.43.241	UDP	46	41846 → 5060 Len=4
201 67.891004	192.168.43.238	192.168.43.241	UDP	46	41846 → 5060 Len=4
217 77.926510	192.168.43.238	192.168.43.241	SIP	485	Status: 486 Busy here |
73 32.051981	192.168.43.241	192.168.43.1	SIP	278	Status: 100 Skusanie |
76 32.154337	192.168.43.241	192.168.43.1	SIP	464	Status: 180 Zvonenie |
77 32.154652	192.168.43.241	192.168.43.1	SIP	464	Status: 180 Zvonenie |
79 32.165770	192.168.43.241	192.168.43.1	SIP	464	Status: 180 Zvonenie |
82 32.201906	192.168.43.241	192.168.43.1	SIP	464	Status: 180 Zvonenie |
121 39.628740	192.168.43.1	192.168.43.241	UDP	46	57652 → 5060 Len=4
204 69.632023	192.168.43.1	192.168.43.241	UDP	46	57652 → 5060 Len=4
218 77.926954	192.168.43.241	192.168.43.1	SIP	421	Status: 486 Obsadene |

- Väčšina je rovnáka ako predchadzajúci scénar iba rozdiel je vtom, že na hovor nikto neodpovedal ,tak na server sa poslal SIP kód 486 Busy here namiesto 200 OK. A zo servera sa na prvý mobil poslal môj vlastný SIP kód 486 Obsadene.

1.3 Scénar: Hovor ukončený volajúcim:
- pcap: Ukonceny_volajucim_WIFI.pcapng

71 23.961223			SIP	340	Request: INVITE sip:lukas@192.168.43.241 |
77 23.961656	192.168.43.238	192.168.43.241	SIP	340	Status: 100 Trying |
79 24.064436	192.168.43.238	192.168.43.241	SIP	527	Status: 180 Ringing |
80 24.064436	192.168.43.238	192.168.43.241	SIP	527	Status: 180 Ringing |
81 24.065215	192.168.43.238	192.168.43.241	SIP	527	Status: 180 Ringing |
85 24.166318	192.168.43.238	192.168.43.241	SIP	527	Status: 180 Ringing |
92 27.445047	192.168.43.241	192.168.43.238	SIP	515	Request: CANCEL sip:lukas@192.168.43.241 |
96 27.957487	192.168.43.241	192.168.43.238	SIP	515	Request: CANCEL sip:lukas@192.168.43.241 |
99 28.880074	192.168.43.241	192.168.43.238	SIP	515	Request: CANCEL sip:lukas@192.168.43.241 |
100 29.903897	192.168.43.238	192.168.43.241	SIP	478	Status: 200 Ok |
101 29.903897	192.168.43.238	192.168.43.241	SIP	494	Status: 487 Request terminated |
102 29.904420	192.168.43.238	192.168.43.241	SIP	377	Status: 481 Call/transaction does not exist |
106 29.906563	192.168.43.238	192.168.43.241	SIP	377	Status: 481 Call/transaction does not exist |
109 30.006619	192.168.43.241	192.168.43.238	SIP	578	Request: ACK sip:lukas@192.168.43.241 |
75 23.961670			SIP/SIP	278	Request: INVITE sip:lukas@192.168.43.241 |
78 23.962209	192.168.43.241	192.168.43.1	SIP	278	Status: 100 Skusanie |
82 24.065385	192.168.43.241	192.168.43.1	SIP	464	Status: 180 Zvonenie |
83 24.066306	192.168.43.241	192.168.43.1	SIP	464	Status: 180 Zvonenie |
84 24.066980	192.168.43.241	192.168.43.1	SIP	464	Status: 180 Zvonenie |
86 24.166843	192.168.43.241	192.168.43.1	SIP	464	Status: 180 Zvonenie |
91 27.444385	192.168.43.1	192.168.43.241	SIP	378	Request: CANCEL sip:lukas@192.168.43.241 |
94 27.956716	192.168.43.1	192.168.43.241	SIP	378	Request: CANCEL sip:lukas@192.168.43.241 |
98 28.879448	192.168.43.1	192.168.43.241	SIP	378	Request: CANCEL sip:lukas@192.168.43.241 |
103 29.904762	192.168.43.241	192.168.43.1	SIP	414	Status: 200 Ok |
104 29.905387	192.168.43.241	192.168.43.1	SIP	427	Status: 487 Ziadost Zrusena |
105 29.905899	192.168.43.241	192.168.43.1	SIP	313	Status: 481 Call/transaction does not exist |
107 29.907034	192.168.43.241	192.168.43.1	SIP	313	Status: 481 Call/transaction does not exist |
108 30.006014	192.168.43.1	192.168.43.241	SIP	441	Request: ACK sip:lukas@192.168.43.241 |

- Väčšina je rovnáka ako predchadzajúci scénar iba rozdiel je vtom, že hovor ukončí volajúci skôr ako niekto stihne naňho odpovedať. Z prvého mobilu sa na server pošle SIP kód 487 Request terminated a zo serveru sa na druhý mobil pošle môj vlastný SIP kód 487 Ziadost Zrusena.

1.4 Scénar: Odmietnutý hovor príjemcom:
- pcap: Odmietnuty_hovor_WIFI.pcapng

34 17.807856	192.168.43.238	192.168.43.241	SIP/SDP	1237	Request: INVITE sip:lenka@192.168.43.241	
37 17.911245	192.168.43.241	192.168.43.238	SIP	282	Status: 100 Skusanie	
39 18.218103	192.168.43.241	192.168.43.238	SIP	468	Status: 180 Zvonenie	
41 20.470550	192.168.43.241	192.168.43.238	SIP	427	Status: 603 Odmietnutie	
42 20.572273	192.168.43.238	192.168.43.241	SIP	445	Request: ACK sip:lenka@192.168.43.241	

35 17.808713	192.168.43.241	192.168.43.1	SIP	1376	Request: INVITE sip:lenka@192.168.43.241	
36 17.910706	192.168.43.1	192.168.43.241	SIP	344	Status: 100 Trying	
38 18.217495	192.168.43.1	192.168.43.241	SIP	531	Status: 180 Ringing	
40 20.469985	192.168.43.1	192.168.43.241	SIP	487	Status: 603 Decline	
43 20.572889	192.168.43.241	192.168.43.1	SIP	584	Request: ACK sip:lenka@192.168.43.241	

- Väčšina je rovnáka ako predchadzajúci scénar iba rozdiel je vtom, že na druhom mobile som odmietol hovor. Druhý mobil pošle na server SIP kód 603 Decline a server pošle prvému mobilu môj vlastný SIP kód 603 Odmietnutie.

2. Scénar: Videohovor medzi dvomi mobilmi:
- V tomto scénari boli použité 2 mobily a jeden PC, ktorý slúžil iba ako server.
- pcap: Videohovor_WIFI.pcapng

59 10.036323	192.168.43.1	192.168.43.241	SIP	671	Request: REGISTER sip:192.168.43.241 (1 binding)	
60 10.036323	192.168.43.1	192.168.43.241	SIP	665	Request: REGISTER sip:192.168.43.241 (1 binding)	
61 10.037559	192.168.43.241	192.168.43.1	SIP	689	Status: 200 0K (1 binding)	
62 10.038715	192.168.43.241	192.168.43.1	SIP	683	Status: 200 0K (1 binding)	
133 29.508821	192.168.43.1	192.168.43.241	SIP/SDP	1230	Request: INVITE sip:lukas@192.168.43.241	
135 30.107514	192.168.43.1	192.168.43.241	SIP/SDP	1230	Request: INVITE sip:lukas@192.168.43.241	
137 31.028656	192.168.43.1	192.168.43.241	SIP/SDP	1230	Request: INVITE sip:lukas@192.168.43.241	
140 32.462577	192.168.43.241	192.168.43.1	SIP	278	Status: 100 Skusanie	
143 32.565087	192.168.43.241	192.168.43.1	SIP	464	Status: 180 Zvonenie	
144 32.565920	192.168.43.241	192.168.43.1	SIP	464	Status: 180 Zvonenie	
146 32.577548	192.168.43.241	192.168.43.1	SIP	464	Status: 180 Zvonenie	
148 34.306815	192.168.43.241	192.168.43.1	SIP/SDP	1278	Status: 200 0k	
149 34.817077	192.168.43.1	192.168.43.241	SIP	443	Request: ACK sip:lukas@192.168.43.238:41822;transport=udp	
156 37.583507	192.168.43.241	192.168.43.1	SIP	247	Request: INVITE sip:lenka@192.168.43.1:60773;transport=udp	
157 37.684295	192.168.43.1	192.168.43.241	SIP	359	Status: 100 Trying	
164 38.913756	192.168.43.1	192.168.43.241	SIP/SDP	157	Status: 200 0k	
168 39.016749	192.168.43.241	192.168.43.1	SIP	546	Request: ACK sip:lenka@192.168.43.1:60773;transport=udp	
170 39.816145	192.168.43.1	192.168.43.241	UDP	46	60773 → 5060 Len=4	
179 46.696114	192.168.43.241	192.168.43.1	SIP	546	Request: BYE sip:lenka@192.168.43.1:60773;transport=udp	
180 46.798354	192.168.43.1	192.168.43.241	SIP	524	Status: 200 0k	

75 16.896886	192.168.43.238	192.168.43.241	SIP	669	Request: REGISTER sip:192.168.43.241 (1 binding)	
76 16.898053	192.168.43.241	192.168.43.238	SIP	689	Status: 200 0K (1 binding)	
134 29.509679	192.168.43.241	192.168.43.238	SIP	1367	Request: INVITE sip:lukas@192.168.43.241	
136 30.108343	192.168.43.241	192.168.43.238	SIP	1367	Request: INVITE sip:lukas@192.168.43.241	
138 31.029492	192.168.43.241	192.168.43.238	SIP	1367	Request: INVITE sip:lukas@192.168.43.241	
139 32.461937	192.168.43.238	192.168.43.241	SIP	340	Status: 100 Trying	
141 32.564313	192.168.43.238	192.168.43.241	SIP	527	Status: 180 Ringing	
142 32.565017	192.168.43.238	192.168.43.241	SIP	527	Status: 180 Ringing	
145 32.576995	192.168.43.238	192.168.43.241	SIP	527	Status: 180 Ringing	
147 34.305988	192.168.43.238	192.168.43.241	SIP/SDP	1342	Status: 200 0k	
150 34.817698	192.168.43.241	192.168.43.238	SIP	543	Request: ACK sip:lukas@192.168.43.238:41822;transport=udp	
154 37.582815	192.168.43.238	192.168.43.241	SIP/SDP	145	Request: INVITE sip:lenka@192.168.43.1:60773;transport=udp, in-dialog	
158 37.684707	192.168.43.241	192.168.43.238	SIP	297	Status: 100 Skusanie	
166 38.914213	192.168.43.241	192.168.43.238	SIP/SDP	93	Status: 200 0k	
167 39.016247	192.168.43.238	192.168.43.241	SIP	444	Request: ACK sip:lenka@192.168.43.1:60773;transport=udp	
177 46.490274	192.168.43.238	192.168.43.241	UDP	46	41822 → 5060 Len=4	
178 46.695661	192.168.43.238	192.168.43.241	SIP	444	Request: BYE sip:lenka@192.168.43.1:60773;transport=udp	
181 46.798755	192.168.43.241	192.168.43.238	SIP	460	Status: 200 0k	

SIP Proxy (telefónna ústredňa)

| 156 37.583507 | 192.168.43.241 | 192.168.43.1 | SIP | 247 | Request: INVITE sip:lenka@192.168.43.1:60773;transport=udp |

```
> Frame 156: 247 bytes on wire (1976 bits), 247 bytes captured (1976 bits) on interface \Device\NPF_{5AF9D89C-C452-404F-A52D-9752C898CB9F}, id 0
> Ethernet II, Src: CloudNet_b2:3c:a1 (48:5f:99:b2:3c:a1), Dst: 26:6c:b7:95:cc:2c (26:6c:b7:95:cc:2c)
> Internet Protocol Version 4, Src: 192.168.43.241, Dst: 192.168.43.1
> User Datagram Protocol, Src Port: 5060, Dst Port: 60773
v Session Initiation Protocol (INVITE)
  > Request-Line: INVITE sip:lenka@192.168.43.1:60773;transport=udp SIP/2.0
  > Message Header
  v Message Body
      Via: SIP/2.0/UDP 192.168.43.241:5060;branch=z9hG4bK.IUTkJyNhgm\r\n
      Via: SIP/2.0/UDP 192.168.43.238:41822;branch=z9hG4bK.IUTkJyNhg;received=192.168.43.238;rport=41822\r\n
      From: <sip:lukas@192.168.43.241>;tag=lHU~Umq\r\n
      To: <sip:lenka@192.168.43.241>;tag=~8Lk286kI\r\n
      CSeq: 111 INVITE\r\n
      Call-ID: nQFnCvf-iq\r\n
      Max-Forwards: 70\r\n
      Subject: Media change\r\n
      Supported: replaces, outbound, gruu\r\n
      Allow: INVITE, ACK, CANCEL, OPTIONS, BYE, REFER, NOTIFY, MESSAGE, SUBSCRIBE, INFO, PRACK, UPDATE\r\n
      Content-Type: application/sdp\r\n
      Content-Length: 817\r\n
      Contact: <sip:lukas@192.168.43.238:41822;transport=udp>;+sip.instance="<urn:uuid:d327458f-b1e8-00d8-a228-c1bf6fce99a6>";+org.linphone.specs="lime"\r\n
      User-Agent: LinphoneAndroid/4.6.1 (AMN-LX9) LinphoneSDK/5.1.1-pre.9+4a71c4e (release/5.1)\r\n
      \r\n
      v=0\r\n
      o=lukas 1967 882 IN IP4 192.168.43.238\r\n
      s=Talk\r\n
      c=IN IP4 192.168.43.238\r\n
      t=0 0\r\n
      a=rtcp-xr:rcvr-rtt=all:10000 stat-summary=loss,dup,jitt,TTL voip-metrics\r\n
      m=audio 7078 RTP/AVP 96 97 98 0 8 18 99 100 101\r\n
      a=rtpmap:96 opus/48000/2\r\n
      a=fmtp:96 useinbandfec=1\r\n
      a=rtpmap:97 speex/16000\r\n
      a=fmtp:97 vbr=on\r\n
      a=rtpmap:98 speex/8000\r\n
      a=fmtp:98 vbr=on\r\n
      a=fmtp:18 annexb=yes\r\n
      a=rtpmap:99 telephone-event/48000\r\n
      a=rtpmap:100 telephone-event/16000\r\n
      a=rtpmap:101 telephone-event/8000\r\n
      a=rtcp-fb:* trr-int 1000\r\n
      a=rtcp-fb:* ccm tmmbr\r\n
      m=video 9078 RTP/AVP 96 97\r\n
      a=rtpmap:96 VP8/90000\r\n
      a=rtpmap:97 H264/90000\r\n
      a=fmtp:97 profile-level-id=42801F\r\n
```

- Pri videohovore prebieha komunikácia podobne ako pri normálnom hovore. Navyše sa pošle INVITE ,ktorý obsahuje informácie nie len o audiu ale aj o videu.

3. **Scénar: Konferečny hovor medzi 2 mobilmi a PC (zároveň server):**
   - V tomto scénari boli použité 2 mobily a jeden PC na vytvorenie konferečného hovoru a zároveň PC slúžil aj ako server.
   - pcap: Konferecny_hovor_WIFI.pcapng , Konferecny_hovor_Loopback.pcapng
   - Konferečný hovor som zahájil z môjho PC a zavolal som naraz na oba mobily.

29 9.170516	192.168.43.241	192.168.43.241	SIP	631	Request: REGISTER sip:192.168.43.241 (1 binding)
30 9.171649	192.168.43.241	192.168.43.241	SIP	651	Status: 200 OK (1 binding)
75 30.562711	192.168.43.241	192.168.43.241	SIP/SDP	1197	Request: INVITE sip:lukas@192.168.43.241
78 30.707687	192.168.43.241	192.168.43.241	SIP	271	Status: 100 Skusanie
79 30.810037	192.168.43.241	192.168.43.241	SIP	457	Status: 180 Zvonenie
80 30.872471	192.168.43.241	192.168.43.241	SIP/SDP	1196	Request: INVITE sip:lenka@192.168.43.241
81 30.930167	192.168.43.241	192.168.43.241	SIP	271	Status: 100 Skusanie
82 31.220004	192.168.43.241	192.168.43.241	SIP	457	Status: 180 Zvonenie
83 32.858842	192.168.43.241	192.168.43.241	SIP/SDP	1260	Status: 200 Ok
84 32.992584	192.168.43.241	192.168.43.241	SIP	434	Request: ACK sip:lenka@192.168.43.1:50306;transport=udp
85 33.823233	192.168.43.241	192.168.43.241	SIP/SDP	1266	Status: 200 Ok
86 33.917456	192.168.43.241	192.168.43.241	SIP	436	Request: ACK sip:lukas@192.168.43.238:53277;transport=udp
99 37.708873	192.168.43.241	192.168.43.241	UDP	36	50511 → 5060 Len=4
128 52.147634	192.168.43.241	192.168.43.241	SIP	436	Request: BYE sip:lukas@192.168.43.238:53277;transport=udp
129 52.178760	192.168.43.241	192.168.43.241	SIP	434	Request: BYE sip:lenka@192.168.43.1:50306;transport=udp
130 52.197095	192.168.43.241	192.168.43.241	SIP	448	Status: 200 Ok
131 52.232223	192.168.43.241	192.168.43.241	SIP	448	Status: 200 Ok

279 9.280896	192.168.43.1	192.168.43.241	SIP	671	Request: REGISTER sip:192.168.43.241 (1 binding) |
280 9.282233	192.168.43.241	192.168.43.1	SIP	689	Status: 200 OK (1 binding) |
281 9.346245	192.168.43.1	192.168.43.241	SIP	665	Request: REGISTER sip:192.168.43.241 (1 binding) |
282 9.347279	192.168.43.241	192.168.43.1	SIP	683	Status: 200 OK (1 binding) |
328 29.760050	192.168.43.241	192.168.43.1	SIP	1345	Request: INVITE sip:lenka@192.168.43.241 |
329 29.816099	192.168.43.1	192.168.43.241	SIP	343	Status: 100 Trying |
331 30.106144	192.168.43.1	192.168.43.241	SIP	530	Status: 180 Ringing |
335 31.744602	192.168.43.1	192.168.43.241	SIP/SDP	1334	Status: 200 Ok |
344 31.879907	192.168.43.241	192.168.43.1	SIP	546	Request: ACK sip:lenka@192.168.43.1:50306;transport=udp |
348 31.924385	192.168.43.1	192.168.43.241	SIP	666	Request: SUBSCRIBE sip:igor@192.168.43.241;conf-id=EkKhi;transport=udp |
349 31.925111	192.168.43.241	192.168.43.1	SIP	650	Status: 200 OK |
1710 38.967636	192.168.43.1	192.168.43.241	UDP	46	50306 → 5060 Len=4
4192 51.066077	192.168.43.241	192.168.43.1	SIP	546	Request: BYE sip:lenka@192.168.43.1:50306;transport=udp |
4198 51.118536	192.168.43.1	192.168.43.241	SIP	522	Status: 200 OK |
4201 51.243000	192.168.43.1	192.168.43.241	SIP	666	Request: SUBSCRIBE sip:lenka@192.168.43.1:50306;transport=udp, in-dialog |
4202 51.243463	192.168.43.241	192.168.43.1	SIP	648	Status: 200 OK |
307 16.076775	192.168.43.238	192.168.43.241	SIP	669	Request: REGISTER sip:192.168.43.241 (1 binding) |
308 16.077924	192.168.43.241	192.168.43.238	SIP	689	Status: 200 OK (1 binding) |
325 29.450291	192.168.43.241	192.168.43.238	SIP	1346	Request: INVITE sip:lukas@192.168.43.241 |
326 29.593817	192.168.43.238	192.168.43.241	SIP	343	Status: 100 Trying |
327 29.696218	192.168.43.238	192.168.43.241	SIP	530	Status: 180 Ringing |
432 32.709467	192.168.43.238	192.168.43.241	SIP/SDP	1340	Status: 200 Ok |
452 32.804876	192.168.43.241	192.168.43.238	SIP	548	Request: ACK sip:lukas@192.168.43.238:53277;transport=udp |
493 33.014858	192.168.43.238	192.168.43.241	SIP	670	Request: SUBSCRIBE sip:igor@192.168.43.241;conf-id=EkKhi;transport=udp |
496 33.015231	192.168.43.241	192.168.43.238	SIP	656	Status: 200 OK |
3092 45.705968	192.168.43.238	192.168.43.241	UDP	46	53277 → 5060 Len=4
4187 51.034891	192.168.43.241	192.168.43.238	SIP	548	Request: BYE sip:lukas@192.168.43.238:53277;transport=udp |
4195 51.083340	192.168.43.238	192.168.43.241	SIP	522	Status: 200 Ok |
4199 51.203413	192.168.43.241	192.168.43.238	SIP	672	Request: SUBSCRIBE sip:lukas@192.168.43.238:53277;transport=udp, in-dialog |
4200 51.203832	192.168.43.241	192.168.43.238	SIP	654	Status: 200 OK |

- Odoslanie INVITE správy na oba mobily.
- Na oboch mobiloch som prijal hovor.
- SUBSCRIBE správa zabezpečí konferenčný hovor (monitorovanie oboch pobočiek)
- Ak niekto hovor ukončí ,tak sa pošle všetkým účastníkom BYE správa.

```
Session Initiation Protocol (SUBSCRIBE)
   Request-Line: SUBSCRIBE sip:igor@192.168.43.241;conf-id=EkKhi;transport=udp SIP/2.0
   Message Header
      Via: SIP/2.0/UDP 192.168.43.1:50306;branch=z9hG4bK.zynHaAxnL;rport
      From: <sip:lenka@192.168.43.241>;tag=dJXl141TU
      To: <sip:igor@192.168.43.241;conf-id=EkKhi>
      CSeq: 20 SUBSCRIBE
      Call-ID: XUMXNJ0O4t
      [Generated Call-ID: XUMXNJ0O4t]
      Max-Forwards: 70
      Supported: replaces, outbound, gruu
      Event: conference
      Expires: 600
      Contact: <sip:lenka@192.168.43.1:50306;transport=udp>;+sip.instance="<urn:uuid:5c6f43dd-e759-0079-b09a-af2700a474f3>";+org.linphone.specs="lime"
      Last-Notify-Version: 0
      User-Agent: LinphoneAndroid/4.6.1 (PPA-LX2) LinphoneSDK/5.1.1-pre.9+4a71c4e (release/5.1)
```

4. Scénar: Presmerovanie hovoru z PC a mobilu na dva mobily:

- V tomto scénari boli použité PC a mobil na hovor a zároveň ďalší mobil na presmerovanie hovoru z PC na mobil (zároveň PC bol ako server).

-pcap: Presmerovanie_hovoru_WIFI.pcapng,

      Presmerovanie_hovoru_Loopback.pcapng

17 5.615014	192.168.43.1	192.168.43.241	SIP	671		Request: REGISTER sip:192.168.43.241 (1 binding) |
18 5.615014	192.168.43.1	192.168.43.241	SIP	665		Request: REGISTER sip:192.168.43.241 (1 binding) |
19 5.616258	192.168.43.241	192.168.43.1	SIP	689		Status: 200 0K (1 binding) |
20 5.617599	192.168.43.241	192.168.43.1	SIP	683		Status: 200 0K (1 binding) |
408 35.310994	192.168.43.1	192.168.43.241	UDP	46		35833 → 5060 Len=4
410 35.743604	192.168.43.241	192.168.43.1	SIP	1323		Request: INVITE sip:lenka@192.168.43.241 |
411 35.822507	192.168.43.1	192.168.43.241	SIP	343		Status: 100 Trying |
412 36.027516	192.168.43.1	192.168.43.241	SIP	530		Status: 180 Ringing |
421 37.666101	192.168.43.1	192.168.43.241	SIP/SDP	1315		Status: 200 0k |
441 37.947900	192.168.43.241	192.168.43.1	SIP	546		Request: ACK sip:lenka@192.168.43.1:35833;transport=udp |
1509 48.170987	192.168.43.241	192.168.43.1	SIP	760		Request: REFER sip:lenka@192.168.43.1:35833;transport=udp |
1517 48.219753	192.168.43.1	192.168.43.241	SIP	530		Status: 202 Accepted |
1528 48.407999	192.168.43.1	192.168.43.241	SIP/SDP	1335		Request: INVITE sip:igor@192.168.43.241:54650;transport=udp, in-dialog |
1531 48.439617	192.168.43.241	192.168.43.1	SIP	292		Status: 100 Skusanie |
1532 48.440707	192.168.43.241	192.168.43.1	SIP/SDP	1238		Status: 200 0k |
1533 48.455241	192.168.43.1	192.168.43.241	SIP/SDP	1284		Request: INVITE sip:lukas@192.168.43.241 |
1548 48.565415	192.168.43.241	192.168.43.1	SIP	442		Request: ACK sip:igor@192.168.43.241:54650;transport=udp |
1549 48.566138	192.168.43.1	192.168.43.241	SIP/si…	561		Request: NOTIFY sip:igor@192.168.43.241:54650;transport=udp | , with Sipfrag(SIP/2.0 100 Trying)
1550 48.566437	192.168.43.241	192.168.43.1	SIP	524		Status: 200 0K |
1570 48.960997	192.168.43.1	192.168.43.241	SIP/SDP	1284		Request: INVITE sip:lukas@192.168.43.241 |
1590 49.275330	192.168.43.241	192.168.43.1	SIP	278		Status: 100 Skusanie |
1600 49.429441	192.168.43.241	192.168.43.1	SIP	464		Status: 180 Zvonenie |
1602 49.444530	192.168.43.1	192.168.43.1	SIP	464		Status: 180 Zvonenie |
1748 52.190470	192.168.43.241	192.168.43.1	SIP/SDP	1279		Status: 200 0k |
1754 52.310332	192.168.43.1	192.168.43.241	SIP/si…	586		Request: NOTIFY sip:igor@192.168.43.241:54650;transport=udp | , with Sipfrag(SIP/2.0 200 0k)
1756 52.310825	192.168.43.241	192.168.43.1	SIP	553		Status: 200 0k |
1762 52.416936	192.168.43.1	192.168.43.241	SIP	443		Request: ACK sip:lukas@192.168.43.238:36840;transport=udp |
2455 65.258953	192.168.43.1	192.168.43.241	UDP	46		35833 → 5060 Len=4
2685 69.381823	192.168.43.241	192.168.43.1	SIP	546		Request: BYE sip:lenka@192.168.43.1:35833;transport=udp |
2688 69.421209	192.168.43.1	192.168.43.241	SIP	522		Status: 200 0k |
2694 74.837156	192.168.43.241	192.168.43.1	SIP	546		Request: BYE sip:lenka@192.168.43.1:35833;transport=udp |
2695 74.939264	192.168.43.1	192.168.43.241	SIP	524		Status: 200 0k |

65 20.735190	192.168.43.241	192.168.43.241	SIP	631		Request: REGISTER sip:192.168.43.241 (1 binding) |
66 20.736335	192.168.43.241	192.168.43.241	SIP	651		Status: 200 0K (1 binding) |
83 28.824760	192.168.43.241	192.168.43.241	SIP	631		Request: REGISTER sip:192.168.43.241 (1 binding) |
84 28.825701	192.168.43.241	192.168.43.241	SIP	651		Status: 200 0K (1 binding) |
89 31.424287	192.168.43.241	192.168.43.241	SIP/XML	994		Request: PUBLISH sip:igor@192.168.43.241 |
90 31.424941	192.168.43.241	192.168.43.241	SIP	511		Status: 200 0K |
110 38.511971	192.168.43.241	192.168.43.241	SIP/SDP	1174		Request: INVITE sip:lenka@192.168.43.241 |
111 38.591775	192.168.43.241	192.168.43.241	SIP	271		Status: 100 Skusanie |
112 38.796774	192.168.43.241	192.168.43.241	SIP	457		Status: 180 Zvonenie |
118 40.435418	192.168.43.241	192.168.43.241	SIP/SDP	1241		Status: 200 0k |
119 40.716304	192.168.43.241	192.168.43.241	SIP	434		Request: ACK sip:lenka@192.168.43.1:35833;transport=udp |
132 49.298734	192.168.43.241	192.168.43.241	UDP	36		54650 → 5060 Len=4
137 50.939446	192.168.43.241	192.168.43.241	SIP	648		Request: REFER sip:lenka@192.168.43.1:35833;transport=udp, in-dialog |
138 50.988974	192.168.43.241	192.168.43.241	SIP	456		Status: 202 Accepted |
139 51.177485	192.168.43.241	192.168.43.241	SIP	1425		Request: INVITE sip:igor@192.168.43.241:54650;transport=udp |
140 51.208107	192.168.43.241	192.168.43.241	SIP	344		Status: 100 Trying |
141 51.209287	192.168.43.241	192.168.43.241	SIP/SDP	1292		Status: 200 0k |
142 51.334756	192.168.43.241	192.168.43.241	SIP	532		Request: ACK sip:igor@192.168.43.241:54650;transport=udp |
179 72.150273	192.168.43.241	192.168.43.241	SIP	434		Request: BYE sip:lenka@192.168.43.1:35833;transport=udp |
180 72.190475	192.168.43.241	192.168.43.241	SIP	448		Status: 200 0k |
193 79.300168	192.168.43.241	192.168.43.241	UDP	36		54650 → 5060 Len=4

```
∨ Session Initiation Protocol (REFER)
  > Request-Line: REFER sip:lenka@192.168.43.1:35833;transport=udp SIP/2.0
  > Message Header
  ∨ Message Body
      Via: SIP/2.0/UDP 192.168.43.241:5060;branch=z9hG4bK.niGv-~iRlm\r\n
      Via: SIP/2.0/UDP 192.168.43.241:54650;branch=z9hG4bK.niGv-~iRl;received=192.168.43.241;rport=54650\r\n
      From: <sip:igor@192.168.43.241>;tag=rYqD~Zf87\r\n
      To: <sip:lenka@192.168.43.241>;tag=p4kkt2J\r\n
      CSeq: 21 REFER\r\n
      Call-ID: WTPAYFQLoA\r\n
      Max-Forwards: 70\r\n
      Refer-To: sip:lukas@192.168.43.241\r\n
      Referred-By: <sip:igor@192.168.43.241>;tag=rYqD~Zf87\r\n
      Contact: <sip:igor@192.168.43.241:54650;transport=udp>;+sip.instance="<urn:uuid:fccc11a7-d5e7-0087-939a-4ab188b5592d>"\r\n
      User-Agent: Linphone Desktop/4.3.2 (Windows 10 Version 2009, Qt 5.14.2) LinphoneCore/5.0.49\r\n
      \r\n
```

- Presmerovanie hovoru z PC (igor) na druhý mobil (lukas).

Využité všetky importy v implementácii:

- import sipfullproxy
- import socketserver
- import socker
- import sys
- import time
- import logging
- import re
- import main