

— Master of Engineering in Information Technology —

WS 2023-24

Mobile Computing

Open5GS-UERANSIM: VoIP, Message, Internet and File Sharing Realization

Presented By

Group 5Gtechtribe

Date: 25.02.2024

Under Guidance - Prof. Dr. Armin Lehmann

MEET OUR TEAM



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1448072

- Project Architecture
- Designing test case planning
- Implement the network slicing scenarios
- Validation of Results



Vinay Bandaru
1447125

- Implementation of test cases
- Integration of all the slices
- Trouble shooting the realtime issues
- Validation of Results



Sahith Singari
1446809

- Research on Topics
- Configuration and Compatibility Testing for realtime issues
- Continuous Readme moderation



Anil Gadiraju
1428607

- Document the Process Steps
- Result Validation and Interpretation
- Power Point Moderation

AGENDA

01 Overview



Anil Kumar Gadiraju

02 Project Architecture and Configuration



Sahith Kumar Singari

03 Network slices



Ankush Patil

04 Project Demo



Vinay Kumar Bandaru

05 Conclusion



Vinay Kumar Bandaru

Section 01

OVERVIEW

PROJECT LANDSCAPE

The objective of this project is to understand, configure, and implement the Open5GS core network along with UE (User Equipment) simulation. This will involve constructing three network slices catering to different functionalities using slicing techniques.

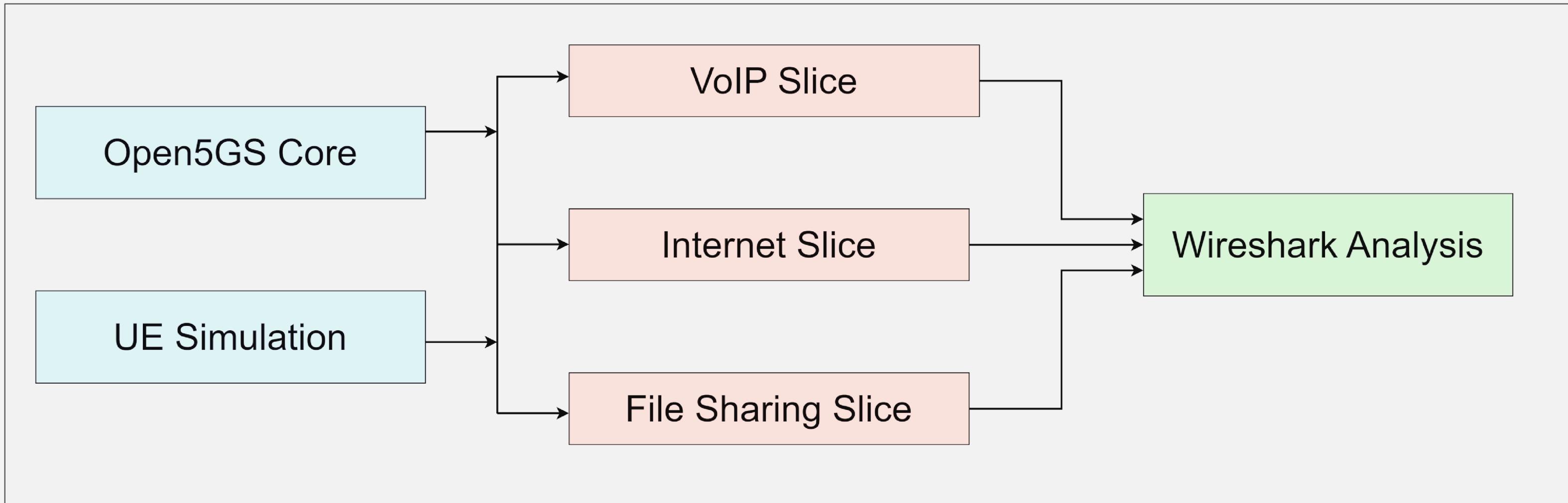


Figure 1 : Project Landscape

PROJECT PLANNING

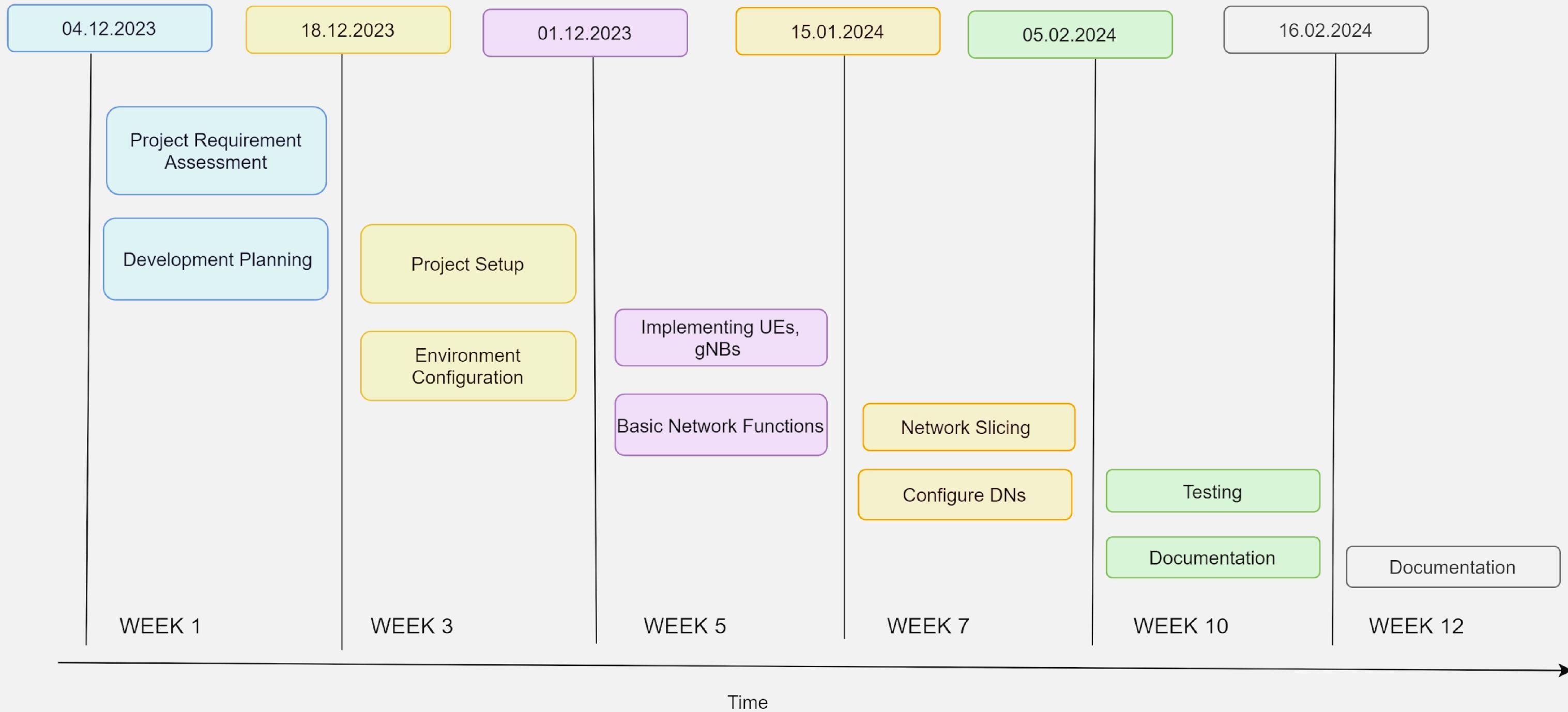


Figure 2: Project Planning

CORE COMPONENTS

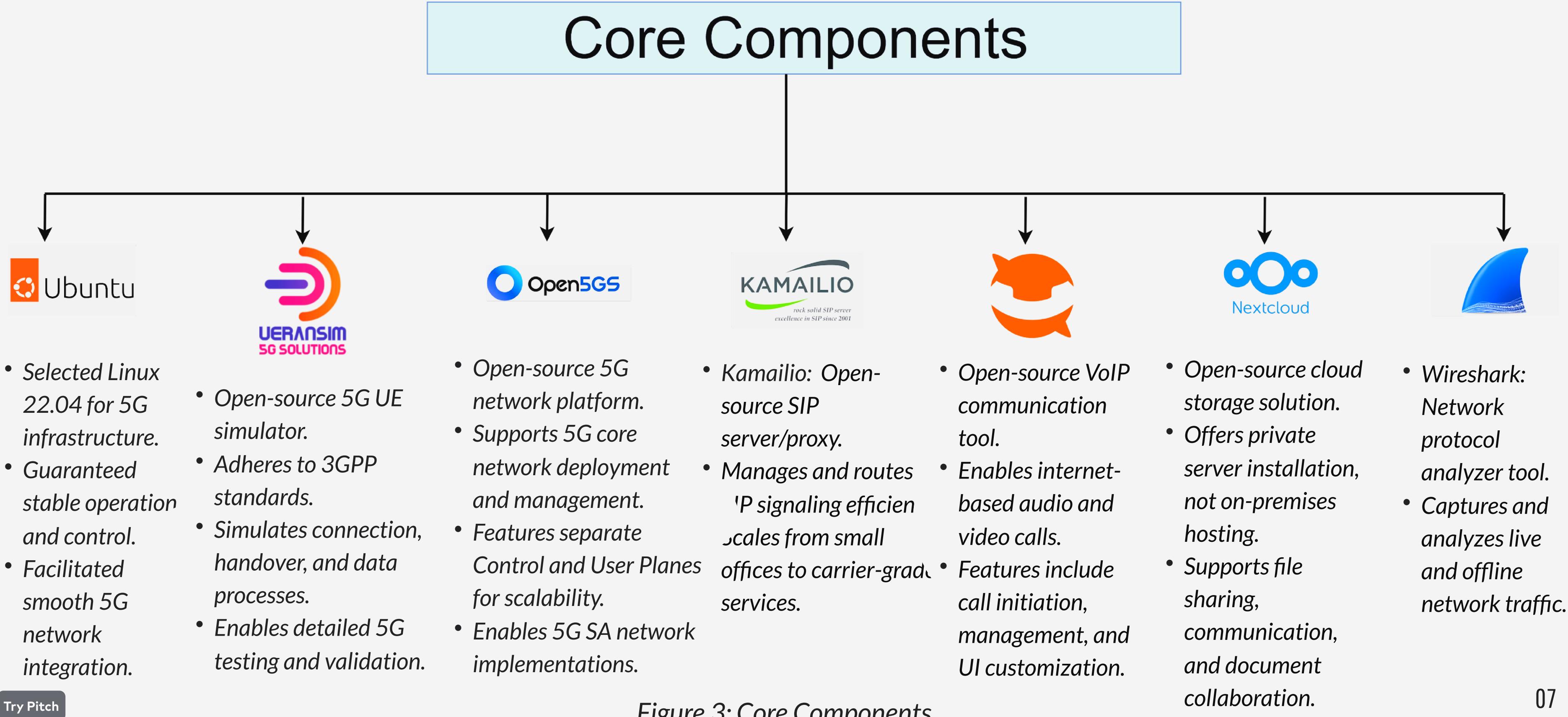


Figure 3: Core Components

OPEN5GS CORE

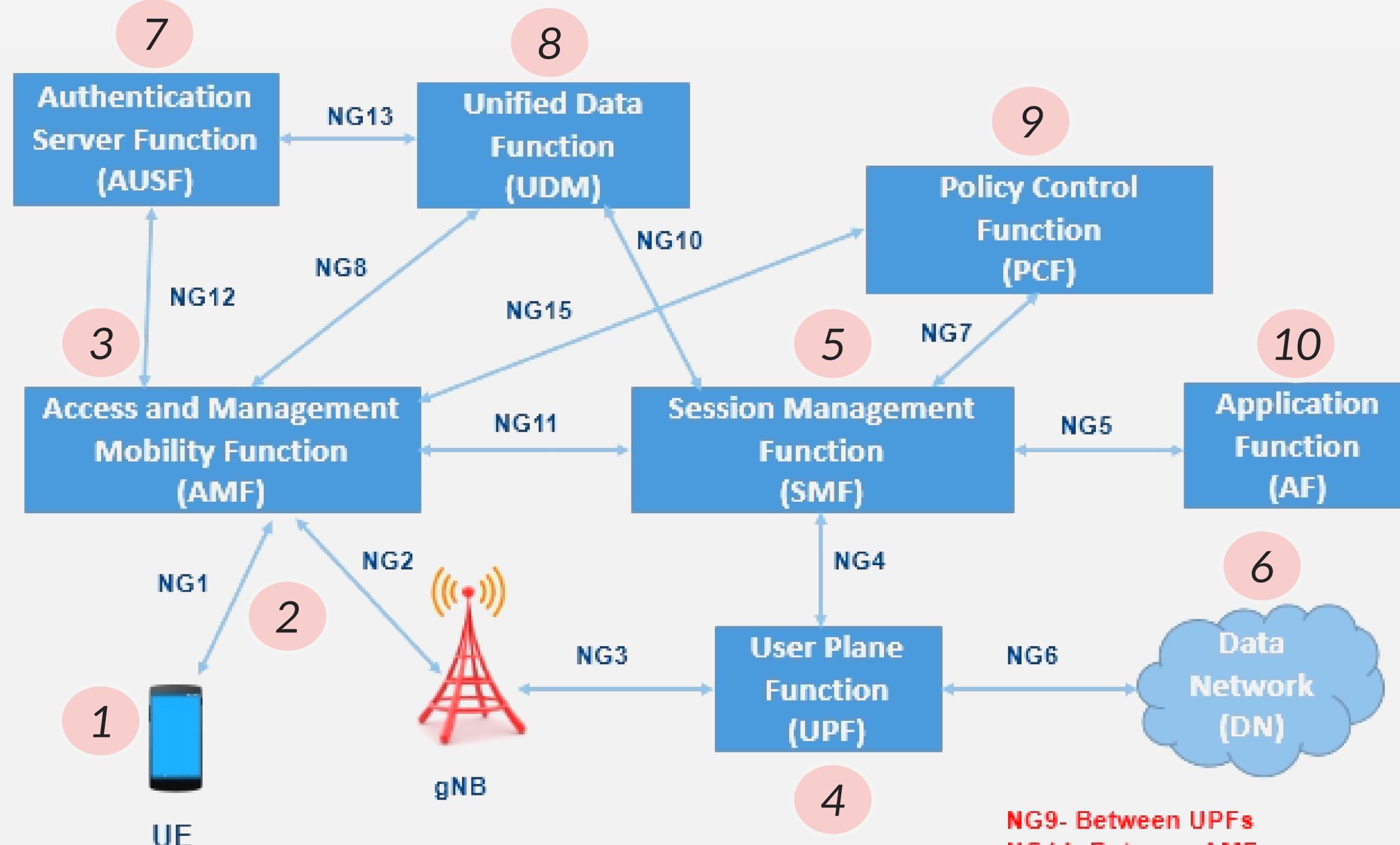


Figure 4: Open5gs Core

1. User Equipment (UE)
2. Next Gen Node Basestation (gNB)
3. Access and Mobility Management Function (AMF)
4. User Plane Function (UPF)
5. Session Management Control Function (SMF)
6. Data Network (DN)
7. Authentication Server Function (AUSF)
8. Unified Data Management (UDM)
9. Policy Control Function (PCF)
10. Application Function (AF)

Section 02

PROJECT ARCHITECTURE AND CONFIGURATION

HIGH LEVEL DIAGRAM

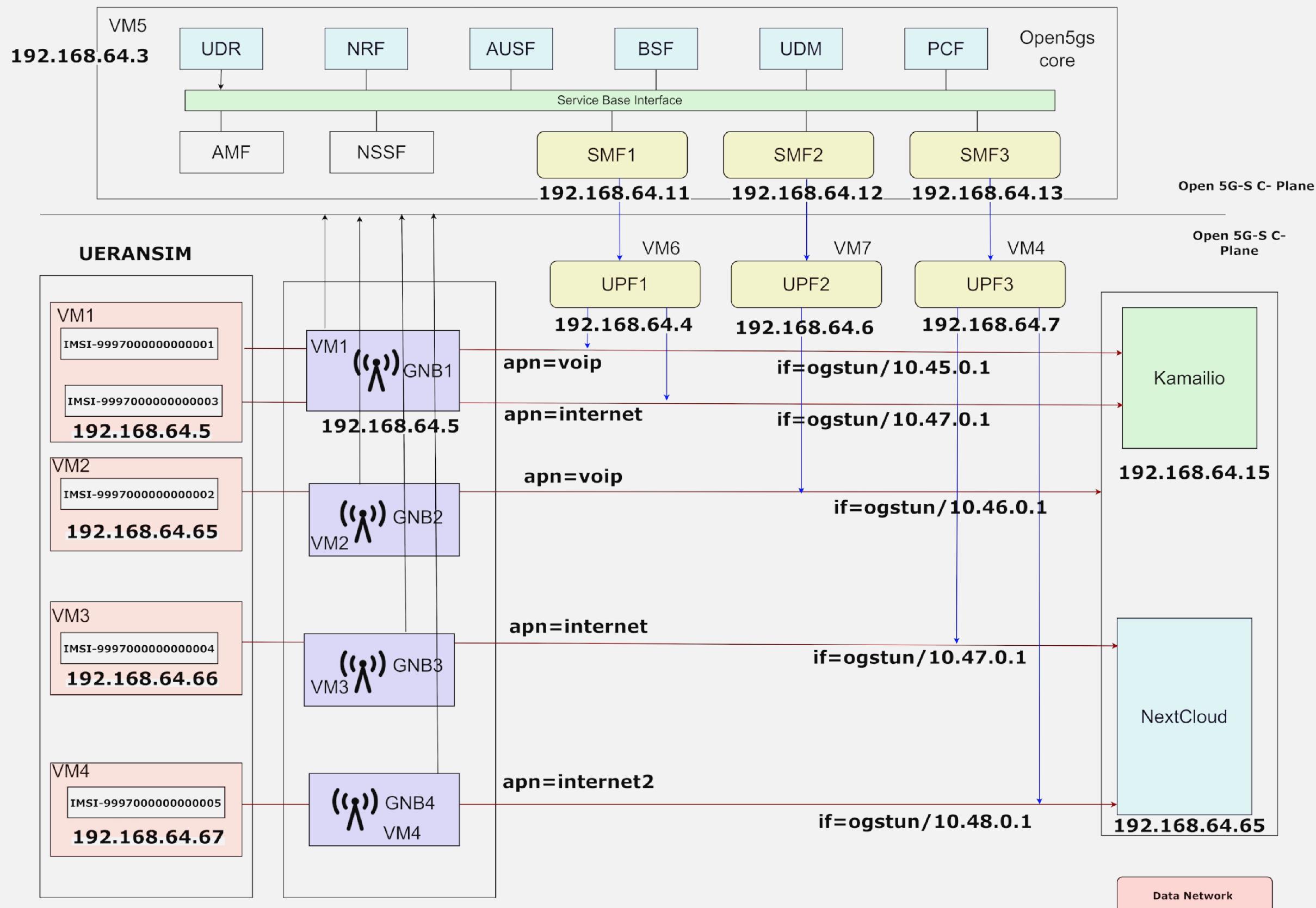


Figure 5: High-Level Diagram

ROLE AND CONFIGURATION SETUP

VM #	SW & Role	IP Address	OS	Memory (Min)	HDD (Min)
VM1	UERANSIM v3.3.0 UE1	192.168.64.5	Ubuntu 22.04	4GB	25GB
VM1	UERANSIM v3.3.0 UE3	192.168.64.5	Ubuntu 22.04	4GB	25GB
VM1	UERANSIM v3.3.0 RAN(gNodeB1)	192.168.64.5	Ubuntu 22.04	4GB	25GB
VM2	NextCloud v24.0.0 for File sharing	192.168.64.65	Ubuntu 22.04	4GB	25GB
VM2	UERANSIM v3.3.0 UE2	192.168.64.65	Ubuntu 22.04	4GB	25GB
VM2	UERANSIM v3.3.0 RAN(gNodeB2)	192.168.64.65	Ubuntu 22.04	4GB	25GB
VM3	UERANSIM v3.3.0 UE4	192.168.64.66	Ubuntu 22.04	4GB	25GB
VM3	UERANSIM v3.3.0 RAN(gNodeB3)	192.168.64.66	Ubuntu 22.04	4GB	25GB
VM4	UERANSIM v3.3.0 UE5	192.168.64.67	Ubuntu 22.04	4GB	25GB
VM4	UERANSIM v3.3.0 RAN(gNodeB4)	192.168.64.67	Ubuntu 22.04	4GB	25GB
VM4	Open5GS v2.6.0 5GC U-Plane3	192.168.64.7	Ubuntu 22.04	4GB	25GB
VM5	Kamailio v5.5.6 for SIP VoIP	192.168.64.15	Ubuntu 22.04	4GB	25GB
VM5	Open5GS v2.6.0 5GC C-Plane	192.168.64.3	Ubuntu 22.04	4GB	25GB
VM6	Open5GS v2.6.0 5GC U-Plane1	192.168.64.4	Ubuntu 22.04	4GB	25GB
VM7	Open5GS v2.6.0 5GC U-Plane2	192.168.64.6	Ubuntu 22.04	4GB	25GB

Table 1: Role and configuration setup

DATA NETWORKS & AMF AND NSSF CONFIGURATION

Data Network	S-NSSAI	TUNnel interface of DN	DNN	TUNnel interface of UE	U-Plane #
10.45.0.1/16	SST:1 SD:0x000001	ogstun/10.45.0.1	Voip	uesimtun0	U-Plane 1
10.46.0.1/16	SST:1 SD:0x000002	ogstun2/10.46.0.1	Voip	uesimtun0	U-Plane 2
10.47.0.1/16	SST:2 SD:0x000001	ogstun3/10.47.0.1	Internet	uesimtun0	U-Plane 1
10.47.0.1/16	SST:2 SD:0x000002	ogstun4/10.47.0.1	Internet	Uesimtun0	U-Plane 3
10.48.0.1/16	SST:2 SD:0x000003	ogstun4/10.48.0.1	Internet2	Uesimtun2	U-Plane 3

Table 2: Data networks

Network Function	IP Address	IP Address on SBI	Supported S-NSSAI
AMF	192.168.64.3	127.0.0.5	SST: 1 SD: 000001, SST: 1 SD: 000002, SST: 2 SD: 000001, SST: 2 SD: 000002, SST: 2 SD: 000003
NSSF-SST1-SD1	192.168.64.3	127.0.0.10	SST: 1 SD: 000001
NSSF-SST1-SD2	192.168.64.3	127.0.0.10	SST: 1 SD: 000002
NSSF-SST2-SD1	192.168.64.3	127.0.0.10	SST: 2 SD: 000001
NSSF-SST2-SD2	192.168.64.3	127.0.0.10	SST: 2 SD: 000002
NSSF-SST2-SD3	192.168.64.3	127.0.0.10	SST: 2 SD: 000003

Table 3: AMF and NSSF configuration

SUBSCRIBER INFORMATION

UE Name	IMSI	DNN	Supported S-NSSAI
Ue1	9017000000000001	voip	SST: 1 SD: 0x000001
Ue2	9017000000000002	voip	SST: 1 SD: 0x000002
Ue3	9017000000000003	Internet	SST: 2 SD: 0x000001
Ue4	9017000000000004	Internet	SST: 2 SD: 0x000002
Ue5	9017000000000005	Internet2	SST: 2 SD: 0x000003

Table 4: Subscriber Information

COMPONENTS CONFIGURATION

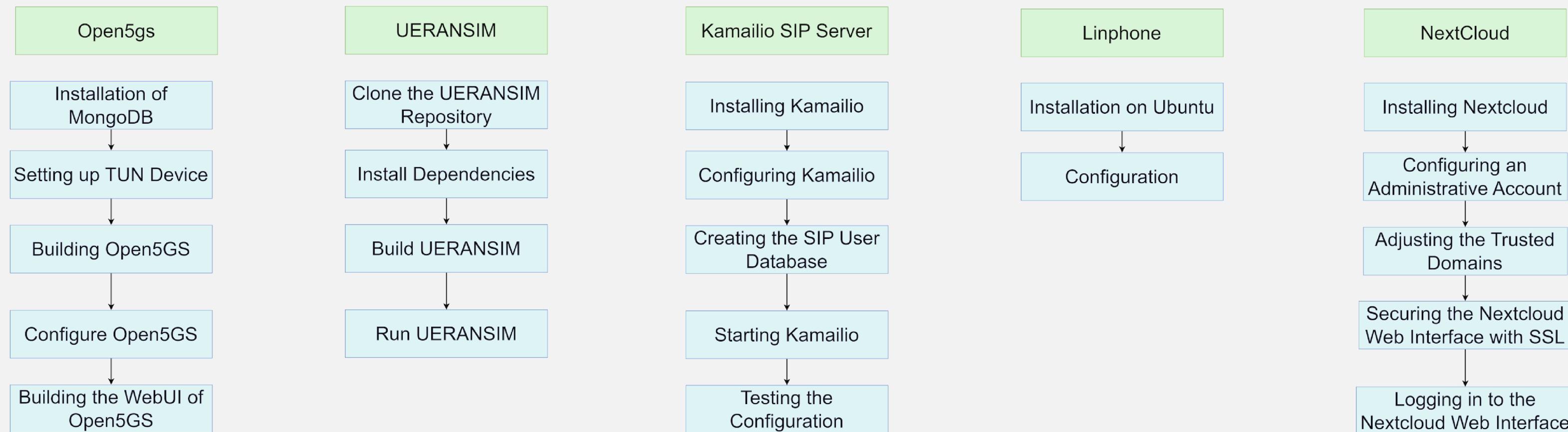


Figure 6: Core Components Configurations

Section 03

NETWORK SLICES

NETWORK SLICING

Implemented Network Slices:

- **VoIP (Voice over Internet Protocol):** Utilizing SIP (Session Initiation Protocol) for establishing voice calls over the Internet.
- **Messaging:** Enabling text-based communication between users over the network.
- **Internet:** Providing access to web services and online resources through the network.
- **File Sharing:** Facilitating the exchange of files and documents between users via the network.

VOIP VOICE CALLING SLICE

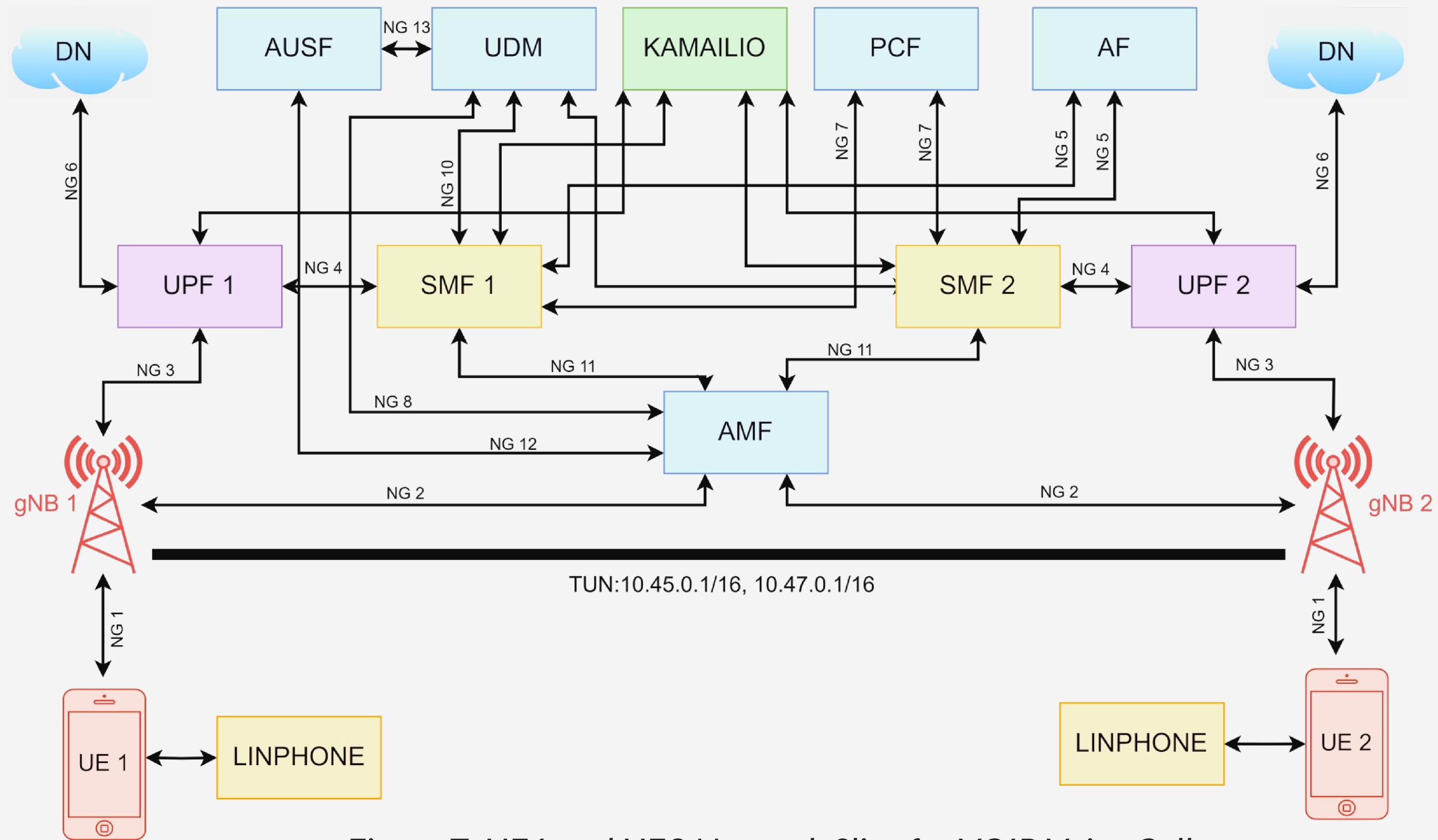
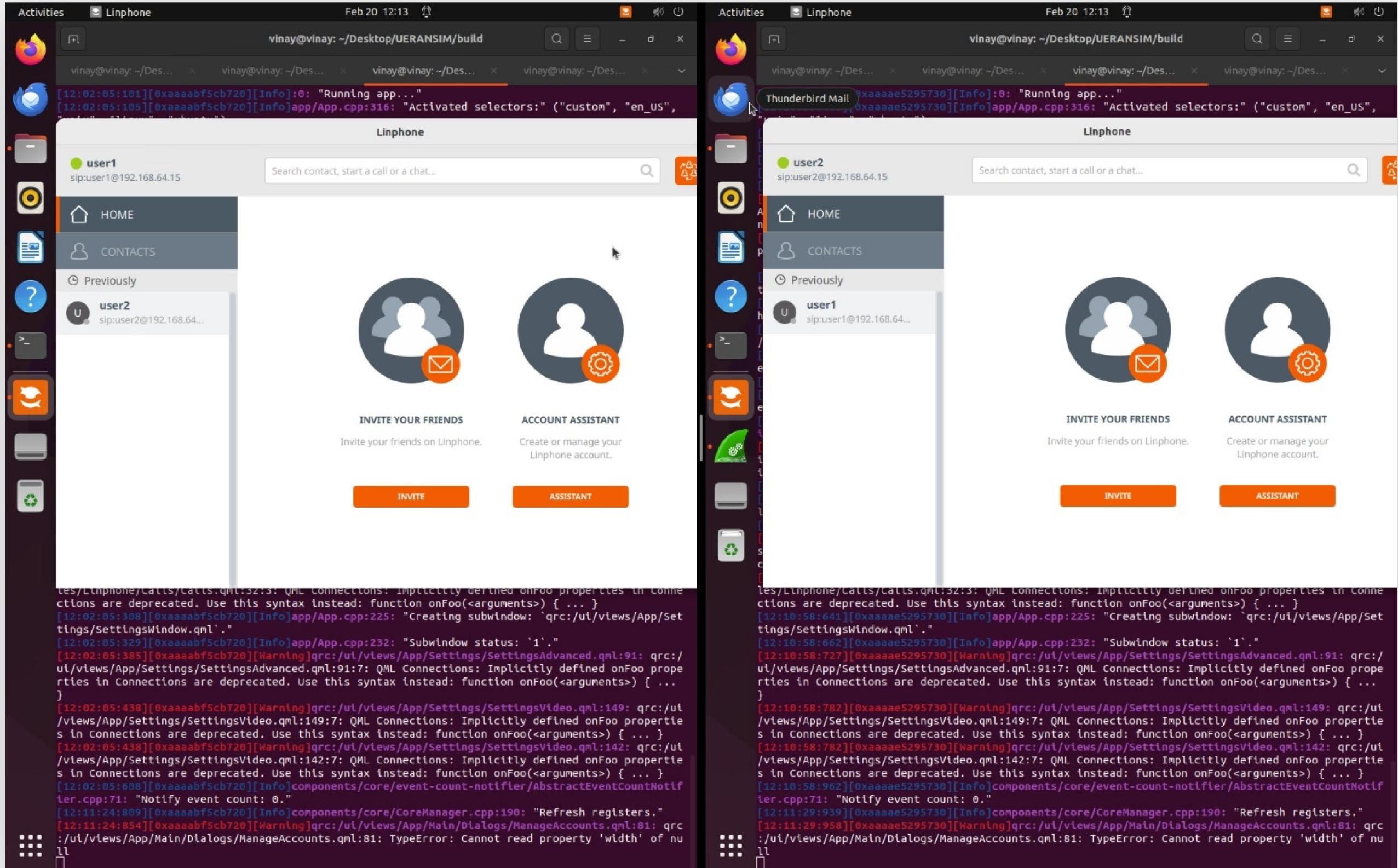


Figure 7: UE1 and UE2 Network Slice for VOIP Voice Calls

The VoIP slice is configured for the UE1 and UE2 to establish the voice communication.

- **Kamailio Server:** Configured to facilitate VoIP communication.
- **Linphone VoIP Client:** Installed and configured for SIP VoIP Calling.
- **User Equipment (UE) 1 and UE 2:** Configured to communicate with each other via VoIP..

VOIP VOICE CALLING SLICE



Linphone Configuration:

- Subscriber accounts registered in Kamailio database logged in on both UEs.
- Activation of both the user to establish the communication

Figure 8: Activation of both user to establish communication

VOIP VOICE CALLING SLICE

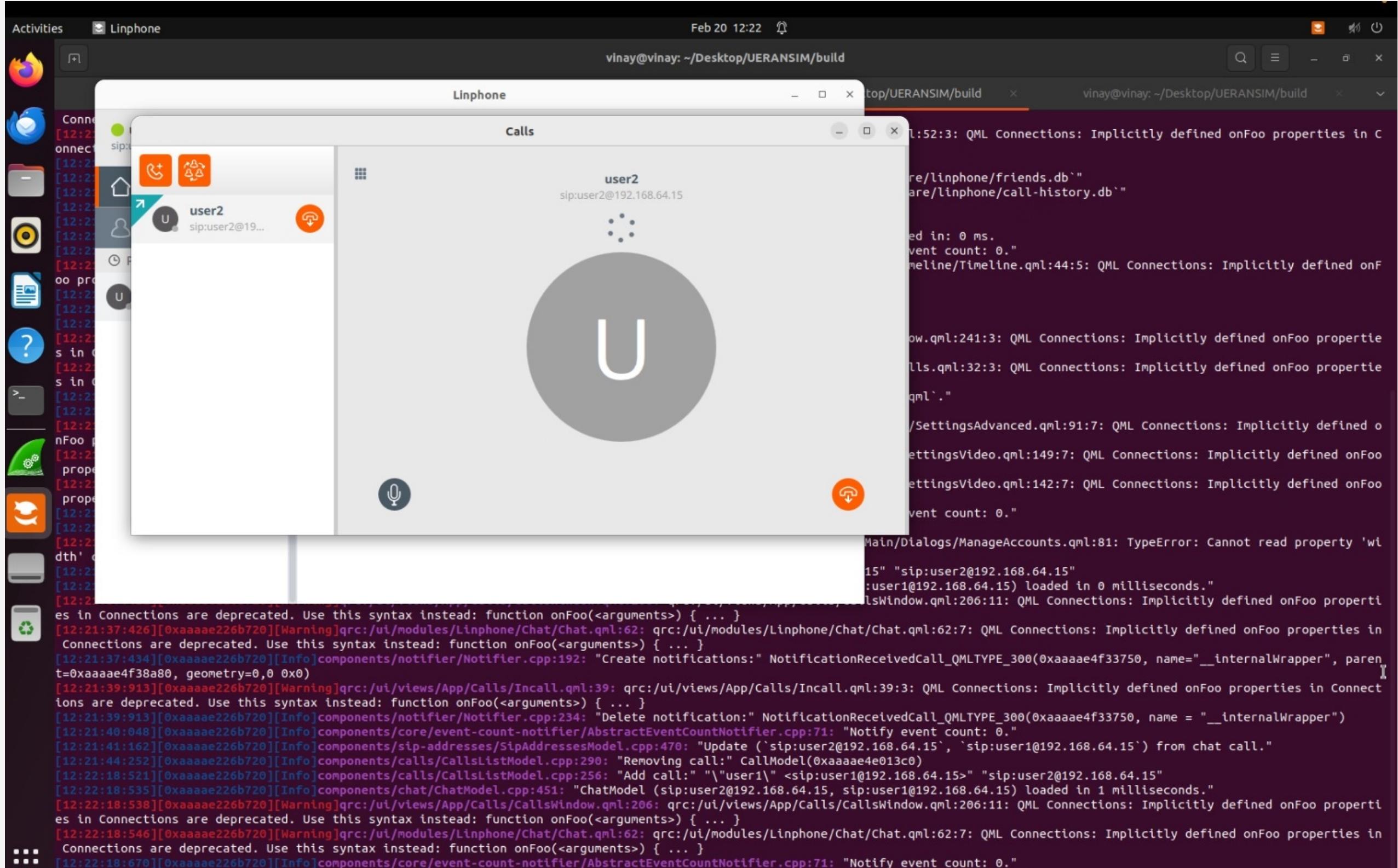


Figure 9: VoIP Call Initiation

Call Initiation form UE1

- UE 1 initiates VoIP call.
- Ringing notification appears on UE2's interface.

VOIP VOICE CALLING SLICE

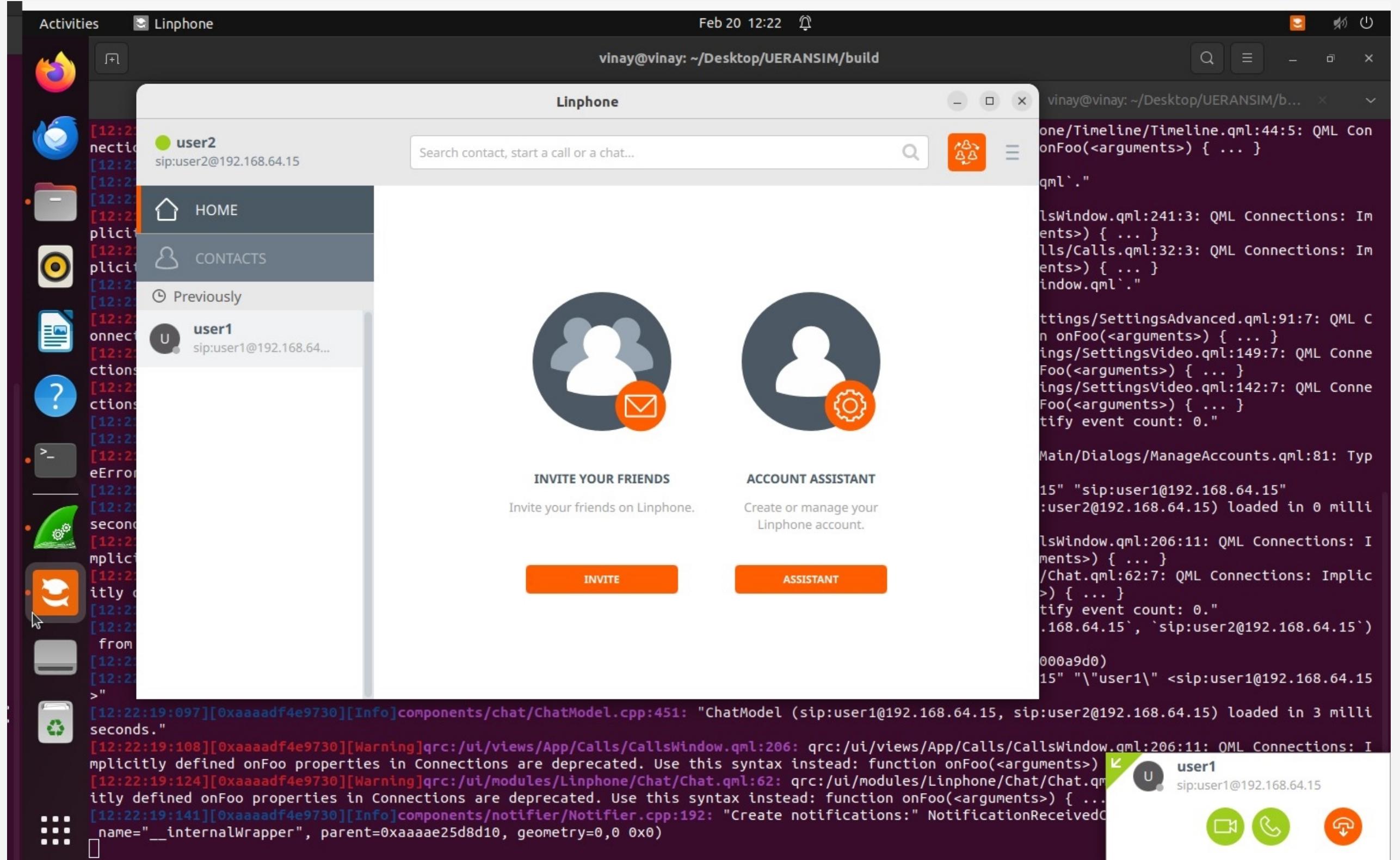
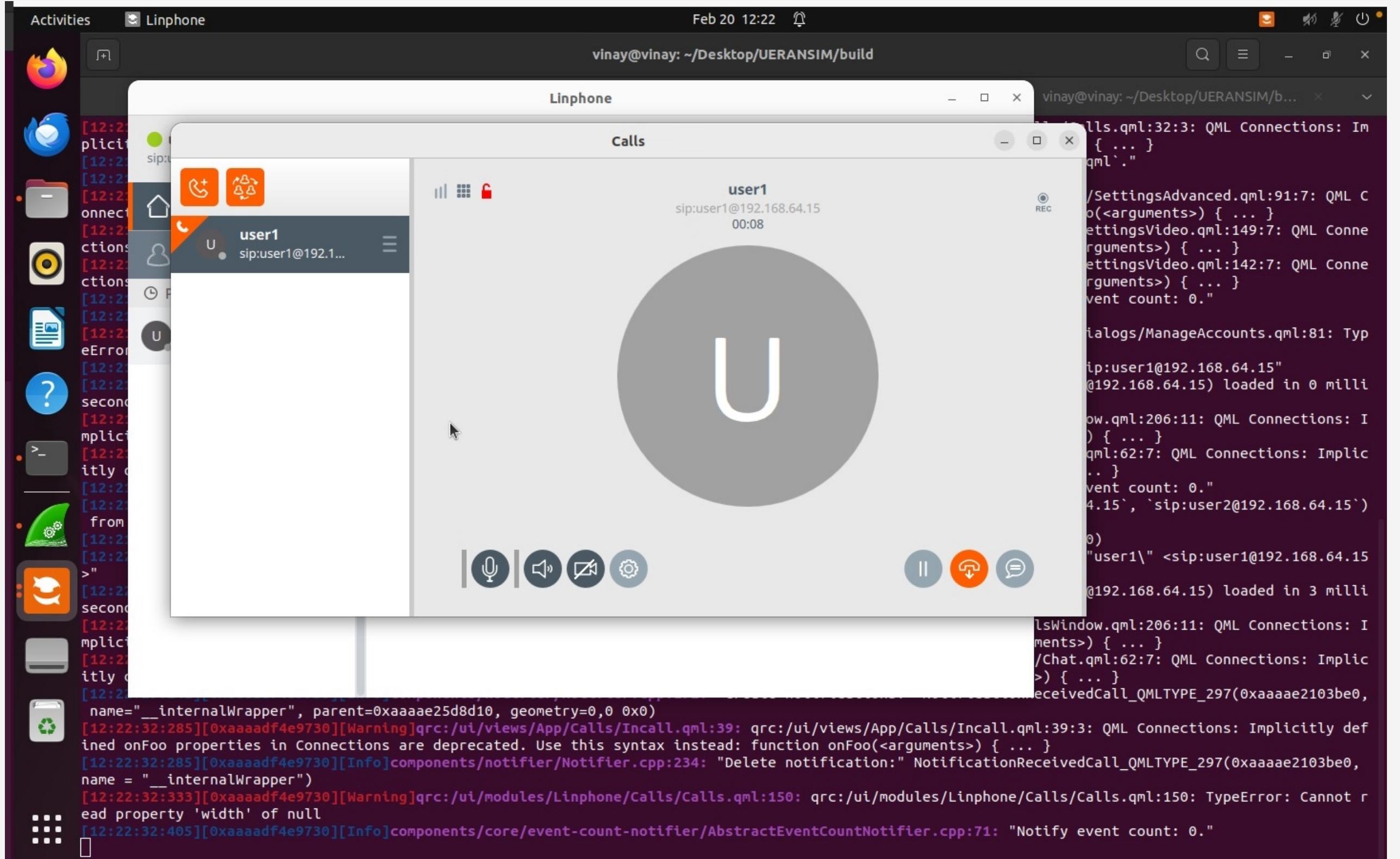


Figure 10: Linphone Interface of UE2 Receives the Call from UE1

Linphone Interface of UE2

- Ringing notification appears on UE2's interface.
- Action - Accept/Reject

VOIP VOICE CALLING SLICE



Acceptance:

- UE2 Accepts the call and session timers started
- Ready to exchange the data over Voice

Figure 11: VoIP Voice call Acceptance from UE2

VOIP VOICE CALLING SLICE

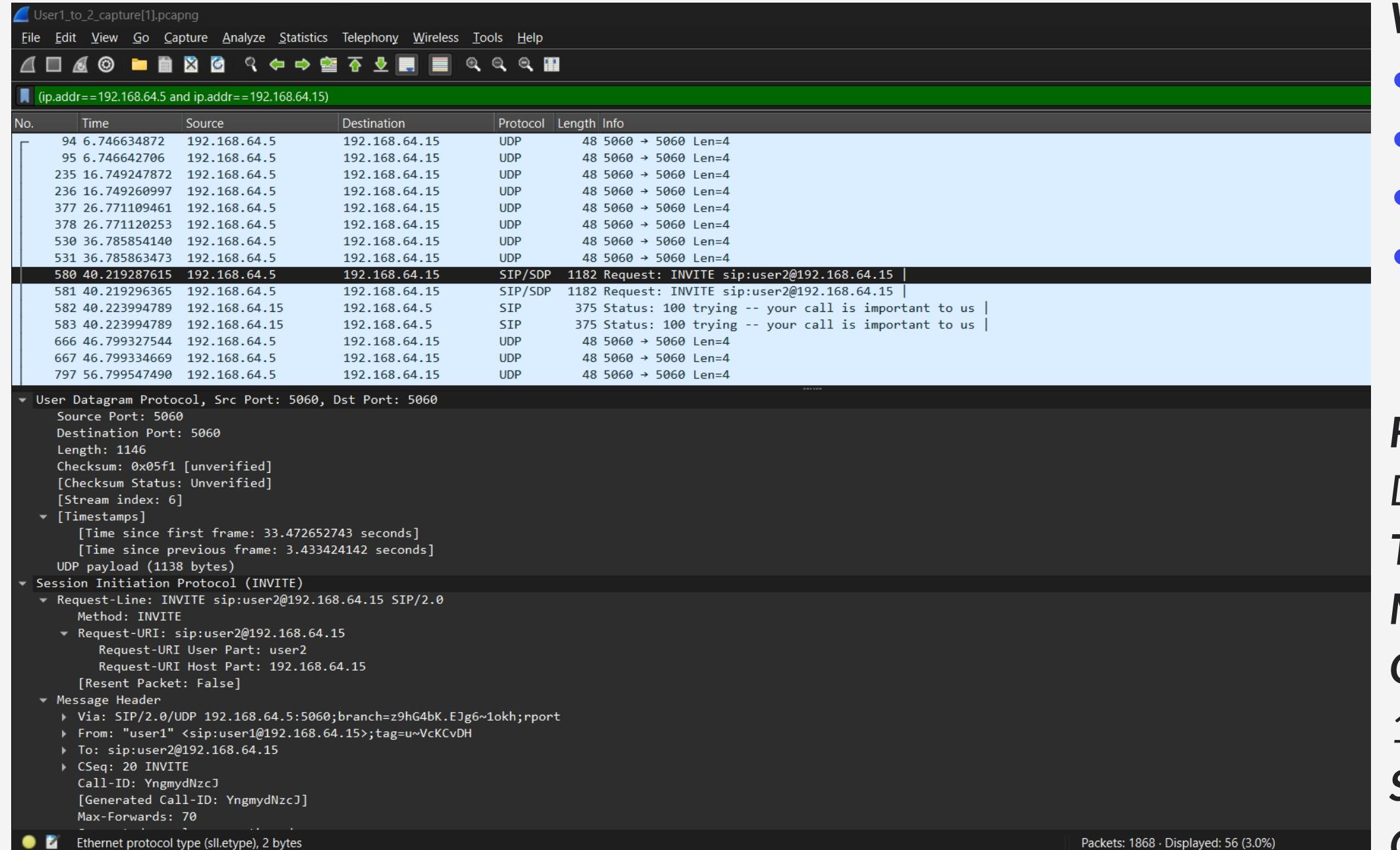


Figure 12: Wireshark Capture on UE1 for Network Slice for VOIP Voice Calls

Wireshark Capture on UE1

- Session Request.
- Initiation of ringing.
- Capture of SIP proxy URI.
- SIP/SDP protocol.

From:"user1<sip:user1@192.168.64.15>;tag=u~VcKCvDH

To: sip:user2@192.168.64.15

Method: INVITE

Owner/Creator, Session Id (o): user1 1709 346 IN IP4

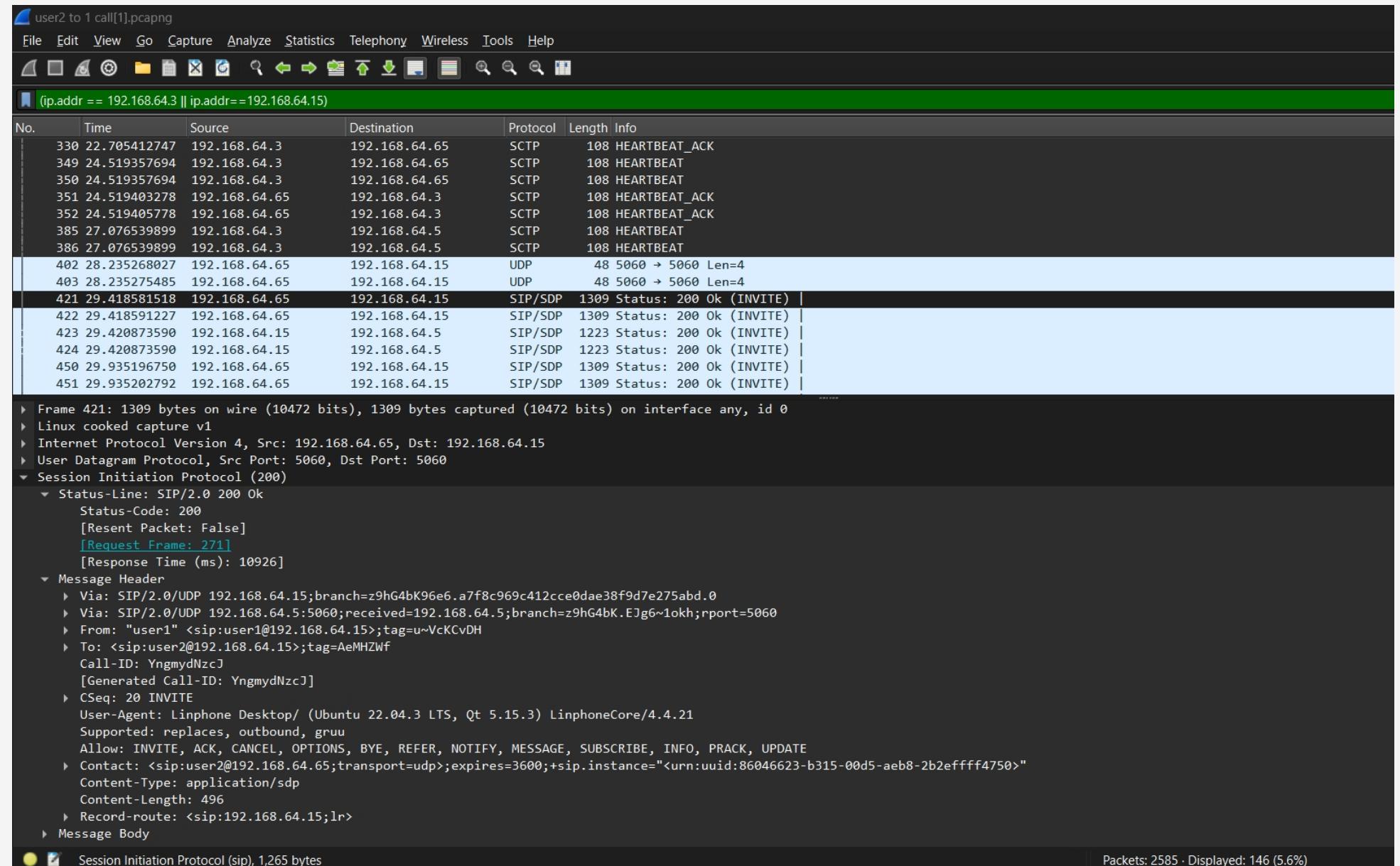
192.168.64.5

Session Name (s): Talk

Codec Used: audio 7078 RTP/AVP 96 97 98 08 101 99

100

VOIP VOICE CALLING SLICE



Wireshark Capture on UE2

- Establishment of session.
- Detection of voice channel establishment.

From: "user1" <sip:user1@192.168.64.15>;tag=u~VcKCvDH

To: <sip:user2@192.168.64.15>;tag=AeMHZWf

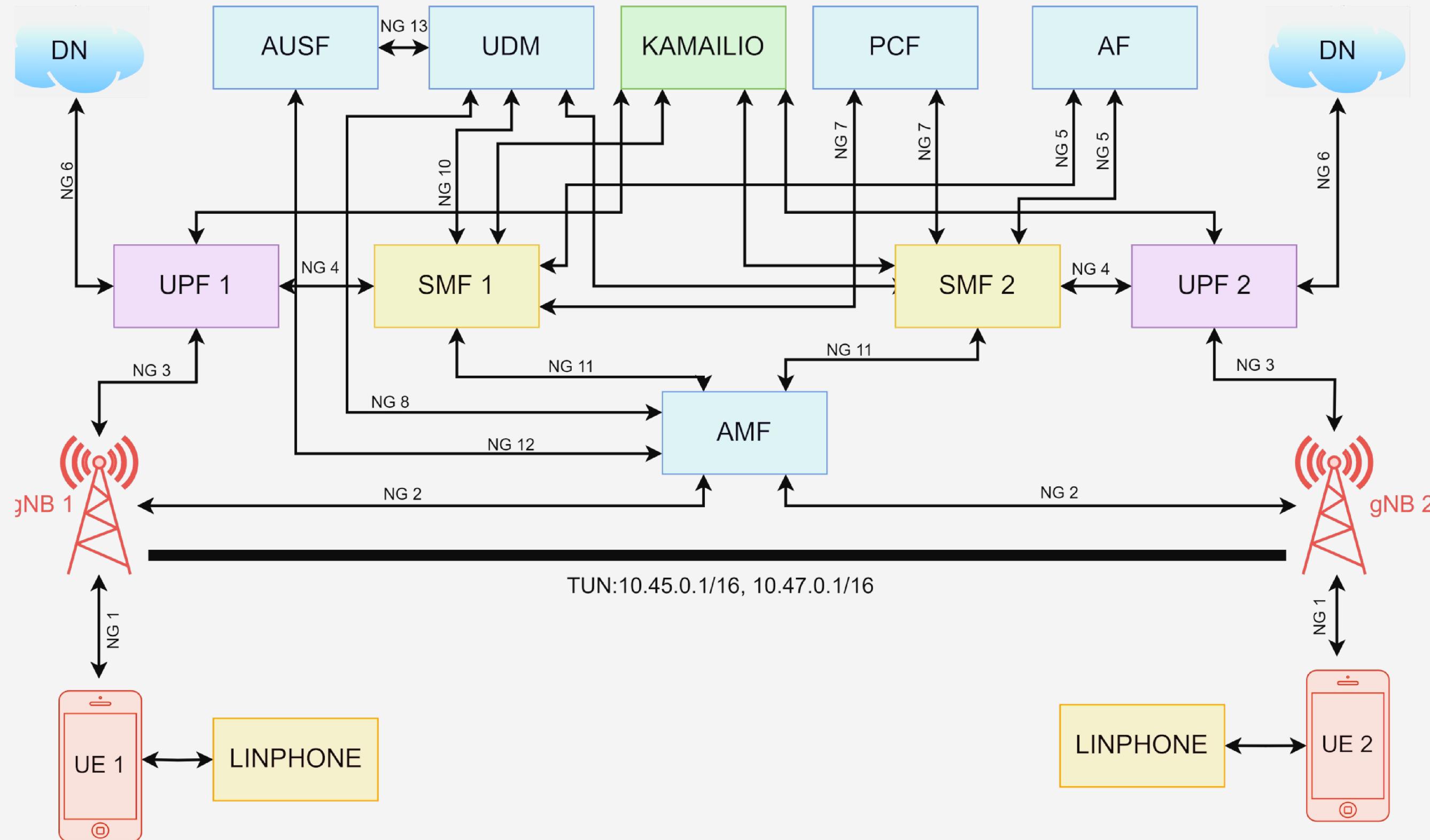
Call-ID: YngmydNzcJ

User-Agent: Linphone Desktop/ (Ubuntu 22.04.3 LTS, Qt

5.15.3) LinphoneCore/4.4.21

Figure 13: Wireshark Capture on UE1 for Network Slice for VOIP Voice Calls

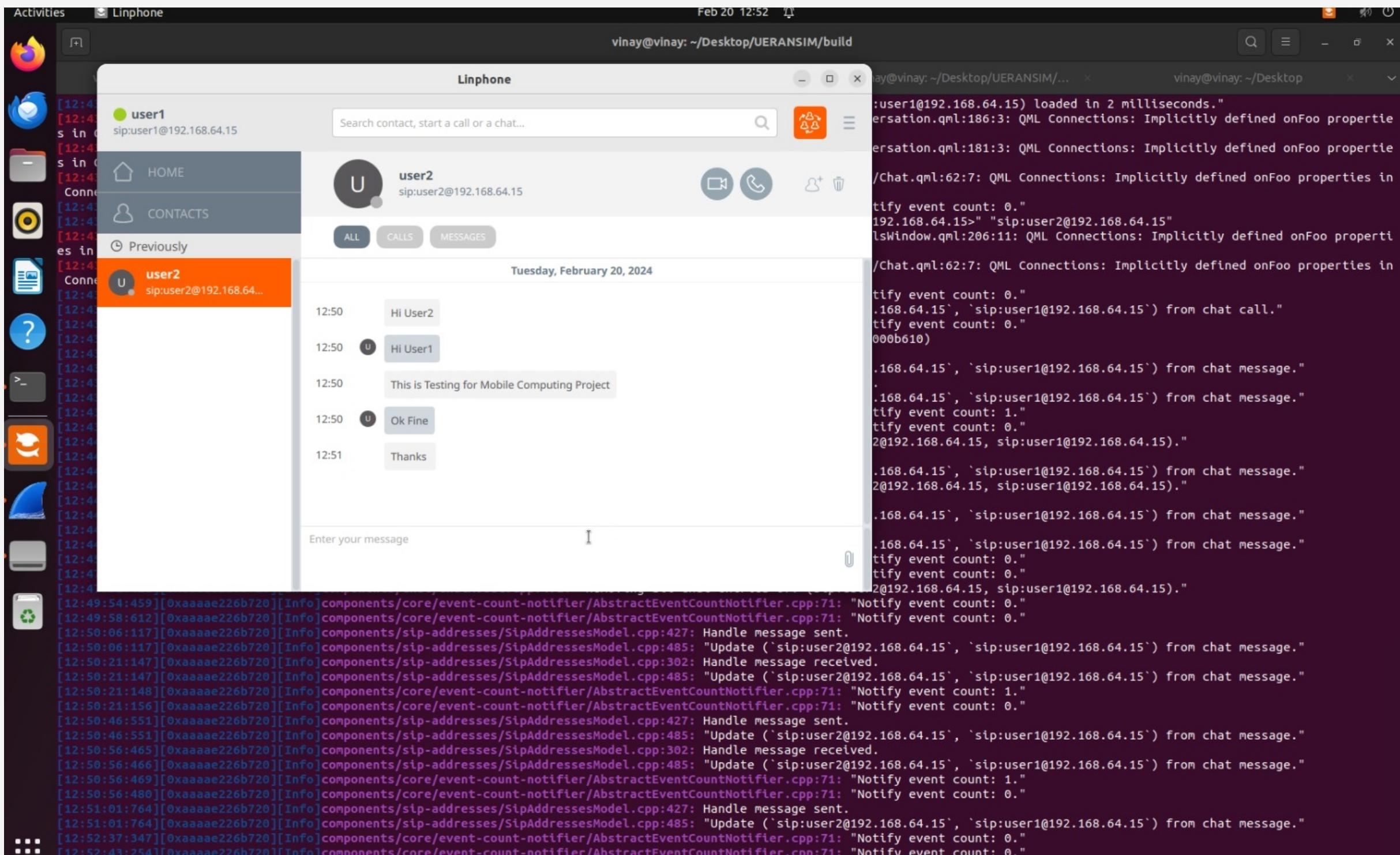
MESSAGING



**Linphone Configuration for
Message Communication
Between UE1 and UE2**

Figure 14 : UE1 and UE2 Network Slice for Messages

MESSAGING



UE1 Message Interface :

- UE1 sends "Hi User2" message to UE2 by using a Kamailio

Figure 15: UE1 Message Interface of Network message slice

MESSAGING

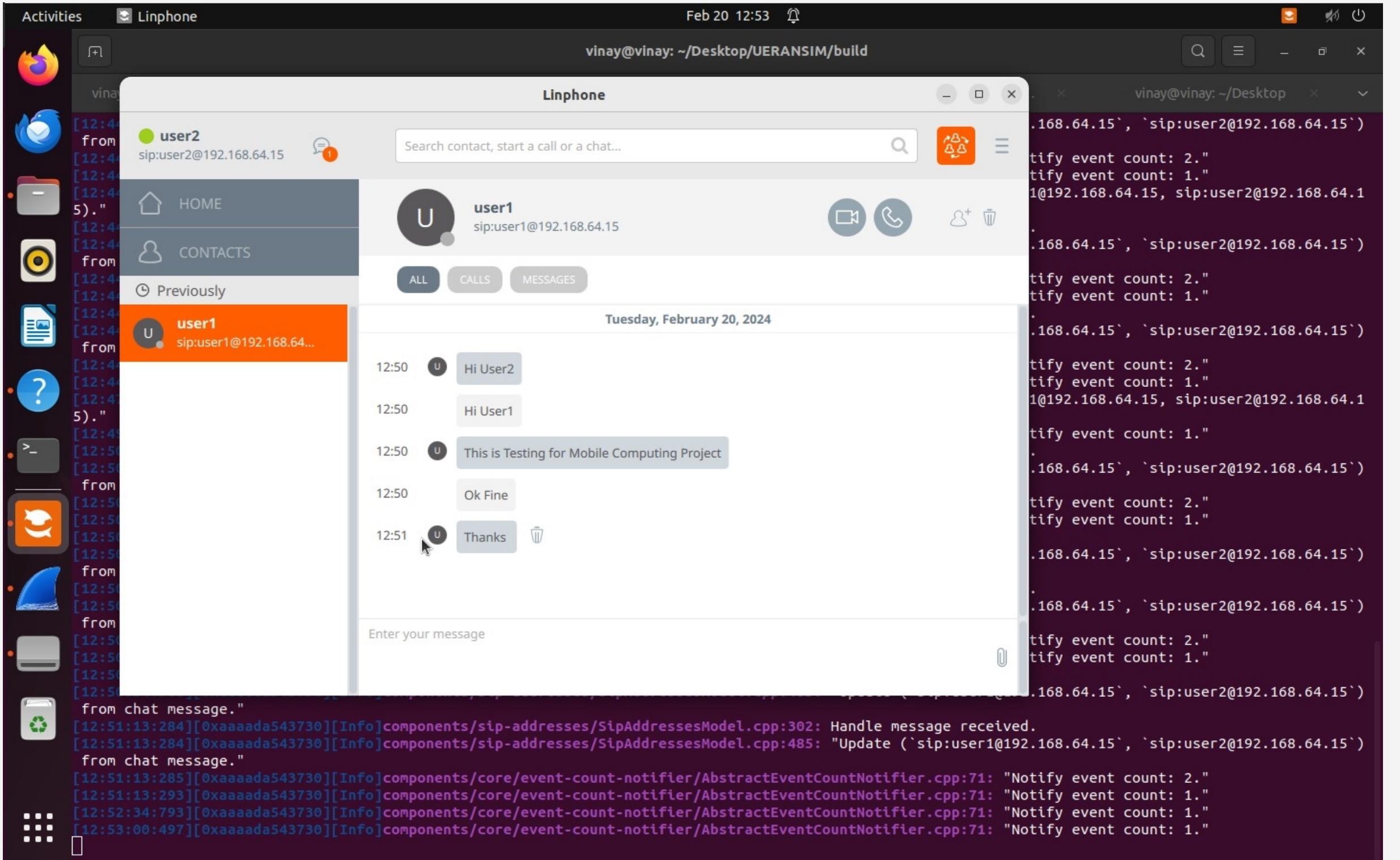
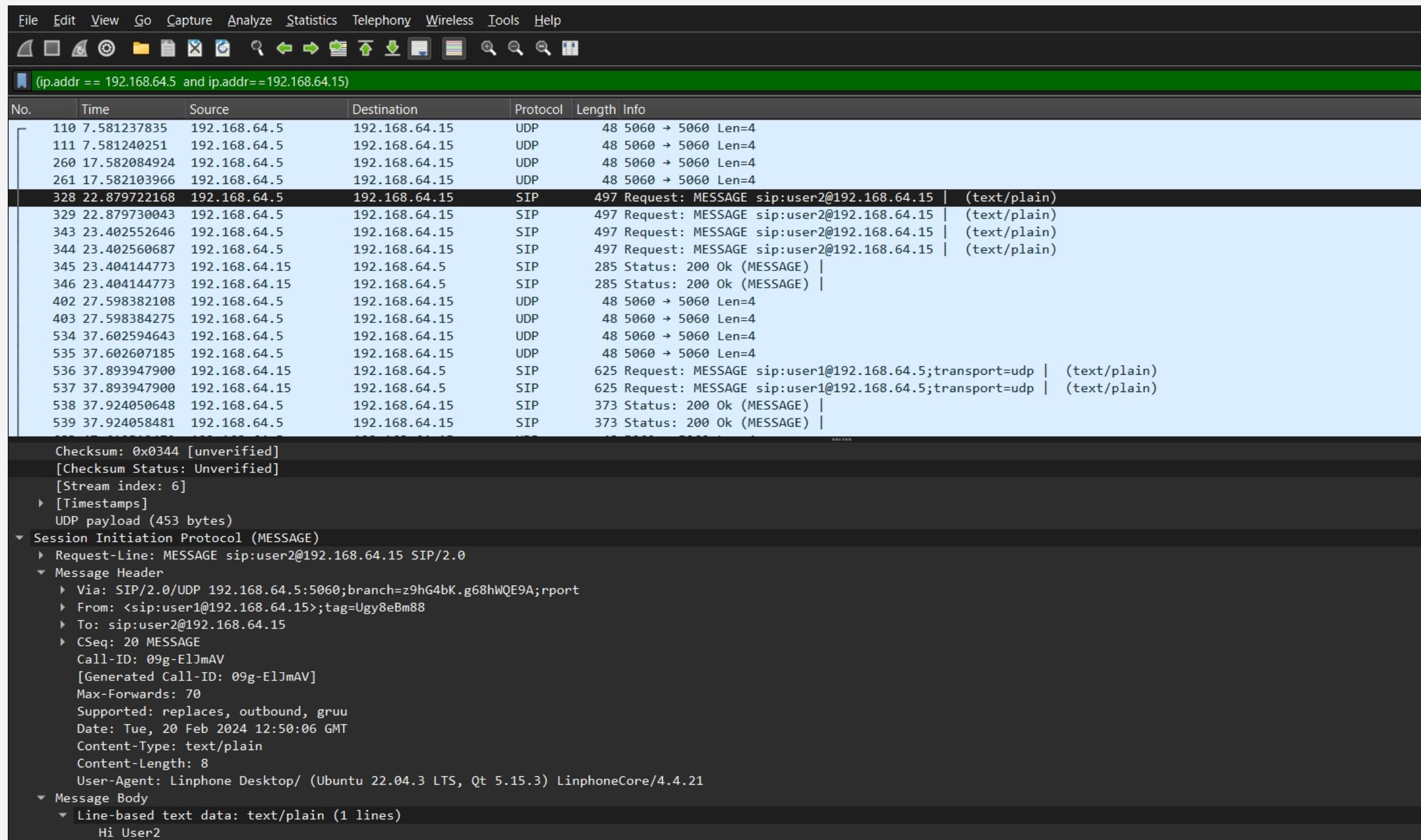


Figure 16: UE2 Message Interface of Network message slice

UE2 Message Interface :

- UE2 reply to U1 by saying "Hi User1" Promptly.

MESSAGING



Wireshark Capture on UE1 :

- UE1 Session Initiation Request
- UE1 Outbound Message to UE2

From:

<sip:user1@192.168.64.15>;tag=Ugy8eBm
88

To: sip:user2@192.168.64.15

Request-URI: sip:user2@192.168.64.15

Message Body

Line-based text data: text/plain (1 lines)

Hi User2

Figure 17: Wireshark capture at UE1 for Network Message Slice

MESSAGING

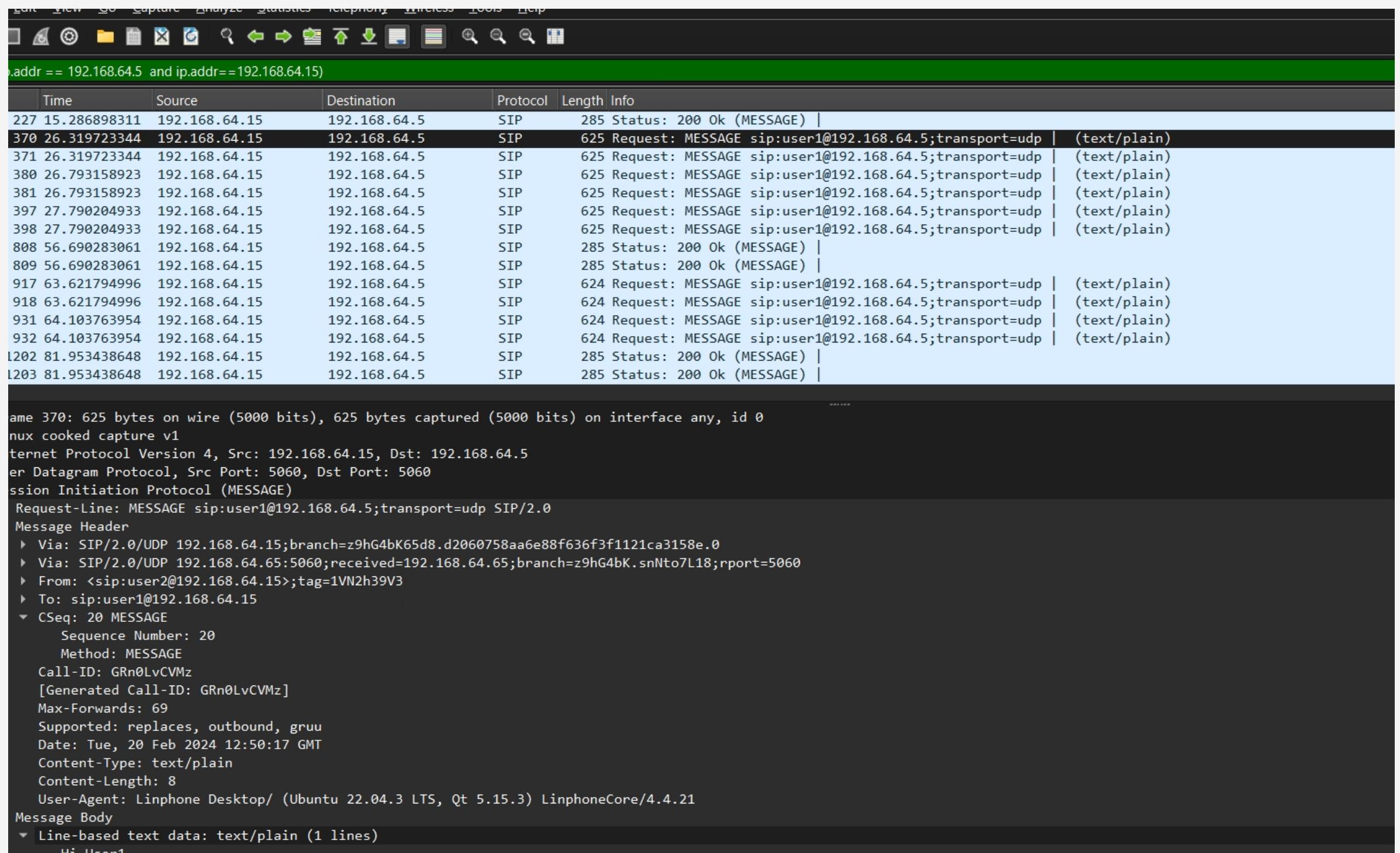


Figure 18: Wireshark capture at UE2

Wireshark Capture on UE1 :

- UE2 Session Initiation Request
- UE2 Outbound Message to UE1

From:

<sip:user2@192.168.64.15>;tag=1VN2h39

V3

To: sip:user1@192.168.64.15

SIP from address: sip:user2@192.168.64.15

SIP from tag: 1VN2h39V3

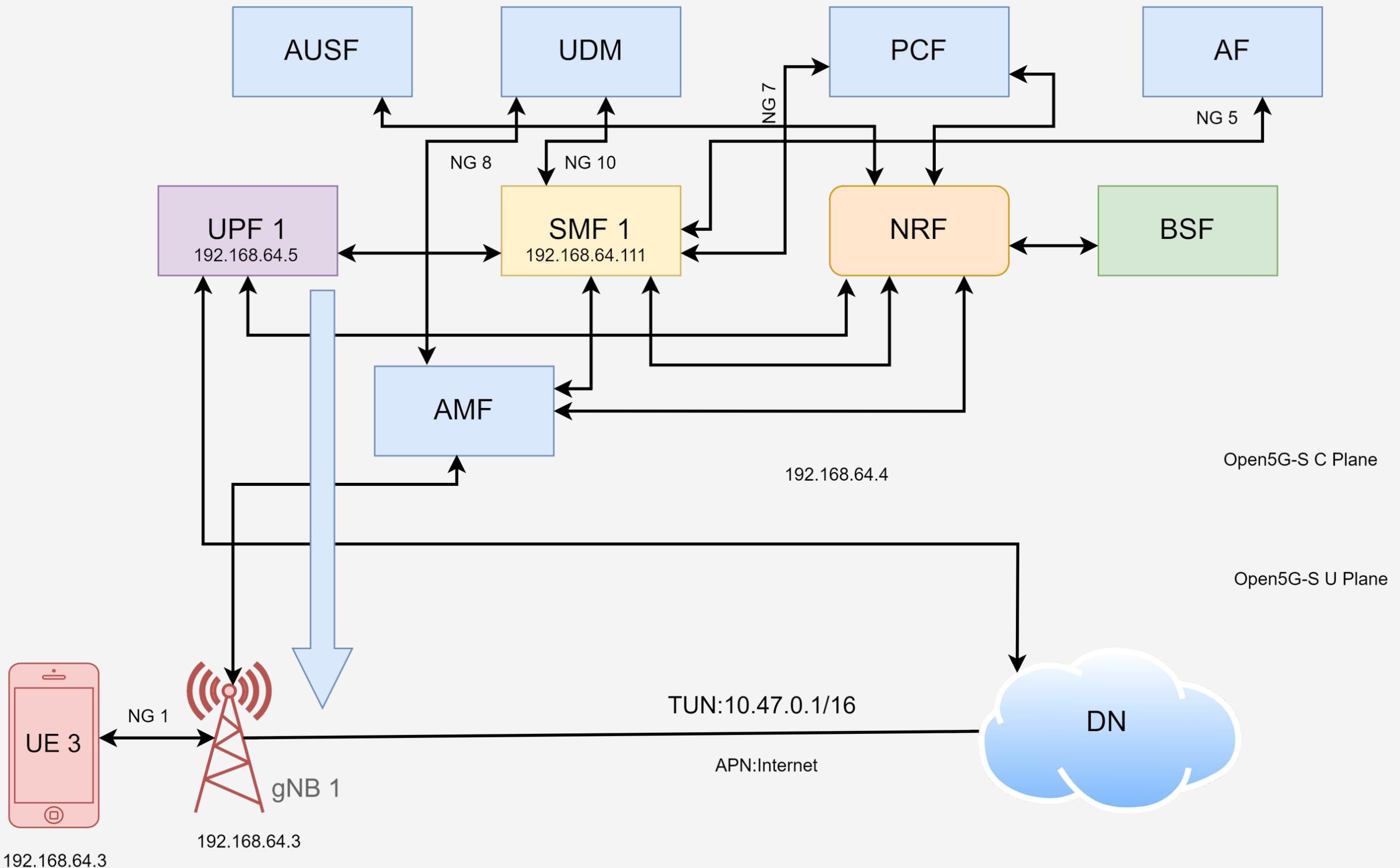
Content-Type: text/plain

Message Bod2

Line-based text data: text/plain (1 lines)

Hi User1

INTERNET

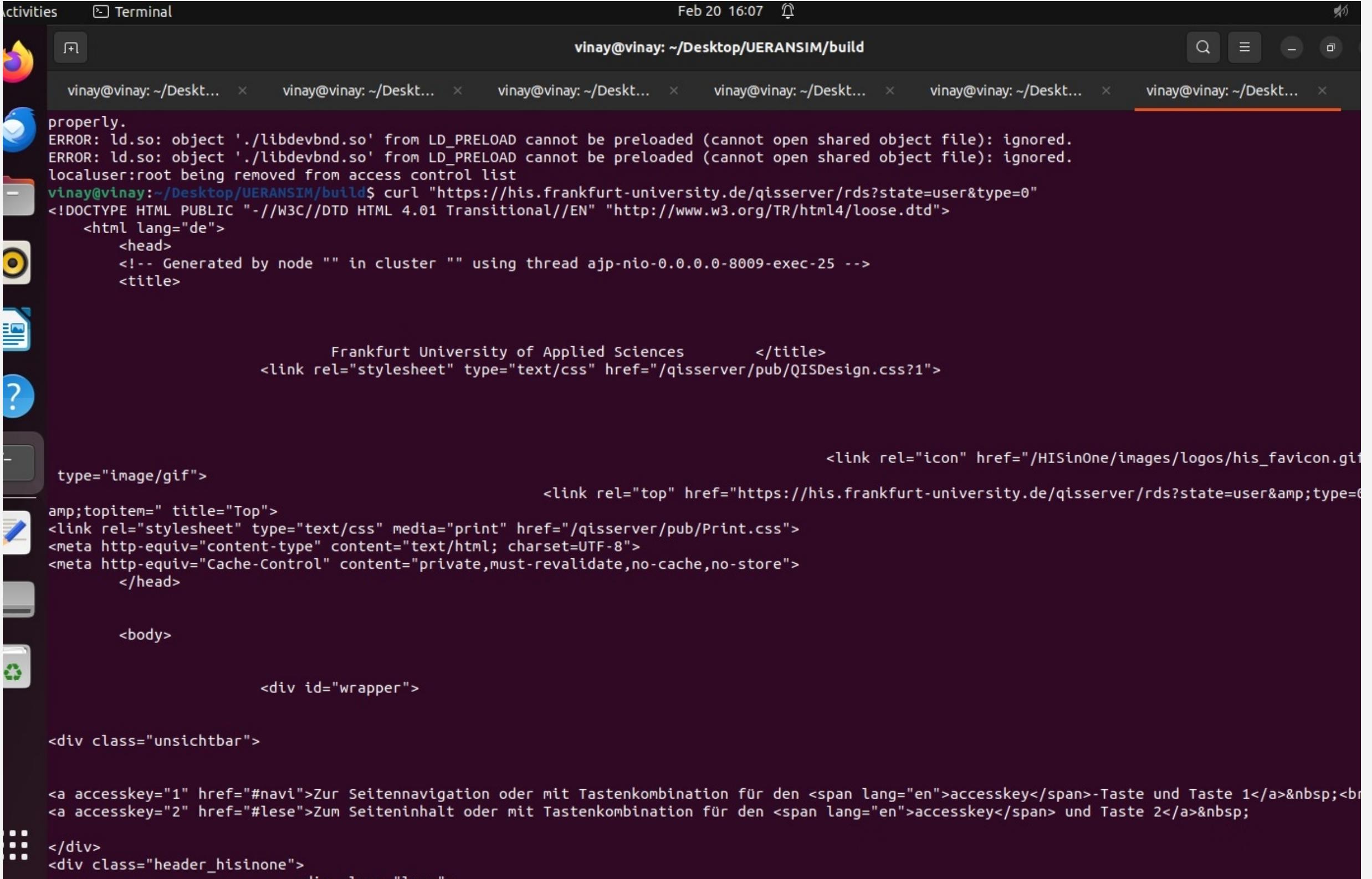


The slice was configured to allow users to open a browser and request data from any domain.

- *Curl command to Frankfurt University of Applied Sciences from UE3*
- *Browsing through Firefox*

Figure 19: UE3 and UE2 Network Slice for Internet

INTERNET



The screenshot shows a terminal window titled "Terminal" with the command "curl" being run. The command is "curl "https://his.frankfurt-university.de/qisserver/rds?state=user&type=0"". The output of the command is displayed, showing the HTML response from the server. The response includes the title "Frankfurt University of Applied Sciences", various CSS links, and meta tags. The terminal window is part of a desktop environment with a dock containing icons for various applications like a browser, file manager, and terminal.

```
properly.  
ERROR: ld.so: object './libdevbnd.so' from LD_PRELOAD cannot be preloaded (cannot open shared object file): ignored.  
ERROR: ld.so: object './libdevbnd.so' from LD_PRELOAD cannot be preloaded (cannot open shared object file): ignored.  
localuser:root being removed from access control list  
vinay@vinay:~/Desktop/UERANSIM/build$ curl "https://his.frankfurt-university.de/qisserver/rds?state=user&type=0"  
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN" "http://www.w3.org/TR/html4/loose.dtd">  
  <html lang="de">  
    <head>  
      <!-- Generated by node "" in cluster "" using thread ajp-nio-0.0.0.0-8009-exec-25 -->  
      <title>  
  
        Frankfurt University of Applied Sciences      </title>  
        <link rel="stylesheet" type="text/css" href="/qisserver/pub/QISDesign.css?1">  
  
        <link rel="icon" href="/HISinOne/images/logos/his_favicon.gif" type="image/gif">  
        &#amp; topitem=" title="Top">  
        <link rel="stylesheet" type="text/css" media="print" href="/qisserver/pub/Print.css">  
        <meta http-equiv="content-type" content="text/html; charset=UTF-8">  
        <meta http-equiv="Cache-Control" content="private,must-revalidate,no-cache,no-store">  
      </head>  
  
      <body>  
        <div id="wrapper">  
  
        <div class="unsichtbar">  
  
          <a accesskey="1" href="#navi">Zur Seitennavigation oder mit Tastenkombination für den <span lang="en">accesskey</span>-Taste und Taste 1</a>&nbsp;<br>  
          <a accesskey="2" href="#lese">Zum Seiteninhalt oder mit Tastenkombination für den <span lang="en">accesskey</span> und Taste 2</a>&nbsp;  
        </div>  
        <div class="header_hisinone">  
          <div class="Logo">  
            <img alt="Frankfurt University of Applied Sciences logo" data-bbox="150 100 200 150"/>  
            <span>Frankfurt University of Applied Sciences</span>  
          </div>  
          <div class="HeaderContent">  
            <div class="HeaderContentInner">  
              <div class="HeaderContentInnerLeft">  
                <div class="HeaderContentInnerLeftItem">  
                  <img alt="Search icon" data-bbox="250 100 270 120"/>  
                  <input type="text" placeholder="Search..."/>  
                </div>  
                <div class="HeaderContentInnerLeftItem">  
                  <img alt="User icon" data-bbox="300 100 320 120"/>  
                  <span>User</span>  
                </div>  
              </div>  
              <div class="HeaderContentInnerRight">  
                <div class="HeaderContentInnerRightItem">  
                  <img alt="Cart icon" data-bbox="350 100 370 120"/>  
                  <span>Cart</span>  
                </div>  
                <div class="HeaderContentInnerRightItem">  
                  <img alt="Logout icon" data-bbox="400 100 420 120"/>  
                  <span>Logout</span>  
                </div>  
              </div>  
            </div>  
            <div class="HeaderContentOuter">  
              <div class="HeaderContentOuterLeft">  
                <img alt="Navigation icon" data-bbox="450 100 470 120"/>  
                <span>Navigation</span>  
              </div>  
              <div class="HeaderContentOuterRight">  
                <img alt="Information icon" data-bbox="500 100 520 120"/>  
                <span>Information</span>  
              </div>  
            </div>  
          </div>  
        </div>  
      </body>  
    </html>
```

Wireshark Capture on UE3

- DNS request and response messages were captured.
- The requested domain of "Frankfurt University of Applied Sciences" was observed in the DNS request query.
- The UDP protocol was used for DNS query/response.
- The well-defined DNS port 53 was observed in the destination address.

Figure 20: Request to fra-uas website through curl command from UE3

INTERNET

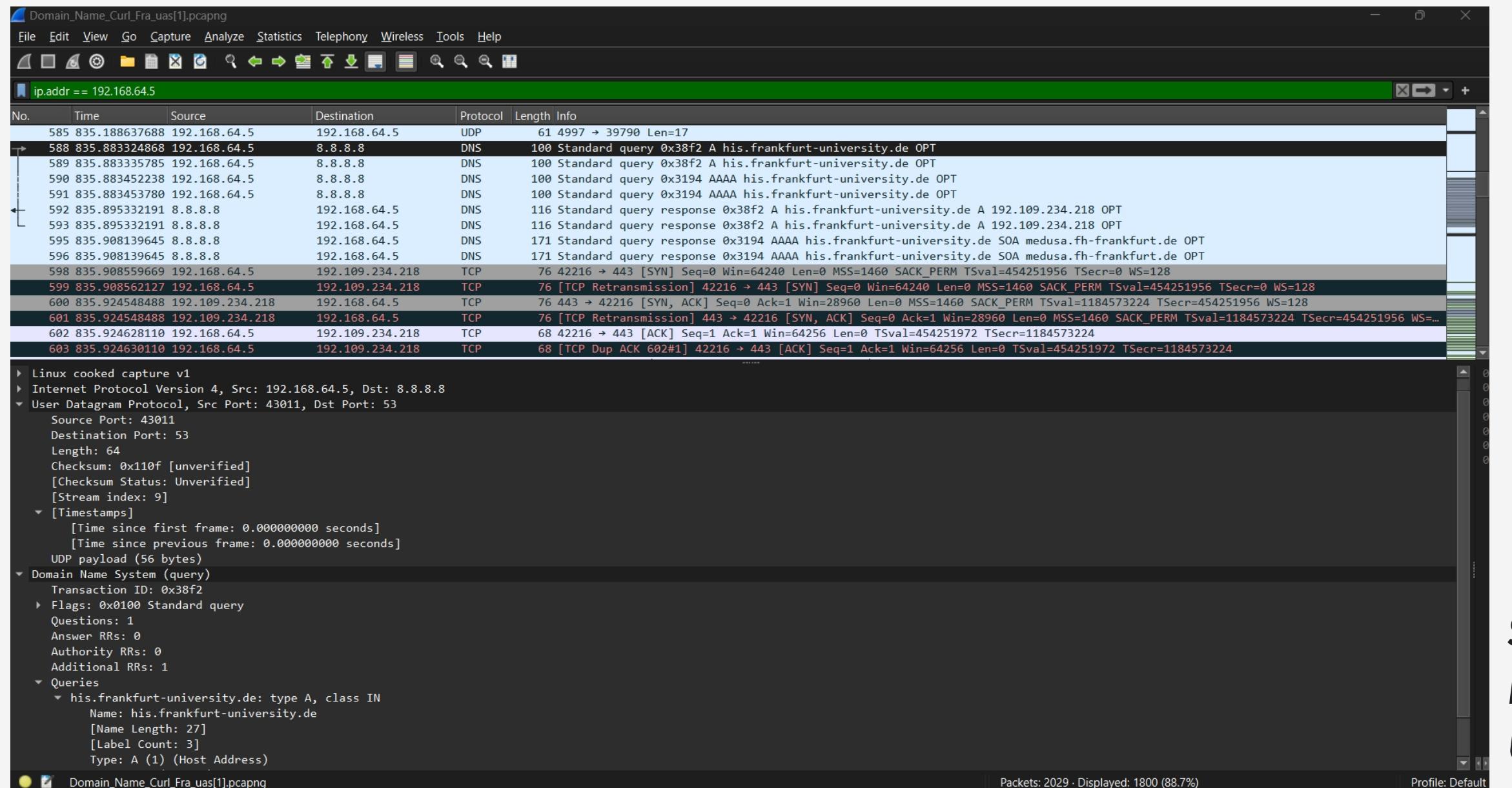


Figure 21: Wireshark Capture on UE3 for Network Internet Slice

Wireshark Capture on UE3

- DNS request and response messages were captured.
- The requested domain of "Frankfurt University of Applied Sciences" was observed in the DNS request query.
- The UDP protocol was used for DNS query/response.
- The well-defined DNS port 53 was observed in the destination address.

Source Address: 192.168.64.5

Destination Address: 8.8.8.8

User Datagram Protocol,

Src Port: 43011,

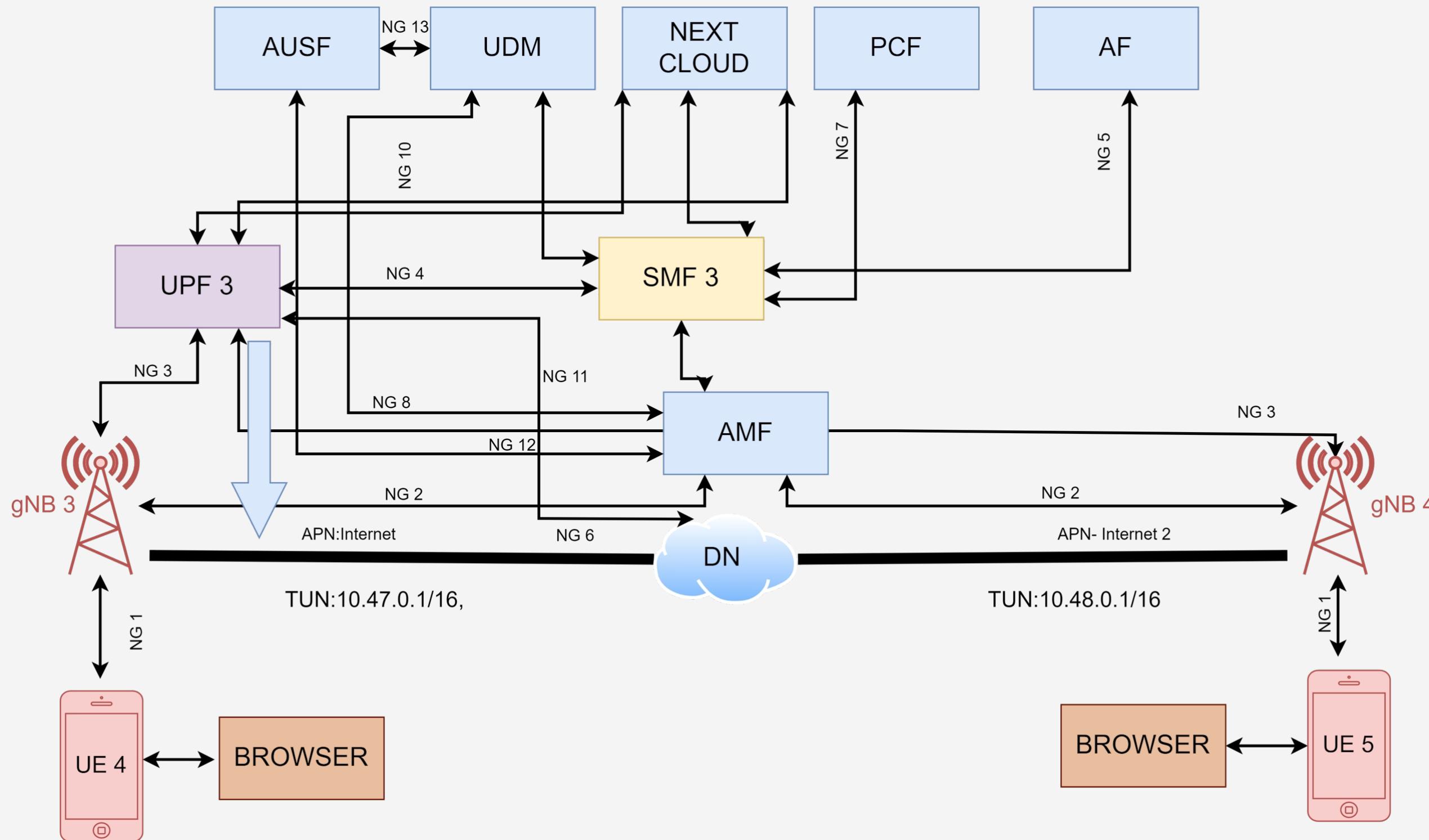
Dst Port: 53

Protocol: UDP (17)

Requested Domain:

his.frankfurt-university.de: type A, class IN

FILE SHARING

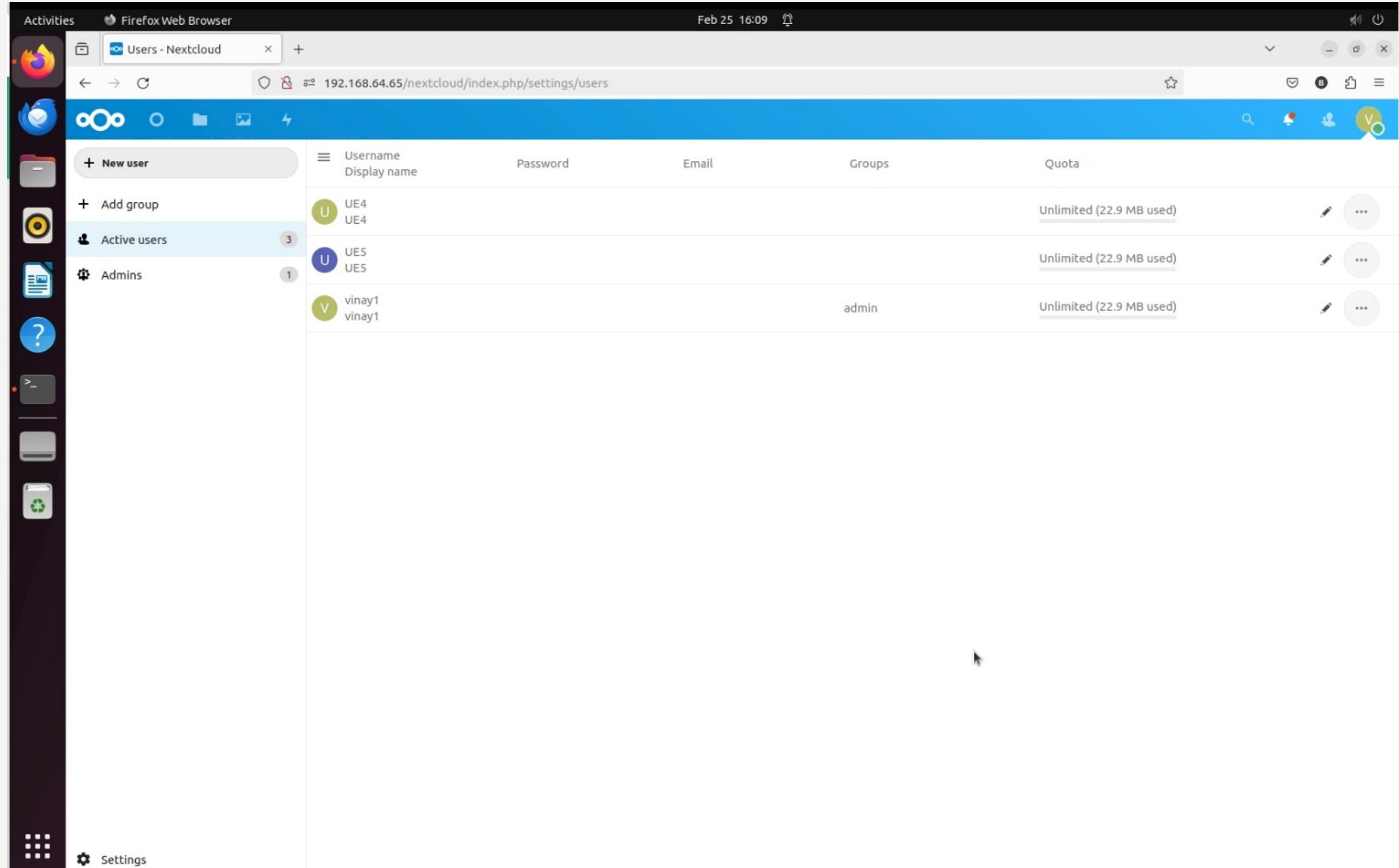


File sharing configuration is done between the UE4 and UE5 using NextCloud .

- Both user and admin configurations were set up to file transfer communication
- *Browsing through Firefox*

Figure 22: UE4 and UE5 Network Slice for File sharing configuration

FILE SHARING

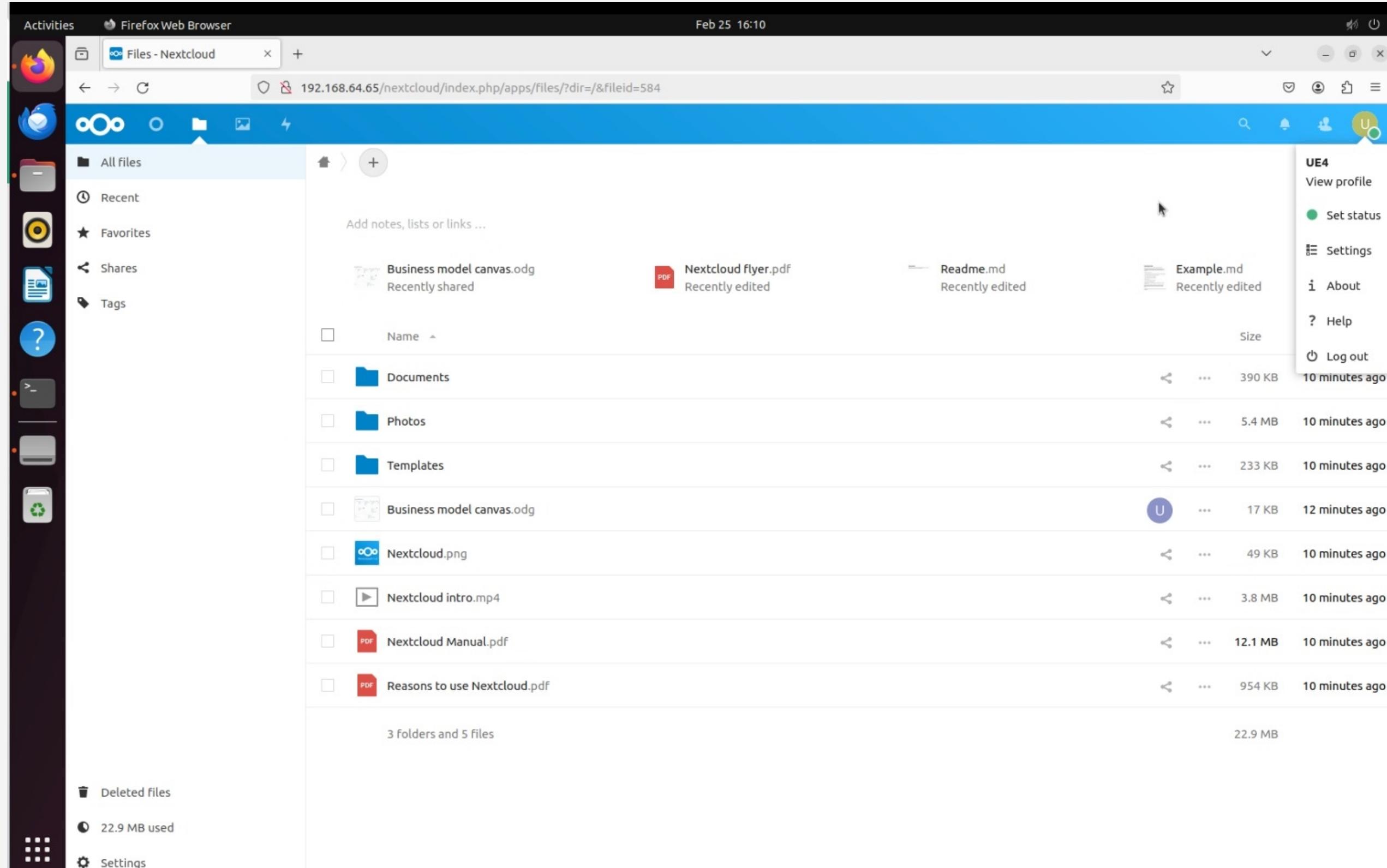


NextCloud Configurations

- UE4 and UE5 are configured on NextCloud Interface for File Transfer.
- This Communication is bidirectional so it means UE4 and UE5 can send the files to each other.
- Simultaneously working on same document can be also done through this communication channel

Figure 23: Next cloud interface for setting up UE4 and UE5 for file transfer communication

FILE SHARING

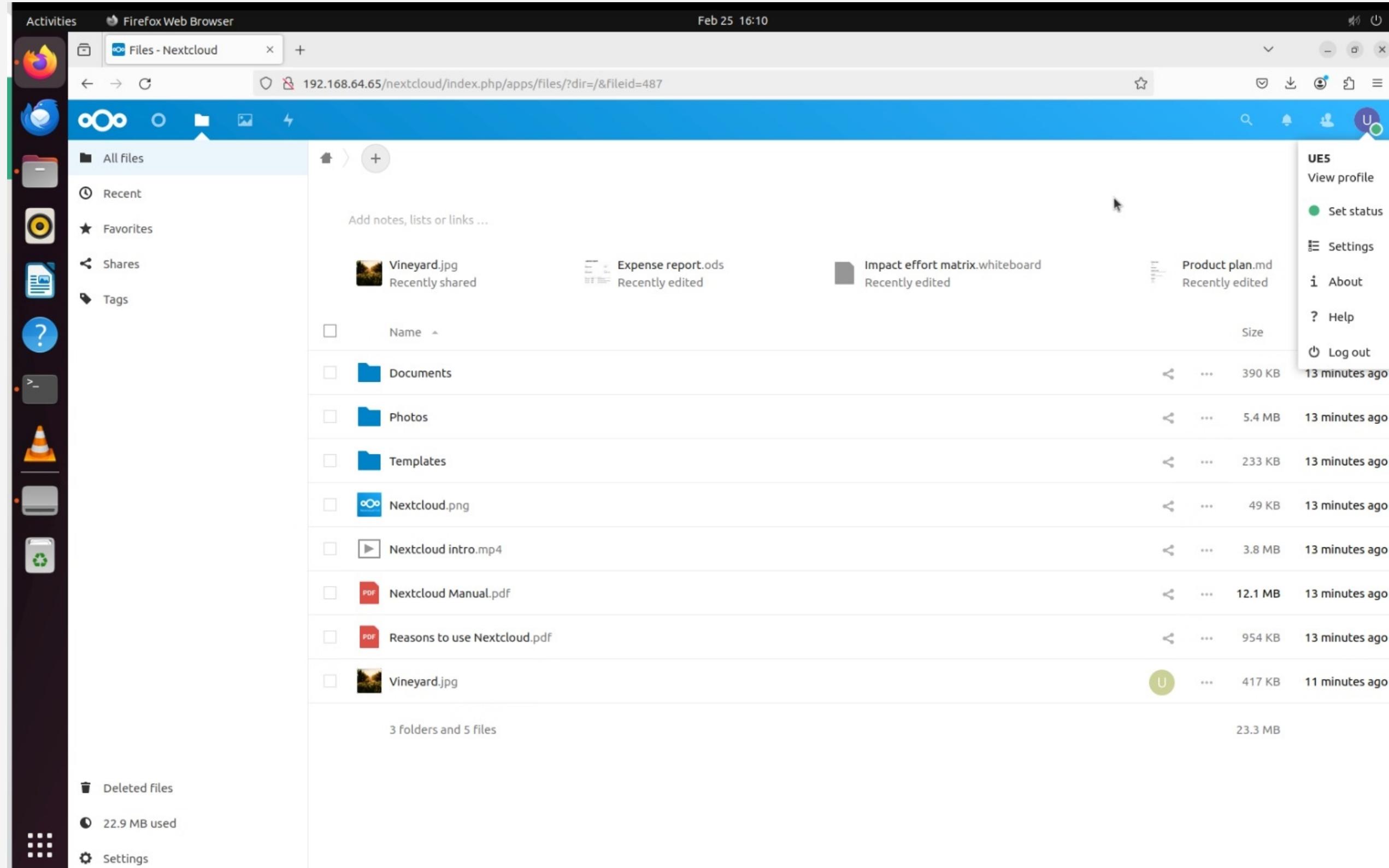


UE4 NextCloud Interface

- UE4 is ready to send the File to UE5 and on other side UE5 can see the file and do read write operation
- UE4 shared the Vineyard.jpg Image with UE5
- UE5 recently shared Business Model Canvas.odg file with UE4 which can be seen in Figure 24

Figure 24: UE4 interface on Next Cloud

FILE SHARING

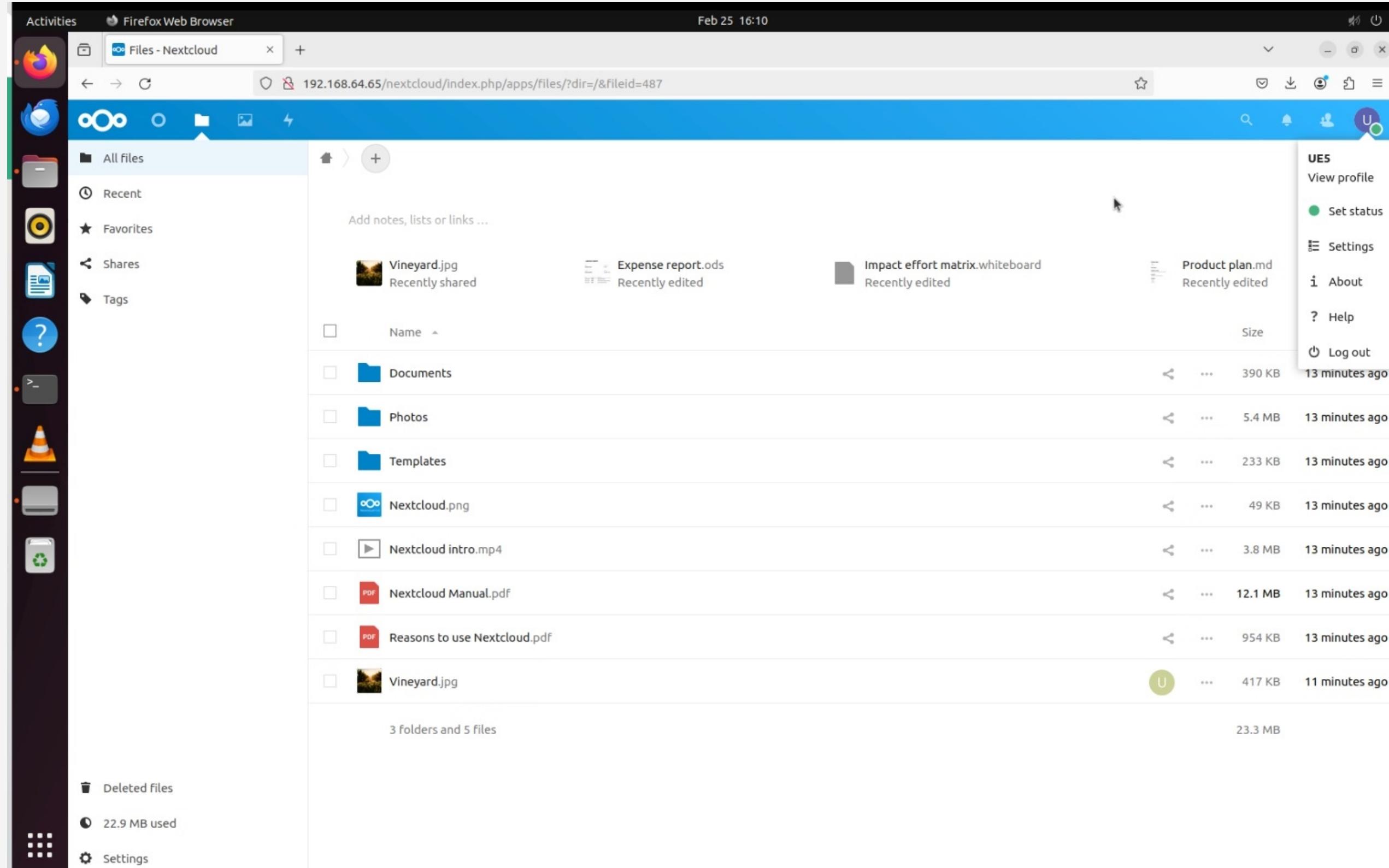


UE5 NextCloud Interface

- UE5 recently received the Vineyard.jpg
- UE5 recently shared Business Model Canvas.odg file with UE4 which can be seen in Figure 24

Figure 25: UE5 interface on Next Cloud

FILE SHARING



UE5 NextCloud Interface

- UE5 recently received the Vineyard.jpg
- UE5 recently shared Business Model Canvas.odg file with UE4 which can be seen in Figure 24

Figure 25: UE5 interface on Next Cloud

FILE SHARING

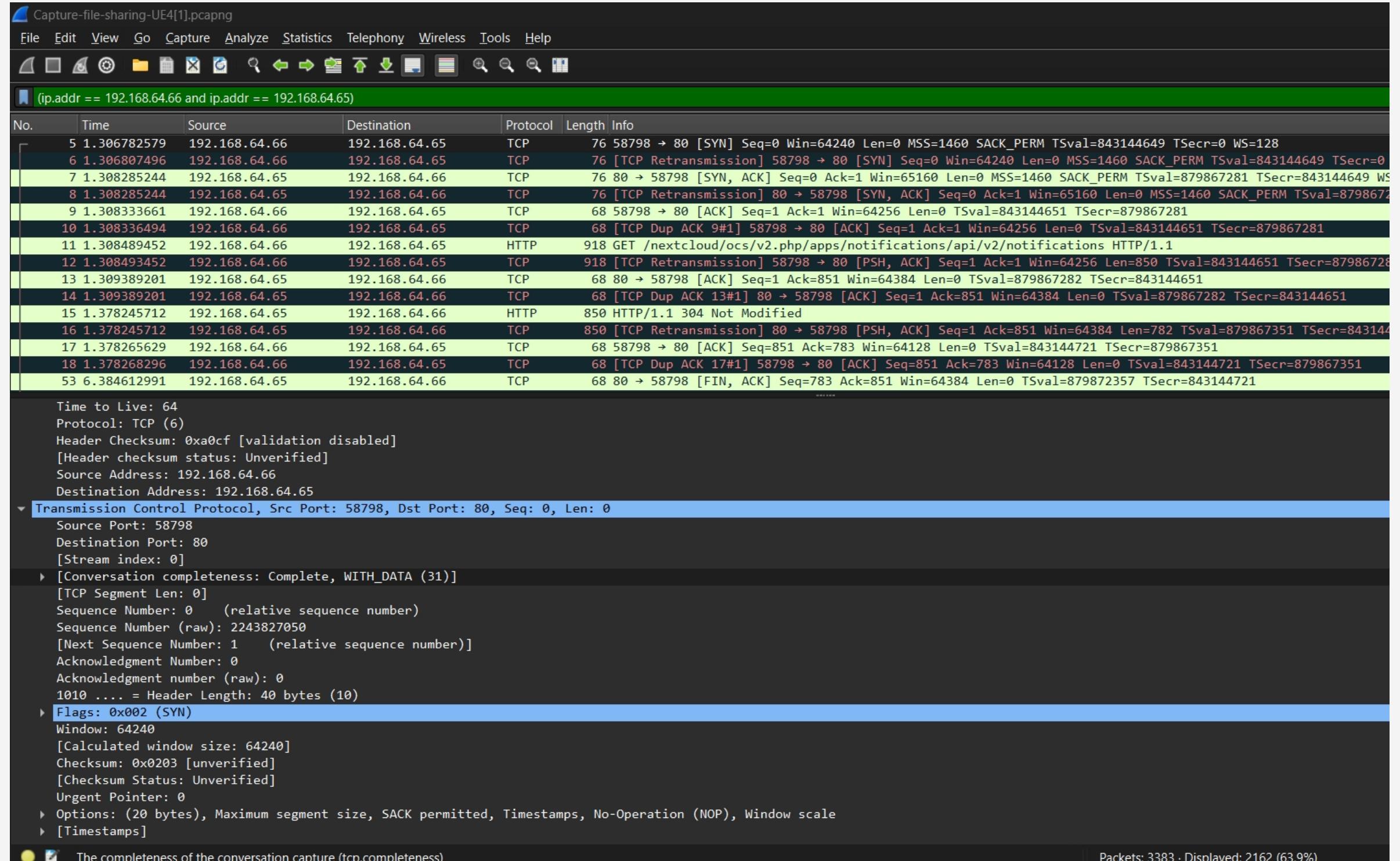


Figure 25: UE4 Wireshark Capture

UE4 Wireshark Capture

- UE5 recently received the Vineyard.jpg
- UE5 recently shared Business Model Canvas.odg file with UE4 which can be seen in Figure 24

Source Address: 192.168.64.66

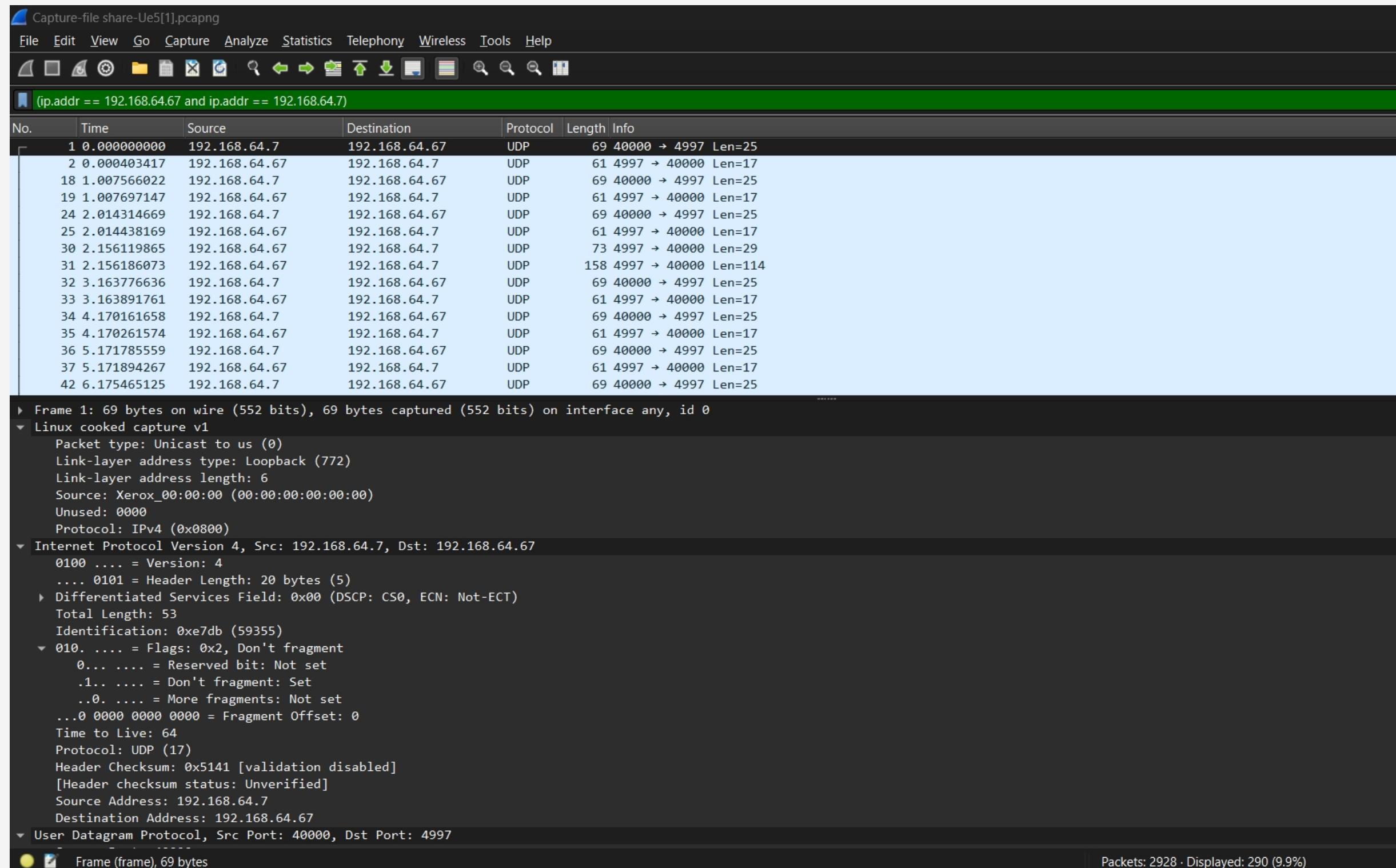
Destination Address: 192.168.64.65

Source Port: 58798

Destination Port: 80

Protocol: TCP (6)

FILE SHARING



UE5 Wireshark Capture

- UE4 shared the Vineyard.jpg Image with UE5
- UE5 recently shared Business Model Canvas.odg file with UE4 which can be seen in Figure 24

Source Address: 192.168.64.7

Destination Address: 192.168.64.67

User Datagram Protocol,

Src Port: 40000, **Dst Port:** 4997

Figure 25: UE4 Wireshark Capture

Section 06

PROJECT DEMO

Section 07

CONCLUSION

CONCLUSION

- Implemented network slicing with Open5GS and UERANSIM for diverse communication services.
- Configured slices for VoIP, messaging, internet, and file sharing to demonstrate network slicing benefits.
- Integrated Kamailio, Linphone, and Nextcloud for unified communication channels.
- Enabled functionalities like voice calls, messaging, browsing, and file transfers.
- Conducted extensive testing and Wireshark analysis to ensure reliable and scalable network operations.

THANK YOU!