

## Mobile Cellular Communications (5G)

### I. Objectives

The objectives of this laboratory are:

- Identify configuration parameters required for the different components
- Understand the main procedures present in a mobile cellular at the control and data planes

### II. Duration

This laboratory should last 2h30.

### III. Used tools

This laboratory will use:

- A 5G Core opensource implementation: Free5GC
- A gNB and UE opensource implementation: UERANSIM
- A VirtualBox VM with both components already installed in the laboratory PCs
- Wireshark also installed in the laboratory PCs

The VM is also available via SSH at port 2222 for user '**ubuntu**' (e.g. '**ssh -p 222 ubuntu@localhost**', from the hosting machine); password is '**ubuntu**' for users '**ubuntu**' and root

### IV. Network diagram

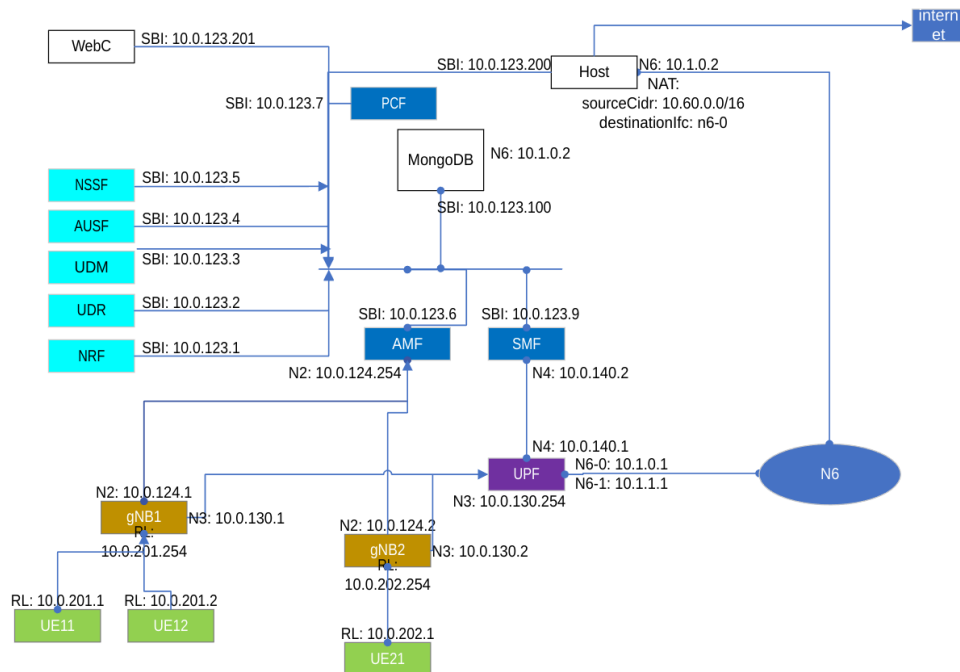


Figure 1: Network diagram

#### Notes:

1. A **hosts** file has been added to Wireshark (**/root/.config/wireshark**) for IP addresses resolution so that you can better interpret the messages exchange (see file contents in annex at the end).
2. The MongoDB component serves as persistent data repository for the other components while the network is running.

3. With UERANSIM, the 5G-NR radio interface ('Radio Link') is emulated over UDP between the UEs and the gNB they are connected to.

## V. Procedure

Linux Namespaces are used to have each 5GC Network Function (NF) running inside its own namespace (see ref [konrad]). This allows the usage of Wireshark to capture traffic packets exchange with the NF, on any of its interfaces (see next fig.).

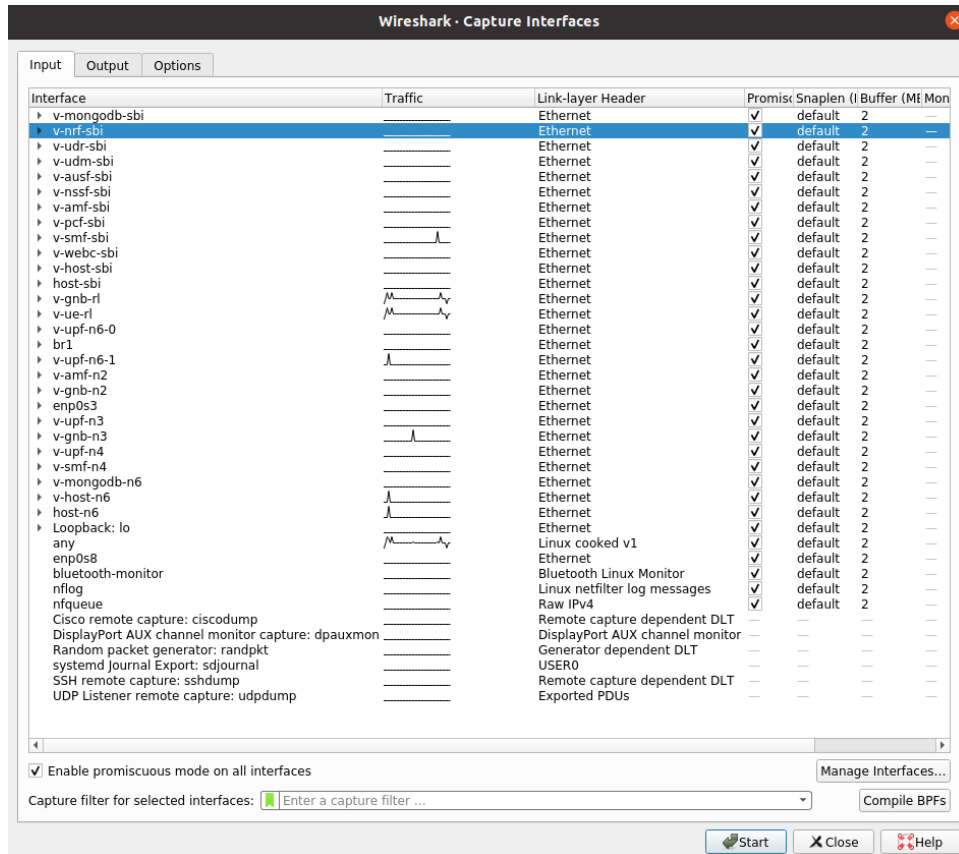


Figure 2: Logical interfaces as seen in Wireshark

## 1. Configurations analysis

- 1) Analyse the configuration files in the list below, located in folder `~/5GLab/netns5g/config` (you may open them with the File Manager) and search for the listed configuration parameters.
  - a. **Files:**
    - i. 5G Core: `amfcfg.yaml`, `smfcfg.yaml`, `upfcfg.yaml`
    - ii. 5G RAN: `free5gc-gnb1.yaml`, `free5gc-gnb2.yaml`
    - iii. 5G UEs:
      - `free5gc-ue11.yaml`
      - `free5gc-ue12-sl1.yaml`, `free5gc-ue12-sl2.yaml`
      - `free5gc-ue21.yaml`
  - b. **Parameters:**
    - i. MCC and MNC
    - ii. NR Cell Identities and TACs
    - iii. Supported slices at gNB1 and gNB2
    - iv. Supported DNN
    - v. List of SUPIs (UE11, UE12 and UE21)

## 2. 5GC start

- 1) Open a terminal window
- 2) Change to directory (`~/5GLab/netns5g`) containing the scripts needed to setup and run the 5G environment
- 3) Initialize environment (create the namespaces and the virtual interfaces)  
`~/5GLab/netns5G$ sudo ./5Gsetup.sh`
- 4) Check created namespaces and connecting links  
`~/5GLab/netns5G$ sudo ip netns` – lists created namespaces  
`~/5GLab/netns5G$ sudo ip link` – lists created links
- 5) Start a Wireshark capture in the interface 'br1' (this will capture all the traffic; you can start other Wireshark instances at specific interfaces, e.g. 'v-amf-sbi')
- 6) Start the 5G Core (free5gc)  
`~/5GLab/netns5G$ sudo ./5Gstart.sh`

At this point 5G Core Network Functions have started, each in its own namespace. Observe the script output and comment the order by which 5G Core components have been started.
- 7) Stop the capture and identify the involved protocols
- 8) Identify the dialogs (suggestion: apply the following display filter: `"!ip.addr==10.0.123.1 and !ip.addr==10.0.123.100 and !ip.addr==10.0.123.101 and !arp"`)

## 3. gNBs start

- 1) Open a (new) terminal window/tab
- 2) (re)Start Wireshark and start capturing in interface br1  
`$ sudo wireshark`  
Capture → Options → select 'br1'
- 3) From the same directory, start the first gNB (gNB1)  
`~/5GLab/netns5G$ ./GNB1start.sh`

```

ubuntu@ubuntu-VirtualBox: ~/5GLab/netns5g
ubuntu@ubuntu-VirtualBox:~/5GLab/netns5g$ ./GNB1start.sh
[sudo] password for ubuntu:
UERANSIM v3.2.6
[2022-11-07 22:23:42.301] [sctp] [info] Trying to establish SCTP connection... (10.0.124.254:38412)
[2022-11-07 22:23:42.303] [sctp] [info] SCTP connection established (10.0.124.254:38412)
[2022-11-07 22:23:42.303] [sctp] [debug] SCTP association setup ascId[9]
[2022-11-07 22:23:42.304] [ngap] [debug] Sending NG Setup Request
[2022-11-07 22:23:42.305] [ngap] [debug] NG Setup Response received
[2022-11-07 22:23:42.305] [ngap] [info] NG Setup procedure is successful

```

- 4) In the live Wireshark capture observe/note the following (suggestion: filter the displayed packets by SCTP and NGAP protocols: "*sctp or ngap or pfcp*"):
  - a. The SCTP connection setup and later the exchanged heartbeats
  - b. Identify by the IP addresses the involved entities
  - c. Detail to the maximum extent, in the Packet Details window, the *NGsetupRequest* and *NGsetupResponse* messages
  - d. Confirm observed values with the ones obtained from the configuration files analysis
- 5) Start the second gNB (gNB2)
 

```
~/5GLab/netns5G$ ./GNB2start.yaml
```
- 6) In the live Wireshark compare the new *NGsetupRequest* and *NGsetupResponse* messages with previous ones (gNB1)
- 7) Observe the logs in the screen and logfiles in: `~/5GLab/netns5g/logs`

#### 4. UE creation, registration and default PDU creation

- 1) Open the Free5GC Web Console from the web browser:
  - a. <http://10.0.123.201:5000>
  - b. credentials: '*admin*'/'*free5gc*'
- 2) Create the 3 UEs from the table below ('*New Subscriber*'; see screen capture in the Annexes):

	UE11	UE12	UE21
PLMN ID (MCC/MNC)	00101	00101	00101
SUPI (IMSI)	0010100000000011	0010100000000012	0010100000000021
SST/SD	1/010203	1/010203 (sl1) 2/112233 (sl2)	1/010203
DNN	internet	internet	internet
UL/DL AMBR	10/20 Mbps	100/200 Mbps	1/2 Mbps
5QI	9	9	9
Note	Will connect to gNB1	Will connect to gNB1	Will connect to gNB2

In the Free5GC "New Subscriber" form, delete the second appearing S-NSSAI (*Single Network Slice Selection Assistance Information*) and the second DNN ('internet2')

Only change fields in the table; you may search and interpret the other parameters.

- 3) Restart the Wireshark, keeping the capture in the same interface ('br1')
- 4) Start the first UE (UE11)
 

```
~/5GLab/netns5G$ ./UE11start.yaml
```

```

ubuntu@ubuntu-VirtualBox: ~/5GLab/netns5g
ubuntu@ubuntu-VirtualBox:~/5GLab/netns5g$ ./UE11start.sh
UERANSIM v3.2.6
[2022-11-07 22:24:37.666] [nas] [info] UE switches to state [MM-DEREGISTERED/PLMN-SEARCH]
[2022-11-07 22:24:37.666] [rrc] [debug] New signal detected for cell[1], total [1] cells in coverage
[2022-11-07 22:24:37.667] [nas] [info] Selected plmn[001/01]
[2022-11-07 22:24:37.667] [rrc] [info] Selected cell plmn[001/01] tac[1] category[SUITABLE]
[2022-11-07 22:24:37.667] [nas] [info] UE switches to state [MM-DEREGISTERED/PS]
[2022-11-07 22:24:37.667] [nas] [info] UE switches to state [MM-DEREGISTERED/NORMAL-SERVICE]
[2022-11-07 22:24:37.667] [nas] [debug] Initial registration required due to [MM-DEREG-NORMAL-SERVICE]
[2022-11-07 22:24:37.667] [nas] [debug] UAC access attempt is allowed for Identity[0], category[MO_sig]
[2022-11-07 22:24:37.667] [nas] [debug] Sending Initial Registration
[2022-11-07 22:24:37.667] [nas] [info] UE switches to state [MM-REGISTER-INITIATED]
[2022-11-07 22:24:37.667] [rrc] [debug] Sending RRC Setup Request
[2022-11-07 22:24:37.668] [rrc] [info] RRC connection established
[2022-11-07 22:24:37.668] [nas] [info] UE switches to state [RRC-CONNECTED]
[2022-11-07 22:24:37.668] [nas] [info] UE switches to state [CM-CONNECTED]
[2022-11-07 22:24:37.683] [nas] [debug] Authentication Request received
[2022-11-07 22:24:37.690] [nas] [debug] Security Mode Command received
[2022-11-07 22:24:37.690] [nas] [debug] Selected integrity[2] ciphering[0]
[2022-11-07 22:24:37.762] [nas] [debug] Registration accept received
[2022-11-07 22:24:37.762] [nas] [info] UE switches to state [MM-REGISTERED/NORMAL-SERVICE]
[2022-11-07 22:24:37.762] [nas] [debug] Sending Registration Complete
[2022-11-07 22:24:37.763] [nas] [info] Initial Registration is successful
[2022-11-07 22:24:37.763] [nas] [debug] Sending PDU Session Establishment Request
[2022-11-07 22:24:37.763] [nas] [debug] UAC access attempt is allowed for Identity[0], category[MO_sig]
[2022-11-07 22:24:38.087] [nas] [debug] PDU Session Establishment Accept received
[2022-11-07 22:24:38.087] [nas] [info] PDU Session establishment is successful PSI[1]
[2022-11-07 22:24:38.016] [app] [info] Connection setup for PDU session[1] is successful, TUN interface[uesimtun0, 10.60.0.2] is up.

```

- 5) Observe the creation of the TUN interface ('uesimtun0'); in a new terminal window, you can check the creation of this interface in namespace 'ue11'; note its IP address

~/5GLab/netns5G\$ sudo ip netns exec ue11 ip addr

```

ubuntu@ubuntu-VirtualBox: ~/5GLab/netns5g
ubuntu@ubuntu-VirtualBox:~/5GLab/netns5g$ sudo ip netns exec ue11 ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
3: uesimtun0: <POINTOPOINT,PROMISC,NOTRAILERS,UP,LOWER_UP> mtu 1400 qdisc fq_codel state UNKNOWN group default qlen 500
    link/none
    inet 10.60.0.2/32 scope global uesimtun0
        valid_lft forever preferred_lft forever
    inet6 fe80::e95b:22f9:e9bd:e373/64 scope link stable-privacy
        valid_lft forever preferred_lft forever
48: ue11-rl@if47: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group default qlen 1000
    link/ether 4e:1a:5d:d1:fd:ab brd ff:ff:ff:ff:ff:ff link-netnsid 0
    inet 10.0.201.1/24 scope global ue11-rl
        valid_lft forever preferred_lft forever
ubuntu@ubuntu-VirtualBox:~/5GLab/netns5g$

```

This interface will be used to exchange the traffic via the 5G network.

- Order the Wireshark capture by 'Protocol' and list the relevant protocols
- 6) Apply a Display Filter to see just NGAP, SCTP and PFCP protocols ("**ngap or pfcip or sctp**")
- Identify the involved 5G control functions (IP addresses are already translated to the functional entity interface, according to the diagram above); identify the dialogs UE-AMF, AMF-SMF, SMF-UPF and their sequence
  - Observe the sequence of exchanged messages, looking into their details in the Packet Details window (see, for instance, the '*PFCP Session Establishment Request*' and compare with message '*PFCP Session Modification Request*')
    - You may filter the display of messages by protocol and pair of entities, filtering the protocol and their IP addresses (e.g. for HTTP2 between AMF and AUSF: "**ip.addr==10.0.123.4 and ip.addr==10.0.123.6 and http2**")

## 5. Connectivity

- Start a Wireshark capture in the interface 'upf-n3' and another capture in the interface 'upf-n6-0'
- Apply a Display Filter to see protocols GTP and ICMP
- In a terminal window, start a ping to 8.8.8.8 from UE11

~/5GLab/netns5G\$ sudo ip netns exec ue11 ping 8.8.8.8 -I uesimtun0

- Analyse, in the Wireshark Packet Details, the GTP encapsulation
  - Observe the *Tunnel Endpoint Identifier* (TEID) in both directions of the communication

- In a new Terminal Window/Tab Start UE12

~/5GLab/netns5G\$ ./UE12start-s11.yaml

(check the contents of file `./config/free5gc-ue12-sl1.yaml`)

- 6) Make a ping from UE11 to UE12

```
~/5GLab/netns5G$ sudo ip netns exec ue11 ping <U12 IP addr> -I uesimtun0
```

- Analyse the observed GTP packets

- 7) In a new Terminal Window/Tab Start UE21

```
~/5GLab/netns5G$ ./UE12start-sl1.yaml
```

(check the contents of file `./config/free5gc-ue21.yaml`)

- 8) Make a ping from UE12 to UE21 and observe the exchanged packets at the UPF

## 6. QoS

- 1) Open a new terminal window

- 2) Start an iperf3 server at the DNN

```
$ iperf3 -s
```

- 3) Check the TUN interface name and assigned IP address

```
$ sudo ip netns exec ue11 ip addr
```

- 4) Start an iperf3 client at UE11 towards the server instance and register the achieved bandwidth in the UL and DL directions

```
$ sudo ip netns exec ue11 iperf3 -c 10.1.0.2 -B <ue11 IP address> -- uplink
```

```
$ sudo ip netns exec ue11 iperf3 -c 10.1.0.2 -R -B <ue11 IP address> -- downlink
```

- 5) Repeat previous measurements with the other two UEs (UE12 and UE21) and compare the results

## 7. Slicing

- 1) Stop UE12 (Ctrl-C)

- 2) Restart UE2, now in the second slice (2/112233) with a new configuration file and check the results

```
~/5GLab/netns5G$ ./UE12start-sl2.yaml
```

(check the contents of file `./config/free5gc-ue12-sl2.yaml`)

- 3) Observe the newly assigned IP address; what are the changes?

- 4) Make a ping from UE11 to UE12, now in different slices and observe the exchanged packets at the UPF; Is there connectivity?

- a. Check routing at the UPF namespace

```
$ sudo ip netns exec upf ip route
```

- b. Add a new route in the UPF namespace

```
$ sudo ip netns exec upf ip route add 10.61.0.0/24 dev upfgtp
```

- 5) Repeat the ping above.

## 8. Stop and reset the environment

- 1) Stop the gNB nodes (Ctrl-C), the UEs, and the 5G Core

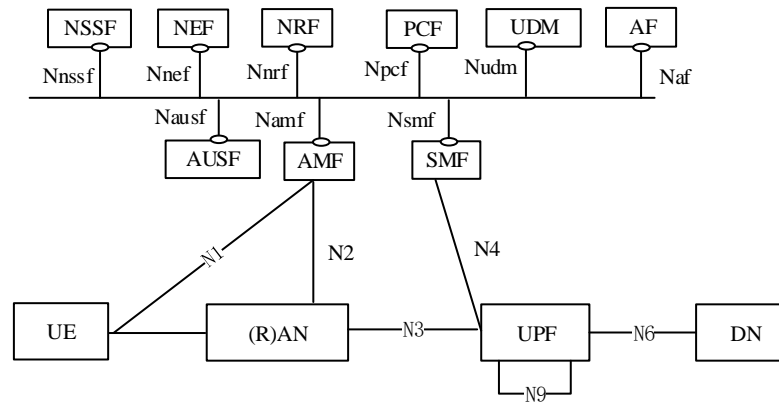
- 2) Wait for final processes to close (this takes some seconds, ending with "NRF terminated")

- 3) Delete the namespaces

```
~/5GLab/netns5G$ sudo ./5Gcleanup.sh
```

## Anexes

### A. 5G System architecture



## B. Example procedure

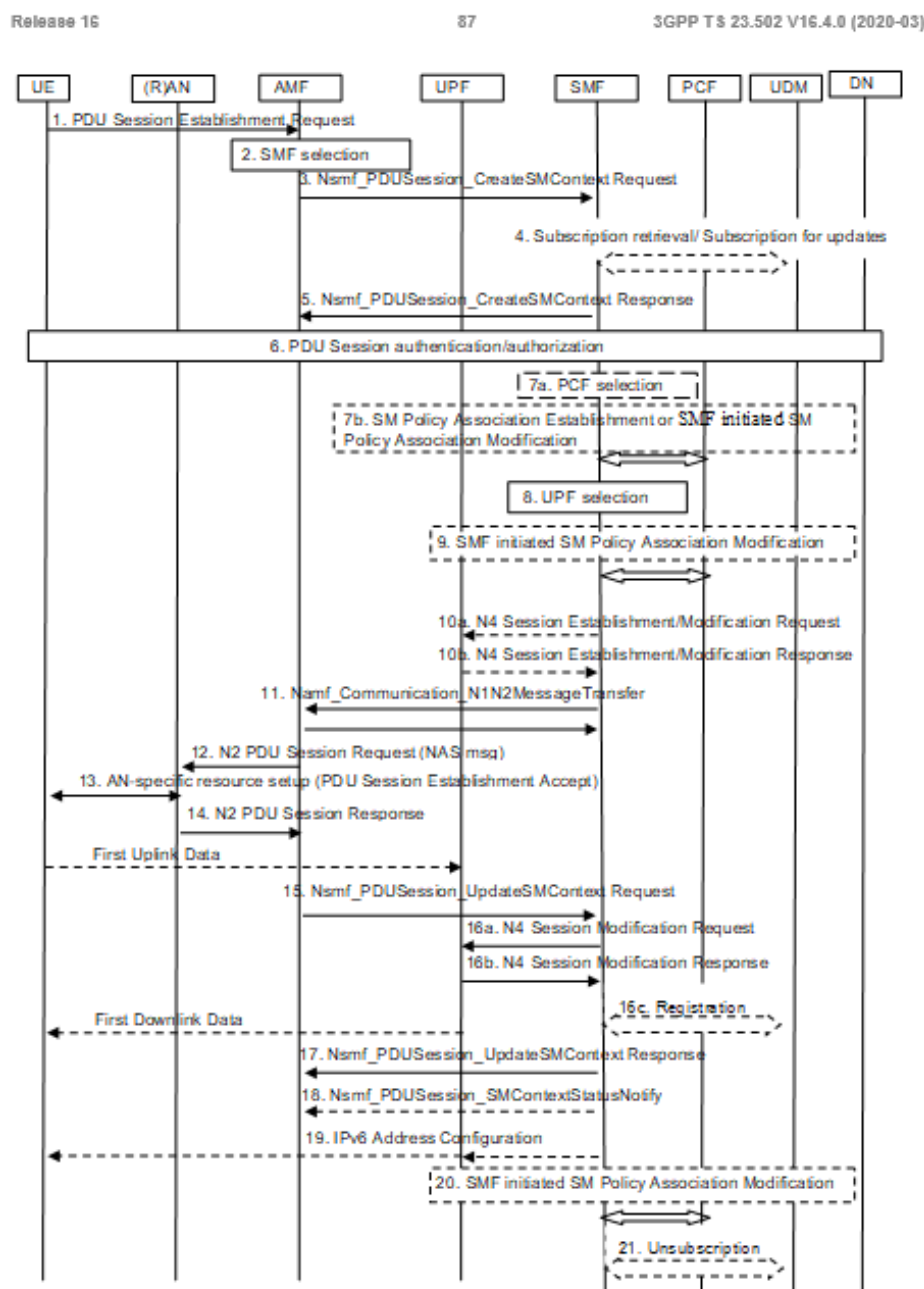
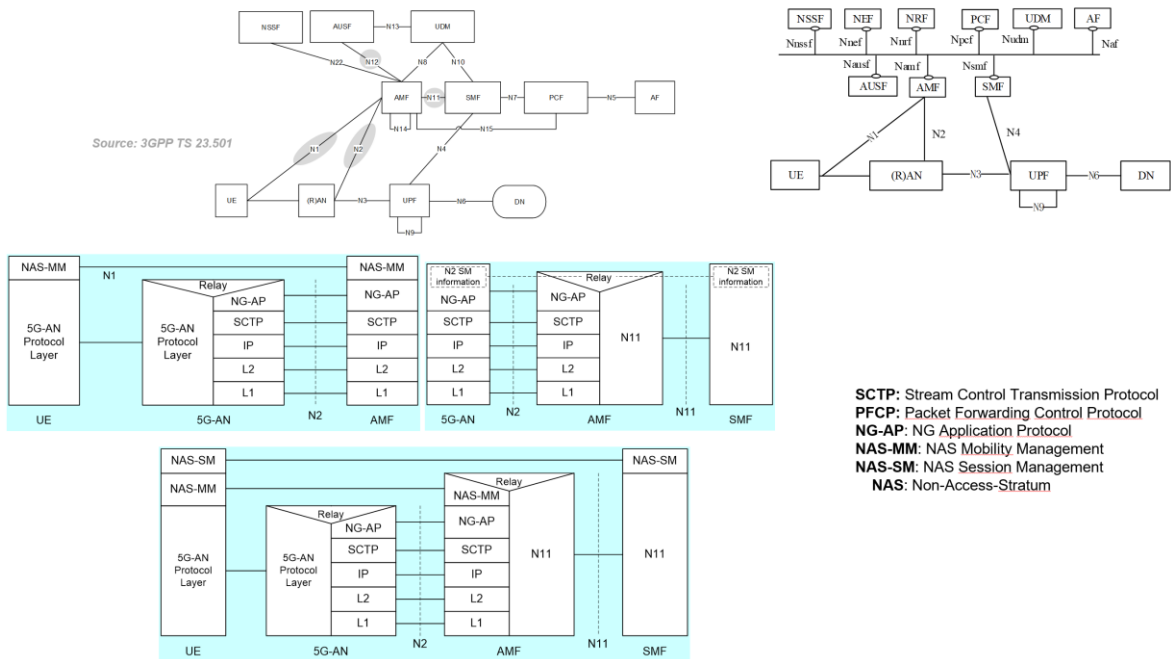


Figure 4.3.2.2.1-1: UE-requested PDU Session Establishment for non-roaming and roaming with local breakout

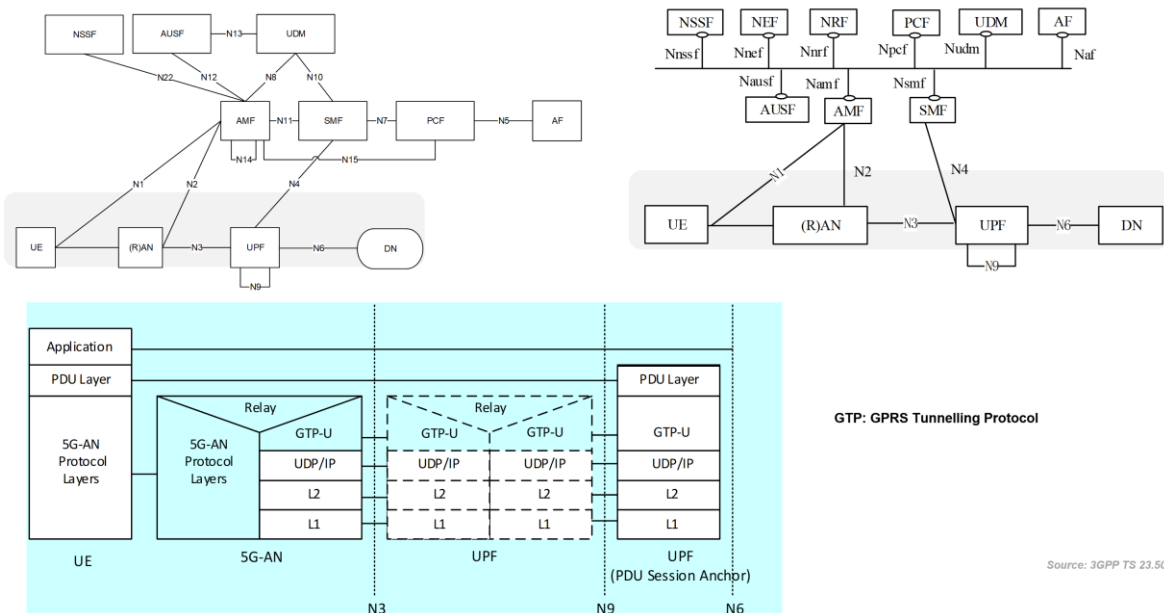


## C. 5G Protocol stacks

# Protocol stacks – control plane



# Protocol stacks – user plane



## D. Free5GC New Subscriber creation form (UE11)

The screenshot displays the 'New Subscriber' form in the Free5GC web interface. The form is titled 'New Subscriber' and includes a 'Subscriber data number (auto-increased with SUP)' field set to 1. Below this are fields for 'PLMN ID' (00101), 'SUPI (IMSI)' (001010000000011), 'Authentication Method' (set to '5G\_AKA'), 'K' (8ba4f73288509487ccbd7097c6862), 'Operator Code Type' (set to 'OPC'), 'Operator Code Value' (8c27b5a6e892e750f2267a3b14605d), and 'SQN' (1482a3f70f5c2). The 'S-NSSAI Configuration' section includes 'snssai' (set to 1), 'SST' (set to 1), 'SD' (set to 010203), and a checked 'Default S-NSSAI' checkbox. The 'DNN Configurations' section includes 'Data Network Name' (set to Internet), 'Uplink AMBR' (set to 10 Mbps), 'Downlink AMBR' (set to 20 Mbps), and 'Default SQI' (set to 9). The 'Flow Rules' section has a '+ ' button. At the bottom, there is a 'UP Security' checkbox and three '+ ' buttons. The form is set against a background of the Free5GC dashboard, which includes a sidebar with 'REALTIME STATUS', 'SUBSCRIBERS', 'ANALYTICS', and 'TENANT AND USER' sections, and a 'Log out' button in the top right corner.

10.0.123.201:5000/#/subscriber

70%

Log out

free5gc

REALTIME STATUS

SUBSCRIBERS

ANALYTICS

TENANT AND USER

New Subscriber

Subscriber data number (auto-increased with SUP)\*

1

PLMN ID\*

00101

SUPI (IMSI)\*

001010000000011

Authentication Method\*

5G\_AKA

K\*

8ba4f73288509487ccbd7097c6862

Operator Code Type\*

OPC

Operator Code Value\*

8c27b5a6e892e750f2267a3b14605d

SQN\*

1482a3f70f5c2

S-NSSAI Configuration

snssai

SST\*

1

SD\*

010203

☒ Default S-NSSAI

DNN Configurations

Data Network Name\*

Internet

Uplink AMBR\*

10 Mbps

Downlink AMBR\*

20 Mbps

Default SQI

9

Flow Rules

☐ UP Security

Subscribe

## E. Example of capture with Wireshark, with addresses resolution and display filter

Wireshark packet capture showing NGAP and SCTP protocols. The packet list displays the following packets:

No.	Time	Source	Destination	Length	Protocol	Info
367	7.176821...	gNB1-N2	AMF-N2	190	NGAP/NAS-5GS	SACK (Ack=2, Arwnd=106496) , UplinkNASTransport
674	7.337237...	AMF-N2	gNB1-N2	246	NGAP/NAS-5GS	SACK (Ack=3, Arwnd=106496) , InitialContextSetupRequest
675	7.337538...	gNB1-N2	AMF-N2	98	NGAP	SACK (Ack=3, Arwnd=106496) , InitialContextSetupResponse
687	7.541107...	AMF-N2	gNB1-N2	62	SCTP	SACK (Ack=4, Arwnd=106496)
688	7.541150...	gNB1-N2	AMF-N2	242	NGAP/NAS-5GS	UplinkNASTransport, UplinkNASTransport
929	7.579055...	SMF-SPI	AMF-SPI	930	HTTP2/JSON/NAS-5GS/NGAP	DATA[3], JavaScript Object Notation (application/json), PDU session establishment accept
937	7.580135...	AMF-N2	gNB1-N2	258	NGAP/NAS-5GS	SACK (Ack=6, Arwnd=106496) , PDU SessionResourceSetupRequest
942	7.582203...	gNB1-N2	AMF-N2	118	NGAP	SACK (Ack=4, Arwnd=106496) , PDU SessionResourceSetupResponse
951	7.583173...	AMF-SPI	SMF-SPI	703	HTTP2/JSON/NGAP	DATA[3], JavaScript Object Notation (application/json)
981	7.785075...	AMF-N2	gNB1-N2	62	SCTP	SACK (Ack=7, Arwnd=106496)

The packet details pane for packet 929 shows the following structure:

- Frame 688: 242 bytes on wire (1936 bits), 242 bytes captured (1936 bits) on interface br1, id 0
- Ethernet II, Src: gNB1-NR (4a:19:ce:1a:48:c0), Dst: AMF-N2 (9a:7b:71:e2:04:2d)
- Internet Protocol Version 4, Src: gNB1-N2 (10.0.124.1), Dst: AMF-N2 (10.0.124.254)
- Stream Control Transmission Protocol, Src Port: 48619 (48619), Dst Port: 38412 (38412)
  - Source port: 48619
  - Destination port: 38412
  - Verification tag: 0x7f9816e7
  - [Association index: disabled (enable in preferences)]
  - Checksum: 0x00000000 [unverified]
  - [Checksum Status: Unverified]
  - DATA chunk (ordered, complete segment, TSN: 5, SID: 1, SSN: 5, PPID: 60, payload length: 57 bytes)
    - Chunk type: DATA (0)
    - Chunk flags: 0x03
    - Chunk length: 73
    - Transmission sequence number (relative): 5
    - Transmission sequence number (absolute): 3845702161
    - Stream identifier: 0x0001
    - Stream sequence number: 5
    - Payload protocol identifier: NGAP (60)
    - Chunk padding: 000000
  - NG Application Protocol (UplinkNASTransport)
    - NGAP-PDU: initiatingMessage (0)
      - initiatingMessage
        - procedureCode: id-UplinkNASTransport (46)
        - criticality: ignore (1)
        - value
          - UplinkNASTransport
            - protocolIEs: 4 items
              - Item 0: id-AMF-UE-NGAP-ID
                - ProtocolIE-Field
                  - id: id-AMF-UE-NGAP-ID (10)
                  - criticality: reject (0)
                  - value
                    - AMF-UE-NGAP-ID: 1
                - Item 1: id-RAN-UE-NGAP-ID
                  - ProtocolIE-Field
                    - id: id-RAN-UE-NGAP-ID (85)
                    - criticality: reject (0)
                    - value
                      -

Wireshark - Packet 937 - 2022.11.09.free5GC.UE11start.pcapng

```

> Frame 937: 258 bytes on wire (2064 bits), 258 bytes captured (2064 bits) on interface br1, id 0
> Ethernet II, Src: AMF-N2 (9a:7b:71:e2:04:2d), Dst: gNB1-NR (4a:19:ce:1a:48:c0)
> Internet Protocol Version 4, Src: AMF-N2 (10.0.124.254), Dst: gNB1-N2 (10.0.124.1)
> Stream Control Transmission Protocol, Src Port: 38412 (38412), Dst Port: 48619 (48619)
▼ NG Application Protocol (PDUSessionResourceSetupRequest)
  ▼ NGAP-PDU: InitiatingMessage (0)
    ▼ InitiatingMessage
      procedureCode: id-PDUSessionResourceSetup (29)
      criticality: reject (0)
      ▼ value
        ▼ PDUSessionResourceSetupRequest
          ▼ protocolIEs: 4 items
            ▼ Item 0: id-AMF-UE-NGAP-ID
              ▼ ProtocolIE-Field
                id: id-AMF-UE-NGAP-ID (10)
                criticality: reject (0)
                ▼ value
                  AMF-UE-NGAP-ID: 1
            ▼ Item 1: id-RAN-UE-NGAP-ID
              ▼ ProtocolIE-Field
                id: id-RAN-UE-NGAP-ID (85)
                criticality: reject (0)
                ▼ value
                  RAN-UE-NGAP-ID: 1
            ▼ Item 2: id-PDUSessionResourceSetupListSUReq
              ▼ ProtocolIE-Field
                id: id-PDUSessionResourceSetupListSUReq (74)
                criticality: reject (0)
                ▼ value
                  ▼ PDUSessionResourceSetupListSUReq: 1 item
                    ▼ Item 0
                      ▼ PDUSessionResourceSetupItemSUReq
                        pDUSessionID: 1
                        ▼ pDUSessionNAS-PDU: 7e02cad24c2a027e00680100432e0101c211000901000631310101ff09060001406000a...
                          ▼ Non-Access-Stratum 5GS (NAS)PDU
                            ▼ Security protected NAS 5GS message
                              Extended protocol discriminator: 5G mobility management messages (126)
                              0000 .... = Spare Half Octet: 0
                              .... 0010 = Security header type: Integrity protected and ciphered (2)
                              Message authentication code: 0xcad24c2a
                              Sequence number: 2
                              Encrypted data
                            ▼ s-NSSAI
                              sST: 01
                              sD: 010203
                            ▼ pDUSessionResourceSetupRequestTransfer
                              ▼ PDUSessionResourceSetupRequestTransfer
                                ▼ protocolIEs: 4 items
                                  ▼ Item 0: id-PDUSessionAggregateMaximumBitRate
                                    ▼ ProtocolIE-Field
                                      id: id-PDUSessionAggregateMaximumBitRate (130)
                                      criticality: reject (0)
                                      ▼ value
                                        ▼ PDUSessionAggregateMaximumBitRate
                                          pDUSessionAggregateMaximumBitRateDL: 200000000bits/s
                                          pDUSessionAggregateMaximumBitRateUL: 100000000bits/s
                                  ▼ Item 1: id-UL-NGU-UP-TNLIInformation
                                    ▼ ProtocolIE-Field
                                      id: id-UL-NGU-UP-TNLIInformation (139)
                                      criticality: reject (0)
                                      ▼ value
                                        ▼ UPTransportLayerInformation: gTPTunnel (0)
                                          ▼ gTPTunnel
                                            ▼ transportLayerAddress: 0a0082fe [bit length 32, 0000 1010 0000 0000 1000 0010 1111 1110 decimal value 167805694]
                                              TransportLayerAddress (IPv4): 10.0.130.254 (10.0.130.254)
                                              gTP-TEID: 00000001
                                  ▼ Item 2: id-PDUSessionType
                                    ▼ ProtocolIE-Field
                                      id: id-PDUSessionType (134)
                                      criticality: reject (0)
                                      ▼ value
                                        PDUSessionType: ipv4 (0)
                                  ▼ Item 3: id-QosFlowSetupRequestList
                                    ▼ ProtocolIE-Field
                                      id: id-QosFlowSetupRequestList (136)
                                      criticality: reject (0)
                                      ▼ value
                                        ▼ QosFlowSetupRequestList: 1 item
                                          ▼ Item 0
                                            ▼ QosFlowSetupRequestItem
                                              qosFlowIdentifier: 0
                                              ▼ qosFlowLevelQosParameters
                                                ▼ qosCharacteristics: nonDynamic5QI (0)
                                                  ▼ nonDynamic5QI
                                                    fiveQI: 9
                                                  ▼ allocationAndRetentionPriority
                                                    priorityLevelARP: 15
                                                    pre-emptionCapability: shall-not-trigger-pre-emption (0)
                                                    pre-emptionVulnerability: not-pre-emptable (0)
                                  ▼ Item 3: id-UEAggregateMaximumBitRate
                                    ▼ ProtocolIE-Field
                                      id: id-UEAggregateMaximumBitRate (110)
                                      criticality: ignore (1)
                                      ▼ value
                                        ▼ UEAggregateMaximumBitRate
                                          uEAggregateMaximumBitRateDL: 2000000000bits/s
                                          uEAggregateMaximumBitRateUL: 1000000000bits/s
          ▼ Item 3: id-UEAggregateMaximumBitRate
            ▼ ProtocolIE-Field
              id: id-UEAggregateMaximumBitRate (110)
              criticality: ignore (1)
              ▼ value
                ▼ UEAggregateMaximumBitRate
                  uEAggregateMaximumBitRateDL: 2000000000bits/s
                  uEAggregateMaximumBitRateUL: 1000000000bits/s

```

☐ Show packet bytes

Close Help

## F. Hosts file

```
#5G Core
10.0.123.1      NRF-SBI
10.0.123.2      UDR-SBI
10.0.123.3      UDM-SBI
10.0.123.4      AUSF-SBI
10.0.123.5      NSSF-SBI
10.0.123.6      AMF-SBI
10.0.123.7      PCF-SBI
10.0.123.9      SMF-SBI
10.0.123.100    MongoDB-SBI
10.0.123.201    WebConsole

10.0.124.254    AMF-N2
10.0.124.1      gNB1-N2
10.0.124.2      gNB2-N2

10.0.140.2      SMF-N4
10.0.140.1      UPF-N4

#5G dataplane
10.1.0.1        UPF-N6
10.1.0.1        Host-N6

#RAN1
10.0.201.1      UE11-NR
10.0.201.2      UE12-NR
10.0.201.254    gNB1-NR

#RAN2
10.0.202.1      UE11-NR
10.0.202.254    gNB1-NR
```

## G. Useful links

- Free5GC:
  - [free5gchome] <https://www.free5gc.org/>
  - [free5gcwiki] <https://github.com/free5gc/free5gc/wiki>
  - [konrad] <https://github.com/konradkar2/netns5g>
- UERANSIM:
  - <https://github.com/aligungr/UERANSIM/wiki>
- 3GPP
  - [www.3gpp.org](http://www.3gpp.org)