

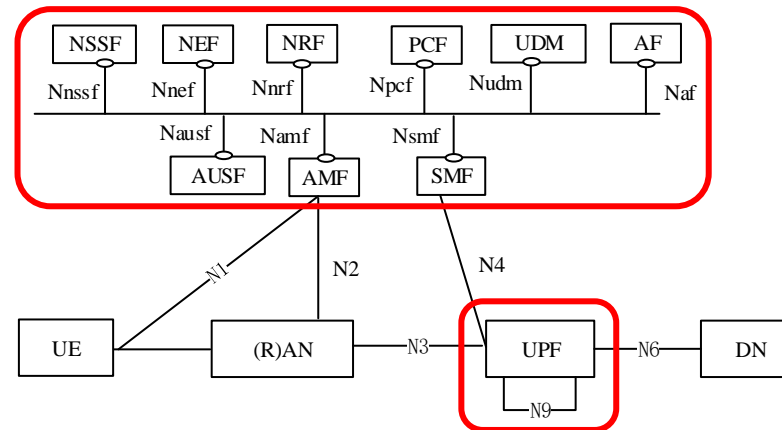
# Comunicações Móveis

Lab3: 5G

2022/2023

# Free5GC summary

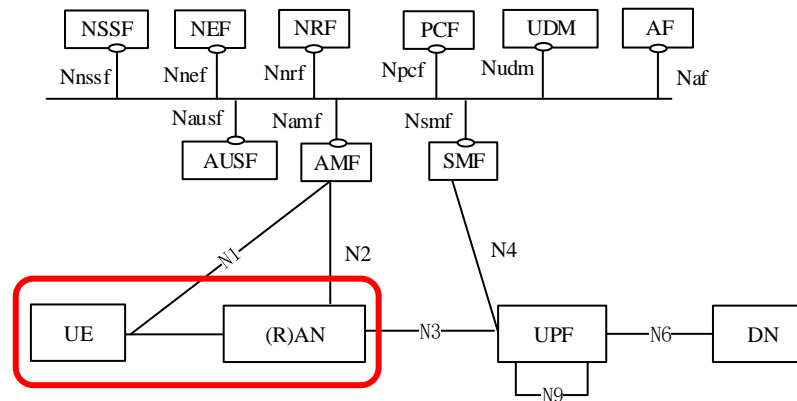
- <https://github.com/free5gc/free5gc/wiki>
- Main components of the 5GCore, Control and User Planes
- 3GPP Release 15 (R15)



- Each component is configured by a specific yaml file
  - E.g. amfcfg.yaml, nssfcfg.yaml and upfcfg.yaml

# UERANSIM summary

- <https://github.com/aligungr/UERANSIM/wiki>
- Two main componentes: UE and gNB

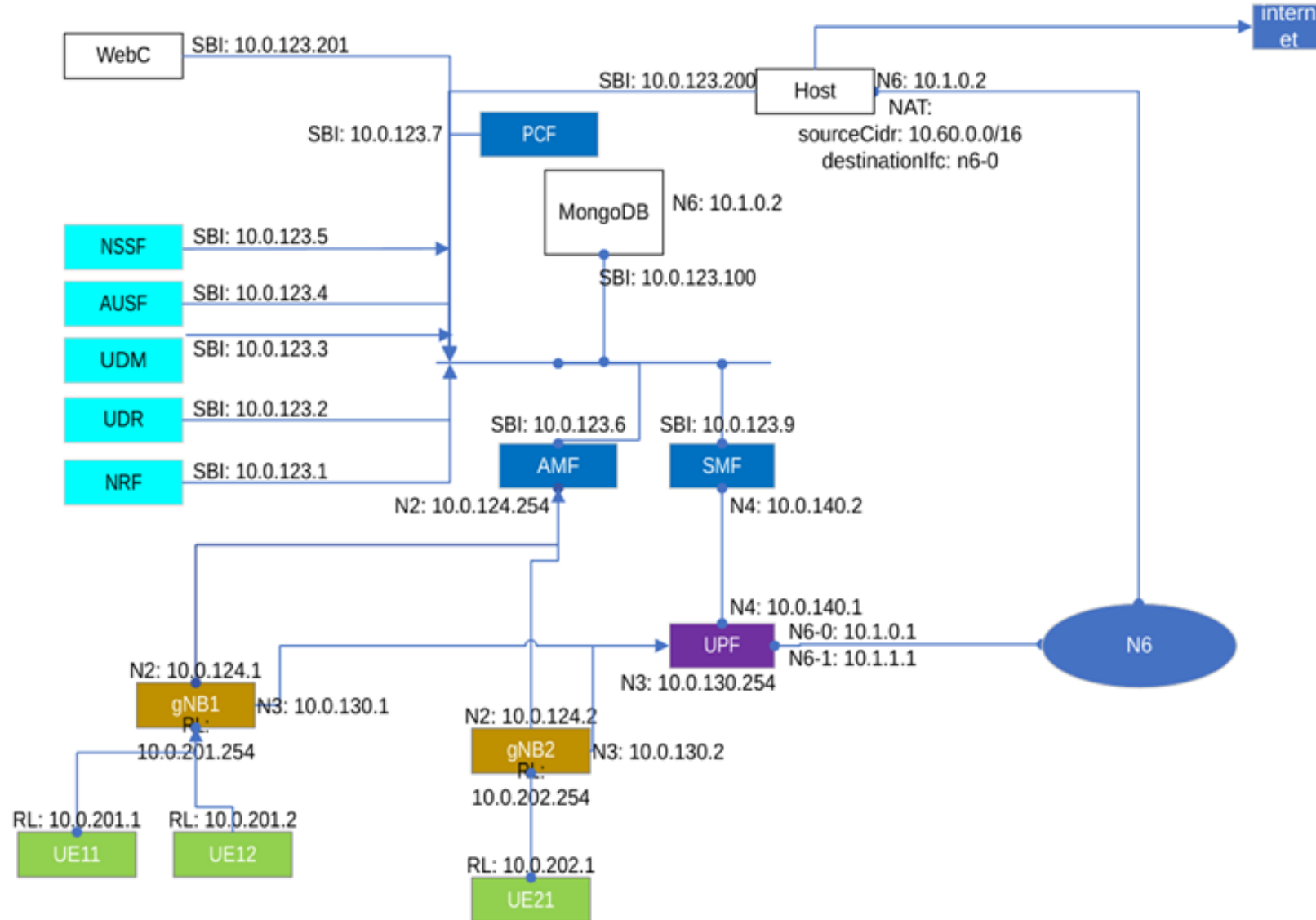


- Usage:

```
$ nr-ue -c myconfig1.yaml  
$ nr-gnb -c myconfig2.yaml
```

<https://github.com/aligungr/UERANSIM/wiki/Configuration>

# Network topology



# Scripts to run the environment

- 5Gsetup.sh
- 5Gstart.sh
- 5Gcleanup.sh
  
- GNB1Start.sh
- GNB2Start.sh
  
- UE11Start.sh
- UE12Start-sl1.sh, UE12Start-sl2.sh
- UE21Start.sh

# 1.1.b

- i. MCC and MNC:
  - MCC: 001
  - MNC: 01
- ii. NR Cell Identities and TACs
  - gNB1: 1, 2
  - gNB2: 2, 1
- iii. Supported slices at gNB1 and gNB2
  - gNB1: 1/010203 and 2/112233
  - gNB2: 1/010203
- iv. Supported DNN:
  - internet
- v. List of SUPIs (UE11, UE12 and UE21)
  - 001 01 0000 0000 11/12/21

```
nssfcfg.yaml
13 pem: config/TLS/
14 key: config/TLS/
15 serviceNameList: # t
16 - nssf-nselectio
17 - nssf-nssaiavail
18 nrfUri: http://10.0.
19 supportedPlmnList: #
20 - mcc: 001 # Mobil
21 mnc: 01 # Mobile
22 supportedNssaiInPlmn
23 - plmnId: # Public
24 mcc: 001 # Mob
25 mnc: 01 # Mobi
26 supportedSnsai
27 - sst: 1 # Sli
28 sd: 010203 #
29 - sst: 2 # Sli
30 sd: 112233 #
31 - sst: 1 # Sli
32 sd: 000003 #
33 - sst: 2 # Sli
34 sd: 000001 #
35 - sst: 2 # Sli
36 sd: 000002 #
37 nsList: # List of a
38 - snsai: # S-NSSA
39 sst: 1 # Slice
40 nsInformationLi
41 # the NRF to b
42 - nrfId: http:
43 nsId: 10
44 - snsai: # S-NSSA
45 sst: 1 # Slice
46 sd: 010203 # S

amfcdg.yaml
5 configuration:
6 amfName: AMF # the name
7 ngapIpList: # the IP l
8 - 10.0.124.254
9 sbi: # Service-based in
10 scheme: http # the pr
11 registerIPv4: 10.0.12
12 bindingIPv4: 10.0.123
13 port: 8000 # port use
14 tls: # the local path
15 pem: config/TLS/amf
16 key: config/TLS/amf
17 serviceNameList: # the
18 - namf-comm # Namf_Coi
19 - namf-evts # Namf_Ev
20 - namf-mt # Namf_MT
21 - namf-loc # Namf_Lo
22 - namf-oam # OAM ser
23 servedGuamiList: # Guam
24 # <GUAMI> = <MCC><MNC>
25 - plmnId: # Public La
26 mcc: 001 # Mobile
27 mnc: 01 # Mobile
28 amfId: cafe00 # AMF
29 supportTailList: # the
30 - plmnId: # Public La
31 mcc: 001 # Mobile
32 mnc: 01 # Mobile
33 tac: 1 # Tracking A
34 - plmnId: # Public La
35 mcc: 001 # Mobile
36 mnc: 01 # Mobile
37 tac: 2 # Tracking A
38 plmnSupportList: # the
39 - plmnId: # Public La
40 mcc: 001 # Mobile
41 mnc: 01 # Mobile
42 snsaiList: # the S
43 - sst: 1 # Slice/
44 sd: 010203 # S
45 - sst: 2 # Slice/
46 sd: 112233 # S

free5gc-ue11.yaml
1 # IMSI number of the UE. IMSI = [MCC|MN
2 supi: 'imsi-001010000000011'
3 # Mobile Country Code value of HPLMN
4 mcc: '001'
5 # Mobile Network Code value of HPLMN (2
6 mnc: '01'
7
8 # Permanent subscription key
9 key: '8baf473f2f8fd09487cccbd7097c6862'
10 # Operator code (OP or OPC) of the UE
11 op: '8e27b6af0e692e750f32667a3b14605d'
12 # This value specifies the OP type and
13 opType: 'OPC'
14 # Authentication Management Field (AMF)
15 amf: '8000'
16 # IMEI number of the device. It is used
17 imei: '356938035643811'
18 # IMEISV number of the device. It is us
19 imeiSv: '4370816125816111'
20
21 # List of gNB IP addresses for Radio Li
22 gnbSearchList:
23 - 10.0.201.254
24
25 # UAC Access Identities Configuration
26 uacAic:
27 mps: false
28 mcs: false
29
30 # UAC Access Control Class
31 uacAcc:
32 normalClass: 0
33 class1: false
34 class2: false
35 class3: false
36 class4: false
37 class5: false
38
39 # Initial PDU sessions to be establishe
40 sessions:
41 - type: 'IPv4'
42 apn: 'internet'
43 slice:
44 sst: 0x1
45 sd: 0x010203
46
47 # Configured NSSAI for this UE by HPLMN
48 configured-nssai:
49 - sst: 0x1
50 sd: 0x010203
51
52 # Default Configured NSSAI for this UE
53 default-nssai:
54 - sst: 1
55 sd: 1

free5gc-grb1.yaml
1 mcc: '001' # Mob
2 mnc: '01' # Mob
3
4 nci: '0x000000001' # NR C
5 idLength: 32 # NR C
6 tac: 1 # Tra
7
8 linkIp: 10.0.201.254 # g
9 ngapIp: 10.0.124.1 # gNB
10 gtpIp: 10.0.130.1 # gNB
11
12 # List of AMF address info
13 amfConfigs:
14 - address: 10.0.124.254
15 port: 38412
16
17 # List of supported S-NSSAI
18 slices:
19 - sst: 0x1
20 sd: 0x010203
21 - sst: 0x2
22 sd: 0x112233
23
24 # Indicates whether or not
25 ignoreStreamIds: true

free5gc-grb2.yaml
1 mcc: '001' # Mob
2 mnc: '01' # Mob
3
4 nci: '0x000000001' # NR C
5 idLength: 32 # NR C
6 tac: 2 # Tra
7
8 linkIp: 10.0.202.254 # g
9 ngapIp: 10.0.124.2 # gNB
10 gtpIp: 10.0.130.2 # gNB
11
12 # List of AMF address info
13 amfConfigs:
14 - address: 10.0.124.254
15 port: 38412
16
17 # List of supported S-NSSAI
18 slices:
19 - sst: 0x1
20 sd: 0x010203
21
22 # Indicates whether or not
23 ignoreStreamIds: true
```

# 2.4

~/5GLab/netns5G\$ *sudo ip netns*

~/5GLab/netns5G\$ *sudo ip link*

```
ubuntu@ubuntu-VirtualBox: ~/5GLab/netns5G
ubuntu@ubuntu-VirtualBox:~/5GLab/netns5G$
ubuntu@ubuntu-VirtualBox:~/5GLab/netns5G$
ubuntu@ubuntu-VirtualBox:~/5GLab/netns5G$
ubuntu@ubuntu-VirtualBox:~/5GLab/netns5G$
ubuntu@ubuntu-VirtualBox:~/5GLab/netns5G$
ubuntu@ubuntu-VirtualBox:~/5GLab/netns5G$ sudo ip netns
ue21 (id: 15)
gnb2 (id: 14)
ue12 (id: 13)
ue11 (id: 12)
gnb1 (id: 11)
webc (id: 10)
smf (id: 9)
upf (id: 8)
pcf (id: 7)
amf (id: 6)
nssf (id: 5)
ausf (id: 4)
udm (id: 3)
udr (id: 2)
nrf (id: 1)
mongodb (id: 0)
ubuntu@ubuntu-VirtualBox:~/5GLab/netns5G$
```

```
ubuntu@ubuntu-VirtualBox: ~/5GLab/netns5G
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN mode DEFAULT group default qlen 1000
   link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
2: enp0s3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP mode DEFAULT group default qlen 1000
   link/ether 08:00:27:9f:81:d6 brd ff:ff:ff:ff:ff:ff
3: enp0s8: <NO-CARRIER,BROADCAST,MULTICAST,UP> mtu 1500 qdisc fq_codel state DOWN mode DEFAULT group default qlen 1000
   link/ether 08:00:27:5e:ae:91 brd ff:ff:ff:ff:ff:ff
4: br1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP mode DEFAULT group default qlen 1000
   link/ether 12:33:6e:f7:ed:46 brd ff:ff:ff:ff:ff:ff
5: v-mongodb-sbi@f6: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master br1 state UP mode DEFAULT group default qlen 1000
   link/ether c6:67:5e:e4:6c:75 brd ff:ff:ff:ff:ff:ff link-netns mongodb
7: v-nrf-sbi@f8: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master br1 state UP mode DEFAULT group default qlen 1000
   link/ether 56:52:fc:ec:66:8e brd ff:ff:ff:ff:ff:ff link-netns nrf
9: v-udr-sbi@f10: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master br1 state UP mode DEFAULT group default qlen 1000
   link/ether 8a:ec:a3:ff:26:db brd ff:ff:ff:ff:ff:ff link-netns udr
11: v-udm-sbi@f12: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master br1 state UP mode DEFAULT group default qlen 1000
   link/ether 46:54:14:f3:af:b0 brd ff:ff:ff:ff:ff:ff link-netns udm
13: v-ausf-sbi@f14: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master br1 state UP mode DEFAULT group default qlen 1000
   link/ether 9e:b5:bf:ca:e5:06 brd ff:ff:ff:ff:ff:ff link-netns ausf
15: v-nssf-sbi@f16: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master br1 state UP mode DEFAULT group default qlen 1000
   link/ether 22:77:a4:18:ac:f7 brd ff:ff:ff:ff:ff:ff link-netns nssf
17: v-amf-sbi@f18: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master br1 state UP mode DEFAULT group default qlen 1000
   link/ether 1e:c5:a7:bf:e4:a5 brd ff:ff:ff:ff:ff:ff link-netns amf
19: v-amf-n2@f20: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master br1 state UP mode DEFAULT group default qlen 1000
   link/ether ce:21:42:88:d1:6c brd ff:ff:ff:ff:ff:ff link-netns amf
21: v-pcf-sbi@f22: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master br1 state UP mode DEFAULT group default qlen 1000
   link/ether 7a:83:07:39:f4:e1 brd ff:ff:ff:ff:ff:ff link-netns pcf
23: v-upf-n3@f24: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master br1 state UP mode DEFAULT group default qlen 1000
   link/ether aa:2c:34:05:17:20 brd ff:ff:ff:ff:ff:ff link-netns upf
25: v-upf-n4@f26: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master br1 state UP mode DEFAULT group default qlen 1000
   link/ether 12:f6:d7:87:b1:83 brd ff:ff:ff:ff:ff:ff link-netns upf
27: v-upf-n6-0@f28: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master br1 state UP mode DEFAULT group default qlen 1000
   link/ether ba:22:62:58:c6:f7 brd ff:ff:ff:ff:ff:ff link-netns upf
29: v-upf-n6-1@f30: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master br1 state UP mode DEFAULT group default qlen 1000
   link/ether de:7e:49:22:37:27 brd ff:ff:ff:ff:ff:ff link-netns upf
31: v-smf-sbi@f32: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master br1 state UP mode DEFAULT group default qlen 1000
   link/ether 86:fa:75:42:8e:d9 brd ff:ff:ff:ff:ff:ff link-netns smf
33: v-smf-n4@f34: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master br1 state UP mode DEFAULT group default qlen 1000
   link/ether de:2e:91:af:72:6e brd ff:ff:ff:ff:ff:ff link-netns smf
35: v-webc-sbi@f36: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master br1 state UP mode DEFAULT group default qlen 1000
   link/ether aa:a6:81:5f:45:89 brd ff:ff:ff:ff:ff:ff link-netns webc
37: v-host-sbi@host-sbi: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master br1 state UP mode DEFAULT group default qlen 1000
   link/ether 26:64:79:64:96:3f brd ff:ff:ff:ff:ff:ff
38: host-sbi@v-host-sbi: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP mode DEFAULT group default qlen 1000
   link/ether f2:2b:47:0d:08:49 brd ff:ff:ff:ff:ff:ff
39: v-host-n6@host-n6: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master br1 state UP mode DEFAULT group default qlen 1000
   link/ether fe:f3:13:a8:9f:42 brd ff:ff:ff:ff:ff:ff
40: host-n6@v-host-n6: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP mode DEFAULT group default qlen 1000
   link/ether 16:e9:c6:27:6e:f1 brd ff:ff:ff:ff:ff:ff
41: v-gnb1-r1@f42: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master br1 state UP mode DEFAULT group default qlen 1000
   link/ether 46:92:85:14:90:15 brd ff:ff:ff:ff:ff:ff link-netns gnb1
43: v-gnb1-n2@f44: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master br1 state UP mode DEFAULT group default qlen 1000
   link/ether 32:0d:d2:16:4e:59 brd ff:ff:ff:ff:ff:ff link-netns gnb1
45: v-gnb1-n3@f46: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master br1 state UP mode DEFAULT group default qlen 1000
   link/ether ae:32:21:e7:52:ac brd ff:ff:ff:ff:ff:ff link-netns gnb1
47: v-ue11-r1@f48: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master br1 state UP mode DEFAULT group default qlen 1000
   link/ether fe:81:5e:16:e5:b2 brd ff:ff:ff:ff:ff:ff link-netns ue11
49: v-ue12-r1@f50: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master br1 state UP mode DEFAULT group default qlen 1000
   link/ether ca:52:db:6f:38:d4 brd ff:ff:ff:ff:ff:ff link-netns ue12
51: v-gnb2-r1@f52: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master br1 state UP mode DEFAULT group default qlen 1000
   link/ether fe:3a:8d:65:a6:10 brd ff:ff:ff:ff:ff:ff link-netns gnb2
53: v-gnb2-n2@f54: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master br1 state UP mode DEFAULT group default qlen 1000
   link/ether de:e0:9e:7d:34:58 brd ff:ff:ff:ff:ff:ff link-netns gnb2
55: v-gnb2-n3@f56: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master br1 state UP mode DEFAULT group default qlen 1000
   link/ether 12:33:6e:f7:ed:46 brd ff:ff:ff:ff:ff:ff link-netns gnb2
57: v-ue21-r1@f58: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master br1 state UP mode DEFAULT group default qlen 1000
   link/ether 3a:28:b1:27:68:2d brd ff:ff:ff:ff:ff:ff link-netns ue21
```

## 2.6

- Ordem: NRF, UDR, UDM, AUSF, NSSF, AMF, PCF, UPF e SMF
- NRF é o primeiro para que os outros se registem
- Depois vem o repositório, depois os componentes de autenticação dos UE (UDR, UDM, AUSF)
- Depois a componente de controlo de registo de UE (NSSF, AMF)
- Depois a componente de sessões (PCF, UPF, SMF)



## 2.7 and 2.8

- All the dialogs are with the NRF (10.0.123.1) and MongoDB (10.0.123.100), except for the PFCP (between SMF and UPF)

## 2.7 and 2.8

- ARP, TCP; HTTP2; PFCP
- !ip.addr==10.0.123.1 and !ip.addr==10.0.123.100 and !ip.addr==10.0.123.101 and !arp
- Apenas há dialogos dos vários components com o NRF, MongoDB e WebConsole
- Excepção é o arranque do PFCP entre o SMF e o UPF

| No. | Time        | Source          | Destination | Length | Protocol | Info                              |
|-----|-------------|-----------------|-------------|--------|----------|-----------------------------------|
| 2   | 0.229756... | 10.0.123.200    | 224.0.0.251 | 183    | MDNS     | Standard query 0x0000 PTR _nfs._t |
| 464 | 32.24427... | 10.0.123.200    | 224.0.0.251 | 183    | MDNS     | Standard query 0x0000 PTR _nfs._t |
| 3   | 0.311544... | 10.1.0.2        | 224.0.0.251 | 183    | MDNS     | Standard query 0x0000 PTR _nfs._t |
| 465 | 32.30489... | 10.1.0.2        | 224.0.0.251 | 183    | MDNS     | Standard query 0x0000 PTR _nfs._t |
| 418 | 27.42592... | SMF-N4          | UPF-N4      | 72     | PFCP     | PFCP Association Setup Request    |
| 419 | 27.42648... | UPF-N4          | SMF-N4      | 72     | PFCP     | PFCP Association Setup Response   |
| 1   | 0.000000... | fe80::9462:5... | ff02::fb    | 203    | MDNS     | Standard query 0x0000 PTR _nfs._t |
| 293 | 22.96788... | fe80::9462:5... | ff02::2     | 70     | ICMPv6   | Router Solicitation from 0a:58:60 |
| 463 | 32.05465... | fe80::9462:5... | ff02::fb    | 203    | MDNS     | Standard query 0x0000 PTR _nfs._t |

### 3.4 gNB1

```

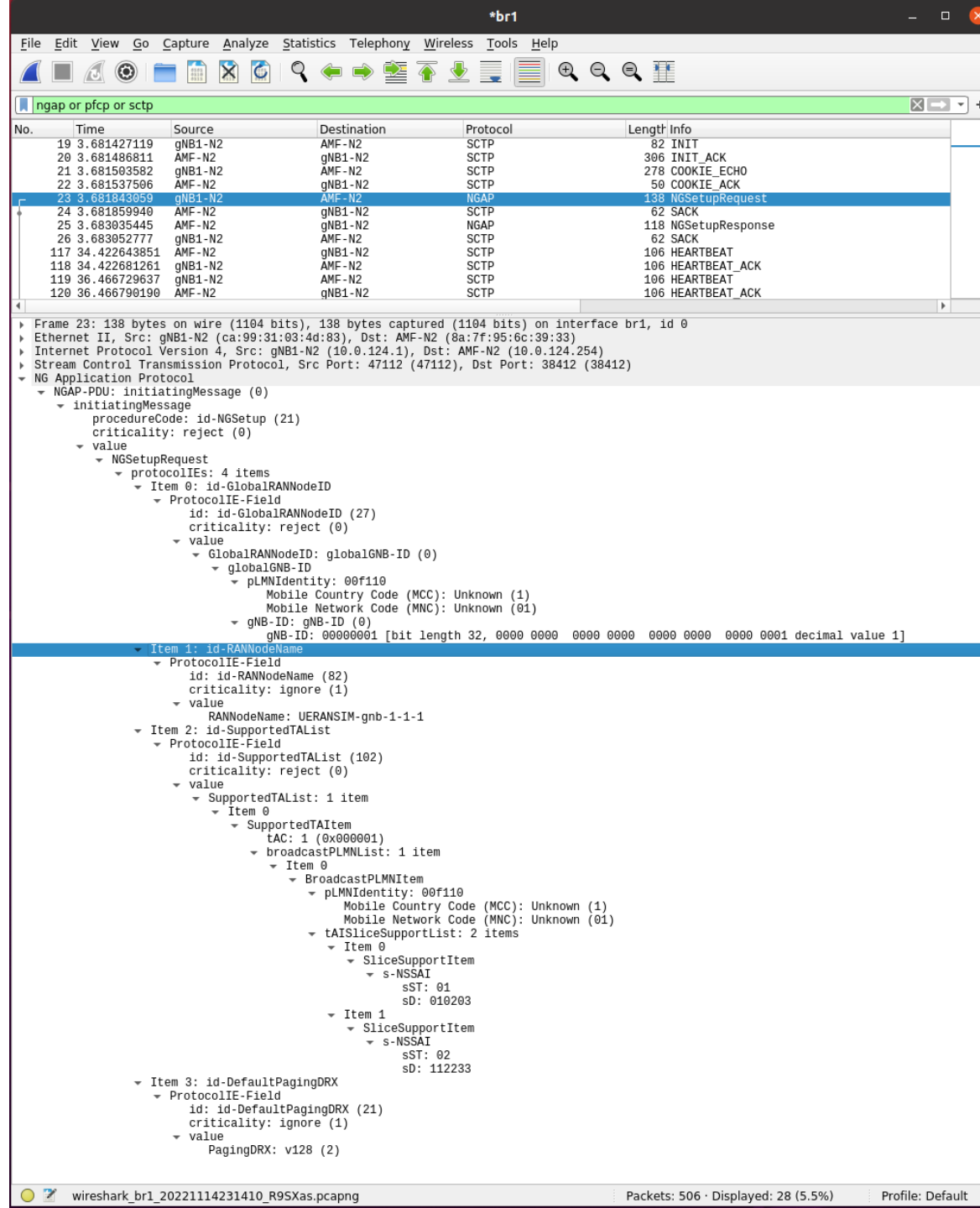
ubuntu@ubuntu-VirtualBox: ~/5GLab/netns5g
ubuntu@ubuntu-VirtualBox:~/5GLab/netns5g$ ./GNB1start.sh
[sudo] password for ubuntu:
USERANSIM v3.2.6
[2022-11-07 22:23:42.301] [sctp] Trying to establish SCTP connection... (10.0.124.254:38412)
[2022-11-07 22:23:42.303] [sctp] [info] SCTP connection established (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

```

| No.  | Time        | Source  | Destination | Length | Protocol | Info           |
|--|-------------|---------|-------------|--------|----------|----------------|
| 49   | 10.94869... | gNB1-N2 | AMF-N2      | 138    | NGAP     | NGSetupRequest |
| <p>&gt; Frame 49: 138 bytes on wire (1104 bits), 138 bytes captured (1104 bits) on interface br1, id 0</p> <p>&gt; Ethernet II, Src: 4e:89:93:1f:35:41 (4e:89:93:1f:35:41), Dst: AMF-N2 (12:85:65:4c:d9:ee)</p> <p>&gt; Internet Protocol Version 4, Src: gNB1-N2 (10.0.124.1), Dst: AMF-N2 (10.0.124.254)</p> <p>&gt; Stream Control Transmission Protocol, Src Port: 54738 (54738), Dst Port: 38412 (38412)</p> <p>&gt; NG Application Protocol (NGSetupRequest)</p> <p>NGAP-PDU: initiatingMessage (0)</p> <ul style="list-style-type: none"> <li>initiatingMessage <ul style="list-style-type: none"> <li>procedureCode: id-NGSetup (21)</li> <li>criticality: reject (0)</li> </ul> </li> <li>value <ul style="list-style-type: none"> <li>NGSetupRequest <ul style="list-style-type: none"> <li>protocolIEs: 4 items <ul style="list-style-type: none"> <li>Item 0: id-GlobalRANNodeID <ul style="list-style-type: none"> <li>ProtocolIE-Field <ul style="list-style-type: none"> <li>id: id-GlobalRANNodeID (27)</li> <li>criticality: reject (0)</li> <li>value <ul style="list-style-type: none"> <li>GlobalRANNodeID: globalGNB-ID (0) <ul style="list-style-type: none"> <li>globalGNB-ID <ul style="list-style-type: none"> <li>pLMNIdentity: 00f110 <ul style="list-style-type: none"> <li>Mobile Country Code (MCC): Unknown (1)</li> <li>Mobile Network Code (MNC): Unknown (01)</li> </ul> </li> <li>gNB-ID: gNB-ID (0) <ul style="list-style-type: none"> <li>gNB-ID: 00000001 [bit length 32, 0000 0000 0000 0000 0000 0000 0000 0001 decimal value 1]</li> </ul> </li> </ul> </li> </ul> </li> </ul> </li> </ul> </li> <li>Item 1: id-RANNodeName <ul style="list-style-type: none"> <li>ProtocolIE-Field <ul style="list-style-type: none"> <li>id: id-RANNodeName (82)</li> <li>criticality: ignore (1)</li> <li>value <ul style="list-style-type: none"> <li>RANNodeName: UERANSIM-gnb-1-1-1</li> </ul> </li> </ul> </li> <li>Item 2: id-SupportedTAList <ul style="list-style-type: none"> <li>ProtocolIE-Field <ul style="list-style-type: none"> <li>id: id-SupportedTAList (102)</li> <li>criticality: reject (0)</li> <li>value <ul style="list-style-type: none"> <li>SupportedTAList: 1 item <ul style="list-style-type: none"> <li>Item 0 <ul style="list-style-type: none"> <li>SupportedTAItem <ul style="list-style-type: none"> <li>tAC: 1 (0x000001)</li> <li>broadcastPLMNList: 1 item <ul style="list-style-type: none"> <li>Item 0 <ul style="list-style-type: none"> <li>BroadcastPLMNItem <ul style="list-style-type: none"> <li>pLMNIdentity: 00f110 <ul style="list-style-type: none"> <li>Mobile Country Code (MCC): Unknown (1)</li> <li>Mobile Network Code (MNC): Unknown (01)</li> </ul> </li> <li>tAISliceSupportList: 2 items <ul style="list-style-type: none"> <li>Item 0 <ul style="list-style-type: none"> <li>SliceSupportItem <ul style="list-style-type: none"> <li>s-NSSAI <ul style="list-style-type: none"> <li>sST: 01</li> <li>sD: 010203</li> </ul> </li> </ul> </li> <li>Item 1 <ul style="list-style-type: none"> <li>SliceSupportItem <ul style="list-style-type: none"> <li>s-NSSAI <ul style="list-style-type: none"> <li>sST: 02</li> <li>sD: 112233</li> </ul> </li> </ul> </li> </ul> </li> </ul> </li> </ul> </li> </ul> </li> </ul> </li> </ul> </li> <li>Item 3: id-DefaultPagingDRX <ul style="list-style-type: none"> <li>ProtocolIE-Field <ul style="list-style-type: none"> <li>id: id-DefaultPagingDRX (21)</li> <li>criticality: ignore (1)</li> <li>value <ul style="list-style-type: none"> <li>PagingDRX: v128 (2)</li> </ul> </li> </ul> </li> </ul> </li> </ul> </li> </ul> </li></ul></li></ul></li></ul></li></ul></li></ul></li></ul></li></ul></li></ul></li></ul></li></ul> |             |         |             |        |          |                |

[illegible]

### 3.4 gNB1



# 4.4

2022.11.19.UA.CM.Lab35G.parcia2UE11Reg.pcapng [Switch3A FastEthernet/11 to Switch3B FastEthernet/11]

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

[[ip.addr==10.0.123.0 and ip.dst==10.0.123.0] or [ip.addr==10.0.123.0 and ip.dst==10.0.123.0] and http2 or ngap or gtpc]

| No. | Time        | Source  | Destination | Length | Protocol      | Info  |
|-----|-------------|---------|-------------|--------|---------------|---|
| 172 | 3.740135904 | gNB1-N2 | AMF-N2      | 128    | NGAP/NAS-SGS  | InitiationMessage, Registration request   |
| 173 | 3.763972578 | AMF-N2  | gNB1-N2     | 146    | NGAP/NAS-SGS  | SACK (Ack=0, Arund=106496) , DownlinkNASTransport, Authentication request   |
| 175 | 3.765031711 | gNB1-N2 | AMF-N2      | 146    | NGAP/NAS-SGS  | SACK (Ack=0, Arund=106496) , UplinkNASTransport, Authentication response  |
| 232 | 3.769757723 | AMF-N2  | gNB1-N2     | 126    | NGAP/NAS-SGS  | SACK (Ack=1, Arund=106496) , DownlinkNASTransport, Security mode command  |
| 235 | 3.770221532 | gNB1-N2 | AMF-N2      | 100    | NGAP/NAS-SGS  | SACK (Ack=1, Arund=106496) , UplinkNASTransport   |
| 462 | 3.784308993 | AMF-N2  | gNB1-N2     | 246    | NGAP/NAS-SGS  | SACK (Ack=2, Arund=106496) , InitialContextSetupRequest   |
| 465 | 3.788330453 | gNB1-N2 | AMF-N2      | 98     | NGAP          | SACK (Ack=2, Arund=106496) , InitialContextSetupResponse  |
| 485 | 3.993001449 | gNB1-N2 | AMF-N2      | 242    | NGAP/NAS-SGS  | UplinkNASTransport, UplinkNASTransport  |
| 544 | 3.999839511 | AMF-SBI | SMF-SBI     | 226    | HTTP2         | [TCP Previous segment not captured] , HEADERS[3]: POST /nsmf-pdusession/v1/sm-contexts  |
| 546 | 3.999880919 | AMF-SBI | SMF-SBI     | 864    | HTTP2/JSON/NL | DATA[3], JavaScript Object Notation (application/json), PDU session establishment request   |
| 573 | 4.001631548 | SMF-N4  | UPF-N4      | 58     | PFPCP         | PFPCP Session Deletion Request  |
| 575 | 4.002628868 | UPF-N4  | SMF-N4      | 63     | PFPCP         | PFPCP Session Deletion Response   |
| 582 | 4.002968836 | SMF-SBI | AMF-SBI     | 186    | HTTP2         | [TCP Previous segment not captured] , HEADERS[3]: POST /namf-callback/v1/smContextStatus/00101cafe00000000d/1                               |
| 584 | 4.002992034 | SMF-SBI | AMF-SBI     | 118    | HTTP2/JSON    | DATA[3], JavaScript Object Notation (application/json)  |
| 733 | 4.013662559 | SMF-N4  | UPF-N4      | 329    | PFPCP         | PFPCP Session Establishment Request   |
| 736 | 4.014246745 | UPF-N4  | SMF-N4      | 89     | PFPCP         | PFPCP Session Establishment Response  |
| 744 | 4.014949778 | SMF-SBI | AMF-SBI     | 246    | HTTP2         | [TCP Previous segment not captured] , HEADERS[3]: POST /namf-comm/v1/ue-contexts/imsi-001010000000011/n1-n2-messages                        |
| 746 | 4.015000348 | SMF-SBI | AMF-SBI     | 930    | HTTP2/JSON/NL | DATA[3], JavaScript Object Notation (application/json), PDU session establishment accept  |
| 756 | 4.015906089 | AMF-N2  | gNB1-N2     | 258    | NGAP/NAS-SGS  | SACK (Ack=3, Arund=106496) , PDUSessionResourceSetupRequest   |
| 761 | 4.018942823 | gNB1-N2 | AMF-N2      | 118    | NGAP          | SACK (Ack=3, Arund=106496) , PDUSessionResourceSetupResponse  |
| 768 | 4.023624933 | AMF-SBI | SMF-SBI     | 263    | HTTP2         | [TCP Previous segment not captured] , HEADERS[3]: POST /nsmf-pdusession/v1/sm-contexts/urn:uuid:4d50321f-f1d7-4a29-97dc-00adc7e6508a/modify |
| 770 | 4.023627241 | AMF-SBI | SMF-SBI     | 703    | HTTP2/JSON/NL | DATA[3], JavaScript Object Notation (application/json)  |
| 780 | 4.024655553 | SMF-N4  | UPF-N4      | 190    | PFPCP         | PFPCP Session Modification Request  |
| 781 | 4.025451344 | UPF-N4  | SMF-N4      | 63     | PFPCP         | PFPCP Session Modification Response   |

001. .... = Rule operation code: Create new QoS rule (1)  
...1 .... = DQR: The QoS rule is the default QoS rule  
.... 0001 = Number of packet filters: 1  
 Packet filter 1  
 ..11 .... = Packet filter direction: Bidirectional (3)  
 .... 0001 = Packet filter identifier: 1  
 Length: 1  
 Packet filter component 1  
 Packet filter component type: Match-all type (1)  
QoS rule precedence: 255  
0... .... = Spare: 0  
.0... .... = Spare: 0  
..00 1001 = Qos flow identifier: 9  
 Session-AMBR  
 Length: 6  
 Unit for Session-AMBR for downlink: value is incremented in multiples of 1 Mbps (6)  
 Session-AMBR for downlink: 20 Mbps (20)  
 Unit for Session-AMBR for uplink: value is incremented in multiples of 1 Mbps (6)  
 Session-AMBR for uplink: 10 Mbps (10)  
 PDU address  
 Element ID: 0x29  
 Length: 5  
 .... 0... = SMF's IPv6 link local address (SI6LLA): Absent  
 .... 001 = PDU session type: IPv4 (1)  
 PDU address information: 10.60.0.14 (10.60.0.14)  
 S-HSSAI  
 Element ID: 0x22  
 Length: 4  
 Slice/service type (SST): eMBB (1)  
 Slice differentiator (SD): 66051  
 QoS flow descriptions - Authorized  
 Element ID: 0x79  
 Length: 6  
 QoS flow description 1 - SQI  
 ..00 1001 = Qos flow identifier: 9  
 001. .... = Operation code: Create new QoS flow description (1)  
 .1... .... = E bit: 1  
 ..00 0001 = Number of parameters: 1  
 Parameter 1  
 Parameter identifier: SQI (1)  
 Length: 1  
 SQI: 9  
 Extended protocol configuration options  
 Element ID: 0x7b  
 Length: 8  
 [Link direction: Network to MS (1)]  
 [.... .... = Extension: True  
 .... 0000 = Configuration Protocol: PPP for use with IP PDP type or IP PON type (0)  
 Protocol or Container ID: DNS Server IPv4 Address (0x0004)  
 Length: 0x04 (4)  
 IPv4: dns.google (8.8.8.8)  
 DNN  
 Element ID: 0x25  
 Length: 9  
 DNN: Internet  
Boundary: \r\n--a70e03ddb466c1377994ef249604db708f0d05e2763fb071a97f93ab9f\r\n  
 Encapsulated multipart part: (application/vnd.3gpp.ngap)  
 Content-Id: H2SmInformation\r\n  
 Content-Type: application/vnd.3gpp.ngap\r\n\r\n  
 NG Application Protocol  
 PDUSessionResourceSetupRequestTransfer  
 > protocolIEs: 4 items  
 Last boundary: \r\n--a70e03ddb466c1377994ef249604db708f0d05e2763fb071a97f93ab9f--\r\n

Packets: 934 - Displayed: 24 (2.6%) - Marked: 1 (0.1%) - Ignored: 36 (3.9%) Profile: Default

## 4.5 UE11

```
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] [rrc] [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 22:24:38.007] [nas] [debug] PDU Session Establishment Accept received
[2022-11-07 22:24:38.007] [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.
```

```
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::e85b: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$
```

# 4.5, 4.6

**\*br1**

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

ngap or sctp or pfcp

| No.  | Time         | Source  | Destination | Protocol           | Length Info  |
|------|--------------|---------|-------------|--------------------|--|
| 34   | 7.280393818  | gNB1-N2 | AMF-N2      | NGAP/NAS-SGS       | 138 InitialUEMessage, Registration request                       |
| 172  | 7.292637760  | AMF-N2  | gNB1-N2     | NGAP/NAS-SGS       | 146 DownlinkNASTransport, Authentication request                 |
| 177  | 7.293349304  | gNB1-N2 | AMF-N2      | NGAP/NAS-SGS       | 146 UplinkNASTransport, Authentication failure (Synch failure)   |
| 267  | 7.300650256  | AMF-N2  | gNB1-N2     | NGAP/NAS-SGS       | 146 DownlinkNASTransport, Authentication request                 |
| 271  | 7.301357712  | gNB1-N2 | AMF-N2      | NGAP/NAS-SGS       | 146 UplinkNASTransport, Authentication response                  |
| 340  | 7.411400226  | AMF-N2  | gNB1-N2     | NGAP/NAS-SGS       | 126 DownlinkNASTransport   |
| 345  | 7.411976827  | gNB1-N2 | AMF-N2      | NGAP/NAS-SGS       | 190 UplinkNASTransport   |
| 609  | 7.468912479  | AMF-N2  | gNB1-N2     | NGAP/NAS-SGS       | 246 InitialContextSetupRequest                                   |
| 611  | 7.469150105  | gNB1-N2 | AMF-N2      | NGAP               | 98 InitialContextSetupResponse                                   |
| 624  | 7.676183517  | AMF-N2  | gNB1-N2     | SCTP               | 62 SACK  |
| 625  | 7.676230846  | gNB1-N2 | AMF-N2      | NGAP/NAS-SGS       | 242 UnlinkNASTransport   |
| 843  | 7.694859851  | SMF-N4  | UPF-N4      | PFPCP              | 329 PFPCP Session Establishment Request                          |
| 847  | 7.695977687  | UPF-N4  | SMF-N4      | PFPCP              | 89 PFPCP Session Establishment Response                          |
| 856  | 7.697085595  | SMF-SBI | AMF-SBI     | HTTP2/NAS-SGS/NGAP | 930 DATA[3] (application/json), PDU session establishment accept |
| 866  | 7.698039905  | AMF-N2  | gNB1-N2     | NGAP/NAS-SGS       | 238 PDUSessionResourceSetupRequest                               |
| 871  | 7.699707512  | gNB1-N2 | AMF-N2      | NGAP               | 118 PDUSessionResourceSetupResponse                              |
| 880  | 7.700313378  | AMF-SBI | SMF-SBI     | HTTP2/NGAP         | 703 DATA[3] (application/json)                                   |
| 888  | 7.702246022  | SMF-N4  | UPF-N4      | PFPCP              | 190 PFPCP Session Modification Request                           |
| 889  | 7.702404610  | UPF-N4  | SMF-N4      | PFPCP              | 62 PFPCP Session Modification Response                           |
| 909  | 7.902680479  | AMF-N2  | gNB1-N2     | SCTP               | 62 SACK  |
| 1210 | 37.903193773 | AMF-N2  | gNB1-N2     | SCTP               | 106 HEARTBEAT  |
| 1212 | 37.903219762 | gNB1-N2 | AMF-N2      | SCTP               | 106 HEARTBEAT_ACK  |
| 1216 | 38.415102270 | gNB1-N2 | AMF-N2      | SCTP               | 106 HEARTBEAT  |
| 1217 | 38.415134721 | AMF-N2  | gNB1-N2     | SCTP               | 106 HEARTBEAT_ACK  |

NG Application Protocol  
 NGAP-PDU: initiatingMessage (0)  
   initiatingMessage  
     procedureCode: id-InitialUEMessage (15)  
     criticality: ignore (1)  
     value  
       InitialUEMessage  
         protocolIEs: 5 items  
           Item 0: id-RAN-UE-NGAP-ID  
             ProtocolIE-Field  
               id: id-RAN-UE-NGAP-ID (85)  
               criticality: reject (0)  
               value  
                 RAN-UE-NGAP-ID: 1  
           Item 1: id-NAS-PDU  
             ProtocolIE-Field  
               id: id-NAS-PDU (38)  
               criticality: reject (0)  
               value  
                 NAS-PDU: 7e00417900d0d100f11000000000000000112e04f0f0f0...  
                   Non-Access-Stratum 5GS (NAS)PDU  
           Item 2: id-UserLocationInformation  
             ProtocolIE-Field  
               id: id-UserLocationInformation (121)  
               criticality: reject (0)  
               value  
                 UserLocationInformation: userLocationInformationNR (1)  
                   userLocationInformationNR  
                     nR-CGI  
                       pLMNIdentity: 00f110  
                         Mobile Country Code (MCC): Unknown (1)  
                         Mobile Network Code (MNC): Unknown (01)  
                         nRCellIdentity: 0x0000000010  
                     tAI  
                       pLMNIdentity: 00f110  
                         Mobile Country Code (MCC): Unknown (1)  
                         Mobile Network Code (MNC): Unknown (01)  
                         tAC: 1 (0x000001)  
                         timeStamp: e71d4dee (Nov 14, 2022 23:29:50 UTC)  
           Item 3: id-RRCEstablishmentCause  
             ProtocolIE-Field

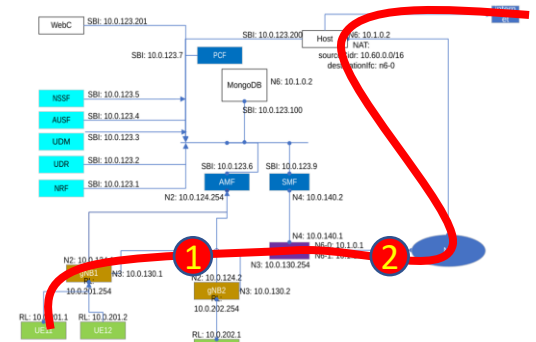
Stream Control Transmission Protocol (sctp), 28 bytes      Packets: 1334 · Displayed: 24 (1.8%) · Dropped: 0 (0.0%)      Profile: Default

# 4.5, 4.6

- ARP
- HTTP2
  - HTTP2
  - HTTP2/NAS-5GS: AMF→SMF
  - HTTP2/NAS-5GS/NGAP: SMF→MF
  - HTTP2/NGAP: AMF→SMF
- NGAP
  - NGAP: gNB1-N2 → AMF
  - NGAP/NAS-5GS: AMF ↔ gNB2-N2
- PFCP: SMF-N4 ↔ UPF-N4
- SCTP: AMF-N2 ↔ gNB1-N2 (Sack e heartbeats)
- UDP & TCP



# 5.3 and 5.4: UE11 ping to 8.8.8.8



ICMP packet gNB1 → UPF (N3)

1

ICMP packet UPF (N6) → Internet (8.8.8.8)

2

ICMP packet Internet (8.8.8.8) → UPF (N6)

2

ICMP packet UPF (N3) → gNB1

1

'clean' ICMP packet  
UE IP address is 'NATed' to UPF N6 IP address

O ip 10.1.0.1 é do UPF e não do host-n6. esse é o 10.1.0.2  
Corrigir no ficheiro de hosts

2022.11.09.free5GC.UE11ping888.pcapng [SwitchL3A FastEthernet1/11 to SwitchL3B FastEthernet1/11]

| No. | Time        | Source     | Destination | Length | Protocol   | Info   |
|-----|-------------|------------|-------------|--------|------------|--|
| 63  | 7.896847... | 10.60.0.1  | dns.google  | 142    | GTP <ICMP> | Echo (ping) request id=0x16c4, seq=1/256, ttl=64 (reply in 69) |
| 67  | 7.896928... | Host-N6    | dns.google  | 98     | ICMP       | Echo (ping) request id=0x16c4, seq=1/256, ttl=63 (reply in 68) |
| 68  | 7.914766... | dns.google | Host-N6     | 98     | ICMP       | Echo (ping) reply id=0x16c4, seq=1/256, ttl=60 (request in 67) |
| 69  | 7.914878... | dns.google | 10.60.0.1   | 142    | GTP <ICMP> | Echo (ping) reply id=0x16c4, seq=1/256, ttl=59 (request in 63) |

Frame 63: 142 bytes on wire (1136 bits), 142 bytes captured (1136 bits) on interface br1, id 0  
> Ethernet II, Src: 42:dc:f6:5c:fd:d3 (42:dc:f6:5c:fd:d3), Dst: 62:89:55:06:b3:ea (62:89:55:06:b3:ea)  
> Internet Protocol Version 4, Src: 10.0.130.1 (10.0.130.1), Dst: 10.0.130.254 (10.0.130.254)  
> User Datagram Protocol, Src Port: 2152, Dst Port: 2152  
▼ GPRS Tunneling Protocol  
  > Flags: 0x34  
  Message Type: T-PDU (0x0ff)  
  Length: 92  
  TEID: 0x00000001 (1)  
  Next extension header type: PDU Session container (0x85)  
  Extension header (PDU Session container)  
    Extension Header Length: 1  
    ▼ PDU Session Container  
      0001 .... = PDU Type: UL PDU SESSION INFORMATION (1)  
      .... 0000 = Spare: 0x0  
      00... .... = Spare: 0x0  
      ..00 1001 = QoS Flow Identifier (QFI): 9  
      Next extension header type: No more extension headers (0x00)  
> Internet Protocol Version 4, Src: 10.60.0.1 (10.60.0.1), Dst: dns.google (8.8.8.8)  
> Internet Control Message Protocol

SA: gNB1 N3

DA: UPF N3

2022.11.09.free5GC.UE11ping888.pcapng [SwitchL3A FastEthernet1/11 to SwitchL3B FastEthernet1/11]

| No. | Time        | Source     | Destination | Length | Protocol   | Info   |
|-----|-------------|------------|-------------|--------|------------|--|
| 63  | 7.896847... | 10.60.0.1  | dns.google  | 142    | GTP <ICMP> | Echo (ping) request id=0x16c4, seq=1/256, ttl=64 (reply in 69) |
| 67  | 7.896928... | Host-N6    | dns.google  | 98     | ICMP       | Echo (ping) request id=0x16c4, seq=1/256, ttl=63 (reply in 68) |
| 68  | 7.914766... | dns.google | Host-N6     | 98     | ICMP       | Echo (ping) reply id=0x16c4, seq=1/256, ttl=60 (request in 67) |
| 69  | 7.914878... | dns.google | 10.60.0.1   | 142    | GTP <ICMP> | Echo (ping) reply id=0x16c4, seq=1/256, ttl=59 (request in 63) |

Frame 67: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface br1, id 0  
> Ethernet II, Src: Host-N6 (c6:ea:04:53:2f:e6), Dst: da:eb:71:8e:06:37 (da:eb:71:8e:06:37)  
> Internet Protocol Version 4, Src: Host-N6 (10.1.0.1), Dst: dns.google (8.8.8.8)  
> Internet Control Message Protocol

2022.11.09.free5GC.UE11ping888.pcapng [SwitchL3A FastEthernet1/11 to SwitchL3B FastEthernet1/11]

| No. | Time        | Source     | Destination | Length | Protocol   | Info   |
|-----|-------------|------------|-------------|--------|------------|--|
| 63  | 7.896847... | 10.60.0.1  | dns.google  | 142    | GTP <ICMP> | Echo (ping) request id=0x16c4, seq=1/256, ttl=64 (reply in 69) |
| 67  | 7.896928... | Host-N6    | dns.google  | 98     | ICMP       | Echo (ping) request id=0x16c4, seq=1/256, ttl=63 (reply in 68) |
| 68  | 7.914766... | dns.google | Host-N6     | 98     | ICMP       | Echo (ping) reply id=0x16c4, seq=1/256, ttl=60 (request in 67) |
| 69  | 7.914878... | dns.google | 10.60.0.1   | 142    | GTP <ICMP> | Echo (ping) reply id=0x16c4, seq=1/256, ttl=59 (request in 63) |

Frame 68: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface br1, id 0  
> Ethernet II, Src: da:eb:71:8e:06:37 (da:eb:71:8e:06:37), Dst: Host-N6 (c6:ea:04:53:2f:e6)  
> Internet Protocol Version 4, Src: dns.google (8.8.8.8), Dst: Host-N6 (10.1.0.1)  
> Internet Control Message Protocol

2022.11.09.free5GC.UE11ping888.pcapng [SwitchL3A FastEthernet1/11 to SwitchL3B FastEthernet1/11]

| No. | Time        | Source     | Destination | Length | Protocol   | Info   |
|-----|-------------|------------|-------------|--------|------------|--|
| 63  | 7.896847... | 10.60.0.1  | dns.google  | 142    | GTP <ICMP> | Echo (ping) request id=0x16c4, seq=1/256, ttl=64 (reply in 69) |
| 67  | 7.896928... | Host-N6    | dns.google  | 98     | ICMP       | Echo (ping) request id=0x16c4, seq=1/256, ttl=63 (reply in 68) |
| 68  | 7.914766... | dns.google | Host-N6     | 98     | ICMP       | Echo (ping) reply id=0x16c4, seq=1/256, ttl=60 (request in 67) |
| 69  | 7.914878... | dns.google | 10.60.0.1   | 142    | GTP <ICMP> | Echo (ping) reply id=0x16c4, seq=1/256, ttl=59 (request in 63) |

Frame 69: 142 bytes on wire (1136 bits), 142 bytes captured (1136 bits) on interface br1, id 0  
> Ethernet II, Src: ca:63:2e:36:6a:48 (ca:63:2e:36:6a:48), Dst: 42:dc:f6:5c:fd:d3 (42:dc:f6:5c:fd:d3)  
> Internet Protocol Version 4, Src: 10.0.130.254 (10.0.130.254), Dst: 10.0.130.1 (10.0.130.1)  
> User Datagram Protocol, Src Port: 2152, Dst Port: 2152  
▼ GPRS Tunneling Protocol  
  > Flags: 0x34  
  Message Type: T-PDU (0x0ff)  
  Length: 92  
  TEID: 0x00000001 (1)  
  Next extension header type: PDU Session container (0x85)  
  Extension header (PDU Session container)  
    Extension Header Length: 1  
    ▼ PDU Session Container  
      0000 .... = PDU Type: DL PDU SESSION INFORMATION (0)  
      .... 0000 = Spare: 0x0  
      0... .... = Paging Policy Presence (PPP): Not Present  
      ..0... .... = Reflective QoS Indicator (RQI): Not Present  
      ..00 1001 = QoS Flow Identifier (QFI): 9  
      Next extension header type: No more extension headers (0x00)  
> Internet Protocol Version 4, Src: dns.google (8.8.8.8), Dst: 10.60.0.1 (10.60.0.1)  
> Internet Control Message Protocol

SA: UPF N3  
DA: gNB1 N3

# 5.3 and 5.4: UE11 ping to 8.8.8.8

2022.11.19.UA.CM.Lab5G.pingUE11.8888.br0.pcapng [SwitchL3A FastEthernet1/11 to SwitchL3B FastEthernet1/11]

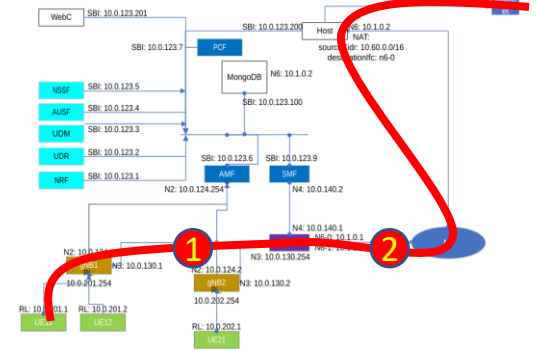
| No. | Time        | Source     | Destination | Length | Protocol   | Info   |
|-----|-------------|------------|-------------|--------|------------|--|
| 292 | 27.19774... | 10.60.0.10 | dns.google  | 142    | GTP <ICMP> | Echo (ping) request id=0x24ac, seq=1/256, ttl=64 (reply in |
| 293 | 27.19780... | UPF-N6     | dns.google  | 98     | ICMP       | Echo (ping) request id=0x24ac, seq=1/256, ttl=63 (reply in |
| 294 | 27.21942... | dns.google | UPF-N6      | 98     | ICMP       | Echo (ping) reply id=0x24ac, seq=1/256, ttl=112 (request   |
| 295 | 27.21951... | dns.google | 10.60.0.10  | 142    | GTP <ICMP> | Echo (ping) reply id=0x24ac, seq=1/256, ttl=111 (request   |

Frame 292: 142 bytes on wire (1136 bits), 142 bytes captured (1136 bits) on interface br1, id 0  
 Ethernet II, Src: f6:48:ab:60:52:9a (f6:48:ab:60:52:9a), Dst: 1a:6d:fc:b3:2f:4d (1a:6d:fc:b3:2f:4d)  
 Internet Protocol Version 4, Src: 10.0.130.1 (10.0.130.1), Dst: 10.0.130.254 (10.0.130.254)  
 User Datagram Protocol, Src Port: 2152, Dst Port: 2152  
 GPRS Tunneling Protocol  
 Flags: 0x34  
 Message Type: T-PDU (0x0ff)  
 Length: 92  
 TEID: 0x00000013 (19)  
 Next extension header type: PDU Session container (0x85)  
 Extension header (PDU Session container)  
 Extension Header Length: 1  
 PDU Session Container  
 Next extension header type: No more extension headers (0x00)  
 Internet Protocol Version 4, Src: 10.60.0.10 (10.60.0.10), Dst: dns.google (8.8.8.8)  
 Internet Control Message Protocol

SA: gNB1 N3  
DA: UPF N3

ICMP packet gNB1→ UPF (N3)

1



ICMP packet UPF (N6)→ Internet (8.8.8.8)

2

2022.11.19.UA.CM.Lab5G.pingUE11.8888.br0.pcapng [SwitchL3A FastEthernet1/11 to SwitchL3B FastEthernet1/11]

| No. | Time        | Source     | Destination | Length | Protocol   | Info   |
|-----|-------------|------------|-------------|--------|------------|--|
| 292 | 27.19774... | 10.60.0.10 | dns.google  | 142    | GTP <ICMP> | Echo (ping) request id=0x24ac, seq=1/256, ttl=64 (reply in |
| 293 | 27.19780... | UPF-N6     | dns.google  | 98     | ICMP       | Echo (ping) request id=0x24ac, seq=1/256, ttl=63 (reply in |
| 294 | 27.21942... | dns.google | UPF-N6      | 98     | ICMP       | Echo (ping) reply id=0x24ac, seq=1/256, ttl=112 (request   |
| 295 | 27.21951... | dns.google | 10.60.0.10  | 142    | GTP <ICMP> | Echo (ping) reply id=0x24ac, seq=1/256, ttl=111 (request   |

Frame 293: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface br1, id 0  
 Ethernet II, Src: UPF-N6 (d2:cc:27:8a:2a:8b), Dst: Host-N6 (6e:67:c4:9b:1c:0d)  
 Internet Protocol Version 4, Src: UPF-N6 (10.1.0.1), Dst: dns.google (8.8.8.8)  
 Internet Control Message Protocol

ICMP packet Internet (8.8.8.8) → UPF (N6)

2

ICMP packet UPF (N3) → gNB1

1

‘clean’ ICMP packet  
UE IP address is ‘NATed’ to UPF N6 IP address

2022.11.19.UA.CM.Lab5G.pingUE11.8888.br0.pcapng [SwitchL3A FastEthernet1/11 to SwitchL3B FastEthernet1/11]

| No. | Time        | Source     | Destination | Length | Protocol   | Info   |
|-----|-------------|------------|-------------|--------|------------|--|
| 292 | 27.19774... | 10.60.0.10 | dns.google  | 142    | GTP <ICMP> | Echo (ping) request id=0x24ac, seq=1/256, ttl=64 (reply in |
| 293 | 27.19780... | UPF-N6     | dns.google  | 98     | ICMP       | Echo (ping) request id=0x24ac, seq=1/256, ttl=63 (reply in |
| 294 | 27.21942... | dns.google | UPF-N6      | 98     | ICMP       | Echo (ping) reply id=0x24ac, seq=1/256, ttl=112 (request   |
| 295 | 27.21951... | dns.google | 10.60.0.10  | 142    | GTP <ICMP> | Echo (ping) reply id=0x24ac, seq=1/256, ttl=111 (request   |

Frame 294: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface br1, id 0  
 Ethernet II, Src: Host-N6 (6e:67:c4:9b:1c:0d), Dst: UPF-N6 (d2:cc:27:8a:2a:8b)  
 Internet Protocol Version 4, Src: dns.google (8.8.8.8), Dst: UPF-N6 (10.1.0.1)  
 Internet Control Message Protocol

2022.11.19.UA.CM.Lab5G.pingUE11.8888.br0.pcapng [SwitchL3A FastEthernet1/11 to SwitchL3B FastEthernet1/11]

| No. | Time        | Source     | Destination | Length | Protocol   | Info   |
|-----|-------------|------------|-------------|--------|------------|--|
| 292 | 27.19774... | 10.60.0.10 | dns.google  | 142    | GTP <ICMP> | Echo (ping) request id=0x24ac, seq=1/256, ttl=64 (reply in |
| 293 | 27.19780... | UPF-N6     | dns.google  | 98     | ICMP       | Echo (ping) request id=0x24ac, seq=1/256, ttl=63 (reply in |
| 294 | 27.21942... | dns.google | UPF-N6      | 98     | ICMP       | Echo (ping) reply id=0x24ac, seq=1/256, ttl=112 (request   |
| 295 | 27.21951... | dns.google | 10.60.0.10  | 142    | GTP <ICMP> | Echo (ping) reply id=0x24ac, seq=1/256, ttl=111 (request   |

Frame 295: 142 bytes on wire (1136 bits), 142 bytes captured (1136 bits) on interface br1, id 0  
 Ethernet II, Src: 1a:6d:fc:b3:2f:4d (1a:6d:fc:b3:2f:4d), Dst: f6:48:ab:60:52:9a (f6:48:ab:60:52:9a)  
 Internet Protocol Version 4, Src: 10.0.130.254 (10.0.130.254), Dst: 10.0.130.1 (10.0.130.1)  
 User Datagram Protocol, Src Port: 2152, Dst Port: 2152  
 GPRS Tunneling Protocol  
 Flags: 0x34  
 Message Type: T-PDU (0x0ff)  
 Length: 92  
 TEID: 0x00000008 (8)  
 Next extension header type: PDU Session container (0x85)  
 Extension header (PDU Session container)  
 Extension Header Length: 1  
 PDU Session Container  
 Next extension header type: No more extension headers (0x00)  
 Internet Protocol Version 4, Src: dns.google (8.8.8.8), Dst: 10.60.0.10 (10.60.0.10)  
 Internet Control Message Protocol

SA: UPF N3  
DA: gNB1 N3

# 5.6: UE11-UE12(sl1) ping

2022.11.19.UA.CM.Lab5G.pingUE11.UE12-sl1.br0.pcapng [SwitchL3A FastEthernet1/11 to SwitchL3B FastEthernet1/11]

| No. | Time        | Source     | Destination | Length | Protocol   | Info   |
|-----|-------------|------------|-------------|--------|------------|--|
| 736 | 50.29821... | 10.60.0.10 | 10.60.0.12  | 142    | GTP <ICMP> | Echo (ping) request id=0x24dd, seq=22/5632, ttl=64 (no res |
| 737 | 50.29826... | 10.60.0.10 | 10.60.0.12  | 142    | GTP <ICMP> | Echo (ping) request id=0x24dd, seq=22/5632, ttl=63 (reply  |
| 740 | 50.29873... | 10.60.0.12 | 10.60.0.10  | 142    | GTP <ICMP> | Echo (ping) reply id=0x24dd, seq=22/5632, ttl=64 (request  |
| 741 | 50.29874... | 10.60.0.12 | 10.60.0.10  | 142    | GTP <ICMP> | Echo (ping) reply id=0x24dd, seq=22/5632, ttl=63 (reply    |

> Frame 736: 142 bytes on wire (1136 bits), 142 bytes captured (1136 bits) on interface br1, id 0  
> Ethernet II, Src: f6:48:ab:69:52:9a (f6:48:ab:69:52:9a), Dst: 1a:6d:fc:b2:2f:de (1a:6d:fc:b2:2f:de)  
> Internet Protocol Version 4, Src: 10.0.130.1 (10.0.130.1), Dst: 10.0.130.254 (10.0.130.254)  
> User Datagram Protocol, Src Port: 2152, Dst Port: 2152  
v GPRS Tunneling Protocol  
  > Flags: 0x34  
  > Message Type: T-PDU (0xff)  
  > Length: 92  
  > TEID: 0x00000013 (19)  
  > Next extension header type: PDU Session container (0x85)  
  > Extension header (PDU Session container)  
> Internet Protocol Version 4, Src: 10.60.0.10 (10.60.0.10), Dst: 10.60.0.12 (10.60.0.12)  
> Internet Control Message Protocol

Internet Control Message Protocol: Protocol   Packets: 774 · Displayed: 105 (13.6%)   Profile: Default

2022.11.19.UA.CM.Lab5G.pingUE11.UE12-sl1.br0.pcapng [SwitchL3A FastEthernet1/11 to SwitchL3B FastEthernet1/11]

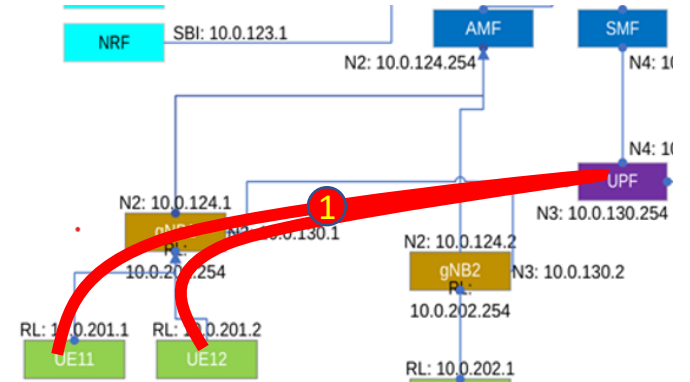
| No. | Time        | Source     | Destination | Length | Protocol   | Info   |
|-----|-------------|------------|-------------|--------|------------|--|
| 736 | 50.29821... | 10.60.0.10 | 10.60.0.12  | 142    | GTP <ICMP> | Echo (ping) request id=0x24dd, seq=22/5632, ttl=64 (no res |
| 737 | 50.29826... | 10.60.0.10 | 10.60.0.12  | 142    | GTP <ICMP> | Echo (ping) request id=0x24dd, seq=22/5632, ttl=63 (reply  |
| 740 | 50.29873... | 10.60.0.12 | 10.60.0.10  | 142    | GTP <ICMP> | Echo (ping) reply id=0x24dd, seq=22/5632, ttl=64 (request  |
| 741 | 50.29874... | 10.60.0.12 | 10.60.0.10  | 142    | GTP <ICMP> | Echo (ping) reply id=0x24dd, seq=22/5632, ttl=63 (reply    |

> Frame 737: 142 bytes on wire (1136 bits), 142 bytes captured (1136 bits) on interface br1, id 0  
> Ethernet II, Src: 1a:6d:fc:b2:2f:de (1a:6d:fc:b2:2f:de), Dst: f6:48:ab:69:52:9a (f6:48:ab:69:52:9a)  
> Internet Protocol Version 4, Src: 10.0.130.254 (10.0.130.254), Dst: 10.0.130.1 (10.0.130.1)  
> User Datagram Protocol, Src Port: 2152, Dst Port: 2152  
v GPRS Tunneling Protocol  
  > Flags: 0x34  
  > Message Type: T-PDU (0xff)  
  > Length: 92  
  > TEID: 0x00000009 (9)  
  > Next extension header type: PDU Session container (0x85)  
  > Extension header (PDU Session container)  
> Internet Protocol Version 4, Src: 10.60.0.10 (10.60.0.10), Dst: 10.60.0.12 (10.60.0.12)  
> Internet Control Message Protocol

Internet Control Message Protocol: Protocol   Packets: 774 · Displayed: 105 (13.6%)   Profile: Default

ICMP packet UPF (N3)→ gNB2 (N3)

ICMP packet gNB1→ UPF (N3)



2022.11.19.UA.CM.Lab5G.pingUE11.UE12-sl1.br0.pcapng [SwitchL3A FastEthernet1/11 to SwitchL3B FastEthernet1/11]

| No. | Time        | Source     | Destination | Length | Protocol   | Info   |
|-----|-------------|------------|-------------|--------|------------|--|
| 736 | 50.29821... | 10.60.0.10 | 10.60.0.12  | 142    | GTP <ICMP> | Echo (ping) request id=0x24dd, seq=22/5632, ttl=64 (no res |
| 737 | 50.29826... | 10.60.0.10 | 10.60.0.12  | 142    | GTP <ICMP> | Echo (ping) request id=0x24dd, seq=22/5632, ttl=63 (reply  |
| 740 | 50.29873... | 10.60.0.12 | 10.60.0.10  | 142    | GTP <ICMP> | Echo (ping) reply id=0x24dd, seq=22/5632, ttl=64 (request  |
| 741 | 50.29874... | 10.60.0.12 | 10.60.0.10  | 142    | GTP <ICMP> | Echo (ping) reply id=0x24dd, seq=22/5632, ttl=63 (reply    |

> Frame 740: 142 bytes on wire (1136 bits), 142 bytes captured (1136 bits) on interface br1, id 0  
> Ethernet II, Src: f6:48:ab:69:52:9a (f6:48:ab:69:52:9a), Dst: 1a:6d:fc:b2:2f:de (1a:6d:fc:b2:2f:de)  
> Internet Protocol Version 4, Src: 10.0.130.1 (10.0.130.1), Dst: 10.0.130.254 (10.0.130.254)  
> User Datagram Protocol, Src Port: 2152, Dst Port: 2152  
v GPRS Tunneling Protocol  
  > Flags: 0x34  
  > Message Type: T-PDU (0xff)  
  > Length: 92  
  > TEID: 0x00000017 (23)  
  > Next extension header type: PDU Session container (0x85)  
  > Extension header (PDU Session container)  
> Internet Protocol Version 4, Src: 10.60.0.12 (10.60.0.12), Dst: 10.60.0.10 (10.60.0.10)  
> Internet Control Message Protocol

Internet Control Message Protocol: Protocol   Packets: 774 · Displayed: 105 (13.6%)   Profile: Default

ICMP packet gNB2 → UPF (N3)

2022.11.19.UA.CM.Lab5G.pingUE11.UE12-sl1.br0.pcapng [SwitchL3A FastEthernet1/11 to SwitchL3B FastEthernet1/11]

| No. | Time        | Source     | Destination | Length | Protocol   | Info   |
|-----|-------------|------------|-------------|--------|------------|--|
| 736 | 50.29821... | 10.60.0.10 | 10.60.0.12  | 142    | GTP <ICMP> | Echo (ping) request id=0x24dd, seq=22/5632, ttl=64 (no res |
| 737 | 50.29826... | 10.60.0.10 | 10.60.0.12  | 142    | GTP <ICMP> | Echo (ping) request id=0x24dd, seq=22/5632, ttl=63 (reply  |
| 740 | 50.29873... | 10.60.0.12 | 10.60.0.10  | 142    | GTP <ICMP> | Echo (ping) reply id=0x24dd, seq=22/5632, ttl=64 (request  |
| 741 | 50.29874... | 10.60.0.12 | 10.60.0.10  | 142    | GTP <ICMP> | Echo (ping) reply id=0x24dd, seq=22/5632, ttl=63 (reply    |

> Frame 741: 142 bytes on wire (1136 bits), 142 bytes captured (1136 bits) on interface br1, id 0  
> Ethernet II, Src: 1a:6d:fc:b2:2f:de (1a:6d:fc:b2:2f:de), Dst: f6:48:ab:69:52:9a (f6:48:ab:69:52:9a)  
> Internet Protocol Version 4, Src: 10.0.130.254 (10.0.130.254), Dst: 10.0.130.1 (10.0.130.1)  
> User Datagram Protocol, Src Port: 2152, Dst Port: 2152  
v GPRS Tunneling Protocol  
  > Flags: 0x34  
  > Message Type: T-PDU (0xff)  
  > Length: 92  
  > TEID: 0x00000008 (8)  
  > Next extension header type: PDU Session container (0x85)  
  > Extension header (PDU Session container)  
> Internet Protocol Version 4, Src: 10.60.0.12 (10.60.0.12), Dst: 10.60.0.10 (10.60.0.10)  
> Internet Control Message Protocol

Internet Control Message Protocol: Protocol   Packets: 774 · Displayed: 105 (13.6%)   Profile: Default

ICMP packet UPF (N3) → gNB1

# 5.8: UE12-UE21 ping

2022.11.19.UA.CM.Lab5G.pingUE11.UE21.br0.pcapng [Switch3A FastEthernet1/11 to Switch3B FastEthernet1/11]

| No. | Time        | Source     | Destination | Length | Protocol   | Info  |
|-----|-------------|------------|-------------|--------|------------|---|
| 544 | 36.75112... | 10.60.0.10 | 10.60.0.11  | 142    | GTP <ICMP> | Echo (ping) request id=0x24e7, seq=15/3840, ttl=64 (no res... |
| 545 | 36.75115... | 10.60.0.10 | 10.60.0.11  | 142    | GTP <ICMP> | Echo (ping) request id=0x24e7, seq=15/3840, ttl=63 (reply     |
| 550 | 36.75186... | 10.60.0.11 | 10.60.0.10  | 142    | GTP <ICMP> | Echo (ping) reply id=0x24e7, seq=15/3840, ttl=64 (request     |
| 551 | 36.75188... | 10.60.0.11 | 10.60.0.10  | 142    | GTP <ICMP> | Echo (ping) reply id=0x24e7, seq=15/3840, ttl=63              |

< Frame 544: 142 bytes on wire (1136 bits), 142 bytes captured (1136 bits) on interface br1, id 0  
 > Ethernet II, Src: f6:48:ab:69:52:9a (f6:48:ab:69:52:9a), Dst: 1a:6d:fc:b2:2f:de (1a:6d:fc:b2:2f:de)  
 > Internet Protocol Version 4, Src: 10.0.130.1 (10.0.130.1), Dst: 10.0.130.254 (10.0.130.254)  
 > User Datagram Protocol, Src Port: 2152, Dst Port: 2152  
 > GPRS Tunneling Protocol  
 > Flags: 0x34  
 > Message Type: T-PDU (0x0ff)  
 > Length: 92  
 > TEID: 0x00000013 (19)  
 > Next extension header type: PDU Session container (0x85)  
 > Extension header (PDU Session container)  
 > Internet Protocol Version 4, Src: 10.60.0.10 (10.60.0.10), Dst: 10.60.0.11 (10.60.0.11)  
 > Internet Control Message Protocol

2022.11.19.UA.CM.Lab5G.pingUE11.UE21.br0.pcapng [Switch3A FastEthernet1/11 to Switch3B FastEthernet1/11]

| No. | Time        | Source     | Destination | Length | Protocol   | Info  |
|-----|-------------|------------|-------------|--------|------------|---|
| 544 | 36.75112... | 10.60.0.10 | 10.60.0.11  | 142    | GTP <ICMP> | Echo (ping) request id=0x24e7, seq=15/3840, ttl=64 (no res... |
| 545 | 36.75115... | 10.60.0.10 | 10.60.0.11  | 142    | GTP <ICMP> | Echo (ping) request id=0x24e7, seq=15/3840, ttl=63 (reply     |
| 550 | 36.75186... | 10.60.0.11 | 10.60.0.10  | 142    | GTP <ICMP> | Echo (ping) reply id=0x24e7, seq=15/3840, ttl=64 (request     |
| 551 | 36.75188... | 10.60.0.11 | 10.60.0.10  | 142    | GTP <ICMP> | Echo (ping) reply id=0x24e7, seq=15/3840, ttl=63              |

< Frame 545: 142 bytes on wire (1136 bits), 142 bytes captured (1136 bits) on interface br1, id 0  
 > Ethernet II, Src: 1a:6d:fc:b2:2f:de (1a:6d:fc:b2:2f:de), Dst: 1e:92:9c:a7:37:80 (1e:92:9c:a7:37:80)  
 > Internet Protocol Version 4, Src: 10.0.130.254 (10.0.130.254), Dst: 10.0.130.2 (10.0.130.2)  
 > User Datagram Protocol, Src Port: 2152, Dst Port: 2152  
 > GPRS Tunneling Protocol  
 > Flags: 0x34  
 > Message Type: T-PDU (0x0ff)  
 > Length: 92  
 > TEID: 0x00000001 (1)  
 > Next extension header type: PDU Session container (0x85)  
 > Extension header (PDU Session container)  
 > Internet Protocol Version 4, Src: 10.60.0.10 (10.60.0.10), Dst: 10.60.0.11 (10.60.0.11)  
 > Internet Control Message Protocol

2022.11.19.UA.CM.Lab5G.pingUE11.UE21.br0.pcapng [Switch3A FastEthernet1/11 to Switch3B FastEthernet1/11]

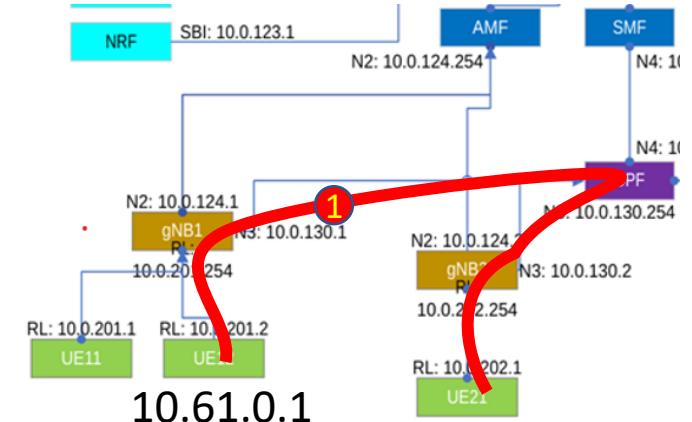
| No. | Time        | Source     | Destination | Length | Protocol   | Info  |
|-----|-------------|------------|-------------|--------|------------|---|
| 544 | 36.75112... | 10.60.0.10 | 10.60.0.11  | 142    | GTP <ICMP> | Echo (ping) request id=0x24e7, seq=15/3840, ttl=64 (no res... |
| 545 | 36.75115... | 10.60.0.10 | 10.60.0.11  | 142    | GTP <ICMP> | Echo (ping) request id=0x24e7, seq=15/3840, ttl=63 (reply     |
| 550 | 36.75186... | 10.60.0.11 | 10.60.0.10  | 142    | GTP <ICMP> | Echo (ping) reply id=0x24e7, seq=15/3840, ttl=64 (request     |
| 551 | 36.75188... | 10.60.0.11 | 10.60.0.10  | 142    | GTP <ICMP> | Echo (ping) reply id=0x24e7, seq=15/3840, ttl=63              |

< Frame 550: 142 bytes on wire (1136 bits), 142 bytes captured (1136 bits) on interface br1, id 0  
 > Ethernet II, Src: 1e:92:9c:a7:37:80 (1e:92:9c:a7:37:80), Dst: 1a:6d:fc:b2:2f:de (1a:6d:fc:b2:2f:de)  
 > Internet Protocol Version 4, Src: 10.0.130.2 (10.0.130.2), Dst: 10.0.130.254 (10.0.130.254)  
 > User Datagram Protocol, Src Port: 2152, Dst Port: 2152  
 > GPRS Tunneling Protocol  
 > Flags: 0x34  
 > Message Type: T-PDU (0x0ff)  
 > Length: 92  
 > TEID: 0x00000015 (21)  
 > Next extension header type: PDU Session container (0x85)  
 > Extension header (PDU Session container)  
 > Internet Protocol Version 4, Src: 10.60.0.11 (10.60.0.11), Dst: 10.60.0.10 (10.60.0.10)  
 > Internet Control Message Protocol

2022.11.19.UA.CM.Lab5G.pingUE11.UE21.br0.pcapng [Switch3A FastEthernet1/11 to Switch3B FastEthernet1/11]

| No. | Time        | Source     | Destination | Length | Protocol   | Info  |
|-----|-------------|------------|-------------|--------|------------|---|
| 544 | 36.75112... | 10.60.0.10 | 10.60.0.11  | 142    | GTP <ICMP> | Echo (ping) request id=0x24e7, seq=15/3840, ttl=64 (no res... |
| 545 | 36.75115... | 10.60.0.10 | 10.60.0.11  | 142    | GTP <ICMP> | Echo (ping) request id=0x24e7, seq=15/3840, ttl=63 (reply     |
| 550 | 36.75186... | 10.60.0.11 | 10.60.0.10  | 142    | GTP <ICMP> | Echo (ping) reply id=0x24e7, seq=15/3840, ttl=64 (request     |
| 551 | 36.75188... | 10.60.0.11 | 10.60.0.10  | 142    | GTP <ICMP> | Echo (ping) reply id=0x24e7, seq=15/3840, ttl=63              |

< Frame 551: 142 bytes on wire (1136 bits), 142 bytes captured (1136 bits) on interface br1, id 0  
 > Ethernet II, Src: 1a:6d:fc:b2:2f:de (1a:6d:fc:b2:2f:de), Dst: f6:48:ab:69:52:9a (f6:48:ab:69:52:9a)  
 > Internet Protocol Version 4, Src: 10.0.130.254 (10.0.130.254), Dst: 10.0.130.1 (10.0.130.1)  
 > User Datagram Protocol, Src Port: 2152, Dst Port: 2152  
 > GPRS Tunneling Protocol  
 > Flags: 0x34  
 > Message Type: T-PDU (0x0ff)  
 > Length: 92  
 > TEID: 0x00000008 (8)  
 > Next extension header type: PDU Session container (0x85)  
 > Extension header (PDU Session container)  
 > Internet Protocol Version 4, Src: 10.60.0.11 (10.60.0.11), Dst: 10.60.0.10 (10.60.0.10)  
 > Internet Control Message Protocol



Ping are seen twice

ICMP packets travel via the UPF in GTP tunnels

- 10.0.130.1 to 10.0.130.254 (ICMP Req)
- 10.0.130.254 to 10.0.130.2 (ICMP Req)
- 10.0.130.2. to 10.0.130.254 (ICMP Reply)
- 10.0.130.254 to 10.0.130.1 (ICMP Reply)

TEIDs:

- UE11: 19 and 8
- UE21: 1 and 21

# 6.x: iperf3

UE11 (with IP 10.60.10); **UL/DL: 10/20Mbps**

ubuntu@ubuntu-VirtualBox:~/5GLab/netns5g\$ **sudo ip netns exec ue11 iperf3 -c 10.1.0.2 -B 10.60.0.10**

Connecting to host 10.1.0.2, port 5201

| [ ID] | Interval   | Transfer        | Bitrate   | Retr | Cwnd        |
|-------|------------|-----------------|-----------|------|-------------|
| [ 5]  | 0.00-1.00  | sec 3.62 MBytes | 30.4 Mb/s | 636  | 17.1 KBytes |
| [ 5]  | 1.00-2.00  | sec 1.17 MBytes | 9.83 Mb/s | 87   | 21.1 KBytes |
| [ 5]  | 2.00-3.00  | sec 1.17 MBytes | 9.83 Mb/s | 124  | 1.32 KBytes |
| [ 5]  | 3.00-4.01  | sec 1.11 MBytes | 9.25 Mb/s | 153  | 15.8 KBytes |
| [ 5]  | 4.01-5.01  | sec 1.11 MBytes | 9.31 Mb/s | 148  | 19.7 KBytes |
| [ 5]  | 5.01-6.00  | sec 1.17 MBytes | 9.89 Mb/s | 145  | 18.4 KBytes |
| [ 5]  | 6.00-7.00  | sec 1.17 MBytes | 9.84 Mb/s | 173  | 17.1 KBytes |
| [ 5]  | 7.00-8.01  | sec 1.11 MBytes | 9.26 Mb/s | 170  | 17.1 KBytes |
| [ 5]  | 8.01-9.00  | sec 1.17 MBytes | 9.93 Mb/s | 137  | 19.7 KBytes |
| [ 5]  | 9.00-10.00 | sec 1.17 MBytes | 9.83 Mb/s | 167  | 34.2 KBytes |

| [ ID] | Interval   | Transfer        | Bitrate   | Retr | sender | receiver |
|-------|------------|-----------------|-----------|------|--------|----------|
| [ 5]  | 0.00-10.00 | sec 14.0 MBytes | 11.7 Mb/s | 1940 |        |          |
| [ 5]  | 0.00-10.05 | sec 12.6 MBytes | 10.5 Mb/s |      |        |          |

iperf Done.

ubuntu@ubuntu-VirtualBox:~/5GLab/netns5g\$ **sudo ip netns exec ue11 iperf3 -c 10.1.0.2 -R -B 10.60.0.10**

Connecting to host 10.1.0.2, port 5201

Reverse mode, remote host 10.1.0.2 is sending

| [ ID] | Interval   | Transfer        | Bitrate   |
|-------|------------|-----------------|-----------|
| [ 5]  | 0.00-1.00  | sec 4.64 MBytes | 38.9 Mb/s |
| [ 5]  | 1.00-2.00  | sec 2.25 MBytes | 18.9 Mb/s |
| [ 5]  | 2.00-3.00  | sec 1.95 MBytes | 16.4 Mb/s |
| [ 5]  | 3.00-4.00  | sec 2.63 MBytes | 22.0 Mb/s |
| [ 5]  | 4.00-5.00  | sec 2.14 MBytes | 18.0 Mb/s |
| [ 5]  | 5.00-6.00  | sec 2.14 MBytes | 17.9 Mb/s |
| [ 5]  | 6.00-7.00  | sec 2.67 MBytes | 22.4 Mb/s |
| [ 5]  | 7.00-8.00  | sec 2.20 MBytes | 18.4 Mb/s |
| [ 5]  | 8.00-9.00  | sec 2.12 MBytes | 17.8 Mb/s |
| [ 5]  | 9.00-10.00 | sec 2.14 MBytes | 17.9 Mb/s |

| [ ID] | Interval   | Transfer        | Bitrate   | Retr | sender | receiver |
|-------|------------|-----------------|-----------|------|--------|----------|
| [ 5]  | 0.00-10.04 | sec 25.2 MBytes | 21.1 Mb/s | 2881 |        |          |
| [ 5]  | 0.00-10.00 | sec 24.9 MBytes | 20.9 Mb/s |      |        |          |

UE12 (with IP 10.60.0.12); **UL/DL: 100/200Mbps**

ubuntu@ubuntu-VirtualBox:~/5GLab/netns5g\$ **sudo ip netns exec ue12 iperf3 -c 10.1.0.2 -B 10.60.0.12**

Connecting to host 10.1.0.2, port 5201

| [ ID] | Interval   | Transfer        | Bitrate   | Retr | Cwnd        |
|-------|------------|-----------------|-----------|------|-------------|
| [ 5]  | 0.00-1.00  | sec 23.9 MBytes | 201 Mb/s  | 406  | 126 KBytes  |
| [ 5]  | 1.00-2.00  | sec 11.7 MBytes | 98.4 Mb/s | 792  | 40.8 KBytes |
| [ 5]  | 2.00-3.00  | sec 11.8 MBytes | 98.9 Mb/s | 532  | 57.9 KBytes |
| [ 5]  | 3.00-4.00  | sec 10.3 MBytes | 86.5 Mb/s | 543  | 282 KBytes  |
| [ 5]  | 4.00-5.00  | sec 11.7 MBytes | 98.2 Mb/s | 722  | 11.8 KBytes |
| [ 5]  | 5.00-6.00  | sec 11.1 MBytes | 93.2 Mb/s | 528  | 63.2 KBytes |
| [ 5]  | 6.00-7.00  | sec 12.3 MBytes | 104 Mb/s  | 761  | 79.0 KBytes |
| [ 5]  | 7.00-8.02  | sec 11.7 MBytes | 96.6 Mb/s | 570  | 11.8 KBytes |
| [ 5]  | 8.02-9.00  | sec 11.8 MBytes | 100 Mb/s  | 585  | 31.6 KBytes |
| [ 5]  | 9.00-10.00 | sec 10.3 MBytes | 86.7 Mb/s | 158  | 18.4 KBytes |

| [ ID] | Interval   | Transfer       | Bitrate  | Retr | sender | receiver |
|-------|------------|----------------|----------|------|--------|----------|
| [ 5]  | 0.00-10.00 | sec 127 MBytes | 106 Mb/s | 6097 |        |          |
| [ 5]  | 0.00-10.04 | sec 125 MBytes | 105 Mb/s |      |        |          |

iperf Done.

ubuntu@ubuntu-VirtualBox:~/5GLab/netns5g\$ **sudo ip netns exec ue12 iperf3 -c 10.1.0.2 -R -B 10.60.0.12**

Connecting to host 10.1.0.2, port 5201

Reverse mode, remote host 10.1.0.2 is sending

| [ ID] | Interval   | Transfer        | Bitrate  |
|-------|------------|-----------------|----------|
| [ 5]  | 0.00-1.00  | sec 41.1 MBytes | 344 Mb/s |
| [ 5]  | 1.00-2.00  | sec 25.3 MBytes | 212 Mb/s |
| [ 5]  | 2.00-3.00  | sec 21.3 MBytes | 178 Mb/s |
| [ 5]  | 3.00-4.00  | sec 23.4 MBytes | 196 Mb/s |
| [ 5]  | 4.00-5.00  | sec 24.3 MBytes | 204 Mb/s |
| [ 5]  | 5.00-6.01  | sec 20.8 MBytes | 173 Mb/s |
| [ 5]  | 6.01-7.00  | sec 24.2 MBytes | 205 Mb/s |
| [ 5]  | 7.00-8.01  | sec 24.2 MBytes | 202 Mb/s |
| [ 5]  | 8.01-9.00  | sec 20.1 MBytes | 170 Mb/s |
| [ 5]  | 9.00-10.01 | sec 24.0 MBytes | 200 Mb/s |

| [ ID] | Interval   | Transfer       | Bitrate  | Retr | sender | receiver |
|-------|------------|----------------|----------|------|--------|----------|
| [ 5]  | 0.00-10.05 | sec 250 MBytes | 208 Mb/s | 6496 |        |          |
| [ 5]  | 0.00-10.01 | sec 249 MBytes | 208 Mb/s |      |        |          |

UE21 (with IP 10.60.0.11); **UL/DL: 1/2Mbps**

ubuntu@ubuntu-VirtualBox:~/5GLab/netns5g\$ **sudo ip netns exec ue21 iperf3 -c 10.1.0.2 -B 10.60.0.11**

Connecting to host 10.1.0.2, port 5201

| [ ID] | Interval   | Transfer       | Bitrate       | Retr | Cwnd        |
|-------|------------|----------------|---------------|------|-------------|
| [ 5]  | 0.00-1.00  | sec 519 KBytes | 4.25 Mb/s     | 88   | 1.32 KBytes |
| [ 5]  | 1.00-2.00  | sec 126 KBytes | 1.03 Mb/s     | 18   | 1.32 KBytes |
| [ 5]  | 2.00-3.00  | sec 126 KBytes | 1.04 Mb/s     | 16   | 2.63 KBytes |
| [ 5]  | 3.00-4.00  | sec 126 KBytes | 1.03 Mb/s     | 16   | 2.63 KBytes |
| [ 5]  | 4.00-5.00  | sec 126 KBytes | 1.04 Mb/s     | 16   | 1.32 KBytes |
| [ 5]  | 5.00-6.00  | sec 126 KBytes | 1.04 Mb/s     | 13   | 2.63 KBytes |
| [ 5]  | 6.00-7.00  | sec 126 KBytes | 1.04 Mb/s     | 19   | 1.32 KBytes |
| [ 5]  | 7.00-8.00  | sec 0.00 Bytes | 0.00 bits/sec | 8    | 1.32 KBytes |
| [ 5]  | 8.00-9.00  | sec 126 KBytes | 1.04 Mb/s     | 18   | 2.63 KBytes |
| [ 5]  | 9.00-10.00 | sec 126 KBytes | 1.03 Mb/s     | 15   | 1.32 KBytes |

| [ ID] | Interval   | Transfer        | Bitrate   | Retr | sender | receiver |
|-------|------------|-----------------|-----------|------|--------|----------|
| [ 5]  | 0.00-10.00 | sec 1.49 MBytes | 1.25 Mb/s | 227  |        |          |
| [ 5]  | 0.00-10.04 | sec 1.26 MBytes | 1.05 Mb/s |      |        |          |

iperf Done.

ubuntu@ubuntu-VirtualBox:~/5GLab/netns5g\$ **sudo ip netns exec ue21 iperf3 -c 10.1.0.2 -R -B 10.60.0.11**

Connecting to host 10.1.0.2, port 5201

Reverse mode, remote host 10.1.0.2 is sending

[ 5] local 10.60.0.11 port 60013 connected to 10.1.0.2 port 5201

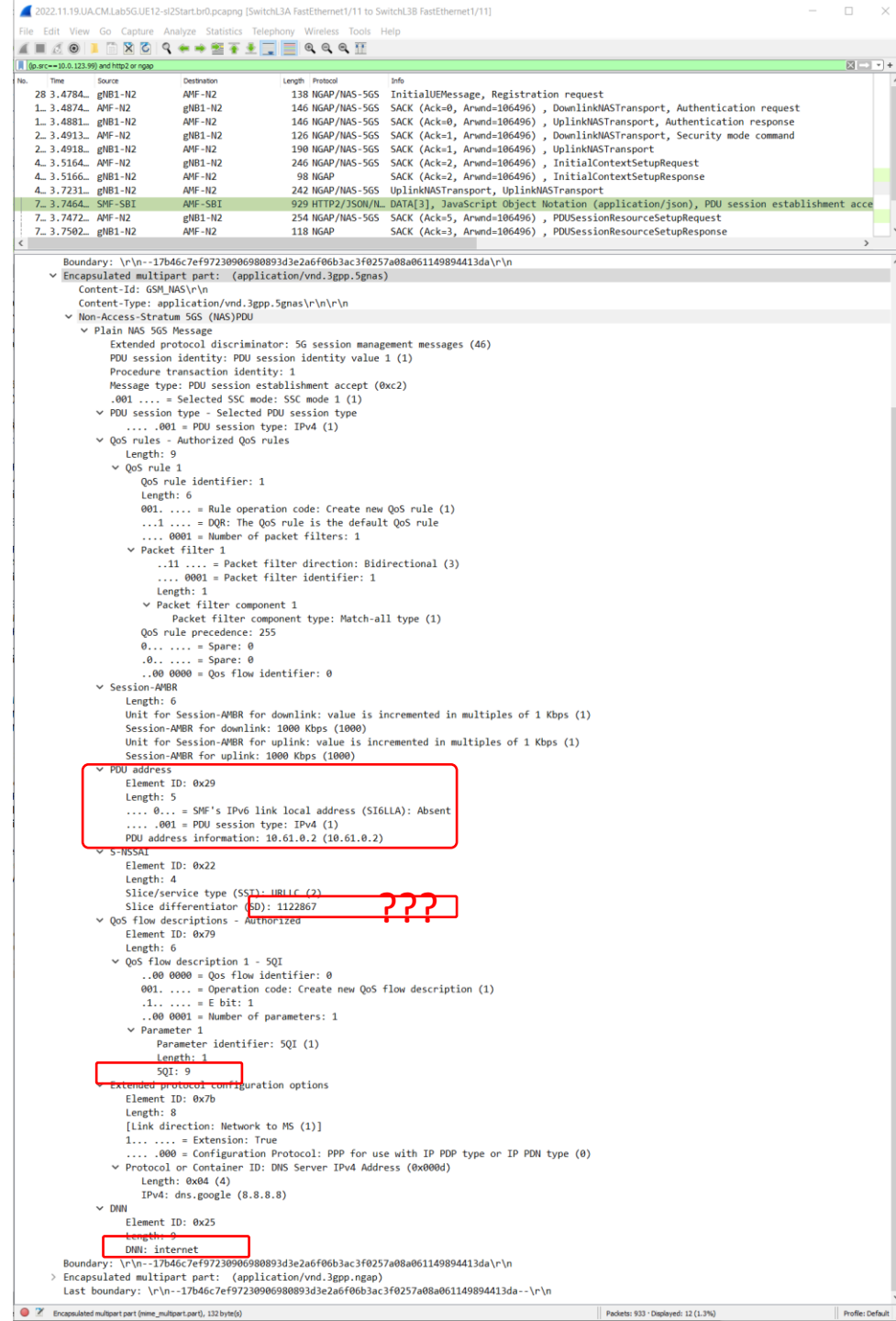
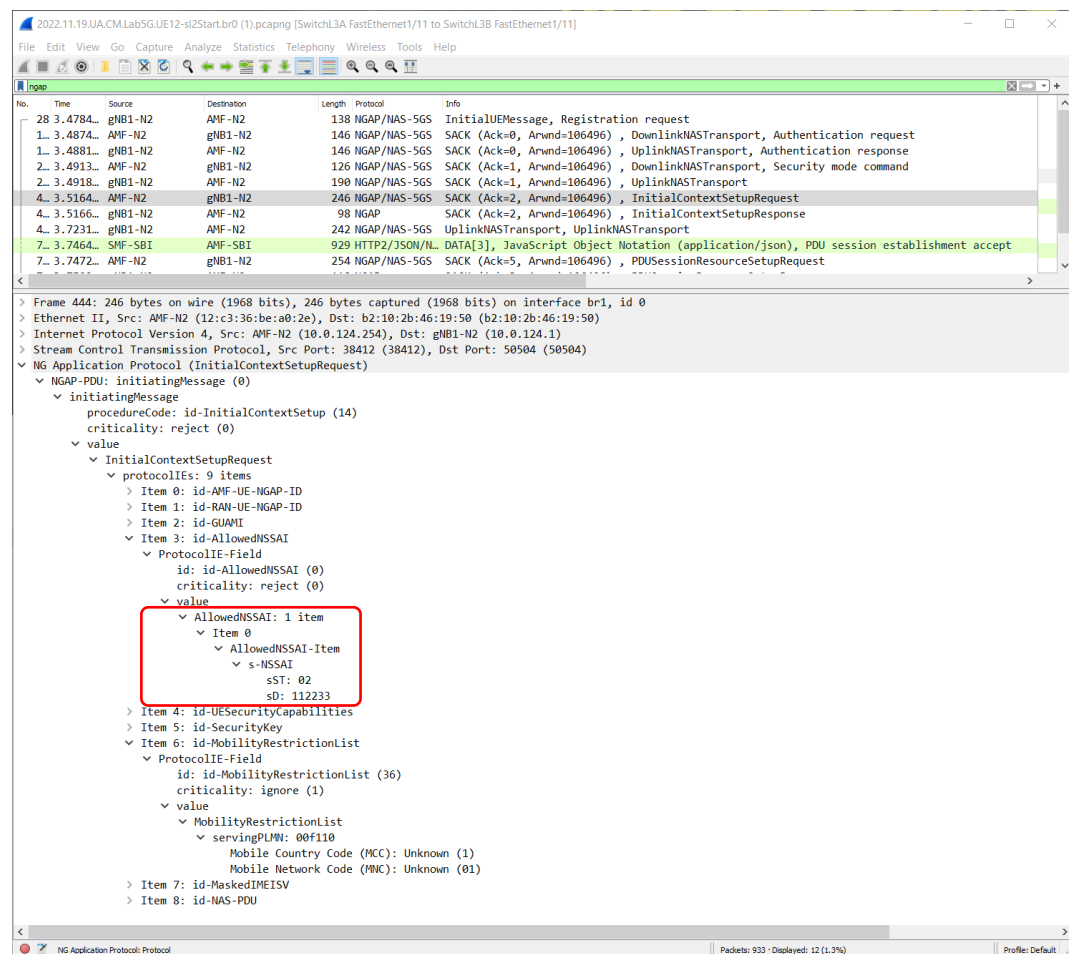
| [ ID] | Interval   | Transfer       | Bitrate   |
|-------|------------|----------------|-----------|
| [ 5]  | 0.00-1.00  | sec 455 KBytes | 3.72 Mb/s |
| [ 5]  | 1.00-2.00  | sec 216 KBytes | 1.77 Mb/s |
| [ 5]  | 2.00-3.00  | sec 274 KBytes | 2.25 Mb/s |
| [ 5]  | 3.00-4.00  | sec 219 KBytes | 1.79 Mb/s |
| [ 5]  | 4.00-5.01  | sec 221 KBytes | 1.80 Mb/s |
| [ 5]  | 5.01-6.00  | sec 271 KBytes | 2.23 Mb/s |
| [ 5]  | 6.00-7.00  | sec 219 KBytes | 1.79 Mb/s |
| [ 5]  | 7.00-8.00  | sec 225 KBytes | 1.84 Mb/s |
| [ 5]  | 8.00-9.00  | sec 220 KBytes | 1.80 Mb/s |
| [ 5]  | 9.00-10.00 | sec 275 KBytes | 2.26 Mb/s |

| [ ID] | Interval   | Transfer        | Bitrate   | Retr | sender | receiver |
|-------|------------|-----------------|-----------|------|--------|----------|
| [ 5]  | 0.00-10.05 | sec 3.06 MBytes | 2.56 Mb/s | 628  |        |          |
| [ 5]  | 0.00-10.00 | sec 2.53 MBytes | 2.13 Mb/s |      |        |          |



## 7.2 and 7.3

- UE12 is allowed in Slice 2/112233
- Assigned IP address is **10.61.0.2** by SMF



# 7.4

```
ubuntu@ubuntu-VirtualBox:~/5GLab/netns5g$ sudo ip netns exec ue11 ping 10.61.0.2 -I uesimtun0
PING 10.61.0.2 (10.61.0.2) from 10.60.0.15 uesimtun0: 56(84) bytes of data.
^C
--- 10.61.0.2 ping statistics ---
5 packets transmitted, 0 received, 100% packet loss, time 4092ms
```

```
ubuntu@ubuntu-VirtualBox:~/5GLab/netns5g$ sudo ip netns exec ue11 ping 10.61.0.2 -I uesimtun0
PING 10.61.0.2 (10.61.0.2) from 10.60.0.15 uesimtun0: 56(84) bytes of data.
64 bytes from 10.61.0.2: icmp_seq=1 ttl=63 time=1.43 ms
From 10.0.130.254: icmp_seq=2 Redirect Host(New nexthop: 10.61.0.2)
64 bytes from 10.61.0.2: icmp_seq=2 ttl=63 time=1.81 ms
From 10.0.130.254: icmp_seq=3 Redirect Host(New nexthop: 10.61.0.2)
64 bytes from 10.61.0.2: icmp_seq=3 ttl=63 time=1.41 ms
From 10.0.130.254: icmp_seq=4 Redirect Host(New nexthop: 10.61.0.2)
64 bytes from 10.61.0.2: icmp_seq=4 ttl=63 time=1.39 ms
From 10.0.130.254: icmp_seq=5 Redirect Host(New nexthop: 10.61.0.2)
64 bytes from 10.61.0.2: icmp_seq=5 ttl=63 time=1.47 ms
From 10.0.130.254: icmp_seq=6 Redirect Host(New nexthop: 10.61.0.2)
64 bytes from 10.61.0.2: icmp_seq=6 ttl=63 time=1.64 ms
64 bytes from 10.61.0.2: icmp_seq=7 ttl=63 time=2.14 ms
From 10.0.130.254: icmp_seq=8 Redirect Host(New nexthop: 10.61.0.2)
64 bytes from 10.61.0.2: icmp_seq=8 ttl=63 time=2.47 ms
64 bytes from 10.61.0.2: icmp_seq=9 ttl=63 time=1.84 ms
64 bytes from 10.61.0.2: icmp_seq=10 ttl=63 time=2.46 ms
From 10.0.130.254: icmp_seq=11 Redirect Host(New nexthop: 10.61.0.2)
64 bytes from 10.61.0.2: icmp_seq=11 ttl=63 time=2.71 ms
64 bytes from 10.61.0.2: icmp_seq=12 ttl=63 time=1.72 ms
64 bytes from 10.61.0.2: icmp_seq=13 ttl=63 time=1.74 ms
64 bytes from 10.61.0.2: icmp_seq=14 ttl=63 time=2.12 ms
64 bytes from 10.61.0.2: icmp_seq=15 ttl=63 time=2.49 ms
64 bytes from 10.61.0.2: icmp_seq=16 ttl=63 time=1.31 ms
```

^C

```
ubuntu@ubuntu-VirtualBox:~/5GLab/netns5g$ sudo ip netns exec upf ip route
default via 10.1.0.2 dev upf-n6-0
10.0.130.0/24 dev upf-n3 proto kernel scope link src 10.0.130.254
10.0.140.0/24 dev upf-n4 proto kernel scope link src 10.0.140.1
10.1.0.0/24 dev upf-n6-0 proto kernel scope link src 10.1.0.1
10.1.1.0/24 dev upf-n6-1 proto kernel scope link src 10.1.1.1
10.60.0.0/24 dev upfgtp proto static
```

```
ubuntu@ubuntu-VirtualBox:~/5GLab/netns5g$ sudo ip netns exec upf ip route add 10.61.0.0/24 dev upfgtp
```

```
ubuntu@ubuntu-VirtualBox:~/5GLab/netns5g$ sudo ip netns exec upf ip route
default via 10.1.0.2 dev upf-n6-0
10.0.130.0/24 dev upf-n3 proto kernel scope link src 10.0.130.254
10.0.140.0/24 dev upf-n4 proto kernel scope link src 10.0.140.1
10.1.0.0/24 dev upf-n6-0 proto kernel scope link src 10.1.0.1
10.1.1.0/24 dev upf-n6-1 proto kernel scope link src 10.1.1.1
10.60.0.0/24 dev upfgtp proto static
10.61.0.0/24 dev upfgtp scope link
```

## 7.5 : UE11-UE12 ping in different slices

- 7.5: Há conectividade porque a DNN é a mesma