

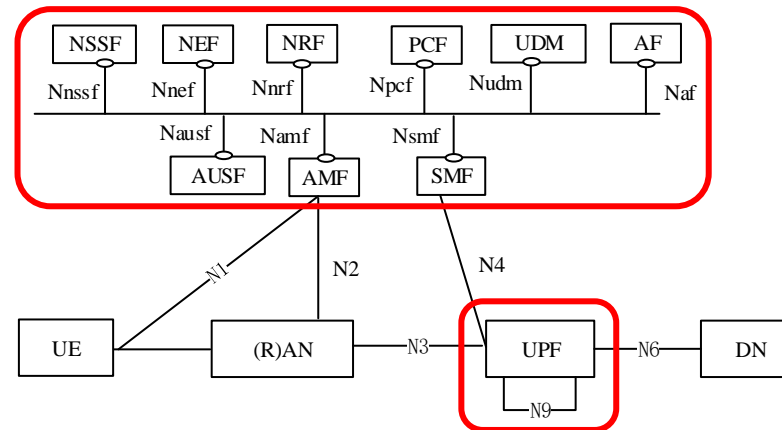
Comunicações Móveis

Lab3: 5G

2022/2023

Free5GC summary

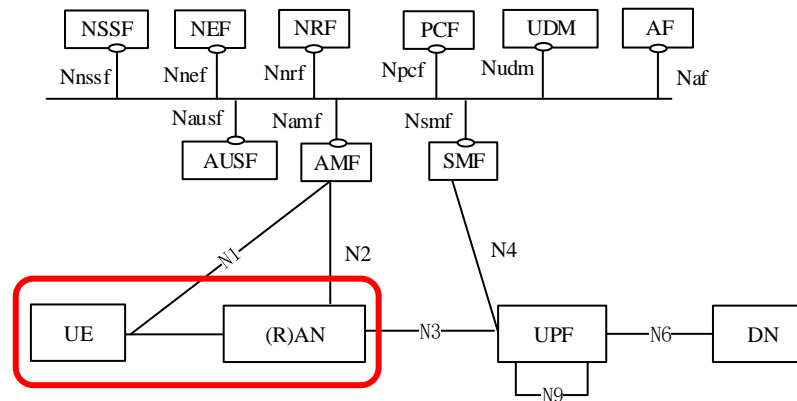
- <https://github.com/free5gc/free5gc/wiki>
- Main components of the 5GCore, Control and User Planes
- 3GPP Release 15 (R15)



- 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

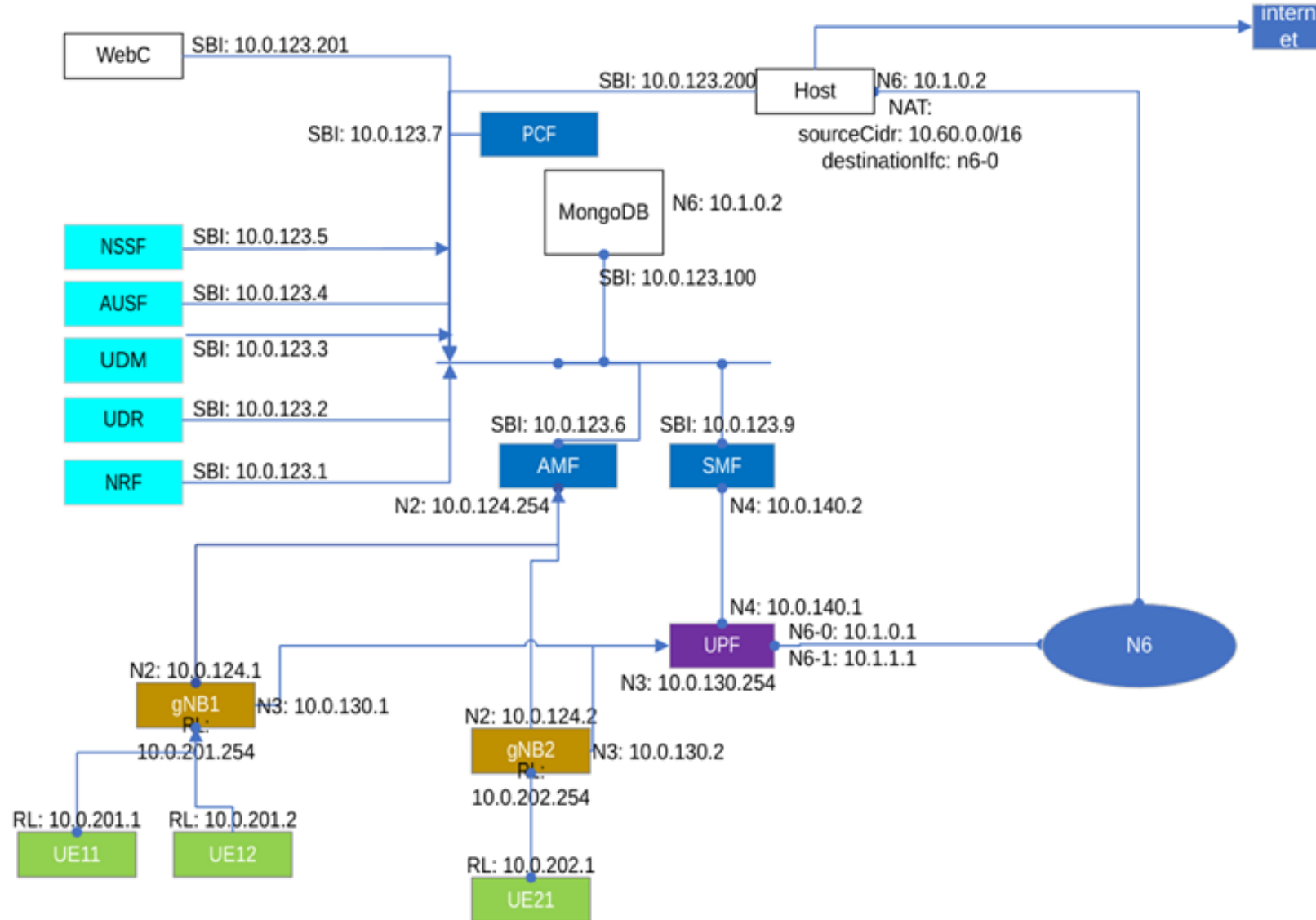


- Usage:

```
$ 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

```
nsscfg.yaml 3
13 pem: config/TLS/
14 key: config/TLS/
15 serviceNameList: # t
16 - nnsf-nselectio
17 - nnsf-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
47 ..

amfcdg.yaml 3
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-evt # 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 # Sli
45 - sst: 2 # Slice/
46 sd: 112233 # Sli

free5gc-ue11.yaml 3
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 3
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 3
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

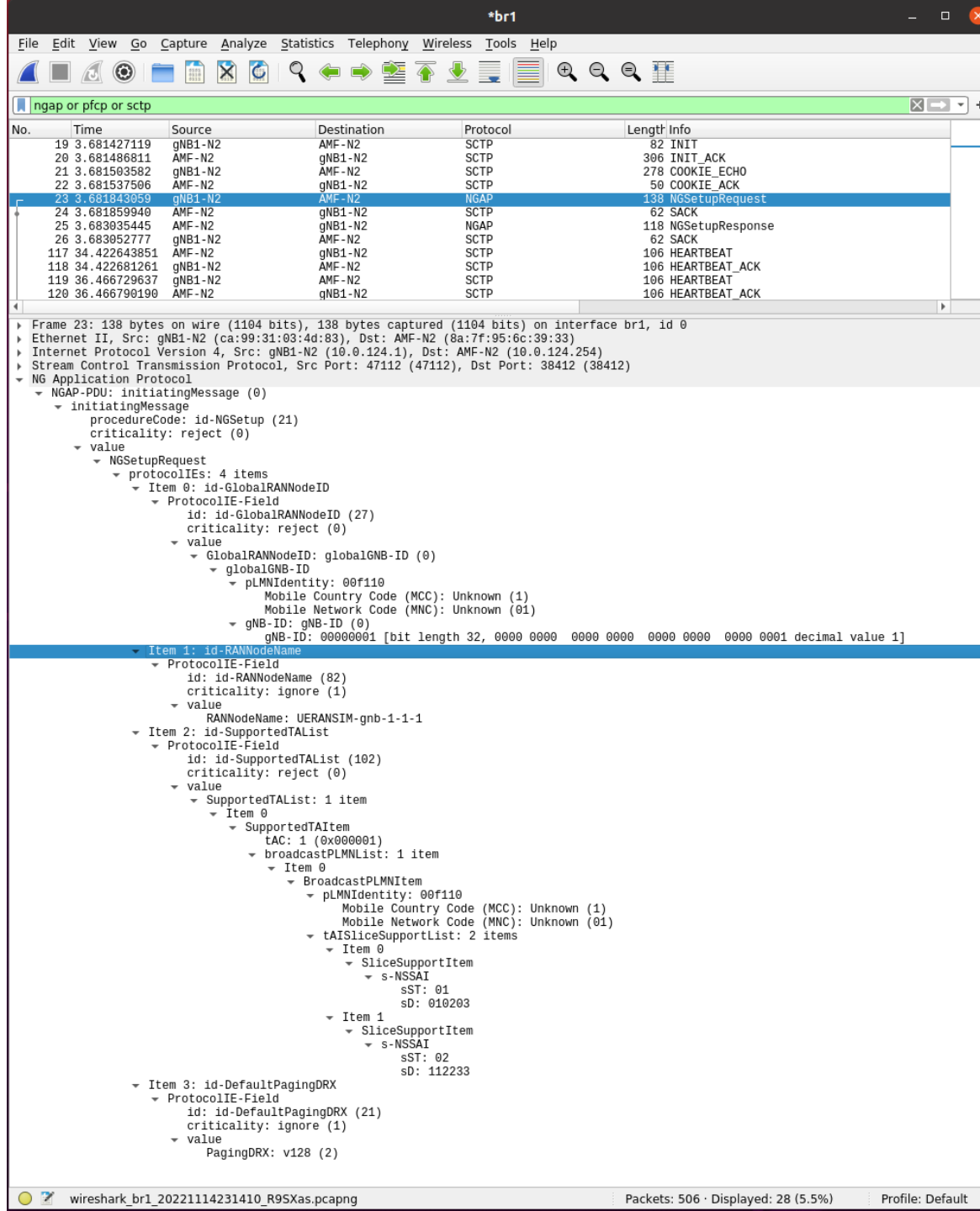
3.4 gNB1

```
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
<pre> > Frame 49: 138 bytes on wire (1104 bits), 138 bytes captured (1104 bits) on interface br1, id 0 > Ethernet II, Src: 4e:89:93:1f:35:41 (4e:89:93:1f:35:41), Dst: AMF-N2 (12:85:65:4c:d9:ee) > Internet Protocol Version 4, Src: gNB1-N2 (10.0.124.1), Dst: AMF-N2 (10.0.124.254) > Stream Control Transmission Protocol, Src Port: 54738 (54738), Dst Port: 38412 (38412) < NG Application Protocol (NGSetupRequest) < NGAP-PDU: initiatingMessage (0) < initiatingMessage procedureCode: id-NGSetup (21) criticality: reject (0) < value < NGSetupRequest < protocolIEs: 4 items < Item 0: id-GlobalRANNodeID < ProtocolIE-Field id: id-GlobalRANNodeID (27) criticality: reject (0) < value < GlobalRANNodeID: globalGNB-ID (0) < globalGNB-ID < pLMNIdentity: 00f110 Mobile Country Code (MCC): Unknown (1) Mobile Network Code (MNC): Unknown (01) < gNB-ID: gNB-ID (0) gNB-ID: 00000001 [bit length 32, 0000 0000 0000 0000 0000 0000 0000 0001 decimal value 1] < Item 1: id-RANNodeName < ProtocolIE-Field id: id-RANNodeName (82) criticality: ignore (1) < value RANNodeName: UERANSIM-gnb-1-1-1 < Item 2: id-SupportedTAList < ProtocolIE-Field id: id-SupportedTAList (102) criticality: reject (0) < value < SupportedTAList: 1 item < Item 0 < SupportedTAItem tAC: 1 (0x000001) < broadcastPLMNList: 1 item < Item 0 < BroadcastPLMNItem < pLMNIdentity: 00f110 Mobile Country Code (MCC): Unknown (1) Mobile Network Code (MNC): Unknown (01) < tAISliceSupportList: 2 items < Item 0 < SliceSupportItem < s-NSSAI sST: 01 sD: 010203 < Item 1 < SliceSupportItem < s-NSSAI sST: 02 sD: 112233 < Item 3: id-DefaultPagingDRX < ProtocolIE-Field id: id-DefaultPagingDRX (21) criticality: ignore (1) < value PagingDRX: v128 (2) </pre>						

[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 gtp

No.	Time	Source	Destination	Length	Protocol	Info
172	3.763972578	AMF-N2	gNB1-N2	146	NGAP/NAS-SGS	InitiationMessage, Registration request
175	3.765031711	AMF-N2	gNB1-N2	146	NGAP/NAS-SGS	SACK (Ack=0, Arund=106496) , DownlinkNASTransport, Authentication request
232	3.769757723	AMF-N2	gNB1-N2	126	NGAP/NAS-SGS	SACK (Ack=0, Arund=106496) , UplinkNASTransport, Authentication response
235	3.770221532	AMF-N2	gNB1-N2	126	NGAP/NAS-SGS	SACK (Ack=1, Arund=106496) , DownlinkNASTransport, Security mode command
462	3.784308993	AMF-N2	gNB1-N2	246	NGAP/NAS-SGS	SACK (Ack=1, Arund=106496) , UplinkNASTransport
465	3.788330453	gNB1-N2	AMF-N2	98	NGAP	SACK (Ack=2, Arund=106496) , InitialContextSetupRequest
485	3.993001449	gNB1-N2	AMF-N2	242	NGAP/NAS-SGS	SACK (Ack=2, Arund=106496) , InitialContextSetupResponse
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 (S16LLA): Absent
 001 = PDU session type: IPv4 (1)
 PDU address information: 10.60.0.14 (10.60.0.14)
 S-RSAI
 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**

No.	Time	Source	Destination	Protocol	Length Info
34	7.288393818	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	PFCP	329 PFCP Session Establishment Request
847	7.695977687	UPF-N4	SMF-N4	PECP	89 PECP 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	PFCP	190 PFCP Session Modification Request
889	7.704046410	UPF-N4	SMF-N4	PFCD	62 PFCD 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

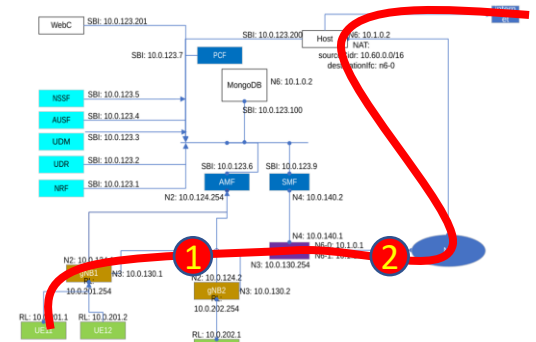
- NG Application Protocol
 - NGAP-PDU: initiatingMessage (0)
 - initiatingMessage
 - procedureCode: id-InitialUEMessage (15)
 - criticality: ignore (1)
 - value
 - InitialUEMessage
 - protocolIEs: 5 items
 - Item 0: id-RAN-UE-NGAP-ID
 - ProtocolIE-Field
 - id: id-RAN-UE-NGAP-ID (85)
 - criticality: reject (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: 7e00417900d0100f1100000000000000112e04f0f0f0...
 Non-Access-Stratum SGS (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: 0x000000010
 - 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)

The screenshot shows a Wireshark packet capture window. The title bar indicates the capture is on the interface '11' of a host named 'Switch3A'. The packet list on the left shows five packets, all of which are ICMP Echo (ping) requests or replies. The packet details pane on the right shows the structure of the selected packet (packet 63), which is an ICMP Echo (ping) request. The packet bytes pane on the right shows the raw data of the selected packet.

| No. | Time | Source | Destination | Length | Protocol | Info |
|-----|-------------|------------|-------------|--------|------------|--|
| 63 | 7.896847... | 10.60.0.1 | dns.google | 142 | FTP <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... | Host-N6 | 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 | FTP <ICMP> | Echo (ping) reply id=0x16c4, seq=1/256, ttl=59 (request in 63) |

SA: gNB1 N3

DA: UPF N3

```

> 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 (0xff)
  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... 00 = Spare: 0x0
      000 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

```

'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.U11ping8888.pcapng [Switch3A FastEthernet1/1 to Switch3B FastEthernet1/1]

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Packet list: 5 packets (1.0 KB) of 1.0 KB

| 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... | Host-N6 | 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
Ethernet II, Src: Host-N6 (c6:ae: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
```

The image shows a Wireshark packet capture window. The title bar indicates the capture is on the interface '2022.11.09.free5GC-UE1\ping8888.pcapng [Switch3L3A FastEthernet1/11 to Switch3L3B FastEthernet1/11]'. The menu bar includes File, Edit, View, Go, Capture, Analyze, Statistics, Telephony, Wireless, Tools, and Help. The toolbar contains icons for various functions like opening files, saving, and zooming. The packet list pane on the left shows five packets, with packet 68 selected. The packet details pane on the right shows the structure of the selected packet: Echo (ping) request, ID 0x16c4, sequence 1/256, TTL 64, reply in 69. The packet bytes pane at the bottom shows the raw data of the packet, including the ICMP header and payload.

| 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
Ethernet II, Src: da:eb:71:8e:06:37 (da:eb:71:8e:06:37), Dst: Host-N6 (c6:ea:04:53:2
Internet Protocol Version 4, Src: dns.google (8.8.8.8), Dst: Host-N6 (10.1.0.1)
Internet Control Message Protocol

```

ICMP packet UPF (N6) → Internet (8.8.8.8)

2

× ICMP packet Internet (8.8.8.8) → UPF (N6)



ICMP packet UPF (N3) → gNB1

The screenshot shows a Wireshark packet capture of ICMP Echo (ping) traffic. The top pane displays the packet list, and the bottom pane shows the packet details for a selected packet (No. 63).

Packet List:

| No. | Time | Source | Destination | Length | Protocol | Info |
|-----|-------------|------------|-------------|--------|------------|--|
| 63 | 7.896847... | 10.60.0.1 | dns.google | 142 | FTP <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 | FTP <ICMP> | Echo (ping) reply id=0x16c4, seq=1/256, ttl=59 (request in 63) |

Packet Details (No. 63):

- Ethernet II, Src: Intel(R) Dual Band Wireless-AC, Dst: 10.60.0.1
- Internet Protocol Version 4, Src: 10.60.0.1, Dst: 10.60.0.1
- ICMP Echo (ping) request id=0x16c4, seq=1/256, ttl=64 (reply in 69)
- Raw (128 bytes)

SA: UPF N3

DA: gNB1 N3

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 (0xff)

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

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]

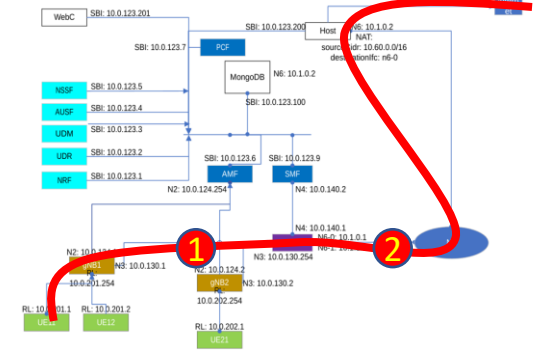
| No. | Time | Source | Destination | Length | Protocol | Info |
|-----|-------------|------------|-------------|--------|------------|--|
| 292 | 27.19774... | 10.60.0.10 | dns.google | 142 | GTP <ICMP> | Echo (ping) request id=0x24ac, seq=1/256, ttl=64 (reply in |
| 293 | 27.19780... | UPF-N6 | dns.google | 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:de (1a:6d:fc:b3:2f: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)
 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

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]

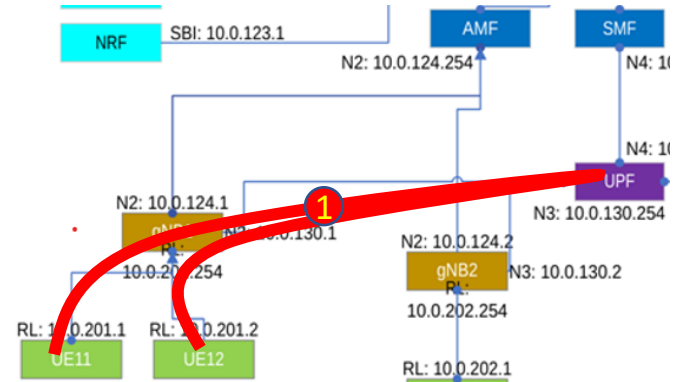
| No. | Time | Source | Destination | Length | Protocol | Info |
|-----|-------------|------------|-------------|--------|------------|--|
| 736 | 50.29821... | 10.60.0.10 | 10.60.0.12 | 142 | GTP <ICMP> | Echo (ping) request id=0x24dd, seq=22/5632, ttl=64 (no res |
| 737 | 50.29826... | 10.60.0.10 | 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.CMLab5G.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.CMLab5G.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.CMLab5G.pingUE11.UE21.br0.pcapng [Switch3A FastEthernet1/11 to Switch3B FastEthernet1/11]

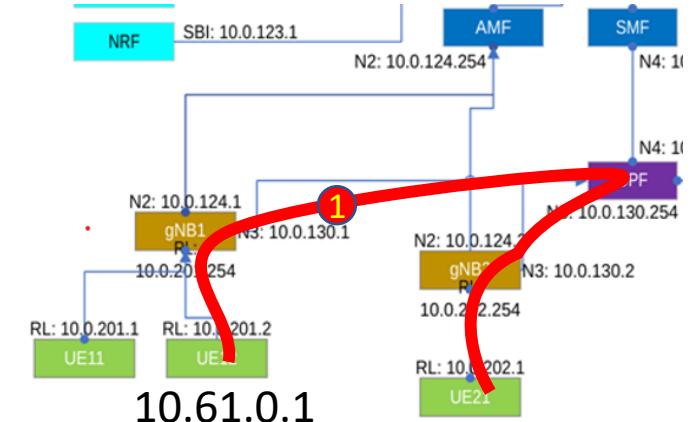
| No. | Time | Source | Destination | Length | Protocol | Info |
|-----|-------------|------------|-------------|--------|------------|--|
| 544 | 36.75112... | 10.60.0.10 | 10.60.0.11 | 142 | GTP <ICMP> | Echo (ping) request id=0x24e7, seq=15/3840, ttl=64 (no res |
| 545 | 36.75115... | 10.60.0.10 | 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.CMLab5G.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 | 458 | 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

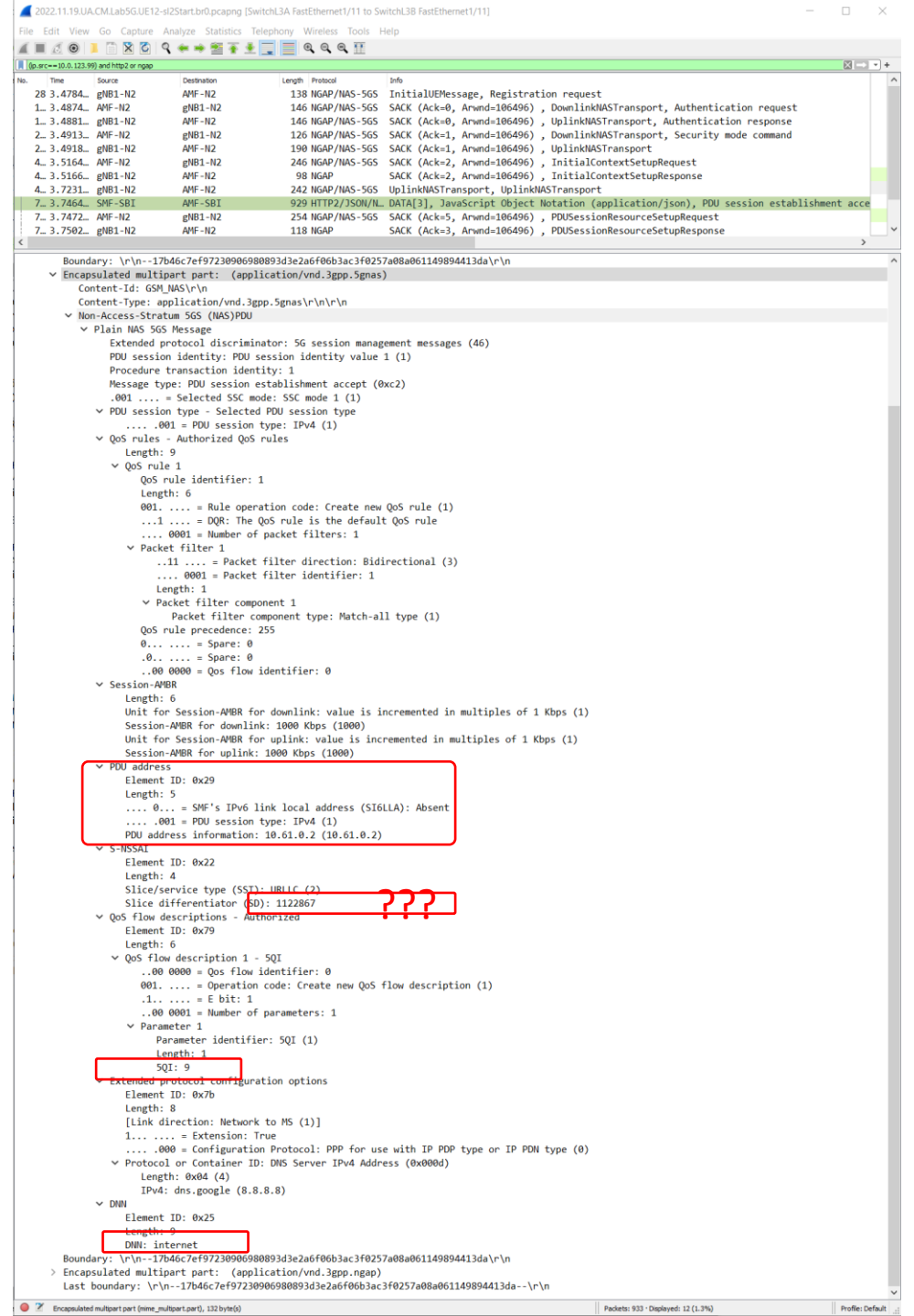
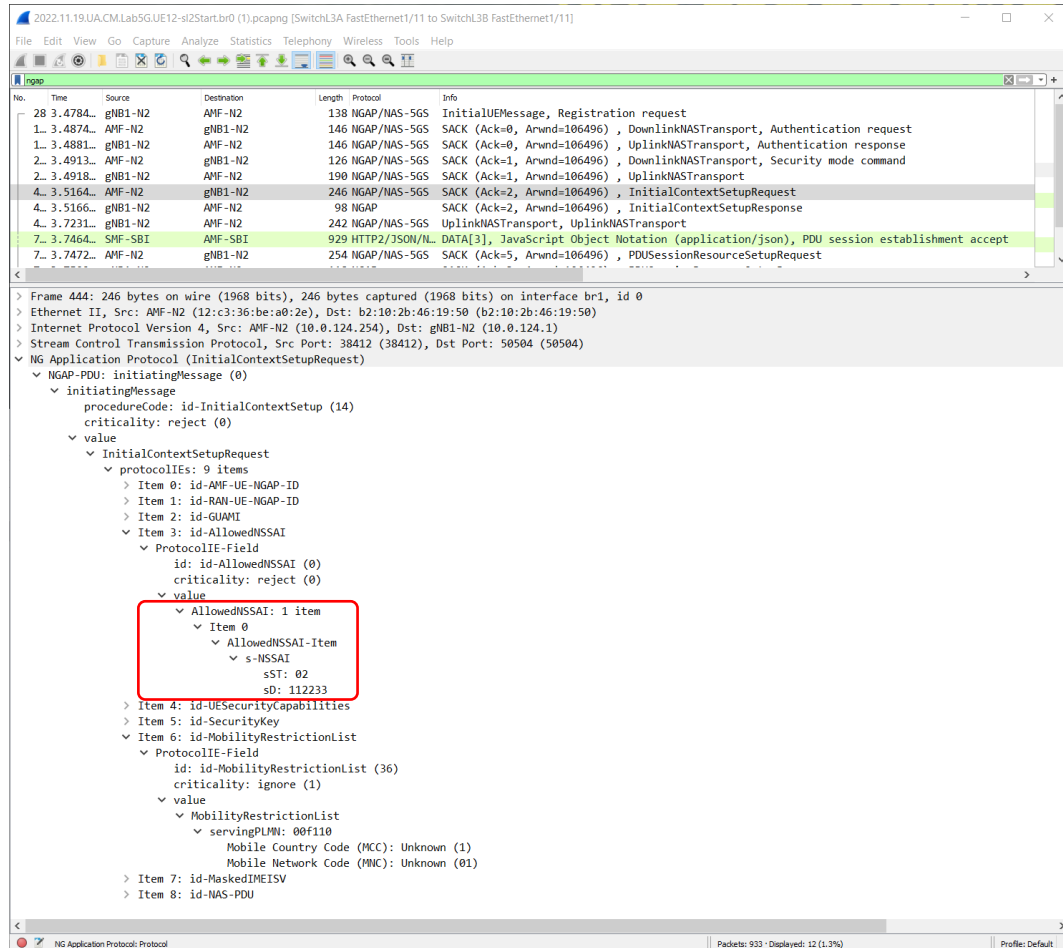
[5] local 10.60.0.11 port 60013 connected to 10.1.0.2 port 5201

| [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 • Assigned IP address is **10.61.0.2** by SMF

- 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