Comunicações Móveis

Lab3: 5G

2023

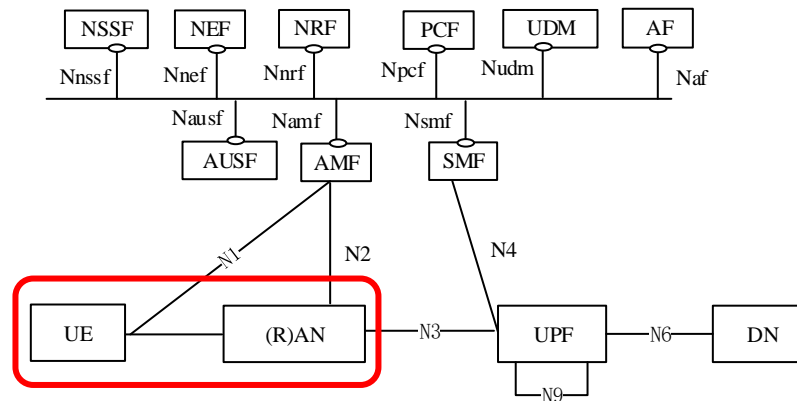# Free5GC summary

- https://github.com/free5gc/free5gc/wiki

- Main components of the 5GCore, Control and User Planes

- 3GPP Release 15 (R15)
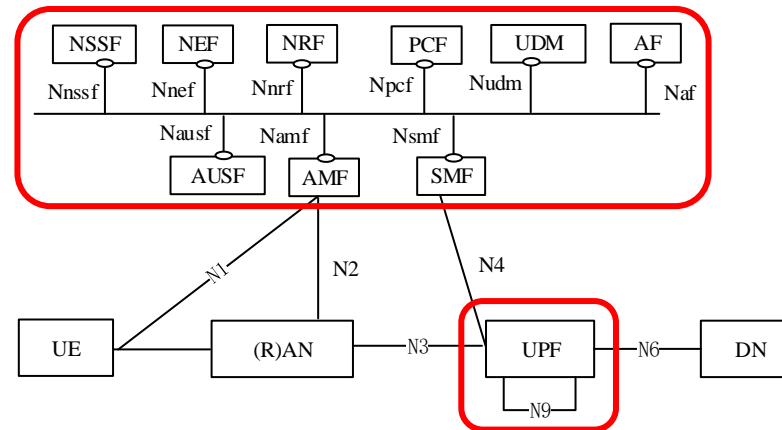
- Each component is configured by a specific yaml file
  - E.g. amfcfg.yaml, nssfcfg.yaml and upfcfg.yaml

UERANSIM summary

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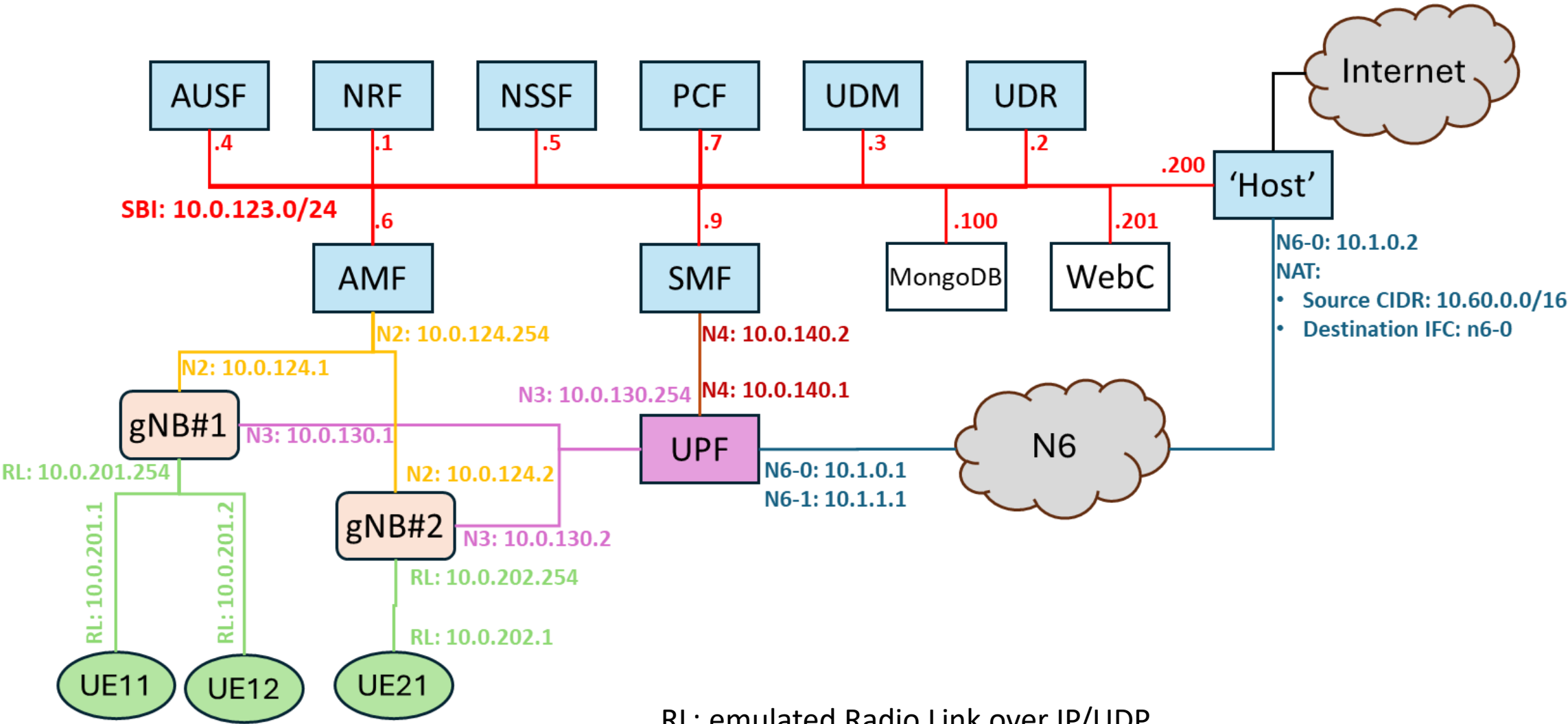
- Two main componentes: UE and gNB

- Usage:

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

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

Network topology

AUSF   NRF   NSSF   PCF   UDM   UDR

.4   .1   .5   .7   .3   .2

Internet

.200

'Host'

SBI: 10.0.123.0/24

.6

.9

.100

.201

AMF

SMF

MongoDB   WebC

N6-0: 10.1.0.2
NAT:
- Source CIDR: 10.60.0.0/16
- Destination IFC: n6-0

N2: 10.0.124.254

N4: 10.0.140.2

N2: 10.0.124.1

N3: 10.0.130.254   N4: 10.0.140.1

gNB#1   N3: 10.0.130.1

N6

RL: 10.0.201.254   N2: 10.0.124.2

UPF   N6-0: 10.1.0.1
N6-1: 10.1.1.1

RL: 10.0.201.1   RL: 10.0.201.2

gNB#2   N3: 10.0.130.2

RL: 10.0.202.254

RL: 10.0.202.1

UE11   UE12   UE21

RL: emulated Radio Link over IP/UDP

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

2.1.b

- i.   MCC and MNC:
  - MCC: 001
  - MNC: 01

- ii.   NR Cell Identities and TACs
  - gNB1: 2, 1
  - gNB2: 1, 2

- 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

3.3   ~/5GLab/netns5G$ *sudo ./5Gsetup.sh*

```
ubuntu@ubuntu-VirtualBox:~/5GLab/netns5g$ sudo ./5Gsetup.sh
net.ipv4.ip_forward = 1
create namespace mongodb
create_interface: if_local mongodb-sbi, if_bridge v-mongodb-sbi, namespace mongodb
configure_interface mongodb-sbi v-mongodb-sbi mongodb 10.0.123.100
disableIpv6IfRequested: interface mongodb-sbi, namespace mongodb
create namespace nrf
create_interface: if_local nrf-sbi, if_bridge v-nrf-sbi, namespace nrf
configure_interface nrf-sbi v-nrf-sbi nrf 10.0.123.1
disableIpv6IfRequested: interface nrf-sbi, namespace nrf
create namespace udr
create_interface: if_local udr-sbi, if_bridge v-udr-sbi, namespace udr
configure_interface udr-sbi v-udr-sbi udr 10.0.123.2
disableIpv6IfRequested: interface udr-sbi, namespace udr
create namespace udm
create_interface: if_local udm-sbi, if_bridge v-udm-sbi, namespace udm
configure_interface udm-sbi v-udm-sbi udm 10.0.123.3
disableIpv6IfRequested: interface udm-sbi, namespace udm
create namespace ausf
create_interface: if_local ausf-sbi, if_bridge v-ausf-sbi, namespace ausf
configure_interface ausf-sbi v-ausf-sbi ausf 10.0.123.4
disableIpv6IfRequested: interface ausf-sbi, namespace ausf
create namespace nssf
create_interface: if_local nssf-sbi, if_bridge v-nssf-sbi, namespace nssf
configure_interface nssf-sbi v-nssf-sbi nssf 10.0.123.5
disableIpv6IfRequested: interface nssf-sbi, namespace nssf
create namespace amf
create_interface: if_local amf-sbi, if_bridge v-amf-sbi, namespace amf
configure_interface amf-sbi v-amf-sbi amf 10.0.123.6
disableIpv6IfRequested: interface amf-sbi, namespace amf
create_interface: if_local amf-n2, if_bridge v-amf-n2, namespace amf
configure_interface amf-n2 v-amf-n2 amf 10.0.124.254
disableIpv6IfRequested: interface amf-n2, namespace amf
```

3.4

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

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

Left terminal:

```
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$
```

Right terminal (ubuntu@ubuntu-VirtualBox: ~/5GLab/netns5g):

```
ubuntu@ubuntu-VirtualBox:~/5GLab/netns5g$ sudo ip link
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@if6: <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@if8: <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@if10: <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@if12: <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@if14: <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@if16: <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@if18: <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@if20: <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@if22: <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@if24: <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@if26: <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@if28: <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@if30: <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@if32: <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@if34: <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@if36: <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-rl@if42: <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@if44: <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@if46: <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-rl@if48: <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-rl@if50: <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-rl@if52: <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@if54: <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@if56: <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-rl@if58: <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
```

33 links are listed, numbered 0 to 57

3.7

- 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)

To register against the NRF (remember the NRF role)

3.8

- 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)

3.8

- Entre components 5G para funções 5G: HTTP2; PFCP

- Outros: ARP, TCP; ICMPv6; MDNS, MONGO

- 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._1
464	32.24427…	10.0.123.200	224.0.0.251	183	MDNS	Standard query 0x0000 PTR _nfs._1
3	0.311544…	10.1.0.2	224.0.0.251	183	MDNS	Standard query 0x0000 PTR _nfs._1
465	32.30489…	10.1.0.2	224.0.0.251	183	MDNS	Standard query 0x0000 PTR _nfs._1
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._1
293	22.96788…	fe80::9462:5…	ff02::2	70	ICMPv6	Router Solicitation from 0a:58:6(
463	32.05465…	fe80::9462:5…	ff02::fb	203	MDNS	Standard query 0x0000 PTR _nfs._1

Protocols: ARP, HTTP2, ICMPv6, MDNS, TCP
5G protocols: PFCP and, indirectly, HTTP2

4.3 gNB1

No.	Time	Source	Destination	Length	Protocol	Info
49	10.94869…	gNB1-N2	AMF-N2	138	NGAP	NGSetupRequest

```
> 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)
v NG Application Protocol (NGSetupRequest)
  v NGAP-PDU: initiatingMessage (0)
    v initiatingMessage
        procedureCode: id-NGSetup (21)
        criticality: reject (0)
      v value
        v NGSetupRequest
          v protocolIEs: 4 items
            v Item 0: id-GlobalRANNodeID
              v ProtocolIE-Field
                  id: id-GlobalRANNodeID (27)
                  criticality: reject (0)
                v value
                  v GlobalRANNodeID: globalGNB-ID (0)
                    v globalGNB-ID
                      v pLMNIdentity: 00f110
                          Mobile Country Code (MCC): Unknown (1)
                          Mobile Network Code (MNC): Unknown (01)
                      v gNB-ID: gNB-ID (0)
                          gNB-ID: 00000001 [bit length 32, 0000 0000  0000 0000  0000 0000  0000 0001 decimal value 1]
            v Item 1: id-RANNodeName
              v ProtocolIE-Field
                  id: id-RANNodeName (82)
                  criticality: ignore (1)
                v value
                    RANNodeName: UERANSIM-gnb-1-1-1
            v Item 2: id-SupportedTAList
              v ProtocolIE-Field
                  id: id-SupportedTAList (102)
                  criticality: reject (0)
                v value
                  v SupportedTAList: 1 item
                    v Item 0
                      v SupportedTAItem
                          tAC: 1 (0x000001)
                        v broadcastPLMNList: 1 item
                          v Item 0
                            v BroadcastPLMNItem
                              v pLMNIdentity: 00f110
                                  Mobile Country Code (MCC): Unknown (1)
                                  Mobile Network Code (MNC): Unknown (01)
                              v tAISliceSupportList: 2 items
                                v Item 0
                                  v SliceSupportItem
                                    v s-NSSAI
                                        sST: 01
                                        sD: 010203
                                v Item 1
                                  v SliceSupportItem
                                    v s-NSSAI
                                        sST: 02
                                        sD: 112233
            v Item 3: id-DefaultPagingDRX
              v ProtocolIE-Field
                  id: id-DefaultPagingDRX (21)
                  criticality: ignore (1)
                v value
                    PagingDRX: v128 (2)
```

No.	Time	Source	Destination	Length	Protocol	Info
51	10.95009…	AMF-N2	gNB1-N2	118	NGAP	NGSetupResponse

```
> Frame 51: 118 bytes on wire (944 bits), 118 bytes captured (944 bits) on interface br1, id 0
> Ethernet II, Src: AMF-N2 (12:85:65:4c:d9:ee), Dst: 4e:89:93:1f:35:41 (4e:89:93:1f:35:41)
> Internet Protocol Version 4, Src: AMF-N2 (10.0.124.254), Dst: gNB1-N2 (10.0.124.1)
> Stream Control Transmission Protocol, Src Port: 38412 (38412), Dst Port: 54738 (54738)
v NG Application Protocol (NGSetupResponse)
  v NGAP-PDU: successfulOutcome (1)
    v successfulOutcome
        procedureCode: id-NGSetup (21)
        criticality: reject (0)
      v value
        v NGSetupResponse
          v protocolIEs: 4 items
            v Item 0: id-AMFName
              v ProtocolIE-Field
                  id: id-AMFName (1)
                  criticality: reject (0)
                v value
                    AMFName: AMF
            v Item 1: id-ServedGUAMIList
              v ProtocolIE-Field
                  id: id-ServedGUAMIList (96)
                  criticality: reject (0)
                v value
                  v ServedGUAMIList: 1 item
                    v Item 0
                      v ServedGUAMIItem
                        v gUAMI
                          v pLMNIdentity: 00f110
                              Mobile Country Code (MCC): Unknown (1)
                              Mobile Network Code (MNC): Unknown (01)
                          aMFRegionID: ca [bit length 8, 1100 1010 decimal value 202]
                          aMFSetID: fe00 [bit length 10, 6 LSB pad bits, 1111 1110  00.. .... decimal value 1016]
                          aMFPointer: 00 [bit length 6, 2 LSB pad bits, 0000 00.. decimal value 0]
            v Item 2: id-RelativeAMFCapacity
              v ProtocolIE-Field
                  id: id-RelativeAMFCapacity (86)
                  criticality: ignore (1)
                v value
                    RelativeAMFCapacity: 255
            v Item 3: id-PLMNSupportList
              v ProtocolIE-Field
                  id: id-PLMNSupportList (80)
                  criticality: reject (0)
                v value
                  v PLMNSupportList: 1 item
                    v Item 0
                      v PLMNSupportItem
                        v pLMNIdentity: 00f110
                            Mobile Country Code (MCC): Unknown (1)
                            Mobile Network Code (MNC): Unknown (01)
                        v sliceSupportList: 2 items
                          v Item 0
                            v SliceSupportItem
                              v s-NSSAI
                                  sST: 01
                                  sD: 010203
                          v Item 1
                            v SliceSupportItem
                              v s-NSSAI
                                  sST: 02
                                  sD: 112233
```

4.4 gNB1

4.5 gNB2

Cell identifiers and the supported slices are different between the two cells