

OAI: Run CN, RAN and UE Platform

ECE 5984: 5G-Advanced, O-RAN & 6G

Virginia Tech

Run Core Network – Terminal 1

```
cd ~/oai-cn5g  
docker compose up -d
```

```
pratheek@Pratheek:~/oai-cn5g$ docker compose up -d  
[+] Running 11/11  
✓Network oai-cn5g-public-net Created  
✓Container oai-nrf Started  
✓Container oai-ext-dn Started  
✓Container ims Started  
✓Container mysql Started  
✓Container oai-udr Started  
✓Container oai-udm Started  
✓Container oai-ausf Started  
✓Container oai-amf Started  
✓Container oai-smf Started  
✓Container oai-upf Started
```

Check if all CN containers are healthy

```
docker ps -a
```

```
pratheek@Pratheek:~/oai/cmake_targets$ docker ps -a
```

CONTAINER ID	IMAGE	NAMES	COMMAND	CREATED	STATUS	PORTS
6148faa592b2	oaisoftwarealliance/oai-upf:develop	oai-upf	"sh /openair-upf/bin..."	55 minutes ago	Up 55 minutes (healthy)	2152/udp, 8805/udp, 5342-5344/tcp
4de375a88bfc	oaisoftwarealliance/oai-smf:develop	oai-smf	"/openair-smf/bin/oa..."	55 minutes ago	Up 55 minutes (healthy)	80/tcp, 5342-5344/tcp, 8080/tcp,
9090/tcp, 8805/udp						
586dfa465dd8	oaisoftwarealliance/oai-amf:develop	oai-amf	"/openair-amf/bin/oa..."	55 minutes ago	Up 55 minutes (healthy)	80/tcp, 5342-5344/tcp, 8080/tcp,
9090/tcp, 38412/sctp						
a9abb0e79235	oaisoftwarealliance/oai-ausf:develop	oai-ausf	"/openair-ausf/bin/o..."	55 minutes ago	Up 55 minutes (healthy)	80/tcp, 5342-5344/tcp, 8080/tcp
f318f32a76e1	oaisoftwarealliance/oai-udm:develop	oai-udm	"/openair-udm/bin/oa..."	55 minutes ago	Up 55 minutes (healthy)	80/tcp, 5342-5344/tcp, 8080/tcp
3f54c5cbe03f	oaisoftwarealliance/oai-udr:develop	oai-udr	"/openair-udr/bin/oa..."	55 minutes ago	Up 55 minutes (healthy)	80/tcp, 8080/tcp
817699455a6c	oaisoftwarealliance/oai-nrf:develop	oai-nrf	"/openair-nrf/bin/oa..."	55 minutes ago	Up 55 minutes (healthy)	80/tcp, 5342-5344/tcp, 8080/tcp
260c02a90bd5	mysql:8.0	mysql	"docker-entrypoint.s..."	55 minutes ago	Up 55 minutes (healthy)	3306/tcp, 33060/tcp
87bdda0809dc	oaisoftwarealliance/trf-gen-cn5g:jammy	oai-ext-dn	"/bin/bash -c ' ip r..."	55 minutes ago	Up 55 minutes (healthy)	
8527a4bf33f3	oaisoftwarealliance/ims:latest	ims	"asterisk -fp"	55 minutes ago	Up 55 minutes (healthy)	

All containers should be
"healthy"

Run gNB – Terminal 2

- To open a new ubuntu session terminal – open a new PowerShell terminal and type,

```
wsl -d Ubuntu
```

- Edit the gNB configuration file to disable E2 agent (for now since we haven't installed flexRIC yet).

```
cd ~/openairinterface5g/targets/PROJECTS/GENERIC-NR-5GC/CONF/  
vim gnb.sa.band78.fr1.106PRB.usrpb210.conf
```

```
#e2_agent = {  
#   near_ric_ip_addr = "127.0.0.1";  
#   sm_dir = "/path/where/the/SMs/are/located/"  
#   sm_dir = "/usr/local/lib/flexric/"  
#};
```

Comment out these lines at the end of the file as shown

Run gNB – Terminal 2

```
cd ~/openairinterface5g/cmake_targets/ran_build/build
```

```
sudo ./nr-softmodem -O ../.././targets/PROJECTS/GENERIC-NR-5GC/CONF/gnb.sa.band78.fr1.106PRB.usrpb210.conf --gNBs.[0].min_rxtxtime 6 --rfsim
```

```
[HW] Version: Branch: develop Abrev. Hash: d47eb536b0 Date: Mon Aug 5 16:46:43 2024 +0000
[NR_PHY] RC.gNB = 0x5bbb92c42920
[NR_PHY] PRB blacklist
[NR_PHY] Copying 0 blacklisted PRB to L1 context
[PHY] L1_RX_THREAD_CORE -1 (15)
[PHY] TX_AMP = 519 (~36 dBFS)
Initializing northbound interface for L1
[PHY] l1_north_init_gNB() RC.nb.nr.L1_inst:1
[PHY] Installing callbacks for IF_Module - UL_indication
[MAC] Allocating shared L1/L2 interface structure for instance 0 @ 0x5bbb92c4ad30
[PHY] l1_north_init_gNB() RC.gNB[0] installing callbacks
[PHY] create_gNB_tasks() Task ready initialize structures
[PHY] No prs_config configuration found !!
[GNB_APP] pdsch_AntennaPorts N1 1 N2 1 XP 1 pusch_AntennaPorts 1
[GNB_APP] minTXRXTIME 2
[GNB_APP] SIB1 TDA 1
[GNB_APP] CSI-RS 1, SRS 1, 256 QAM may be on, delta_MCS off, maxMIMO_Layers -1, HARQ feedback enabled
[GNB_APP] sr_ProhibitTimer 0, sr_TransMax 64, sr_ProhibitTimer_v1700 0, t300 400, t301 400, t310 2000, n310 10, t311 3000,
[RRR] Read in ServingCellConfigCommon (PhysCellId 0, ABSFREQSSB 641280, DLBand 78, ABSFREQPOINTA 640000, DLBW 106, RACH_Targ
[RRR] absoluteFrequencySSB 641280 corresponds to 3619200000 Hz
[MAC] [MAIN] Init function start:nb_nr_macrlc_inst=1
[UTIL] threadCreate() for MAC_STATS: creating thread with affinity ffffffff, priority 2
[PHY] Installing callbacks for IF_Module - UL_indication
[NR_MAC] Configuring common parameters from NR ServingCellConfig
[NR_MAC] DL_Bandwidth:40
[NR_MAC] DL_Bandwidth:40
[NR_MAC] ssb_OffsetPointA 86, ssb_SubcarrierOffset 0
[NR_MAC] Set RX antenna number to 1, Set TX antenna number to 1 (num ssb 1: 80000000,0)
[NR_MAC] Setting TDD configuration period to 6
DL frequency 3619200000: band 48, UL frequency 3619200000
[PHY] DL frequency 3619200000 Hz, UL frequency 3619200000 Hz: band 48, uldl offset 0 Hz
[PHY] Configuring MIB for instance 0, : (Mid_cell 0, DL freq 3619200000, UL freq 3619200000)
[PHY] Initializing frame parms for mu 1, N_RB 106, Ncp 0
[PHY] Init: N_RB_DL 106, first_carrier_offset 1412, nb_prefix_samples 144, nb_prefix_samples0 176, ofdm_symbol_size 2048
[PHY] Doing symbol rotation calculation for TX/RX, f0 3619200000.000000 Hz, Nsymb 28
[PHY] Doing symbol rotation calculation for TX/RX, f0 3619200000.000000 Hz, Nsymb 28
[PHY] gNB 0 configured
```

**gNB configuration – Look for
CSI-RS, SRS settings, MIB,
DL/UL freq.**

Check AMF logs in Core Network Terminal

```
docker logs oai-amf -f
```

```
}
[2025-10-07 20:49:13.168] [ngap] [debug] Encoded size (49)
[2025-10-07 20:49:13.168] [sctp] [debug] [Socket 4, Assoc ID 4] Sending buffer 0x7f3ff0000e00 of 49 bytes on stream 0 with PPID 60
[2025-10-07 20:49:13.168] [sctp] [debug] Successfully sent 49 bytes on stream 0
[2025-10-07 20:49:13.168] [amf_n2] [debug] Sending NG_SETUP_RESPONSE Ok
[2025-10-07 20:49:13.168] [amf_n2] [debug] gNB with gNB_id 0xe00, assoc_id 4 has been attached to AMF
[2025-10-07 20:49:13.169] [amf_app] [debug] A new gNB has been successfully added!
[2025-10-07 20:49:13.169] [ngap] [debug] Free NGAP Message PDU
[2025-10-07 20:49:13.169] [ngap] [debug] Free NGAP Message PDU
[2025-10-07 20:49:14.795] [amf_app] [debug] Send ITTI msg to SBI task to trigger NRF Heartbeat
[2025-10-07 20:49:14.795] [amf_sbi] [info] Receive Update NF Instance Request, handling ...
[2025-10-07 20:49:14.795] [amf_sbi] [debug] Send NF Update to NRF
[2025-10-07 20:49:14.795] [amf_sbi] [info] Send HTTP message to http://oai-nrf:8080/nnrf-nfm/v1/nf-instances/01f5098b-62aa-4960-bd66-d9725a515b26
[2025-10-07 20:49:14.795] [amf_sbi] [info] HTTP message Body: [{"op":"replace","path":"/nfStatus","value":"REGISTERED"}]
[2025-10-07 20:49:14.795] [amf_sbi] [debug] Send a simple HTTP request
[2025-10-07 20:49:14.797] [amf_sbi] [info] Get response with HTTP code (204)
[2025-10-07 20:49:14.798] [amf_sbi] [info] Could not get JSON content from the response
[2025-10-07 20:49:14.798] [amf_app] [debug] Received SBI_UPDATE_NF_INSTANCE_RESPONSE
[2025-10-07 20:49:14.798] [amf_app] [debug] Handle NF Update response
[2025-10-07 20:49:14.798] [amf_app] [debug] Set a timer to the next Heart-beat (10)
[2025-10-07 20:49:18.889] [amf_app] [info]
```

gNBs' Information				
Index	Status	Global Id	gNB Name	PLMN
1	Connected	0xe00	gNB-OAI	001,01

UEs' Information							
Index	5GMM State	IMSI	GUTI	RAN UE NGAP ID	AMF UE NGAP ID	PLMN	Cell Id
-	-	-	-	-	-	-	-

```
[2025-10-07 20:49:24.798] [amf_app] [debug] Send ITTI msg to SBI task to trigger NRF Heartbeat
```

Run the UE – Terminal 3

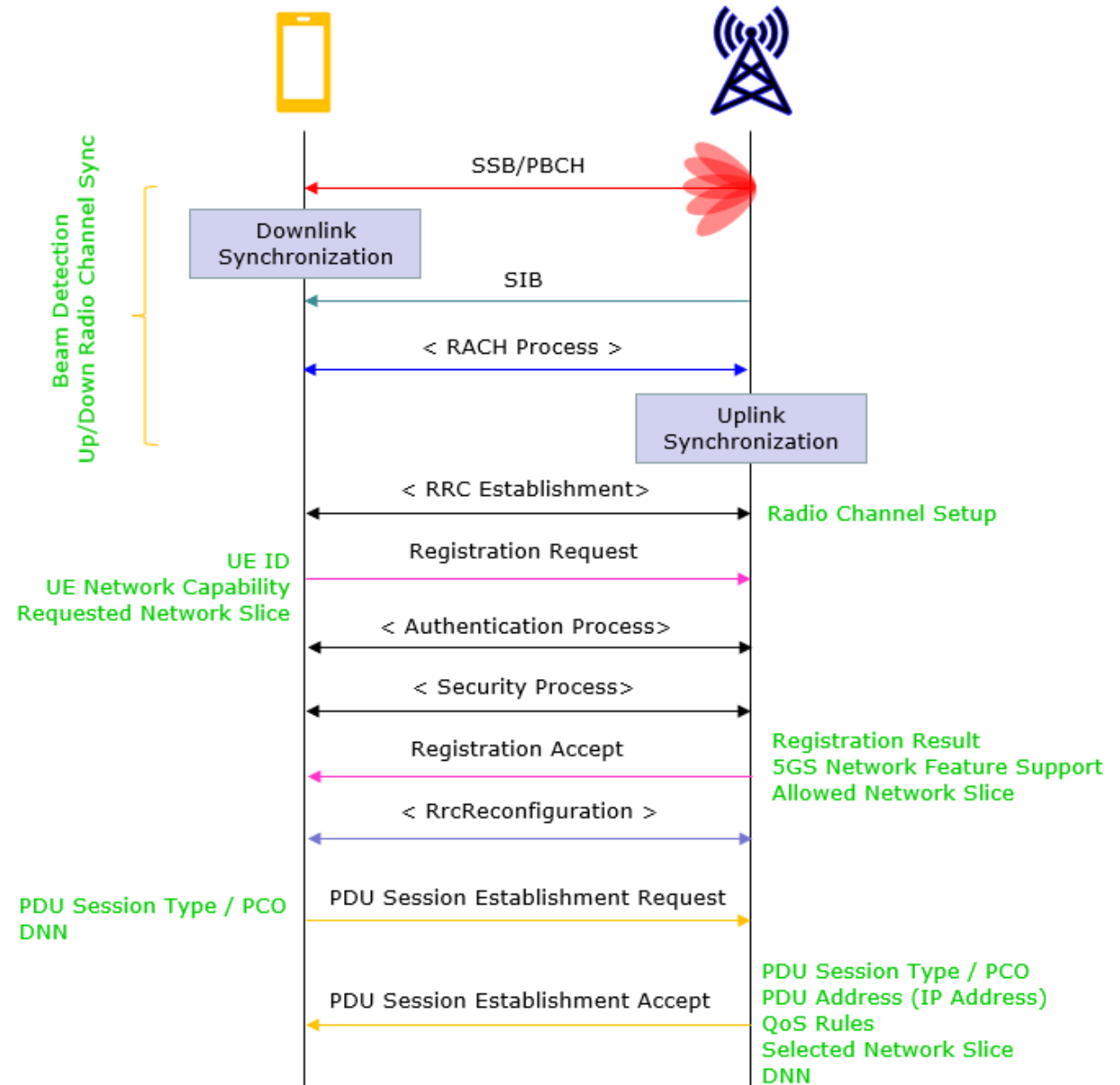
```
cd
~/openairinterface5g/cmake_targets/ran_build/build
```

```
sudo ./nr-uesoftmodem -r 106 --numerology 1
--band 78 -C 3619200000 --uicc0.imsi
0010100000000001 --rfsim
```

```
[PHY] Connect() to 127.0.0.1:4045 failed, errno(0)
[PHY] SSB position provided
[NR_PHY] Starting sync detection
[PHY] [UE thread Synch] Running Initial Synch
[NR_PHY] Starting cell search with center freq: 3619200000, bandwidth: 106. Scanning for 1 number of GSCN.
[NR_PHY] Scanning GSCN: 0, with SSB offset: 516, SSB Freq: 0.000000
[PHY] Initial sync: pbch decoded successfully, ssb index 0
[PHY] pbch rx ok. rsrp:51 dB/RE, adjust_rxgain:-1 dB
[NR_PHY] Cell Detected with GSCN: 0, SSB SC offset: 516, SSB Ref: 0.000000, PSS Corr peak: 99 dB, PSS Corr Average: 61
[PHY] [UE0] In synch, rx_offset 276480 samples
[PHY] [UE 0] Measured Carrier Frequency offset 16 Hz
[PHY] Initial sync successful, PCI: 0
[PHY] HW: Configuring channel 0 (rf_chain 0): setting tx_freq 3619200016 Hz, rx_freq 3619200016 Hz, tune_offset 0
[PHY] Got synch: hw_slot_offset 18, carrier off 16 Hz, rxgain 0.000000 (DL 3619200016.000000 Hz, UL 3619200016.000000 Hz)
[PHY] UE synchronized! decoded_frame_rx=484 UE->init_sync_frame=0 trashed_frames=56
[PHY] Resynchronizing RX by 276480 samples
[HW] received write reorder clear context
[HW] Gap in writing to USRP: last written 1590681599, now 1590772959, gap 91360
[NR_RRC] SIB1 decoded
[NR_PHY] =====
[NR_PHY] [UE 0] Harq round stats for Downlink: 1/0/0
[NR_PHY] =====
[NR_MAC] Initialization of 4-step contention-based random access procedure
[NR_MAC] PRACH scheduler: Selected R0 Frame 631, Slot 19, Symbol 0, Fdm 0
[PHY] PRACH [UE 0] in frame.slot 631.19, placing PRACH in position 2828, msg1 frequency start 0 (k1 0), preamble_offset 9,
[NR_MAC] Trying to process acknack for an inactive harq process (0)
[NR_MAC] [UE 0][RAPROC][RA-RNTI 0005] Got BI RAR subPDU 267 ms
[NR_MAC] [UE 0][RAPROC][RA-RNTI 010b] Got RAPID RAR subPDU
[NR_MAC] [UE 0][RAPROC][632.7] Found RAR with the intended RAPID 37
[MAC] received TA command 31
[PHY] RAR-Msg2 decoded
[NR_MAC] [RAPROC][632.17] RA-Msg3 transmitted
[MAC] [UE 0]Frame 633 Contention resolution identity: 0x15c608f230e6 Terminating RA procedure
[MAC] [UE 0][633.12][RAPROC] RA procedure succeeded. CB-RA: Contention Resolution is successful.
[NR_RRC] [UE0][RAPROC] Logical Channel DL-CCCH (SRB0), Received NR_RRCSetup
[RLC] Added srb 1 to UE 0
[MAC] [UE 0] Applying CellGroupConfig from gNodeB
[NR_RRC] State = NR_RRC_CONNECTED
[NR_RRC] [UE 0][RAPROC] Logical Channel UL-DCCH (SRB1), Generating RRCSetupComplete (bytes33)
```

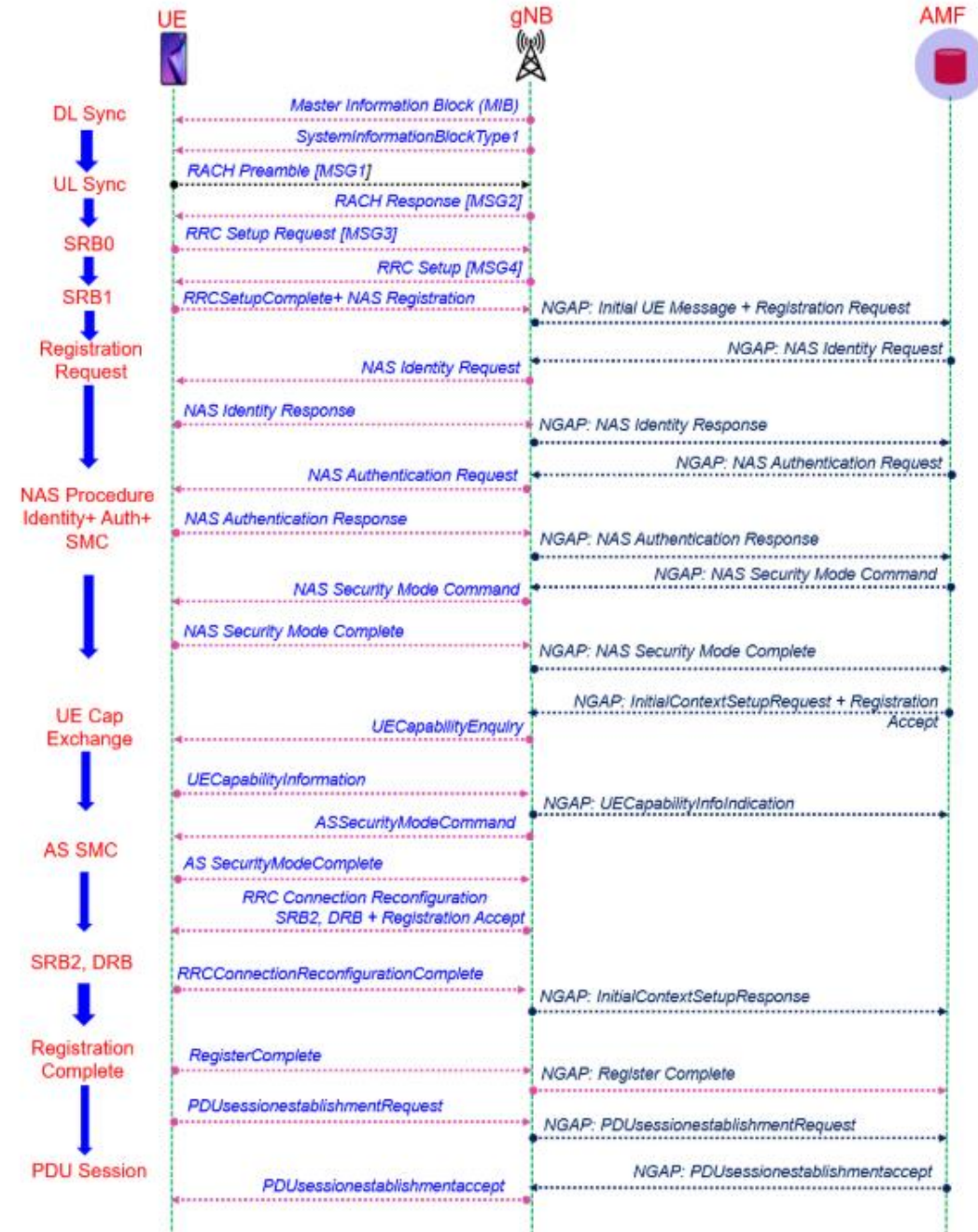
- Check the AMF logs again and verify if the UE is “registered”.

UE registration Call flow



- Trace the UE registration with the gNB and CN

Detailed UE registration call flow



gNB output Interpretation

```
[NR_MAC]   Frame.Slot 768.0
UE RNTI 8f47 CU-UE-ID 1 in-sync PH 52 dB PCMAX 20 dBm, average RSRP -44 (16 meas)
UE 8f47: UL-RI 1, TPMI 0
UE 8f47: dlsch_rounds 14/1/0/0, dlsch_errors 0, pucch0_DTX 0, BLER 0.07290 MCS (0) 9
UE 8f47: ulsch_rounds 29/1/0/0, ulsch_errors 0, ulsch_DTX 0, BLER 0.12138 MCS (0) 9 (Qm 2 dB) NPRB 5 SNR 51.0 dB
UE 8f47: MAC:      TX      1833 RX      1652 bytes
UE 8f47: LCID 1: TX      531 RX      290 bytes
UE 8f47: LCID 2: TX      0 RX      0 bytes
UE 8f47: LCID 4: TX      0 RX      0 bytes

[NR_MAC]   Frame.Slot 896.0
UE RNTI 8f47 CU-UE-ID 1 in-sync PH 52 dB PCMAX 20 dBm, average RSRP -44 (16 meas)
```

- The scheduler periodically outputs statistics that can help you judge the radio channel quality.
- In the first line,
 - UE RNTI
 - PH: Power Headroom - the amount of power the UE has left.
 - RSRP: measured power of the DL reference signals at the UE.
 - SINR: measured signal to interference and noise ratio of the SSB received at the UE.
- *LCID X* shows the amount of MAC SDU/RLC PDU data for Logical Channel ID with ID X in transmit and receive directions.
 - LCIDs 1 and 2 are mapped to SRBs 1 and 2.
 - LCIDs 4 and onward are mapped to DRBs 1 onward.
 - If you have an LCID 4, it means you have a PDU session.