Performing End to End Test With OAI (OpenAirInterface)

Jason Theo Salim
Sekolah Teknik Elektro dan Informatika
Institut Teknologi Bandung
Bandung, Indonesia
13222106@std.stei.itb.ac.id

***Abstract*—This report presents an experimental analysis of an end-to-end 5G network deployment using OpenAirInterface (OAI5G), focusing on the performance of the gNodeB (gNB), User Equipment (UE), and core network components. The study evaluates key metrics such as latency, signal quality, and data throughput to assess the system's stability and efficiency. The results validate the OAI5G stack's capability to support basic 5G connectivity while highlighting areas for improvement, such as latency consistency and radio signal optimization.**

***Keywords*—OpenAirInterface (OAI), gNB, UE,**

I. Introduction

This report documents the RF simulation of OpenAirInterface (OAI) 5G**,** focusing on the gNB and nrUE components**.** The primary goal of this simulation is to validate the connectivity and performance of the system under test conditions. The tests conducted for this end to end performance test include :

1. Setup and deployment of gNB and nrUE through the OpenAirInterface (OAI)

2. Perform a network connectivity test (Ping Test) to verify successful transmission and reception of packets.

By performing the mentioned tests, the achieved goals for this end to end performance test include :

1. Understand the basics of OAI 5G functionality

2. Verify successful attachment of the nrUE to the gNB

3. Confirm IP level connectivity between the simulated components.

II. Theoretical Background

A. OpenAirInterface (OAI)

OpenAirInterface (OAI) is an open-source software that is designed for 5G Radio Access Network (RAN) development and testing. OAI makes simulation and 5G emulation possible. One of the methods of simulation include the RF Simulation method, as it simulates real world radio behaviour without requiring actual hardware, so that software based testing can still be done while yielding realistic results.[1]

B. gNB and nrUE

In this simulation, the primary components utilized are the gNB (Next Generation Node B) and nrUE (New Radio User Equipment). The gNB serves as the base station, managing radio communications with the nrUE, which represents the end-user device. Establishing a simulated connection between these components allows assessment of the network functionality in a controlled and simulated environment.
The gNB is responsible for key functions that include scheduling and resource allocation for user data transmission. It is also responsible for error handling and managing connection setups (RRC signaling control).
On the other hand, the nrUE is responsible for receiving and processing data packets that are sent from the gNB, as well as sending data back to the gNB for uplink transmissions.[2]

III. Methodology

Provided below are the steps required to complete the simulation.

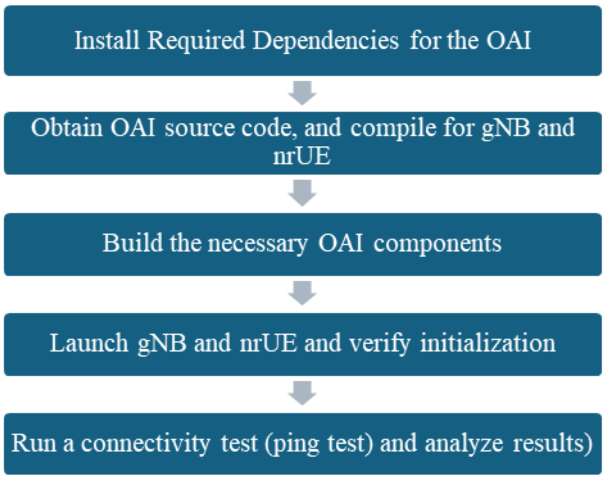

Install Required Dependencies for the OAI
Obtain OAI source code, and compile for gNB and nrUE
Build the necessary OAI components
Launch gNB and nrUE and verify initialization
Run a connectivity test (ping test) and analyze results)

Fig. 1. Flowchart outlining the simulation process

IV. Results And Analysis

The logs (Fig 2.1) confirm that the OAI5G core network components were successfully deployed using docker. Initial errors related to the hcd command and sudo password attempts were resolved, where the permission issues were resolved with utilizing the sudo commands for access. ensuring proper initialization of the core network. Further verifying the proper setup of the network, running the OAI CN5G before the gNB and nrUE were activated has also yieleded correct results, and no present errors. This indicates

that successful deployment of the core network, and that the OAI5G setup is successful.
The gNB and nrUE logs (Fig 2.2 and Fig 2.3) provide several insights, and several radio metrics that provide information on the results of the simulations ran. First, the average RSRP (Reference Signal Received Power) value is -42 dBm. This is a metric used to measure the power of the reference signal received in a network. A value of -42 dBm indicates that the simulation yields a strong signal value[3].

Another observable metric is the SNR (Signal to Noise Ratio), which is ranged around 5-5.5 dB, indicating that there is a relatively large amount of noise, but is still acceptable for most radio conditions. An unexpected value that is obtained from an RF simulation is that there is a considerable amount of noise, indicated by the relatively high SNR. An RF simulation generates results that match real-world conditions, meaning that it will program certain parameters to meet the expected output of an unideal condition, instead of the usual perfect result we get from simulations. The OAI RF simulation emulates real world channel conditions, including path loss, fading effects, and artifical noise in a programmed parameter, in order to replicate real world behavior.

The BLER (Block Error Rate) is 0% for both uplink and downlink transmissions. This metric being at 0% means that for communication throughout the simulation process, every transmission and data exchange successfully occurred without errors. This indicates the success of the Round Trip Test performed.

The MAC (Medium Access Control) layer metrics in Fig 2.2, is a sublayer of the data link layer in a 5G protocol stack. This layer handles scheduling, multiplexing, error control, and other logical channel managament. Through the MAC layer log, we can observe the bidirectional transmission (uplink and downlink) between the nrUE and gNB happening, represented by the 35,544 transferred bits (TX) and 266,645 received bits (RX). The LCID (Logical Channel IDs) also reveals the logical channels used, and can reveal traffic distributions[4]. In the results of the simulation, we can observe two IDs, being LCID 1 and LCID 4. In a 5G connection, the control signaling is minimal compared to the user data transmission, hence LCID 1 is most likely representative of the control signal, and LCID 4 is most likely representative of the user data.

To further validate the results of this simulation, a network test (ping test) is performed. The ping test results (Fig 2.4) shows that firstly, communcication between the UE and the IP is successful, because of existing results. Next, the latency and stability of the connection between the UE and the target IP is also proven through an average RTT (round trip time) of 24.122ms, with slight variation in the latency values obtained. In a 5G network, latency happens due to three main contributing factors :

- Processing delay, the time taken for gNB and nrUE to process the packets before a transmission process.
- Transmission delay, the time required to send packets of data over the channel. In this case, the channel is a simulated RF channel which also has programmed parameters of delay values.
- Queueing delay, the delay caused by buffering between different network layers before packets are transmitted.

Despite the fluctuations, the average RTT value yield is satisfactory for an end to end test, and also, a 0% packet loss yield confirms that the connection is stable and that there are no errors that cause the connection to face any interruptions.

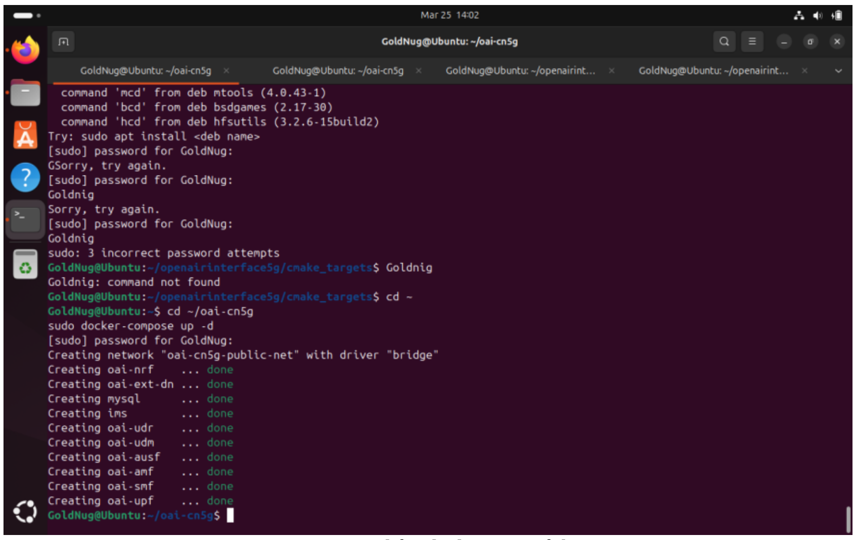
V. Conclusion

- The RF simulation of OpenAirInterface (OAI) 5G was successfully conducted, validated by the connectivity and performance of the system under test conditions.
- The gNB and nrUE were successfully deployed, and their functionality was verified through various performance metrics.
- The overall simulation results validate that OAI 5G can successfully emulate a 5G network, allowing end-to-end testing and performance evaluation without physical hardware.

References

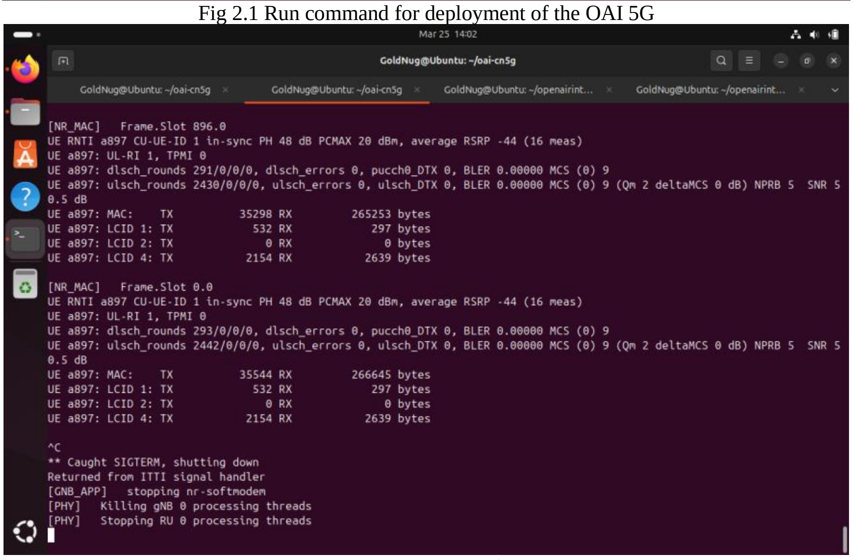
[1] "https://openairinterface.org/oai-5g-ran-project." Mar. 30, 2025.
[2] "https://gitlab.eurecom.fr/oai/openairinterface5g/-/blob/develop/doc/RUNMODEM.md?" Mar. 30, 2025.
[3] "https://www.digi.com/support/knowledge-base/important-information-for-contacting-digi-technica."
[4] "https://techlteworld.com/5g-nr-mac-layer-overview/."

APPENDIX


Mar 25 14:02
GoldNug@Ubuntu: ~/oai-cn5g
GoldNug@Ubuntu: ~/oai-cn5g
GoldNug@Ubuntu: ~/oai-cn5g
GoldNug@Ubuntu: ~/openairint...
GoldNug@Ubuntu: ~/openairint...

```
  command 'mcd' from deb mtools (4.0.43-1)
  command 'bcd' from deb bsdgames (2.17-30)
  command 'hcd' from deb hfsutils (3.2.6-15build2)
Try: sudo apt install <deb name>
[sudo] password for GoldNug:
GSorry, try again.
[sudo] password for GoldNug:
Goldnig
Sorry, try again.
[sudo] password for GoldNug:
Goldnig
sudo: 3 incorrect password attempts
GoldNug@Ubuntu:~/openairinterface5g/cmake_targets$ Goldnig
Goldnig: command not found
GoldNug@Ubuntu:~/openairinterface5g/cmake_targets$ cd ~
GoldNug@Ubuntu:~$ cd ~/oai-cn5g
sudo docker-compose up -d
[sudo] password for GoldNug:
Creating network "oai-cn5g-public-net" with driver "bridge"
Creating oai-nrf    ... done
Creating oai-ext-dn ... done
Creating mysql      ... done
Creating ims        ... done
Creating oai-udr    ... done
Creating oai-udm    ... done
Creating oai-ausf   ... done
Creating oai-amf    ... done
Creating oai-smf    ... done
Creating oai-upf    ... done
GoldNug@Ubuntu:~/oai-cn5g$ 
```

Fig 2.1 Run command for deployment of the OAI 5G

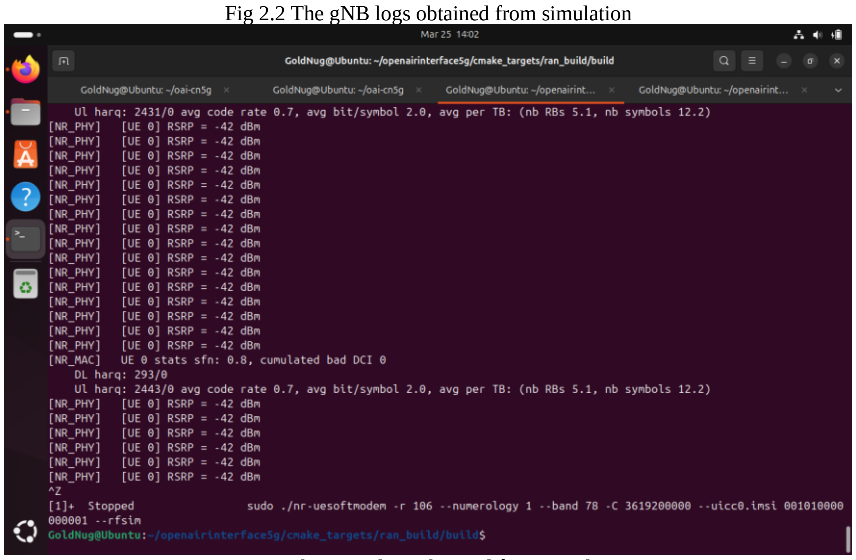

Mar 25 14:02
GoldNug@Ubuntu: ~/oai-cn5g
GoldNug@Ubuntu: ~/oai-cn5g
GoldNug@Ubuntu: ~/oai-cn5g
GoldNug@Ubuntu: ~/openairint...
GoldNug@Ubuntu: ~/openairint...

```
[NR_MAC]   Frame.Slot 896.0
UE RNTI a897 CU-UE-ID 1 in-sync PH 48 dB PCMAX 20 dBm, average RSRP -44 (16 meas)
UE a897: UL-RI 1, TPMI 0
UE a897: dlsch_rounds 291/0/0/0, dlsch_errors 0, pucch0_DTX 0, BLER 0.00000 MCS (0) 9
UE a897: ulsch_rounds 2430/0/0/0, ulsch_errors 0, ulsch_DTX 0, BLER 0.00000 MCS (0) 9 (Qm 2 deltaMCS 0 dB) NPRB 5  SNR 5
0.5 dB
UE a897: MAC:    TX          35298 RX         265253 bytes
UE a897: LCID 1: TX            532 RX            297 bytes
UE a897: LCID 2: TX              0 RX              0 bytes
UE a897: LCID 4: TX           2154 RX           2639 bytes

[NR_MAC]   Frame.Slot 0.0
UE RNTI a897 CU-UE-ID 1 in-sync PH 48 dB PCMAX 20 dBm, average RSRP -44 (16 meas)
UE a897: UL-RI 1, TPMI 0
UE a897: dlsch_rounds 293/0/0/0, dlsch_errors 0, pucch0_DTX 0, BLER 0.00000 MCS (0) 9
UE a897: ulsch_rounds 2442/0/0/0, ulsch_errors 0, ulsch_DTX 0, BLER 0.00000 MCS (0) 9 (Qm 2 deltaMCS 0 dB) NPRB 5  SNR 5
0.5 dB
UE a897: MAC:    TX          35544 RX         266645 bytes
UE a897: LCID 1: TX            532 RX            297 bytes
UE a897: LCID 2: TX              0 RX              0 bytes
UE a897: LCID 4: TX           2154 RX           2639 bytes

^C
** Caught SIGTERM, shutting down
Returned from ITTI signal handler
[GNB_APP]   stopping nr-softmodem
[PHY]   Killing gNB 0 processing threads
[PHY]   Stopping RU 0 processing threads
```

Fig 2.2 The gNB logs obtained from simulation


Mar 25 14:02
GoldNug@Ubuntu: ~/openairinterface5g/cmake_targets/ran_build/build
GoldNug@Ubuntu: ~/oai-cn5g
GoldNug@Ubuntu: ~/oai-cn5g
GoldNug@Ubuntu: ~/openairint...
GoldNug@Ubuntu: ~/openairint...

```
    Ul harq: 2431/0 avg code rate 0.7, avg bit/symbol 2.0, avg per TB: (nb RBs 5.1, nb symbols 12.2)
[NR_PHY]   [UE 0] RSRP = -42 dBm
[NR_PHY]   [UE 0] RSRP = -42 dBm
[NR_PHY]   [UE 0] RSRP = -42 dBm
[NR_PHY]   [UE 0] RSRP = -42 dBm
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[NR_PHY]   [UE 0] RSRP = -42 dBm
[NR_PHY]   [UE 0] RSRP = -42 dBm
[NR_PHY]   [UE 0] RSRP = -42 dBm
[NR_PHY]   [UE 0] RSRP = -42 dBm
[NR_PHY]   [UE 0] RSRP = -42 dBm
[NR_PHY]   [UE 0] RSRP = -42 dBm
[NR_MAC]   UE 0 stats sfn: 0.8, cumulated bad DCI 0
    DL harq: 293/0
    Ul harq: 2443/0 avg code rate 0.7, avg bit/symbol 2.0, avg per TB: (nb RBs 5.1, nb symbols 12.2)
[NR_PHY]   [UE 0] RSRP = -42 dBm
[NR_PHY]   [UE 0] RSRP = -42 dBm
[NR_PHY]   [UE 0] RSRP = -42 dBm
[NR_PHY]   [UE 0] RSRP = -42 dBm
[NR_PHY]   [UE 0] RSRP = -42 dBm
[NR_PHY]   [UE 0] RSRP = -42 dBm
^Z
[1]+  Stopped                 sudo ./nr-uesoftmodem -r 106 --numerology 1 --band 78 -C 3619200000 --uicc0.imsi 001010000
000001 --rfsim
GoldNug@Ubuntu:~/openairinterface5g/cmake_targets/ran_build/build$
```
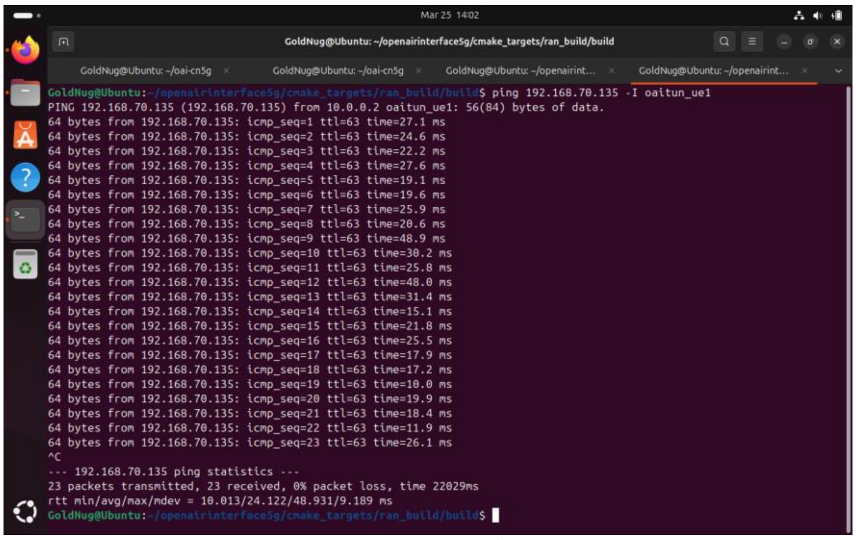

Fig 2.3 The nrUE logs obtained from simulation


Mar 25 14:02
GoldNug@Ubuntu: ~/openairinterface5g/cmake_targets/ran_build/build
GoldNug@Ubuntu: ~/oai-cn5g
GoldNug@Ubuntu: ~/oai-cn5g
GoldNug@Ubuntu: ~/openairint...
GoldNug@Ubuntu: ~/openairint...

```
GoldNug@Ubuntu:~/openairinterface5g/cmake_targets/ran_build/build$ ping 192.168.70.135 -I oaitun_ue1
PING 192.168.70.135 (192.168.70.135) from 10.0.0.2 oaitun_ue1: 56(84) bytes of data.
64 bytes from 192.168.70.135: icmp_seq=1 ttl=63 time=27.1 ms
64 bytes from 192.168.70.135: icmp_seq=2 ttl=63 time=24.6 ms
64 bytes from 192.168.70.135: icmp_seq=3 ttl=63 time=22.2 ms
64 bytes from 192.168.70.135: icmp_seq=4 ttl=63 time=27.6 ms
64 bytes from 192.168.70.135: icmp_seq=5 ttl=63 time=19.1 ms
64 bytes from 192.168.70.135: icmp_seq=6 ttl=63 time=19.6 ms
64 bytes from 192.168.70.135: icmp_seq=7 ttl=63 time=25.9 ms
64 bytes from 192.168.70.135: icmp_seq=8 ttl=63 time=20.6 ms
64 bytes from 192.168.70.135: icmp_seq=9 ttl=63 time=48.9 ms
64 bytes from 192.168.70.135: icmp_seq=10 ttl=63 time=30.2 ms
64 bytes from 192.168.70.135: icmp_seq=11 ttl=63 time=25.8 ms
64 bytes from 192.168.70.135: icmp_seq=12 ttl=63 time=48.0 ms
64 bytes from 192.168.70.135: icmp_seq=13 ttl=63 time=31.4 ms
64 bytes from 192.168.70.135: icmp_seq=14 ttl=63 time=15.1 ms
64 bytes from 192.168.70.135: icmp_seq=15 ttl=63 time=21.8 ms
64 bytes from 192.168.70.135: icmp_seq=16 ttl=63 time=25.5 ms
64 bytes from 192.168.70.135: icmp_seq=17 ttl=63 time=17.9 ms
64 bytes from 192.168.70.135: icmp_seq=18 ttl=63 time=17.2 ms
64 bytes from 192.168.70.135: icmp_seq=19 ttl=63 time=10.0 ms
64 bytes from 192.168.70.135: icmp_seq=20 ttl=63 time=19.9 ms
64 bytes from 192.168.70.135: icmp_seq=21 ttl=63 time=18.4 ms
64 bytes from 192.168.70.135: icmp_seq=22 ttl=63 time=11.9 ms
64 bytes from 192.168.70.135: icmp_seq=23 ttl=63 time=26.1 ms
^C
--- 192.168.70.135 ping statistics ---
23 packets transmitted, 23 received, 0% packet loss, time 22029ms
rtt min/avg/max/mdev = 10.013/24.122/48.931/9.189 ms
GoldNug@Ubuntu:~/openairinterface5g/cmake_targets/ran_build/build$
```

Fig 2.4 The ping test logs obtained from the simulation.