# A Comparative Study of an OpenAirInterface 5G NR UE Implementation and a Commercial 5G UE

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***Abstract*—This paper introduces a comparative study of OpenAirInterface (OAI)-based 5G New Radio (NR) User Equipment (UE) implemented on a USRP X410 and a Commercial-Off-The-Shelf (COTS) UE, such as a smartphone, within a Standalone (SA) 5G network testbed. The importance of deployable platforms in 5G research is first discussed, highlighting the role of open-source tools such as OAI in enabling flexible experimentation. The system architecture of the OAI NR UE is then introduced and compared with that of a commercial 5G smartphone, focusing on the trade-offs between performance and flexibility. Through experiments evaluating throughput, latency, configurability, and debugging observability, we conclude that the OAI NR UE underperformed in throughput and stability but offers reproducibility and greater control, which are essential for academic research. The results support the use of OAI NR UE for protocol research and development purposes, while commercial 5G UEs serve as reference baselines for fundamental performance evaluation.**

***Index Terms*—Wireless Communication, Testbed, 5G User Equipment, COTS, OpenAirInterface, Comparison Study**

## I. Introduction

The Fifth-Generation (5G) New Radio (NR) enables ultra-fast connectivity, low-latency applications, and massive device connections. Building a real-world 5G testbed is critical for researchers and developers. However, commercial base stations and user equipment are usually expensive, with closed protocol stacks, restricted debugging interfaces, and reduced system flexibility, which limit the ability to conduct detailed experiments. Open-source implementations of 5G systems provide an alternative solution to these challenges. OpenAirInterface (OAI) is one of the most active open-source implementations of 5G, supporting a full stack from the Physical Layer (PHY) to the Non-Access Stratum (NAS). Combined with Software-Defined Radio (SDR) hardware, OAI enables the construction of controllable, repeatable, and scalable 5G test platforms at relatively low cost. These platforms provide experimental conditions comparable to commercial deployments, while allowing detailed control and debugging of protocols at each layer (e.g., [1], [2]). In particular, the OAI nrUE software provides an open and customizable 5G User Equipment (UE) implementation for research tasks such as protocol testing, algorithm validation, and system optimization. However, the performance differences between an SDR-based OAI NR UE and a commercial 5G UE have not been fully characterized.

This paper evaluates the differences between an SDR-based OAI NR UE and a commercial 5G UE under the same testbed. An NI Ettus Universal Software Radio Peripheral (USRP) X410 [3], a high-end SDR platform, is combined with OAI nrUE to conduct performance benchmarks for throughput and latency in 5G standalone (SA) networking mode. The results are compared with those of a commercial 5G UE. This comparison identifies the strengths and limitations of open-source UEs in real-world environments, and provides a reference for the construction of open-source 5G testbeds and experimental mobile network platforms.

In summary, our work contributes...

- an *evaluation* of an OAI NR UE and a commercial 5G UE on the same testbed,
- an *analysis* of the limitations and advantages of OAI NR UE for flexible protocol experimentation,
- and *recommendations* on when to use OAI NR UE or a commercial 5G UE in 5G research and development.

## II. Background and Related Work

This section introduces the background of 5G UE and the OAI implementation and reviews related work on OAI-based 5G research platforms. It contrasts commercial UEs with OAI NR UE and summarizes relevant prior studies on 5G testbeds.

### A. Background of 5G UEs and OAI Features

Commercial 5G UEs are typically characterized by low power consumption, high performance, and high stability. However, these devices are based on closed-source protocol stacks from vendors such as Qualcomm, which limit system flexibility [1]. Only a limited set of AT command interfaces is provided to enable basic debugging and diagnostics. Since access to critical parameters in the physical layer and the media access control (MAC) layer is unavailable, experimental reproducibility can not be guaranteed. Therefore, commercial UEs provide limited access to lower layers and allow limited control, which restricts their use in detailed protocol research.

TABLE I
KEY DIFFERENCES BETWEEN COMMERCIAL 5G-UE AND OAI NR UE

| Feature | OAI-UE | COTS-UE |
|---|---|---|
| Access to Stack | Open-source | Closed |
| Protocol Control | Full Control | Very Limited |
| Stability | Moderate | High |
| Power Efficiency | Low | High |
| Repeatability | Excellent | Poor |

In contrast, the OAI nrUE software offers an open-source implementation of the 5G NR UE protocol stack, and provides users with access to the full stack, including PHY, MAC, Radio Link Control (RLC), Packet Data Convergence Protocol (PDCP) and higher-layer. OAI nrUE allows deep inspection and modification of protocol behavior to support experimental verification and system innovation.

OAI nrUE can be paired with various SDR platforms, such as NI Ettus USRP B210 [4] or X410 [3], supporting flexible signal processing and custom waveform generation. This open architecture significantly reduces the threshold for constructing of 5G testbeds, and enables rapid prototyping and customized research of 5G protocol stack [1]. A comparison between the SDR-based OAI NR UE and commercial 5G UEs is summarized in Table I.

### B. OAI Research Testbeds

Existing studies have extensively used open-source 5G SA platforms for experimental performance evaluations. Phan et al. [5] and Doria et al. [6] focused on deploying 5G core networks using platforms such as Open5GS[1], OAI Core Network[2], and UERANSIM[3], highlighting deployment architectures and basic benchmarking, but without analyzing UE-level performance. Amini and Rosenberg [7] constructed and benchmarked over 30 5G SA testbeds with various combinations of Next-Generation Node B (gNB), UE, and core network configurations. Their work focuses on the classification of test platforms and setup methods without addressing the protocol behavior of UEs. Raffeck et al. [8] conducted an in-depth study of the effects of TDD configurations on throughput and latency, but used only a single industrial module UE, lacking a comparative perspective with open-source UEs. Rouili et al. [9] compared three types of RAN deployment methods: real radio devices (SDR + mobile phone), a radio simulator, and fully virtualized platforms (e.g., UERANSIM), highlighting differences in latency, power consumption, and signaling behavior among these solutions. In another experimental comparison of Alves et al. [10], the performance and functional differences between srsRAN and OpenAirInterface were evaluated and the respective advantages in academic use cases were highlighted. However, their evaluation only covered a single type of commercial 5G UE and did not include software-defined UEs. Motaung et al. [11] further compared srsRAN and OAI. They analyzed not only throughput and latency but also system-level aspects such as development complexity and virtualization environments. Their experiments were also conducted using a commercial 5G UE and did not investigate SDR-based UEs.

The existing OAI-related research primarily focuses on RAN and 5G Core network implementations and on system-level evaluations, mainly using commercial UEs. The performance evaluation of the OAI NR UE and the impact of different UE types remain limited. Compared with the prior work, this study presents a controlled performance comparison of two types of UEs, an SDR-based open-source OAI NR UE and a commercial 5G UE, under an identical OAI-based 5G SA testbed. With this work and studies, we aim fill the research gap in the current literature regarding comparative evaluations of UE types.

[1]Open5GS. Link: https://github.com/open5gs/open5gs
[2]OAI Core Network. Link: https://openairinterface.org/core-network/
[3]UERANSIM. Link: https://github.com/aligungr/UERANSIM

## III. HARDWARE SETUP OF THE RESEARCH TESTBED

This section describes the lab-scale 5G testbed used in the comparative study (see Fig. 1 and Table II). The experimental testbed implements an OAI-based standalone (SA) network, including 5G core (5GC), gNB, an OAI NR UE, and a COTS UE. Each OAI component was deployed on a separate machine to avoid resource contention and to ensure stable operation. All OAI machines run Ubuntu 22.04 and OAI version 2025.w31.

### 5GC *5G Core*

The 5GC implementation in the testbed is based on the OAI 5G Core Network and runs on a separate desktop PC (5GC-PC). The basic 5GC components (AMF, SMF, UPF, NRF, UDM, AUSF) are deployed in a Docker-based environment [12].

### gNB *Next-Generation Node B*

We deployed the OAI 5G gNB software stack on a high-performance workstation (denoted gNB-PC). A NI Ettus USRP X410 is utilized as the radio frontend, and is connected to the workstation via dual QSFP28 10 Gbps Ethernet links for


Fig. 1. **5G SA Testbed** for performance comparison.

TABLE II
HARDWARE SPECIFICATIONS OF THE EXPERIMENTAL TESTBED

| Part | CPU | RAM |
|---|---|---|
| 5GC | 6-core, 3.2 GHz (Intel Core i7-8700) | 32 GB |
| gNB | 16-core, 4.3 GHz (AMD Ryzen 9 9950X) | 64 GB |
| OAI-UE | 16-core, 3.5 GHz (AMD Ryzen 9 3950X) | 48 GB |

low-latency and high-throughput data transfer. The Radio Access Network (RAN) was configured to operate in standalone mode on band n78 at 3.75 GHz, with 40 MHz bandwidth, and 30 kHz subcarrier spacing (SCS) in time division duplexing (TDD) mode. gNB-PC and 5GC-PC are interconnected via an Ethernet switch and static IP routing, enabling reliable communication across the N2 and N3 interfaces.

*UEs - User Equipment*

Two distinct types of UEs are considered in this study:

- **OAI-UE** An open-source software-defined 5G NR UE based on OAI nrUE and SDR (referred to as OAI NR UE). The software stack runs on a high-performance workstation, which is connected to a second USRP X410 to enable an over-the-air connection to the gNB. The workstation and USRP are interconnected via a dual QSFP28 connection.
- **COTS-UE** A Crosscall CORE-Z5 smartphone[4] was employed as a reference COTS UE and connected to the gNB over the air (referred to as the commercial 5G UE). It is equipped with the Qualcomm QCM6490 processor and Android 12 OS, serves as a reference point for benchmarking throughput, latency, and reconfiguration behavior against the OAI NR UE.

## IV. Evaluation and Measurements

Under the consistent experimental conditions described above, a series of comparative tests were conducted on OAI NR UE and a commercial 5G UE, to evaluate performance and system flexibility, highlighting their respective advantages and limitations.

**TP** *Throughput (Downlink and Uplink)*

In this first experiment, downlink (DL) and uplink (UL) throughput were evaluated under identical conditions. Data traffic was exchanged between the UEs and the OAI core network's external data network (oai-ext-dn). Throughput was measured using the widely used tool iperf3[5] under different load conditions. In this study, UDP traffic was used to characterize the upper bound of the wireless link's transport capacity.

**L** *Latency (Ping delay; Downlink and Uplink)*

In addition to throughput, end-to-end user-plane latency was measured using Internet Control Message Protocol (ICMP) echo requests. The tests were executed using the standard ping command. Latency distribution over time shows jitter characteristics and the capability to support real-time application, which are key requirements for the 5G Ultra-Reliable Low-Latency Communication (uRLLC) scenario.

[4]Crosscall CORE-Z5. Link: https://www.crosscall.com/en/products/core-z5
[5]iperf3: Link: https://github.com/esnet/iperf

**RFDC** *Radio Frequency Debug & Control*

In addition to throughput and latency, the RF configurability and debugging observability of the UEs were evaluated. *RF parameter configurability:* the ability to configure parameters such as operating frequency, bandwidth, and transmit/receive gains; *Debugging visibility:* This metric evaluates the granularity of available internal protocol stack data for performance analysis. Tests were conducted under the same controlled laboratory conditions as in the previous experiments. Both UEs connect to the core network through the gNB.

## V. Results of the Experiments

In the following section, we present the experimental results of the measurements conducted in section IV.

**TP↓** *Throughput: Downlink*

First, we benchmarked downlink UDP throughput using iperf3 in a 5G standalone (SA) setup with OAI gNB and OAI 5GC. Traffic was generated from the data network (oai-ext-dn) toward each UE at offered rates ranging from 10 to 180 Mbit/s. We extracted both the UDP throughput and the corresponding UDP packet-loss ratio from the server-side iperf logs for each offered load. We performed statistical analysis of throughput only for measurements taken after the first 2 seconds, to exclude the low initial throughput caused by Modulation and Coding Scheme (MCS) ramp-up and buffer filling. Minor throughput overshoots appear at high offered loads, because iperf3 reports UDP bandwidth including protocol headers. The overshoot does not affect the steady-state comparison.

Fig. 2 shows both the steady-state UDP throughput and the corresponding packet-loss ratio as a function of the offered rate. The throughput curves include 95% confidence intervals computed from the per-interval server-side measurements.

Up to 80 Mbit/s, the two UEs exhibit nearly identical behavior. Both UEs achieve mean throughputs close to the offered load, and their confidence intervals strongly overlap. The packet-loss ratio in this range remains essentially zero for both UEs. This demonstrates that, for typical moderate-rate application scenarios—such as IoT traffic, control signaling, lightweight video streaming, or general research testbeds—the SDR-based OAI NR UE can reliably reproduce the performance of a commercial 5G UE.

For offered rates above 80 Mbit/s, the behavior becomes inconsistent. The throughput of the commercial 5G UE continues to rise almost linearly with the offered load. Across high-rate measurements up to 140 Mbit/s, the commercial 5G UE maintains a packet-loss ratio close to zero, indicating stable high-MCS operation and sufficient PHY/MAC processing headroom. In contrast, the throughput of OAI NR UE saturates at approximately 80 Mbit/s. For all offered loads from 80 to 180 Mbit/s, the measured mean throughput remains in the range 79 to 81 Mbit/s, and the associated 95% confidence intervals overlap almost perfectly. Beyond this saturation point, the OAI NR UE exhibits a rapidly increasing packet-loss ratio, rising from roughly 5% at 100 Mbit/s to more than 40% at 160 Mbit/s and reaching 50% at 180 Mbit/s.

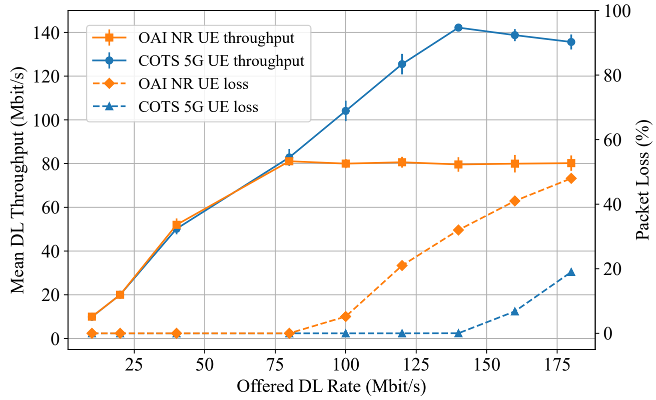


Fig. 2. TP↓ **DL UDP Throughput and Packet Loss** versus offered Rate (t >2s, 95% CI).

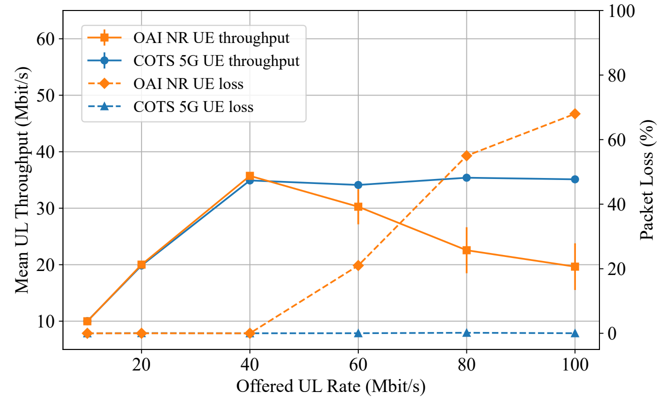


Fig. 3. TP↑ **UL UDP Throughput and Packet Loss** versus offered Rate (t >2s, 95% CI).

This increase in loss reflects throughput saturation, indicating that the OAI NR UE cannot process the incoming data streams at higher transmission rates. When the offered downlink traffic increased from 80 Mbit/s to 100 Mbit/s, the OAI-log on UE side reports `pdcp_data_ind queue is full`, while the CPU utilization of the thread `PCDP data ind` rises sharply to around 90%. At the same time, the other OAI-related threads remain below saturation, and no packet drops or buffer errors are detected at the tunnel interface or UDP socket level. This observation indicates that the throughput bottleneck is located in the internal PDCP data indication path of OAI nrUE and in the execution on a general-purpose CPU.

The combined throughput and reliability results highlight the contrast: The OAI NR UE is highly competitive with the commercial 5G UE at low and moderate data rates, but its applicability in high-throughput scenarios is limited by its internal software packet processing path and its processing performance.

TP↑ *Throughput: Uplink*

Figure 3 presents the uplink UDP throughput and packet loss ratio for the commercial 5G UE and the OAI NR UE. As in the downlink analysis, only samples with $t > 2s$ are considered to exclude startup transients and to observe steady-state performance.

Both UEs exhibit nearly identical uplink performance up to 40 Mbit/s offered load. This uplink transmission capacity is fundamentally limited by the relatively low UL duty cycle of the by gNB-configured TDD frame structure. The mean throughputs of both UEs can approximately reach 35 Mbit/s with negligible packet loss. At 60 Mbit/s, the OAI NR UE already exhibits saturation, achieving 30.3 ± 3.1 Mbit/s with a 21% loss ratio, whereas the commercial 5G UE maintains 34.8 ± 0.4 Mbit/s with only 0.16% loss. At the maximum offered load of 100 Mbit/s, the commercial 5G UE remains stable (35.1 ± 0.3 Mbit/s, 0.02% loss), while the OAI NR UE drops to 19.7 ± 4.1 Mbit/s with greater packet loss (68%).

For the commercial 5G UE, increasing the offered rate beyond 35 Mbit/s does not result in higher received throughput at the server, but also does not cause a noticeable increase in packet loss. This indicates that the commercial modem and gNB scheduler implement a stable uplink capacity limit: excess traffic is effectively limited or dropped within the UE's protocol stack or operating system before becoming transmitted traffic on the radio link. Thus, the air interface can remain stable and lightly loaded, and the uplink throughput observed by the server is saturated but reliable.

In contrast, for the OAI NR UE, we observe that the server continues to receive packets slightly beyond the 20-seconds transmission interval configured at the client. This indicates that the uplink packets are buffered within the OAI nrUE software and SDR processing chain and are transmitted with additional delay, even after the iperf3 client has stopped sending. As a consequence, the effective measurement duration on the receiver side exceeds 20 seconds, resulting in a drop in the average throughput reported by the iperf3 server. OAI-Log further shows repeated `SDU buffer full` events at the UE side under overload, which indicates that the offered traffic exceeds the uplink transmission capacity. The packet loss ratio increases due to buffer overflows.

In summary, the SDR-based OAI NR UE matches the performance of commercial 5G UE up to moderate loads ($\leq$35 Mbit/s), but exhibits a clear, sharp degradation once the offered rate exceeds its uplink processing capacity. OAI NR UE tends to accumulate and release uplink traffic under overload, which causes additional latency that reduces average throughput and increases packet loss rates. In contrast, commercial 5G UE maintains low packet loss rates by enforcing a hard uplink capacity limit and throttling excess traffic before transmission.

L↓ *Latency: Downlink*

We compared the Round-Trip Time (RTT) performance of the OAI NR UE and the commercial 5G UE. RTT measurements were obtained using ping (ICMP echo requests) transmitted at 0.5-second intervals, from the oai-ext-dn to the UEs. The corresponding RTT statistics are shown in Table III.

The OAI NR UE achieved a mean RTT of 6.78 millisecond (ms) with a median of 6.35 ms, while the commercial 5G UE showed a higher mean RTT of 9.69 ms and a median of 9.10

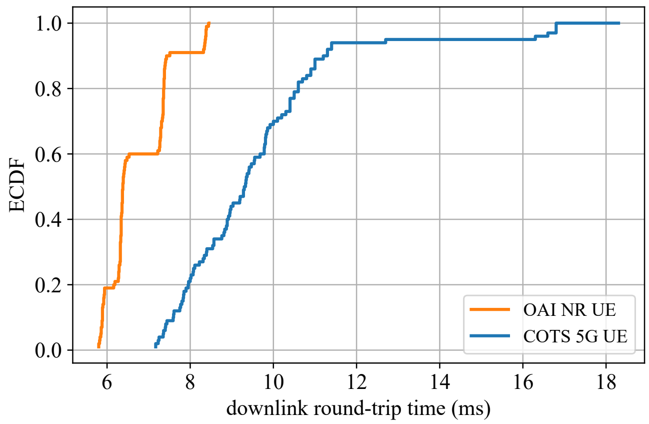


Fig. 4. L↓ Empirical cumulative distribution function (ECDF) of **downlink round-trip times** (RTTs) comparing OAI NR UE and commercial 5G-UE.

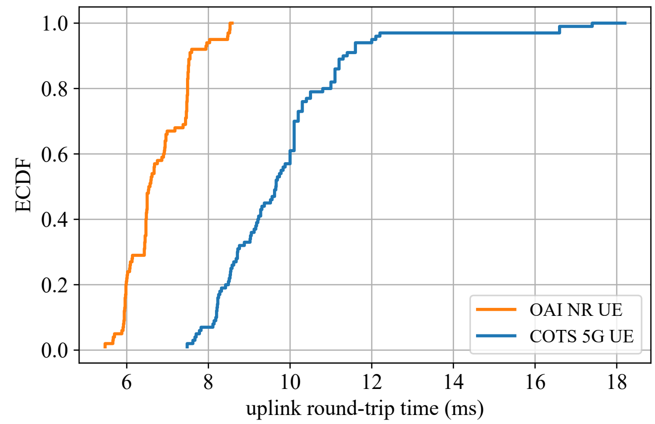


Fig. 5. L↑ Empirical cumulative distribution function (ECDF) of **uplink round-trip time** (RTTs) comparing OAI NR UE and commercial 5G-UE.

ms. At the 90th percentile, the OAI NR UE maintained RTTs below 7.8 ms, while the commercial 5G UE reached 11.3 ms. The maximum observed RTT was 8.45 ms for the OAI NR UE, compared to 18.33 ms for the commercial UE. The OAI NR UE shows lower jitter, i.e., standard deviation (0.76 ms), than the smartphone (2.19 ms), indicating more stable short-term behavior. 0% packet loss was observed by both UEs, confirming equal reliability under identical test conditions.

The RTT distribution is shown in the empirical cumulative distribution function (ECDF) in Figure 4. The curve for OAI NR UE rises steeply, with over 90% of the samples below 8 ms, indicating that the distribution is tightly centered around the median. In contrast, the ECDF distribution for commercial 5G UE is more spread out. The tail of the commercial 5G UE's curve extends over 16 ms, reflecting increased latency variability. These differences can be attributed to the differences in UE design and operating behavior. Commercial 5G UEs usually adopt power-saving techniques such as Discontinuous Reception (DRX) and sleep modes [13], which may cause additional latency due to sleep cycles and wake-up procedures before data transmission [14]. In contrast, OAI NR UE operates continuously without aggressive power-saving constraints and offers lower and more deterministic latency.

In summary, the results show that OAI NR UE achieves lower RTT values and less jitter than the commercial 5G UE in all test configurations. The RTT distribution of the OAI NR UE is characterized by a narrow range, while the commercial 5G UE exhibits a wider distribution within an acceptable delay range. In the downlink latency tests, OAI NR UE exhibits performance comparable to that of a commercial 5G UE. The commercial 5G UE represents an actual trade-off between energy efficiency and latency.

TABLE III
RTT STATISTICS (STANDARD PING, 100 PACKETS, 0.5 S INTERVAL)

| observed Metric | OAI-UE | COTS-UE |
|---|---|---|
| Min. (ms) | 5.80 | 7.17 |
| Avg. (ms) | 6.78 | 9.69 |
| Max. (ms) | 8.45 | 18.33 |
| Std. Dev. (ms) | 0.76 | 2.19 |
| P90 (ms) | 7.80 | 11.30 |

### L↑ *Latency: Uplink*

For uplink assessment, the UE transmits ICMP echo requests to the 5GC's external data network at 0.5-second intervals. The corresponding empirical cumulative distribution function (ECDF) of RTT are shown in Figure 5.

As presented in Figure 5, the uplink RTT distribution exhibits trends similar to those observed in the downlink measurements. The OAI NR UE demonstrates a steeply rising ECDF. The majority of RTT samples are located within a narrow latency range. In contrast, the commercial 5G UE exhibits a flatter ECDF with greater dispersion and a noticeable extension, reflecting increased RTT variability.

The average uplink RTT for OAI NR UE was 6.80 ms, compared to 9.92 ms for commercial 5G UE. The higher percentile RTT for OAI NR UE remained consistently lower. No packet loss was observed for either UE during the measurement period. In the evaluated setting, uplink results confirm that latency characteristics are fundamentally consistent with the downlink, without additional directional effects.

### RFDC *Radio Frequency Debug & Control*

OAI NR UE supports operation across any frequency range supported by the SDR hardware. It allows explicit configuration of RF parameters such as carrier frequency, bandwidth, and transmit or receive gains [1]. The configuration is handled via command-line arguments and UE configuration files. This process is completed prior to nrUE process initialization. Although the RF reconfiguration of OAI NR UE requires a process restart, the deterministic setting of the RF frontend ensures highly reproducible experimental results, which is a key requirement for 5G research.

In contrast, the commercial UE is restricted to predefined 3GPP NR frequency bands. Its carrier frequency and bandwidth are determined by the internal configuration of the modem and by the Absolute Radio Frequency Channel

Number (ARFCN) value of the gNB signal [10]. It relies on proprietary modem algorithms. Neither transmit power nor internal gain parameters are directly configurable or visible.

OAI NR UE functions as a “white-box” system, visualizes real-time I/Q constellations and channel estimation (CSI) maps using the OAI Softscope utility, and provides PHY statistics in slot level, which is essential for PHY-layer research. For example, we were able to directly correlate throughput fluctuations with constellation smearing and CSI deviations.

The commercial 5G UE behaves as a “black-box” device, providing only high-level indicators such as Reference Signal Received Power (RSRP), and Signal-to-Interference-plus-Noise Ratio (SINR) [15], by accessing the device’s internal diagnostic logging interfaces or standard Android/iOS APIs [16]. Low-level control and parameters, such as MCS and CSI reporting, are not observable.

These observations demonstrate that the OAI NR UE enables controlled RF experimentation and deep-trace debugging, while the commercial UE functions primarily as a closed reference device optimized for end-user performance rather than research flexibility.

## VI. Discussion

Although OAI NR UE and commercial 5G UE operate under identical wireless and core network conditions in this study, their performance differences reflect differing design priorities.

The commercial 5G UE consistently delivers higher and more stable throughput, particularly under high-load conditions. This is achieved via hardware-accelerated base-band processing, integrated modem designs, and optimized capacity limits, ensuring sustained throughput and stability. In contrast, OAI NR UE employs software-based physical layer processing and a software-defined radio pipeline running on a general-purpose CPU. This approach leads to throughput saturation at relatively lower data rates due to a bottleneck in the internal packet-processing path, but enables fine-grained control and observation of protocol behavior.

Latency measurements indicate that the OAI NR UE provides more deterministic RTTs with lower jitter. This behavior is attributable to its avoidance of proprietary buffering and power-saving mechanisms commonly used in commercial equipment. Although such mechanisms improve energy efficiency in practical deployments, they introduce uncontrollable variability in controlled experiments. OAI NR UE’s more deterministic delay characteristic offers significant advantages for controlled experimentation and protocol-layer analysis.

OAI NR UE offers full access to protocol stack and RF parameters, enabling repeatable experiments and detailed cross-layer debugging. Its observability and determinism outweigh its performance limitations in research-oriented scenarios. In contrast, commercial UEs offer robustness and energy efficiency, but limited configurability due to the closed design. Therefore, OAI NR UEs are better suited for controlled protocol experimentation, while commercial UEs are preferable for realistic performance evaluation.

Like most research, our study also has certain limitations. First, the evaluation was conducted using an OAI-based gNB and 5GC instead of a commercial operator network. The main reason was to focus on UE-side behavior under controlled, reproducible conditions. This setup also provides access to gNB and 5GC logs for detailed analysis. In contrast, commercial operator networks are less observable and less controllable. Second, only one SDR platform (USRP X410) was evaluated. Although it represents high performance and is widely adopted for 5G research, the results may not be directly generalizable to other SDR platforms. Third, the evaluation of the commercial 5G UE was limited to a single smartphone model. The results therefore do not represent the full diversity of commercial 5G modems. Fourth, the comparison did not consider the scenario involving multiple simultaneous UEs. Multi-UE operation will introduce scheduling interactions and resource contention, potentially leading to performance variations.

## VII. Conclusions and Outlook

In this paper, we presented a comparative evaluation of the open-source software-defined OAI NR UE running on a USRP X410 and a commercial 5G UE (Crosscall Core-Z5) within the same 5G standalone testbed. The results of the experiments show that, the OAI NR UE achieves comparable performance to the commercial UE at low to moderate traffic loads, but exhibits throughput saturation under higher load scenario. However, it provides lower, more stable latency and greater RF configurability. Our comparisons confirm that OAI NR UE is especially suitable for 5G research tasks such as protocol development, performance analysis, and system validation, thanks to its transparency and repeatability. Commercial UEs are highly suitable as reference devices for benchmarking and validating realistic communication performance.

In future work, we will extend the experiments and the evaluation to commercial operator networks, additional SDR platforms and commercial UE models, multi-UE scenarios, and TCP-based performance analyses. We will also focus on improving the stability and real-time performance of the OAI NR UE protocol stack, especially under high traffic loads. The open-source architecture of OAI NR UE provides a flexible platform for future investigation of advanced features, such as sidelink communication for device-to-device scenarios. The presented testbed and methodology provide a foundation for early beyond-5G and 6G research, including new air-interface designs and early-stage protocol evaluation and validation.

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