

Dataset Catalog: Network Performance and Power Consumption for UPF Implementations

1 Introduction

This dataset captures the energy and performance profiles of two distinct User Plane Function (UPF) implementations within a 5G Core network: a DPDK-based UPF deployed using the SD-Core framework [1], and a user-space UPF implemented with OpenAirInterface [2]. The primary objective is to analyze performance and power consumption patterns under various traffic loads, supporting the development of energy-efficient decision-making strategies in 5G network management.

2 System Architecture

The infrastructure includes a fully operational 5G test environment deployed on bare-metal servers, featuring:

- **SD-Core UPF:** High-throughput, hardware-accelerated processing on AMD EPYC 9474F, 512GB RAM, 100Gbps NIC.
- **User-Space UPF:** Software-based user-space packet handling on Intel E5-2680 v4, 256GB RAM, 40Gbps NIC.

Traffic loads were generated using Keysight LoadCore [3], leveraging two dedicated agents to simulate network behavior. The first agent, acting as the NGRAN simulator (as shown in Fig. 1), emulated User Equipment (UE) and Radio Access Network (RAN) behavior, while the second agent functioned as the Data Network (DN) simulator. This setup enabled stress-testing of UPF performance across diverse scenarios. Power consumption was monitored via Scaphandre, while network metrics (throughput, latency, packet loss) were collected from LoadCore to correlate energy usage with operational efficiency.

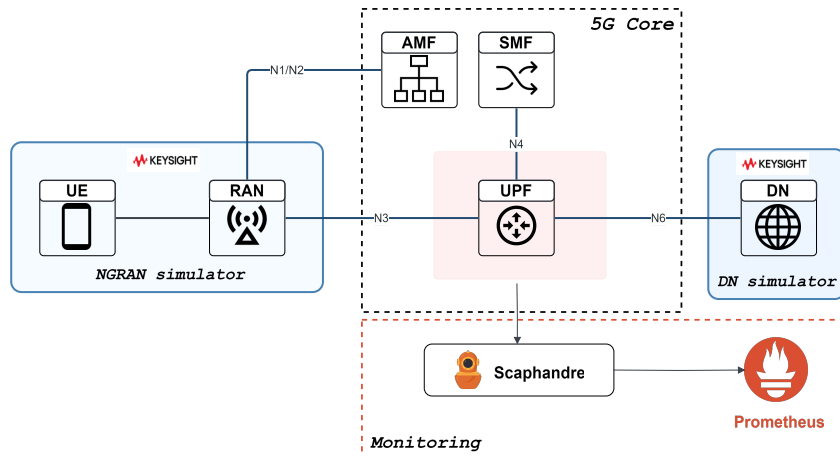


Figure 1: System Architecture

3 Traffic Generation and Test Configuration

Traffic is generated using Load Core, with configurable payload size and packet rate. 22 distinct theoretical throughput levels were tested.

- **Traffic Type:** Stateless UDP
- **Packet Size:** 1250 bytes, maintaining consistency across tests.
- **Packet Rate:** Adjusted according to the throughput requirement.
- **Throughputs:** From 0.01 Mbps to 5000 Mbps, in both directions, uplink and downlink, covering a wide range of network loads.
- **Test Repetition:** Each throughput scenario was tested for 2 minutes, repeated 5 times for statistical reliability.
- **Total Tests per UPF:** 110 tests (22 throughputs, \times 5 repetitions)

4 Data Collection and Metrics

4.1 Data Sources

- **UPF Metrics:**
 - **Monitored Using:** Scaphandre
 - **Metrics:** CPU usage, Power consumption (in microwatts)
- **Network Metrics:**
 - **Generated By:** Load Core
 - **Files:** Provided as CSV files, containing metrics for each test case.

5 Dataset Structure

The dataset is organized into separate folders for each UPF, including raw data from Ixcore, monitoring tools (Scaphandre), and processed combined CSV files. The information about the test cases is explained in a dedicated CSV file.

5.1 Folder Structure Example

```
SD-Core DPKD
+-- Ixcore
|   +-- DPKD_10K_TS_1
|       +-- Fullcoreapplicationtraffic.OneWayDelayAverage_DN.csv
|       +-- Fullcoreapplicationtraffic.GTPuKbitss_DN.csv
|       +-- ...
|
|   +-- DPKD_100K_TS_1
|   +-- ...
|
+-- Prometheus
|   +-- DPKD_10K_TS_1
|       +-- Scaphandre
|           +-- scaph_process_cpu_usage_percentage.csv
|           +-- scaph_process_power_consumption_microwatts.csv
|       +-- ...
|
+-- Processed
    +-- DPKD_100K_TS_1.csv
    +-- DPKD_1M_TS_1.csv
    +-- ...
```

The column in each combined CSV file is as described in Table 1.

Column Name	Description
timestamp	Timestamp of the data collection.
RAN_Tx_Mbits/s	Radio Access Network transmission rate (Mbps).
DN_Rx_Mbits/s	Data Network reception rate (Mbps).
RAN_Packets_Tx/s	Radio Access Network transmission packets.
DN_Packets_Rx/s	Data Network reception packets.
UL_delay_ms	Uplink delay (ms).
UL_jitter	Uplink jitter (ms).
DN_Tx_Mbits/s	Data Network transmission rate (Mbps).
RAN_Rx_Mbits/s	Radio Access Network reception rate (Mbps).
DN_Packets_Tx/s	Data Network transmission packets.
RAN_Packets_Rx/s	Radio Access Network reception packets.
DL_delay_ms	Downlink delay (ms).
DL_jitter	Downlink jitter (ms).
CPU_usage	CPU usage percentage.
power_consumption_watt	Power consumption (watts).
Total_packet_loss	Cumulative packet loss (%) for the whole test.
Test_Case_ID	Identifier for each test case.

Table 1: Combined Files Structure

5.2 Test Case Details

Parameter	Description
Throughput	22 levels of theoretical throughput.
Test Set	1 to 5
UPF Type	DPDK-based (SD-Core) or User-space (OAI).

Table 2: Test Case Parameters

The test cases are identified by the ID in the format:

`<UPF_Type>_<Throughput>_TS_<TestSet>`

Example Test Cases:

- DPDK-based UPF with 1 Gbps throughput, Test Set 1: `DPDK_1000M_TS_1`
- OAI UPF with 500 Mbps throughput, Test Set 3: `OAI_500M_TS_3`
- DPDK-based UPF with 10 Kbps throughput, Test Set 2: `DPDK_10K_TS_2`
- No traffic scenario (Set 0): `DPDK_0_TS_0` or `OAI_0_TS_0`

The information about the test cases is included in `test_cases.csv`.

5.3 List of CSV Files

Each test case includes the following CSV files in the `ixcore` folder that can provide more information that may not be included in processed files:

- Fullcoreapplicationtraffic_GTPuKbitss_DN.csv
- Fullcoreapplicationtraffic_GTPuKbitss_NGRAN.csv
- Fullcoreapplicationtraffic_GTPuPacketss_DN.csv
- Fullcoreapplicationtraffic_GTPuPacketss_NGRAN.csv
- Fullcoreapplicationtraffic_OneWayDelayAverage_DN.csv
- Fullcoreapplicationtraffic_OneWayDelayAverage_RAN.csv
- Fullcoreapplicationtraffic_UplinkDataOneWayDelayDistribution.csv
- Fullcoreapplicationtraffic_DownlinkOneWayDelayDistribution.csv
- Fullcoreapplicationtraffic_UserPlaneThroughput.csv
- Fullcoreapplicationtraffic_UserPlaneThroughput_DNRxTraffic.csv
- Fullcoreapplicationtraffic_UserPlaneThroughput_DNTxTraffic.csv
- Fullcoreapplicationtraffic_UserPlaneThroughput_RANRxTraffic.csv
- Fullcoreapplicationtraffic_UserPlaneThroughput_RANTxTraffic.csv
- Fullcoreapplicationtraffic_DelayVariationJitterAverage_DN.csv
- Fullcoreapplicationtraffic_DelayVariationJitterAverage_RAN.csv

The Prometheus folder consists of two metrics monitored by the scaphandre:

- scaph_process_cpu_usage_percentage.csv
- scaph_process_power_consumption_microwatts.csv

References

- [1] Open Networking Foundation (ONF). Sd-core. <https://opennetworking.org/sd-core/>.
- [2] OpenAirInterface. Openairinterface: 5g software alliance for democratising wireless innovation. <https://openairinterface.org>.
- [3] Keysight. P8900s loadcore – core network solutions. <https://www.keysight.com/us/en/product/P8900S/loadcore-core-network-solutions.html>.