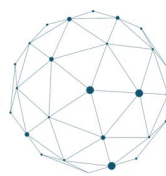


NANCY

5G Coverage Expansion Dataset 1



MINDS



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Abstract

The dataset is the experimental output of a 5G New Radio (NR) coverage expansion use case in the context of the NANCY project (<https://nancy-project.eu/>). Two experimental scenarios were carried out, namely a) a scenario where a user equipment (UE) is directly connected to a Base Station (BS) through a 5G NR link, and b) a scenario where an intermediate node is employed, which acts as a relay between the base station and the UE. To this end, two 5G BSs were deployed, using Ettus Research USRP B210 devices. Also, two 5G modules equipped with custom SIM cards were used as end devices that connect to the BSs. From a software perspective, the srsRAN was used to deploy the USRP-based BSs, while the Open5GS software was used for Core Network functionality. Furthermore, iPerf3 and VLC Media Player were utilized to generate network traffic between the BS and the end device.

The dataset's potential applications are wide; for instance, it can be used to provide insights into how the different video streaming resolutions affect the network load. The data collected from the video streaming sessions was critical in evaluating the network's ability to handle video content of varying quality. In this respect, higher video resolutions resulted in more data-intensive streaming and higher requirements in terms of network capacity. Furthermore, the dataset can be leveraged by Machine Learning (ML) and Artificial Intelligence (AI) algorithms for proactively orchestrating the network resources to maximize the users' quality of experience and quality of service.

1. Testbed and Scenarios Description

1.1. Testbed Topology

The topology of the testbed is depicted in Figure 1. The following hardware equipment is used for deploying two 5G base stations BSs: a) two high-performance laptops for managing the USRPs using the USRP Hardware Driver (UHD) [1], b) two Ettus Research USRP B210 [2], one acting as the main BS and one as the intermediate BS, and c) a Quectel RM520N-GL 5G Module is used to connect the intermediate node to the main BS [3]. Furthermore, a Waveshare 5G Hat [4], based on the SIM8200A-M2 5G module, is used as UE that connects to the main and intermediate BS. Finally, two sysmocom sysmoSIM-SJA2 subscriber identity modules (SIMs) [5] were configured to connect and authenticate with the respective BSs.

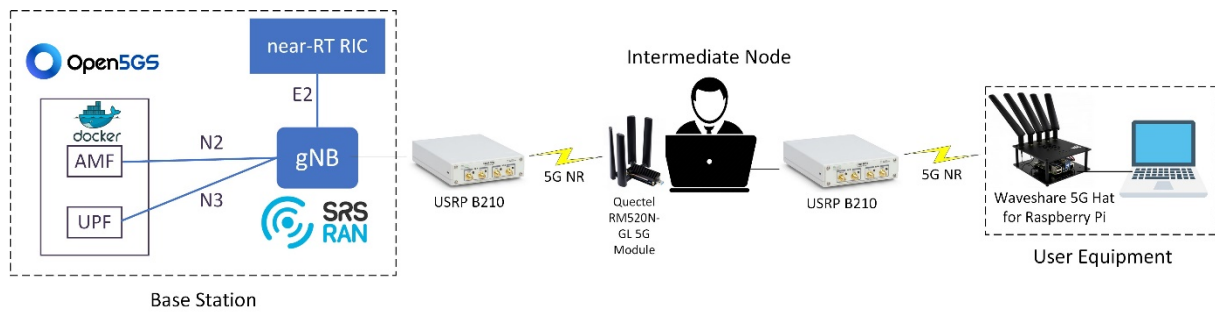


Figure 1: Testbed Topology

1.2. Software Components

For offering core network functionalities, Open5GS [6] is employed, while srsRAN [7] is used for deploying a USRP-based 5G NR BS. Additionally, FlexRIC [8] is used as a near-real-time Radio Access Network (RAN) Intelligent Controller. Table 1 provides a summary of the srsRAN configuration parameters. For the generation of network traffic, two tools are utilized, namely the iPerf3 [9] and the VLC Media Player [10]. Specifically, iPerf3 is configured to generate both Transmission Control Protocol (TCP) and User Datagram Protocols (UDP) traffic between two endpoints. On the other hand, VLC Media Player is configured to run a) as a video streaming server in the main BS, and b) as a video streaming client in the UE.

Table 1: 5G Base Station Parameters

Parameter	Main Base Station	Intermediate Base Station
Device	Ettus Research USRP B210	Ettus Research USRP B210
Frequency Downlink/Uplink (DL/UL)	3489.39 MHz/3489.39 MHz	4050 MHz/4050 MHz
Duplexing	Time Division Duplexing (TDD)	
5G NR Band	n78	n77
Subcarrier Spacing	30 KHz	
Bandwidth	40 MHz	
Antenna Configuration	Single Input Single Output	
Modulation	256-Quadrature Amplitude Modulation	

1.3. Experimental Scenarios

Two different topologies/scenarios were implemented, as shown in Figure 2. Specifically, in Scenario A, the UE is directly connected to the main BS through 5G NR wireless interfaces, whereas, in Scenario B, an intermediate node (e.g., a user with a 5G-enabled laptop) is employed to provide 5G NR connectivity to the UE.

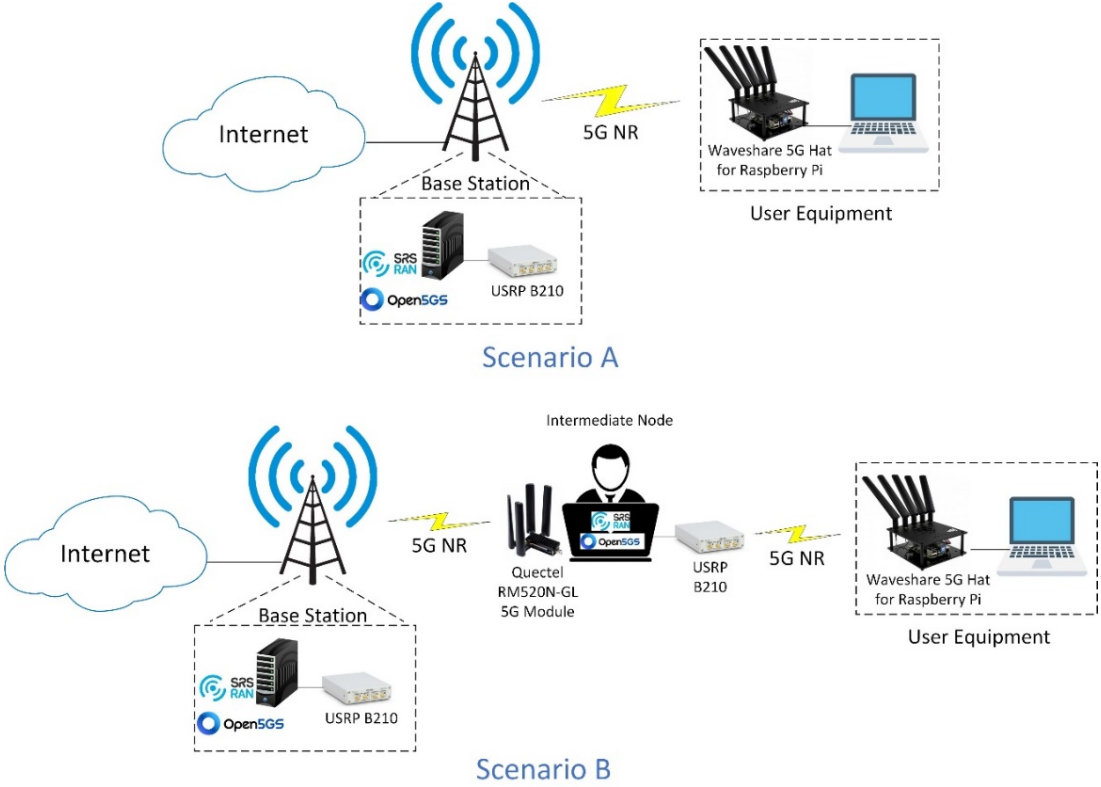


Figure 2: Experimental Scenarios

2. Dataset Structure

The whole folder structure is depicted in a tree view in the Appendix. In the folder root, **BaseStation_resource_utilization.json** and **IntermediateNode_resource_utilization.json** contain the resource statistics of the main and intermediate BSs, respectively. A sample of these files is presented in Figure 3:

```
{
  "date": "2023-12-08",
  "time": "16:58:12",
  "cpu_usage": 1.0,
  "memory_usage": 3931.0,
  "transfers_per_sec": 16.41,
  "kb_read_per_sec": 262.34,
  "kb_written_per_sec": 3730.97,
  "kb_discarded_per_sec": 0.00,
  "kb_read": 4424084,
  "kb_written": 62917681,
  "kb_discarded": 0,
},
{
  "date": "2023-12-08",
  "time": "16:58:14",
  "cpu_usage": 0.5,
  "memory_usage": 3934.0,
  "transfers_per_sec": 16.41,
  "kb_read_per_sec": 262.33,
  "kb_written_per_sec": 3730.71,
  "kb_discarded_per_sec": 0.00,
  "kb_read": 4424084,
  "kb_written": 62917681,
  "kb_discarded": 0,
},
}
```

Figure 3: System Resource Utilization Sample

Moreover, the **ScenarioA** and **ScenarioB** folders are included in the root folder, respectively for the each of the two scenarios as shown in Figure 4.

<pre>+---BaseStation +---iperf3_tcp +---iperf3_udp +---video_streaming_1080p +---video_streaming_1440p +---video_streaming_2160p \---video_streaming_720p \---UserEquipment +---iperf3_tcp +---iperf3_udp +---video_streaming_1080p +---video_streaming_1440p +---video_streaming_2160p \---video_streaming_720p</pre>	<pre>+---BaseStation +---iperf3_tcp +---iperf3_udp +---video_streaming_1080p +---video_streaming_1440p +---video_streaming_2160p \---video_streaming_720p +---IntermediateNode +---iperf3_tcp +---iperf3_udp +---video_streaming_1080p +---video_streaming_1440p +---video_streaming_2160p \---video_streaming_720p \---UserEquipment +---iperf3_tcp +---iperf3_udp +---video_streaming_1080p +---video_streaming_1440p +---video_streaming_2160p \---video_streaming_720p</pre>
--	--

Scenario A Folder

Scenario B Folder

Figure 4: Folder Structure of the Two Scenarios

ScenarioA includes multiple subfolders that contain the respective data when running the experiments using iPerf3 (both TCP and UDP), as well as video streaming in various quality formats. The **BaseStation** subfolder contains data from the BS, while the **UserEquipment** subfolder contains data from the UE. **ScenarioB** has a similar structure, including the **IntermediateNode** subfolder, which contains the intermediate node data.

The data generated while running the iPerf3 experiments are included in the **iperf3_[udp|tcp]** folders. Two types of files are used for storing the data, namely .json and .pcap files. The .json files store various statistics, while the .pcap files store network traffic. The descriptions of the respective files are presented in Table 2. In the filename, *[BS|inter]* indicates the origin of the data (i.e., the BS or the intermediate node), while *[TCP|UDP]* indicates the type of the generated traffic.

Table 2: iPerf3 Dataset

Filename	Description
gnb_e1ap_ <i>[BS inter]</i> _ <i>[tcp udp]</i> .pcap	These files contain E1AP layer traffic exported by the srsRAN gNodeB tool.
gnb_gtpu_ <i>[BS inter]</i> _ <i>[tcp udp]</i> .pcap	These files contain GTPU layer traffic exported by the srsRAN gNodeB tool.
gnb_mac_ <i>[BS inter]</i> _ <i>[tcp udp]</i> .pcap	These files contain MAC layer traffic exported by the srsRAN gNodeB tool.
gnb_ngap_ <i>[BS inter]</i> _ <i>[tcp udp]</i> .pcap	These files contain NGAP layer traffic exported by the srsRAN gNodeB tool.
gnb_rlc_ <i>[BS inter]</i> _ <i>[tcp udp]</i> .pcap	These files contain RLC layer traffic exported by the srsRAN gNodeB tool.
rlc_metrics_ <i>[BS inter]</i> _ <i>[tcp udp]</i> .json	These files contain the statistics exported by the srsRAN gNodeB tool.
iperf_server_BS_ <i>[tcp udp]</i> .json	These files contain the statistics exported by iPerf3 running as a server in the main BS.
iperf_client_ <i>[tcp udp]</i> .json	These files contain the statistics exported by iPerf3 running as a client in the UE.
wireless_metrics_ <i>[tcp udp]</i> .json	These files contain the channel metrics that were exported by the SIMCOM module that is mounted in the Waveshare 5G Hat.

The video streaming experiments data are placed in the **video_streaming_[720p|1080p|1440p|2160p]** folders. Two types of files are used for storing the data, namely .json and .pcap files. The .json files store various statistics, while the .pcap files store network traffic. Table 3 provides a description of each file's contents. In the filename, *[BS|inter]* indicates the origin of the data (i.e., the BS or the intermediate node), while *[720p|1080p|1440p|2160p]* indicates the type of the generated traffic.

Table 3: Video Streaming Dataset

Filename	Description
gnb_e1ap_ <i>[BS inter]</i> _ <i>[720p 1080p 1440p 2160p]</i> .pcap	These files contain E1AP layer traffic exported by the srsRAN gNodeB tool.
gnb_gtpu_ <i>[BS inter]</i> _ <i>[720p 1080p 1440p 2160p]</i> .pcap	These files contain GTPU layer traffic exported by the srsRAN gNodeB tool.
gnb_mac_ <i>[BS inter]</i> _ <i>[720p 1080p 1440p 2160p]</i> .pcap	These files contain MAC layer traffic exported by the srsRAN gNodeB tool.
gnb_ngap_ <i>[BS inter]</i> _ <i>[720p 1080p 1440p 2160p]</i> .pcap	These files contain NGAP layer traffic exported by the srsRAN gNodeB tool.

<code>gnb_rlc_[BS inter]_[720p 1080p 1440p 2160p].pcap</code>	These files contain RLC layer traffic exported by the srsRAN gNodeB tool.
<code>rlc_metrics_[BS inter]_[720p 1080p 1440p 2160p].json</code>	These files contain the statistics exported by the srsRAN gNodeB tool.
<code>wireless_metrics_[720p 1080p 1440p 2160p].json</code>	These files contain the channel metrics that were exported by the SIMCOM module that is mounted in the Waveshare 5G Hat.
<code>vlc_statistics_[720p 1080p 1440p 2160p].json</code>	These files contain audio, video, and I/O statistics as calculated by VLC Media Player.

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-

Appendix – Tree View of the Dataset Folder

A tree view of the whole dataset structure is presented as follows:

```
|   BaseStation_resource_utilization.json
|   IntermediateNode_resource_utilization.json
|
+---ScenarioA
|   +---BaseStation
|   |   +---iperf3_tcp
|   |   |       gnb_elap_BS_tcp.pcap
|   |   |       gnb_gtpu_BS_tcp.pcap
|   |   |       gnb_mac_BS_tcp.pcap
|   |   |       gnb_ngap_BS_tcp.pcap
|   |   |       gnb_rlc_BS_tcp.pcap
|   |   |       iperf_server_BS_tcp.json
|   |   |       rlc_metrics_BS_tcp.json
|   |   |
|   |   +---iperf3_udp
|   |   |       gnb_elap_BS_udp.pcap
|   |   |       gnb_gtpu_BS_udp.pcap
|   |   |       gnb_mac_BS_udp.pcap
|   |   |       gnb_ngap_BS_udp.pcap
|   |   |       gnb_rlc_BS_udp.pcap
|   |   |       iperf_server_BS_udp.json
|   |   |       rlc_metrics_BS_udp.json
|   |   |
|   |   +---video_streaming_1080p
|   |   |       gnb_elap_BS_1080p.pcap
|   |   |       gnb_gtpu_BS_1080p.pcap
|   |   |       gnb_mac_BS_1080p.pcap
|   |   |       gnb_ngap_BS_1080p.pcap
|   |   |       gnb_rlc_BS_1080p.pcap
|   |   |       rlc_metrics_BS_1080p.json
|   |   |
|   |   +---video_streaming_1440p
|   |   |       gnb_elap_BS_1440p.pcap
|   |   |       gnb_gtpu_BS_1440p.pcap
|   |   |       gnb_mac_BS_1440p.pcap
|   |   |       gnb_ngap_BS_1440p.pcap
|   |   |       gnb_rlc_BS_1440p.pcap
|   |   |       rlc_metrics_BS_1440p.json
|   |   |
|   |   +---video_streaming_2160p
|   |   |       gnb_elap_BS_2160p.pcap
|   |   |       gnb_gtpu_BS_2160p.pcap
|   |   |       gnb_mac_BS_2160p.pcap
|   |   |       gnb_ngap_BS_2160p.pcap
|   |   |       gnb_rlc_BS_2160p.pcap
|   |   |       rlc_metrics_BS_2160p.json
|   |   |
|   |   \---video_streaming_720p
|   |   |       gnb_elap_BS_720p.pcap
|   |   |       gnb_gtpu_BS_720p.pcap
|   |   |       gnb_mac_BS_720p.pcap
|   |   |       gnb_ngap_BS_720p.pcap
|   |   |       gnb_rlc_BS_720p.pcap
|   |   |       rlc_metrics_BS_720p.json
|   |   |
|   |   \---UserEquipment
|   |       +---iperf3_tcp
```



```
| | gnb_gtpu_BS_2160p.pcap
| | gnb_mac_BS_2160p.pcap
| | gnb_ngap_BS_2160p.pcap
| | gnb_rlc_BS_2160p.pcap
| | rlc_metrics_BS_2160p.json
| |
| | \---video_streaming_720p
| | gnb_elap_BS_720p.pcap
| | gnb_gtpu_BS_720p.pcap
| | gnb_mac_BS_720p.pcap
| | gnb_ngap_BS_720p.pcap
| | gnb_rlc_BS_720p.pcap
| | rlc_metrics_BS_720p.json
| |
+---IntermediateNode
| +---iperf3_tcp
| | gnb_elap_inter_tcp.pcap
| | gnb_gtpu_inter_tcp.pcap
| | gnb_mac_inter_tcp.pcap
| | gnb_ngap_inter_tcp.pcap
| | gnb_rlc_inter_tcp.pcap
| | rlc_metrics_inter_tcp.json
| |
| +---iperf3_udp
| | gnb_elap_inter_udp.pcap
| | gnb_gtpu_inter_udp.pcap
| | gnb_mac_inter_udp.pcap
| | gnb_ngap_inter_udp.pcap
| | gnb_rlc_inter_udp.pcap
| | rlc_metrics_inter_udp.json
| |
| +---video_streaming_1080p
| | gnb_elap_inter_1080p.pcap
| | gnb_gtpu_inter_1080p.pcap
| | gnb_mac_inter_1080p.pcap
| | gnb_ngap_inter_1080p.pcap
| | gnb_rlc_inter_1080p.pcap
| | rlc_metrics_inter_1080p.json
| |
| +---video_streaming_1440p
| | gnb_elap_inter_1440p.pcap
| | gnb_gtpu_inter_1440p.pcap
| | gnb_mac_inter_1440p.pcap
| | gnb_ngap_inter_1440p.pcap
| | gnb_rlc_inter_1440p.pcap
| | rlc_metrics_inter_1440p.json
| |
| +---video_streaming_2160p
| | gnb_elap_inter_2160p.pcap
| | gnb_gtpu_inter_2160p.pcap
| | gnb_mac_inter_2160p.pcap
| | gnb_ngap_inter_2160p.pcap
| | gnb_rlc_inter_2160p.pcap
| | rlc_metrics_inter_2160p.json
| |
| | \---video_streaming_720p
| | gnb_elap_inter_720p.pcap
| | gnb_gtpu_inter_720p.pcap
| | gnb_mac_inter_720p.pcap
| | gnb_ngap_inter_720p.pcap
| | gnb_rlc_inter_720p.pcap
```

```
|          rlc_metrics_inter_720p.json
|
\---UserEquipment
  +---iperf3_tcp
  |     iperf_client_tcp.json
  |     wireless_metrics_tcp.json
  |
  +---iperf3_udp
  |     iperf_client_udp.json
  |     wireless_metrics_udp.json
  |
  +---video_streaming_1080p
  |     vlc_statistics_1080p.json
  |     wireless_metrics_1080p.json
  |
  +---video_streaming_1440p
  |     vlc_statistics_1440p.json
  |     wireless_metrics_1440p.json
  |
  +---video_streaming_2160p
  |     vlc_statistics_2160p.json
  |     wireless_metrics_2160p.json
  |
  \---video_streaming_720p
      vlc_statistics_720p.json
      wireless_metrics_720p.json
```