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Deliverable 6.5

Greek in-lab testbed dataset 1

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List of Acronyms

Acronym	Definition
5G	Fifth-Generation
AMF	Access and Mobility Management Function
B5G	Beyond Fifth Generation
BS	Base Station
CN	Core Network
DL	Downlink
DLT	Diagnostic Log and Trace
DX.Y	Deliverable X.Y
FHD	Full High Definition
GTP-U	General Packet Radio Service Tunneling Protocol – User Plane
HD	High Definition
HTTP	Hypertext Transfer Protocol
MAC	Medium Access Control
mMTC	Massive Machine Type Communications
NGAP	Next Generation Application Protocol
PDU	Protocol Data Unit
QAM	Quadrature Amplitude Modulation
QoS	Quality of Service
RAN	Radio Access Network
RIC	RAN Intelligent Controller
RLC	Radio Link Control
RT	Real Time
SCTP	Stream Control Transmission Protocol
SIM	Subscriber Identity
SISO	Single Input Single Output
TCP	Transmission Control Protocol
TDD	Time Division Duplexing
TX.Y	Task X.Y
UDP	User Datagram Protocol
UE	User Equipment
UHD	USRP Hardware Driver
UL	Uplink
URLLC	Ultra Reliable Low Latency Communications
WPX	Work Package X

Executive summary

This deliverable constitutes the first version of the dataset that was generated in the Greek in-lab testbed. The Greek in-lab testbed aims to assess and validate the NANCY Blockchain-enabled radio access network architecture in a wireless range expansion use case. In more detail, the experiments involve two scenarios: a) a scenario where a user equipment is directly connected to a base station through a 5G new radio link, and b) a scenario where an intermediate node is employed, which acts as a relay between the base station and the user equipment. The present dataset, along with the forthcoming datasets derived from the Greek in-lab testbed, will be utilized in the design of an experimentally driven modeling framework and for the optimization of the NANCY solution.

The dataset can be found on IEEE DataPort at: <http://ieee-dataport.org/12120> and on Zenodo at: <https://zenodo.org/records/10442969>. Also, the dataset can be found through the following Digital Object Identifier: <https://dx.doi.org/10.21227/vm3z-ww28>.

1. Introduction

1.1. Purpose of the Deliverable

D6.5 “Greek in-lab testbed dataset 1” is the first deliverable of T6.5 “Greek in-lab testbed”, which aims to deploy a laboratory testbed for assessing and validating the NANCY B-RAN architecture in the range expansion scenario. This dataset, along with the subsequent datasets that will be generated, will be leveraged for the development experimental-driven modeling framework, as well as the overall optimization of the NANCY B-RAN architecture.

1.2. Relation to Other Deliverables

D6.5 “Greek in-lab testbed dataset 1” is mainly related to D6.4 “In-lab testbeds definition”. Specifically, D6.4 defines the topology of the testbed, as well as the scenarios that will be implemented in each of the in-lab testbeds. In addition, D6.5 “Greek in-lab testbed dataset 1” receives inputs from D2.1 “NANCY Requirements Analysis” and D3.1 “NANCY Architecture Design”. Finally, in the context of T6.5 “Greek in-lab testbed”, several of the NANCY technical outcomes developed in WP2-WP5 will be integrated towards outputting D6.7 “Greek in-lab testbed dataset 2” and contributing to D6.9 “Outdoor Demonstration Planning, Evaluation Methodology and KPIs” and D6.10 “NANCY Pilots’ Documentation and Evaluations”.

1.3. Structure of the Deliverable

The structure of D6.5 “Greek in-lab testbed dataset 1” is described as follows:

- **Section 1 – Introduction:** This section serves as the introduction to the deliverable and its objectives.
- **Section 2 – Testbed Description:** This section provides a description of the testbed, focusing on its topology, as well as the utilized hardware and software components.
- **Section 3 – Dataset Description:** This section describes the experimental scenarios that were carried out in order to generate the datasets. In addition, Section 3 provides an overview of the captured data.
- **Section 4 – Conclusion:** This section concludes the deliverable.
- **Appendix A – Tree View of the Dataset Folder:** The first appendix provides a tree-view of the whole dataset structure.
- **Appendix B – Wireshark Protocol Hierarchy Statistics:** The second appendix presents the protocol hierarchy statistics that are generated using the respective Wireshark functionality.
- **Appendix C – VLC Media Player Statistics:** The third appendix includes screenshots from the VLC Media Player that depict the streaming statistics.

2. Testbed Description

2.1. Testbed Topology and Hardware

Figure 1 depicts the network topology of the testbed. In more detail, the following hardware equipment is used for deploying two fifth-generation (5G) base stations (BSs) (i.e., two gNodeBs):

1. Two Ettus Research USRP B210 [1], one acting as the main BS and one as the intermediate BS.
2. Two high-performance laptops for managing the USRPs using the USRP Hardware Driver (UHD) [2]:
 - Intel i7 20-thread & Intel i7 12-thread CPUs
 - 32 & 16 GB of RAM
3. 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 user equipment (UE) that connects to the main and intermediate BS. Finally, two programmable sysmocom sysmoSIM-SJA2 subscriber identity modules (SIMs) [5] are configured to connect and authenticate with the respective BSs.

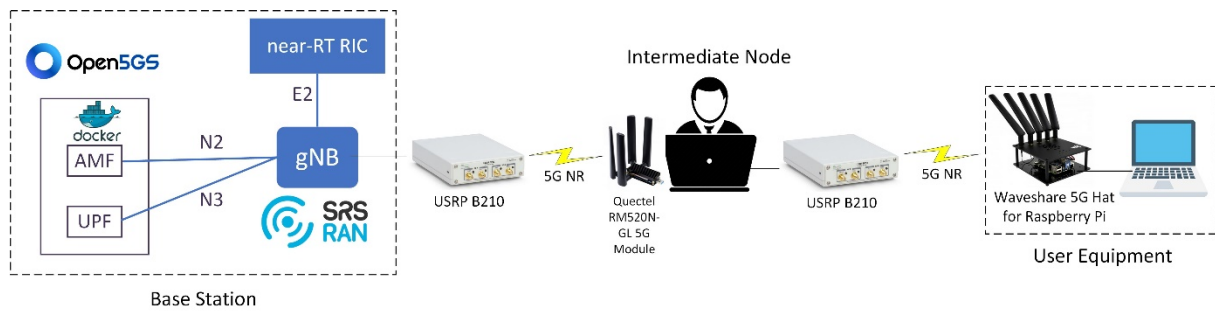


Figure 1: Greek In-lab Testbed Topology

The hardware components of the testbed are illustrated in Figure 2. Of note, to optimize the throughput and link reliability of the testbed, various topologies were tested. As the Raspberry Pi 3 cannot effectively handle 4K videos, it is configured to act as a network bridge between the 5G New Radio (NR) and a laptop. Also, for demonstration purposes in the respective figure, all components have been placed in close proximity to each other.

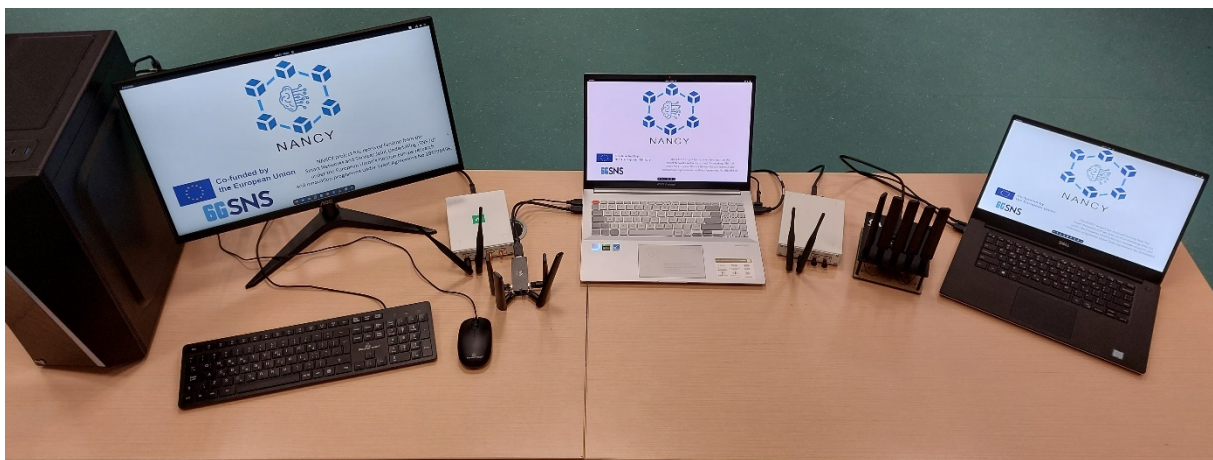


Figure 2: Hardware Components of the Greek in-lab Testbed

2.2. Software Components

Concerning the software components, Open5GS [6] is used for providing core network (CN) functionality, while srsRAN [7] is used for deploying a USRP-based 5G NR BS. Moreover, FlexRIC [8] is used as a near-real-time (near-RT) RAN intelligent controller (RIC). The srsRAN configuration parameters for deploying the two 5G BSs are summarized in Table 2. Finally, 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. Furthermore, the 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
5G NR Band	n78	n77
Frequency Downlink/Uplink (DL/UL)	3489.39 MHz/3489.39 MHz	4050 MHz/4050 MHz
Duplexing	Time Division Duplexing (TDD)	
Bandwidth	40 MHz	
Subcarrier Spacing	30 KHz	
Modulation	256-Quadrature Amplitude Modulation (256-QAM)	
Antenna Configuration	Single Input Single Output (SISO)	

3. Dataset Generation Process and Structure Description

3.1. Experimental Scenarios

The Greek in-lab testbed is focused on evaluating and validating the NANCY outcomes in coverage expansion scenarios. To this end, two different topologies/scenarios were implemented, as shown in Figure 3. 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.

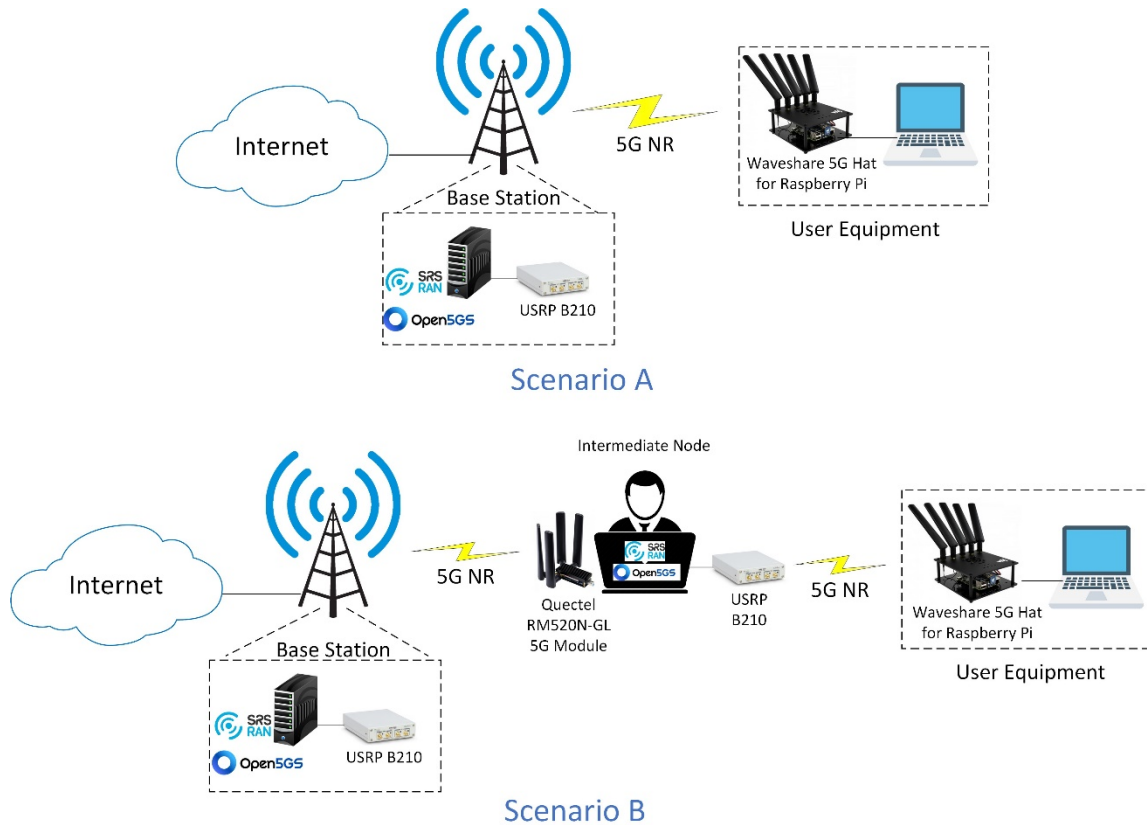


Figure 3: Greek In-lab Testbed Scenarios

First, the iPerf3 tool is used to generate both TCP and UDP traffic. To evaluate TCP traffic, in both scenarios, iPerf3 is installed in server mode on the base station and in client mode on the UE. The experiment is initiated by executing the following command on the UE:

```
iperf3 -c 10.45.0.1 -t 60 -R -J --logfile iperf_client_direct_tcp.json
```

The parameters of the command are explained as follows:

- **-c 10.45.0.1:** Connects to the iPerf3 server at IP address 10.45.0.1 of the main server.
- **-t 60:** Sets the time duration of the test to 60 seconds.
- **-R:** The test is run in reverse mode, meaning the data is sent from the server to the client.
- **-J:** Outputs the results in JSON format, which is useful for automated parsing and analysis.
- **--logfile iperf_client_direct_tcp.json:** Saves the output of the test in a file named iperf_client_direct_tcp.json.

A connection was made to the iPerf3 server at IP address 10.45.0.1 and the test was run for 60 seconds. The experiment was executed in reverse mode, with the data flow directed from the server to the client, which is useful for evaluating network performance from a different perspective and more

appropriate in the specific scenario. To facilitate the analysis, the iPerf3 output was saved in JSON format. Throughout the 60-second test, TCP traffic was generated by iPerf3 from the main server to the UE. The use of TCP protocol ensured reliable and error-checked data delivery. The performance metrics, such as bandwidth, packet loss, and jitter, were subsequently collected from the JSON file.

A similar procedure was followed for UDP traffic. Specifically, the following command was executed on the UE:

```
iperf3 -c 10.45.0.1 -u -t 60 -R -b 10G -J --logfile iperf_client_direct_udp.json
```

The parameters of the command are explained as follows:

- **-u:** This flag indicated that the test was to be conducted using the UDP protocol, which is different from TCP in that it allows for faster data transmission at the cost of reliability.
- **-t 60:** The duration of the test was set to 60 seconds.
- **-R:** The test was executed in reverse mode, meaning the data was transmitted from the server to the client, providing a different perspective on network performance.
- **-b 10G:** This specified a bandwidth of 10 Gbps for the test, ensuring the assessment of the network's capability to handle high-speed data transfer.
- **-J:** The results were to be output in JSON format for ease of subsequent analysis.
- **--logfile iperf_client_direct_udp.json:** The output was saved in a file named 'iperf_client_direct_udp.json'.

During the test, UDP traffic was generated by iPerf3 from the main server to the UE over a period of 60 seconds. Experimenting with UDP traffic type enables the assessment of network performance under conditions where the data transfer speed is prioritized over link reliability.

Furthermore, experiments involving a video streaming application were conducted, using VLC Media Player, employing various types of video quality for assessing the network's ability to handle video streaming at different resolutions. For these tests, a video with a 1-minute duration was used, which was encoded with the VP9 and Opus 48KHz video and audio codec, respectively. These codecs are widely used due to their efficiency in streaming applications. Four different video resolutions were chosen for the experiment, each representing a standard in video quality, as follows:

- 720p - High definition (HD) with a resolution of 1280px by 720px
- 1080p - Full high definition (FHD) with a resolution of 1920px by 1080px
- 1440p - 2K resolution of 2560px by 1440px
- 2160p - 4K resolution of 3840px by 2160px

In the experiment, each of these video qualities was streamed from the main BS to the UE using VLC Media Player. More specifically, the videos were streamed using Hypertext Transfer Protocol (HTTP) at the main server, without transcoding, while the MP4 or WebM codec option was selected. The process involved setting up VLC Media Player to stream at each resolution, one at a time, and then monitoring the performance of the network.

3.2. System Resource Utilization Logging

In addition to the network's performance, a Linux Bash script was developed to continuously monitor and log the utilization of the system resources. The script was run in both main and intermediate BSs and is presented as follows:

```
#!/bin/bash
while:
do
```

```

cpuUsage=$(top -bn1 | awk '/Cpu/ { print $2}')
```

```

memUsage=$(free -m | awk '/Mem/{print $3}')
```

```

echo "`(date +"%m_%d_%Y_%H:%M:%S")` CPU Usage: $cpuUsage%"
echo "`(date +"%m_%d_%Y_%H:%M:%S")` Memory Usage: $memUsage MB"
echo "`(date +"%m_%d_%Y_%H:%M:%S")` I/O Usage: `(iostat -d -p sda)` "
echo "~~~"

sleep 1
done
```

The output of the Bash script is also written into a file; a sample of the output is presented below:

```

12_08_2023_16:57:28 CPU Usage: 5,7%
12_08_2023_16:57:28 Memory Usage: 2844 MB
12_08_2023_16:57:28 I/O Usage: Linux 6.2.0-37-generic 08/12/2023 _x86_64_ (20 CPU)

Device      tps      kB_read/s    kB_wrtn/s    kB_dscd/s    kB_read    kB_wrtn    kB_dscd
sda         79,64      2240,15      1564,57      0,00      2727385    1904868    0
~~~
12_08_2023_16:57:29 CPU Usage: 5,4%
12_08_2023_16:57:29 Memory Usage: 2852 MB
12_08_2023_16:57:29 I/O Usage: Linux 6.2.0-37-generic 08/12/2023 _x86_64_ (20 CPU)

Device      tps      kB_read/s    kB_wrtn/s    kB_dscd/s    kB_read    kB_wrtn    kB_dscd
sda         79,64      2240,15      1564,57      0,00      2727385    1904868    0
~~~
```

Finally, to transform the log files generated from the aforementioned script into JSON-formatted files, a Python tool was developed. The source code of the tool is presented as follows:

```

import os
import sys
from dateutil.parser import parse

file_name = "BaseStation_resource_utilization.log"
if not os.path.isfile(file_name):
    print("{} does not exist".format(file_name), file=sys.stderr)
    sys.exit(-1)

input_file = open(file_name, 'r')
lines = input_file.readlines()
input_file.close()

output_file = open("BaseStation_resource_utilization.json", 'w')

count = 0
for line in lines:
    if count==0:
        stats = line.split()
        parsed_date= parse(stats[0], fuzzy=True).date()
        parsed_time = parse(stats[0], fuzzy=True).time()
        cpu_usage = float(stats[3].replace('%', '').replace(',','.'))
    elif count==1:
        stats = line.split()
        memory_usage=float(stats[3])
    elif count==5:
        stats = line.split()
        transfers_per_sec=stats[1].replace(",",".")
        kb_read_per_sec=stats[2].replace(",",".")
        kb_written_per_sec = stats[3].replace(",",".")
        kB_discarded_per_sec = stats[4].replace(",",".")
        kb_read = stats[5].replace(",",".")
```



```

kb_written = stats[6].replace(",", ".")
kb_discarded = stats[7].replace(",", ".")

if line == "~~~\n":
    count = 0
    output_file.write("{\n")
    output_file.write("\t \"date\": \""+str(parsed_date)+"\", \n")
    output_file.write("\t \"time\": \"" + str(parsed_time) + "\", \n")
    output_file.write("\t \"cpu_usage\": " + str(cpu_usage) + ", \n")
    output_file.write("\t \"memory_usage\": " + str(memory_usage) + ", \n")
    output_file.write("\t \"transfers_per_sec\": " + str(transfers_per_sec) + ", \n")
    output_file.write("\t \"kb_read_per_sec\": " + str(kb_read_per_sec) + ", \n")
    output_file.write("\t \"kb_written_per_sec\": " + str(kb_written_per_sec) + ", \n")
    output_file.write("\t \"kB_discarded_per_sec\": "+str(kB_discarded_per_sec) + ", \n")
    output_file.write("\t \"kb_read\": " + str(kb_read) + ", \n")
    output_file.write("\t \"kb_written\": " + str(kb_written) + ", \n")
    output_file.write("\t \"kb_discarded\": " + str(kb_discarded) + ", \n")
    output_file.write("}, \n")
else:
    count = count + 1

output_file.close()

```

3.3. Network Traffic Capture

According to the Open-RAN specifications [11], the network is split into three units, namely the Radio Units (RUs) that are responsible for the data transmission and reception through the wireless channel, the Distributed Units (DUs) that handle user traffic, and the Central Unit (CU) that manages and controls the DUs. This disaggregated approach allows for better infrastructure utilization and increased flexibility.

The srsRAN software has the ability to export network traffic from multiple layers of the Open-RAN-based gNB in the form of .pcap files. The analysis and dissection of these files provide details on the data that are exchanged among the aforementioned Open-RAN units, the gNB and the UE, as well as the 5G CN components.

In more detail, srsRAN can export traffic from the following protocols:

- The E1AP protocol is part of the E2 interface implemented on top of Stream Control Transmission Protocol (SCTP) and is responsible for signaling and orchestration of the RAN components and user mobility.
- General Packet Radio Service Tunneling Protocol - User Plane (GTP-U) is an encapsulation protocol commonly used in mobile networks and it is tasked with securely handling user traffic. Using GTP-U an operator can efficiently route user traffic, enforce quality of service (QoS) policies, and compress data when possible.
- Next Generation Application Protocol (NGAP) is a 3GPPP protocol that is integrated into 5G mobile networks. It is part of the N2 interface, connecting a gNB with the 5G CN Access and Mobility Function (AMF). NGAP is responsible for ensuring 5G capabilities, such as ultra-reliable low latency communications (URLLC) or massive machine type communications (mMTC).
- The Medium Access Control (MAC) layer is the bridge between the physical layer and the higher layers of the gNB stack. srsRAN encapsulates data units in UDP packets and forwards them to the physical layer for transmission.

- The Radio Link Control (RLC) layer operates on top of the MAC layer and is responsible for the reliable and efficient transmission of data over a radio link. It ensures that the data is correctly segmented and transmitted between the user and gNB, while also enforcing flow control.

For analyzing the network traffic stored in the .pcap files, the Wireshark software is used [12]. According to the srsRAN documentation¹, the following User Diagnostic Log and Trace (DLT) parameters should be configured in order for Wireshark to dissect the packets correctly. Additionally, the "mac_nr_udp" and "Try to detect and decode 5G-EA0 ciphered messages" settings should be enabled. A summary of the DLT parameters is shown in Table 2.

Table 2: User Diagnostic Log and Trace Parameters

DLT	Payload Dissector
User 2 (DLT=149)	udp
User 5 (DLT=152)	ngap
User 6 (DLT=153)	e1ap
User 7 (DLT=154)	f1ap
User 8 (DLT=155)	e2ap
User 9 (DLT=156)	gtp

3.4. Dataset Structure

The whole folder structure is depicted in a tree view in Appendix A. In the folder root, there exist two log files containing resource utilization statistics that were generated using the scripts presented in Section 3.2.

Specifically, **BaseStation_resource_utilization.json** and **IntermediateNode_resource_utilization.json** contain the resource statistics of the main and intermediate BS s, respectively. A sample of these log files is presented below:

```
{
  "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,
```

¹ https://docs.srsran.com/projects/project/en/latest/user_manuals/source/outputs.html

```
"kb_discarded": 0,
},
```

Moreover, the **ScenarioA** and **ScenarioB** folders are included in the root folder, respectively for each of the two scenarios, which contain the following subfolders:

<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

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 device. **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 .pcap files and .json files. The .pcap files store network traffic, while the .json files store various statistics. The descriptions of the respective files are presented in Table 3. 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 3: iPerf3 Dataset

Filename	Description
gnb_e1ap_ [BS inter] _ [tcp udp] .pcap	These files contain E1AP layer traffic exported by the srsRAN gNodeB tool.
gnb_gtpu_ [BS inter] _ [tcp udp] .pcap	These files contain GTPU layer traffic exported by the srsRAN gNodeB tool.
gnb_mac_ [BS inter] _ [tcp udp] .pcap	These files contain MAC layer traffic exported by the srsRAN gNodeB tool.
gnb_ngap_ [BS inter] _ [tcp udp] .pcap	These files contain NGAP layer traffic exported by the srsRAN gNodeB tool.

gnb_rlc_[BS inter]_[tcp udp].pcap	These files contain RLC layer traffic exported by the srsRAN gNodeB tool.
rlc_metrics_[BS inter]_[tcp udp].json	These files contain the statistics exported by the srsRAN gNodeB tool.
iperf_server_BS_[tcp udp].json	These files contain the statistics exported by iPerf3 running as a server in the main BS.
iperf_client_[tcp udp].json	These files contain the statistics exported by iPerf3 running as a client in the UE.
wireless_metrics_[tcp udp].json	These files contain the channel metrics that were exported by the SIMCOM module that is mounted in the Waveshare 5G Hat.

The data generated while running the video streaming experiments are included in the **video_streaming_[720p|1080p|1440p|2160p]** folders. Two types of files are used for storing the data, namely .pcap files and .json files. The .pcap files store network traffic, while the .json files store various statistics. The descriptions of the respective files are presented in Table 4. 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 4: Video Streaming Dataset

Filename	Description
gnb_e1ap_[BS inter]_[720p 1080p 1440p 2160p].pcap	These files contain E1AP layer traffic exported by the srsRAN gNodeB tool.
gnb_gtpu_[BS inter]_[720p 1080p 1440p 2160p].pcap	These files contain GTPU layer traffic exported by the srsRAN gNodeB tool.
gnb_mac_[BS inter]_[720p 1080p 1440p 2160p].pcap	These files contain MAC layer traffic exported by the srsRAN gNodeB tool.
gnb_ngap_[BS inter]_[720p 1080p 1440p 2160p].pcap	These files contain NGAP layer traffic exported by the srsRAN gNodeB tool.
gnb_rlc_[BS inter]_[720p 1080p 1440p 2160p].pcap	These files contain RLC layer traffic exported by the srsRAN gNodeB tool.
rlc_metrics_[BS inter]_[720p 1080p 1440p 2160p].json	These files contain the statistics exported by the srsRAN gNodeB tool.
wireless_metrics_[720p 1080p 1440p 2160p].json	These files contain the channel metrics that were exported by the SIMCOM module that is mounted in the Waveshare 5G Hat.
vlc_statistics_[720p 1080p 1440p 2160p].json	These files contain audio, video, and I/O statistics as calculated by VLC Media Player.

4. Conclusion

This deliverable is the first version of the dataset generated using the Greek in-lab testbed. The objective of the Greek in-lab testbed is to evaluate and validate the NANCY B-RAN architecture, specifically in the context of a wireless range expansion use case. To elaborate, the experiments involve two scenarios: a) one where a user equipment directly connects to a base station through a 5G NR link, and b) another where an intermediate node serves as a relay between the base station and the user equipment. The dataset, along with subsequent datasets originating from the Greek in-lab testbed, will be employed in the development of an experimentally driven modeling framework and for optimizing the NANCY solution.

In summary, the deliverable provides an overview of the testbed's structure, topology, as well as the employed hardware and software components. Moreover, the experimental scenarios carried out to generate the datasets were described, along with insights into the dataset's structure and content. In particular, streaming videos at different resolutions provided useful insights into how the testbed handles different levels of data load. Higher video resolutions resulted in more data-intensive streaming and higher requirements in terms of network capacity. The data collected from these streaming sessions was critical in evaluating the network's ability to handle video content of varying quality. This aspect of the experiment is particularly relevant in today's context, where streaming video represents a significant portion of network traffic. Understanding how different resolutions affect network performance helps optimize the network for a better user experience, especially in scenarios where high-definition video streaming is in high demand.

The dataset can be found on IEEE DataPort at: <http://ieee-dataport.org/12120> and on Zenodo at: <https://zenodo.org/records/10442969>. Also, the dataset can be found through the following Digital Object Identifier: <https://dx.doi.org/10.21227/vm3z-ww28>.

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Appendix A – 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
```

```
| | 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  
|  
\---ScenarioB  
| +---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
| |
+---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
```

Appendix B - Wireshark Protocol Hierarchy Statistics

This appendix presents the Protocol Hierarchy Statistics that are generated using the respective Wireshark functionality. The appendix organization adopts the structure of the dataset; therefore, there are two main sections, namely Scenario A and Scenario B, each one containing multiple subsections, respectively for each experiment. Each screenshot depicts the following information for each protocol:

- percent of packets
- number of packets
- percent of size
- size (in bytes)
- number of captured bits per second
- number of packets of the last dissected protocol
- size of the last dissected protocol (in bytes)
- number of captured bits per second of the last dissected protocol
- number of Protocol Data Units (PDUs)

Finally, the name of the corresponding .pcap file is included below each screenshot.

Scenario A

iPerf3 (TCP) – Base Station

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
▼ Frame	100.0	6	100.0	374	86	0	0	0	6
▼ DLT User	100.0	6	100.0	374	86	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	86	6	374	86	6

gnb_e1ap_BS_tcp.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
▼ Frame	100.0	384251	100.0	528515118	61 M	0	0	0	384251
▼ DLT User	100.0	384251	100.0	528515118	61 M	0	0	0	384251
▼ GPRS Tunneling Protocol	100.0	384251	100.0	528515118	61 M	0	0	0	384251
▼ Internet Protocol Version 4	100.0	384251	1.5	7685020	894 k	0	0	0	384251
▼ User Datagram Protocol	0.0	60	0.0	480	55	0	0	0	60
Domain Name System	0.0	60	0.0	2363	275	60	2363	275	60
▼ Transmission Control Protocol	100.0	384187	97.4	514678983	59 M	13840	3637337	423 k	384187
▼ iPerf3 Speed Test	96.4	370347	94.5	499190542	58 M	14	499	58	370348
Data	96.4	370333	94.5	499189748	58 M	370333	499189748	58 M	370333
Internet Control Message Protocol	0.0	4	0.0	256	29	4	256	29	4

gnb_gtpu_BS_tcp.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
▼ Frame	100.0	86673	100.0	531329762	42 M	0	0	0	86673
▼ DLT User	100.0	86673	100.0	531329762	42 M	0	0	0	86673
▼ User Datagram Protocol	100.0	86673	0.1	693384	55 k	0	0	0	86673
MAC-NR	100.0	86673	99.5	528642899	42 M	86673	528642899	42 M	86673

gnb_mac_BS_tcp.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
▼ Frame	100.0	20	100.0	1764	153	0	0	0	20
▼ DLT User	100.0	20	100.0	1764	153	0	0	0	20
NG Application Protocol	100.0	20	100.0	1764	153	20	1764	153	20

gnb_ngap_BS_tcp.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
▼ Frame	100.0	473499	100.0	537303676	56 M	0	0	0	473499
▼ DLT User	100.0	473499	100.0	537303676	56 M	0	0	0	473499
▼ User Datagram Protocol	100.0	473499	0.7	3787992	396 k	0	0	0	473499
Data	100.0	473499	99.3	533515684	55 M	473499	533515684	55 M	473499

gnb_rlc_BS_tcp.pcap

iPerf3 (UDP) – Base Station

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	6	100.0	374	92	0	0	0	6
▼ DLT User	100.0	6	100.0	374	92	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	92	6	374	92	6

gnb_e1ap_BS_udp.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	2614647	100.0	3639439610	429 M	0	0	0	2614647
▼ DLT User	100.0	2614647	100.0	3639439610	429 M	0	0	0	2614647
▼ GPRS Tunneling Protocol	100.0	2614647	100.0	3639439610	429 M	0	0	0	2614647
▼ Internet Protocol Version 4	100.0	2614647	1.4	52292940	6168 k	0	0	0	2614647
▼ User Datagram Protocol	100.0	2614586	0.6	20916688	2467 k	0	0	0	2614586
▼ iPerf3 Speed Test	100.0	2614535	96.8	3524390492	415 M	2	8	0	2614535
Data	100.0	2614533	96.0	3493016088	412 M	2614533	3493016088	412 M	2614533
Domain Name System	0.0	51	0.0	2045	241	51	2045	241	51
▼ Transmission Control Protocol	0.0	57	0.0	2837	334	41	1545	182	57
iPerf3 Speed Test	0.0	12	0.0	776	91	12	483	56	14
Data	0.0	4	0.0	4	0	4	4	0	4
Internet Control Message Protocol	0.0	4	0.0	256	30	4	256	30	4

gnb_gtpu_BS_udp.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	87186	100.0	551258319	44 M	0	0	0	87186
▼ DLT User	100.0	87186	100.0	551258319	44 M	0	0	0	87186
▼ User Datagram Protocol	100.0	87186	0.1	697488	56 k	0	0	0	87186
MAC-NR	100.0	87186	99.5	548555553	44 M	87186	548555553	44 M	87186

gnb_mac_BS_udp.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	20	100.0	1764	158	0	0	0	20
▼ DLT User	100.0	20	100.0	1764	158	0	0	0	20
NG Application Protocol	100.0	20	100.0	1764	158	20	1764	158	20

gnb_ngap_BS_udp.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	469983	100.0	544556900	57 M	0	0	0	469983
▼ DLT User	100.0	469983	100.0	544556900	57 M	0	0	0	469983
▼ User Datagram Protocol	100.0	469983	0.7	3759864	396 k	0	0	0	469983
Data	100.0	469983	99.3	540797036	56 M	469983	540797036	56 M	469983

gnb_rlc_BS_udp.pcap

Video Streaming (720p) – Base Station

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	6	100.0	374	110	0	0	0	6
▼ DLT User	100.0	6	100.0	374	110	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	110	6	374	110	6

gnb_e1ap_BS_720p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	14979	100.0	18940056	2293 k	0	0	0	14979
▼ DLT User	100.0	14979	100.0	18940056	2293 k	0	0	0	14979
▼ GPRS Tunneling Protocol	100.0	14979	100.0	18940056	2293 k	0	0	0	14979
▼ Internet Protocol Version 4	100.0	14979	1.6	299580	36 k	0	0	0	14979
▼ User Datagram Protocol	0.4	61	0.0	488	59	0	0	0	61
Domain Name System	0.4	61	0.0	2417	292	61	2417	292	61
▼ Transmission Control Protocol	99.6	14918	97.1	18397907	2228 k	14917	18397743	2228 k	14918
Hypertext Transfer Protocol	0.0	1	0.0	132	15	1	132	15	1

gnb_gtpu_BS_720p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	5165	100.0	19529615	1720 k	0	0	0	5165
▼ DLT User	100.0	5165	100.0	19529615	1720 k	0	0	0	5165
▼ User Datagram Protocol	100.0	5165	0.2	41320	3639	0	0	0	5165
MAC-NR	100.0	5165	99.2	19369500	1705 k	5165	19369500	1705 k	5165

gnb_mac_BS_720p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	20	100.0	1764	166	0	0	0	20
▼ DLT User	100.0	20	100.0	1764	166	0	0	0	20
NG Application Protocol	100.0	20	100.0	1764	166	20	1764	166	20

gnb_ngap_BS_720p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	19843	100.0	19529003	2118 k	0	0	0	19843
▼ DLT User	100.0	19843	100.0	19529003	2118 k	0	0	0	19843
▼ User Datagram Protocol	100.0	19843	0.8	158744	17 k	0	0	0	19843
Data	100.0	19843	99.2	19370259	2100 k	19843	19370259	2100 k	19843

gnb_rlc_BS_720p.pcap

Video Streaming (1080p) – Base Station

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	6	100.0	374	109	0	0	0	6
▼ DLT User	100.0	6	100.0	374	109	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	109	6	374	109	6

gnb_e1ap_BS_1080p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	29358	100.0	38971411	4354 k	0	0	0	29358
▼ DLT User	100.0	29358	100.0	38971411	4354 k	0	0	0	29358
▼ GPRS Tunneling Protocol	100.0	29358	100.0	38971411	4354 k	0	0	0	29358
▼ Internet Protocol Version 4	100.0	29358	1.5	587160	65 k	0	0	0	29358
▼ User Datagram Protocol	0.2	72	0.0	576	64	0	0	0	72
Domain Name System	0.2	72	0.0	2827	315	72	2827	315	72
▼ Transmission Control Protocol	99.8	29286	97.3	37911120	4235 k	29285	37910956	4235 k	29286
Hypertext Transfer Protocol	0.0	1	0.0	132	14	1	132	14	1

gnb_gtpu_BS_1080p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	8115	100.0	39531124	3295 k	0	0	0	8115
▼ DLT User	100.0	8115	100.0	39531124	3295 k	0	0	0	8115
▼ User Datagram Protocol	100.0	8115	0.2	64920	5412	0	0	0	8115
MAC-NR	100.0	8115	99.4	39279559	3274 k	8115	39279559	3274 k	8115

gnb_mac_BS_1080p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	20	100.0	1764	165	0	0	0	20
▼ DLT User	100.0	20	100.0	1764	165	0	0	0	20
NG Application Protocol	100.0	20	100.0	1764	165	20	1764	165	20

gnb_ngap_BS_1080p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	37168	100.0	39811690	4062 k	0	0	0	37168
▼ DLT User	100.0	37168	100.0	39811690	4062 k	0	0	0	37168
▼ User Datagram Protocol	100.0	37168	0.7	297344	30 k	0	0	0	37168
Data	100.0	37168	99.3	39514346	4032 k	37168	39514346	4032 k	37168

gnb_rlc_BS_1080p.pcap

Video Streaming (1440p) – Base Station

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	6	100.0	374	86	0	0	0	6
▼ DLT User	100.0	6	100.0	374	86	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	86	6	374	86	6

gnb_e1ap_BS_1440p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	44077	100.0	59533149	6730 k	0	0	0	44077
▼ DLT User	100.0	44077	100.0	59533149	6730 k	0	0	0	44077
▼ GPRS Tunneling Protocol	100.0	44077	100.0	59533149	6730 k	0	0	0	44077
▼ Internet Protocol Version 4	100.0	44077	1.5	881540	99 k	0	0	0	44077
▼ User Datagram Protocol	0.1	48	0.0	384	43	0	0	0	48
Domain Name System	0.1	48	0.0	1920	217	48	1920	217	48
▼ Transmission Control Protocol	99.9	44025	97.3	57943817	6550 k	44024	57943653	6550 k	44025
Hypertext Transfer Protocol	0.0	1	0.0	132	14	1	132	14	1
Internet Control Message Protocol	0.0	4	0.0	256	28	4	256	28	4

gnb_gtpu_BS_1440p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	11485	100.0	59946383	4690 k	0	0	0	11485
▼ DLT User	100.0	11485	100.0	59946383	4690 k	0	0	0	11485
▼ User Datagram Protocol	100.0	11485	0.2	91880	7189	0	0	0	11485
MAC-NR	100.0	11485	99.4	59590348	4662 k	11485	59590348	4662 k	11485

gnb_mac_BS_1440p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	20	100.0	1764	150	0	0	0	20
▼ DLT User	100.0	20	100.0	1764	150	0	0	0	20
NG Application Protocol	100.0	20	100.0	1764	150	20	1764	150	20

gnb_ngap_BS_1440p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	55243	100.0	60549412	6370 k	0	0	0	55243
▼ DLT User	100.0	55243	100.0	60549412	6370 k	0	0	0	55243
▼ User Datagram Protocol	100.0	55243	0.7	441944	46 k	0	0	0	55243
Data	100.0	55243	99.3	60107468	6323 k	55243	60107468	6323 k	55243

gnb_rlc_BS_1440p.pcap

Video Streaming (2160p) – Base Station

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	6	100.0	374	36	0	0	0	6
▼ DLT User	100.0	6	100.0	374	36	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	36	6	374	36	6

gnb_e1ap_BS_2160p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	83276	100.0	109554168	12 M	0	0	0	83276
▼ DLT User	100.0	83276	100.0	109554168	12 M	0	0	0	83276
▼ GPRS Tunneling Protocol	100.0	83276	100.0	109554168	12 M	0	0	0	83276
▼ Internet Protocol Version 4	100.0	83276	1.5	1665520	188 k	0	0	0	83276
▼ User Datagram Protocol	0.1	60	0.0	480	54	0	0	0	60
Domain Name System	0.1	60	0.0	2412	272	60	2412	272	60
▼ Transmission Control Protocol	99.9	83202	97.3	106552444	12 M	83201	106552280	12 M	83202
Hypertext Transfer Protocol	0.0	1	0.0	132	14	1	132	14	1
Internet Control Message Protocol	0.0	14	0.0	896	101	14	896	101	14

gnb_gtpu_BS_2160p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	24883	100.0	111543588	5938 k	0	0	0	24883
▼ DLT User	100.0	24883	100.0	111543588	5938 k	0	0	0	24883
▼ User Datagram Protocol	100.0	24883	0.2	199064	10 k	0	0	0	24883
MAC-NR	100.0	24883	99.3	110772215	5897 k	24883	110772215	5897 k	24883

gnb_mac_BS_2160p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	34	100.0	2828	222	0	0	0	34
▼ DLT User	100.0	34	100.0	2828	222	0	0	0	34
NG Application Protocol	100.0	34	100.0	2828	222	34	2828	222	34

gnb_ngap_BS_2160p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	107150	100.0	112111906	7334 k	0	0	0	107150
▼ DLT User	100.0	107150	100.0	112111906	7334 k	0	0	0	107150
▼ User Datagram Protocol	100.0	107150	0.8	857200	56 k	0	0	0	107150
Data	100.0	107150	99.2	111254706	7278 k	107150	111254706	7278 k	107150

gnb_rlc_BS_2160p.pcap

Scenario B

iPerf3 (TCP) – Base Station

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	6	100.0	374	74	0	0	0	6
▼ DLT User	100.0	6	100.0	374	74	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	74	6	374	74	6

gnb_e1ap_BS_tcp.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	477070	100.0	662808261	47 M	0	0	0	477070
▼ DLT User	100.0	477070	100.0	662808261	47 M	0	0	0	477070
▼ GPRS Tunneling Protocol	100.0	477070	100.0	662808261	47 M	0	0	0	477070
▼ Internet Protocol Version 4	100.0	477070	1.4	9541400	687 k	0	0	0	477070
▼ User Datagram Protocol	0.0	192	0.0	1536	110	0	0	0	192
Domain Name System	0.0	174	0.0	12152	875	174	12152	875	174
Data	0.0	18	0.0	153	11	18	153	11	18
▼ Transmission Control Protocol	100.0	476865	97.4	645618316	46 M	11430	3375133	243 k	476865
Transport Layer Security	0.0	17	0.0	10520	757	17	10520	757	17
▼ iPerf3 Speed Test	97.6	465408	94.6	627340381	45 M	14	496	35	465409
Data	97.6	465394	94.6	627339612	45 M	465394	627339612	45 M	465394
▼ Hypertext Transfer Protocol	0.0	10	0.0	2273	163	8	1760	126	10
Line-based text data	0.0	2	0.0	98	7	2	98	7	2
▼ Internet Control Message Protocol	0.0	13	0.0	1584	114	6	384	27	13
Domain Name System	0.0	7	0.0	948	68	7	948	68	7

gnb_gtpu_BS_tcp.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	77854	100.0	663997442	35 M	0	0	0	77854
▼ DLT User	100.0	77854	100.0	663997442	35 M	0	0	0	77854
▼ User Datagram Protocol	100.0	77854	0.1	622832	33 k	0	0	0	77854
MAC-NR	100.0	77854	99.6	661583968	35 M	77854	661583968	35 M	77854

gnb_mac_BS_tcp.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	15	100.0	1185	236	0	0	0	15
▼ DLT User	100.0	15	100.0	1185	236	0	0	0	15
NG Application Protocol	100.0	15	100.0	1185	236	15	1185	236	15

gnb_ngap_BS_tcp.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	556512	100.0	672812918	44 M	0	0	0	556512
▼ DLT User	100.0	556512	100.0	672812918	44 M	0	0	0	556512
▼ User Datagram Protocol	100.0	556512	0.7	4452096	292 k	0	0	0	556512
Data	100.0	556512	99.3	668360822	43 M	556512	668360822	43 M	556512

gnb_rlc_BS_tcp.pcap

iPerf3 (UDP) – Base Station

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	6	100.0	374	75	0	0	0	6
▼ DLT User	100.0	6	100.0	374	75	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	75	6	374	75	6

gnb_e1ap_BS_udp.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	1093052	100.0	1519960064	106 M	0	0	0	1093052
▼ DLT User	100.0	1093052	100.0	1519960064	106 M	0	0	0	1093052
▼ GPRS Tunneling Protocol	100.0	1093052	100.0	1519960064	106 M	0	0	0	1093052
▼ Internet Protocol Version 4	100.0	1093052	1.4	21861040	1534 k	0	0	0	1093052
▼ User Datagram Protocol	99.9	1092135	0.6	8737080	613 k	0	0	0	1092135
QUIC IETF	0.0	31	0.0	42792	3004	31	23669	1661	48
iPerf3 Speed Test	99.9	1091807	96.8	1471753148	103 M	2	8	0	1091807
Domain Name System	0.0	234	0.0	16660	1169	234	16660	1169	234
Data	99.9	1091868	96.0	1458652009	102 M	1091868	1458652009	102 M	1091868
▼ Transmission Control Protocol	0.1	901	0.0	71876	5045	815	45989	3228	901
Transport Layer Security	0.0	55	0.0	28919	2030	55	24855	1744	56
▼ iPerf3 Speed Test	0.0	11	0.0	772	54	8	181	12	13
Unassembled Fragmented Packet	0.0	3	0.0	0	0	3	0	0	3
▼ Hypertext Transfer Protocol	0.0	18	0.0	5180	363	11	2626	184	18
Online Certificate Status Protocol	0.0	2	0.0	588	41	2	588	41	2
Line-based text data	0.0	5	0.0	204	14	5	204	14	5
Data	0.0	2	0.0	2	0	2	2	0	2
▼ Internet Control Message Protocol	0.0	16	0.0	1771	124	8	512	35	16
Domain Name System	0.0	8	0.0	971	68	8	971	68	8

gnb_gtpu_BS_udp.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	87657	100.0	664521645	35 M	0	0	0	87657
▼ DLT User	100.0	87657	100.0	664521645	35 M	0	0	0	87657
▼ User Datagram Protocol	100.0	87657	0.1	701256	37 k	0	0	0	87657
MAC-NR	100.0	87657	99.6	661804278	35 M	87657	661804278	35 M	87657

gnb_mac_BS_udp.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	15	100.0	1185	237	0	0	0	15
▼ DLT User	100.0	15	100.0	1185	237	0	0	0	15
NG Application Protocol	100.0	15	100.0	1185	237	15	1185	237	15

gnb_ngap_BS_udp.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	561949	100.0	670108747	42 M	0	0	0	561949
▼ DLT User	100.0	561949	100.0	670108747	42 M	0	0	0	561949
▼ User Datagram Protocol	100.0	561949	0.7	4495592	287 k	0	0	0	561949
Data	100.0	561949	99.3	665613155	42 M	561949	665613155	42 M	561949

gnb_rlc_BS_udp.pcap

Video Streaming (720p) – Base Station

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	6	100.0	374	72	0	0	0	6
▼ DLT User	100.0	6	100.0	374	72	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	72	6	374	72	6

gnb_e1ap_BS_720p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	14555	100.0	18192262	1345 k	0	0	0	14555
▼ DLT User	100.0	14555	100.0	18192262	1345 k	0	0	0	14555
▼ GPRS Tunneling Protocol	100.0	14555	100.0	18192262	1345 k	0	0	0	14555
▼ Internet Protocol Version 4	100.0	14555	1.6	291100	21 k	0	0	0	14555
▼ User Datagram Protocol	1.1	166	0.0	1328	98	0	0	0	166
Domain Name System	1.0	150	0.1	10748	794	150	10748	794	150
Data	0.1	16	0.0	136	10	16	136	10	16
▼ Transmission Control Protocol	98.7	14372	97.0	17653945	1305 k	14342	17644964	1305 k	14372
Transport Layer Security	0.1	21	0.0	5891	435	21	5891	435	21
▼ Hypertext Transfer Protocol	0.1	9	0.0	2130	157	7	1616	119	9
Line-based text data	0.0	2	0.0	98	7	2	98	7	2
▼ Internet Control Message Protocol	0.1	17	0.0	2125	157	8	512	37	17
Domain Name System	0.1	9	0.0	1289	95	9	1289	95	9

gnb_gtpu_BS_720p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	4899	100.0	19179920	1044 k	0	0	0	4899
▼ DLT User	100.0	4899	100.0	19179920	1044 k	0	0	0	4899
▼ User Datagram Protocol	100.0	4899	0.2	39192	2134	0	0	0	4899
MAC-NR	100.0	4899	99.2	19028051	1036 k	4899	19028051	1036 k	4899

gnb_mac_BS_720p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	15	100.0	1185	229	0	0	0	15
▼ DLT User	100.0	15	100.0	1185	229	0	0	0	15
NG Application Protocol	100.0	15	100.0	1185	229	15	1185	229	15

gnb_ngap_BS_720p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	18533	100.0	18792368	1257 k	0	0	0	18533
▼ DLT User	100.0	18533	100.0	18792368	1257 k	0	0	0	18533
▼ User Datagram Protocol	100.0	18533	0.8	148264	9918	0	0	0	18533
Data	100.0	18533	99.2	18644104	1247 k	18533	18644104	1247 k	18533

gnb_rlc_BS_720p.pcap

Video Streaming (1080p) – Base Station

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	6	100.0	374	78	0	0	0	6
▼ DLT User	100.0	6	100.0	374	78	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	78	6	374	78	6

gnb_e1ap_BS_1080p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	26873	100.0	35206811	2293 k	0	0	0	26873
▼ DLT User	100.0	26873	100.0	35206811	2293 k	0	0	0	26873
▼ GPRS Tunneling Protocol	100.0	26873	100.0	35206811	2293 k	0	0	0	26873
▼ Internet Protocol Version 4	100.0	26873	1.5	537460	35 k	0	0	0	26873
▼ User Datagram Protocol	0.8	202	0.0	1616	105	0	0	0	202
Domain Name System	0.7	184	0.0	12571	819	184	12571	819	184
Data	0.1	18	0.0	153	9	18	153	9	18
▼ Transmission Control Protocol	99.2	26658	97.2	34223545	2229 k	26600	34202857	2228 k	26658
Transport Layer Security	0.2	49	0.1	46860	3052	49	31896	2078	52
▼ Hypertext Transfer Protocol	0.0	9	0.0	2130	138	7	1616	105	9
Line-based text data	0.0	2	0.0	98	6	2	98	6	2
▼ Internet Control Message Protocol	0.0	13	0.0	1498	97	6	384	25	13
Domain Name System	0.0	7	0.0	862	56	7	862	56	7

gnb_gtpu_BS_1080p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	7114	100.0	36231731	1828 k	0	0	0	7114
▼ DLT User	100.0	7114	100.0	36231731	1828 k	0	0	0	7114
▼ User Datagram Protocol	100.0	7114	0.2	56912	2872	0	0	0	7114
MAC-NR	100.0	7114	99.4	36011197	1817 k	7114	36011197	1817 k	7114

gnb_mac_BS_1080p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	15	100.0	1185	249	0	0	0	15
▼ DLT User	100.0	15	100.0	1185	249	0	0	0	15
NG Application Protocol	100.0	15	100.0	1185	249	15	1185	249	15

gnb_ngap_BS_1080p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	33019	100.0	36058245	2143 k	0	0	0	33019
▼ DLT User	100.0	33019	100.0	36058245	2143 k	0	0	0	33019
▼ User Datagram Protocol	100.0	33019	0.7	264152	15 k	0	0	0	33019
Data	100.0	33019	99.3	35794093	2128 k	33019	35794093	2128 k	33019

gnb_rlc_BS_1080p.pcap

Video Streaming (1440p) – Base Station

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	6	100.0	374	77	0	0	0	6
▼ DLT User	100.0	6	100.0	374	77	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	77	6	374	77	6

gnb_e1ap_BS_1440p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	43326	100.0	58277141	3117 k	0	0	0	43326
▼ DLT User	100.0	43326	100.0	58277141	3117 k	0	0	0	43326
▼ GPRS Tunneling Protocol	100.0	43326	100.0	58277141	3117 k	0	0	0	43326
▼ Internet Protocol Version 4	100.0	43326	1.5	866520	46 k	0	0	0	43326
▼ User Datagram Protocol	0.4	156	0.0	1248	66	0	0	0	156
Domain Name System	0.3	132	0.0	9911	530	132	9911	530	132
Data	0.1	24	0.0	204	10	24	204	10	24
▼ Transmission Control Protocol	99.6	43158	97.3	56704817	3033 k	43124	56695404	3033 k	43158
Transport Layer Security	0.1	23	0.0	5920	316	23	5920	316	23
▼ Hypertext Transfer Protocol	0.0	11	0.0	2405	128	9	1892	101	11
Line-based text data	0.0	2	0.0	98	5	2	98	5	2
▼ Internet Control Message Protocol	0.0	12	0.0	1225	65	7	420	22	12
Domain Name System	0.0	5	0.0	625	33	5	625	33	5

gnb_gtpu_BS_1440p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	9997	100.0	59314604	2553 k	0	0	0	9997
▼ DLT User	100.0	9997	100.0	59314604	2553 k	0	0	0	9997
▼ User Datagram Protocol	100.0	9997	0.1	79976	3443	0	0	0	9997
MAC-NR	100.0	9997	99.5	59004697	2540 k	9997	59004697	2540 k	9997

gnb_mac_BS_1440p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	15	100.0	1185	244	0	0	0	15
▼ DLT User	100.0	15	100.0	1185	244	0	0	0	15
NG Application Protocol	100.0	15	100.0	1185	244	15	1185	244	15

gnb_ngap_BS_1440p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	52317	100.0	59451103	2952 k	0	0	0	52317
▼ DLT User	100.0	52317	100.0	59451103	2952 k	0	0	0	52317
▼ User Datagram Protocol	100.0	52317	0.7	418536	20 k	0	0	0	52317
Data	100.0	52317	99.3	59032567	2932 k	52317	59032567	2932 k	52317

gnb_rlc_BS_1440p.pcap

Video Streaming (2160p) – Base Station

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	6	100.0	374	78	0	0	0	6
▼ DLT User	100.0	6	100.0	374	78	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	78	6	374	78	6

gnb_e1ap_BS_2160p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	84583	100.0	114138469	6627 k	0	0	0	84583
▼ DLT User	100.0	84583	100.0	114138469	6627 k	0	0	0	84583
▼ GPRS Tunneling Protocol	100.0	84583	100.0	114138469	6627 k	0	0	0	84583
▼ Internet Protocol Version 4	100.0	84583	1.5	1691660	98 k	0	0	0	84583
▼ User Datagram Protocol	0.2	167	0.0	1336	77	0	0	0	167
Domain Name System	0.2	145	0.0	10165	590	145	10165	590	145
Data	0.0	22	0.0	187	10	22	187	10	22
▼ Transmission Control Protocol	99.8	84404	97.3	111080416	6449 k	84371	111071179	6449 k	84404
Transport Layer Security	0.0	22	0.0	5857	340	22	5857	340	22
▼ Hypertext Transfer Protocol	0.0	11	0.0	2324	134	9	1810	105	11
Line-based text data	0.0	2	0.0	98	5	2	98	5	2
▼ Internet Control Message Protocol	0.0	12	0.0	1377	79	6	384	22	12
Domain Name System	0.0	6	0.0	777	45	6	777	45	6

gnb_gtpu_BS_2160p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	21306	100.0	116702580	5375 k	0	0	0	21306
▼ DLT User	100.0	21306	100.0	116702580	5375 k	0	0	0	21306
▼ User Datagram Protocol	100.0	21306	0.1	170448	7850	0	0	0	21306
MAC-NR	100.0	21306	99.4	116042094	5344 k	21306	116042094	5344 k	21306

gnb_mac_BS_2160p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	15	100.0	1185	247	0	0	0	15
▼ DLT User	100.0	15	100.0	1185	247	0	0	0	15
NG Application Protocol	100.0	15	100.0	1185	247	15	1185	247	15

gnb_ngap_BS_2160p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	104048	100.0	116672941	6246 k	0	0	0	104048
▼ DLT User	100.0	104048	100.0	116672941	6246 k	0	0	0	104048
▼ User Datagram Protocol	100.0	104048	0.7	832384	44 k	0	0	0	104048
Data	100.0	104048	99.3	115840557	6201 k	104048	115840557	6201 k	104048

gnb_rlc_BS_2160p.pcap

iPerf3 (TCP) – Intermediate Node

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	6	100.0	374	94	0	0	0	6
▼ DLT User	100.0	6	100.0	374	94	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	94	6	374	94	6

gnb_e1ap_inter_tcp.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	479532	100.0	663002792	77 M	0	0	0	479532
▼ DLT User	100.0	479532	100.0	663002792	77 M	0	0	0	479532
▼ GPRS Tunneling Protocol	100.0	479532	100.0	663002792	77 M	0	0	0	479532
▼ Internet Protocol Version 4	100.0	479532	1.4	9590640	1115 k	0	0	0	479532
▼ User Datagram Protocol	0.0	64	0.0	512	59	0	0	0	64
Domain Name System	0.0	64	0.0	2558	297	64	2558	297	64
▼ Transmission Control Protocol	100.0	479464	97.4	645736314	75 M	14025	3460097	402 k	479464
▼ iPerf3 Speed Test	97.1	465439	94.6	627382169	72 M	14	496	57	465440
Data	97.1	465425	94.6	627381400	72 M	465425	627381400	72 M	465425
Internet Control Message Protocol	0.0	4	0.0	256	29	4	256	29	4

gnb_gtpu_inter_tcp.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	83404	100.0	667218652	55 M	0	0	0	83404
▼ DLT User	100.0	83404	100.0	667218652	55 M	0	0	0	83404
▼ User Datagram Protocol	100.0	83404	0.1	667232	55 k	0	0	0	83404
MAC-NR	100.0	83404	99.6	664633128	55 M	83404	664633128	55 M	83404

gnb_mac_inter_tcp.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	20	100.0	1781	159	0	0	0	20
▼ DLT User	100.0	20	100.0	1781	159	0	0	0	20
NG Application Protocol	100.0	20	100.0	1781	159	20	1781	159	20

gnb_ngap_inter_tcp.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	567771	100.0	676714241	71 M	0	0	0	567771
▼ DLT User	100.0	567771	100.0	676714241	71 M	0	0	0	567771
▼ User Datagram Protocol	100.0	567771	0.7	4542168	478 k	0	0	0	567771
Data	100.0	567771	99.3	672172073	70 M	567771	672172073	70 M	567771

gnb_rlc_inter_tcp.pcap

iPerf3 (UDP) – Intermediate Node

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	6	100.0	374	103	0	0	0	6
▼ DLT User	100.0	6	100.0	374	103	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	103	6	374	103	6

gnb_e1ap_inter_udp.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	476018	100.0	662454959	72 M	0	0	0	476018
▼ DLT User	100.0	476018	100.0	662454959	72 M	0	0	0	476018
▼ GPRS Tunneling Protocol	100.0	476018	100.0	662454959	72 M	0	0	0	476018
▼ Internet Protocol Version 4	100.0	476018	1.4	9520360	1046 k	0	0	0	476018
▼ User Datagram Protocol	100.0	475958	0.6	3807664	418 k	0	0	0	475958
▼ iPerf3 Speed Test	100.0	475896	96.8	641505120	70 M	2	8	0	475896
Data	100.0	475894	96.0	635794384	69 M	475894	635794384	69 M	475894
Domain Name System	0.0	62	0.0	2468	271	62	2468	271	62
▼ Transmission Control Protocol	0.0	56	0.0	2803	308	43	1613	177	56
▼ iPerf3 Speed Test	0.0	11	0.0	772	84	8	181	19	13
Unreassembled Fragmented Packet	0.0	3	0.0	0	0	3	0	0	3
Data	0.0	2	0.0	2	0	2	2	0	2
Internet Control Message Protocol	0.0	4	0.0	256	28	4	256	28	4

gnb_gtpu_inter_udp.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	82550	100.0	647821911	53 M	0	0	0	82550
▼ DLT User	100.0	82550	100.0	647821911	53 M	0	0	0	82550
▼ User Datagram Protocol	100.0	82550	0.1	660400	54 k	0	0	0	82550
MAC-NR	100.0	82550	99.6	645262861	53 M	82550	645262861	53 M	82550

gnb_mac_inter_udp.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	20	100.0	1781	169	0	0	0	20
▼ DLT User	100.0	20	100.0	1781	169	0	0	0	20
NG Application Protocol	100.0	20	100.0	1781	169	20	1781	169	20

gnb_ngap_inter_udp.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	546075	100.0	656173353	63 M	0	0	0	546075
▼ DLT User	100.0	546075	100.0	656173353	63 M	0	0	0	546075
▼ User Datagram Protocol	100.0	546075	0.7	4368600	424 k	0	0	0	546075
Data	100.0	546075	99.3	651804753	63 M	546075	651804753	63 M	546075

gnb_rlc_inter_udp.pcap

Video Streaming (720p) – Intermediate Node

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	6	100.0	374	82	0	0	0	6
▼ DLT User	100.0	6	100.0	374	82	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	82	6	374	82	6

gnb_e1ap_inter_720p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	14054	100.0	17937553	2148 k	0	0	0	14054
▼ DLT User	100.0	14054	100.0	17937553	2148 k	0	0	0	14054
▼ GPRS Tunneling Protocol	100.0	14054	100.0	17937553	2148 k	0	0	0	14054
▼ Internet Protocol Version 4	100.0	14054	1.6	281080	33 k	0	0	0	14054
▼ User Datagram Protocol	0.4	60	0.0	480	57	0	0	0	60
Domain Name System	0.4	60	0.0	2374	284	60	2374	284	60
▼ Transmission Control Protocol	99.5	13990	97.2	17428499	2087 k	13989	17428335	2087 k	13990
Hypertext Transfer Protocol	0.0	1	0.0	132	15	1	132	15	1
Internet Control Message Protocol	0.0	4	0.0	256	30	4	256	30	4

gnb_gtpu_inter_720p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	4882	100.0	18896317	1540 k	0	0	0	4882
▼ DLT User	100.0	4882	100.0	18896317	1540 k	0	0	0	4882
▼ User Datagram Protocol	100.0	4882	0.2	39056	3183	0	0	0	4882
MAC-NR	100.0	4882	99.2	18744975	1527 k	4882	18744975	1527 k	4882

gnb_mac_inter_720p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	20	100.0	1781	153	0	0	0	20
▼ DLT User	100.0	20	100.0	1781	153	0	0	0	20
NG Application Protocol	100.0	20	100.0	1781	153	20	1781	153	20

gnb_ngap_inter_720p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	17996	100.0	18732002	2006 k	0	0	0	17996
▼ DLT User	100.0	17996	100.0	18732002	2006 k	0	0	0	17996
▼ User Datagram Protocol	100.0	17996	0.8	143968	15 k	0	0	0	17996
Data	100.0	17996	99.2	18588034	1991 k	17996	18588034	1991 k	17996

gnb_rlc_inter_720p.pcap

Video Streaming (1080p) – Intermediate Node

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	6	100.0	374	91	0	0	0	6
▼ DLT User	100.0	6	100.0	374	91	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	91	6	374	91	6

gnb_e1ap_inter_1080p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	26295	100.0	34942089	3280 k	0	0	0	26295
▼ DLT User	100.0	26295	100.0	34942089	3280 k	0	0	0	26295
▼ GPRS Tunneling Protocol	100.0	26295	100.0	34942089	3280 k	0	0	0	26295
▼ Internet Protocol Version 4	100.0	26295	1.5	525900	49 k	0	0	0	26295
▼ User Datagram Protocol	0.3	72	0.0	576	54	0	0	0	72
Domain Name System	0.3	72	0.0	2836	266	72	2836	266	72
▼ Transmission Control Protocol	99.7	26219	97.3	33991801	3191 k	26218	33991637	3191 k	26219
Hypertext Transfer Protocol	0.0	1	0.0	132	12	1	132	12	1
Internet Control Message Protocol	0.0	4	0.0	256	24	4	256	24	4

gnb_gtpu_inter_1080p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	7426	100.0	36088612	2551 k	0	0	0	7426
▼ DLT User	100.0	7426	100.0	36088612	2551 k	0	0	0	7426
▼ User Datagram Protocol	100.0	7426	0.2	59408	4200	0	0	0	7426
MAC-NR	100.0	7426	99.4	35858406	2535 k	7426	35858406	2535 k	7426

gnb_mac_inter_1080p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	20	100.0	1781	157	0	0	0	20
▼ DLT User	100.0	20	100.0	1781	157	0	0	0	20
NG Application Protocol	100.0	20	100.0	1781	157	20	1781	157	20

gnb_ngap_inter_1080p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	32832	100.0	36153616	3124 k	0	0	0	32832
▼ DLT User	100.0	32832	100.0	36153616	3124 k	0	0	0	32832
▼ User Datagram Protocol	100.0	32832	0.7	262656	22 k	0	0	0	32832
Data	100.0	32832	99.3	35890960	3102 k	32832	35890960	3102 k	32832

gnb_rlc_inter_1080p.pcap

Video Streaming (1440p) – Intermediate Node

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	12	100.0	728	82	0	0	0	12
▼ DLT User	100.0	12	100.0	728	82	0	0	0	12
E1 Application Protocol	100.0	12	100.0	728	82	12	728	82	12

gnb_e1ap_inter_1440p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	42741	100.0	57817844	6243 k	0	0	0	42741
▼ DLT User	100.0	42741	100.0	57817844	6243 k	0	0	0	42741
▼ GPRS Tunneling Protocol	100.0	42741	100.0	57817844	6243 k	0	0	0	42741
▼ Internet Protocol Version 4	100.0	42741	1.5	854820	92 k	0	0	0	42741
▼ User Datagram Protocol	0.1	32	0.0	256	27	0	0	0	32
Domain Name System	0.1	32	0.0	1269	137	32	1269	137	32
▼ Transmission Control Protocol	99.9	42705	97.3	56277387	6076 k	42704	56277223	6076 k	42705
Hypertext Transfer Protocol	0.0	1	0.0	132	14	1	132	14	1
Internet Control Message Protocol	0.0	4	0.0	256	27	4	256	27	4

gnb_gtpu_inter_1440p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	9918	100.0	58621498	3470 k	0	0	0	9918
▼ DLT User	100.0	9918	100.0	58621498	3470 k	0	0	0	9918
▼ User Datagram Protocol	100.0	9918	0.1	79344	4697	0	0	0	9918
MAC-NR	100.0	9918	99.5	58314040	3452 k	9918	58314040	3452 k	9918

gnb_mac_inter_1440p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	33	100.0	2685	166	0	0	0	33
▼ DLT User	100.0	33	100.0	2685	166	0	0	0	33
NG Application Protocol	100.0	33	100.0	2685	166	33	2685	166	33

gnb_ngap_inter_1440p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU/s
▼ Frame	100.0	51515	100.0	59016063	6271 k	0	0	0	51515
▼ DLT User	100.0	51515	100.0	59016063	6271 k	0	0	0	51515
▼ User Datagram Protocol	100.0	51515	0.7	412120	43 k	0	0	0	51515
Data	100.0	51515	99.3	58603943	6227 k	51515	58603943	6227 k	51515

gnb_rlc_inter_1440p.pcap

Video Streaming (2160p) – Intermediate Node

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	12	100.0	728	95	0	0	0	12
▼ DLT User	100.0	12	100.0	728	95	0	0	0	12
E1 Application Protocol	100.0	12	100.0	728	95	12	728	95	12

gnb_e1ap_inter_2160p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	85400	100.0	113523234	12 M	0	0	0	85400
▼ DLT User	100.0	85400	100.0	113523234	12 M	0	0	0	85400
▼ GPRS Tunneling Protocol	100.0	85400	100.0	113523234	12 M	0	0	0	85400
▼ Internet Protocol Version 4	100.0	85400	1.5	1708000	193 k	0	0	0	85400
▼ User Datagram Protocol	0.1	47	0.0	376	42	0	0	0	47
Domain Name System	0.1	47	0.0	1855	210	47	1855	210	47
▼ Transmission Control Protocol	99.9	85349	97.3	110446347	12 M	85348	110446183	12 M	85349
Hypertext Transfer Protocol	0.0	1	0.0	132	14	1	132	14	1
Internet Control Message Protocol	0.0	4	0.0	256	29	4	256	29	4

gnb_gtpu_inter_2160p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	22746	100.0	116063205	7307 k	0	0	0	22746
▼ DLT User	100.0	22746	100.0	116063205	7307 k	0	0	0	22746
▼ User Datagram Protocol	100.0	22746	0.2	181968	11 k	0	0	0	22746
MAC-NR	100.0	22746	99.4	115358079	7263 k	22746	115358079	7263 k	22746

gnb_mac_inter_2160p.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	33	100.0	2685	177	0	0	0	33
▼ DLT User	100.0	33	100.0	2685	177	0	0	0	33
NG Application Protocol	100.0	33	100.0	2685	177	33	2685	177	33

gnb_ngap_inter_2160p.pcap

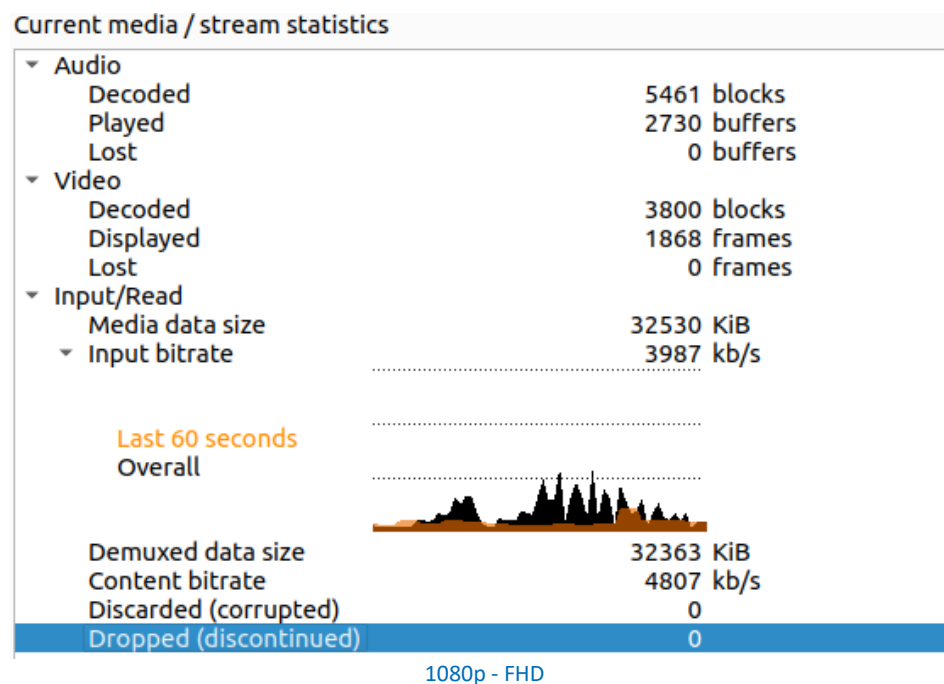
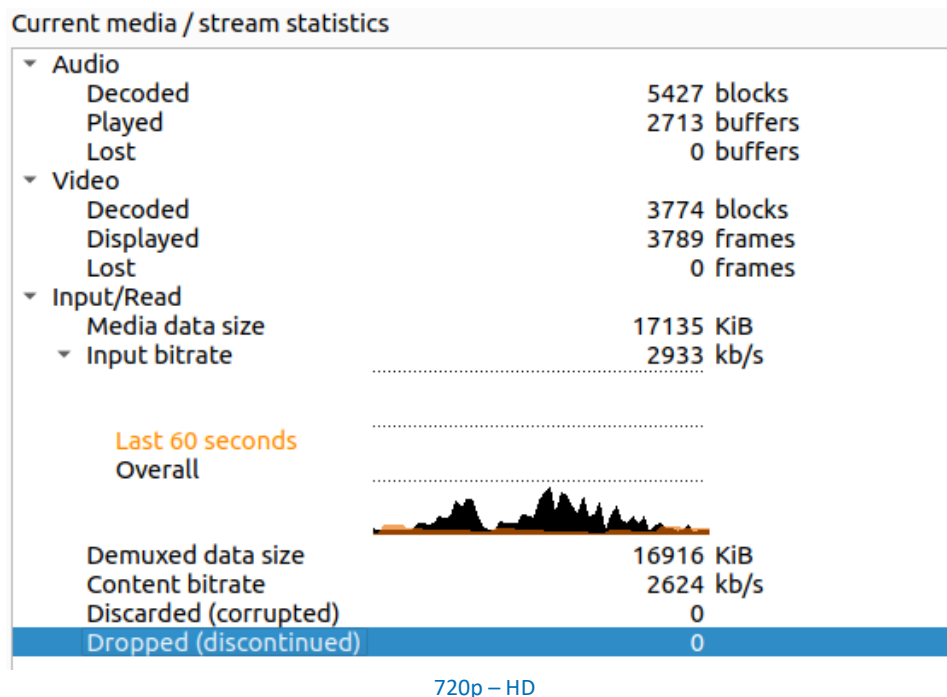
Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDU's
▼ Frame	100.0	104807	100.0	116565732	12 M	0	0	0	104807
▼ DLT User	100.0	104807	100.0	116565732	12 M	0	0	0	104807
▼ User Datagram Protocol	100.0	104807	0.7	838456	89 k	0	0	0	104807
Data	100.0	104807	99.3	115727276	12 M	104807	115727276	12 M	104807

gnb_rlc_inter_2160p.pcap

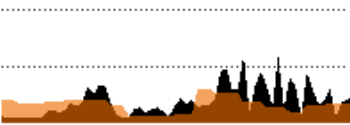
Appendix C – VLC Media Player Statistics

The following screenshots depict the video streaming statistics as obtained from VLC Media Player running in the UE.

Scenario A

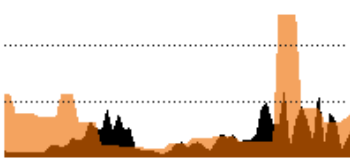


Current media / stream statistics

▼ Audio	
Decoded	0 blocks
Played	0 buffers
Lost	0 buffers
▼ Video	
Decoded	3736 blocks
Displayed	1855 frames
Lost	0 frames
▼ Input/Read	
Media data size	54657 KiB
▼ Input bitrate	7202 kb/s
<div> <div>Last 60 seconds</div> <div>Overall</div> </div> 	
Demuxed data size	54146 KiB
Content bitrate	5458 kb/s
Discarded (corrupted)	0
Dropped (discontinued)	0

1440p – 2K

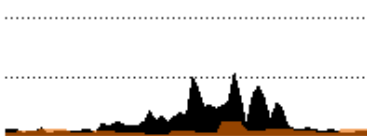
Current media / stream statistics

▼ Audio	
Decoded	6262 blocks
Played	3131 buffers
Lost	0 buffers
▼ Video	
Decoded	3684 blocks
Displayed	1830 frames
Lost	0 frames
▼ Input/Read	
Media data size	97745 KiB
▼ Input bitrate	17851 kb/s
<div> <div>Last 60 seconds</div> <div>Overall</div> </div> 	
Demuxed data size	97158 KiB
Content bitrate	14391 kb/s
Discarded (corrupted)	0
Dropped (discontinued)	0

2160p – 4K

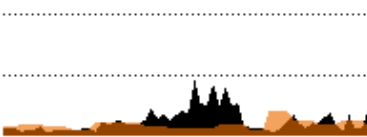
Scenario B

Current media / stream statistics

▼ Audio	
Decoded	5367 blocks
Played	2683 buffers
Lost	0 buffers
▼ Video	
Decoded	3732 blocks
Displayed	1834 frames
Lost	0 frames
▼ Input/Read	
Media data size	16582 KiB
▼ Input bitrate	2695 kb/s
<div> <div>Last 60 seconds</div> <div>Overall</div> </div> 	
Demuxed data size	16427 KiB
Content bitrate	2691 kb/s
Discarded (corrupted)	0
Dropped (discontinued)	0


720p – HD

Current media / stream statistics

▼ Audio	
Decoded	5439 blocks
Played	2719 buffers
Lost	0 buffers
▼ Video	
Decoded	3784 blocks
Displayed	1860 frames
Lost	0 frames
▼ Input/Read	
Media data size	32375 KiB
▼ Input bitrate	3356 kb/s
<div> <div>Last 60 seconds</div> <div>Overall</div> </div> 	
Demuxed data size	32247 KiB
Content bitrate	4920 kb/s
Discarded (corrupted)	0
Dropped (discontinued)	0

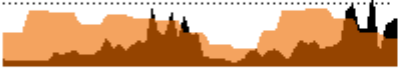
1080p – FHD

Current media / stream statistics

▼ Audio	
Decoded	0 blocks
Played	0 buffers
Lost	0 buffers
▼ Video	
Decoded	3703 blocks
Displayed	5575 frames
Lost	0 frames
▼ Input/Read	
Media data size	53502 KiB
▼ Input bitrate	11145 kb/s
.....	
Last 60 seconds	
Overall	
.....	
	
Demuxed data size	53139 KiB
Content bitrate	9714 kb/s
Discarded (corrupted)	0
Dropped (discontinued)	0

1440p – 2K

Current media / stream statistics

▼ Audio	
Decoded	6424 blocks
Played	3212 buffers
Lost	0 buffers
▼ Video	
Decoded	3775 blocks
Displayed	1873 frames
Lost	0 frames
▼ Input/Read	
Media data size	105150 KiB
▼ Input bitrate	8918 kb/s
.....	
Last 60 seconds	
Overall	
.....	
	
Demuxed data size	103658 KiB
Content bitrate	10140 kb/s
Discarded (corrupted)	0
Dropped (discontinued)	0

2160p – 4K