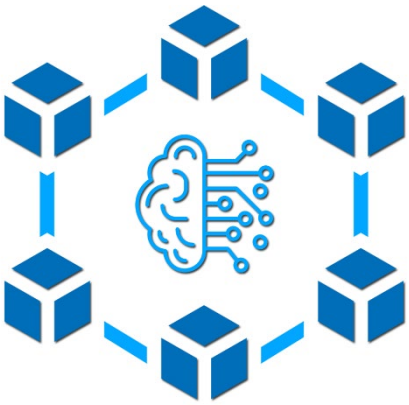

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Deliverable 6.7

Greek in-lab testbed dataset 2

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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	User Diagnostic Log and Trace
DoS	Denial of Service
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
NR	New Radio
NN	Neural Network
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
VR	Virtual Reality
XGB	eXtreme Gradient Boosting
WPX	Work Package X

Executive summary

This deliverable documents the datasets that were generated in the Greek in-lab testbed. The Greek in-lab testbed is focused on investigating a wireless range expansion use case, where a micro-operator expands the main operator's wireless coverage. Specifically, the experiments are structured into two topologies, namely Topology A, where the user equipment is directly connected to a base station through a 5G new radio link, and Topology B, where a micro-operator is employed as a relay between the main base station and the user equipment. Two datasets are documented in this deliverable that be found through the following links:

1) VR Video Streaming & iPerf3 on O-RAN 5G Testbed Dataset
    - IEEE DataPort: https://dx.doi.org/10.21227/j56t-ww52
    - Zenodo: https://doi.org/10.5281/zenodo.13863832
2) Cyberattacks on O-RAN 5G Testbed Dataset
    - IEEE DataPort: https://dx.doi.org/10.21227/vjf4-y322
    - Zenodo: https://doi.org/10.5281/zenodo.13863735

1. Introduction

1.1. Purpose of the Deliverable

D6.7 “Greek in-lab testbed dataset 2” is the second deliverable of T6.5 “Greek in-lab testbed” and documents the datasets that were generated using the Greek in-lab testbed. The dataset generation scenarios include streaming a virtual reality (VR) video in the User Equipment (UE), as well as carrying out cyberattacks against services that run in the operators. During the experimentation, various network statistics were collected along with network traffic captures. The aim was to evaluate the performance of the two different network topologies under various load types and capacities, both low-intensity TCP/UDP traffic as well as highly demanding high-resolution virtual reality (VR) video streaming from the Base Station towards the User Equipment. Furthermore, concerning the cyberattack dataset, the aim was to generate data for training AI-based cyberattack detection algorithms. Both datasets will be used in the context of the project for the development of relevant NANCY components. For instance, the cyberattack dataset is used for the development of detection techniques based on Artificial Intelligence.

1.2. Relation to Other Deliverables

D6.7 “Greek in-lab testbed dataset 2” is related to D6.4 “In-lab testbeds definition” as well as D6.5 “Greek in-lab testbed dataset 1”. In more detail, D6.4 defines the network architecture, as well as the two topologies, namely Topology A, consisting of a single operator, and Topology B, consisting of the main and the micro operator, that were implemented. Additionally, D6.7 “Greek in-lab testbed dataset 2” is associated with D2.1 “NANCY Requirements Analysis”, D3.1 “NANCY Architecture Design”, and D6.1 “B-RAN and 5G End-to-end Facilities Setup”.

1.3. Structure of the Deliverable

The structure of D6.7 “Greek in-lab testbed dataset 2” is presented as follows:

- **Section 1 – Introduction:** This section includes a brief introduction to this deliverable's purpose and how it is related to other deliverables. Also, this section outlines the deliverable’s structure.
- **Section 2 – Greek In-lab Testbed Description:** This section describes the Greek in-lab testbed, focusing on the topology, and the utilized hardware and software components.
- **Section 3 – Datasets Generation Process and Structure Description:** This section includes the experimental scenarios carried out to generate the datasets. Moreover, it presents the approaches for collecting network traffic capture, E2 metrics, carrying out cyberattacks, and annotating the network traffic flows.
- **Section 4 – Conclusion:** This section summarizes and concludes the deliverable.
- **Appendix A – Tree View of the VR Video Streaming and iPerf3 Dataset Structure:** The first appendix provides a hierarchical overview of the dataset’s folder structure.
- **Appendix B – Cyberattacks Timeline in the Cyberattack Detection Dataset:** The second appendix provides details related to the attack type, target and the time frame of the attacks.
- **Appendix C – Wireshark Protocol Hierarchy Statistics:** The second appendix presents the protocol hierarchy statistics that are generated using the respective Wireshark functionality.
- **Appendix D – xApp for Collecting E2 Metrics:** The third appendix presents the source code of the xApp that was used to collect E2 metrics and export them into a csv file.

2. Greek In-lab Testbed Description

2.1. Testbed Topology and Hardware

Figure 1 illustrates the network topology of the Greek in-lab testbed. Specifically, the following hardware components are utilized to deploy two 5G Standalone (SA) networks:

- Two Ettus Research USRP B210 devices [1], for the main operator's and micro-operator's base stations (BSs), respectively.
- Two high-performance laptops (Intel i7 and 32/16 GB RAM), that manage the USRPs via the USRP Hardware Driver (UHD) [2].
- A Quectel RM520N-GL 5G module [3] connects the intermediate to the main BS.
- A ZTE MC888 Pro 5G [4] router that connects through the 5G new radio (NR) interface with the micro-operator and enables the connection of non-5G devices with the network.
- Three programmable Sysmocom sysmolSIM-SJA2 subscriber identity modules (SIMs) that are configured to connect and authenticate with the respective BSs.

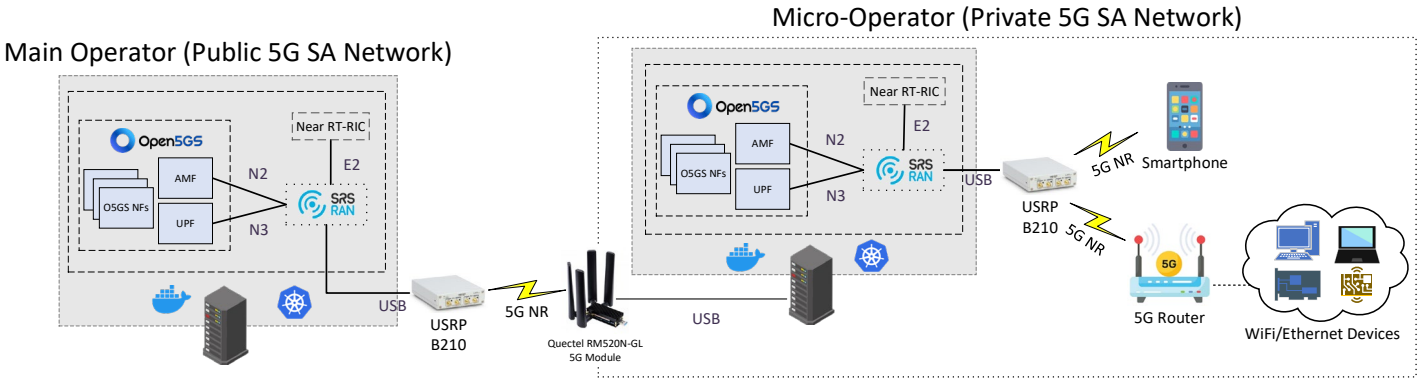

Figure 1: Greek in-lab Testbed Topology

The hardware components of the Greek in-lab testbed are shown in Figure 2. Please note that, for demonstration purposes in the figure below, all components are positioned in close proximity.

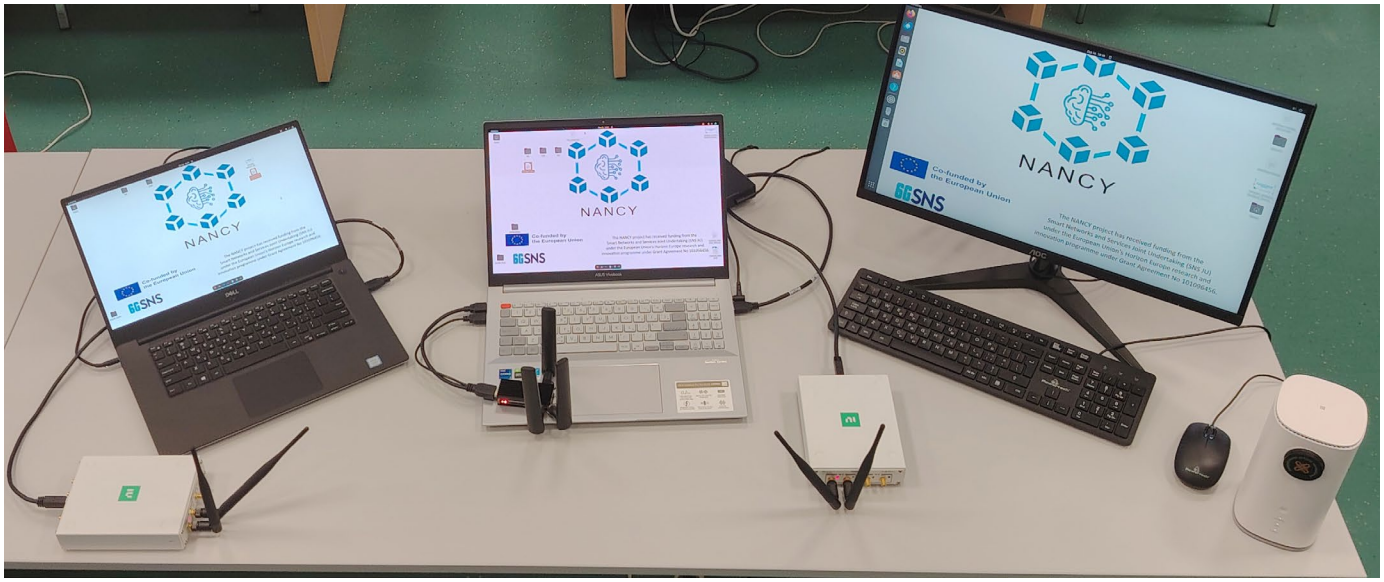

Figure 2: Hardware Components of the Greek in-lab Testbed

2.2. Software Components

Regarding the software components, Open5GS [5] is used to provide core network (CN) functionalities, while srsRAN from Software Radio Systems [6] is employed to deploy a USRP-based 5G NR base station. Additionally, the Near Realtime RAN Intelligent Controller (RIC) [7] from O-RAN Software Community is employed to collect the network statistics and metrics that are exposed from srsRAN through the E2 interface. The srsRAN configuration parameters for setting up the two 5G base stations are outlined in Table 1. To generate the statistics, a virtual reality (VR) video from YouTube was streamed, along with benchmarks from iPerf3 [8]. Specifically, iPerf3 is configured to generate both Transmission Control Protocol (TCP) and User Datagram Protocol (UDP) traffic between two endpoints.

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. VR Video Streaming & iPerf3 on O-RAN 5G Testbed

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 2. Specifically, in the first topology, the UE is directly connected to the main operator's network through the 5G NR interface, whereas, in the second topology, the UE is connected to the micro-operator's network.

3.1.1. Topology and experiment description

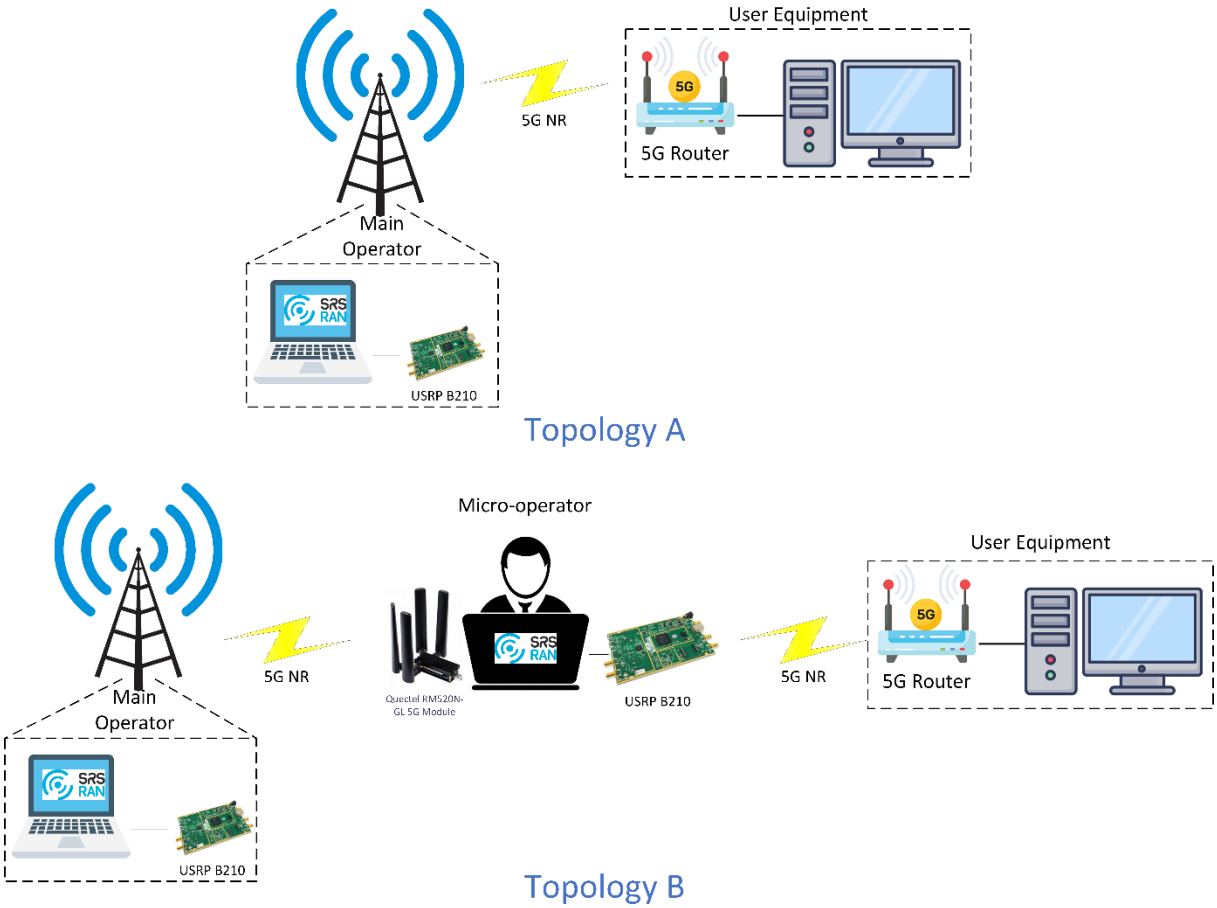

Figure 2: Greek In-lab Testbed Scenarios

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 10.46.0.1 -t 180 -R -J --logfile output.json
```

The parameters of the command are explained as follows:

- **-c 10.46.0.1:** Connects to the iPerf3 server at IP address 10.46.0.1 of the main server.
- **-t 180:** Sets the time duration of the test to 180 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 output.json:** The output was saved in a file named output.json.

A connection was made to the iPerf3 server at IP address 10.46.0.1 and the test was run for 180 seconds. The experiment was executed in reverse mode, meaning that the data flow was directed from the server to the client. The output of iPerf3 was saved in a JSON format to facilitate the analysis. During the 180-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, including bandwidth, packet loss, and jitter, are stored in the JSON file.

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

```
iperf3 -c 10.46.0.1 -u -R -b 10G -J --logfile output.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. This experiment is different from TCP as it enables faster data transmission at the cost of reliability
- **-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
- **-J:** The results were to be output in JSON format for ease of subsequent analysis
- **--logfile output.json:** The output was saved in a file named output.json

During the test, UDP traffic was generated by iPerf3 from the main server to the UE over a period of 180 seconds. Experimenting with UDP traffic type enables the assessment of network performance under conditions where the data transfer speed is prioritized over link reliability.

Additionally, experiments focusing on streaming VR video from YouTube were carried out. Specifically, the video "*360° Explore the ancient Acropolis in Athens – BBC*", which can be found at https://www.youtube.com/watch?v=8A63jbyk4bM, was chosen for the experiments. Three different video resolutions were used for the experiment, each representing a standard in video quality, as follows:

- 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

Table 2 lists the IPs of the YouTube servers that delivered the video in various resolutions throughout all experiments that were carried out.

Table 2: YouTube IP Mapping to Streaming Experiments

Scenario	Resolution	IP
Topology A – High Channel Quality	FHD	74.125.155.138
	2K	74.125.155.138
	4k	74.125.155.138
Topology A – Low Channel Quality	FHD	172.217.17.246
	2K	74.125.155.138
	4k	74.125.155.138
Topology B – High Channel Quality	FHD	74.125.163.198
	2K	74.125.163.198
	4k	173.194.55.10
Topology B – Low Channel Quality	FHD	74.125.155.138
	2K	74.125.163.198
	4k	74.125.155.138

3.1.2. Network traffic capture

According to the Open-RAN specifications [9], 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. Adhering to these specifications, srsRAN exports network traffic from multiple layers of the gNB in the form of .pcap files. The analysis and dissection of these files provide details on the data that are exchanged between the gNBs, UEs, and core network.

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.
- The Next Generation Application Protocol (NGAP) is a 3GPPP protocol integrated into 5G mobile networks and is part of the N2 interface. This interface connects a gNB to the 5G CN Access and Mobility Function (AMF). The NGAP implements 5G capabilities, such as ultra-reliable low latency communications (URLLC) or massive machine type communications (mMTC).
- The Medium Access Control (MAC) stands between the physical layer and the higher layers of the gNB stack. The srsRAN software 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 ensures the reliable and efficient transmission of data over a radio link. Moreover, it ensures that the data is correctly segmented and transmitted between the user and gNB and enforces flow control.

For analyzing the network traffic stored in the .pcap files, the Wireshark software is used [10]. According to the srsRAN documentation[1], 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 3.

Table 3: 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

Finally, tcpdump [11] was used to capture the traffic that passed through the main operator and micro-operator, in addition to the aforementioned traffic captures. Specifically, the following command was used:

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

```
tcpdump -i ogstun -w output.pcap
```

The parameters of the command are explained as follows:

- **-i ogstun:** Specifies the interface for capturing traffic. ogstun is a virtual network interface that is created by Open5GS and is used by UPF to capture and forward encapsulated UE traffic.
- **-w output.pcap:** Specifies that the captured network traffic will be written to a particular file.

3.1.3. Metrics exposed from the E2 interface

During the experiments, an xApp ran in the near-real-time RIC and collected various metrics which were exposed by srsRAN through the E2 interface. Table 4 lists the collected metrics along with the respective descriptions.

Table 4: Description of Metrics Exposed by srsRAN

Metric	Description
CQI	Channel quality indicator
RSRP	Received power of the reference signal
RSRQ	Received quality of the reference signal
RRU.PrbAvailDl	Average number of physical resource blocks (PRBs) that are available in the downlink
RRU.PrbAvailUl	Average number of physical resource blocks (PRBs) that are available in the uplink
RRU.PrbTotDl	Percentage of utilized PRBs in the downlink
RRU.PrbTotUl	Percentage of utilized PRBs in the uplink
DRB.RlcSduDelayDl	Average RLC delay on the downlink within the gNB-DU for the initial transmission of all RLC packets
DRB.PacketSuccessRateUlgNBUu	Percentage of packet data convergence protocol (PDCP) packets that were successfully received at the gNB
DRB.UEThpDl	Average throughput of the UE in the downlink
DRB.UEThpUl	Average throughput of the UE in the uplink
DRB.RlcPacketDropRateDl	Percentage of the radio link control packets that are dropped in the downlink channel due to high traffic load
DRB.RlcSduTransmittedVolumeDL	Volume of data that are transmitted in the downlink
DRB.RlcSduTransmittedVolumeUL	Volume of data that are transmitted in the uplink
DRB.AirIfDelayUl	Average over-the-air packet delay in the uplink
DRB.RlcDelayUl	Average RLC packet delay in the uplink

3.1.4. Dataset Structure

The dataset folder structure is presented and explained in Appendix A. The data were collected when the UE is directly connected to the main operator (topology A) and when the UE is connected through the micro-operator's network (topology B). In detail, the following data and metrics are collected in each operator:

1. Network traffic from multiple gNB stack layers (.pcap files).
2. RAN metrics exposed to the near-real-time RIC by the E2 interface (.csv files).
3. Network traffic from the 5G CN that was captured using tcpdump (.pcap files).
4. Network performance metrics exported by iPerf3 (.json files).

Under each topology, two sub-scenarios are included, namely 1) when the wireless propagation environment is optimal (e.g., the UEs are close to the BSs, there are no obstructions, etc.), and 2) when the wireless propagation environment is sub-optimal due to the distance and obstructions.

Finally, for each category five experiments were conducted (i.e., iPerf3 TCP/UDP modes, VR video in FHD, 2K, and 4K resolutions) resulting to a total of 20 experiments.

The data generated while running the iPerf3 experiments are included in the iPerf 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. Additionally, the data generated while running the VR video streaming experiments are included in the VR_FHD, VR_2K, and VR_4K folders. Two types of files are used for storing the data, namely .pcap files and .json files. The descriptions of the respective files are presented in Table 5.

Table 5: iPerf and VR Streaming Dataset

Filename	Description
gnb_e1ap.pcap	These files contain E1AP traffic exported by the srsRAN gNodeB tool.
gnb_e2ap.pcap	These files contain E2AP traffic exported by the srsRAN gNodeB tool.
gnb_f1ap.pcap	These files contain F1AP lyer traffic exported by the srsRAN gNodeB tool.
gnb_mac.pcap	These files contain MAC traffic exported by the srsRAN gNodeB tool.
gnb_n3.pcap	These files contain N3 traffic exported by the srsRAN gNodeB tool.
gnb_ngap.pcap	These files contain NGAP traffic exported by the srsRAN gNodeB tool.
gnb_rlc.pcap	These files contain RLC traffic exported by the srsRAN gNodeB tool.
tcpdump.pcap	These files contain the network traffic that was captured by using tcpdump in the CN.
iperf_stats_server.json	These files contain the statistics exported by iPerf3 running as a server in the main BS.
iperf_stats_client.json	These files contain the statistics exported by iPerf3 running as a client.
RAN_metrics.csv	These files contain the metrics that are exposed by srsRAN and retrieved by the xApp through the E2 interface.

3.2. Cyberattacks on O-RAN 5G Testbed Dataset

3.2.1. Topology and experiment description

In this experiment, a malicious user carries out cyberattacks against various services running in the main operator and the micro-operator. The topology for implementing the experiments with cyberattack detection is illustrated in Figure 3.

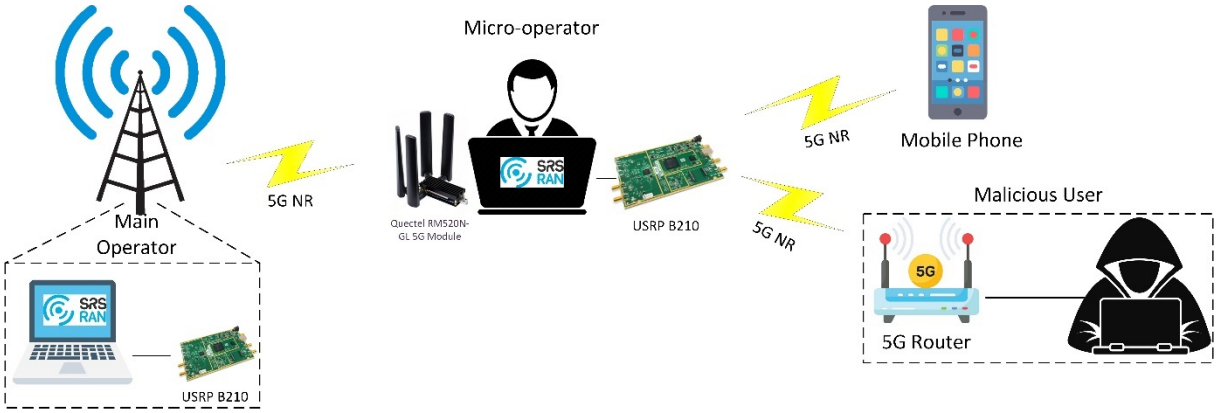

Figure 3: Topology for the Cyberattack Detection Experiments

The aforementioned topology was used to generate the traffic for training the artificial intelligence (AI)-based cyberattack detection component. Specifically, seven attacks were carried out against the main operator and micro-operator services, namely Reconnaissance Attack, UDP Scan, TCP Connect Scan, SYN Scan, SYN Flood, ICMP Flood, HTTP Flood, and Slow-rate DoS. Table 6 provides the respective descriptions of these attacks.

Table 6: Description of Attacks

Attack	Description
Reconnaissance Attack	A Reconnaissance Attack is a type of cyberattack where the attacker aims to gather information about a target system or network. The main goal is to find weak security entry points, which can potentially be of use later, such as open ports, outdated software, or weak security policies.
UDP Scan	UDP Scan is a process of finding and exploiting open (vulnerable) UDP ports. While TCP scans try to establish a connection through a three-way handshake, UDP protocol does not rely on three-way handshakes, thus UDP scans are more difficult to make. There are available tools (namely Nmap) that are utilized to perform UDP scans and penetration testing in general.
TCP Connect	A TCP Connect attack is based on the vulnerability of the TCP three-way handshake system. The goal is to try and initiate as many connection requests as possible without completing the required three-way handshakes. This leads the target system to overload and consequently exhaust its' resources and degrade its services.
SYN Scan	The way a SYN scan attack works is by initiating three-way handshakes without ever aiming to complete them. The goal is to identify open TCP ports on the target system. The attacker sends a SYN packet to a specific port, which initializes the TCP three-way handshake. Consequently, if the port is open, the targeted system

	responds with a SYN-ACK packet. After receiving the SYN-ACK packet from the target system, the attacker sends a RST packet instead of the normally concluding the three-way handshake. This process prematurely terminates the connection which leads to the connection not being logged by the target system hence this approach's stealth.
SYN Flood	A TCP SYN flood attack is a cyberattack that aims to request and cause the target system to allocate as many resources as possible. This is accomplished through "flooding" the target system with numerous TCP SYN packets, initiating many TCP three-way handshakes which in turn are never terminated with a SYN-ACK packet. Therefore, the target system ends up allocating numerous resources for this specific attacker and ultimately loses the ability to serve new clients, which in turn degrades the quality of service of the target system and can even disable the target system completely.
ICMP Flood	An ICMP Flood cyber-attack is another Denial of Service (DoS) attack, this time using ICMP Echo packets. In the beginning, the attacker issues numerous "Echo" packets towards the target system. The target system is then obligated to respond to all those ICMP packets with Echo Reply packets. Through this process a large percentage of the target system's resources and services are bound to the attacker, while denying them from actual clients.
HTTP Flood	An HTTP Flood attack is a type of Distributed DoS attack. As with regular Denial of Service attacks, the goal of the attacker is to slow down or even disable the target system, by requesting as many resources and/or services as possible from the target system, ultimately denying their use by legitimate clients. The attacker "floods" the target system with HTTP (GET or POST) requests, in turn obligating the target system to respond to those same requests. Unlike other types of cyber-attacks that rely on spoofed or malformed packets, this type of cyber-attack utilizes valid requests. The actual volume of these requests to the target system makes it hard to manage and ultimately exhausts the target system's resources.
Slow-rate DoS	Slow-rate Denial of Service cyber-attacks, similarly to other conventional methods of DoS attacks (like the ones explained above), try to initiate numerous connections with the ultimate goal to try and force the target system to allocate as many of its resources as possible to the attacker. In contrast with other DoS cyber-attacks, the slow-rate DoS attack aims to spread the initiation of its' connections through a large timeframe instead of flooding the target system constantly, with either malformed or valid packets, while keeping as many of them as possible open while periodically sending HTTP headers to the target system in order to keep the connections open and ultimately consume as many resources of the target system as possible. These lead to degrading the target system's services and preventing the serving of actual clients.

3.2.2. Data collection and training of the AI model

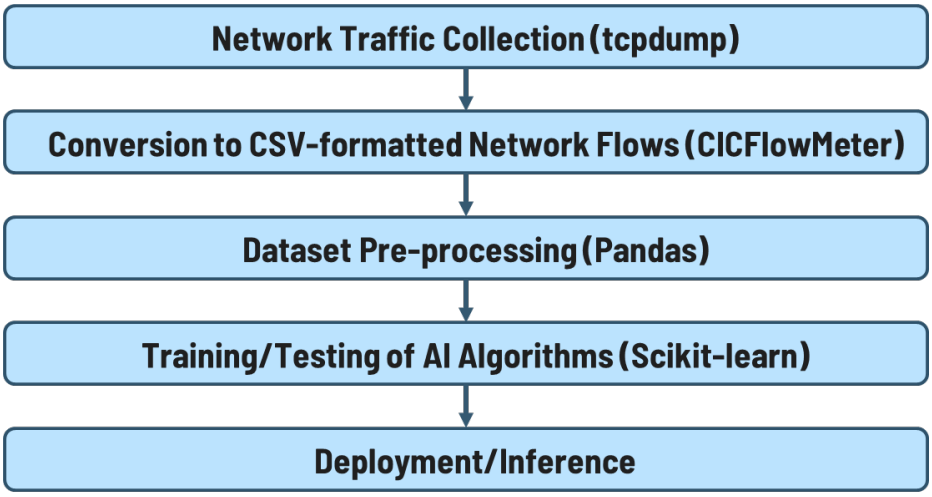

Figure 4: Main Steps of the Cyberattack Detection Experiments

The main steps involved in the AI-based cyberattack detection experiments are summarized in Figure 4. Initially, the network traffic was collected from the micro-operator in .pcap files. After the collection of network traffic, the network flows were extracted into a .csv file using the CICFlowMeter software [12]. Next, the information about the timeline and type of the attacks, the .csv file was annotated and the flows were classified into benign flows and attack flows. Finally, the scikit-learn framework [13] was used for the training and testing of the AI algorithms.

Figure 5 illustrates the samples of each traffic type that are included in the dataset. In total, 587.733 samples are included in the dataset, with each one having 84 features. Moreover, Figure 6 shows the accuracy and F1-score of the neural network (NN) and the eXtreme Gradient Boosting (XGB) algorithms.

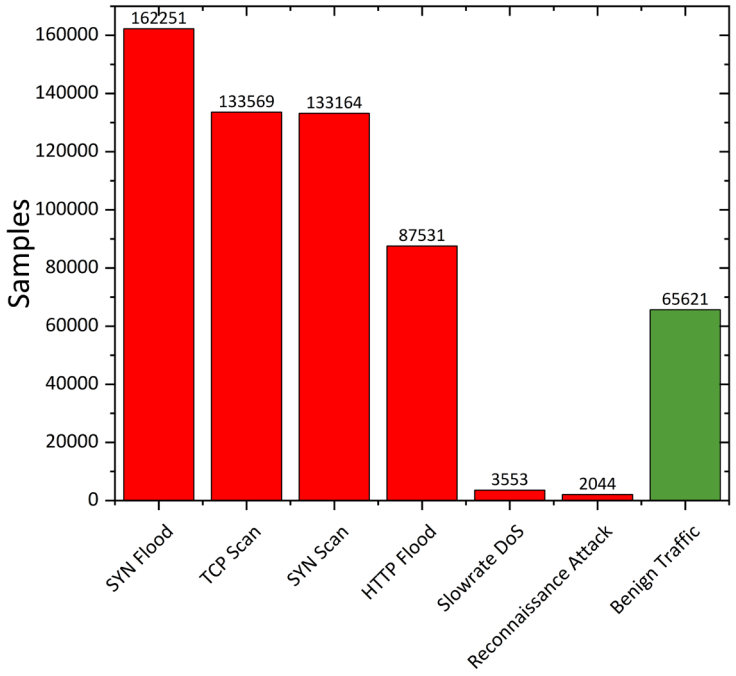

Figure 5: Samples and Traffic Type

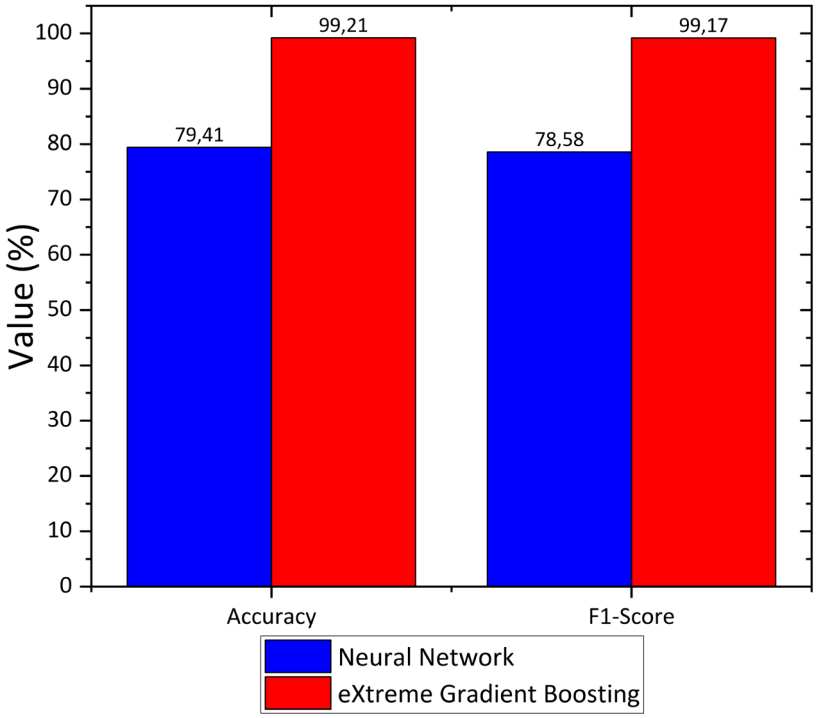

Figure 6: Performance of Neural Network and eXtreme Gradient Boosting

3.2.3. Dataset Structure

Table 7 provides the description of the respective files that are included in the dataset.

Table 7: Cyberattacks Dataset Structure

File	Description
Network_Traffic_Capture.pcap	This file includes all the packets that were captured during the experimentation. Specifically, it contains packets from benign and malicious network traffic. The benign traffic is associated with browsing and video streaming activities, while the malicious traffic is associated with the 7 types of attacks that were carried out against the main operator and micro-operator services.
Network_Flows_Annotated.csv	This file is the output of the CICFlowMeter, along with the respective annotations that map the flows to benign traffic or to one of the 7 attacks.

4. Conclusion

This document describes the 2nd dataset generated using the Greek in-lab testbed. The objective of the Greek in-lab testbed is to evaluate the NANCY outcomes, specifically in the context of a wireless range expansion use case. To elaborate, the experiments involve two topologies: a) one where a UE directly connects to the main operator's network through a 5G NR link, and b) one where a UE connects through the micro-operator's network.

In summary, the deliverable provides an overview of the Greek in-lab testbed topology and describes the main hardware and software components. Moreover, it outlines the experiments that were carried out to generate the datasets and provides details of the dataset structure and content. Streaming VR videos at different resolutions provided useful insights into how the testbed handles different levels of data load. The data collected from the streaming of videos of various resolutions aimed to assess the Greek in-lab testbed in handling large data volumes without compromising the user experience. As expected, when the video resolution was increased, the collected network metrics (e.g., downlink throughput, downlink data volume, etc.) were also increased. Finally, the aim of the cyberattack experimentation scenarios was to generate benign and malicious traffic flows in order to form a dataset for training and evaluating AI-based detection mechanisms.

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Appendix A – VR Video Streaming & iPerf3 on O-RAN 5G Testbed

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

```
├──Topology A
│   ├──Optimal_Propagation_Environment
│   │   ├──iPerf_TCP
│   │   │       gnb_e1ap.pcap
│   │   │       gnb_e2ap.pcap
│   │   │       gnb_f1ap.pcap
│   │   │       gnb_mac.pcap
│   │   │       gnb_n3.pcap
│   │   │       gnb_ngap.pcap
│   │   │       gnb_rlc.pcap
│   │   │       iperf_stats_client.json
│   │   │       iperf_stats_server.json
│   │   │       RAN_metrics.csv
│   │   │       tcpdump.pcap
│   │   │
│   │   ├──iPerf_UDP
│   │   │       gnb_e1ap.pcap
│   │   │       gnb_e2ap.pcap
│   │   │       gnb_f1ap.pcap
│   │   │       gnb_mac.pcap
│   │   │       gnb_n3.pcap
│   │   │       gnb_ngap.pcap
│   │   │       gnb_rlc.pcap
│   │   │       iperf_stats_client.json
│   │   │       RAN_metrics.csv
│   │   │       tcpdump.pcap
│   │   │
│   │   ├──VR_2K
│   │   │       gnb_e1ap.pcap
│   │   │       gnb_e2ap.pcap
│   │   │       gnb_f1ap.pcap
│   │   │       gnb_mac.pcap
│   │   │       gnb_n3.pcap
│   │   │       gnb_ngap.pcap
│   │   │       gnb_rlc.pcap
│   │   │       RAN_metrics.csv
│   │   │       tcpdump.pcap
│   │   │
│   │   ├──VR_4K
│   │   │       gnb_e1ap.pcap
│   │   │       gnb_e2ap.pcap
│   │   │       gnb_f1ap.pcap
│   │   │       gnb_mac.pcap
│   │   │       gnb_n3.pcap
│   │   │       gnb_ngap.pcap
│   │   │       gnb_rlc.pcap
│   │   │       RAN_metrics.csv
│   │   │       tcpdump.pcap
│   │   │
│   │   └──VR_FHD
│   │           gnb_e1ap.pcap
│   │           gnb_e2ap.pcap
│   │           gnb_f1ap.pcap
│   │           gnb_mac.pcap
│   │           gnb_n3.pcap
│   │           gnb_ngap.pcap
│   │           gnb_rlc.pcap
```

```
│   │           RAN_metrics.csv
│   │           tcpdump.pcap
│   │
│   └──Suboptimal_Propagation_Environment
│       ├──iPerf_TCP
│       │       gnb_e1ap.pcap
│       │       gnb_e2ap.pcap
│       │       gnb_f1ap.pcap
│       │       gnb_mac.pcap
│       │       gnb_n3.pcap
│       │       gnb_ngap.pcap
│       │       gnb_rlc.pcap
│       │       iperf_stats_client.json
│       │       iperf_stats_server.json
│       │       RAN_metrics.csv
│       │       tcpdump.pcap
│       │
│       ├──iPerf_UDP
│       │       gnb_e1ap.pcap
│       │       gnb_e2ap.pcap
│       │       gnb_f1ap.pcap
│       │       gnb_mac.pcap
│       │       gnb_n3.pcap
│       │       gnb_ngap.pcap
│       │       gnb_rlc.pcap
│       │       iperf_stats_client.json
│       │       RAN_metrics.csv
│       │       tcpdump.pcap
│       │
│       ├──VR_2K
│       │       gnb_e1ap.pcap
│       │       gnb_e2ap.pcap
│       │       gnb_f1ap.pcap
│       │       gnb_mac.pcap
│       │       gnb_n3.pcap
│       │       gnb_ngap.pcap
│       │       gnb_rlc.pcap
│       │       RAN_metrics.csv
│       │       tcpdump.pcap
│       │
│       ├──VR_4K
│       │       gnb_e1ap.pcap
│       │       gnb_e2ap.pcap
│       │       gnb_f1ap.pcap
│       │       gnb_mac.pcap
│       │       gnb_n3.pcap
│       │       gnb_ngap.pcap
│       │       gnb_rlc.pcap
│       │       RAN_metrics.csv
│       │       tcpdump.pcap
│       │
│       └──VR_FHD
│               gnb_e1ap.pcap
│               gnb_e2ap.pcap
│               gnb_f1ap.pcap
│               gnb_mac.pcap
│               gnb_n3.pcap
│               gnb_ngap.pcap
│               gnb_rlc.pcap
│               RAN_metrics.csv
│               tcpdump.pcap
```

```
└──Topology B
    ├──Optimal_Propagation_Environment
    │   ├──iPerf_TCP
    │   │   │   iperf_stats_client.json
    │   │   │
    │   │   ├──Main_Operator
    │   │   │       gnb_e1ap.pcap
    │   │   │       gnb_e2ap.pcap
    │   │   │       gnb_f1ap.pcap
    │   │   │       gnb_mac.pcap
    │   │   │       gnb_n3.pcap
    │   │   │       gnb_ngap.pcap
    │   │   │       gnb_rlc.pcap
    │   │   │       iperf_stats_server.json
    │   │   │       RAN_metrics.csv
    │   │   │       tcpdump.pcap
    │   │   │
    │   │   └──Micro_Operator
    │   │           gnb_e1ap.pcap
    │   │           gnb_e2ap.pcap
    │   │           gnb_f1ap.pcap
    │   │           gnb_mac.pcap
    │   │           gnb_n3.pcap
    │   │           gnb_ngap.pcap
    │   │           gnb_rlc.pcap
    │   │           RAN_metrics.csv
    │   │           tcpdump.pcap
    │   │
    │   ├──iPerf_UDP
    │   │   │   iperf_stats_client.json
    │   │   │
    │   │   ├──Main_Operator
    │   │   │       gnb_e1ap.pcap
    │   │   │       gnb_e2ap.pcap
    │   │   │       gnb_f1ap.pcap
    │   │   │       gnb_mac.pcap
    │   │   │       gnb_n3.pcap
    │   │   │       gnb_ngap.pcap
    │   │   │       gnb_rlc.pcap
    │   │   │       RAN_metrics.csv
    │   │   │       tcpdump.pcap
    │   │   │
    │   │   └──Micro_Operator
    │   │           gnb_e1ap.pcap
    │   │           gnb_e2ap.pcap
    │   │           gnb_f1ap.pcap
    │   │           gnb_mac.pcap
    │   │           gnb_n3.pcap
    │   │           gnb_ngap.pcap
    │   │           gnb_rlc.pcap
    │   │           RAN_metrics.csv
    │   │           tcpdump.pcap
    │   │
    │   ├──VR_2K
    │   │   ├──Main_Operator
    │   │   │       gnb_e1ap.pcap
    │   │   │       gnb_e2ap.pcap
    │   │   │       gnb_f1ap.pcap
    │   │   │       gnb_mac.pcap
    │   │   │       gnb_n3.pcap
```

```
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│   │   │       gnb_rlc.pcap
│   │   │       RAN_metrics.csv
│   │   │       tcpdump.pcap
│   │   │
│   │   └──Micro_Operator
│   │           gnb_e1ap.pcap
│   │           gnb_e2ap.pcap
│   │           gnb_f1ap.pcap
│   │           gnb_mac.pcap
│   │           gnb_n3.pcap
│   │           gnb_ngap.pcap
│   │           gnb_rlc.pcap
│   │           RAN_metrics.csv
│   │           tcpdump.pcap
│   │
│   ├──VR_4K
│   │   ├──Main_Operator
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│   │   │       gnb_e2ap.pcap
│   │   │       gnb_f1ap.pcap
│   │   │       gnb_mac.pcap
│   │   │       gnb_n3.pcap
│   │   │       gnb_ngap.pcap
│   │   │       gnb_rlc.pcap
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│   │   │       tcpdump.pcap
│   │   │
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│   │           gnb_e2ap.pcap
│   │           gnb_f1ap.pcap
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│   │           gnb_n3.pcap
│   │           gnb_ngap.pcap
│   │           gnb_rlc.pcap
│   │           RAN_metrics.csv
│   │           tcpdump.pcap
│   │
│   └──VR_FHD
│       ├──Main_Operator
│       │       gnb_e1ap.pcap
│       │       gnb_e2ap.pcap
│       │       gnb_f1ap.pcap
│       │       gnb_mac.pcap
│       │       gnb_n3.pcap
│       │       gnb_ngap.pcap
│       │       gnb_rlc.pcap
│       │       RAN_metrics.csv
│       │       tcpdump.pcap
│       │
│       └──Micro_Operator
│               gnb_e1ap.pcap
│               gnb_e2ap.pcap
│               gnb_f1ap.pcap
│               gnb_mac.pcap
│               gnb_n3.pcap
│               gnb_ngap.pcap
│               gnb_rlc.pcap
│               RAN_metrics.csv
│               tcpdump.pcap
```

```
└──Suboptimal_Propagation_Environment
    ├──iPerf_TCP
    │   │   iperf_stats_client.json
    │   │
    │   ├──Main_Operator
    │   │       gnb_e1ap.pcap
    │   │       gnb_e2ap.pcap
    │   │       gnb_f1ap.pcap
    │   │       gnb_mac.pcap
    │   │       gnb_n3.pcap
    │   │       gnb_ngap.pcap
    │   │       gnb_rlc.pcap
    │   │       iperf_stats_server.json
    │   │       RAN_metrics.csv
    │   │       tcpdump.pcap
    │   │
    │   └──Micro_Operator
    │           gnb_e1ap.pcap
    │           gnb_e2ap.pcap
    │           gnb_f1ap.pcap
    │           gnb_mac.pcap
    │           gnb_n3.pcap
    │           gnb_ngap.pcap
    │           gnb_rlc.pcap
    │           RAN_metrics.csv
    │           tcpdump.pcap
    │
    ├──iPerf_UDP
    │   │   iperf_stats_client.json
    │   │
    │   ├──Main_Operator
    │   │       gnb_e1ap.pcap
    │   │       gnb_e2ap.pcap
    │   │       gnb_f1ap.pcap
    │   │       gnb_mac.pcap
    │   │       gnb_n3.pcap
    │   │       gnb_ngap.pcap
    │   │       gnb_rlc.pcap
    │   │       RAN_metrics.csv
    │   │       tcpdump.pcap
    │   │
    │   └──Micro_Operator
    │           gnb_e1ap.pcap
    │           gnb_e2ap.pcap
    │           gnb_f1ap.pcap
    │           gnb_mac.pcap
    │           gnb_n3.pcap
    │           gnb_ngap.pcap
    │           gnb_rlc.pcap
    │           RAN_metrics.csv
    │           tcpdump.pcap
    │
    ├──VR_2K
    │   ├──Main_Operator
    │   │       gnb_e1ap.pcap
    │   │       gnb_e2ap.pcap
    │   │       gnb_f1ap.pcap
    │   │       gnb_mac.pcap
    │   │       gnb_n3.pcap
    │   │       gnb_ngap.pcap
```

```
│   │       gnb_rlc.pcap
│   │       RAN_metrics.csv
│   │       tcpdump.pcap
│   │
│   └──Micro_Operator
│           gnb_e1ap.pcap
│           gnb_e2ap.pcap
│           gnb_f1ap.pcap
│           gnb_mac.pcap
│           gnb_n3.pcap
│           gnb_ngap.pcap
│           gnb_rlc.pcap
│           RAN_metrics.csv
│           tcpdump.pcap
│
├──VR_4K
│   ├──Main_Operator
│   │       gnb_e1ap.pcap
│   │       gnb_e2ap.pcap
│   │       gnb_f1ap.pcap
│   │       gnb_mac.pcap
│   │       gnb_n3.pcap
│   │       gnb_ngap.pcap
│   │       gnb_rlc.pcap
│   │       RAN_metrics.csv
│   │       tcpdump.pcap
│   │
│   └──Micro_Operator
│           gnb_e1ap.pcap
│           gnb_e2ap.pcap
│           gnb_f1ap.pcap
│           gnb_mac.pcap
│           gnb_n3.pcap
│           gnb_ngap.pcap
│           gnb_rlc.pcap
│           RAN_metrics.csv
│           tcpdump.pcap
│
└──VR_FHD
    ├──Main_Operator
    │       gnb_e1ap.pcap
    │       gnb_e2ap.pcap
    │       gnb_f1ap.pcap
    │       gnb_mac.pcap
    │       gnb_n3.pcap
    │       gnb_ngap.pcap
    │       gnb_rlc.pcap
    │       RAN_metrics.csv
    │       tcpdump.pcap
    │
    └──Micro_Operator
            capture.pcap
            gnb_e1ap.pcap
            gnb_e2ap.pcap
            gnb_f1ap.pcap
            gnb_mac.pcap
            gnb_n3.pcap
            gnb_ngap.pcap
            gnb_rlc.pcap
            RAN_metrics.csv
```

Appendix B – Cyberattacks Timeline in the Cyberattack Detection Dataset

The following table provides details related to the attack type, target and the time frame of the attack:

No.	Time	Attack Type	Target (IP)
1	13:46 - 14:09	Reconnaissance Attack	Main Operator (10.45.0.1)
2	14:16 - 14:37	Reconnaissance Attack	Micro-Operator (10.46.0.1)
3	14:48 - 15:16	UDP Scan (All 65.535 ports)	Main Operator (10.45.0.1)
4	15:28 - 15:30	TCP Connect Scan (All 65.535 ports)	Main Operator (10.45.0.1)
5	15:35 - 15:57	UDP Scan (All 65.535 ports)	Micro-Operator (10.46.0.1)
6	16:03 - 16:04	TCP Connect Scan (All 65.535 ports)	Micro-Operator (10.46.0.1)
7	16:08 - 16:10	SYN Scan (All 65.535 ports)	Main Operator (10.45.0.1)
8	16:16 - 16:17	SYN Scan (All 65.535 ports)	Micro-Operator (10.46.0.1)
9	16:30 - 16:31	Reconnaissance Attack (Probe common ports & OS detection)	Main Operator (10.45.0.1)
10	16:40 - 16:41	Reconnaissance Attack (Probe common ports & OS detection)	Micro-Operator (10.46.0.1)
11	16:52 - 16:56	SYN Flood (Ports: 1-10.000)	Main Operator (10.45.0.1)
12	17:48 - 17:50	ICMP Flood (Ports: 1-10.000)	Main Operator (10.45.0.1)
13	17:55 – 17:55	ICMP Flood (Ports: 1-10.000)	Main Operator (10.45.0.1)
14	18:26 - 18:27	SYN Flood (Port: 80)	Main Operator (10.45.0.1)
15	18:39 – 18:40	SYN Flood (Port: 80)	Micro-Operator (10.46.0.1)
16	19:13 – 19:21	HTTP Flood (Port 80)	Main Operator (10.45.0.1)
17	19:25 – 19:32	HTTP Flood (Port: 80)	Micro-Operator (10.46.0.1)
18	19:34 – 19:34	HTTP Flood (Port: 3000)	Main Operator (10.45.0.1)
19	19:49 – 19:54	Slowrate DoS (Slowloris)	Main Operator (10.45.0.1)
20	19:56 – 20:01	Slowrate DoS (Slowloris)	Micro-Operator (10.46.0.1)

Appendix C - 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.

Topology A

Optimal Propagation Environment

iPerf3 – Main Operator

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	6	100.0	374	57	0	0	0	6
DLT User	100.0	6	100.0	374	57	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	57	6	374	57	6

gnb_e1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	249	100.0	111581	3232	0	0	0	249
DLT User	100.0	249	100.0	111581	3232	0	0	0	249
E2 Application Protocol	100.0	249	100.0	111581	3232	200	88368	2559	249
Malformed Packet	0.4	1	0.0	0	0	1	0	0	1
Dissector Bug	19.3	48	0.0	0	0	48	0	0	48

gnb_e2ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	77	100.0	10363	293	0	0	0	77
DLT User	100.0	77	100.0	10363	293	0	0	0	77
F1 Application Protocol	100.0	77	100.0	10363	293	77	10363	293	77

gnb_f1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	237440	100.0	2021800846	57 M	0	0	0	237440
DLT User	100.0	237440	100.0	2021800846	57 M	0	0	0	237440
User Datagram Protocol	100.0	237440	0.1	1899520	53 k	0	0	0	237440
MAC-NR	100.0	237440	99.6	2014440206	57 M	237440	2014440206	57 M	237440

gnb_mac.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	1530106	100.0	1998638725	70 M	0	0	0	1530106
DLT User	100.0	1530106	100.0	1998638725	70 M	0	0	0	1530106
GPRS Tunneling Protocol	100.0	1530106	1.2	24481696	866 k	0	0	0	1530106
Internet Protocol Version 4	100.0	1530106	1.5	30602120	1082 k	0	0	0	1530106
User Datagram Protocol	0.1	1319	0.0	10552	373	0	0	0	1319
Simple Network Management Protocol	0.0	206	0.0	15239	539	206	15239	539	206
QUIC IETF	0.0	556	0.0	237883	8415	556	222918	7886	598
Network Time Protocol	0.0	2	0.0	96	3	2	96	3	2
Domain Name System	0.0	555	0.0	61008	2158	555	61008	2158	555
Transmission Control Protocol	99.9	1528493	1.5	30595836	1082 k	120379	2433460	86 k	1528493
Transport Layer Security	0.3	3875	0.2	3380179	119 k	3875	3262413	115 k	3917
iPerf3 Speed Test	91.8	1404074	95.5	1908443793	67 M	14	537	18	1404076
Hypertext Transfer Protocol	0.0	8	0.0	1190	42	4	530	18	8
Line-based text data	0.0	4	0.0	88	3	4	88	3	4
Internet Control Message Protocol	0.0	117	0.0	57279	2026	117	57279	2026	117
Data	91.8	1404394	95.5	1908699413	67 M	1404394	1908699413	67 M	1404394

gnb_n3.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	56	100.0	8348	298	0	0	0	56
DLT User	100.0	56	100.0	8348	298	0	0	0	56
NG Application Protocol	100.0	56	100.0	8348	298	56	8348	298	56

gnb_ngap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	1781896	100.0	2037405932	59 M	0	0	0	1781896
DLT User	100.0	1781896	100.0	2037405932	59 M	0	0	0	1781896
User Datagram Protocol	100.0	1781896	0.7	14255168	417 k	0	0	0	1781896
RLC-NR	100.0	1781896	97.7	1991076636	58 M	1781896	1991076636	58 M	1781896

gnb_rlc.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	1529846	100.0	1974115931	53 M	0	0	0	1529846
Raw packet data	100.0	1529846	100.0	1974115931	53 M	0	0	0	1529846
Internet Protocol Version 4	100.0	1529846	1.5	30596920	828 k	0	0	0	1529846
User Datagram Protocol	0.1	1298	0.0	10384	281	0	0	0	1298
Simple Network Management Protocol	0.0	204	0.0	15005	406	204	15005	406	204
QUIC IETF	0.0	547	0.0	230075	6231	547	217585	5893	585
Network Time Protocol	0.0	2	0.0	96	2	2	96	2	2
Domain Name System	0.0	545	0.0	60374	1635	545	60374	1635	545
Transmission Control Protocol	99.9	1528256	1.5	30590956	828 k	120203	2429800	65 k	1528256
Transport Layer Security	0.2	3815	0.2	3360699	91 k	3815	3242933	87 k	3857
iPerf3 Speed Test	91.8	1404074	96.7	1908443793	51 M	14	537	14	1404076
Hypertext Transfer Protocol	0.0	8	0.0	1190	32	4	530	14	8
Line-based text data	0.0	4	0.0	88	2	4	88	2	4
Internet Control Message Protocol	0.0	116	0.0	56723	1536	116	56723	1536	116
Data	91.8	1404392	96.7	1908698036	51 M	1404392	1908698036	51 M	1404392

tcpdump.pcap

VR_FHD – Main Operator

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	6	100.0	374	53	0	0	0	6
DLT User	100.0	6	100.0	374	53	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	53	6	374	53	6

gnb_e1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	358	100.0	160697	3114	0	0	0	358
DLT User	100.0	358	100.0	160697	3114	0	0	0	358
E2 Application Protocol	100.0	358	100.0	160697	3114	175	77190	1495	358
Malformed Packet	0.3	1	0.0	0	0	1	0	0	1
Dissector Bug	50.8	182	0.0	0	0	182	0	0	182

gnb_e2ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	113	100.0	15272	293	0	0	0	113
DLT User	100.0	113	100.0	15272	293	0	0	0	113
F1 Application Protocol	100.0	113	100.0	15272	293	113	15272	293	113

gnb_f1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	38481	100.0	126173881	2429 k	0	0	0	38481
DLT User	100.0	38481	100.0	126173881	2429 k	0	0	0	38481
User Datagram Protocol	100.0	38481	0.2	307848	5928	0	0	0	38481
MAC-NR	100.0	38481	99.1	124980970	2406 k	38481	124980970	2406 k	38481

gnb_mac.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	125198	100.0	119089466	2678 k	0	0	0	125198
DLT User	100.0	125198	100.0	119089466	2678 k	0	0	0	125198
GPRS Tunneling Protocol	100.0	125198	1.7	2003168	45 k	0	0	0	125198
Internet Protocol Version 4	100.0	125198	2.1	2503960	56 k	0	0	0	125198
User Datagram Protocol	77.8	97428	0.7	779424	17 k	0	0	0	97428
QUIC IETF	76.8	96145	87.1	103685841	2331 k	96145	103526767	2328 k	96326
Network Time Protocol	0.0	2	0.0	96	2	2	96	2	2
Domain Name System	1.0	1281	0.1	114502	2575	1281	114502	2575	1281
Transmission Control Protocol	19.8	24738	0.7	814388	18 k	15578	523240	11 k	24738
Transport Layer Security	7.3	9077	6.7	7953452	178 k	9077	5871054	132 k	9529
Post Office Protocol	0.0	15	0.0	459	10	15	459	10	15
Internet Message Access Protocol	0.0	6	0.0	354	7	6	354	7	6
Hypertext Transfer Protocol	0.0	2	0.0	597	13	1	427	9	2
Line-based text data	0.0	1	0.0	22	0	1	22	0	1
Internet Control Message Protocol	0.3	356	0.1	89298	2008	356	89298	2008	356
Data	2.2	2736	3.1	3722779	83 k	2736	3722779	83 k	2736

gnb_n3.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	82	100.0	9910	197	0	0	0	82
DLT User	100.0	82	100.0	9910	197	0	0	0	82
NG Application Protocol	100.0	82	100.0	9910	197	82	9910	197	82

gnb_ngap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	155578	100.0	122775268	2443 k	0	0	0	155578
DLT User	100.0	155578	100.0	122775268	2443 k	0	0	0	155578
User Datagram Protocol	100.0	155578	1.0	1244624	24 k	0	0	0	155578
RLC-NR	100.0	155578	96.7	118730240	2363 k	155578	118730240	2363 k	155578

gnb_rlc.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	125196	100.0	117090266	2187 k	0	0	0	125196
Raw packet data	100.0	125196	100.0	117090266	2187 k	0	0	0	125196
Internet Protocol Version 6	0.0	1	0.0	40	0	0	0	0	1
Internet Control Message Protocol v6	0.0	1	0.0	16	0	1	16	0	1
Internet Protocol Version 4	100.0	125195	2.1	2503900	46 k	0	0	0	125195
User Datagram Protocol	77.8	97428	0.7	779424	14 k	0	0	0	97428
QUIC IETF	76.8	96145	88.6	103685841	1937 k	96145	103526767	1934 k	96326
Network Time Protocol	0.0	2	0.0	96	1	2	96	1	2
Domain Name System	1.0	1281	0.1	114502	2139	1281	114502	2139	1281
Transmission Control Protocol	19.8	24735	0.7	814628	15 k	15559	522968	9770	24735
Transport Layer Security	7.3	9093	6.8	7957810	148 k	9093	5875412	109 k	9545
Post Office Protocol	0.0	15	0.0	459	8	15	459	8	15
Internet Message Access Protocol	0.0	6	0.0	354	6	6	354	6	6
Hypertext Transfer Protocol	0.0	2	0.0	597	11	1	427	7	2
Line-based text data	0.0	1	0.0	22	0	1	22	0	1
Internet Control Message Protocol	0.3	356	0.1	89298	1668	356	89298	1668	356
Data	2.2	2736	3.2	3722779	69 k	2736	3722779	69 k	2736

tcpdump.pcap

VR_2K – Main Operator

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	6	100.0	374	52	0	0	0	6
DLT User	100.0	6	100.0	374	52	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	52	6	374	52	6

gnb_e1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	277	100.0	124220	3029	0	0	0	277
DLT User	100.0	277	100.0	124220	3029	0	0	0	277
E2 Application Protocol	100.0	277	100.0	124220	3029	121	52961	1291	277
Malformed Packet	0.4	1	0.0	0	0	1	0	0	1
Dissector Bug	56.0	155	0.0	0	0	155	0	0	155

gnb_e2ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	77	100.0	10357	251	0	0	0	77
DLT User	100.0	77	100.0	10357	251	0	0	0	77
F1 Application Protocol	100.0	77	100.0	10357	251	77	10357	251	77

gnb_f1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	48577	100.0	279142387	6788 k	0	0	0	48577
DLT User	100.0	48577	100.0	279142387	6788 k	0	0	0	48577
User Datagram Protocol	100.0	48577	0.1	388616	9450	0	0	0	48577
MAC-NR	100.0	48577	99.5	277636500	6751 k	48577	277636500	6751 k	48577

gnb_mac.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	252506	100.0	272840755	8073 k	0	0	0	252506
DLT User	100.0	252506	100.0	272840755	8073 k	0	0	0	252506
GPRS Tunneling Protocol	100.0	252506	1.5	4040096	119 k	0	0	0	252506
Internet Protocol Version 4	100.0	252506	1.9	5050120	149 k	0	0	0	252506
User Datagram Protocol	94.7	239223	0.7	1913784	56 k	0	0	0	239223
QUIC IETF	94.5	238535	94.1	256629636	7593 k	238535	256560486	7591 k	238620
Network Time Protocol	0.0	2	0.0	96	2	2	96	2	2
Domain Name System	0.3	686	0.0	60835	1800	686	60835	1800	686
Transmission Control Protocol	5.2	13061	0.2	419344	12 k	8937	289380	8562	13061
Transport Layer Security	1.6	4055	1.6	4234603	125 k	4055	4042971	119 k	4084
Post Office Protocol	0.0	10	0.0	306	9	10	306	9	10
Internet Message Access Protocol	0.0	6	0.0	354	10	6	354	10	6
Hypertext Transfer Protocol	0.0	4	0.0	1194	35	2	854	25	4
Line-based text data	0.0	2	0.0	44	1	2	44	1	2
Data	0.0	49	0.0	48810	1444	49	48810	1444	49
Internet Control Message Protocol	0.0	91	0.0	18876	558	91	18876	558	91
Data	0.1	131	0.1	180256	5333	131	180256	5333	131

gnb_n3.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	56	100.0	8339	294	0	0	0	56
DLT User	100.0	56	100.0	8339	294	0	0	0	56
NG Application Protocol	100.0	56	100.0	8339	294	56	8339	294	56

gnb_ngap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	297703	100.0	278727307	7140 k	0	0	0	297703
DLT User	100.0	297703	100.0	278727307	7140 k	0	0	0	297703
User Datagram Protocol	100.0	297703	0.9	2381624	61 k	0	0	0	297703
RLC-NR	100.0	297703	97.2	270987029	6941 k	297703	270987029	6941 k	297703

gnb_rlc.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	252494	100.0	268802478	7454 k	0	0	0	252494
Raw packet data	100.0	252494	100.0	268802478	7454 k	0	0	0	252494
Internet Protocol Version 4	100.0	252494	1.9	5049880	140 k	0	0	0	252494
User Datagram Protocol	94.7	239223	0.7	1913784	53 k	0	0	0	239223
QUIC IETF	94.5	238535	95.5	256629636	7116 k	238535	256560486	7114 k	238620
Network Time Protocol	0.0	2	0.0	96	2	2	96	2	2
Domain Name System	0.3	686	0.0	60835	1686	686	60835	1686	686
Transmission Control Protocol	5.2	13049	0.2	419224	11 k	8920	289100	8016	13049
Transport Layer Security	1.6	4060	1.6	4235064	117 k	4060	4043432	112 k	4089
Post Office Protocol	0.0	10	0.0	306	8	10	306	8	10
Internet Message Access Protocol	0.0	6	0.0	354	9	6	354	9	6
Hypertext Transfer Protocol	0.0	4	0.0	1194	33	2	854	23	4
Line-based text data	0.0	2	0.0	44	1	2	44	1	2
Data	0.0	49	0.0	48810	1353	49	48810	1353	49
Internet Control Message Protocol	0.0	91	0.0	18876	523	91	18876	523	91
Data	0.1	131	0.1	180256	4998	131	180256	4998	131

tcpdump.pcap

VR_4K – Main Operator

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	6	100.0	374	51	0	0	0	6
DLT User	100.0	6	100.0	374	51	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	51	6	374	51	6

gnb_e1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	316	100.0	141848	2994	0	0	0	316
DLT User	100.0	316	100.0	141848	2994	0	0	0	316
E2 Application Protocol	100.0	316	100.0	141848	2994	158	69658	1470	316
Malformed Packet	0.3	1	0.0	0	0	1	0	0	1
Dissector Bug	49.7	157	0.0	0	0	157	0	0	157

gnb_e2ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	81	100.0	10729	225	0	0	0	81
DLT User	100.0	81	100.0	10729	225	0	0	0	81
F1 Application Protocol	100.0	81	100.0	10729	225	81	10729	225	81

gnb_f1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	75985	100.0	470601679	9889 k	0	0	0	75985
DLT User	100.0	75985	100.0	470601679	9889 k	0	0	0	75985
User Datagram Protocol	100.0	75985	0.1	607880	12 k	0	0	0	75985
MAC-NR	100.0	75985	99.5	468246144	9839 k	75985	468246144	9839 k	75985

gnb_mac.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	397482	100.0	460355259	11 M	0	0	0	397482
DLT User	100.0	397482	100.0	460355259	11 M	0	0	0	397482
GPRS Tunneling Protocol	100.0	397482	1.4	6359712	158 k	0	0	0	397482
Internet Protocol Version 4	100.0	397482	1.7	7949640	197 k	0	0	0	397482
User Datagram Protocol	94.7	376579	0.7	3012632	75 k	0	0	0	376579
QUIC IETF	94.6	375985	94.2	433583869	10 M	375985	433520464	10 M	376060
Network Time Protocol	0.0	8	0.0	384	9	8	384	9	8
Domain Name System	0.1	586	0.0	51258	1276	586	51258	1276	586
Transmission Control Protocol	4.8	19040	0.1	621552	15 k	13374	441064	10 k	19040
Transport Layer Security	1.4	5632	1.7	7953497	198 k	5632	5219704	129 k	5964
Post Office Protocol	0.0	5	0.0	153	3	5	153	3	5
Internet Message Access Protocol	0.0	3	0.0	175	4	3	175	4	3
Hypertext Transfer Protocol	0.0	5	0.0	1390	34	2	854	21	5
Line-based text data	0.0	3	0.0	358	8	3	358	8	3
Internet Control Message Protocol	0.0	150	0.0	49708	1237	150	49708	1237	150
Data	0.4	1734	0.5	2374281	59 k	1734	2374281	59 k	1734

gnb_n3.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	60	100.0	8696	182	0	0	0	60
DLT User	100.0	60	100.0	8696	182	0	0	0	60
NG Application Protocol	100.0	60	100.0	8696	182	60	8696	182	60

gnb_ngap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	468853	100.0	470126660	10 M	0	0	0	468853
DLT User	100.0	468853	100.0	470126660	10 M	0	0	0	468853
User Datagram Protocol	100.0	468853	0.8	3750824	82 k	0	0	0	468853
RLC-NR	100.0	468853	97.4	457936482	10 M	468853	457936482	10 M	468853

gnb_rlc.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	397578	100.0	454024299	9156 k	0	0	0	397578
Raw packet data	100.0	397578	100.0	454024299	9156 k	0	0	0	397578
Internet Protocol Version 6	0.0	1	0.0	40	0	0	0	0	1
Internet Control Message Protocol v6	0.0	1	0.0	16	0	1	16	0	1
Internet Protocol Version 4	100.0	397577	1.8	7951540	160 k	0	0	0	397577
User Datagram Protocol	94.7	376585	0.7	3012680	60 k	0	0	0	376585
QUIC IETF	94.6	375991	95.5	433584085	8744 k	375991	433520680	8742 k	376066
Network Time Protocol	0.0	8	0.0	384	7	8	384	7	8
Domain Name System	0.1	586	0.0	51258	1033	586	51258	1033	586
Transmission Control Protocol	4.8	19121	0.1	624420	12 k	13426	443040	8934	19121
Transport Layer Security	1.4	5661	1.8	7962322	160 k	5661	5228529	105 k	5993
Post Office Protocol	0.0	5	0.0	153	3	5	153	3	5
Internet Message Access Protocol	0.0	3	0.0	175	3	3	175	3	3
Hypertext Transfer Protocol	0.0	5	0.0	1390	28	2	854	17	5
Line-based text data	0.0	3	0.0	358	7	3	358	7	3
Internet Control Message Protocol	0.0	150	0.0	49708	1002	150	49708	1002	150
Data	0.4	1742	0.5	2385289	48 k	1742	2385289	48 k	1742

tcpdump.pcap

Suboptimal Propagation Environment

iPerf3 – Main Operator

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	6	100.0	374	40	0	0	0	6
DLT User	100.0	6	100.0	374	40	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	40	6	374	40	6

gnb_e1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	251	100.0	112729	2906	0	0	0	251
DLT User	100.0	251	100.0	112729	2906	0	0	0	251
E2 Application Protocol	100.0	251	100.0	112729	2906	216	95761	2468	251
Malformed Packet	0.4	1	0.0	0	0	1	0	0	1
Dissector Bug	13.5	34	0.0	0	0	34	0	0	34

gnb_e2ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	77	100.0	10363	264	0	0	0	77
DLT User	100.0	77	100.0	10363	264	0	0	0	77
F1 Application Protocol	100.0	77	100.0	10363	264	77	10363	264	77

gnb_f1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	246952	100.0	942932400	24 M	0	0	0	246952
DLT User	100.0	246952	100.0	942932400	24 M	0	0	0	246952
User Datagram Protocol	100.0	246952	0.2	1975616	50 k	0	0	0	246952
MAC-NR	100.0	246952	99.2	935276888	23 M	246952	935276888	23 M	246952

gnb_mac.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	762293	100.0	933359483	31 M	0	0	0	762293
DLT User	100.0	762293	100.0	933359483	31 M	0	0	0	762293
GPRS Tunneling Protocol	100.0	762293	1.3	12196688	408 k	0	0	0	762293
Internet Protocol Version 4	100.0	762293	1.6	15245860	510 k	0	0	0	762293
User Datagram Protocol	0.2	1321	0.0	10568	354	0	0	0	1321
Simple Network Management Protocol	0.0	141	0.0	11385	381	141	11385	381	141
QUIC IETF	0.1	842	0.0	310919	10 k	842	295586	9902	885
Network Time Protocol	0.0	2	0.0	96	3	2	96	3	2
Domain Name System	0.0	330	0.0	37962	1271	330	37962	1271	330
Transmission Control Protocol	99.8	760800	1.7	15500480	519 k	107210	2428632	81 k	760800
Transport Layer Security	0.5	4101	0.7	6129343	205 k	4101	5311245	177 k	4216
iPerf3 Speed Test	85.2	649344	94.6	882778673	29 M	14	537	17	649346
Hypertext Transfer Protocol	0.0	7	0.0	1025	34	4	530	17	7
Line-based text data	0.0	3	0.0	66	2	3	66	2	3
Internet Control Message Protocol	0.0	60	0.0	27784	930	60	27784	930	60
Data	85.2	649586	94.6	882951091	29 M	649586	882951091	29 M	649586

gnb_n3.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	56	100.0	8348	276	0	0	0	56
DLT User	100.0	56	100.0	8348	276	0	0	0	56
NG Application Protocol	100.0	56	100.0	8348	276	56	8348	276	56

gnb_ngap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	1021667	100.0	955633019	27 M	0	0	0	1021667
DLT User	100.0	1021667	100.0	955633019	27 M	0	0	0	1021667
User Datagram Protocol	100.0	1021667	0.9	8173336	234 k	0	0	0	1021667
RLC-NR	100.0	1021667	97.2	929069677	26 M	1021667	929069677	26 M	1021667

gnb_rlc.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	764172	100.0	923842580	24 M	0	0	0	764172
Raw packet data	100.0	764172	100.0	923842580	24 M	0	0	0	764172
Internet Protocol Version 4	100.0	764172	1.7	15283440	403 k	0	0	0	764172
User Datagram Protocol	0.2	1321	0.0	10568	279	0	0	0	1321
Simple Network Management Protocol	0.0	141	0.0	11385	300	141	11385	300	141
QUIC IETF	0.1	842	0.0	310919	8211	842	295586	7806	885
Network Time Protocol	0.0	2	0.0	96	2	2	96	2	2
Domain Name System	0.0	330	0.0	37962	1002	330	37962	1002	330
Transmission Control Protocol	99.8	762679	1.7	15538060	410 k	106911	2422652	63 k	762679
Transport Layer Security	0.5	4107	0.7	6129913	161 k	4107	5311815	140 k	4222
iPerf3 Speed Test	85.3	651516	95.9	885731329	23 M	14	537	14	651518
Hypertext Transfer Protocol	0.0	7	0.0	1025	27	4	530	13	7
Line-based text data	0.0	3	0.0	66	1	3	66	1	3
Internet Control Message Protocol	0.0	60	0.0	27784	733	60	27784	733	60
Data	85.3	651758	95.9	885903747	23 M	651758	885903747	23 M	651758

tcpdump.pcap

VR_FHD – Main Operator

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	6	100.0	374	53	0	0	0	6
DLT User	100.0	6	100.0	374	53	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	53	6	374	53	6

gnb_e1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	227	100.0	101717	2712	0	0	0	227
DLT User	100.0	227	100.0	101717	2712	0	0	0	227
E2 Application Protocol	100.0	227	100.0	101717	2712	104	45231	1206	227
Malformed Packet	0.4	1	0.0	0	0	1	0	0	1
Dissector Bug	53.7	122	0.0	0	0	122	0	0	122

gnb_e2ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	81	100.0	9679	256	0	0	0	81
DLT User	100.0	81	100.0	9679	256	0	0	0	81
F1 Application Protocol	100.0	81	100.0	9679	256	81	9679	256	81

gnb_f1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	36713	100.0	124944070	3313 k	0	0	0	36713
DLT User	100.0	36713	100.0	124944070	3313 k	0	0	0	36713
User Datagram Protocol	100.0	36713	0.2	293704	7788	0	0	0	36713
MAC-NR	100.0	36713	99.1	123805967	3283 k	36713	123805967	3283 k	36713

gnb_mac.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	114590	100.0	121862593	3942 k	0	0	0	114590
DLT User	100.0	114590	100.0	121862593	3942 k	0	0	0	114590
GPRS Tunneling Protocol	100.0	114590	1.5	1833440	59 k	0	0	0	114590
Internet Protocol Version 4	100.0	114590	1.9	2291800	74 k	0	0	0	114590
User Datagram Protocol	94.1	107836	0.7	862688	27 k	0	0	0	107836
QUIC IETF	93.8	107530	94.1	114711325	3711 k	107530	114680231	3710 k	107571
Network Time Protocol	0.0	2	0.0	96	3	2	96	3	2
Domain Name System	0.3	304	0.0	27447	888	304	27447	888	304
Transmission Control Protocol	5.8	6670	0.2	212644	6879	4035	129572	4192	6670
Transport Layer Security	2.3	2601	1.4	1652909	53 k	2601	1256316	40 k	2718
Post Office Protocol	0.0	10	0.0	306	9	10	306	9	10
Internet Message Access Protocol	0.0	3	0.0	177	5	3	177	5	3
Hypertext Transfer Protocol	0.0	2	0.0	597	19	1	427	13	2
Line-based text data	0.0	1	0.0	22	0	1	22	0	1
Internet Control Message Protocol	0.0	34	0.0	3824	123	34	3824	123	34
Data	0.1	69	0.1	80039	2589	69	80039	2589	69

gnb_n3.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	60	100.0	6492	203	0	0	0	60
DLT User	100.0	60	100.0	6492	203	0	0	0	60
NG Application Protocol	100.0	60	100.0	6492	203	60	6492	203	60

gnb_ngap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	149340	100.0	124917417	3480 k	0	0	0	149340
DLT User	100.0	149340	100.0	124917417	3480 k	0	0	0	149340
User Datagram Protocol	100.0	149340	1.0	1194720	33 k	0	0	0	149340
RLC-NR	100.0	149340	96.9	121034577	3372 k	149340	121034577	3372 k	149340

gnb_rlc.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	114618	100.0	120031028	3527 k	0	0	0	114618
Raw packet data	100.0	114618	100.0	120031028	3527 k	0	0	0	114618
Internet Protocol Version 4	100.0	114618	1.9	2292360	67 k	0	0	0	114618
User Datagram Protocol	94.1	107836	0.7	862688	25 k	0	0	0	107836
QUIC IETF	93.8	107530	95.6	114711325	3371 k	107530	114680231	3370 k	107571
Network Time Protocol	0.0	2	0.0	96	2	2	96	2	2
Domain Name System	0.3	304	0.0	27447	806	304	27447	806	304
Transmission Control Protocol	5.8	6698	0.2	213636	6278	4062	130532	3836	6698
Transport Layer Security	2.3	2602	1.4	1653027	48 k	2602	1256434	36 k	2719
Post Office Protocol	0.0	10	0.0	306	8	10	306	8	10
Internet Message Access Protocol	0.0	3	0.0	177	5	3	177	5	3
Hypertext Transfer Protocol	0.0	2	0.0	597	17	1	427	12	2
Line-based text data	0.0	1	0.0	22	0	1	22	0	1
Internet Control Message Protocol	0.0	34	0.0	3824	112	34	3824	112	34
Data	0.1	69	0.1	80039	2352	69	80039	2352	69

tcpdump.pcap

VR_2K – Main Operator

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	6	100.0	374	52	0	0	0	6
DLT User	100.0	6	100.0	374	52	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	52	6	374	52	6

gnb_e1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	299	100.0	133641	3044	0	0	0	299
DLT User	100.0	299	100.0	133641	3044	0	0	0	299
E2 Application Protocol	100.0	299	100.0	133641	3044	117	51114	1164	299
Malformed Packet	0.3	1	0.0	0	0	1	0	0	1
Dissector Bug	60.5	181	0.0	0	0	181	0	0	181

gnb_e2ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	77	100.0	10357	234	0	0	0	77
DLT User	100.0	77	100.0	10357	234	0	0	0	77
F1 Application Protocol	100.0	77	100.0	10357	234	77	10357	234	77

gnb_f1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	77151	100.0	269755640	6144 k	0	0	0	77151
DLT User	100.0	77151	100.0	269755640	6144 k	0	0	0	77151
User Datagram Protocol	100.0	77151	0.2	617208	14 k	0	0	0	77151
MAC-NR	100.0	77151	99.1	267363959	6089 k	77151	267363959	6089 k	77151

gnb_mac.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	238790	100.0	265046827	7149 k	0	0	0	238790
DLT User	100.0	238790	100.0	265046827	7149 k	0	0	0	238790
GPRS Tunneling Protocol	100.0	238790	1.4	3820640	103 k	0	0	0	238790
Internet Protocol Version 4	100.0	238790	1.8	4775800	128 k	0	0	0	238790
User Datagram Protocol	94.6	225894	0.7	1807152	48 k	0	0	0	225894
QUIC IETF	94.4	225476	94.1	249336862	6725 k	225476	249302345	6724 k	225517
Network Time Protocol	0.0	8	0.0	384	10	8	384	10	8
Domain Name System	0.2	410	0.0	35503	957	410	35503	957	410
Transmission Control Protocol	4.6	11059	0.1	360672	9728	7383	243872	6578	11059
Transport Layer Security	1.5	3648	1.7	4540719	122 k	3648	3026093	81 k	3937
Post Office Protocol	0.0	5	0.0	153	4	5	153	4	5
Internet Message Access Protocol	0.0	3	0.0	177	4	3	177	4	3
Hypertext Transfer Protocol	0.0	2	0.0	597	16	1	427	11	2
Line-based text data	0.0	1	0.0	22	0	1	22	0	1
Internet Control Message Protocol	0.1	126	0.0	49776	1342	126	49776	1342	126
Data	0.7	1729	0.9	2364921	63 k	1729	2364921	63 k	1729

gnb_n3.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	56	100.0	8339	300	0	0	0	56
DLT User	100.0	56	100.0	8339	300	0	0	0	56
NG Application Protocol	100.0	56	100.0	8339	300	56	8339	300	56

gnb_ngap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	314559	100.0	271534379	6451 k	0	0	0	314559
DLT User	100.0	314559	100.0	271534379	6451 k	0	0	0	314559
User Datagram Protocol	100.0	314559	0.9	2516472	59 k	0	0	0	314559
RLC-NR	100.0	314559	97.0	263355845	6256 k	314559	263355845	6256 k	314559

gnb_rlc.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	238765	100.0	261224785	8887 k	0	0	0	238765
Raw packet data	100.0	238765	100.0	261224785	8887 k	0	0	0	238765
Internet Protocol Version 4	100.0	238765	1.8	4775300	162 k	0	0	0	238765
User Datagram Protocol	94.6	225889	0.7	1807112	61 k	0	0	0	225889
QUIC IETF	94.4	225476	95.4	249336862	8483 k	225476	249302345	8481 k	225517
Network Time Protocol	0.0	6	0.0	288	9	6	288	9	6
Domain Name System	0.2	407	0.0	35349	1202	407	35349	1202	407
Transmission Control Protocol	4.6	11039	0.1	360248	12 k	7364	243480	8283	11039
Transport Layer Security	1.5	3647	1.7	4540595	154 k	3647	3025969	102 k	3936
Post Office Protocol	0.0	5	0.0	153	5	5	153	5	5
Internet Message Access Protocol	0.0	3	0.0	177	6	3	177	6	3
Hypertext Transfer Protocol	0.0	2	0.0	597	20	1	427	14	2
Line-based text data	0.0	1	0.0	22	0	1	22	0	1
Internet Control Message Protocol	0.1	126	0.0	49776	1693	126	49776	1693	126
Data	0.7	1729	0.9	2364921	80 k	1729	2364921	80 k	1729

tcpdump.pcap

VR_4K – Main Operator

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	6	100.0	374	63	0	0	0	6
DLT User	100.0	6	100.0	374	63	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	63	6	374	63	6

gnb_e1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	257	100.0	115058	2912	0	0	0	257
DLT User	100.0	257	100.0	115058	2912	0	0	0	257
E2 Application Protocol	100.0	257	100.0	115058	2912	130	57004	1443	257
Malformed Packet	0.4	1	0.0	0	0	1	0	0	1
Dissector Bug	49.0	126	0.0	0	0	126	0	0	126

gnb_e2ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	77	100.0	10363	251	0	0	0	77
DLT User	100.0	77	100.0	10363	251	0	0	0	77
F1 Application Protocol	100.0	77	100.0	10363	251	77	10363	251	77

gnb_f1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	133158	100.0	482569540	11 M	0	0	0	133158
DLT User	100.0	133158	100.0	482569540	11 M	0	0	0	133158
User Datagram Protocol	100.0	133158	0.2	1065264	25 k	0	0	0	133158
MAC-NR	100.0	133158	99.1	478441642	11 M	133158	478441642	11 M	133158

gnb_mac.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	417513	100.0	474745002	14 M	0	0	0	417513
DLT User	100.0	417513	100.0	474745002	14 M	0	0	0	417513
GPRS Tunneling Protocol	100.0	417513	1.4	6680208	197 k	0	0	0	417513
Internet Protocol Version 4	100.0	417513	1.8	8350260	247 k	0	0	0	417513
User Datagram Protocol	97.4	406775	0.7	3254200	96 k	0	0	0	406775
QUIC IETF	97.3	406436	95.4	453128324	13 M	406436	453016629	13 M	406563
Network Time Protocol	0.0	2	0.0	96	2	2	96	2	2
Domain Name System	0.1	337	0.0	30503	903	337	30503	903	337
Transmission Control Protocol	2.5	10387	0.1	335372	9928	6184	202020	5980	10387
Transport Layer Security	1.0	4165	0.5	2482706	73 k	4165	2303290	68 k	4229
Post Office Protocol	0.0	5	0.0	153	4	5	153	4	5
Internet Message Access Protocol	0.0	3	0.0	177	5	3	177	5	3
Hypertext Transfer Protocol	0.0	4	0.0	1350	39	2	794	23	4
Online Certificate Status Protocol	0.0	1	0.0	504	14	1	504	14	1
Line-based text data	0.0	1	0.0	22	0	1	22	0	1
Internet Control Message Protocol	0.1	231	0.0	18196	538	231	18196	538	231
Data	0.0	146	0.0	180656	5348	146	180656	5348	146

gnb_n3.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	56	100.0	8348	297	0	0	0	56
DLT User	100.0	56	100.0	8348	297	0	0	0	56
NG Application Protocol	100.0	56	100.0	8348	297	56	8348	297	56

gnb_ngap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	549448	100.0	485747524	12 M	0	0	0	549448
DLT User	100.0	549448	100.0	485747524	12 M	0	0	0	549448
User Datagram Protocol	100.0	549448	0.9	4395584	108 k	0	0	0	549448
RLC-NR	100.0	549448	97.1	471461876	11 M	549448	471461876	11 M	549448

gnb_rlc.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	416029	100.0	467416491	12 M	0	0	0	416029
Raw packet data	100.0	416029	100.0	467416491	12 M	0	0	0	416029
Internet Protocol Version 4	100.0	416029	1.8	8320580	231 k	0	0	0	416029
User Datagram Protocol	97.6	406197	0.7	3249576	90 k	0	0	0	406197
QUIC IETF	97.6	405884	96.9	452807253	12 M	405884	452710225	12 M	405997
Network Time Protocol	0.0	2	0.0	96	2	2	96	2	2
Domain Name System	0.1	311	0.0	28348	788	311	28348	788	311
Transmission Control Protocol	2.3	9513	0.1	307316	8544	5659	185116	5146	9513
Transport Layer Security	0.9	3819	0.5	2249474	62 k	3819	2073091	57 k	3877
Post Office Protocol	0.0	5	0.0	153	4	5	153	4	5
Internet Message Access Protocol	0.0	3	0.0	177	4	3	177	4	3
Hypertext Transfer Protocol	0.0	4	0.0	1350	37	2	794	22	4
Online Certificate Status Protocol	0.0	1	0.0	504	14	1	504	14	1
Line-based text data	0.0	1	0.0	22	0	1	22	0	1
Internet Control Message Protocol	0.0	200	0.0	12400	344	200	12400	344	200
Data	0.0	142	0.0	177408	4932	142	177408	4932	142

tcpdump.pcap

Topology B

Optimal Propagation Environment

iPerf3 – Main Operator

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
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.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	233	100.0	98555	2756	0	0	0	233
DLT User	100.0	233	100.0	98555	2756	0	0	0	233
E2 Application Protocol	100.0	233	100.0	98555	2756	118	51648	1444	233
Malformed Packet	7.7	18	0.0	0	0	18	0	0	18
Dissector Bug	41.6	97	0.0	0	0	97	0	0	97

gnb_e2ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	35	100.0	7436	207	0	0	0	35
DLT User	100.0	35	100.0	7436	207	0	0	0	35
F1 Application Protocol	100.0	35	100.0	7436	207	35	7436	207	35

gnb_f1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	207118	100.0	1526792220	42 M	0	0	0	207118
DLT User	100.0	207118	100.0	1526792220	42 M	0	0	0	207118
User Datagram Protocol	100.0	207118	0.1	1656944	46 k	0	0	0	207118
MAC-NR	100.0	207118	99.6	1520371562	42 M	207118	1520371562	42 M	207118

gnb_mac.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	1135893	100.0	1508848760	48 M	0	0	0	1135893
DLT User	100.0	1135893	100.0	1508848760	48 M	0	0	0	1135893
GPRS Tunneling Protocol	100.0	1135893	1.2	18174288	587 k	0	0	0	1135893
Internet Protocol Version 6	0.0	30	0.0	1200	38	0	0	0	30
User Datagram Protocol	0.0	14	0.0	112	3	0	0	0	14
Domain Name System	0.0	14	0.0	704	22	14	704	22	14
Internet Control Message Protocol v6	0.0	16	0.0	1544	49	16	1544	49	16
Internet Protocol Version 4	100.0	1135863	1.5	22717260	734 k	0	0	0	1135863
User Datagram Protocol	0.2	2060	0.0	16480	533	0	0	0	2060
Simple Network Management Protocol	0.0	48	0.0	3744	121	48	3744	121	48
QUIC IETF	0.1	1433	0.0	611921	19 k	1433	584541	18 k	1524
Domain Name System	0.0	541	0.0	52242	1689	541	52242	1689	541
Data	0.0	38	0.0	323	10	38	323	10	38
Transmission Control Protocol	99.8	1133790	1.5	23105064	747 k	71995	1868948	60 k	1133790
Transport Layer Security	0.4	4711	0.4	5936391	192 k	4711	5563322	179 k	4768
iPerf3 Speed Test	93.1	1057024	95.3	1437514335	46 M	23	760	24	1057025
Data	93.1	1057001	95.3	1437513280	46 M	1057001	1437513280	46 M	1057001
Hypertext Transfer Protocol	0.0	12	0.0	1882	60	5	727	23	12
Line-based text data	0.0	7	0.0	154	4	7	154	4	7
Data	0.0	48	0.0	48	1	48	48	1	48
Internet Control Message Protocol	0.0	13	0.0	1513	48	13	1513	48	13

gnb_n3.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	22	100.0	5672	1101	0	0	0	22
DLT User	100.0	22	100.0	5672	1101	0	0	0	22
NG Application Protocol	100.0	22	100.0	5672	1101	22	5672	1101	22

gnb_ngap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	1351302	100.0	1541992188	48 M	0	0	0	1351302
DLT User	100.0	1351302	100.0	1541992188	48 M	0	0	0	1351302
User Datagram Protocol	100.0	1351302	0.7	10810416	339 k	0	0	0	1351302
RLC-NR	100.0	1351302	97.7	1506858336	47 M	1351302	1506858336	47 M	1351302

gnb_rlc.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	1137903	100.0	1495565550	39 M	0	0	0	1137903
Raw packet data	100.0	1137903	100.0	1495565550	39 M	0	0	0	1137903
Internet Protocol Version 6	0.0	28	0.0	1120	29	0	0	0	28
User Datagram Protocol	0.0	14	0.0	112	2	0	0	0	14
Domain Name System	0.0	14	0.0	704	18	14	704	18	14
Internet Control Message Protocol v6	0.0	14	0.0	1488	39	14	1488	39	14
Internet Protocol Version 4	100.0	1137875	1.5	22757500	608 k	0	0	0	1137875
User Datagram Protocol	0.2	2059	0.0	16472	440	0	0	0	2059
Simple Network Management Protocol	0.0	48	0.0	3744	100	48	3744	100	48
QUIC IETF	0.1	1433	0.0	611921	16 k	1433	584541	15 k	1524
Domain Name System	0.0	540	0.0	52201	1395	540	52201	1395	540
Data	0.0	38	0.0	323	8	38	323	8	38
Transmission Control Protocol	99.8	1135803	1.5	23120812	618 k	70080	1806136	48 k	1135803
Transport Layer Security	0.4	4764	0.4	5965525	159 k	4764	5592456	149 k	4821
iPerf3 Speed Test	93.2	1060899	96.5	1442784335	38 M	23	760	20	1060900
Data	93.2	1060876	96.5	1442783280	38 M	1060876	1442783280	38 M	1060876
Hypertext Transfer Protocol	0.0	12	0.0	1882	50	5	727	19	12
Line-based text data	0.0	7	0.0	154	4	7	154	4	7
Data	0.0	48	0.0	48	1	48	48	1	48
Internet Control Message Protocol	0.0	13	0.0	1513	40	13	1513	40	13

tcpdump.pcap

iPerf3 – Micro Operator

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	6	100.0	374	41	0	0	0	6
DLT User	100.0	6	100.0	374	41	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	41	6	374	41	6

gnb_e1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	220	100.0	99161	2117	0	0	0	220
DLT User	100.0	220	100.0	99161	2117	0	0	0	220
E2 Application Protocol	100.0	220	100.0	99161	2117	197	87452	1867	220
Malformed Packet	0.5	1	0.0	0	0	1	0	0	1
Dissector Bug	10.0	22	0.0	0	0	22	0	0	22

gnb_e2ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	77	100.0	10363	220	0	0	0	77
DLT User	100.0	77	100.0	10363	220	0	0	0	77
F1 Application Protocol	100.0	77	100.0	10363	220	77	10363	220	77

gnb_f1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	226779	100.0	1545023057	32 M	0	0	0	226779
DLT User	100.0	226779	100.0	1545023057	32 M	0	0	0	226779
User Datagram Protocol	100.0	226779	0.1	1814232	38 k	0	0	0	226779
MAC-NR	100.0	226779	99.5	1537992908	32 M	226779	1537992908	32 M	226779

gnb_mac.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	1198585	100.0	1512435407	41 M	0	0	0	1198585
DLT User	100.0	1198585	100.0	1512435407	41 M	0	0	0	1198585
GPRS Tunneling Protocol	100.0	1198585	1.3	19177360	529 k	0	0	0	1198585
Internet Protocol Version 4	100.0	1198585	1.6	23971700	661 k	0	0	0	1198585
User Datagram Protocol	0.2	2945	0.0	23560	650	0	0	0	2945
Simple Network Management Protocol	0.0	52	0.0	4056	111	52	4056	111	52
QUIC IETF	0.1	1433	0.0	611921	16 k	1433	584541	16 k	1524
Domain Name System	0.1	1460	0.0	88840	2451	1460	88840	2451	1460
Transmission Control Protocol	99.8	1195617	1.6	24394612	673 k	135476	3191792	88 k	1195617
Transport Layer Security	0.4	4738	0.4	6004914	165 k	4738	5627672	155 k	4796
iPerf3 Speed Test	88.0	1055342	94.9	1435225456	39 M	24	761	20	1055343
Data	88.0	1055318	94.9	1435224400	39 M	1055318	1435224400	39 M	1055318
Hypertext Transfer Protocol	0.0	13	0.0	1993	54	6	838	23	13
Line-based text data	0.0	7	0.0	154	4	7	154	4	7
Data	0.0	48	0.0	48	1	48	48	1	48
Internet Control Message Protocol	0.0	23	0.0	2092	57	23	2092	57	23

gnb_n3.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	56	100.0	8398	274	0	0	0	56
DLT User	100.0	56	100.0	8398	274	0	0	0	56
NG Application Protocol	100.0	56	100.0	8398	274	56	8398	274	56

gnb_ngap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	1442712	100.0	1551430332	35 M	0	0	0	1442712
DLT User	100.0	1442712	100.0	1551430332	35 M	0	0	0	1442712
User Datagram Protocol	100.0	1442712	0.7	11541696	267 k	0	0	0	1442712
RLC-NR	100.0	1442712	97.6	1513919820	35 M	1442712	1513919820	35 M	1442712

gnb_rlc.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	1196881	100.0	1493153915	30 M	0	0	0	1196881
Raw packet data	100.0	1196881	100.0	1493153915	30 M	0	0	0	1196881
Internet Protocol Version 6	0.0	18	0.0	800	16	0	0	0	18
User Datagram Protocol	0.0	8	0.0	64	1	0	0	0	8
eXtensible Markup Language	0.0	8	0.0	4856	99	8	4856	99	8
Internet Control Message Protocol v6	0.0	10	0.0	280	5	10	280	5	10
Internet Protocol Version 4	100.0	1196863	1.6	23937300	491 k	0	0	0	1196863
User Datagram Protocol	0.2	2945	0.0	23560	483	0	0	0	2945
Simple Network Management Protocol	0.0	52	0.0	4056	83	52	4056	83	52
QUIC IETF	0.1	1433	0.0	611921	12 k	1433	584541	12 k	1524
eXtensible Markup Language	0.0	4	0.0	2428	49	4	2428	49	4
Domain Name System	0.1	1456	0.0	88683	1821	1456	88683	1821	1456
Transmission Control Protocol	99.7	1193885	1.6	24322876	499 k	133488	3114936	63 k	1193885
Transport Layer Security	0.4	4735	0.4	6001990	123 k	4735	5624748	115 k	4793
iPerf3 Speed Test	88.2	1055601	96.1	1435577696	29 M	24	761	15	1055602
Data	88.2	1055577	96.1	1435576640	29 M	1055577	1435576640	29 M	1055577
Hypertext Transfer Protocol	0.0	13	0.0	1993	40	6	838	17	13
Line-based text data	0.0	7	0.0	154	3	7	154	3	7
Data	0.0	48	0.0	48	0	48	48	0	48
Internet Group Management Protocol	0.0	10	0.0	160	3	10	160	3	10
Internet Control Message Protocol	0.0	23	0.0	2092	42	23	2092	42	23

tcpdump.pcap

VR_FHD – Main Operator

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	6	100.0	374	73	0	0	0	6
DLT User	100.0	6	100.0	374	73	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	73	6	374	73	6

gnb_e1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	324	100.0	124077	2524	0	0	0	324
DLT User	100.0	324	100.0	124077	2524	0	0	0	324
E2 Application Protocol	100.0	324	100.0	124077	2524	83	35757	727	324
Malformed Packet	17.3	56	0.0	0	0	56	0	0	56
Dissector Bug	57.1	185	0.0	0	0	185	0	0	185

gnb_e2ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	35	100.0	7436	150	0	0	0	35
DLT User	100.0	35	100.0	7436	150	0	0	0	35
F1 Application Protocol	100.0	35	100.0	7436	150	35	7436	150	35

gnb_f1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	28231	100.0	99968133	2028 k	0	0	0	28231
DLT User	100.0	28231	100.0	99968133	2028 k	0	0	0	28231
User Datagram Protocol	100.0	28231	0.2	225848	4583	0	0	0	28231
MAC-NR	100.0	28231	99.1	99092972	2011 k	28231	99092972	2011 k	28231

gnb_mac.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	98846	100.0	91475062	2061 k	0	0	0	98846
DLT User	100.0	98846	100.0	91475062	2061 k	0	0	0	98846
GPRS Tunneling Protocol	100.0	98846	1.7	1581536	35 k	0	0	0	98846
Internet Protocol Version 6	0.0	10	0.0	400	9	0	0	0	10
User Datagram Protocol	0.0	4	0.0	32	0	0	0	0	4
Domain Name System	0.0	4	0.0	214	4	4	214	4	4
Internet Control Message Protocol v6	0.0	6	0.0	494	11	6	494	11	6
Internet Protocol Version 4	100.0	98836	2.2	1976720	44 k	0	0	0	98836
User Datagram Protocol	71.4	70614	0.6	564912	12 k	0	0	0	70614
QUIC IETF	71.1	70253	82.9	75832374	1709 k	70253	75761364	1707 k	70346
Network Time Protocol	0.0	2	0.0	96	2	2	96	2	2
Domain Name System	0.3	305	0.0	26778	603	305	26778	603	305
Data	0.1	54	0.0	459	10	54	459	10	54
Transmission Control Protocol	28.4	28084	1.0	901844	20 k	15986	516472	11 k	28084
Transport Layer Security	12.2	12069	11.6	10585499	238 k	12069	8795112	198 k	12408
Post Office Protocol	0.0	10	0.0	306	6	10	306	6	10
Internet Message Access Protocol	0.0	12	0.0	716	16	12	716	16	12
Hypertext Transfer Protocol	0.0	2	0.0	440	9	1	315	7	2
Line-based text data	0.0	1	0.0	68	1	1	68	1	1
Data	0.0	5	0.0	1375	30	5	1375	30	5
Internet Control Message Protocol	0.1	138	0.0	4968	111	138	4968	111	138

gnb_n3.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	22	100.0	5672	1105	0	0	0	22
DLT User	100.0	22	100.0	5672	1105	0	0	0	22
NG Application Protocol	100.0	22	100.0	5672	1105	22	5672	1105	22

gnb_ngap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	121176	100.0	94738549	2096 k	0	0	0	121176
DLT User	100.0	121176	100.0	94738549	2096 k	0	0	0	121176
User Datagram Protocol	100.0	121176	1.0	969408	21 k	0	0	0	121176
RLC-NR	100.0	121176	96.7	91587973	2026 k	121176	91587973	2026 k	121176

gnb_rlc.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	99285	100.0	89948021	1781 k	0	0	0	99285
Raw packet data	100.0	99285	100.0	89948021	1781 k	0	0	0	99285
Internet Protocol Version 6	0.0	8	0.0	320	6	0	0	0	8
User Datagram Protocol	0.0	4	0.0	32	0	0	0	0	4
Domain Name System	0.0	4	0.0	214	4	4	214	4	4
Internet Control Message Protocol v6	0.0	4	0.0	438	8	4	438	8	4
Internet Protocol Version 4	100.0	99277	2.2	1985540	39 k	0	0	0	99277
User Datagram Protocol	71.1	70616	0.6	564928	11 k	0	0	0	70616
QUIC IETF	70.8	70255	84.3	75832446	1502 k	70255	75761436	1500 k	70348
Network Time Protocol	0.0	2	0.0	96	1	2	96	1	2
Domain Name System	0.3	305	0.0	26778	530	305	26778	530	305
Data	0.1	54	0.0	459	9	54	459	9	54
Transmission Control Protocol	28.7	28523	1.0	915784	18 k	16367	528568	10 k	28523
Transport Layer Security	12.2	12127	11.8	10590655	209 k	12127	8800268	174 k	12466
Post Office Protocol	0.0	10	0.0	306	6	10	306	6	10
Internet Message Access Protocol	0.0	12	0.0	716	14	12	716	14	12
Hypertext Transfer Protocol	0.0	2	0.0	440	8	1	315	6	2
Line-based text data	0.0	1	0.0	68	1	1	68	1	1
Data	0.0	5	0.0	1375	27	5	1375	27	5
Internet Control Message Protocol	0.1	138	0.0	4968	98	138	4968	98	138

tcpdump.pcap

VR_FHD – Micro Operator

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	6	100.0	374	38	0	0	0	6
DLT User	100.0	6	100.0	374	38	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	38	6	374	38	6

gnb_e1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	310	100.0	138251	2977	0	0	0	310
DLT User	100.0	310	100.0	138251	2977	0	0	0	310
E2 Application Protocol	100.0	310	100.0	138251	2977	101	43707	941	310
Malformed Packet	0.3	1	0.0	0	0	1	0	0	1
Dissector Bug	67.1	208	0.0	0	0	208	0	0	208

gnb_e2ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	77	100.0	10357	221	0	0	0	77
DLT User	100.0	77	100.0	10357	221	0	0	0	77
F1 Application Protocol	100.0	77	100.0	10357	221	77	10357	221	77

gnb_f1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	27065	100.0	97975467	2098 k	0	0	0	27065
DLT User	100.0	27065	100.0	97975467	2098 k	0	0	0	27065
User Datagram Protocol	100.0	27065	0.2	216520	4638	0	0	0	27065
MAC-NR	100.0	27065	99.1	97136452	2080 k	27065	97136452	2080 k	27065

gnb_mac.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	98908	100.0	91464403	2598 k	0	0	0	98908
DLT User	100.0	98908	100.0	91464403	2598 k	0	0	0	98908
GPRS Tunneling Protocol	100.0	98908	1.7	1582528	44 k	0	0	0	98908
Internet Protocol Version 4	100.0	98908	2.2	1978160	56 k	0	0	0	98908
User Datagram Protocol	71.3	70508	0.6	564064	16 k	0	0	0	70508
QUIC IETF	71.0	70247	82.9	75833504	2154 k	70247	75762494	2152 k	70340
Network Time Protocol	0.0	2	0.0	96	2	2	96	2	2
Domain Name System	0.3	259	0.0	22535	640	259	22535	640	259
Transmission Control Protocol	28.6	28261	1.0	907128	25 k	15930	514420	14 k	28261
Transport Layer Security	12.4	12305	11.6	10643748	302 k	12305	8828741	250 k	12647
Post Office Protocol	0.0	10	0.0	306	8	10	306	8	10
Internet Message Access Protocol	0.0	12	0.0	716	20	12	716	20	12
Hypertext Transfer Protocol	0.0	2	0.0	440	12	1	315	8	2
Line-based text data	0.0	1	0.0	68	1	1	68	1	1
Data	0.0	2	0.0	2696	76	2	2696	76	2
Internet Control Message Protocol	0.1	139	0.0	5524	156	139	5524	156	139

gnb_n3.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	56	100.0	8389	261	0	0	0	56
DLT User	100.0	56	100.0	8389	261	0	0	0	56
NG Application Protocol	100.0	56	100.0	8389	261	56	8389	261	56

gnb_ngap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	120631	100.0	94664037	2246 k	0	0	0	120631
DLT User	100.0	120631	100.0	94664037	2246 k	0	0	0	120631
User Datagram Protocol	100.0	120631	1.0	965048	22 k	0	0	0	120631
RLC-NR	100.0	120631	96.7	91527631	2172 k	120631	91527631	2172 k	120631

gnb_rlc.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	98572	100.0	89869600	2528 k	0	0	0	98572
Raw packet data	100.0	98572	100.0	89869600	2528 k	0	0	0	98572
Internet Protocol Version 4	100.0	98572	2.2	1971440	55 k	0	0	0	98572
User Datagram Protocol	71.5	70513	0.6	564104	15 k	0	0	0	70513
QUIC IETF	71.3	70252	84.4	75833684	2133 k	70252	75762674	2131 k	70345
Network Time Protocol	0.0	2	0.0	96	2	2	96	2	2
Domain Name System	0.3	259	0.0	22535	633	259	22535	633	259
Transmission Control Protocol	28.3	27920	1.0	896516	25 k	15585	503680	14 k	27920
Transport Layer Security	12.5	12309	11.8	10644970	299 k	12309	8829963	248 k	12651
Post Office Protocol	0.0	10	0.0	306	8	10	306	8	10
Internet Message Access Protocol	0.0	12	0.0	716	20	12	716	20	12
Hypertext Transfer Protocol	0.0	2	0.0	440	12	1	315	8	2
Line-based text data	0.0	1	0.0	68	1	1	68	1	1
Data	0.0	2	0.0	2696	75	2	2696	75	2
Internet Control Message Protocol	0.1	139	0.0	5524	155	139	5524	155	139

tcpdump.pcap

VR_2K – Main Operator

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	6	100.0	374	79	0	0	0	6
DLT User	100.0	6	100.0	374	79	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	79	6	374	79	6

gnb_e1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	427	100.0	121839	2046	0	0	0	427
DLT User	100.0	427	100.0	121839	2046	0	0	0	427
E2 Application Protocol	100.0	427	100.0	121839	2046	75	32176	540	427
Malformed Packet	42.2	180	0.0	0	0	180	0	0	180
Dissector Bug	40.3	172	0.0	0	0	172	0	0	172

gnb_e2ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	35	100.0	7430	124	0	0	0	35
DLT User	100.0	35	100.0	7430	124	0	0	0	35
F1 Application Protocol	100.0	35	100.0	7430	124	35	7430	124	35

gnb_f1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	55574	100.0	281138549	4700 k	0	0	0	55574
DLT User	100.0	55574	100.0	281138549	4700 k	0	0	0	55574
User Datagram Protocol	100.0	55574	0.2	444592	7433	0	0	0	55574
MAC-NR	100.0	55574	99.4	279415755	4671 k	55574	279415755	4671 k	55574

gnb_mac.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	245942	100.0	262784210	4745 k	0	0	0	245942
DLT User	100.0	245942	100.0	262784210	4745 k	0	0	0	245942
GPRS Tunneling Protocol	100.0	245942	1.5	3935072	71 k	0	0	0	245942
Internet Protocol Version 6	0.0	26	0.0	1040	18	0	0	0	26
User Datagram Protocol	0.0	12	0.0	96	1	0	0	0	12
Domain Name System	0.0	12	0.0	636	11	12	636	11	12
Internet Control Message Protocol v6	0.0	14	0.0	1364	24	14	1364	24	14
Internet Protocol Version 4	100.0	245916	1.9	4918320	88 k	0	0	0	245916
User Datagram Protocol	91.0	223828	0.7	1790624	32 k	0	0	0	223828
QUIC IETF	90.9	223509	92.8	243782391	4402 k	223509	243741503	4401 k	223571
Network Time Protocol	0.0	2	0.0	96	1	2	96	1	2
Domain Name System	0.1	251	0.0	22556	407	251	22556	407	251
Data	0.0	66	0.0	561	10	66	561	10	66
Transmission Control Protocol	8.9	21992	0.3	710704	12 k	12865	419132	7569	21992
Transport Layer Security	3.7	9110	2.9	7521302	135 k	9110	6096415	110 k	9373
Post Office Protocol	0.0	5	0.0	153	2	5	153	2	5
Internet Message Access Protocol	0.0	6	0.0	358	6	6	358	6	6
Hypertext Transfer Protocol	0.0	15	0.0	10304	186	3	695	12	16
Line-based text data	0.0	1	0.0	68	1	1	68	1	1
Data	0.0	2	0.0	1858	33	2	1858	33	2
Internet Control Message Protocol	0.0	96	0.0	12842	231	96	12842	231	96

gnb_n3.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	22	100.0	5663	1209	0	0	0	22
DLT User	100.0	22	100.0	5663	1209	0	0	0	22
NG Application Protocol	100.0	22	100.0	5663	1209	22	5663	1209	22

gnb_ngap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	293451	100.0	269666401	4798 k	0	0	0	293451
DLT User	100.0	293451	100.0	269666401	4798 k	0	0	0	293451
User Datagram Protocol	100.0	293451	0.9	2347608	41 k	0	0	0	293451
RLC-NR	100.0	293451	97.2	262036675	4663 k	293451	262036675	4663 k	293451

gnb_rlc.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	246295	100.0	258890135	4592 k	0	0	0	246295
Raw packet data	100.0	246295	100.0	258890135	4592 k	0	0	0	246295
Internet Protocol Version 6	0.0	24	0.0	960	17	0	0	0	24
User Datagram Protocol	0.0	12	0.0	96	1	0	0	0	12
Domain Name System	0.0	12	0.0	636	11	12	636	11	12
Internet Control Message Protocol v6	0.0	12	0.0	1308	23	12	1308	23	12
Internet Protocol Version 4	100.0	246271	1.9	4925420	87 k	0	0	0	246271
User Datagram Protocol	90.9	223828	0.7	1790624	31 k	0	0	0	223828
QUIC IETF	90.7	223509	94.2	243782391	4324 k	223509	243741503	4323 k	223571
Network Time Protocol	0.0	2	0.0	96	1	2	96	1	2
Domain Name System	0.1	251	0.0	22556	400	251	22556	400	251
Data	0.0	66	0.0	561	9	66	561	9	66
Transmission Control Protocol	9.1	22347	0.3	721956	12 k	13178	429052	7611	22347
Transport Layer Security	3.7	9152	2.9	7524337	133 k	9152	6099450	108 k	9415
Post Office Protocol	0.0	5	0.0	153	2	5	153	2	5
Internet Message Access Protocol	0.0	6	0.0	358	6	6	358	6	6
Hypertext Transfer Protocol	0.0	15	0.0	10304	182	3	695	12	16
Line-based text data	0.0	1	0.0	68	1	1	68	1	1
Data	0.0	2	0.0	1858	32	2	1858	32	2
Internet Control Message Protocol	0.0	96	0.0	12842	227	96	12842	227	96

tcpdump.pcap

VR_2K – Micro Operator

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	6	100.0	374	18	0	0	0	6
DLT User	100.0	6	100.0	374	18	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	18	6	374	18	6

gnb_e1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	206	100.0	92429	1629	0	0	0	206
DLT User	100.0	206	100.0	92429	1629	0	0	0	206
E2 Application Protocol	100.0	206	100.0	92429	1629	79	33976	599	206
Malformed Packet	0.5	1	0.0	0	0	1	0	0	1
Dissector Bug	61.2	126	0.0	0	0	126	0	0	126

gnb_e2ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	77	100.0	10363	181	0	0	0	77
DLT User	100.0	77	100.0	10363	181	0	0	0	77
F1 Application Protocol	100.0	77	100.0	10363	181	77	10363	181	77

gnb_f1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	52613	100.0	274856833	4822 k	0	0	0	52613
DLT User	100.0	52613	100.0	274856833	4822 k	0	0	0	52613
User Datagram Protocol	100.0	52613	0.2	420904	7384	0	0	0	52613
MAC-NR	100.0	52613	99.4	273225830	4793 k	52613	273225830	4793 k	52613

gnb_mac.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	246115	100.0	262775011	7523 k	0	0	0	246115
DLT User	100.0	246115	100.0	262775011	7523 k	0	0	0	246115
GPRS Tunneling Protocol	100.0	246115	1.5	3937840	112 k	0	0	0	246115
Internet Protocol Version 4	100.0	246115	1.9	4922300	140 k	0	0	0	246115
User Datagram Protocol	90.9	223717	0.7	1789736	51 k	0	0	0	223717
QUIC IETF	90.8	223509	92.8	243782391	6979 k	223509	243741503	6978 k	223571
Network Time Protocol	0.0	2	0.0	96	2	2	96	2	2
Domain Name System	0.1	206	0.0	18362	525	206	18362	525	206
Transmission Control Protocol	9.1	22302	0.3	720304	20 k	13015	423720	12 k	22302
Transport Layer Security	3.8	9270	2.9	7535537	215 k	9270	6109302	174 k	9534
Post Office Protocol	0.0	5	0.0	153	4	5	153	4	5
Internet Message Access Protocol	0.0	6	0.0	358	10	6	358	10	6
Hypertext Transfer Protocol	0.0	16	0.0	10328	295	3	695	19	17
Line-based text data	0.0	1	0.0	68	1	1	68	1	1
Data	0.0	2	0.0	1858	53	2	1858	53	2
Internet Control Message Protocol	0.0	96	0.0	12842	367	96	12842	367	96

gnb_n3.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	56	100.0	8398	197	0	0	0	56
DLT User	100.0	56	100.0	8398	197	0	0	0	56
NG Application Protocol	100.0	56	100.0	8398	197	56	8398	197	56

gnb_ngap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	295103	100.0	270030473	6449 k	0	0	0	295103
DLT User	100.0	295103	100.0	270030473	6449 k	0	0	0	295103
User Datagram Protocol	100.0	295103	0.9	2360824	56 k	0	0	0	295103
RLC-NR	100.0	295103	97.2	262357795	6266 k	295103	262357795	6266 k	295103

gnb_rlc.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	245712	100.0	258824494	7319 k	0	0	0	245712
Raw packet data	100.0	245712	100.0	258824494	7319 k	0	0	0	245712
Internet Protocol Version 4	100.0	245712	1.9	4914240	138 k	0	0	0	245712
User Datagram Protocol	91.0	223717	0.7	1789736	50 k	0	0	0	223717
QUIC IETF	91.0	223509	94.2	243782391	6894 k	223509	243741503	6893 k	223571
Network Time Protocol	0.0	2	0.0	96	2	2	96	2	2
Domain Name System	0.1	206	0.0	18362	519	206	18362	519	206
Transmission Control Protocol	8.9	21899	0.3	707816	20 k	12602	410912	11 k	21899
Transport Layer Security	3.8	9280	2.9	7537589	213 k	9280	6111354	172 k	9544
Post Office Protocol	0.0	5	0.0	153	4	5	153	4	5
Internet Message Access Protocol	0.0	6	0.0	358	10	6	358	10	6
Hypertext Transfer Protocol	0.0	16	0.0	10328	292	3	695	19	17
Line-based text data	0.0	1	0.0	68	1	1	68	1	1
Data	0.0	2	0.0	1858	52	2	1858	52	2
Internet Control Message Protocol	0.0	96	0.0	12842	363	96	12842	363	96

tcpdump.pcap

VR_4K – Main Operator

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	6	100.0	374	46	0	0	0	6
DLT User	100.0	6	100.0	374	46	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	46	6	374	46	6

gnb_e1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	212	100.0	87772	2467	0	0	0	212
DLT User	100.0	212	100.0	87772	2467	0	0	0	212
E2 Application Protocol	100.0	212	100.0	87772	2467	87	37588	1056	212
Malformed Packet	9.9	21	0.0	0	0	21	0	0	21
Dissector Bug	49.1	104	0.0	0	0	104	0	0	104

gnb_e2ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	35	100.0	7430	206	0	0	0	35
DLT User	100.0	35	100.0	7430	206	0	0	0	35
F1 Application Protocol	100.0	35	100.0	7430	206	35	7430	206	35

gnb_f1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	71347	100.0	461482543	12 M	0	0	0	71347
DLT User	100.0	71347	100.0	461482543	12 M	0	0	0	71347
User Datagram Protocol	100.0	71347	0.1	570776	15 k	0	0	0	71347
MAC-NR	100.0	71347	99.5	459270786	12 M	71347	459270786	12 M	71347

gnb_mac.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	376135	100.0	451732920	16 M	0	0	0	376135
DLT User	100.0	376135	100.0	451732920	16 M	0	0	0	376135
GPRS Tunneling Protocol	100.0	376135	1.3	6018160	214 k	0	0	0	376135
Internet Protocol Version 6	0.0	28	0.0	1120	39	0	0	0	28
User Datagram Protocol	0.0	13	0.0	104	3	0	0	0	13
Network Time Protocol	0.0	3	0.0	144	5	3	144	5	3
Domain Name System	0.0	10	0.0	442	15	10	442	15	10
Internet Control Message Protocol v6	0.0	15	0.0	1370	48	15	1370	48	15
Internet Protocol Version 4	100.0	376107	1.7	7522140	267 k	0	0	0	376107
User Datagram Protocol	97.7	367459	0.7	2939672	104 k	0	0	0	367459
QUIC IETF	97.6	367132	95.8	432901454	15 M	367132	432883251	15 M	367160
OMA UserPlane Location Protocol	0.0	4	0.0	4800	170	3	3600	128	4
Malformed Packet	0.0	1	0.0	0	0	1	0	0	1
Network Time Protocol	0.0	2	0.0	96	3	2	96	3	2
Domain Name System	0.1	287	0.0	24580	874	287	24580	874	287
Data	0.0	34	0.0	289	10	34	289	10	34
Transmission Control Protocol	2.3	8638	0.1	273960	9750	4854	154468	5497	8638
Transport Layer Security	1.0	3771	0.5	2065372	73 k	3770	1658660	59 k	3868
Data	0.0	1	0.0	1198	42	1	1198	42	1
Post Office Protocol	0.0	5	0.0	153	5	5	153	5	5
Internet Message Access Protocol	0.0	6	0.0	358	12	6	358	12	6
Data	0.0	2	0.0	2696	95	2	2696	95	2
Internet Control Message Protocol	0.0	10	0.0	436	15	10	436	15	10

gnb_n3.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	22	100.0	5663	709	0	0	0	22
DLT User	100.0	22	100.0	5663	709	0	0	0	22
NG Application Protocol	100.0	22	100.0	5663	709	22	5663	709	22

gnb_ngap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	444015	100.0	461004994	15 M	0	0	0	444015
DLT User	100.0	444015	100.0	461004994	15 M	0	0	0	444015
User Datagram Protocol	100.0	444015	0.8	3552120	122 k	0	0	0	444015
RLC-NR	100.0	444015	97.5	449460604	15 M	444015	449460604	15 M	444015

gnb_rlc.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	376181	100.0	445729075	15 M	0	0	0	376181
Raw packet data	100.0	376181	100.0	445729075	15 M	0	0	0	376181
Internet Protocol Version 6	0.0	26	0.0	1040	36	0	0	0	26
User Datagram Protocol	0.0	13	0.0	104	3	0	0	0	13
Network Time Protocol	0.0	3	0.0	144	5	3	144	5	3
Domain Name System	0.0	10	0.0	442	15	10	442	15	10
Internet Control Message Protocol v6	0.0	13	0.0	1314	46	13	1314	46	13
Internet Protocol Version 4	100.0	376155	1.7	7523100	266 k	0	0	0	376155
User Datagram Protocol	97.7	367459	0.7	2939672	104 k	0	0	0	367459
QUIC IETF	97.6	367132	97.1	432901454	15 M	367132	432883251	15 M	367160
OMA UserPlane Location Protocol	0.0	4	0.0	4800	170	3	3600	127	4
Malformed Packet	0.0	1	0.0	0	0	1	0	0	1
Network Time Protocol	0.0	2	0.0	96	3	2	96	3	2
Domain Name System	0.1	287	0.0	24580	871	287	24580	871	287
Data	0.0	34	0.0	289	10	34	289	10	34
Transmission Control Protocol	2.3	8686	0.1	275388	9767	4892	155588	5518	8686
Transport Layer Security	1.0	3781	0.5	2068099	73 k	3780	1661387	58 k	3878
Data	0.0	1	0.0	1198	42	1	1198	42	1
Post Office Protocol	0.0	5	0.0	153	5	5	153	5	5
Internet Message Access Protocol	0.0	6	0.0	358	12	6	358	12	6
Data	0.0	2	0.0	2696	95	2	2696	95	2
Internet Control Message Protocol	0.0	10	0.0	436	15	10	436	15	10

tcpdump.pcap

VR_4K – Micro Operator

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	6	100.0	374	62	0	0	0	6
DLT User	100.0	6	100.0	374	62	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	62	6	374	62	6

gnb_e1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	200	100.0	89779	1704	0	0	0	200
DLT User	100.0	200	100.0	89779	1704	0	0	0	200
E2 Application Protocol	100.0	200	100.0	89779	1704	97	42094	799	200
Malformed Packet	0.5	1	0.0	0	0	1	0	0	1
Dissector Bug	51.0	102	0.0	0	0	102	0	0	102

gnb_e2ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	87	100.0	11592	218	0	0	0	87
DLT User	100.0	87	100.0	11592	218	0	0	0	87
F1 Application Protocol	100.0	87	100.0	11592	218	87	11592	218	87

gnb_f1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	72316	100.0	464976270	8782 k	0	0	0	72316
DLT User	100.0	72316	100.0	464976270	8782 k	0	0	0	72316
User Datagram Protocol	100.0	72316	0.1	578528	10 k	0	0	0	72316
MAC-NR	100.0	72316	99.5	462734474	8740 k	72316	462734474	8740 k	72316

gnb_mac.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	377324	100.0	451911261	9741 k	0	0	0	377324
DLT User	100.0	377324	100.0	451911261	9741 k	0	0	0	377324
GPRS Tunneling Protocol	100.0	377324	1.3	6037184	130 k	0	0	0	377324
Internet Protocol Version 4	100.0	377324	1.7	7546480	162 k	0	0	0	377324
User Datagram Protocol	97.5	367957	0.7	2943656	63 k	0	0	0	367957
QUIC IETF	97.3	367206	95.8	432998054	9333 k	367206	432979851	9333 k	367234
Domain Name System	0.2	751	0.0	40146	865	751	40146	865	751
Transmission Control Protocol	2.5	9349	0.1	306448	6605	5492	184788	3983	9349
Transport Layer Security	1.0	3844	0.5	2073014	44 k	3844	1680916	36 k	3944
Post Office Protocol	0.0	5	0.0	153	3	5	153	3	5
Internet Message Access Protocol	0.0	6	0.0	358	7	6	358	7	6
Data	0.0	2	0.0	2696	58	2	2696	58	2
Internet Control Message Protocol	0.0	18	0.0	1973	42	18	1973	42	18

gnb_n3.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	66	100.0	9906	186	0	0	0	66
DLT User	100.0	66	100.0	9906	186	0	0	0	66
NG Application Protocol	100.0	66	100.0	9906	186	66	9906	186	66

gnb_ngap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	448548	100.0	463645315	9289 k	0	0	0	448548
DLT User	100.0	448548	100.0	463645315	9289 k	0	0	0	448548
User Datagram Protocol	100.0	448548	0.8	3588384	71 k	0	0	0	448548
RLC-NR	100.0	448548	97.5	451983067	9055 k	448548	451983067	9055 k	448548

gnb_rlc.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	377335	100.0	445878124	9611 k	0	0	0	377335
Raw packet data	100.0	377335	100.0	445878124	9611 k	0	0	0	377335
Internet Protocol Version 6	0.0	10	0.0	448	9	0	0	0	10
User Datagram Protocol	0.0	4	0.0	32	0	0	0	0	4
eXtensible Markup Language	0.0	4	0.0	2428	52	4	2428	52	4
Internet Control Message Protocol v6	0.0	6	0.0	168	3	6	168	3	6
Internet Protocol Version 4	100.0	377325	1.7	7546524	162 k	0	0	0	377325
User Datagram Protocol	97.5	367959	0.7	2943672	63 k	0	0	0	367959
QUIC IETF	97.3	367206	97.1	432998054	9333 k	367206	432979851	9333 k	367234
eXtensible Markup Language	0.0	2	0.0	1214	26	2	1214	26	2
Domain Name System	0.2	751	0.0	40146	865	751	40146	865	751
Transmission Control Protocol	2.5	9342	0.1	306224	6600	5487	184628	3979	9342
Transport Layer Security	1.0	3842	0.5	2072959	44 k	3842	1680861	36 k	3942
Post Office Protocol	0.0	5	0.0	153	3	5	153	3	5
Internet Message Access Protocol	0.0	6	0.0	358	7	6	358	7	6
Data	0.0	2	0.0	2696	58	2	2696	58	2
Internet Group Management Protocol	0.0	6	0.0	96	2	6	96	2	6
Internet Control Message Protocol	0.0	18	0.0	1973	42	18	1973	42	18

tcpdump.pcap

Suboptimal Propagation Environment

iPerf3 – Main Operator

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	24	100.0	1436	35	0	0	0	24
DLT User	100.0	24	100.0	1436	35	0	0	0	24
E1 Application Protocol	100.0	24	100.0	1436	35	24	1436	35	24

gnb_e1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	217	100.0	95605	1934	0	0	0	217
DLT User	100.0	217	100.0	95605	1934	0	0	0	217
E2 Application Protocol	100.0	217	100.0	95605	1934	139	61092	1236	217
Malformed Packet	3.2	7	0.0	0	0	7	0	0	7
Dissector Bug	32.7	71	0.0	0	0	71	0	0	71

gnb_e2ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	89	100.0	20081	404	0	0	0	89
DLT User	100.0	89	100.0	20081	404	0	0	0	89
F1 Application Protocol	100.0	89	100.0	20081	404	89	20081	404	89

gnb_f1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	244543	100.0	404830799	8150 k	0	0	0	244543
DLT User	100.0	244543	100.0	404830799	8150 k	0	0	0	244543
User Datagram Protocol	100.0	244543	0.5	1956344	39 k	0	0	0	244543
MAC-NR	100.0	244543	98.1	397249966	7997 k	244543	397249966	7997 k	244543

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	322879	100.0	391456050	8760 k	0	0	0	322879
DLT User	100.0	322879	100.0	391456050	8760 k	0	0	0	322879
GPRS Tunneling Protocol	100.0	322879	1.3	5166064	115 k	0	0	0	322879
Internet Protocol Version 6	0.0	30	0.0	1200	26	0	0	0	30
User Datagram Protocol	0.0	14	0.0	112	2	0	0	0	14
Domain Name System	0.0	14	0.0	734	16	14	734	16	14
Internet Control Message Protocol v6	0.0	16	0.0	1574	35	16	1574	35	16
Internet Protocol Version 4	100.0	322849	1.6	6456980	144 k	0	0	0	322849
User Datagram Protocol	0.7	2191	0.0	17528	392	0	0	0	2191
Simple Network Management Protocol	0.0	152	0.0	13211	295	152	13211	295	152
QUIC IETF	0.4	1138	0.1	372131	8327	1138	355043	7945	1187
Domain Name System	0.3	847	0.0	77605	1736	847	77605	1736	847
Data	0.0	54	0.0	459	10	54	459	10	54
Transmission Control Protocol	99.3	320477	1.7	6507116	145 k	46636	1021788	22 k	320477
Transport Layer Security	1.8	5926	1.7	6743859	150 k	5926	6002385	134 k	6034
Post Office Protocol	0.0	5	0.0	153	3	5	153	3	5
iPerf3 Speed Test	82.9	267761	93.0	364072806	8147 k	15	540	12	267762
Internet Message Access Protocol	0.0	4	0.0	303	6	4	303	6	4
Hypertext Transfer Protocol	0.0	14	0.0	3785	84	13	3519	78	14
Online Certificate Status Protocol	0.0	1	0.0	471	10	1	471	10	1
Data	83.0	267877	93.0	364073338	8147 k	267877	364073338	8147 k	267877
Internet Control Message Protocol	0.1	181	0.0	47189	1056	181	47189	1056	181

gnb_mac.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	52	100.0	15662	384	0	0	0	52
DLT User	100.0	52	100.0	15662	384	0	0	0	52
NG Application Protocol	100.0	52	100.0	15662	384	52	15662	384	52

gnb_n3.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	52	100.0	15662	384	0	0	0	52
DLT User	100.0	52	100.0	15662	384	0	0	0	52
NG Application Protocol	100.0	52	100.0	15662	384	52	15662	384	52

gnb_ngap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	573633	100.0	405768380	8930 k	0	0	0	573633
DLT User	100.0	573633	100.0	405768380	8930 k	0	0	0	573633
User Datagram Protocol	100.0	573633	1.1	4589064	100 k	0	0	0	573633
RLC-NR	100.0	573633	96.3	390853922	8602 k	573632	390853883	8602 k	573633
Malformed Packet	0.0	1	0.0	0	0	1	0	0	1

gnb_rlc.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	313155	100.0	380775267	13 M	0	0	0	313155
Raw packet data	100.0	313155	100.0	380775267	13 M	0	0	0	313155
Internet Protocol Version 6	0.0	4	0.0	160	5	0	0	0	4
User Datagram Protocol	0.0	2	0.0	16	0	0	0	0	2
Domain Name System	0.0	2	0.0	116	4	2	116	4	2
Internet Control Message Protocol v6	0.0	2	0.0	228	8	2	228	8	2
Internet Protocol Version 4	100.0	313151	1.6	6263020	221 k	0	0	0	313151
User Datagram Protocol	0.3	837	0.0	6696	237	0	0	0	837
Simple Network Management Protocol	0.0	110	0.0	9520	337	110	9520	337	110
QUIC IETF	0.1	187	0.0	111740	3958	187	98629	3494	221
Domain Name System	0.1	254	0.0	22984	814	254	22984	814	254
Data	0.1	286	0.0	9620	340	286	9620	340	286
Transmission Control Protocol	99.7	312198	1.7	6338852	224 k	41319	912680	32 k	312198
Transport Layer Security	0.9	2907	0.5	1781223	63 k	2907	1686225	59 k	2960
Post Office Protocol	0.0	5	0.0	153	5	5	153	5	5
iPerf3 Speed Test	85.6	267910	95.7	364275446	12 M	15	540	19	267911
Data	85.5	267895	95.7	364274608	12 M	267895	364274608	12 M	267895
Internet Message Access Protocol	0.0	4	0.0	303	10	4	303	10	4
Data	0.0	53	0.0	53	1	53	53	1	53
Internet Control Message Protocol	0.0	116	0.0	32364	1146	116	32364	1146	116

tcpdump.pcap

iPerf3 – Micro Operator

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
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.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	216	100.0	97156	2238	0	0	0	216
DLT User	100.0	216	100.0	97156	2238	0	0	0	216
E2 Application Protocol	100.0	216	100.0	97156	2238	186	82317	1897	216
Malformed Packet	0.5	1	0.0	0	0	1	0	0	1
Dissector Bug	13.4	29	0.0	0	0	29	0	0	29

gnb_e2ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	55	100.0	6985	160	0	0	0	55
DLT User	100.0	55	100.0	6985	160	0	0	0	55
F1 Application Protocol	100.0	55	100.0	6985	160	55	6985	160	55

gnb_f1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	148605	100.0	423054244	9699 k	0	0	0	148605
DLT User	100.0	148605	100.0	423054244	9699 k	0	0	0	148605
User Datagram Protocol	100.0	148605	0.3	1188840	27 k	0	0	0	148605
MAC-NR	100.0	148605	98.9	418447489	9593 k	148605	418447489	9593 k	148605

gnb_mac.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	334658	100.0	390118922	10 M	0	0	0	334658
DLT User	100.0	334658	100.0	390118922	10 M	0	0	0	334658
GPRS Tunneling Protocol	100.0	334658	1.4	5354528	139 k	0	0	0	334658
Internet Protocol Version 4	100.0	334658	1.7	6693160	174 k	0	0	0	334658
User Datagram Protocol	0.6	2088	0.0	16704	436	0	0	0	2088
Simple Network Management Protocol	0.0	153	0.0	13255	346	153	13255	346	153
QUIC IETF	0.3	1138	0.1	372131	9721	1138	355043	9274	1187
Domain Name System	0.2	797	0.0	72602	1896	797	72602	1896	797
Transmission Control Protocol	99.3	332389	1.7	6743200	176 k	60033	1287608	33 k	332389
Transport Layer Security	1.8	5944	1.7	6772856	176 k	5944	6031382	157 k	6052
Post Office Protocol	0.0	5	0.0	153	3	5	153	3	5
iPerf3 Speed Test	79.6	266258	92.8	362028726	9457 k	15	540	14	266259
Internet Message Access Protocol	0.0	4	0.0	303	7	4	303	7	4
Hypertext Transfer Protocol	0.0	14	0.0	3785	98	13	3519	91	14
Online Certificate Status Protocol	0.0	1	0.0	471	12	1	471	12	1
Data	79.6	266374	92.8	362029258	9457 k	266374	362029258	9457 k	266374
Internet Control Message Protocol	0.1	181	0.0	47189	1232	181	47189	1232	181

gnb_n3.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	42	100.0	5161	179	0	0	0	42
DLT User	100.0	42	100.0	5161	179	0	0	0	42
NG Application Protocol	100.0	42	100.0	5161	179	42	5161	179	42

gnb_ngap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	450920	100.0	399469885	9693 k	0	0	0	450920
DLT User	100.0	450920	100.0	399469885	9693 k	0	0	0	450920
User Datagram Protocol	100.0	450920	0.9	3607360	87 k	0	0	0	450920
RLC-NR	100.0	450920	97.1	387745965	9409 k	450920	387745965	9409 k	450920

gnb_rlc.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	324427	100.0	379032785	13 M	0	0	0	324427
Raw packet data	100.0	324427	100.0	379032785	13 M	0	0	0	324427
Internet Protocol Version 6	0.0	1	0.0	40	1	0	0	0	1
Internet Control Message Protocol v6	0.0	1	0.0	16	0	1	16	0	1
Internet Protocol Version 4	100.0	324426	1.7	6488520	234 k	0	0	0	324426
User Datagram Protocol	0.2	799	0.0	6392	230	0	0	0	799
Simple Network Management Protocol	0.0	111	0.0	9564	345	111	9564	345	111
QUIC IETF	0.1	187	0.0	111740	4035	187	98629	3561	221
Domain Name System	0.1	249	0.0	22166	800	249	22166	800	249
Data	0.1	252	0.0	9331	336	252	9331	336	252
Transmission Control Protocol	99.7	323511	1.7	6561128	236 k	54327	1168988	42 k	323511
Transport Layer Security	0.9	2864	0.5	1775216	64 k	2864	1680218	60 k	2917
Post Office Protocol	0.0	5	0.0	153	5	5	153	5	5
iPerf3 Speed Test	82.1	266258	95.5	362028726	13 M	15	540	19	266259
Data	82.1	266243	95.5	362027888	13 M	266243	362027888	13 M	266243
Internet Message Access Protocol	0.0	4	0.0	303	10	4	303	10	4
Data	0.0	53	0.0	53	1	53	53	1	53
Internet Control Message Protocol	0.0	116	0.0	32364	1168	116	32364	1168	116

tcpdump.pcap

VR_FHD – Main Operator

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
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.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	265	100.0	119069	2905	0	0	0	265
DLT User	100.0	265	100.0	119069	2905	0	0	0	265
E2 Application Protocol	100.0	265	100.0	119069	2905	75	32180	785	265
Malformed Packet	0.4	1	0.0	0	0	1	0	0	1
Dissector Bug	71.3	189	0.0	0	0	189	0	0	189

gnb_e2ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	35	100.0	7436	180	0	0	0	35
DLT User	100.0	35	100.0	7436	180	0	0	0	35
F1 Application Protocol	100.0	35	100.0	7436	180	35	7436	180	35

gnb_f1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	48866	100.0	88136226	2141 k	0	0	0	48866
DLT User	100.0	48866	100.0	88136226	2141 k	0	0	0	48866
User Datagram Protocol	100.0	48866	0.4	390928	9497	0	0	0	48866
MAC-NR	100.0	48866	98.3	86621380	2104 k	48866	86621380	2104 k	48866

gnb_mac.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	94522	100.0	82741608	2188 k	0	0	0	94522
DLT User	100.0	94522	100.0	82741608	2188 k	0	0	0	94522
GPRS Tunneling Protocol	100.0	94522	1.8	1512352	40 k	0	0	0	94522
Internet Protocol Version 6	0.1	126	0.0	5040	133	0	0	0	126
User Datagram Protocol	0.0	16	0.0	128	3	0	0	0	16
Domain Name System	0.0	16	0.0	870	23	16	870	23	16
Transmission Control Protocol	0.1	56	0.0	2240	59	56	2240	59	56
Internet Control Message Protocol v6	0.1	54	0.0	4960	131	54	4960	131	54
Internet Protocol Version 4	99.9	94396	2.3	1887920	49 k	0	0	0	94396
User Datagram Protocol	76.7	72469	0.7	579752	15 k	0	0	0	72469
QUIC IETF	76.3	72118	87.7	72556377	1919 k	72118	72504535	1918 k	72180
Network Time Protocol	0.0	2	0.0	96	2	2	96	2	2
Domain Name System	0.3	303	0.0	26727	707	303	26727	707	303
Data	0.0	46	0.0	391	10	46	391	10	46
Transmission Control Protocol	23.1	21858	0.9	703992	18 k	13092	424152	11 k	21858
XMPP Protocol	0.0	1	0.0	1777	47	1	1777	47	1
Transport Layer Security	9.3	8747	6.6	5501133	145 k	8747	5144609	136 k	8877
Post Office Protocol	0.0	5	0.0	153	4	5	153	4	5
Internet Message Access Protocol	0.0	9	0.0	537	14	9	537	14	9
Hypertext Transfer Protocol	0.0	4	0.0	544	14	4	544	14	4
Internet Control Message Protocol	0.1	69	0.0	2484	65	69	2484	65	69

gnb_n3.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	22	100.0	5672	1570	0	0	0	22
DLT User	100.0	22	100.0	5672	1570	0	0	0	22
NG Application Protocol	100.0	22	100.0	5672	1570	22	5672	1570	22

gnb_ngap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	140339	100.0	86391260	2237 k	0	0	0	140339
DLT User	100.0	140339	100.0	86391260	2237 k	0	0	0	140339
User Datagram Protocol	100.0	140339	1.3	1122712	29 k	0	0	0	140339
RLC-NR	100.0	140339	95.8	82742446	2143 k	140339	82742446	2143 k	140339

gnb_rlc.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	94800	100.0	81259726	2449 k	0	0	0	94800
Raw packet data	100.0	94800	100.0	81259726	2449 k	0	0	0	94800
Internet Protocol Version 6	0.0	34	0.0	1360	41	0	0	0	34
User Datagram Protocol	0.0	4	0.0	32	0	0	0	0	4
Domain Name System	0.0	4	0.0	218	6	4	218	6	4
Transmission Control Protocol	0.0	14	0.0	560	16	14	560	16	14
Internet Control Message Protocol v6	0.0	16	0.0	1498	45	16	1498	45	16
Internet Protocol Version 4	100.0	94766	2.3	1895320	57 k	0	0	0	94766
User Datagram Protocol	76.4	72422	0.7	579376	17 k	0	0	0	72422
QUIC IETF	76.1	72118	89.3	72556377	2187 k	72118	72504535	2185 k	72180
Network Time Protocol	0.0	2	0.0	96	2	2	96	2	2
Domain Name System	0.3	262	0.0	22735	685	262	22735	685	262
Data	0.0	40	0.0	340	10	40	340	10	40
Transmission Control Protocol	23.5	22275	0.9	717176	21 k	13454	435588	13 k	22275
XMPP Protocol	0.0	1	0.0	1777	53	1	1777	53	1
Transport Layer Security	9.3	8806	6.8	5498893	165 k	8806	5142369	155 k	8936
Post Office Protocol	0.0	5	0.0	153	4	5	153	4	5
Internet Message Access Protocol	0.0	9	0.0	537	16	9	537	16	9
Internet Control Message Protocol	0.1	69	0.0	2484	74	69	2484	74	69

tcpdump.pcap

VR_FHD – Micro Operator

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	6	100.0	374	63	0	0	0	6
DLT User	100.0	6	100.0	374	63	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	63	6	374	63	6

gnb_e1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	238	100.0	106332	2783	0	0	0	238
DLT User	100.0	238	100.0	106332	2783	0	0	0	238
E2 Application Protocol	100.0	238	100.0	106332	2783	133	58324	1526	238
Malformed Packet	0.4	1	0.0	0	0	1	0	0	1
Dissector Bug	43.7	104	0.0	0	0	104	0	0	104

gnb_e2ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	77	100.0	10357	267	0	0	0	77
DLT User	100.0	77	100.0	10357	267	0	0	0	77
F1 Application Protocol	100.0	77	100.0	10357	267	77	10357	267	77

gnb_f1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	35205	100.0	90354067	2352 k	0	0	0	35205
DLT User	100.0	35205	100.0	90354067	2352 k	0	0	0	35205
User Datagram Protocol	100.0	35205	0.3	281640	7332	0	0	0	35205
MAC-NR	100.0	35205	98.8	89262712	2324 k	35205	89262712	2324 k	35205

gnb_mac.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	94459	100.0	82717750	2699 k	0	0	0	94459
DLT User	100.0	94459	100.0	82717750	2699 k	0	0	0	94459
GPRS Tunneling Protocol	100.0	94459	1.8	1511344	49 k	0	0	0	94459
Internet Protocol Version 4	100.0	94459	2.3	1889180	61 k	0	0	0	94459
User Datagram Protocol	76.6	72363	0.7	578904	18 k	0	0	0	72363
QUIC IETF	76.3	72119	87.7	72557759	2367 k	72119	72505917	2366 k	72181
Network Time Protocol	0.0	2	0.0	96	3	2	96	3	2
Domain Name System	0.3	242	0.0	20868	681	242	20868	681	242
Transmission Control Protocol	23.3	22026	0.9	709144	23 k	13109	424508	13 k	22026
XMPP Protocol	0.0	1	0.0	1777	57	1	1777	57	1
Transport Layer Security	9.4	8902	6.7	5544004	180 k	8902	5185145	169 k	9034
Post Office Protocol	0.0	5	0.0	153	4	5	153	4	5
Internet Message Access Protocol	0.0	9	0.0	537	17	9	537	17	9
Internet Control Message Protocol	0.1	70	0.0	3040	99	70	3040	99	70

gnb_n3.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	56	100.0	8389	298	0	0	0	56
DLT User	100.0	56	100.0	8389	298	0	0	0	56
NG Application Protocol	100.0	56	100.0	8389	298	56	8389	298	56

gnb_ngap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	121077	100.0	85233897	2266 k	0	0	0	121077
DLT User	100.0	121077	100.0	85233897	2266 k	0	0	0	121077
User Datagram Protocol	100.0	121077	1.1	968616	25 k	0	0	0	121077
RLC-NR	100.0	121077	96.3	82085895	2182 k	121077	82085895	2182 k	121077

gnb_rlc.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	94082	100.0	81190668	2320 k	0	0	0	94082
Raw packet data	100.0	94082	100.0	81190668	2320 k	0	0	0	94082
Internet Protocol Version 6	0.0	8	0.0	352	10	0	0	0	8
User Datagram Protocol	0.0	4	0.0	32	0	0	0	0	4
eXtensible Markup Language	0.0	4	0.0	2428	69	4	2428	69	4
Internet Control Message Protocol v6	0.0	4	0.0	112	3	4	112	3	4
Internet Protocol Version 4	100.0	94074	2.3	1881492	53 k	0	0	0	94074
User Datagram Protocol	76.9	72365	0.7	578920	16 k	0	0	0	72365
QUIC IETF	76.7	72119	89.4	72557759	2073 k	72119	72505917	2072 k	72181
Network Time Protocol	0.0	2	0.0	96	2	2	96	2	2
eXtensible Markup Language	0.0	2	0.0	1214	34	2	1214	34	2
Domain Name System	0.3	242	0.0	20868	596	242	20868	596	242
Transmission Control Protocol	23.0	21636	0.9	696892	19 k	12719	412256	11 k	21636
XMPP Protocol	0.0	1	0.0	1777	50	1	1777	50	1
Transport Layer Security	9.5	8902	6.8	5544004	158 k	8902	5185145	148 k	9034
Post Office Protocol	0.0	5	0.0	153	4	5	153	4	5
Internet Message Access Protocol	0.0	9	0.0	537	15	9	537	15	9
Internet Group Management Protocol	0.0	3	0.0	48	1	3	48	1	3
Internet Control Message Protocol	0.1	70	0.0	3040	86	70	3040	86	70

tcpdump.pcap

VR_2K – Main Operator

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	6	100.0	374	414	0	0	0	6
DLT User	100.0	6	100.0	374	414	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	414	6	374	414	6

gnb_e1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	291	100.0	130926	3249	0	0	0	291
DLT User	100.0	291	100.0	130926	3249	0	0	0	291
E2 Application Protocol	100.0	291	100.0	130926	3249	128	56187	1394	291
Malformed Packet	0.3	1	0.0	0	0	1	0	0	1
Dissector Bug	55.7	162	0.0	0	0	162	0	0	162

gnb_e2ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	18	100.0	4466	110	0	0	0	18
DLT User	100.0	18	100.0	4466	110	0	0	0	18
F1 Application Protocol	100.0	18	100.0	4466	110	18	4466	110	18

gnb_f1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	179604	100.0	261166462	6455 k	0	0	0	179604
DLT User	100.0	179604	100.0	261166462	6455 k	0	0	0	179604
User Datagram Protocol	100.0	179604	0.6	1436832	35 k	0	0	0	179604
MAC-NR	100.0	179604	97.9	255598738	6317 k	179604	255598738	6317 k	179604

gnb_mac.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	264829	100.0	251968742	6330 k	0	0	0	264829
DLT User	100.0	264829	100.0	251968742	6330 k	0	0	0	264829
GPRS Tunneling Protocol	100.0	264829	1.7	4237264	106 k	0	0	0	264829
Internet Protocol Version 6	0.0	8	0.0	320	8	0	0	0	8
User Datagram Protocol	0.0	4	0.0	32	0	0	0	0	4
Domain Name System	0.0	4	0.0	232	5	4	232	5	4
Internet Control Message Protocol v6	0.0	4	0.0	456	11	4	456	11	4
Internet Protocol Version 4	100.0	264821	2.1	5296420	133 k	0	0	0	264821
User Datagram Protocol	90.1	238637	0.8	1909096	47 k	0	0	0	238637
UA/UDP Encapsulation Protocol	0.0	35	0.0	17981	451	35	17981	451	35
QUIC IETF	89.9	238171	92.5	233113781	5856 k	238171	233082344	5855 k	238224
Echo	0.0	2	0.0	96	2	2	96	2	2
Domain Name System	0.1	279	0.0	24963	627	279	24963	627	279
Data	0.1	150	0.0	1275	32	150	1275	32	150
Transmission Control Protocol	9.9	26091	0.3	839416	21 k	16053	518956	13 k	26091
Transport Layer Security	3.8	10019	2.6	6538553	164 k	10019	6073750	152 k	10177
Post Office Protocol	0.0	10	0.0	306	7	10	306	7	10
Internet Message Access Protocol	0.0	9	0.0	537	13	9	537	13	9
Internet Control Message Protocol	0.0	93	0.0	3360	84	93	3360	84	93

gnb_n3.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	8	100.0	3435	3722	0	0	0	8
DLT User	100.0	8	100.0	3435	3722	0	0	0	8
NG Application Protocol	100.0	8	100.0	3435	3722	8	3435	3722	8

gnb_ngap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	446975	100.0	262383398	6588 k	0	0	0	446975
DLT User	100.0	446975	100.0	262383398	6588 k	0	0	0	446975
User Datagram Protocol	100.0	446975	1.4	3575800	89 k	0	0	0	446975
RLC-NR	100.0	446975	95.6	250762048	6296 k	446975	250762048	6296 k	446975

gnb_rlc.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	264526	100.0	247695419	6704 k	0	0	0	264526
Raw packet data	100.0	264526	100.0	247695419	6704 k	0	0	0	264526
Internet Protocol Version 6	0.0	4	0.0	160	4	0	0	0	4
User Datagram Protocol	0.0	2	0.0	16	0	0	0	0	2
Domain Name System	0.0	2	0.0	116	3	2	116	3	2
Internet Control Message Protocol v6	0.0	2	0.0	228	6	2	228	6	2
Internet Protocol Version 4	100.0	264522	2.1	5290440	143 k	0	0	0	264522
User Datagram Protocol	90.2	238526	0.8	1908208	51 k	0	0	0	238526
UA/UDP Encapsulation Protocol	0.0	35	0.0	17981	486	35	17981	486	35
QUIC IETF	90.0	238171	94.1	233113781	6309 k	238171	233082344	6309 k	238224
Echo	0.0	2	0.0	96	2	2	96	2	2
Domain Name System	0.1	274	0.0	24145	653	274	24145	653	274
Data	0.0	44	0.0	374	10	44	374	10	44
Transmission Control Protocol	9.8	25909	0.3	833192	22 k	15886	513212	13 k	25909
Transport Layer Security	3.8	10004	2.6	6535632	176 k	10004	6070829	164 k	10162
Post Office Protocol	0.0	10	0.0	306	8	10	306	8	10
Internet Message Access Protocol	0.0	9	0.0	537	14	9	537	14	9
Internet Control Message Protocol	0.0	87	0.0	3132	84	87	3132	84	87

tcpdump.pcap

VR_2K – Micro Operator

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	6	100.0	374	58	0	0	0	6
DLT User	100.0	6	100.0	374	58	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	58	6	374	58	6

gnb_e1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	269	100.0	120169	3229	0	0	0	269
DLT User	100.0	269	100.0	120169	3229	0	0	0	269
E2 Application Protocol	100.0	269	100.0	120169	3229	185	81482	2190	269
Malformed Packet	0.4	1	0.0	0	0	1	0	0	1
Dissector Bug	30.9	83	0.0	0	0	83	0	0	83

gnb_e2ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	102256	100.0	273214601	7294 k	0	0	0	102256
DLT User	100.0	102256	100.0	273214601	7294 k	0	0	0	102256
User Datagram Protocol	100.0	102256	0.3	818048	21 k	0	0	0	102256
MAC-NR	100.0	102256	98.8	270044665	7210 k	102256	270044665	7210 k	102256

gnb_f1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	102256	100.0	273214601	7294 k	0	0	0	102256
DLT User	100.0	102256	100.0	273214601	7294 k	0	0	0	102256
User Datagram Protocol	100.0	102256	0.3	818048	21 k	0	0	0	102256
MAC-NR	100.0	102256	98.8	270044665	7210 k	102256	270044665	7210 k	102256

gnb_mac.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	264770	100.0	251943782	8099 k	0	0	0	264770
DLT User	100.0	264770	100.0	251943782	8099 k	0	0	0	264770
GPRS Tunneling Protocol	100.0	264770	1.7	4236320	136 k	0	0	0	264770
Internet Protocol Version 4	100.0	264770	2.1	5295400	170 k	0	0	0	264770
User Datagram Protocol	90.1	238481	0.8	1907848	61 k	0	0	0	238481
QUIC IETF	90.0	238207	92.5	233131803	7494 k	238207	233100172	7493 k	238262
Network Time Protocol	0.0	2	0.0	96	3	2	96	3	2
Domain Name System	0.1	272	0.0	23471	754	272	23471	754	272
Transmission Control Protocol	9.9	26202	0.3	842560	27 k	15902	513788	16 k	26202
Transport Layer Security	3.9	10281	2.6	6581260	211 k	10281	6113138	196 k	10442
Post Office Protocol	0.0	10	0.0	306	9	10	306	9	10
Internet Message Access Protocol	0.0	9	0.0	537	17	9	537	17	9
Internet Control Message Protocol	0.0	87	0.0	3132	100	87	3132	100	87

gnb_n3.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	56	100.0	8389	296	0	0	0	56
DLT User	100.0	56	100.0	8389	296	0	0	0	56
NG Application Protocol	100.0	56	100.0	8389	296	56	8389	296	56

gnb_ngap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	344457	100.0	258850895	7139 k	0	0	0	344457
DLT User	100.0	344457	100.0	258850895	7139 k	0	0	0	344457
User Datagram Protocol	100.0	344457	1.1	2755656	76 k	0	0	0	344457
RLC-NR	100.0	344457	96.5	249895013	6892 k	344457	249895013	6892 k	344457

gnb_rlc.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	264365	100.0	247686230	7103 k	0	0	0	264365
Raw packet data	100.0	264365	100.0	247686230	7103 k	0	0	0	264365
Internet Protocol Version 4	100.0	264365	2.1	5287300	151 k	0	0	0	264365
User Datagram Protocol	90.2	238481	0.8	1907848	54 k	0	0	0	238481
QUIC IETF	90.1	238207	94.1	233131803	6685 k	238207	233100172	6684 k	238262
Network Time Protocol	0.0	2	0.0	96	2	2	96	2	2
Domain Name System	0.1	272	0.0	23471	673	272	23471	673	272
Transmission Control Protocol	9.8	25797	0.3	829768	23 k	15504	501220	14 k	25797
Transport Layer Security	3.9	10274	2.7	6581067	188 k	10274	6112945	175 k	10435
Post Office Protocol	0.0	10	0.0	306	8	10	306	8	10
Internet Message Access Protocol	0.0	9	0.0	537	15	9	537	15	9
Internet Control Message Protocol	0.0	87	0.0	3132	89	87	3132	89	87

tcpdump.pcap

VR_4K – Main Operator

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	18	100.0	1082	21	0	0	0	18
DLT User	100.0	18	100.0	1082	21	0	0	0	18
E1 Application Protocol	100.0	18	100.0	1082	21	18	1082	21	18

gnb_e1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	392	100.0	176186	3425	0	0	0	392
DLT User	100.0	392	100.0	176186	3425	0	0	0	392
E2 Application Protocol	100.0	392	100.0	176186	3425	175	77417	1505	392
Malformed Packet	0.3	1	0.0	0	0	1	0	0	1
Dissector Bug	55.1	216	0.0	0	0	216	0	0	216

gnb_e2ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	48	100.0	12592	243	0	0	0	48
DLT User	100.0	48	100.0	12592	243	0	0	0	48
F1 Application Protocol	100.0	48	100.0	12592	243	48	12592	243	48

gnb_f1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	262391	100.0	477215872	9241 k	0	0	0	262391
DLT User	100.0	262391	100.0	477215872	9241 k	0	0	0	262391
User Datagram Protocol	100.0	262391	0.4	2099128	40 k	0	0	0	262391
MAC-NR	100.0	262391	98.3	469081751	9083 k	262391	469081751	9083 k	262391

gnb_mac.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	461193	100.0	465588878	9112 k	0	0	0	461193
DLT User	100.0	461193	100.0	465588878	9112 k	0	0	0	461193
GPRS Tunneling Protocol	100.0	461193	1.6	7379088	144 k	0	0	0	461193
Internet Protocol Version 6	0.0	4	0.0	160	3	0	0	0	4
User Datagram Protocol	0.0	2	0.0	16	0	0	0	0	2
Domain Name System	0.0	2	0.0	116	2	2	116	2	2
Internet Control Message Protocol v6	0.0	2	0.0	228	4	2	228	4	2
Internet Protocol Version 4	100.0	461189	2.0	9223780	180 k	0	0	0	461189
User Datagram Protocol	91.1	420097	0.7	3360776	65 k	0	0	0	420097
QUIC IETF	90.9	419129	93.7	436390487	8541 k	419129	436355042	8540 k	419195
Network Time Protocol	0.0	2	0.0	96	1	2	96	1	2
Malformed Packet	0.0	16	0.0	0	0	16	0	0	16
Domain Name System	0.1	606	0.0	50833	994	606	50833	994	606
Data	0.1	344	0.0	113664	2224	344	113664	2224	344
Transmission Control Protocol	8.9	40958	0.3	1279900	25 k	25951	810656	15 k	40958
Transport Layer Security	3.3	14990	1.7	7810613	152 k	14990	6682853	130 k	15276
Post Office Protocol	0.0	5	0.0	153	2	5	153	2	5
Internet Message Access Protocol	0.0	12	0.0	716	14	12	716	14	12
Internet Control Message Protocol	0.0	134	0.0	44871	878	134	44871	878	134

gnb_n3.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	26	100.0	10041	201	0	0	0	26
DLT User	100.0	26	100.0	10041	201	0	0	0	26
NG Application Protocol	100.0	26	100.0	10041	201	26	10041	201	26

gnb_ngap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	730246	100.0	482096385	9432 k	0	0	0	730246
DLT User	100.0	730246	100.0	482096385	9432 k	0	0	0	730246
User Datagram Protocol	100.0	730246	1.2	5841968	114 k	0	0	0	730246
RLC-NR	100.0	730246	96.1	463109989	9060 k	730246	463109989	9060 k	730246

gnb_rlc.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	460200	100.0	458662689	9263 k	0	0	0	460200
Raw packet data	100.0	460200	100.0	458662689	9263 k	0	0	0	460200
Internet Protocol Version 6	0.0	4	0.0	160	3	0	0	0	4
User Datagram Protocol	0.0	2	0.0	16	0	0	0	0	2
Domain Name System	0.0	2	0.0	116	2	2	116	2	2
Internet Control Message Protocol v6	0.0	2	0.0	228	4	2	228	4	2
Internet Protocol Version 4	100.0	460196	2.0	9203920	185 k	0	0	0	460196
User Datagram Protocol	91.3	420299	0.7	3362392	67 k	0	0	0	420299
QUIC IETF	91.2	419747	95.3	437134991	8829 k	419747	437101136	8828 k	419802
Network Time Protocol	0.0	2	0.0	96	1	2	96	1	2
Domain Name System	0.1	458	0.0	40191	811	458	40191	811	458
Data	0.0	92	0.0	1037	20	92	1037	20	92
Transmission Control Protocol	8.7	39811	0.3	1238276	25 k	24838	770120	15 k	39811
Transport Layer Security	3.2	14956	1.7	7802660	157 k	14956	6674900	134 k	15242
Post Office Protocol	0.0	5	0.0	153	3	5	153	3	5
Internet Message Access Protocol	0.0	12	0.0	716	14	12	716	14	12
Internet Control Message Protocol	0.0	86	0.0	4748	95	86	4748	95	86

tcpdump.pcap

VR_4K – Micro Operator

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	6	100.0	374	33	0	0	0	6
DLT User	100.0	6	100.0	374	33	0	0	0	6
E1 Application Protocol	100.0	6	100.0	374	33	6	374	33	6

gnb_e1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	328	100.0	146528	3042	0	0	0	328
DLT User	100.0	328	100.0	146528	3042	0	0	0	328
E2 Application Protocol	100.0	328	100.0	146528	3042	246	108726	2257	328
Malformed Packet	0.3	1	0.0	0	0	1	0	0	1
Dissector Bug	24.7	81	0.0	0	0	81	0	0	81

gnb_e2ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	77	100.0	10357	214	0	0	0	77
DLT User	100.0	77	100.0	10357	214	0	0	0	77
F1 Application Protocol	100.0	77	100.0	10357	214	77	10357	214	77

gnb_f1ap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	205631	100.0	488589570	10 M	0	0	0	205631
DLT User	100.0	205631	100.0	488589570	10 M	0	0	0	205631
User Datagram Protocol	100.0	205631	0.3	1645048	34 k	0	0	0	205631
MAC-NR	100.0	205631	98.7	482215009	9977 k	205631	482215009	9977 k	205631

gnb_mac.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	459068	100.0	464637780	12 M	0	0	0	459068
DLT User	100.0	459068	100.0	464637780	12 M	0	0	0	459068
GPRS Tunneling Protocol	100.0	459068	1.6	7345088	197 k	0	0	0	459068
Internet Protocol Version 4	100.0	459068	2.0	9181360	246 k	0	0	0	459068
User Datagram Protocol	91.3	419149	0.7	3353192	90 k	0	0	0	419149
QUIC IETF	91.2	418660	93.8	435803810	11 M	418660	435769955	11 M	418715
Network Time Protocol	0.0	2	0.0	96	2	2	96	2	2
Domain Name System	0.1	453	0.0	39373	1059	453	39373	1059	453
Data	0.0	34	0.0	544	14	34	544	14	34
Transmission Control Protocol	8.7	39833	0.3	1238348	33 k	24429	757240	20 k	39833
Transport Layer Security	3.4	15387	1.7	7809948	210 k	15387	6682188	179 k	15673
Post Office Protocol	0.0	5	0.0	153	4	5	153	4	5
Internet Message Access Protocol	0.0	12	0.0	716	19	12	716	19	12
Internet Control Message Protocol	0.0	86	0.0	4748	127	86	4748	127	86

gnb_n3.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	56	100.0	8389	261	0	0	0	56
DLT User	100.0	56	100.0	8389	261	0	0	0	56
NG Application Protocol	100.0	56	100.0	8389	261	56	8389	261	56

gnb_ngap.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	640432	100.0	477892614	11 M	0	0	0	640432
DLT User	100.0	640432	100.0	477892614	11 M	0	0	0	640432
User Datagram Protocol	100.0	640432	1.1	5123456	120 k	0	0	0	640432
RLC-NR	100.0	640432	96.5	461241382	10 M	640432	461241382	10 M	640432

gnb_rlc.pcap

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s	End Packets	End Bytes	End Bits/s	PDUs
Frame	100.0	458763	100.0	457272693	11 M	0	0	0	458763
Raw packet data	100.0	458763	100.0	457272693	11 M	0	0	0	458763
Internet Protocol Version 4	100.0	458763	2.0	9175260	224 k	0	0	0	458763
User Datagram Protocol	91.4	419149	0.7	3353192	81 k	0	0	0	419149
QUIC IETF	91.3	418660	95.3	435803810	10 M	418660	435769955	10 M	418715
Network Time Protocol	0.0	2	0.0	96	2	2	96	2	2
Domain Name System	0.1	453	0.0	39373	961	453	39373	961	453
Data	0.0	34	0.0	544	13	34	544	13	34
Transmission Control Protocol	8.6	39528	0.3	1228816	30 k	24126	747772	18 k	39528
Transport Layer Security	3.4	15385	1.7	7808662	190 k	15385	6680902	163 k	15671
Post Office Protocol	0.0	5	0.0	153	3	5	153	3	5
Internet Message Access Protocol	0.0	12	0.0	716	17	12	716	17	12
Internet Control Message Protocol	0.0	86	0.0	4748	115	86	4748	115	86

tcpdump.pcap

Appendix D - xApp for Collecting E2 Metrics

The following Python script runs as an xApp in the near-real-time RIC, collects the E2 metrics exposed by srsRAN, and exports them into a csv file. The script is a modified version of the xApp examples that can be found at: https://github.com/srsran/oran-sc-ric

```
#!/usr/bin/env python3
import argparse
import signal
from lib.xAppBase import xAppBase
import datetime as dt
import pandas as pd

class MyXapp(xAppBase):
    def __init__(self, config, http_server_port, rmr_port):
        super(MyXapp, self).__init__(config, http_server_port, rmr_port)
        with open('ran_metrics.csv', 'w') as csv:

csv.write("Timestamp,CQI,RSRP,RSRQ,RRU.PrbAvailDl,RRU.PrbAvailUl,RRU.PrbTotDl,RRU.PrbTotUl,DRB.RlcSduDelayDl,DRB.PacketS
uccessRateUlgNBUu,DRB.UEThpDl,DRB.UEThpUl,DRB.RlcPacketDropRateDl,DRB.RlcSduTransmittedVolumeDL,DRB.RlcSduTransmittedVol
umeUL,DRB.AirIfDelayUl,DRB.RlcDelayUl\n")

    def my_subscription_callback(self, e2_agent_id, subscription_id, indication_hdr, indication_msg, kpm_report_style,
ue_id):
        if kpm_report_style == 2:
            print("\nRIC Indication Received from {} for Subscription ID: {}, KPM Report Style: {}, UE ID:
{}".format(e2_agent_id, subscription_id, kpm_report_style, ue_id))
        else:
            print("\nRIC Indication Received from {} for Subscription ID: {}, KPM Report Style: {}".format(e2_agent_id,
subscription_id, kpm_report_style))

        indication_hdr = self.e2sm_kpm.extract_hdr_info(indication_hdr)
        meas_data = self.e2sm_kpm.extract_meas_data(indication_msg)

        print("E2SM_KPM RIC Indication Content:")
        print("-ColletStartTime: ", indication_hdr['colletStartTime'])
        print("-Measurements Data:")

        # print("Creating csv file with name: {} as a pandas dataframe", self.csv_fname)
```

```
        dflist =
["CQI","RSRP","RSRQ","RRU.PrbAvailDl","RRU.PrbAvailUl","RRU.PrbTotDl","RRU.PrbTotUl","DRB.RlcSduDelayDl","DRB.PacketSucc
essRateUlgNBUu","DRB.UEThpDl","DRB.UEThpUl","DRB.RlcPacketDropRateDl","DRB.RlcSduTransmittedVolumeDL","DRB.RlcSduTransmi
ttedVolumeUL","DRB.AirIfDelayUl","DRB.RlcDelayUl"]
        with open('ran_metrics.csv', 'a') as csv:
            granulPeriod = meas_data.get("granulPeriod", None)
            if granulPeriod is not None:
                print("-granulPeriod: {}".format(granulPeriod))

            if kpm_report_style in [1,2]:
                line = str(dt.datetime.now().isoformat())+","
                for metric_name, value in meas_data["measData"].items():
                    print("--Metric: {}, Value: {}".format(metric_name, value))
                    if len(value) > 0:
                        line = line + str(value[0]) + ","
                    else:
                        line = line + ","
                print(meas_data["measData"].items())
                line = line[:-1]
                line = line + "\n"
                print(line)
                csv.writelines(line)
                csv.flush()
            else:
                for ue_id, ue_meas_data in meas_data["ueMeasData"].items():
                    print("--UE_id: {}".format(ue_id))
                    granulPeriod = ue_meas_data.get("granulPeriod", None)
                    if granulPeriod is not None:
                        print("---granulPeriod: {}".format(granulPeriod))

                    # to sort a dict: '''sorted_dict = dict(sorted(my_dict.items()))'''
                    line = ""
                    for metric_name, value in ue_meas_data["measData"].items():
                        print("--Metric: {}, Value: {}".format(metric_name, value))
                        line = line + str(value[0]) + ","
                    line = line
```

```
    # Mark the function as xApp start function using xAppBase.start_function decorator.
    # It is required to start the internal msg receive loop.
    @xAppBase.start_function
    def start(self, e2_node_id, kpm_report_style, ue_ids, metric_names):
        report_period = 1000
        granul_period = 1000

        # use always the same subscription callback, but bind kpm_report_style parameter
        subscription_callback = lambda agent, sub, hdr, msg: self.my_subscription_callback(agent, sub, hdr, msg,
kpm_report_style, None)

        if (kpm_report_style == 1):
            print("Subscribe to E2 node ID: {}, RAN func: e2sm_kpm, Report Style: {}, metrics: {}".format(e2_node_id,
kpm_report_style, metric_names))
            self.e2sm_kpm.subscribe_report_service_style_1(e2_node_id, report_period, metric_names, granul_period,
subscription_callback)

        elif (kpm_report_style == 2):
            # need to bind also UE_ID to callback as it is not present in the RIC indication in the case of E2SM KPM
Report Style 2
            subscription_callback = lambda agent, sub, hdr, msg: self.my_subscription_callback(agent, sub, hdr, msg,
kpm_report_style, ue_ids[0])

            print("Subscribe to E2 node ID: {}, RAN func: e2sm_kpm, Report Style: {}, UE_id: {}, metrics:
{}".format(e2_node_id, kpm_report_style, ue_ids[0], metric_names))
            self.e2sm_kpm.subscribe_report_service_style_2(e2_node_id, report_period, ue_ids[0], metric_names,
granul_period, subscription_callback)

        elif (kpm_report_style == 3):
            if (len(metric_names) > 1):
                metric_names = metric_names[0]
                print("INFO: Currently only 1 metric can be requested in E2SM-KPM Report Style 3, selected metric:
{}".format(metric_names))

            matchingConds = [{'matchingCondChoice': ('testCondInfo', {'testType': ('ul-rSRP', 'true'), 'testExpr':
'lessthan', 'testValue': ('valueInt', 1000)})}]

            print("Subscribe to E2 node ID: {}, RAN func: e2sm_kpm, Report Style: {}, metrics: {}".format(e2_node_id,
kpm_report_style, metric_names))
```

```
            self.e2sm_kpm.subscribe_report_service_style_3(e2_node_id, report_period, matchingConds, metric_names,
granul_period, subscription_callback)

        elif (kpm_report_style == 4):

            matchingUeConds = [{'testCondInfo': {'testType': ('ul-rSRP', 'true'), 'testExpr': 'lessthan', 'testValue':
('valueInt', 1000)}}]

            print("Subscribe to E2 node ID: {}, RAN func: e2sm_kpm, Report Style: {}, metrics: {}".format(e2_node_id,
kpm_report_style, metric_names))
            self.e2sm_kpm.subscribe_report_service_style_4(e2_node_id, report_period, matchingUeConds, metric_names,
granul_period, subscription_callback)

        elif (kpm_report_style == 5):
            if (len(ue_ids) < 2):
                dummyUeId = ue_ids[0] + 1
                ue_ids.append(dummyUeId)
                print("INFO: Subscription for E2SM_KPM Report Service Style 5 requires at least two UE IDs -> add dummy
UeID: {}".format(dummyUeId))

            print("Subscribe to E2 node ID: {}, RAN func: e2sm_kpm, Report Style: {}, UE_ids: {}, metrics:
{}".format(e2_node_id, kpm_report_style, ue_ids, metric_names))
            self.e2sm_kpm.subscribe_report_service_style_5(e2_node_id, report_period, ue_ids, metric_names,
granul_period, subscription_callback)

        else:
            print("INFO: Subscription for E2SM_KPM Report Service Style {} is not supported".format(kpm_report_style))
            exit(1)


if __name__ == '__main__':
    parser = argparse.ArgumentParser(description='My example xApp')
    parser.add_argument("--config", type=str, default='', help="xApp config file path")
    parser.add_argument("--http_server_port", type=int, default=8092, help="HTTP server listen port")
    parser.add_argument("--rmr_port", type=int, default=4562, help="RMR port")
    parser.add_argument("--e2_node_id", type=str, default='gnbd_001_002_00019b_0', help="E2 Node ID")
    parser.add_argument("--ran_func_id", type=int, default=2, help="RAN function ID")
    parser.add_argument("--kpm_report_style", type=int, default=1, help="xApp config file path")
    parser.add_argument("--ue_ids", type=str, default='0', help="UE ID")
```

```
    parser.add_argument("--metrics", type=str, default='DRB.UEThpUl,DRB.UEThpDl', help="Metrics name as comma-separated
string")
    parser.add_argument("--csv", type=str, default="ran_metrics.csv", help="CSV metrics filename")

    args = parser.parse_args()
    config = args.config
    e2_node_id = args.e2_node_id
    ran_func_id = args.ran_func_id
    ue_ids = list(map(int, args.ue_ids.split(","))) # Note: the UE id has to exist at E2 node!
    kpm_report_style = args.kpm_report_style
    metrics = args.metrics.split(",")

    # Create MyXapp.
    myXapp = MyXapp(config, args.http_server_port, args.rmr_port)
    myXapp.e2sm_kpm.set_ran_func_id(ran_func_id)

    # Connect exit signals.
    signal.signal(signal.SIGQUIT, myXapp.signal_handler)
    signal.signal(signal.SIGTERM, myXapp.signal_handler)
    signal.signal(signal.SIGINT, myXapp.signal_handler)

    # Start xApp.
    myXapp.start(e2_node_id, kpm_report_style, ue_ids, metrics)
    # Note: xApp will unsubscribe all active subscriptions at exit.
```