

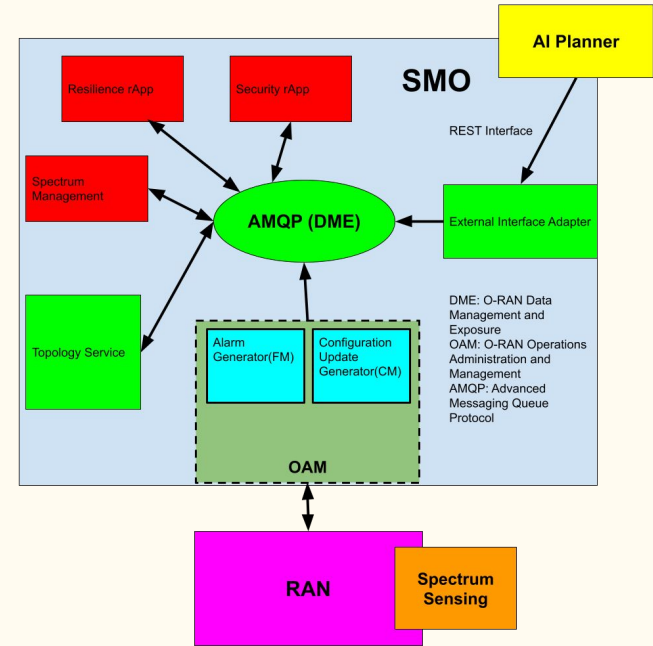
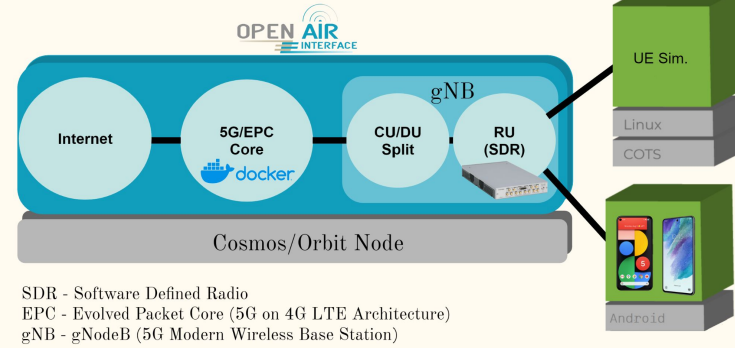


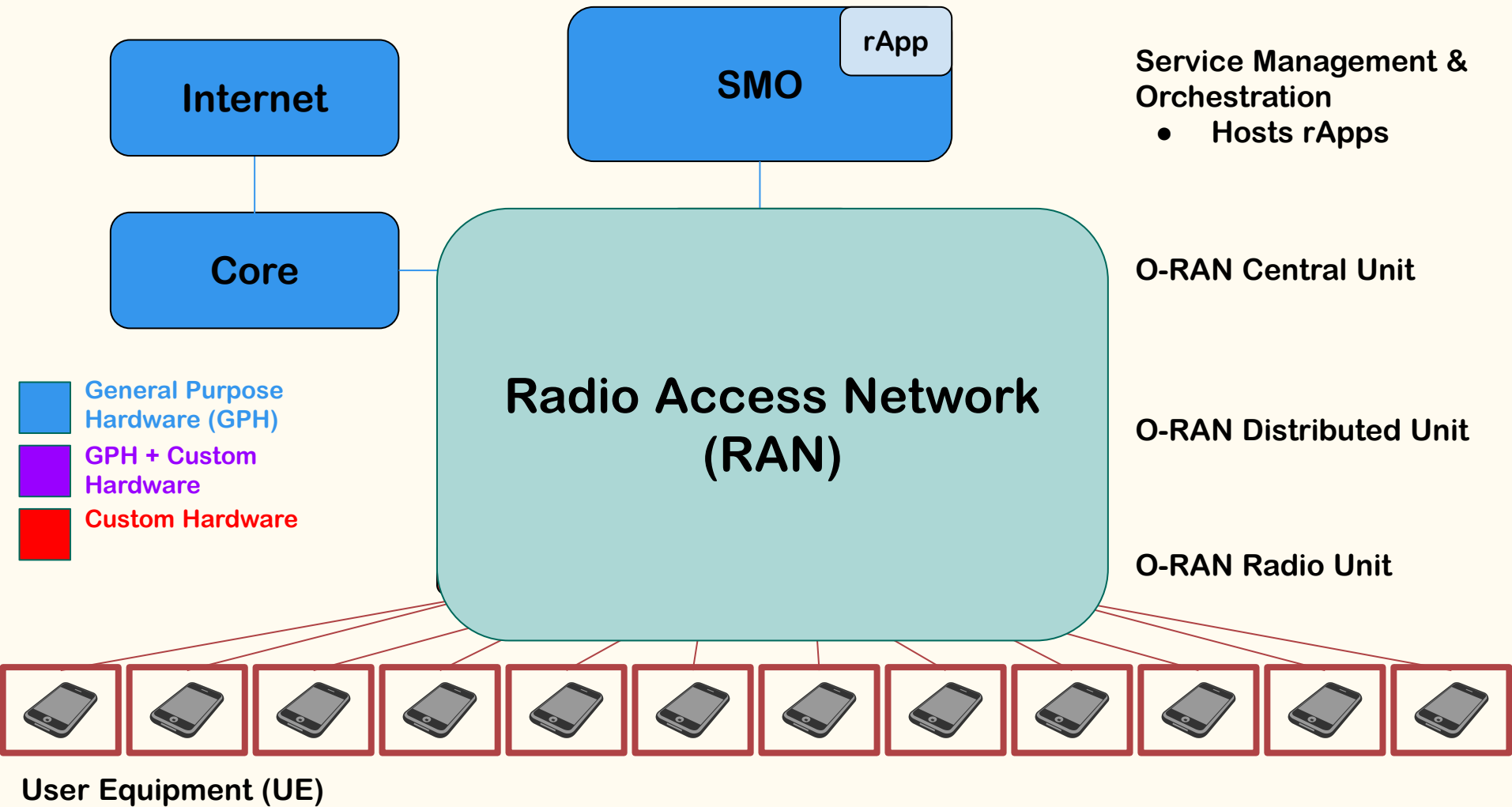
5G/NextG Final Presentation

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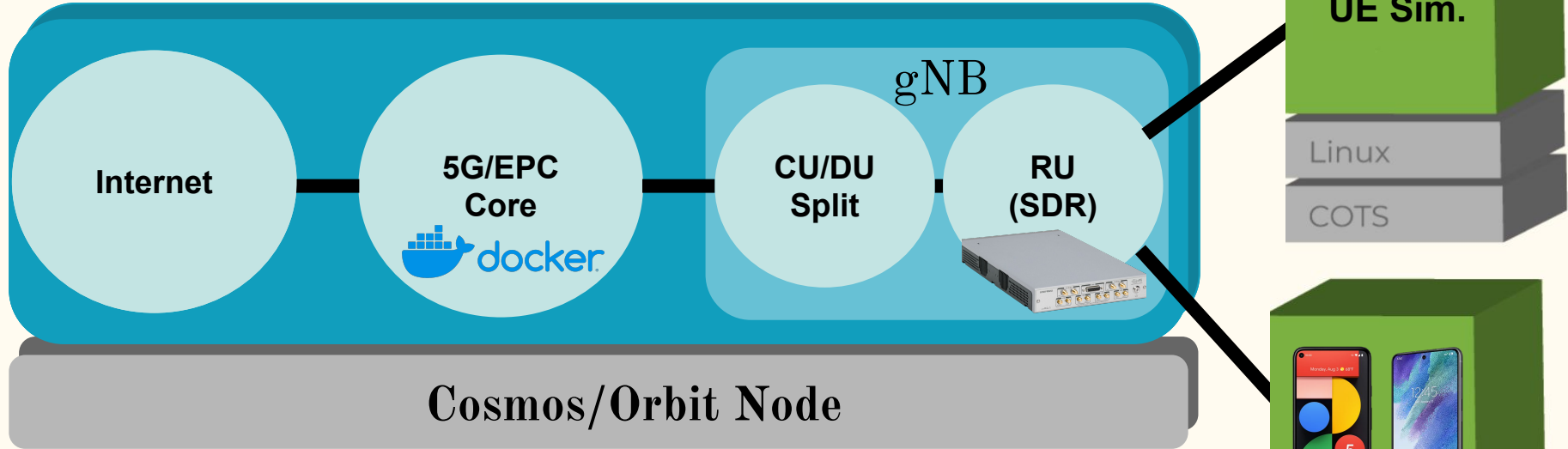
Project Objectives:

- Open source implementation of 5G
 - End to end session from UE to Internet
- Network control and management applications (SMO)
 - Applications (rApps)
 - Resilience
 - Security
 - Frequency
 - Framework Services
 - Topology Service
 - Topology Visualization
 - Alarm Generator
 - Spectrum Sensing Service
- Done in context of Open RAN (O-RAN)





O-RAN Implementation

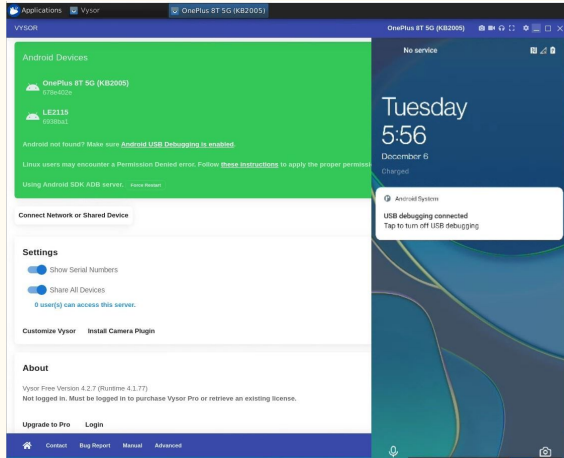


SDR - Software Defined Radio

EPC - Evolved Packet Core (5G on 4G LTE Architecture)

gNB - gNodeB (5G Modern Wireless Base Station)

Results from OAI System



5:51

iPerf

START

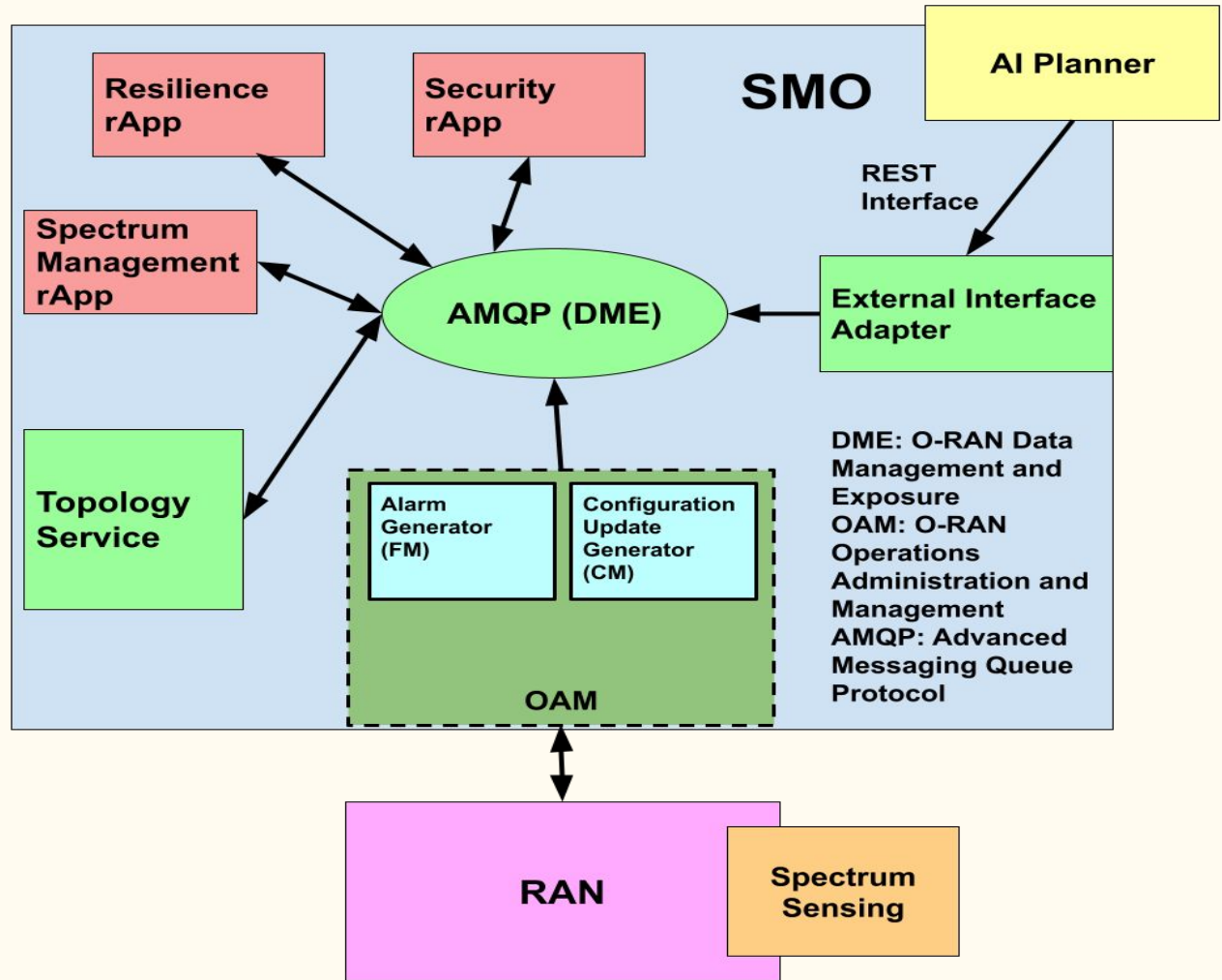
Interval	Retr	Cwnd	Bytes	Bandwidth
sec		Bytes		bit/sec
1	-	-	1.18M	9.85M
2	-	-	1.5M	12.6M
3	-	-	1.57M	13.1M
4	-	-	1.51M	12.6M
5	-	-	1.8M	15.1M
6	-	-	2.01M	16.9M
7	-	-	2.3M	19.3M
8	-	-	2.25M	18.9M
9	-	-	2.34M	19.7M
10	-	-	2.24M	18.8M
10.5	-	-	317.0K	5.11M
Sender summary				
0.0-10.51	-	-	19.0M	15.2M

```

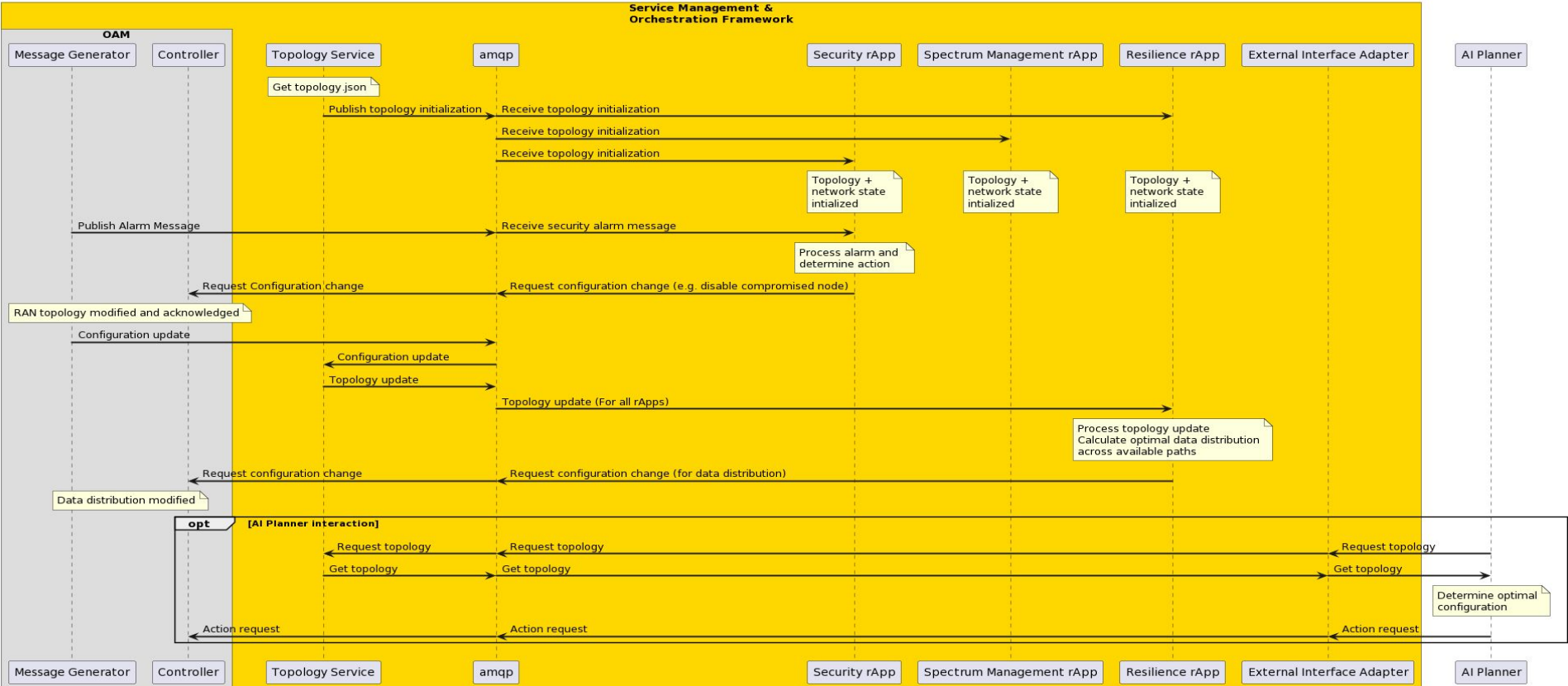
root@sdri-in3:~/SIM200_code# cd GooLine/
root@sdri-in3:~/SIM200_code/GooLine# ls
GobiNetCM.c MPQCTL.h MPQMI.h MPQMUX.c MPQMUX.h Makefile QMThread.c QMThread.h QmiWanCM.c
root@sdri-in3:~/SIM200_code/GooLine# ./simcom-cn
[08-10_11:03:21:687] Build Verston: 2020-07-14 10:20:15
[08-10_11:03:21:688] SIMCOM_CN START...
[08-10_11:03:21:688] ./simcom-cn profile[1] = (null)/(null)/(null)/0, pincode = (null)
[08-10_11:03:21:688] Find /sys/bus/usb/devices/2-4.4 idVendor=1e0e IdProduct=9801
[08-10_11:03:21:688] Find /sys/bus/usb/devices/2-4.4.1.5/Vendor=wwp0s20f0u4u415
[08-10_11:03:21:688] Find usbnet_adapter = wwp0s20f0u4u415
[08-10_11:03:21:688] Find /sys/bus/usb/devices/2-4.4.1.5/usbnlsc/cdc-wdm0
[08-10_11:03:21:688] Find qmichannel = /dev/cdc-wdm0
[08-10_11:03:21:688] netcard driver = qmi_wwan_simcom
[08-10_11:03:21:691] cdc_wdm_fd = 7
[08-10_11:03:21:767] Get clientWDS = 15
[08-10_11:03:21:799] Get clientDMS = 1
[08-10_11:03:21:831] Get clientNAS = 2
[08-10_11:03:21:863] Get clientUIM = 1
[08-10_11:03:21:895] Get clientWDA = 1
[08-10_11:03:21:927] requestBaseBandVersion SIMSS.HI.2.0.c3-00246-SDX55_CPEALL_PACK-1 1 [Oct 26 20
[08-10_11:03:21:991] requestGetSIMStatus SIMSTATUS: SIM_READY
[08-10_11:03:22:023] requestGetProfile[1] oai//0
[08-10_11:03:22:055] requestRegistrationState2 MCC: 310, MNC: 260, PS: Detached, DataCap: UNKNOW
[08-10_11:03:22:087] requestQueryDataCall IPv4ConnectionStatus: DISCONNECTED
[08-10_11:03:22:151] requestRegistrationState2 MCC: 310, MNC: 260, PS: Detached, DataCap: UNKNOW
[08-10_11:03:26:695] requestRegistrationState2 MCC: 310, MNC: 14, PS: Detached, DataCap: UNKNOW
[08-10_11:03:27:207] requestRegistrationState2 MCC: 310, MNC: 14, PS: Detached, DataCap: UNKNOW
[08-10_11:03:32:263] requestRegistrationState2 MCC: 310, MNC: 14, PS: Detached, DataCap: UNKNOW
[08-10_11:03:37:319] requestRegistrationState2 MCC: 310, MNC: 14, PS: Detached, DataCap: UNKNOW
[08-10_11:03:42:375] requestRegistrationState2 MCC: 310, MNC: 14, PS: Detached, DataCap: UNKNOW
[08-10_11:03:47:431] requestRegistrationState2 MCC: 310, MNC: 14, PS: Detached, DataCap: UNKNOW
[08-10_11:03:52:487] requestRegistrationState2 MCC: 310, MNC: 14, PS: Detached, DataCap: UNKNOW
[08-10_11:03:57:543] requestRegistrationState2 MCC: 310, MNC: 14, PS: Detached, DataCap: UNKNOW
[08-10_11:04:02:599] requestRegistrationState2 MCC: 310, MNC: 14, PS: Detached, DataCap: UNKNOW
[08-10_11:04:07:655] requestRegistrationState2 MCC: 310, MNC: 14, PS: Detached, DataCap: UNKNOW
[08-10_11:04:07:655] requestSetOperatingMode(1)
[08-10_11:04:07:687] requestSetOperatingMode(0)
[08-10_11:04:08:103] requestRegistrationState2 MCC: 0, MNC: 0, PS: Detached, DataCap: UNKNOW
[08-10_11:04:08:135] requestRegistrationState2 MCC: 0, MNC: 0, PS: Detached, DataCap: UNKNOW
[08-10_11:04:08:295] requestRegistrationState2 MCC: 310, MNC: 14, PS: Detached, DataCap: UNKNOW
[08-10_11:04:08:327] requestRegistrationState2 MCC: 310, MNC: 14, PS: Detached, DataCap: UNKNOW
[08-10_11:04:09:255] requestRegistrationState2 MCC: 310, MNC: 14, PS: Attached, DataCap: NR5G
[08-10_11:04:09:319] requestRegistrationState2 MCC: 310, MNC: 14, PS: Attached, DataCap: NR5G
[08-10_11:04:09:735] requestSetupDataCall WdsConnectionIPv4Handle: 0x7837c750
[08-10_11:04:09:799] requestQueryDataCall IPv4ConnectionStatus: CONNECTED
[08-10_11:04:09:831] ifconfig wwp0s20f0u4u415 up
[08-10_11:04:09:833] Fail to access /usr/share/udhccp/default.script, errno: 2 (No such file or di
[08-10_11:04:09:833] busybox udhccp -f -n -q -t 5 -s /usr/share/udhccp/default.script -l wwp0s20f0
udhccp: started, v1.27.2
udhccp: sending discover
udhccp: sending select for 12.1.159
udhccp: lease of 12.1.159 obtained, lease time 7200

```

SMO Applications Overview



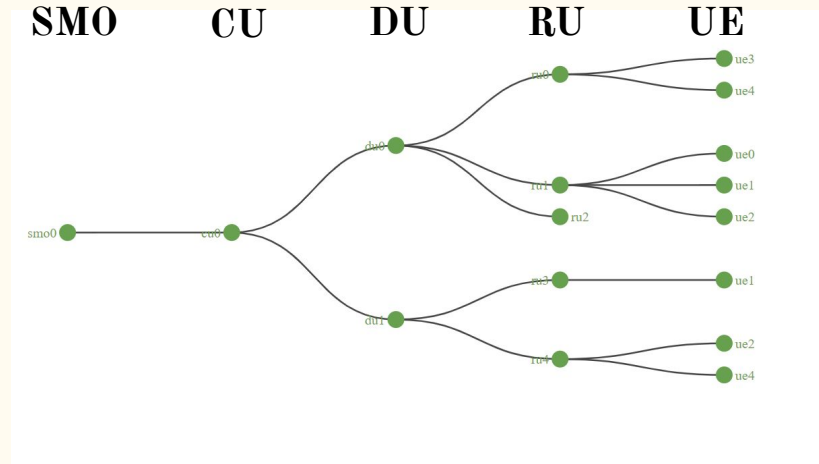
SMO Applications Dataflow



Topology Service

- Maintains updated network topology information
- Provides initial topology to rApps and AI planner
- Handles communication of changes in topology (deltas) to all rApps
- Provides updates whenever topology changes

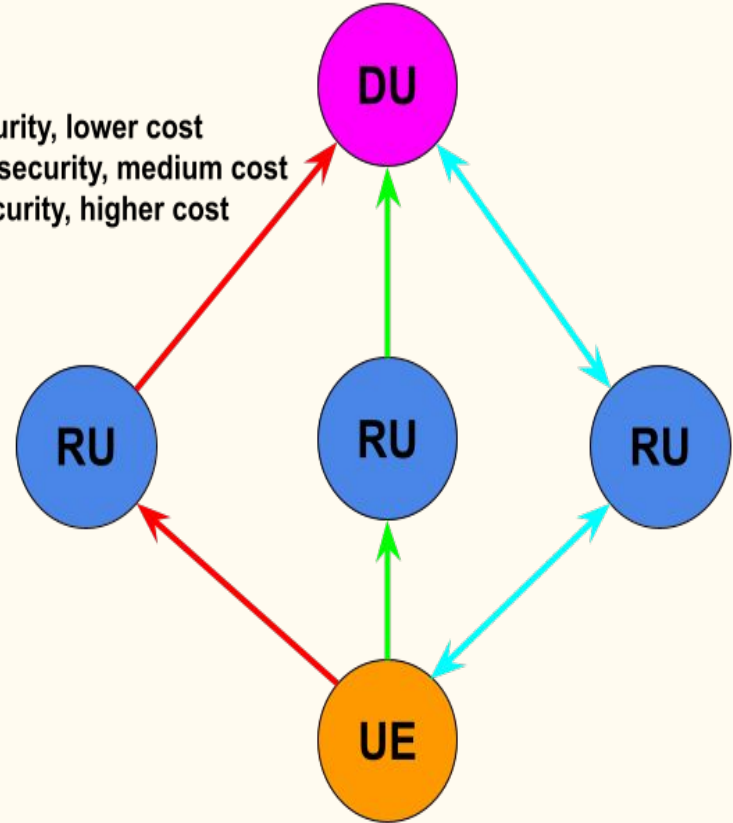
Topology
visualization
via D3



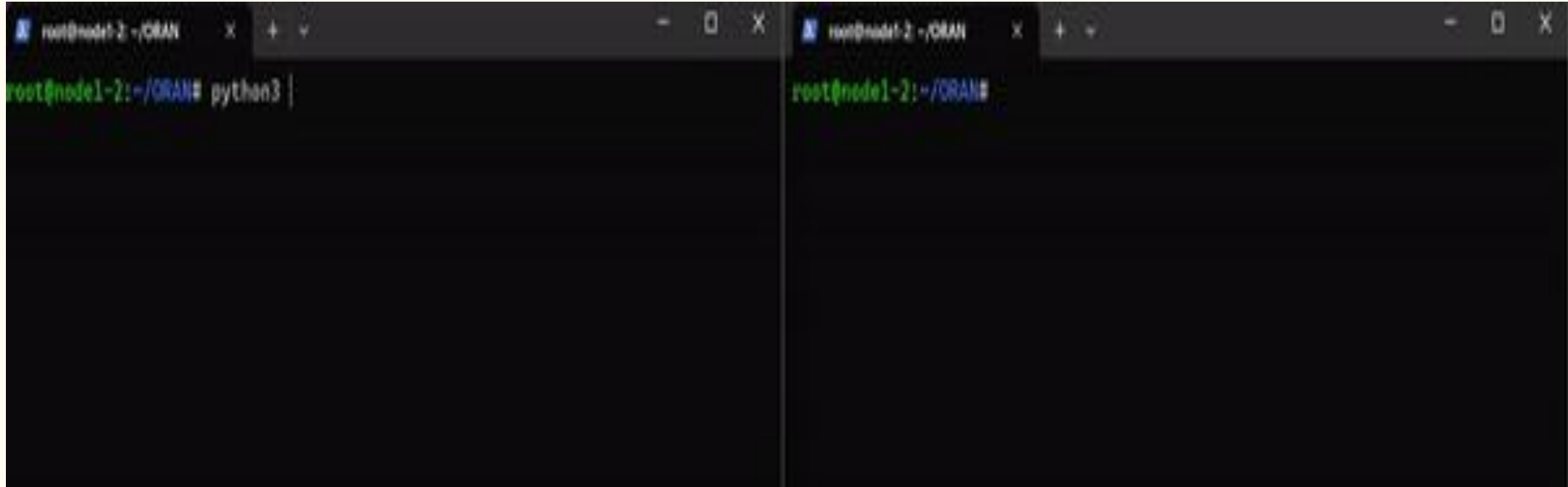
Resilience rApp

- Maintains information regarding topology
- Ensures constant connectivity for UE
- Calculates optimal distribution of data among paths
- Example: Data split between a low-cost-low-security path and a high-cost-high security path.

Red: Lower security, lower cost
Green: Medium security, medium cost
Blue: Higher security, higher cost



Output Example

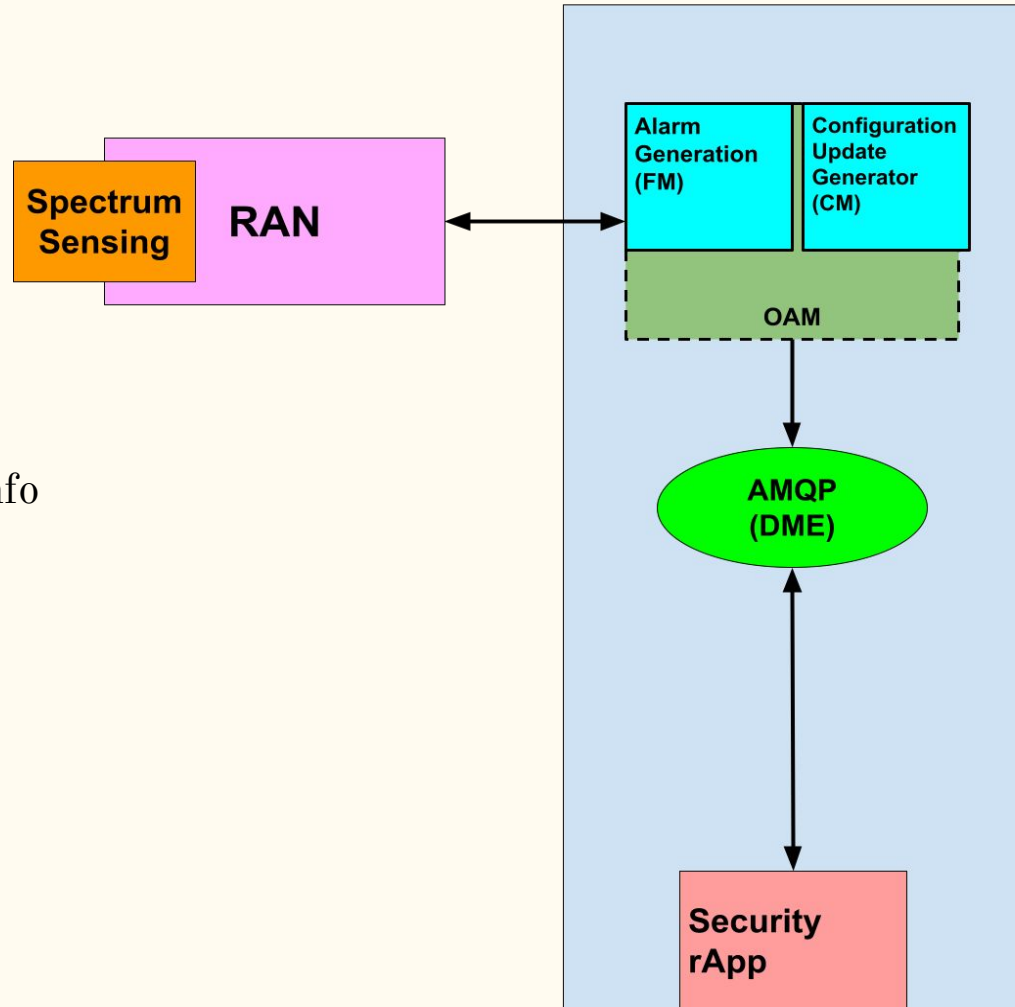


```
root@node1-2:~/ORAN# python3 |
```

```
root@node1-2:~/ORAN#
```

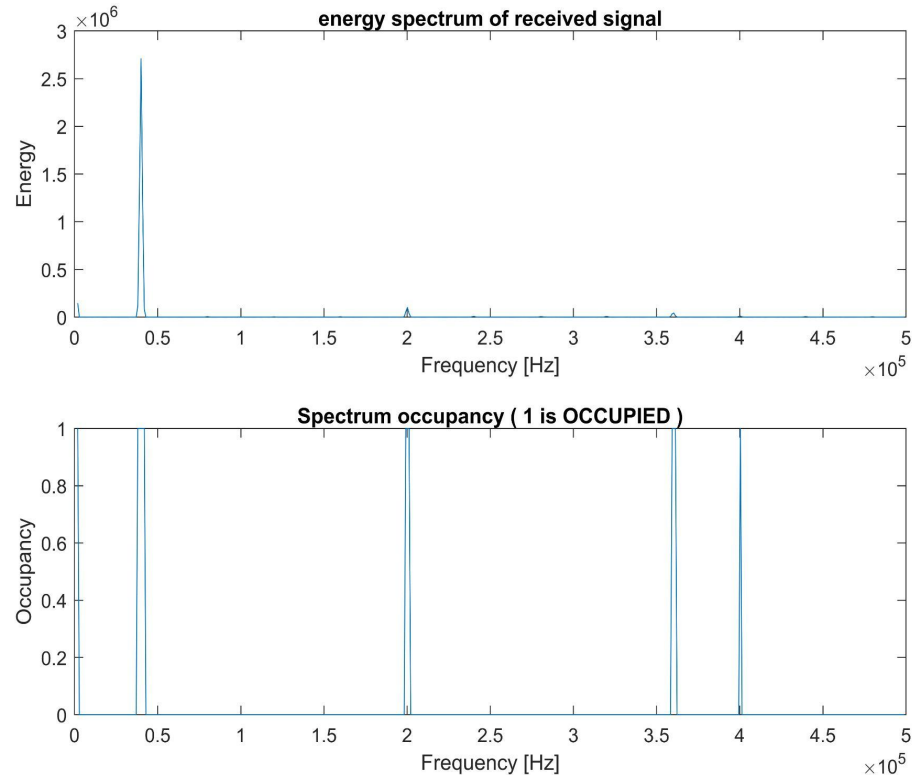
Security rApp

- Reads security alarms sent to AMQP server from the node
- Analyzes Alarm Severity
- Sends commands to RAN network (info forwarded to topology service)



Spectrum Management rApp

- Goal: Manage frequency band distribution among the available RUs
- Energy detection(GNU Radio) + occupancy estimation(NG-Scope)
- Communication via AMQP



Output Example

```
root@node1-2: ~
frequency channel RU 2 : 4
frequency channel RU 3 : 12
frequency channel RU 4 : 16
frequency channel RU 5 : 17
frequency channel RU6: 21
THIS IS THE DELTA!
frequency channel RU7: 22
THIS IS THE DELTA!
frequency channel RU 8 : 24
frequency channel RU 9 : 25
frequency channel RU 10 : 32
frequency channel RU 11 : 33
frequency channel RU 12 : 34
frequency channel RU 13 : 36
frequency channel RU 14 : 39
frequency channel RU15: 37
THIS IS THE DELTA!
frequency channel RU 16 : 14
frequency channel RU 17 : 35
frequency channel RU 18 : 3
frequency channel RU 19 : 28
[0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0,
 0, 0, 0, 0, 0, 0, 0, 0]
frequency channel RU 0 : 13
frequency channel RU 1 : 8
frequency channel RU 2 : 4
frequency channel RU 3 : 12
frequency channel RU 4 : 16
frequency channel RU 5 : 17
frequency channel RU 6 : 21
frequency channel RU 7 : 22
frequency channel RU 8 : 24
frequency channel RU 9 : 25
frequency channel RU 10 : 32
frequency channel RU 11 : 33
frequency channel RU 12 : 34
frequency channel RU 13 : 36
frequency channel RU 14 : 39
frequency channel RU 15 : 37
frequency channel RU 16 : 14
frequency channel RU 17 : 35
frequency channel RU 18 : 3
frequency channel RU 19 : 28

root@node1-2: # root@node1-2: # python3 bit_vector.py
[x] Message Sent.
[0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 1, 0,
 0, 0, 0, 0, 0, 0, 0, 0]
[x] Message Sent.
[0, 0, 1, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0,
 0, 0, 0, 0, 0, 0, 1, 0, 0]
[x] Message Sent.
[0, 0, 0, 0, 0, 0, 1, 0, 1, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 1,
 1, 0, 0, 0, 0, 0, 0, 0]
[x] Message Sent.
[0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1,
 0, 0, 0, 0, 0, 0, 0, 0]
[x] Message Sent.
[1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 1, 1, 1, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0,
 0, 0, 0, 0, 0, 0, 0, 1, 0]
[x] Message Sent.
[0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0,
 0, 0, 0, 0, 0, 0, 0, 0]
```

Questions?

<https://www.orbit-lab.org/wiki/Other/Summer/2023/5G6G>