5G Challenge 2023
Host Lab Configuration

Date: February 1, 2023

Version: 1.0

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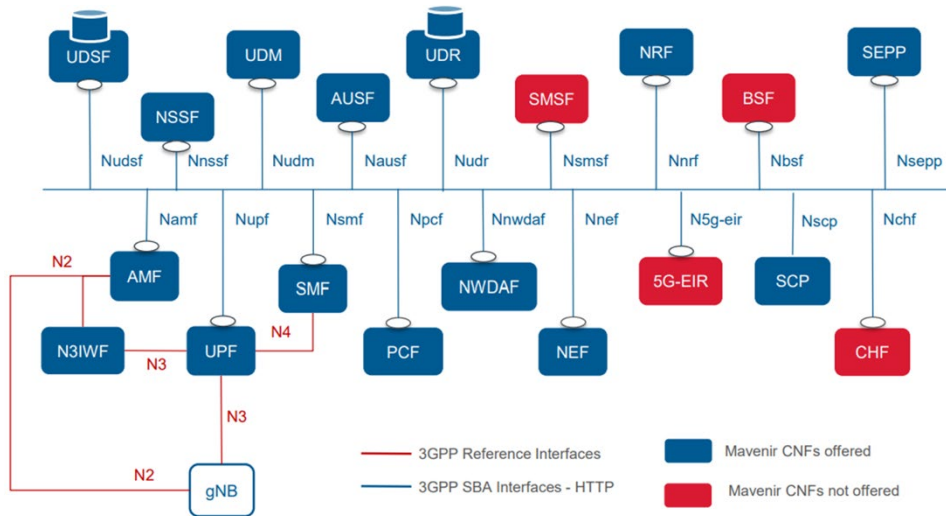
1 Baseline Systems

Note: O-RAN ALLIANCE subsystems are abbreviated as CU, DU, and RU throughout this document, not as O-CU, O-DU, and O-RU.

1.1 Mavenir

1.1.1 Mavenir 5G SA Core (5GC) (Rel-15 compliant)

- Mavenir (AMF, SMF, UPF, PCF, AUSF, UDM, UDR, UDSF, NSSF, NRF, SEPP, SCP, NEF, NWDAF)
- Network Details
    - Maximum subs = 10,000
    - Average Active Users = 5000-7000 (Depending on Traffic Call Model)
    - Throughput = 10Gbps

1.1.2 Mavenir vRAN
- Mavenir vRAN solution is based on O-RAN open interfaces and is compliant to O-RAN architecture.
- Mavenir vRAN architecture supports both higher layer split (3GPP Option 2) and a lower layer split (3GPP Option 7 / ORAN 7-2 or CPRI).
- RU: n78, 4x4 MIMO, 4x40W TDD Mode, Bandwidth 100 MHz., Category A
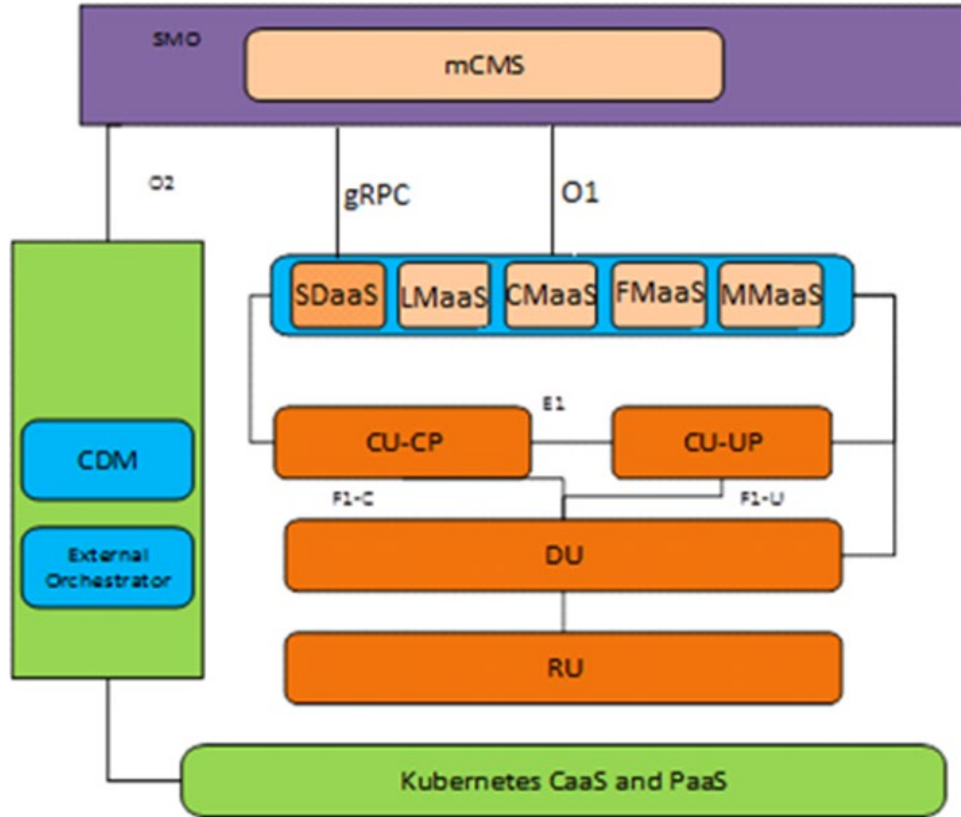- Interface support - NG, F1, Xn

Figure 1 - Mavenir vRAN Component Architecture

1.2 Accelleran™ CU + EffNet™/ Phluido™ DU + Benetel™ RU
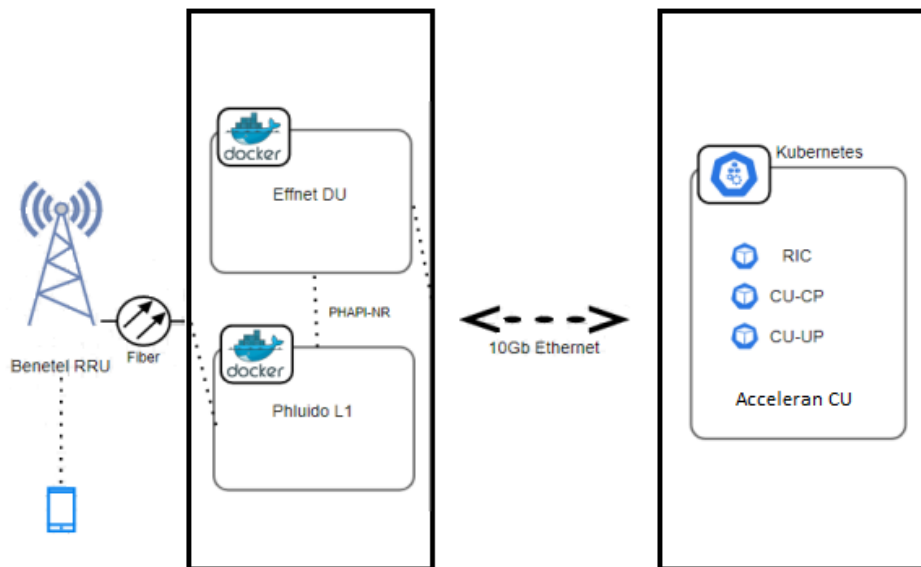
Figure 2 - Accelleran vRAN Component Architecture

1.2.1 5G RU (Benetel)

- Band Support - TDD Band n78
  - ○ DL: 3400MHz to 3800MHz
  - ○ UL: 3400MHz to 3800MHz
- Transceiver Specification - 2 x 2 MIMO; 20dBm/100mW RF power per antenna port (TDD); 1 transceiver per unit (single cell); BW support: 40MHz
- Sync – GPS
- Network Interfaces - ORAN v2.0; 10 Gbe port, fiber; Functional Split: 7-2x; Category B

1.2.2 5G DU (Effnet L2 and Phluido Upper L1 SW)

- Fully containerized SW
- L2
  - ○ Northbound: Option 2 of 3GPP TR 38.801 (F1-C and F1-U interface to CU)
  - ○ Southbound: 5G FAPI
- Upper L1
  - ○ Northbound: 5G FAPI
  - ○ Southbound: 3GPP Split 7-2

1.2.3 5G CU (Accelleran)

- Fully containerized SW
- QoS and Bearer Management - Up to 2 PDU session per UE; 1 DRB per PDU session
- Security - Basic 3GPP Security, Control Plane Integrity Protection (NIA1); User Plane Ciphering (NEA1)
- Interface support - NG, F1

2 Test Equipment and Tools

2.1 5G SA Core Emulator

A software-based 5G SA Core emulator capable of testing 3GPP NG (N1, N2, N3) interfaces.

Table 1. 5G SA Core Emulator

Vendor	Model	SW release	SW release date	Capacity
VIAVI	Tera VM TVM6000	v2.49	Nov-2022	N3: 10Gbps, N2: 10k TPS
Keysight	CoreSIM	IxLoad 9.30	Dec-2022	N3: 10Gbps, N2: 1k TPS

2.2 7-2 Fronthaul Emulator

The O-RAN DU Fronthaul emulator implements the required DU portions of the gNB Fronthaul (FH) functions, as defined by O-RAN split option 7-2x, which is used for RU testing purposes. It supports both Category A and Category B RUs. In the lab, two sets of such equipment are available, as shown in the table below.

Table 2. Available DU Fronthaul emulators for RU testing

Vendor	Model	SW release	SW release date	Capacity
VIAVI	TM500 RU Tester	NRA 1.12.0	Dec-2022	FH 10Gbps/25Gbps
Keysight	Open RAN Studio	2.3.10944.0	Oct-2022	FH 10Gbps/25Gbps

2.3 UE Emulator

An RF UE emulator that can generate traffic from 100+ eMBB 5G NR UE in a realistic mobile environment. UE emulators listed in Table 4 support the features below:

- 5G NR eMBB 100MHz - 2TRx - TDD
- 5G NR eMBB 20MHz - 2TRx - FDD
- 5G NR DL 1 CC - 4Rx 100MHz
- 5G NR DL 2 CC CA - 2Rx 100MHz
- 5G NR 100+ eMBB UE - 2Tx 2Rx
- 5G NR FRAME STR 30kHz - 14SYM .5ms SLOT
- 5G NR FRAME STR 15KHz - FDD
- 5G NR 256 QAM DL - 2Rx 4Rx 100MHz
- 5G NR 256 QAM UL - 2Tx 100MHz 30kHz
- 5G NR eMBB UE; K1 and K2 equals 2 and 3; 30kHz SCS 2x2
- 5G NR MOBILITY
- 5G NR FAST FADING
- 5G NR O-RAN FH OPT 7-2 SW - 4 LAYERS 1RU
- 5G NR O-RAN FH OPT 7-2 SW - 2RU
- 5G NR L3 STANDALONE

Table 3 - Available UE emulators

Vendor	Model	SW release	SW release date	Capacity
VIAVI	TK5000/E500	NLA 5.13.1	Feb-2022	128 eMBB UE
Keysight	UeSIM	v23.2.1	Dec-2022	100 eMBB UE

2.4 RU Fronthaul Emulator

An O-RAN RU Fronthaul emulator implements the required RU portions of the gNB functions, as defined by O-RAN ALLIANCE split option 7-2x.

Table 4 - Available RU Fronthaul Emulators for DU Testing

Vendor	Model	SW release	SW release date	Capacity
VIAVI	TM500 RU Sim	NLA 5.13.1	Feb-2022	ChBW: 100MHz; 2 RUs
Keysight	RuSIM	v23.1	Dec-2022	ChBW: 100MHz; 2 RUs

2.5 Fronthaul Analyzer

The transport protocol analyzer is used to validate the health of the Open Fronthaul interface. It provides visibility into the protocol messages exchanged between the DU and RU.

- Model #: Wireshark
- Software release/date: 4.0.3
- Capacity: 1 Gbytes of filtered capture of Ethernet packets.

2.6 Front/Mid/Back-Haul (xHaul) Transport Switch

An xHaul high-capacity and low latency transport and timing switch with integrated PTP Grandmaster and compatible with O-RAN architecture. It supports extensive sync and timing options like SyncE and PTP (PTRC/GM, BC, TC).

Table 5 - xHaul Transport Switch(es)

Vendor	Model	SW release	SW release date	Capacity
FibroLAN	Falcon-RX	Falcon_RX812G_8-0-17-4	Jan-2022	200Gbps / FDX 400 Gbps switch fabric

2.7 RF Signal & Spectrum Analyzer

An RF signal and spectrum analysis instrument that is used to analyze NR waveform and test I/Q signals.

Table 6 - RF Signal and Spectrum Analyzer(s)

Vendor	Model	SW release	SW release date	Capacity
Rohde-Schwarz	FSW3007 – 7.5GHz	V1.90	Aug-2022	200MHz signal analysis bandwidth
Keysight	M9411A - PXIe VXT - vector signal analyzer	M.32.57	Sept-2022	300 MHz signal analysis bandwidth

2.8   RF Signal Generator

An RF generator for digitally modulated I/Q signals.

Table 7 - RF Signal Generator(s)

Vendor	Model	SW release	SW release date	Capacity
Rohde-Schwarz	SMW200A - 7.5GHz	5.10.035.29	Dec-2022	200MHz I/Q modulation bandwidth
Keysight	M9411A - PXIe VXT - vector signal generator	M.32.57	Sept-2022	300MHz I/Q modulation bandwidth

2.9   5G NR Signal Analysis & Signal Generation Software

A PC based software, used to analyze and generate test I/Q signals. It supports 5G-NR uplink & downlink plus O-RAN measurements.

Table 8 - 5G NR Signal Analysis & Signal Generation Software

Vendor	Model	SW release	SW release date	Capacity
Rohde-Schwarz	VSE	2.20SP1	Dec-2022	One (1) individual user
Keysight	O-RAN Studio	2.3.10944.0	Oct-2022	One (1) individual user
		6.2.0.3	Feb-2021	

2.10 Qualcomm QXDM diagnostic monitor

QXDM software is used to capture and monitor UE (built upon Qualcomm chipset) diagnostic logs, messages, and events

- Model #: QXDM
- Software release/date: v5.1.340.2 / Feb 2022
- Capacity: two (2) individual user licenses
- License: one (1) per user

2.11 Qualcomm QCAT analysis tool

QCAT software is used to analyze UE (built upon Qualcomm chipset) diagnostic logs, messages, and events.

- Model #: QCAT

- Software release/date: v06.30.111.03 / Feb 2022
- Capacity: two (2) individual user licenses
- License: one (1) per user

2.12 Traffic Generator iPerf

iPerf is a tool for active measurements of the maximum achievable bandwidth on IP networks. For each test it reports the bandwidth, loss, and other parameters.

- Model #: iPerf2, iPerf3
- Software release/date: iPerf2 2.0.8 / Jan 2015; iPerf3 3.1.3/ June 2016
- Capacity: 1Gbps/10Gbps
- Supports: IPv4 or IPv6

3 Test Environments

3.1 Stage Two

The objective is to verify the openness of the interfaces and nodes under test using emulated traffic before proceeding to Stage 3 testing.

In scope:

- Open Fronthaul (7-2x), NG, Xn interfaces
- RU, CU+DU combo nodes

3.1.1 Standalone RU

The RU wrap-around tester (ORUWT) surrounds the RU connecting to its fronthaul and RF interfaces.

The ORUWT consists of (a) DU Emulator (CUSM-Plane Emulator), (b) PTP source, (c) an RF signal analyzer, and (d) an RF signal generator as shown in the figure below.
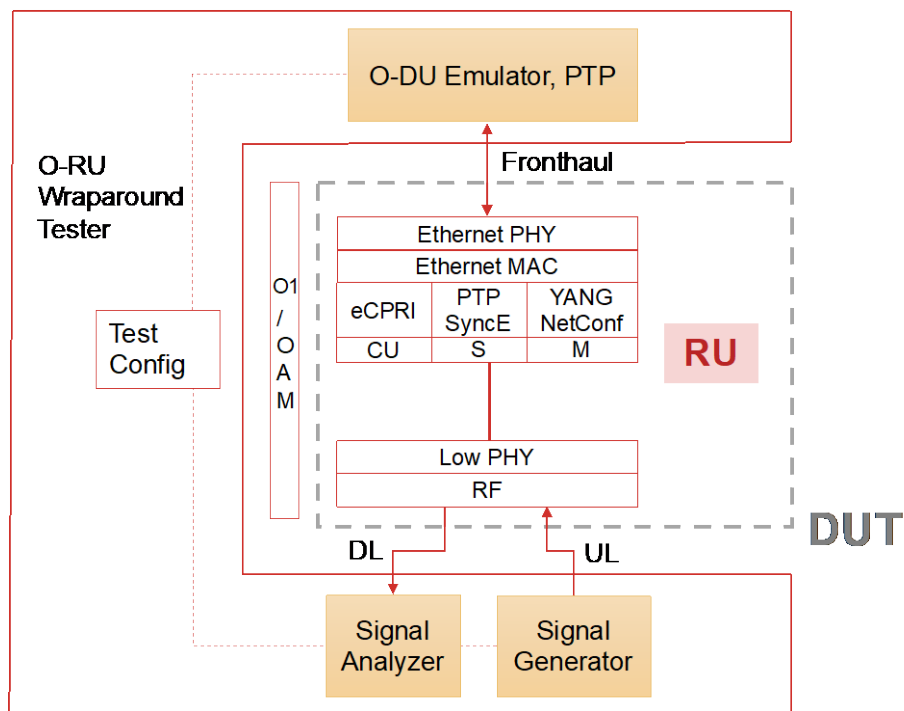

Figure 3 - RU as a Device Under Test (DUT) in a fully emulated test environment

3.1.2 Standalone DU+CU combo / gNB DU+CU combo

The DU+CU wrap-around tester (ODUCUWT) surrounds the DU+CU sub-System Under test (SUT) via its NG interface towards the 5G SA Core, Xn interface towards the CU Emulator, the

front haul interface towards the RU+UE Emulator, and optionally the O1 or EMS interface towards the test configuration entity, as shown in the figure below.
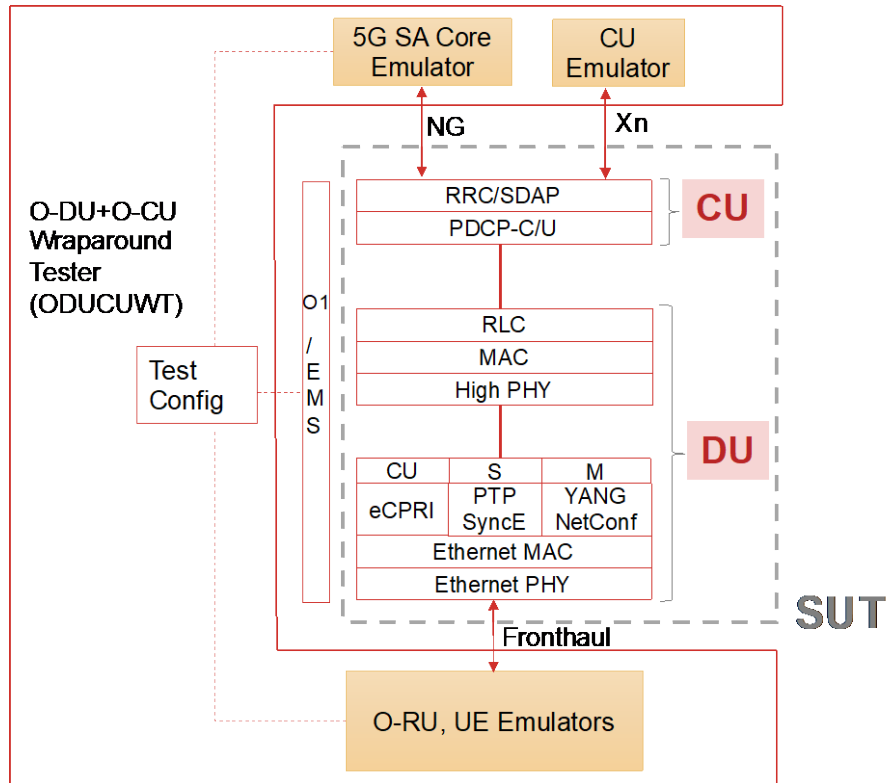

Figure 4 – DU+CU combo as a Sub-system Under Test (SUT), in a fully emulated test environment

3.2 Stage Three

The objective is to test the E2E system functionality, performance, reliability and stability using real or emulated 5G SA Core and real or emulated UE.

In scope:

- 5G NR Uu, NG interfaces
- Single vendor gNB, multi-vendor gNB (RU and CU+DU combo)

The System Under Test (SUT), i.e., CU+DU+RU, is connected via its NG interface towards the baseline 5G SA Core and its NR air-interface towards a UE Emulator (or actual UE), as shown in the figure below.
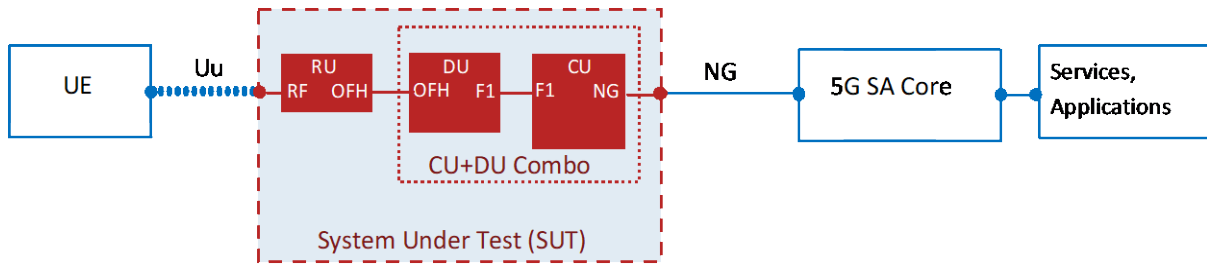
Figure 5. End-to-end test environment

3.3 Stage Four

The objective is to test inter-gNB mobility, using the test environments defined below.
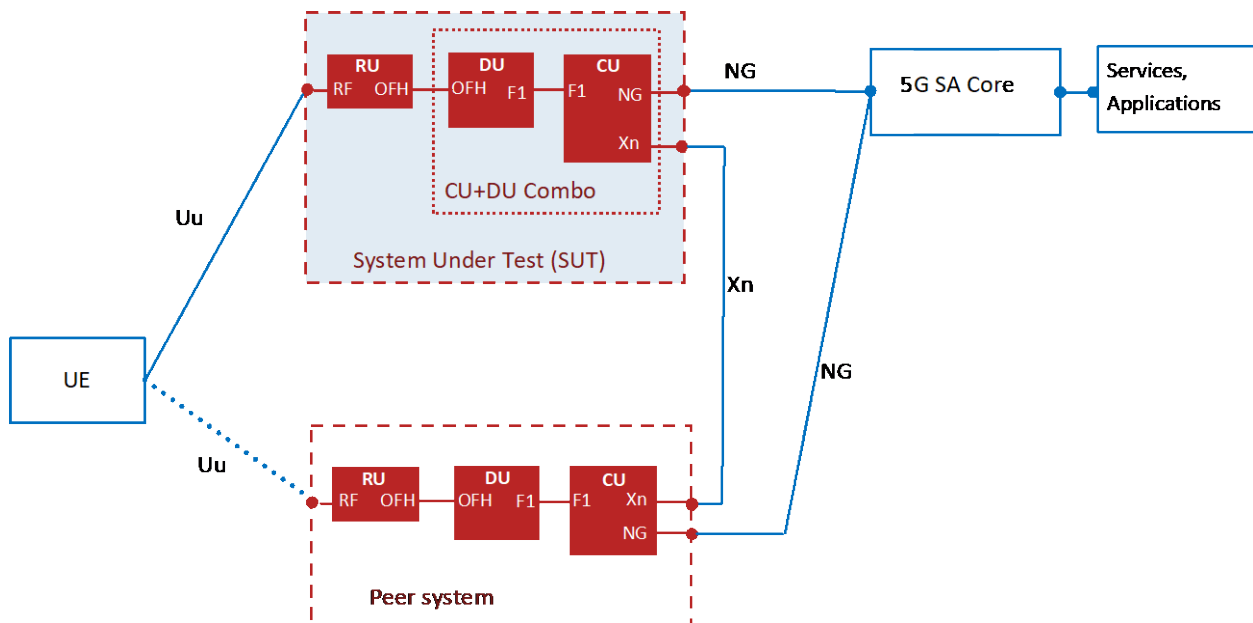

Figure 6. Inter-gNB, inter-CU mobility test environment

4 Release and Versioning

4.1 3GPP

Host Lab test equipment and network is compliant with 3GPP Rel 15 (Jun-Dec 19), Rel 16 (Jun-Dec 20). Key 3GPP specs include:

- 3GPP TS 38.410 NG-RAN; NG general aspects and principles
- 3GPP TS 38.411 NG-RAN; NG layer 1
- 3GPP TS 38.412 NG-RAN; NG signaling transport
- 3GPP TS 38.413 NG-RAN; NG Application Protocol (NGAP)
- 3GPP TS 38.414 NG-RAN; NG data transport
- 3GPP TS 38.470 NG-RAN; F1 general aspects and principles
- 3GPP TS 38.471 NG-RAN; F1 layer 1
- 3GPP TS 38.472 NG-RAN; F1 signaling transport
- 3GPP TS 38.473 NG-RAN; F1 Application Protocol (F1AP)
- 3GPP TS 38.474 NG-RAN; F1 data transport
- 3GPP TS 38.425 NG-RAN; NR user plane protocol
- 3GPP TS 33.501 Security architecture and procedures for 5G System

4.2 O-RAN ALLIANCE

Host Lab test equipment and network is compliant with key ORAN specs listed below:

- ORAN-WG4.CUS.0-v05.00, Control, User and Synchronization Plane Specification
- O-RAN.WG4.MP.0-v05.00, Management Plane Specification
- O-RAN.WG4.CONF.0-v03.00, Conformance Test Specification
- O-RAN.WG4.IOT.0-v05.00, Fronthaul Interoperability Test Specification (IOT)
- O-RAN.WG5.U.0-v03.00 NR U-plane profile
- O-RAN.WG5.C.1-v03.00 NR C-plane profile (NR Standalone)
- O-RAN.WG5.Transport.0-v1.00 Transport Specification

5 Additional Test Equipment/Systems

5.1 Ancillary Equipment

Contestant's RU(s) should support an SFP from the below list to connect to test equipment. Contestants are responsible for bringing their own SFPs. Contestants should consult with the Host Lab well in advance of their entry date for a list of compatible SFPs.

- 25GbE SFP28 Multimode Transceiver (25GBASE-SR)
  https://www.fs.com/products/71007.html
- 25GbE SFP28 Singlemode Transceiver (25GBASE-LR)
  https://www.fs.com/products/71014.html
- 10GbE SFP+ Multimode Transceiver (10GBASE-SR)
  https://www.fs.com/products/65334.html
- 10GbE SFP+ Singlemode Transceiver (10GBASE-LR)
  https://www.fs.com/products/65335.html

6 System Access and Work

Contestants will be able to access their systems for set-up, configuration, operational and diagnostic purposes either remotely or onsite at the host lab. Remote access will be granted via a VPN system provided by the host lab. Contestants must comply with the security and operational requirements for accessing the host lab network(s) hosting their systems.

Contestants will request access by filling out the form at https://vpnrequest.cablelabs.com and selecting "5G Challenge" under "What needs to be accessed?" The employer should match the leading party for the submission (if there is more than one party). This will ensure you are given access to the correct system(s). This request will be routed for approval and processed by the host lab's IT group. The contestant will then be notified with instructions on how to access. Contestants will need to download and install the VPN client application from GlobalProtect (link will be included in the instructions). Only Windows and Mac platforms are currently supported.

Access via VPN will be limited to the set-up and testing window provided to the contestant. If the contestant advances to further stages of testing, the VPN will be re-enabled for that period.

It is highly recommended that contestants deploy their systems under test in the host lab facilities (either installed on host lab servers or installed on contestant-provided hardware) to minimize latency and other performance limitation that may occur with remotely installed systems.

If the contestant chooses to install their subsystem on host lab provided systems, they will be limited to designated namespaces with the appropriate Role Based Access Controls (RBAC) controls in the OpenShift CaaS/PaaS. If broader root level access is required on the hardware, then the servers will be purged/wiped prior to the install of the contestant subsystem. In either case, the contestant will need to provide details on the system and networking requirements in advance of their configuration and testing window.

If the contestant chooses to install their subsystem on their own hardware, details on the space, power, and networking requirements will need to be provided to the host lab in advance of their configuration and testing window.