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OAI based NSA System (2019-2020)

Next Phase Priorities
1. SA
2. Fully O-RAN Compliant CUS/M-Plane Fronthaul
O-RAN

• **Openness**
  – bring service agility and cloud–scale economics to enable smaller vendors and operators to introduce their own services or customize the network to suit their own unique needs.
  – open interfaces enable multi-vendor deployments, enabling a more competitive and vibrant supplier ecosystem.

• **Automation**
  – Simplifying operation and maintenance by embedding intelligence using emerging deep learning techniques, which in turn will reduce OPEX.
C/U PLANE OVERVIEW
O-RAN 7.2x Functional Blocks
Open RAN Split 7-2x Category A and Category B

- Category B O-RUs enable greater tolerance of Non-ideal Fronthaul characteristics such as constrained throughput and higher delay.

- Multiple O-DU Vendors
- Intel FlexRAN
- OAI
Split 7.2 O-RU FPGA Block Diagram DL

Primary CC Path. All others are Secondary CCs

Secondary CC

Primary CC Path. All others are Secondary CCs

Secondary CC

M-Plane Interface

S-Plane Interface

10GBASE_R 10GBASE_T

Packet Sort

Ethernet Interface

TRX1, Antenna 0
TRX1, Antenna 1
TRX2, Antenna 2
TRX2, Antenna 3

Mandatory feature set defined in CUS Spec Table 8-2

S-Plane and M-Plane contain Open Source Components
S-PLANE OVERVIEW
O-RAN Synchronization

• O-RAN fronthaul can have following synchronization options over an Ethernet network:
  – Frequency Sync where clocks are aligned in frequency
  – Phase Sync where clocks are aligned in phase
  – Time Sync where clocks are aligned to a common base time

• Open fronthaul networks can be synchronized in several modes and O-RAN CUS Specification WG4 has defined four configurations.
  – Configuration LLS-C1
  – Configuration LLS-C2
  – Configuration LLS-C3
  – Configuration LLS-C4

• ITU PTP Profiles
  – G.8275.1
  – G.8275.2
M-PLANE OVERVIEW
Motivation for M-Plane

• Public Networks
  – 5G systems are more complex than previous generations and automation is needed to configure and manage the network.

• Private Networks
  – Although these have far fewer cell sites than public networks, they may need to be installed and managed by organizations without previous cellular network experience. Automation also benefits this case.
• The O-RU has 2 independent interfaces carried over separate **VLANs** on the same ethernet fronthaul connection
  - CUS Plane
  - M-Plane

• In the **Hierarchical Model**, the RU M-Plane connects only to the DU

• In the **Hybrid Model** the RU connects to both the DU and a Network Management System in parallel.

• The M-Plane uses the **NETCONF** protocol and **YANG** Data Models to enable a multivendor interface.

• M-Plane support is mandatory in O-RAN and comprises approximately 33% of both Conformance and IoT test cases
Access Control Groups
1. Sudo
2. Nms
3. Fm-pm
4. Swm
5. Smo
6. Hybrid -odu

Access Control Group privileges are defined per namespace for read "R", write "W" and execute "X" RPC operations / Notification Subscription e.g.
- User Plane Config
- Supervision
- Software Management
Services Provided by M-Plane

- IP Address Assignment
- Synchronization Monitoring
- ‘Call Home’ to the O-RU controller (DU or NMS)
- Configuration of new management login accounts
- Supervision of the M-Plane connection
- Monitoring of the CU-Plane connectivity

- Automated remote SW/FW update
- Delay Profile management
- O-RU configuration, Freq, Power, Which stream goes to which antenna....
- Fault Management
- Performance Management, capturing logs of performance metrics
- O-RU state management, e.g. Activate carriers, disable/enable RU,
O-RU Start-up Sequence Steps

1. O-RU performs **M-Plane transport layer resolution** (DHCP, MAC, VLAN, IP, etc.) and recovers IP address(es) of O-RU controller(s)
2. O-RU begins *synchronization* of the O-RU against a Primary Reference Clock.
3. O-RU performs **NETCONF Call Home** to discovered O-RU controller(s)
4. O-RU controller performs **SSH connection** establishment.
5. O-RU and O-RU controller perform **NETCONF capability discovery**.
6. O-RU controller performs optional **provisioning of new management accounts**
7. O-RU and O-RU controller perform **supervision** of NETCONF connection.
8. O-RU controller performs **retrieval of O-RU information**.
9. O-RU controller performs **SW management**.
10. O-DU performs **CU-Plane transport configuration**
11. (opt) O-DU performs **LBM configuration**
12. (opt) O-DU performs initial **C/U-Plane transport connectivity checking**
13. O-RU controller retrieves the **O-RU delay profile** from the O-RU.
14. O-RU controller performs **U-Plane configuration**
15. O-DU optionally performs **C/U-Plane delay measurements** between O-DU and O-RU.
16. O-RU controller performs **Fault Management activation** by creating subscription to fault management event stream.
17. O-RU controller activates **performance measurement**
18. O-RU controller **retrieves O-RU state**, including synchronization information.
19. O-RU controller **configures the O-RU operational parameters**.
20. Service available.
O-RU CONFORMANCE TESTS
ORAN Conformance Test DUT Configuration

- IOT Profiles CUS & M-Plane defined in O-RAN IOT Specification
- Mandatory Test Cases defined in O-RAN CONF and IOT Specifications
# O-RU Conformance Test Cases

<table>
<thead>
<tr>
<th>ID</th>
<th>Section</th>
<th>Test Count</th>
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<tbody>
<tr>
<td>1</td>
<td>M-Plane</td>
<td>31</td>
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<tr>
<td>2</td>
<td>UC-Plane O-RU Scenario Class NR testing Generic (NRG),</td>
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<td>3</td>
<td>O-RU Scenario Class Beamforming (BFM)</td>
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<td>UC-Plane O-RU Scenario Class Compression (CMP)</td>
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<td>UC-Plane O-RU Scenario Class Delay Management (DLM)</td>
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<td>6</td>
<td>UC-Plane O-RU Scenario Class LAA (LAA)</td>
<td>1</td>
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<td>7</td>
<td>LTE (LTE)</td>
<td>6</td>
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<td>8</td>
<td>UC-Plane O-RU Scenario Class Section Type 3 (ST3)</td>
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<td>9</td>
<td>S-Plane Conformance Tests</td>
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<td></td>
<td><strong>Total Test Case Count</strong></td>
<td><strong>87</strong></td>
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## O-RU Conformance Test Case subset

<table>
<thead>
<tr>
<th>ORAN Test case number</th>
<th>Test description</th>
<th>O-RU Test Requirement</th>
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<tbody>
<tr>
<td>3.2.5.1.1</td>
<td>UC-Plane O-RU Scenario Class Base 3GPP DL/UL</td>
<td>Mandatory</td>
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<td>3.2.5.1.2</td>
<td>UC-Plane O-RU Scenario Class Extended 3GPP DL/UL – Resource Allocation</td>
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<td>3.2.5.1.3</td>
<td>UC-Plane O-RU Scenario Class Extended using RB parameter 3GPP DL/UL – Resource Allocation</td>
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<td>3.2.5.8.1</td>
<td>UC-Plane O-RU Scenario Class Section Type 3 (ST3)</td>
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<td>UC-Plane O-RU Scenario Class ST3 Test #1: NR PRACH</td>
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<tr>
<td>3.2.5.4.1</td>
<td>UC-Plane O-RU Scenario Class DLM Test #1: Downlink – Positive testing</td>
<td>Mandatory</td>
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<tr>
<td>3.2.5.4.2</td>
<td>UC-Plane O-RU Scenario Class DLM Test #2: Uplink – Positive testing</td>
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<td>3.2.5.4.3</td>
<td>UC-Plane O-RU Scenario Class DLM Test #3: Downlink – Negative testing</td>
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<td>3.2.5.4.4</td>
<td>UC-Plane O-RU Scenario Class DLM Test #4: Uplink – Negative Testing</td>
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<td>3.3.2-3</td>
<td>Functional &amp; Performance test of O-RU using ITU-T G.8275.1 Profile (LLS-C1/C2/C3)</td>
<td>Mandatory</td>
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O-RAN IOT TEST
• Interoperability involves testing the FH interface in terms of M-Plane, S-Plane, C-Plane and U-Plane. Some aspects of these planes may be tested independently. However, some tests, such as those that require the devices to be brought into service and a call established entail simultaneous activity across multiple planes.

• Interoperability testing is performed to prove that the end-to-end functionality between the O-DU and O-RU is as required by the O-RAN FH CUS-Plane and M-Plane specifications on which these components are based. This requires system level testing with O-DU and O-RU as an integrated system.

• FH interoperability testing by way of system test involves creation of a stimulus in the O-DU to O-RU direction using an actual or emulated O-CU, potentially with CN support/emulation, and measurement of the result at the output of the O-RU in the RF domain by an actual or emulated UE together with an RF signal/spectrum analyzer as required. Likewise, in the reverse direction, the stimulus to probe the FH in the O-RU to O-DU direction is provided by an actual or emulated UE and is measured at the output of the O-DU by an actual or emulated O-CU with CN support/emulation as required.
IoT Profiles (O-RAN IOT Specification)

- **M-Plane IOT Profile 1 Hierarchical**-sudo
- **M-Plane IOT Profile 2 Hybrid**-sudo+nms
- **M-Plane IOT Profile 3 Hierarchical**-sudo-IPv6
- **NR TDD IOT Profile 1** - NR-TDD-FR1-CAT-A-NoBF
- **NR TDD IOT Profile 2** - NR-TDD-FR1-CAT-A-DBF
- **NR TDD IOT Profile 3** - NR-TDD-FR2-CAT-A-ABF
- **NR TDD IOT M-MIMO Profile 1** - NR-TDD-FR1-CAT-B-mMIMO-RTWeights-BFP
- **NR TDD IOT M-MIMO Profile 2** - NR-TDD-FR1-CAT-B-mMIMO-RTWeights-ModComp
- **NR TDD IOT M-MIMO Profile 3** - NR-TDD-FR1-CAT-B-mMIMO-ChInfo-BFP
- **NR TDD IOT M-MIMO Profile 4** - NR-TDD-FR1-CAT-B-mMIMO-ChInfo-ModComp
- **NR FDD IOT Profile 1** - NR-FDD-FR1(15kHzSCS)-CAT-B-DBF
- **NR FDD IOT Profile 2** - NR-FDD-FR1-CAT-B-DBF
- **NR FDD IOT Profile 3** - NR-FDD-FR1-CAT-A-NoBF
- **NR FDD IOT Profile 4** - NR-FDD-FR1(15kHzSCS)-CAT-A-NoBF
- **LTE FDD IOT Profile 1** - LTE-FDD-FR1-CAT-B-DBF
- **LTE FDD IOT Profile 2** - LTE-FDD-FR1-CAT-A-NoBF
- **LTE TDD IOT Profile 1** - LTE-TDD-FR1-CAT-A-DBF

**General Configuration**
- Delay Mgt
- C/U Plane Configuration
- Digital Power Scaling
- Beamforming
- C-Plane Configuration
- S-Plane Configuration
ORAN IoT Test Setup, Standalone/Combined

Source: O-RAN.WG4.IOT.0-v06.01, Figure 2-4
Interoperability Test Cases

• M-Plane IOT Test
  – 1. Startup Installation: O-DU and O-RU getting in Service

• S-Plane IOT Tests
  – 1. Functional test of O-DU + O-RU using ITU-T G.8275.1 profile (LLS-C1)
  – 2. Functional test of O-DU + bridged network + O-RU using ITU-T G.8275.1 profile (LLS-C2)
  – 4. Performance test of O-DU + Two O-RUs using ITU-T G.8275.1 profile (LLS-C1)
  – 5. Performance test of O-DU + bridged network + Two O-RUs using ITU-T G.8275.1 profile (LLS-C2)
  – 6. Performance test of O-DU + bridged network + Two O-RUs using ITU-T G.8275.1 profile (LLS-C3)

• C/U-Plane IOT Tests
  – 1. Radio Layer 3 C-Plane establishment and Initial Radio U-Plane data transfer
  – 2. Radio U-Plane downlink data transfer (Downlink throughput performance)
  – 3. Radio U-Plane uplink data transfer (Uplink throughput performance)

• C/U-Plane Delay Management Test
  – 1. Test with minimum fronthaul latency
  – 2. Test with maximum fronthaul latency
  – 3. Test with a fronthaul latency value between maximum and minimum
  – 4. Test larger fronthaul latency then supported
Summary Key Points for O-RU Integration

- Alignment on Specification Points from CUS Spec Table 8-2
- Alignment on CUS-Plane IoT Profile and M-Plane IoT Profile
- Execution of O-RAN Conformance Test Cases
- IoT & End to End Testing
THANK YOU

Q&A

Contact: johndoyle@benetel.com

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