O-RU/O-DU Integration Challenges in an Open RAN Environment

Joint whitepaper by Vodafone and DOCOMO

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Summary

It is well known that Open RAN provides great flexibility with its Multi-Vendor Environment allowing operators to select the most appropriate solution for their Radio Access Network. It not only drives innovation in RAN but also will reduce the TCO in future.
However, Open RAN Ecosystem continues to mature and as such comes with its own complexities. One example of this is the time taken to onboard and integrate new O-RU/O-DU combinations in the lab, sometimes going up 2-3 months. For complicated cases like MaMiMo it can even go up to 9 months. This not only impacts the time to market but also creates a bottleneck for a fully open and easy to upgrade Ecosystem. The biggest challenge in Open RAN is the integration of its network components provided by different HW and SW vendors. Whilst O-RU/O-DU integration involves many steps from integration plan development to testing, this white paper focuses on the testing and debugging of O-RU/O-DU integrations.

Reducing the time and cost to test and debug this O-RU/O-DU integration is key in achieving one of the main benefits of Open RAN. Through the combined experience that both DOCOMO and Vodafone have gained in Open RAN testing over the past few years they have accumulated a number of key learnings which address the integration challenges between the O-RU and O-DU.

Based on the experiences mentioned above, several root causes have been identified that pose a challenge to efficient O-RU/O-DU integration. For the benefit of this document these are highlighted below.

- Different interpretations of the 3GPP and O-RAN specifications.
- Incompatibilities between the O-RU and O-CU/DU caused by optionality provided in O-RAN specifications.
- Product exclusion of mandatory features defined in O-RAN specifications.
- Use of different versions of specification by the O-RU/O-DU vendors.

These misunderstandings seem to be due to the miscommunication between vendors and thus it becomes important that MNO's collaborates with the vendors, e.g. by sharing a set of recommended parameters and configurations, which will allow them to work in collaboration as per MNO's requirements.

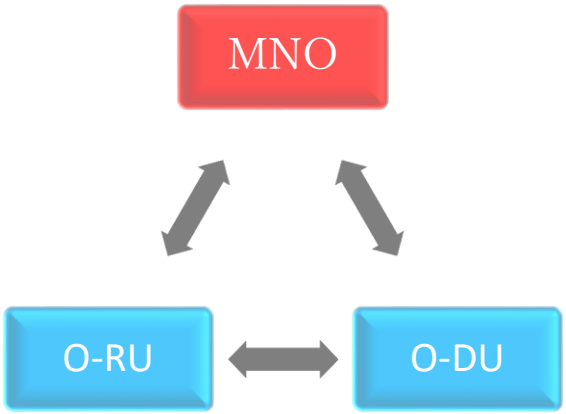

Figure 1. Represents collaboration between MNO and Vendors

In this document, we address the major issues leading to mentioned root causes and provide recommendations.

1. Facilitating efficient testing for Open RAN

1.1 Split of test responsibility between MNOs and Vendors

It is vital to have common understanding on the test responsibility between MNOs, O-RU and the O-CU/O-DU vendors. First of all, vendors should be responsible of their product implementations including conformance to O-RAN interface specifications providing the basis for multi-vendor interoperability. Vendors should also have their product tested at their labs (or 3rd party open labs) before working with MNOs to perform E2E Testing. It is noted that the vendors should satisfy the MNO's IOT profile (ref. Section 1.2.1) already at this stage to ensure efficient and smooth testing later with the MNO.

- **Multi Solution Providers:**
  Some Vendors provide both O-RU and O-CU/O-DU solutions and as such can perform a preliminary "single-vendor IOT" prior to bringing the device to MNO.
- **Single Solution Providers:**
  Vendors that either provide O-RU only or O-DU/O-CU only must perform preliminary tests using emulators which can mimic the O-RU/O-DU and provide some reassurance to other vendors and MNO's with respect to interoperability. In addition, vendors may seek to perform such testing at open labs including OTICs and TIP Community Labs.

Vendors are encouraged to obtain certification and badging through OTIC.
The diagram below depicts the recommended testing process that should be followed by the vendors and MNO's to optimize the integration activity.

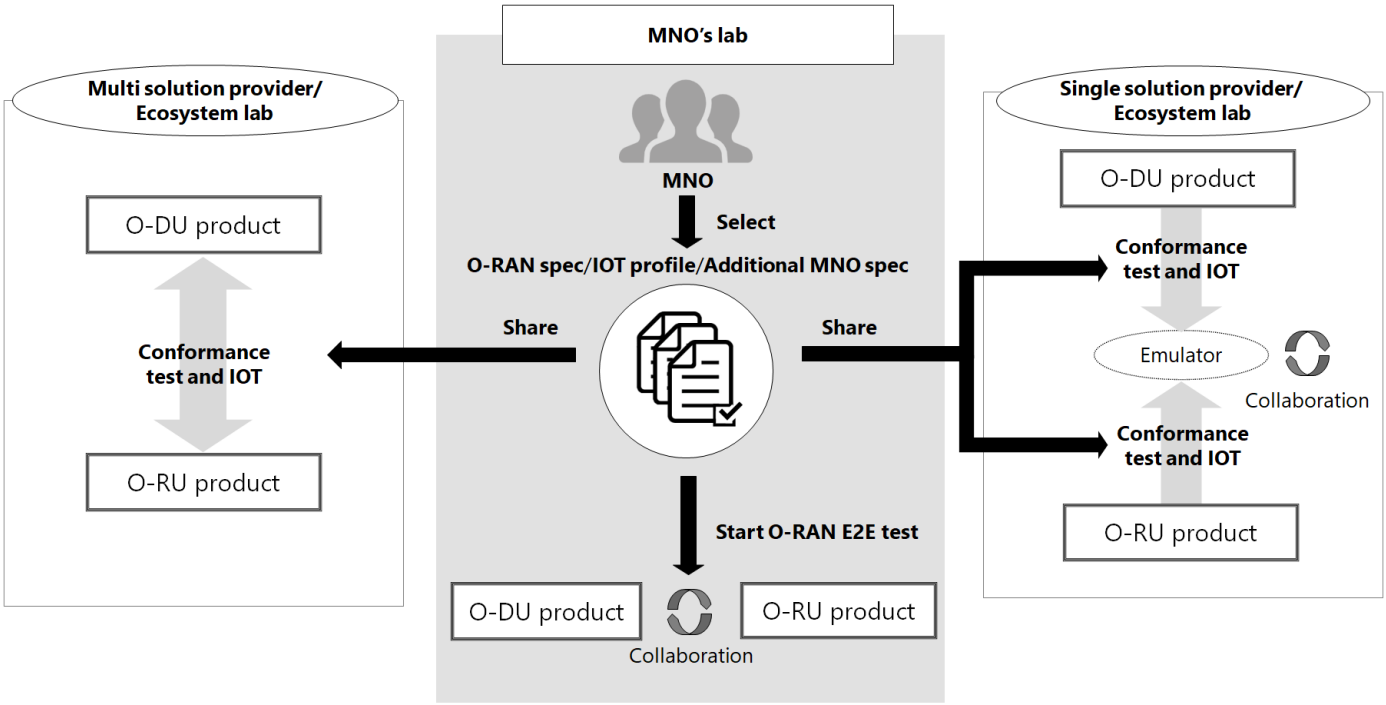

Figure 2. Recommended testing process for O-RU – O-DU IOT

1.2 Specification of MNO requirements for multi-vendor IOT

1.2.1 IOT profiles

Although O-RAN interface specifications provide enough details to enable multi-vendor IOT, they also include a multitude of optional features/configurations. To help achieve alignment on the optionality and to facilitate multi-vendor IOT, O-RAN also specifies IOT profiles. Standardized IOT profiles should cater for the needs of various MNO's and their various deployment scenarios. As such Fronthaul specifications requirements and IOT profiles have been aligned and specified by O-RAN WG4 to cover a broad range of use cases (e.g. LTE/NR, FDD/TDD(FR1/FR2), small/macro cell, analog/digital beamforming). However, MNO's will have their specific requirements, and as such it becomes crucial that the MNO takes the ownership of the required IOT profile to facilitate smooth coordination between O-RU and O-DU vendors. MNO's must work alongside the vendors to identify gaps prior to onboarding the solution and allow vendors to conduct preliminary interoperability tests.

However, to simplify further, it is recommended to have a rationalised set of IOT profiles defined in O-RAN ALLIANCE to cater for 80% of requirements of MNO's. This will avoid each MNO creating their own profile and will provide a catalogue for specific features (e.g. Beamforming) leading to simplification.

1.2.2 Additional MNO specifications

In addition to the O-RAN interface specifications and IOT profiles laying out the foundation for multi-

vendor IOT, additional complementary specification from MNO would be necessary in practice to align on details for realizing multi-vendor IOT. Examples of such details could include requirements on specification versions, CUS-plane processing capabilities (e.g., Number of fronthaul C-plane messages/sections required by the O-DU beamformer/scheduler and that can be processed by the O-RU), M-plane YANG parameter presence, and other details found as required from IOT. These are items that is expected to be specified by the MNO based on its requirements and/or as a result of MNO coordination with the vendors involved. Such additional complementary MNO specification for multi-vendor IOT will significantly help coordination among vendors and reduce time for successful integration, especially at onboarding of a new O-RU device into an existing and commercial MNO's Open RAN network.

1.3 Efficient testing solution

To reduce the time and cost of integration, it is critical that test solutions are created to allow testing to be performed swiftly and eliminate discrepancies. Test automation is essential in this regard. Furthermore, scripts to run the test equipment (e.g. UE / UE emulators, O-RU/O-DU emulators) which connects to the device under test form an integral part of test automation, and they must be created according to the required parameters of O-RAN specifications. Vendors have the knowledge and skills to create such test scripts, it is recommended that this task is delegated to the vendor.

DOCOMO, having learnt from its experience with the time-consuming integration of O-RU with O-DU, is developing an automated test script suite at its Lab in Yokosuka Japan with the aspiration to significantly reduce the O-RU test and integration time. Vodafone, having experienced similar integration challenges, is also working with test solution providers to implement the O-RAN test solution at various levels at its central lab in Newbury, UK .

As mentioned above, automatic testing will be key to shortening the integration time be it in the vendor's labs for conformance or MNO/Ecosystem labs for end-to-end testing. As such recommendation would be for vendors to develop their own test scripts based on MNO's feedback for testing in their own labs or Ecosystem labs. In addition to this, it provides incentive for test providers to develop automated test solutions for the industry.

2. Collaboration and information sharing between vendors

Due to the Open RAN multi-vendor ecosystem, information sharing has become critical and integration between O-RU and O-DU simply isn't possible without collaboration. The vendors must be prepared to work with each other and allow sharing of information so that integration is efficient. The below points summarize the information that must be shared and how it can help in removing bottlenecks in integration.

2.1 Sharing of O-RAN YANG Data Model

In the specifications of O-RAN ALLIANCE WG4, the YANG Data Model is used to indicate the structure, device states (idle, active, sleep, etc.), and parameters between O-DU and O-RU. The MNOs have learnt

that there are certain patterns of discrepancies which tend to reoccur when integrating the O-RU and O-DU, resulting in various errors when interconnecting the devices through the Open Fronthaul M-Plane and CUS-Plane interfaces. Such discrepancies are found with capabilities and configuration parameters in the O-RAN YANG Data Models of the devices, and can be roughly classified into four categories:

1. Inconsistent parameter value - Incompatible or wrong type (i.e., unit16, Boolean etc.) of values between devices.
2. Missing parameter – Absence of required parameter as per MNO requirements.
3. Extra or invalid parameters - The parameter not required as per MNO requirements.
4. Unacceptable character string - invalid character, invalid string, or syntax error.

There can be a multitude of causes of these discrepancies. Given the complexity of the task at hand for both vendors and the MNO, simple human error is to be expected. But differing versions and interpretations of the standards, or different choices of options provided by the specifications can also be cause for the discrepancy. Deeper rooted differences such as design or implementation discrepancies are also conceivable as an underlying reason.

Irrespective of the underlying causes, an efficient way to identify discrepancies in an early phase of integration would be to perform a desk-based visual cross check between the O-RAN YANG Data Models of the O-RU and O-DU to be interconnected. To do this, the O-DU vendor would need to share its data model, with the facilitation of the MNO, to the O-RU vendor, and vice versa. The cross checking must be performed by both vendors and any mismatch must be removed. DOCOMO and Vodafone have found it useful to perform such cross checking with vendors in clarifying the discrepancies and reducing the time for integration. Otherwise, each discrepancy would be found during IOT, and MNO having to coordinate between the involved vendors for each and every discrepancy would be very inefficient.

2.2 Sharing of other Parameters and Implementation Details

Besides the Data Model discussed in the previous section, vendors must be prepared to share additional information on other implementation specific parameters to ensure a smooth integration process and optimal results. This is especially true in those cases where the computation of a functional element is split between O-RU and O-DU, requiring both elements to exchange information with each other in a highly coordinated, timing-sensitive, and tightly coupled manner.
For example, with beamforming methods defined in the O-RAN Fronthaul specifications where the beamforming implementation is split between O-RU and O-DU, a significant amount of information is exchanged between the two subsystems in a time critical manner. Even though O-RAN Fronthaul specifications address the information that needs to be shared, to ease the implementation of the beamforming method especially in the O-RU, it would be necessary to know how exactly the O-DU will send the section types and with what periodicity.

The above example signifies the importance of information sharing and thus, the order and format in which the implementation details are shared needs to be agreed between the two vendors to enable perfect deployment.

Conclusion

The issues that have been raised and highlighted throughout this whitepaper create a level of complexity requiring complex discussions and ultimately delays to the integration of O-RU to O-DU. The current situation also leads to higher integration costs and lack of interoperability. This creates a bottleneck across the various permutations and combinations of vendors in Open RAN and impacts the very essence of a disaggregated ecosystem.

Intercommunication, and adopting the parameters and configurations set by the MNO and Open RAN community will assist immensely in helping vendors in eradicating uncertainty, and the ultimate reduction in complexity and delays around integration.

In conclusion, the creation and adoption of such an agreement will help the vendors to test and develop the interfaces between O-RU and O-DU in their own labs before bringing to the MNO's central lab or ecosystem labs. This will lead to simplification and innovation within ORAN, and help it reach its fullest potential.

Glossary:

3GPP	Third Generation Partnership Project
FDD	Frequency Division Duplex
HW	Hardware
IOT	Interoperability
LTE	Long Term Evolution
MNO	Mobile Network Operator
NR	New Radio
O-CU	O-RAN Central Unit
O-DU	O-RAN Distributive unit
O-RAN	Open Radio Access Network
O-RU	O-RAN Radio Unit
OTIC	Open Testing and Integration Centre
RAN	Radio Access Network
SW	Software

TCO	Total Cost of Ownership
TDD	Time Division Duplex
TIP	Telecom Infra Project
UE	User Equipment
YANG	Yet Another Next Generation