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Deutsche Telekom and partners focus on operator value in multi-vendor TIP validation testing and badging

Change Tracking

Date	Revision	Author(s)	Comment
05/01/2024	v0.1	Abdel Bagegni	Draft version
06/11/2024	V1	Noah Lavallee	Final version

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Executive Summary

As a concrete measure to improve the value of badging and validation of Open RAN solutions, Deutsche Telekom implemented a review and improvement process for a TIP-defined RIC use case with partners AirHop, Juniper Networks and Keysight. Validation testing was executed in the i14y Lab, resulting in the award of a TIP Silver Badge for PCI optimization based on improved validation guidance.

Towards higher confidence in RAN intelligence products and their validation

As is typical for emerging technologies, Open RAN has needed time to become mature enough to be a real candidate for deployment. New entrants to the market needed to develop a plethora of features while incumbents have been challenged with transforming their solutions towards cloud-based solutions with open interfaces. Open RAN solutions are now an accepted alternative to traditional radio access network (RAN) products. Nevertheless, integration complexity remains a topic to be tackled and it is here that the O-RAN ALLIANCE and the Telecom Infra Project - with their open labs - can jointly play a role to drive confidence in available solutions based on rigorous industry validation and badging.

That is why Deutsche Telekom and its partners embarked jointly on a journey to improve the value of validation and badging in the area of RAN intelligence. The value of comparability and reliability of results for operators lies in the increased confidence during vendor selection as well as minimizing complexity and efforts in subsequent phases, such as system integration and operator-specific acceptance testing.

Project targets and roles

The target of the joint project has been to advance TIP's badging process on selected RIC use cases and reflect these improvements with the awarding of a TIP Silver Badge based on the enhanced process. TIP's Silver Badge represents a proof point of performance and functionality for an Open RAN solution, conducted in a controlled environment, in this case, the i14y Lab. TIP's non-RT RIC use case 11 (UC11) implementing PCI optimization has been selected for the joint undertaking. The rApp has been provided by AirHop Communications, running on a RIC platform from Juniper Networks. The testing aspects were covered by Keysight Technologies. Tests were executed in the i14y Lab[1], the European open lab supported by major European operators.

To make a difference and improve the results' quality, the current use case description and test plan has been rigorously examined from an operator perspective by Deutsche Telekom. This technical paper elaborates on the improvements of the validation and badging process, the technical work done, the learnings and the next steps to make the validation and badging a relevant cornerstone of the Open RAN ecosystem.

Introduction to the PCI optimization use case

In 4G and 5G cellular networks, Physical Cell Identity (PCI) is a unique identifier assigned to each cell serving as a low bandwidth reference for the User Equipment (UE) to distinguish and connect to specific cells. The significance of PCI lies in its contribution to the seamless and efficient handover and synchronization processes. Without a proper assignment of PCIs, the ambiguity of recognizing the serving cell and/or neighbor cells can considerably degrade the network performance. Improper assignments of PCIs are categorized into the following PCI conflicts:

- PCI collision: A PCI confusion occurs when two or more neighbor cells of a home cell are assigned the same PCI, and the neighbor cells are on the same frequency. In this case, the UEs will not be able to properly identify the neighbor cells which results in degradation in the handover performance.

- PCI confusion: A PCI confusion occurs when two or more neighbor cells of a home cell are assigned the same PCI, and the neighbor cells are on the same frequency. In this case, the UEs will not be able to properly identify the neighbor cells which

[1] i14y Lab is a consortium of Deutsche Telekom, Telefonica, Vodafone, BISDN, Capgemini Engineering, EANTC, Fraunhofer HHI, highstreet technologies, Nokia, Rohde&Schwarz and TU Berlin.

results in degradation in the handover performance.

The AirHop PCI optimization rApp retrieves the network topology from the non-RT RIC, and queries the configuration parameters (CMs) from the RAN through the R1 and O1 interfaces. Once a PCI conflict is detected, new PCI values are suggested on the R1 interface which are communicated to the RAN on the O1 interface.

Enhancements of the RIA use case

TIP's RAN Intelligence and Automation (RIA) sub-group, part of the TIP OpenRAN Project Group, enables MNOs and the Open RAN ecosystem to collaborate on RAN use case development, testing and deployment. The community efforts through the RIA subgroup leverage the strength of data science, AI/ML technologies and open interfaces to define use cases, set requirements for RIC platforms and test and validate the functionality of xApps and rApps.

As part of the testing efforts, TIP's original PCI use case compliance requirements were updated to include optimizing PCIs for 5G.

Several enhancements to the TIP RIA sub-group published use case descriptions were required to ensure there was a consistent and comprehensive alignment of the Deutsche Telekom-driven use case requirements and the use case compliance requirements outlined in the RIA use case description. Additionally, the validation process looked to exercise and verify levels of performance for the UC11 that exceed the scope of the compliance requirements in the RIA use case description. In order to define a meaningful validation process for UC11, the following enhancements to the RIA use case requirements were included in the use case description or validation test plan:

- Scaling of the use case across both the number of cells under consideration and the number of simultaneous frequency bands under consideration of the UC11 rApp
- Measure the number of iterations to achieve conflict-free resolution as well as time-to-resolution to have comparable metrics for similar rApps
- Define a specific test plan to address both the Deutsche Telekom led conflict

scenarios and scaling
- Define a specific test network topology to facilitate the execution of the test plan

Multi-vendor test setup

The high level diagram for this test setup shown in Figure 1.

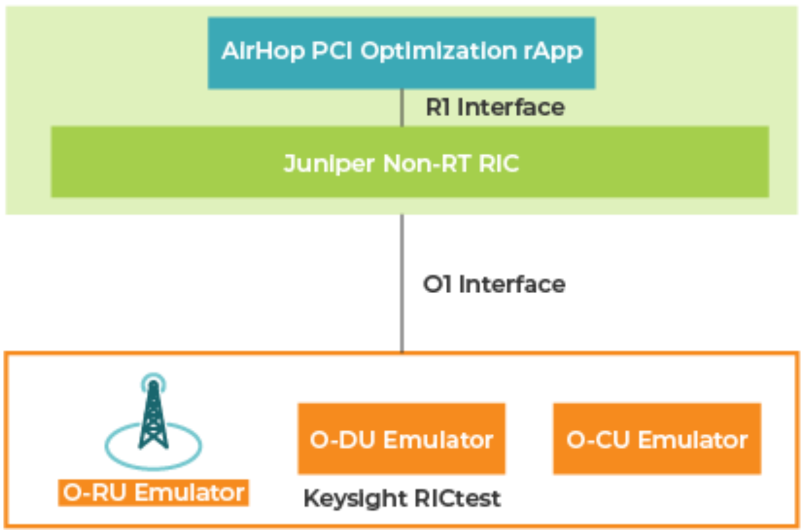

Figure 1: High Level Test System Diagram

PCI optimization rApp provided by Airhop

AirHop collaborated with Deutsche Telekom and Keysight to define the conflict scenarios to be included in the UC11 validation process and establish a topology to facilitate the test cases in addition to the scale test requirements. Jointly defined test scenarios include PCI collision between two (2) cells (Figure 2), PCI collision between three (3) cells (Figure 3), PCI confusion between two (2) cells (Figure 4), and chain of conflict and confusion for six (6) cells (Figure 5).

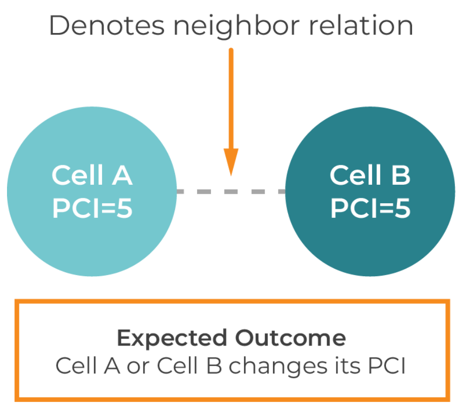

Figure 2. PCI Collision Between Two (2) Cells

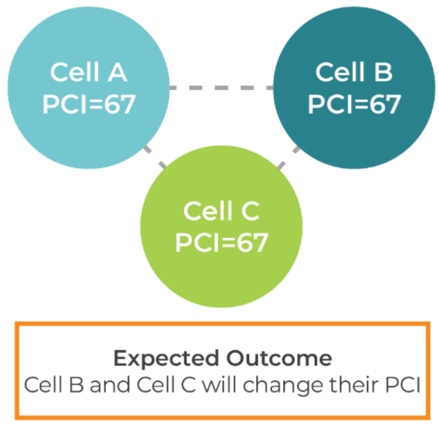

Figure 3. PCI Collision Between Three (3) Cells

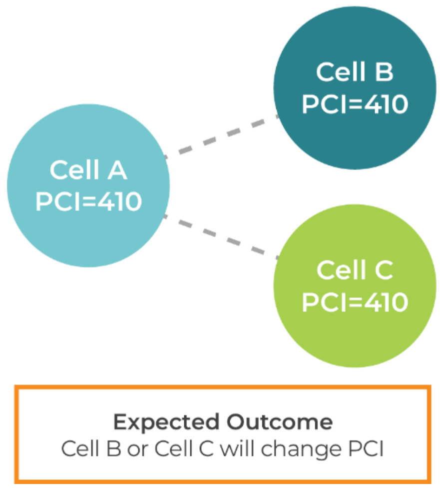

Figure 4. PCI Confusion Between Two (2) Cells

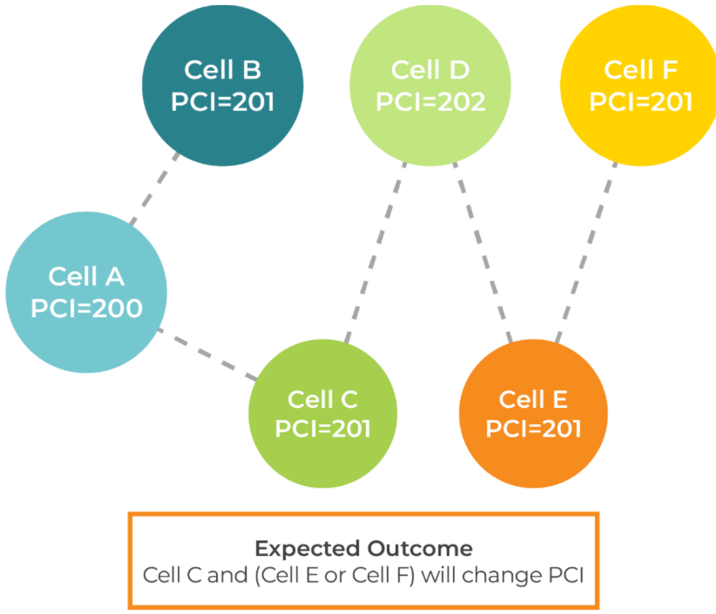

Figure 5. Chain of Conflict and Confusion for Six (6) Cells

Non-RT RIC provided by Juniper Networks

Juniper provided the Non-RT RIC platform and led the definition of the end-to-end use case flows, starting with the rApp onboarding and deployment, the R1 interface interactions between AirHop rApp and Juniper Non-RT RIC platform, the O1 interface aspects and the O1 integration with Keysight. Juniper worked with AirHop and Keysight on the use case integration and then supported Deutsche Telekom, i14y Lab and TIP for the execution of the test cases via the Non-RT RIC platform.

O1 emulator and tester provided by Keysight

The role of Keysight RICtest is to provide a simulation of an Open RAN network at scale which may otherwise be impractical with real elements in a lab setting, and do so with the fidelity of standards and behavior that provide value in observed results. The procedures and messages for relevant interfaces can be reviewed for compliance and the interoperability of system components confirmed. Operators gain confidence in RAN optimization algorithms and the multi-vendor integrations that deliver them in pre-production test environments.

The Open RAN network simulated in the PCI Optimization use case scenarios for the Silver Badging exercise implements a combination of requirements from Airhop's Auptim PCI optimization rApp methods, TIP's criteria for Use Case 11, and Deutsche Telekom's additional inputs for scale and complexity that operators consider relevant. The simulated network is described by the following attributes:

- 100 Open RAN gNB nodes providing NETCONF service ports and VNF Event Streaming (VES) clients connected to Juniper's SMO components.
- Each Open RAN gNB node consists of an instance of the YANG model which is composed of node-specific and cell-specific parameters. YANG is a data modeling language [RFC 7950] originally designed to model configuration and state data manipulated by the Network Configuration Protocol (NETCONF), NETCONF Remote Procedure Calls, and NETCONF notifications [RFC6241]. These node and cell-specific parameters include factors used by AirHop's Auptim rApp PCI optimization methods. These factors are described as attributes of Information

Object Classes (IOC) in 3GPP TS 28.541, and include the following: gNbId, cellLocalId, arfcnDl, arfcnUl, nRPci, and nRCellRelation.
- Each Open RAN gNB node provides three inter-frequency cells. The use of inter-frequency cells provides additional complexity as the rApp must determine conflicts and confusion for each ARFCN. The entire simulated network therefore consists of 300 coverage cells and 3 frequency layers.
- Neighbor relationships for any single cell are allocated from identified cell centers within a 4-kilometer diameter from its center.
- Of the three hundred (300) defined cells, five percent (5%) of them will be in conflict.
  - As an interpretation, the number of cells in conflict represents the cells which would be anticipated to receive O1 NETCONF edits during the validation test run. The total number of cells participating in confusion and collision scenarios is therefore much higher.
  - As an absolute value, 5% of 300 is 15. Therefore, the topology was defined with overlaid scenarios which anticipate a total of fifteen (15) or more edited cells for remediation.
- Cell technology type is NR
- Keysight RICtest's simulated Open RAN network topology supports the O1 interface. E2 interface is not a requirement to fulfill the use case and was not enabled.

Once a PCI conflict is detected, the rApp suggests a non-conflicting PCI on the R1 interface which in turn is communicated to the simulated Open RAN network on the O1 interface where NETCONF is used to update the Open RAN node.

In order to satisfy the required number of conflicts and confusions, multiple instances of the scenarios described in Figures 2 through 5 were configured in the simulated Open RAN network. Keysight RICtest provided logging of the NETCONF and VES actions required to correlate AirHop Auptim rApp corrective actions to each instance. The node and cell topology information, logs, and O1 interface compliance information were contributed as part of the submission by AirHop to TIP for Silver Badging of Use Case 11.

Installation of the components in i14y Lab

The components described before have been installed at i14y Lab. The topology, connectivity and addressing of the different instances to test UC11 are shown in Figure 6.

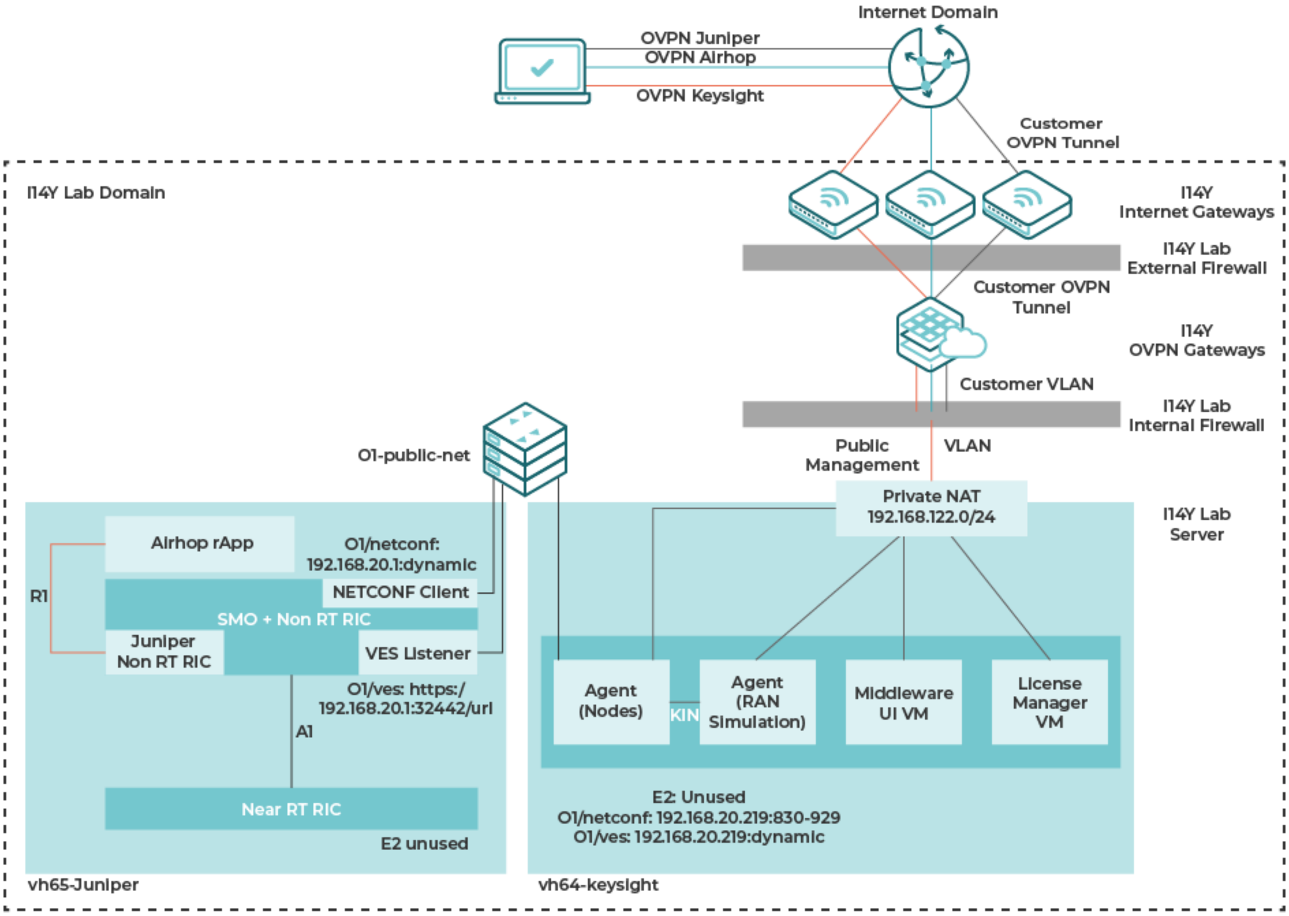

Figure 6. Test Setup in the i14y Lab

The i14y Lab provides lab (server room) space and office/working space. It is hosted and operated by Deutsche Telekom in its own premises, but physically separated. Lab and office/working space are interconnected equipment, tools, and DUTs/SUTs in the lab, enabling remote access and management. The lab's server room offers >20 server racks and an RF corner for the installation of RF equipment. Each rack can be locked, and individually controlled and configured both locally and remotely. The racks can be equipped with IP cameras for client's remote observability of their DUTs/SUTs.

Lab users are assigned credentials that allow access to specific areas. Each rack, which can be dedicated per client or project, can be locked. Client equipment could be visible to other clients due to the shared nature of the common lab area. However, access is strictly controlled, and operation of the test equipment is limited to the hosts. It is not allowed to take pictures in the lab. Each client or project is assigned IP addresses from its own isolated subnet range depending on the scale of each project.

The i14y Lab offers a broad range of testing services to clients and partners. It provides subsystem and system testing for conformance, interoperability and end-to-end setups in a laboratory environment as well as field setups. The quality and performance of new products during design and development can be verified and checked by i14y Lab as well. Additional expert support includes results interpretation, troubleshooting, root cause analysis, and consulting services. Services can be customized and combined.

Open RAN test capabilities of i14y Lab are summarized in table 1.

	RF	OFH-CUSM	F1-C/U	X2-C/U	Xn-C/U	E1	O1	O2	O-Cloud API	E2	A1	R1	Near-RT RIC API
O-RU normal mode	x	x											
O-RU cascade mode		x											
FHM		x											
FHGW		x											
O-DU		x	x							x			
O-CU-CP/UP			x	x	x	x				x			
O-eNB													
Near-RT RIC							x			x	x		
Non-RT RIC (part of SMO)							x				x	x	
O-Cloud													
SMO													
xApp													x
rApp												x	
Transport xHAUL		x	x	x	x	x	x	x		x	x		

Table 1: Open RAN Test Capabilities of the i14y Lab

Conclusion

The joint project is seen as one step in a series of actions to improve the value of validation and badging for operators. Major points of improvement are:

- A multi-vendor/operator cooperation with platform, rApp and test equipment from different parties and Deutsche Telekom creating relevant requirements.
- Those requirements pushed the testing further towards realistic network conditions. One area of focus has been the significant topology size (100 gNodeBs). This level of scale gives a better impression of how the tested App and RIC platform would behave in a commercial network.
- Agreed pass criteria needed to be met to achieve the Silver Badge. Those pass criteria could be used in other badging projects to achieve comparability between competitors or even different versions of the same product.
- Learnings on topologies/models and used data sets, performance parameters and badging criteria can be fed back to the RIA sub-project group.

Still, further work is required to more tightly link the TIP badging process to operator-internal acceptance testing in order to maximize the efficiency gain of open lab testing.

Future work

While the presented work already shows good progress in open testing and badging of RIC solutions, there is a backlog of learnings to be transformed into development actions. This will now be driven forward by the present project group.

It is intended to incorporate these learnings as part of the planned work of the validation of additional use cases. The next planned use case is TIP's UC17 - RAN Slice SLA Assurance, which is supplied by Juniper as an rApp + xApp pair. Juniper, Deutsche Telekom, TIP and Keysight will work jointly to add further requirements to the use case, with special focus on test scenarios and test cases based on Deutsche Telekom's and other potential operator's input.

Some important items of consideration for this work are the levels of SMO involvement, especially how the slice management events (like slice creation, modification, deletion) from RAN Slice Subnet Management Function (RAN NSSMF) can be triggered and/or emulated, how the actual slice SLA achieved during runtime will be monitored and compared against the desired/provisioned slice SLA, the RAN slice topology and the covered Tracking Areas and the respective cells, the number of simultaneous slices and the types of slices in the test case.

i14y Lab is planned to be utilized for the execution and verification of the test results, and the captured test results will then be submitted to TIP for the validation process.

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