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Keysight and Intel Create Automated 5G mMIMO vRAN Test Framework

The market for massive multiple-in, multiple-out (mMIMO) RANs is growing because mMIMO maximizes the utilization of 5G network spectrum capacity; Keysight, using Intel® technologies, has developed an accurate, controllable and repeatable mMIMO test framework using Keysight RuSIM and Intel® FlexRAN™ reference software

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5G standalone networks promise improved performance over 4G with throughput of up to 100Mbps, reduced latency and increased network capacity. One of the main technology enablers for these improvements is massive multiple-input / multiple-output (mMIMO) radio access network (RAN) technology.

mMIMO technology started out as just MIMO, a technology that uses a small array of multiple antennas to make connections between multiple devices using the same frequency and the same time domain. Using spatial diversity and spatial multiplexing technologies, dataflows (known as streams) from different users can be transmitted on the same frequency band and mux time slot. In this way, the MIMO antenna can accommodate streams from multiple users simultaneously.

The first use of MIMO in cellular networks was in LTE (3GPP Release 8), which specified a two transmitter – two receiver (2 x 2) configuration. Later that would grow to 4 x 4. In the first massive MIMO specification (3GPP Release 16), a 32 x 32 MIMO configuration, is specified for 5G with plans to increase that to 64 x 64 in future releases.

Figure 1 illustrates how the technology works. The mMIMO antenna on the left points its beams toward user one, a device with a single antenna that is only able to decode the traffic meant for it. User two shows the process in reverse with the single antenna transmitting the data back to the base station.

Fast Growth Predicted for mMIMO

The importance of mMIMO to 5G standalone networks means that the market size for the technology is growing. According to market analyst firm Rethink Wireless Research, "Massive MIMO will consolidate its position in 5G RAN and increase its rate of growth in all markets, with total units installed per year rising just over three times - from 930,000 in 2023 to 3.07 million in 2031. By then, the cumulative number of mMIMO units deployed globally will be around 22 million."[1]

mMIMO is such a critical component of 5G networks, and such a new technology for MNOs, that it's important to validate the network quality-of-experience for user equipment (UE). Intel and Keysight, an Intel® Industry Solution Builders' Network Builders Titanium Tier ecosystem member, have built a joint validation test framework to make it easy for mobile network operators (MNOs) to have accurate, controllable, and repeatable validation of the function and performance of their mMIMO networks.

Table of Contents

This white paper describes the test framework, which simplifies the validation aspect of the deployment of mMIMO use cases on Intel® architecture servers. The three key technologies in this solution are Keysight RuSIM network emulation tool, Robot Framework for test automation, and Intel® FlexRAN™ reference software for enhanced Common Public Radio Interface (eCPRI) connectivity.

RuSIM Emulates Data Traffic for RAN Testing

RuSIM is a traffic emulator for 4G and 5G user equipment (UE) and Open RAN radio unit (O-RU) traffic. The software enables infrastructure vendors, chipset providers and mobile operators and integrators to run functional testing, conformance testing and performance testing of O-RAN distributed units over an option 7.2x functional split fronthaul interface.

RuSIM generates IP traffic load and simulates applications running on multiple concurrent devices operating real voice and data sessions. The solution can be used to assess full protocol stacks for 5G NR (non-standalone or standalone) over the eCPRI. It also performs full-stack O-DU testing using Keysight's CuSIM Open RAN centralized unit (O-CU) emulator.

Functional and Stress Testing of mMIMO Networks

In mMIMO applications, RuSIM enables functional and stress testing of the O-DU's proprietary scheduler via a simultaneous emulation of O-RU, spatial channel and mMIMO UEs in a software solution running on commercial off the shelf (COTS) servers.

This provides the spatial, frequency- and time-selective characteristics within each RF channel between the O-RU and a sufficiently large population of UEs for thorough testing

of the scheduler. Beamforming is a central element of 5G mMIMO scheduling algorithms, and the RuSIM can emulate mMIMO channel conditions that have been very difficult to recreate in laboratory environments.

In addition, RuSIM's spatial channel emulation, operating in the subcarrier domain, associates user-plane spatial streams (which carry only IQ data) with their target UE.

Advantages of RuSIM mMIMO emulation include:

- Full visibility of beamforming weight vectors.
- Enables off-line analysis of performance of the O-DU's beamforming algorithm response to a given stimulus (e.g., SRS).
- No requirement for phase-coherent calibration of the RF channel (conducted or near-field).

Defining the mMIMO Test Framework

To enable user-friendly end-to-end mMIMO testing, Intel and Keysight have combined RuSIM with FlexRAN to provide a real-time test framework delivering emulation of a mMIMO O-RU with spatial MU-MIMO channels, and a population of UEs on an O-DU device under test (DUT). This framework can be used for the following use cases:

- mMIMO function validation
- mMIMO E2E performance validation in L1 mode
- mMIMO E2E performance validation in full stack mode

The solution features RuSIM connected to the FlexRAN software at the eCPRI fronthaul interface and uses the Robot Framework for automation (see Figure 2).
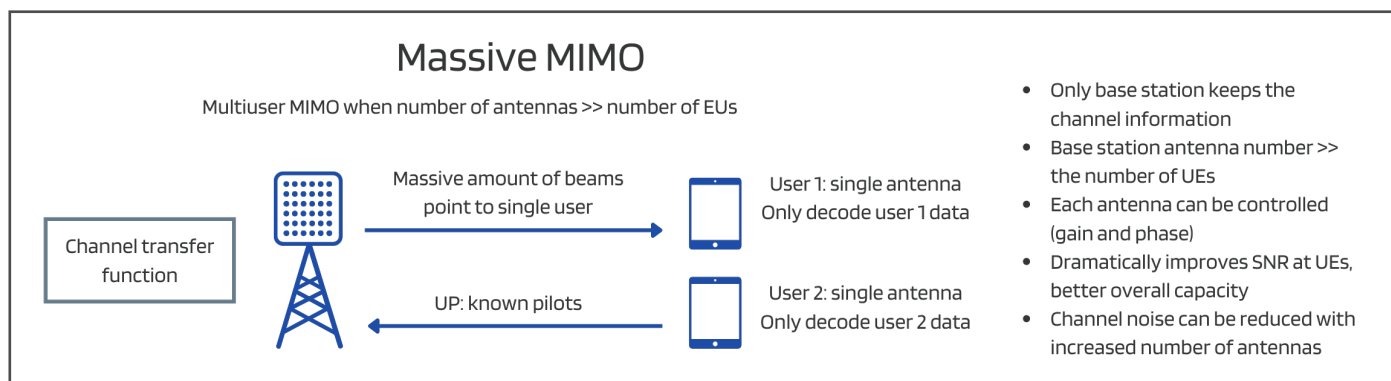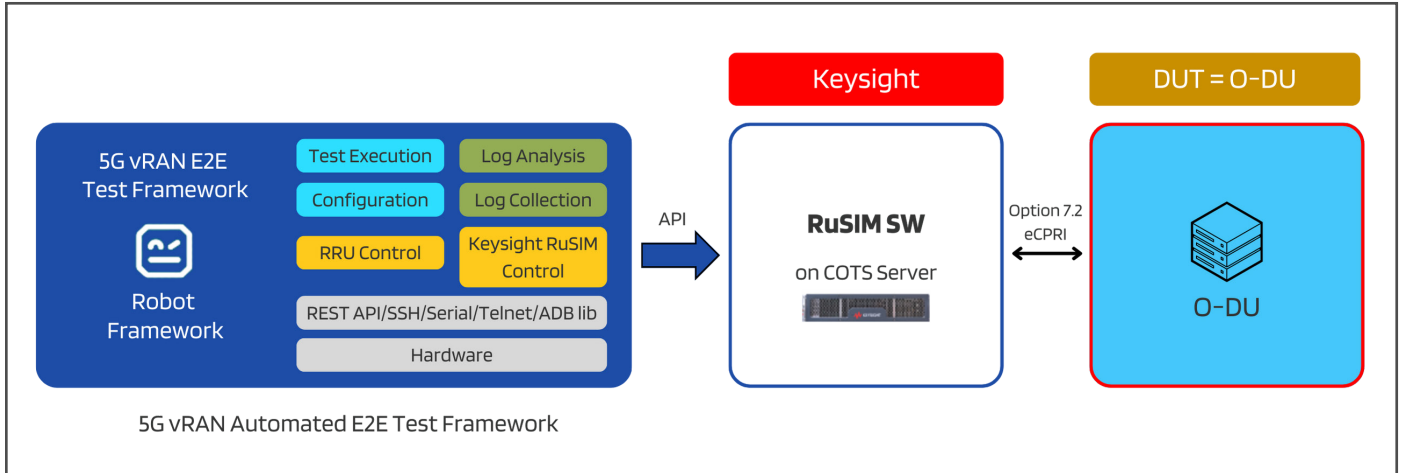

Figure 1. How mMIMO works.

Figure 2. Block diagram of end-to-end Intel and Keysight mMIMO test framework.

Robot Framework Provides Automation

Robot Framework is an open source automation framework for acceptance testing. Automation comes from support of acceptance test-driven development (ATDD), behavior driven development (BDD) and robotic process automation (RPA). The framework has an ecosystem that has developed software libraries and tools that can customize the software. It has become popular thanks to its user-friendly syntax and use of keywords.

Robot Framework also provides the log collection and log analysis functions to evaluate the test results and determine whether the channels established matched the criteria presented and measure performance and latency and functionality parameters.

The RuSIM, FlexRAN software, and DUT are running on servers powered by 4th Gen Intel® Xeon® Scalable processors with Intel® vRAN Boost, which provides the processing capacity for compute-intensive processes and complex scheduling. Intel® Xeon® Scalable processors feature an optimized architecture that supports Open RAN and other workloads with built-in Intel vRAN Boost acceleration and hardware-based security features. This processor family

delivers compute agility and scalability and benefits from decades of innovation for the most in-demand workload requirements.

FlexRAN Software for Virtual RANs

FlexRAN software is a 4G/5G PHY reference architecture for building and deploying highly optimized, feature-rich 4G and 5G scalable cloud-native RANs on Intel® architecture processors.

It is comprised of modular, virtualized control functions with well-defined interfaces that allow flexible and programmable control of the layer 1 wireless infrastructure.

FlexRAN software supports control and data plane separation to deliver more scalability in each function.

Technologies that accelerate FlexRAN software's performance include Intel® Advanced Vector Extensions (AVX) for vRAN, a parallel processing instruction set, and Data Plane Development Kit (DPDK).
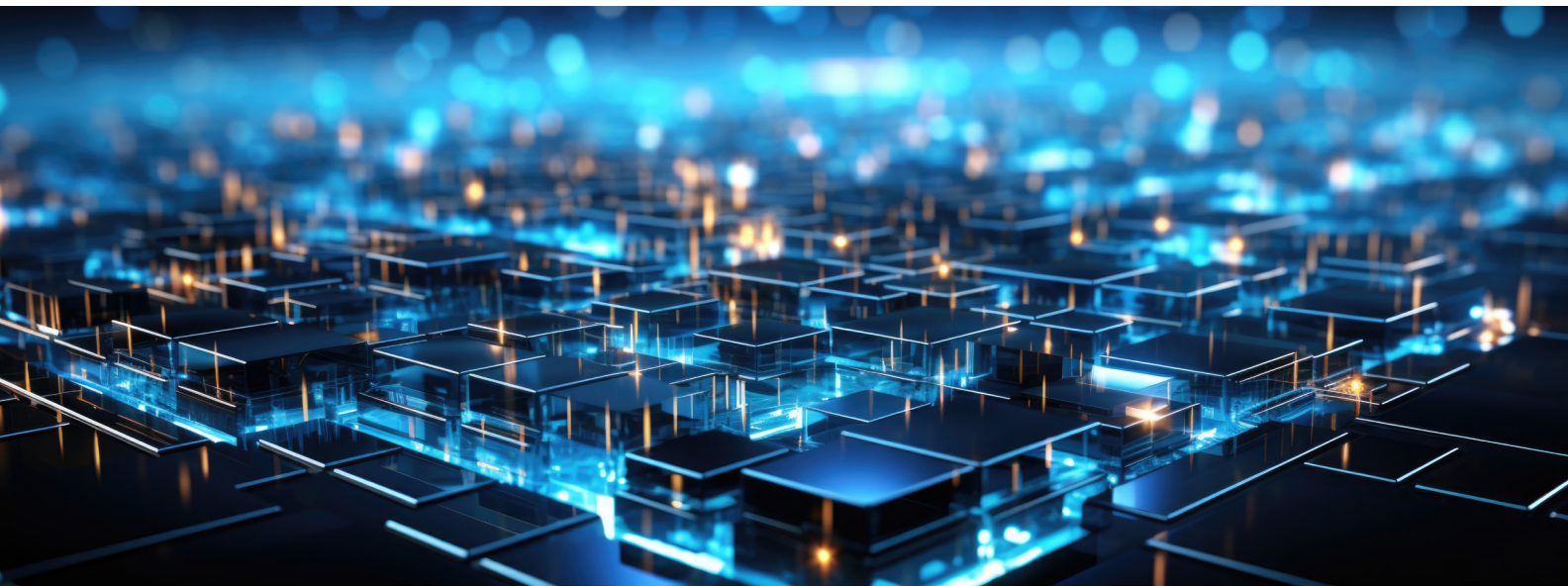
Conclusion

The market for mMIMO RAN technology is expected to grow significantly as MNOs build out their standalone 5G networks. mMIMO antennas and technology are central to delivering the data throughput and capacity promised for 5G networks. To ensure quality of experience, the O-DUs that support a mMIMO network need acceptance, performance and validation testing.

Keysight's RuSIM provides a complete emulation system for mMIMO testing providing function validation, L1 performance validation and full stack performance validation. The eCPRI connection for this testing is provided by FlexRAN software, a reference architecture for building Open vRANs. This testing framework, combined with test automation from Robot Framework, offers a complete solution for end-to-end mMIMO O-DU testing.

Learn More

RuSIM Product Website

RuSIM Datasheet

Robot Framework

Intel® Network Builders

Intel® FlexRAN™ website

4th Gen Intel® Xeon® Scalable processors

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[1] https://rethinkresearch.biz/report/massive-mimo-market-forecast-2024-2031/