SOLUTION
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OAI Reference Architecture for 5G and 6G Research with the USRP

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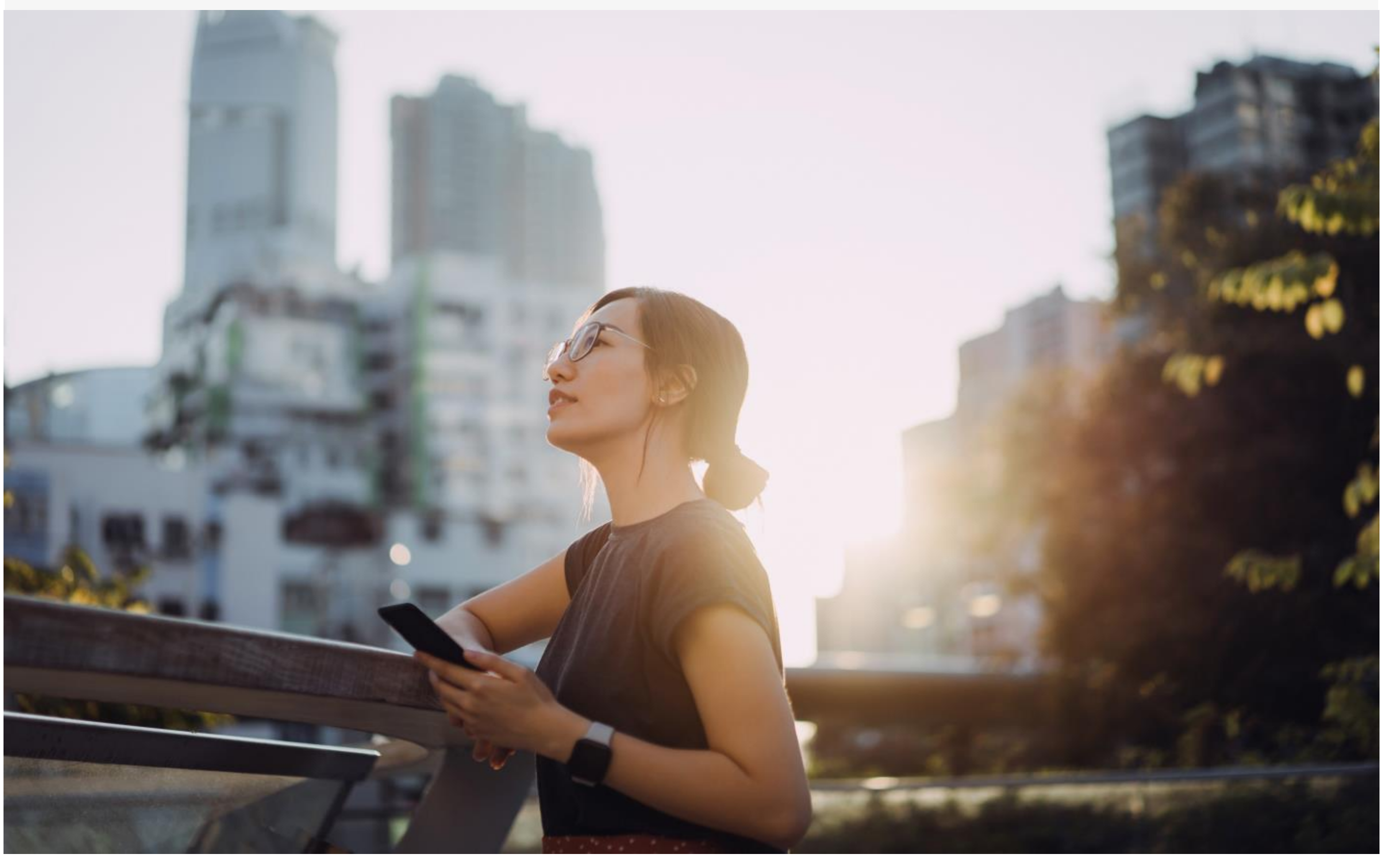
Explore NI’s Solutions

The latest generation of cellular communications standards for 5G are significantly more complex than previous generations. NI offers engineers and researchers an end-to-end, standard compliant and flexible system that provides a great starting point for research.



Evolution of 5G toward 6G

As 5G deployments gain traction and infrastructure providers roll out new capabilities, the research community is starting to look beyond 5G. 6G is coming and could involve covering much higher frequencies (into the THz bands), phased-array antenna solutions, and increasing bandwidths and modulation densities. We can also expect to see the proliferation of new use cases in massive machine-to-machine communication as well as new levels of reliability, security, and network response time. The vision for 6G is just starting to be defined and will expand to more applications based on new enabling technologies. Some interesting and important technical areas that have been identified for 6G such as joint communications and sensing, THz/sub-THz, extreme MIMO, and artificial intelligence/machine learning (AI/ML), and more. These will require the wireless experimentation platform to meet the bandwidth, frequency, and flexibility needs of such projects.

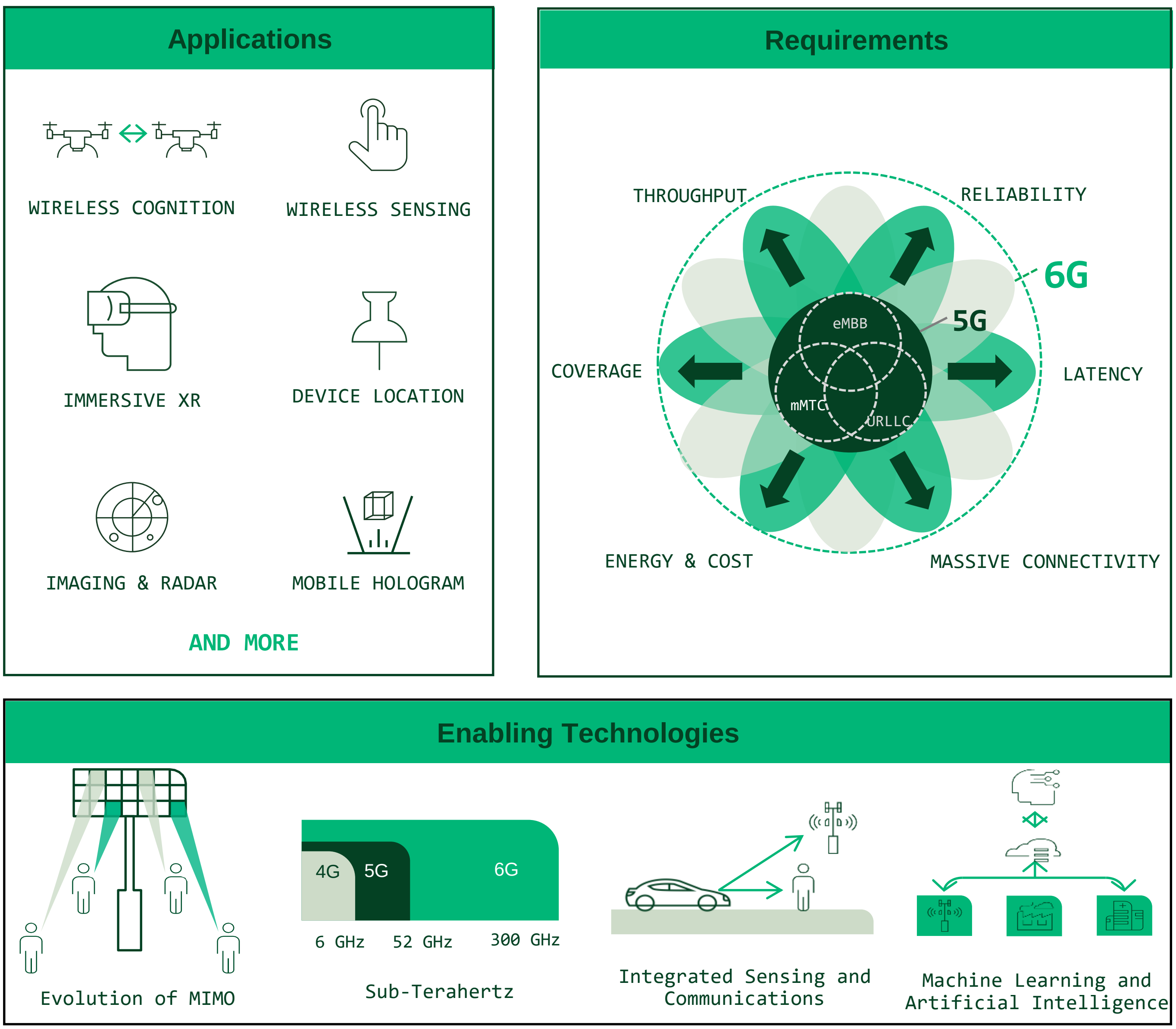


FIG 1 | 6G innovation

Rapidly Prototyping the New Concept

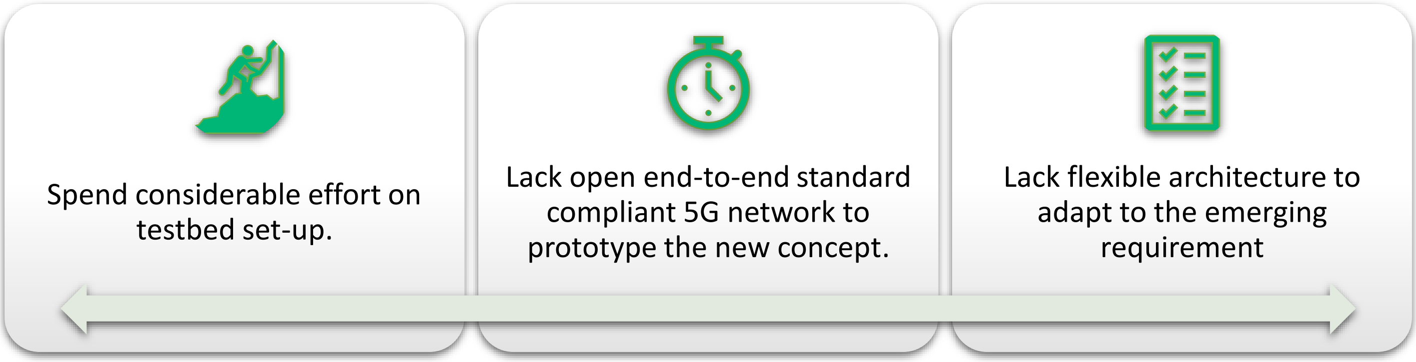


FIG 2 | Pain Points in 5G/6G Research

While demonstrating the diverse applications of 6G, wireless researchers still face the pressure to innovate faster and prototype new concepts in key areas. Building testbed infrastructure is complicated and time consuming, and it is more valuable for researchers to focus on their ideas rather than spend considerable time proving the testbed works. Researchers must also find flexible, standard compliant solutions that can adapt to emerging requirements, scale for multichannel architectures, have artificial intelligence for cognitive capability, and employ software framework to rapidly gather real data. NI's software defined radio (SDR) with a standard reference architecture accelerates this transition from concept to reality.

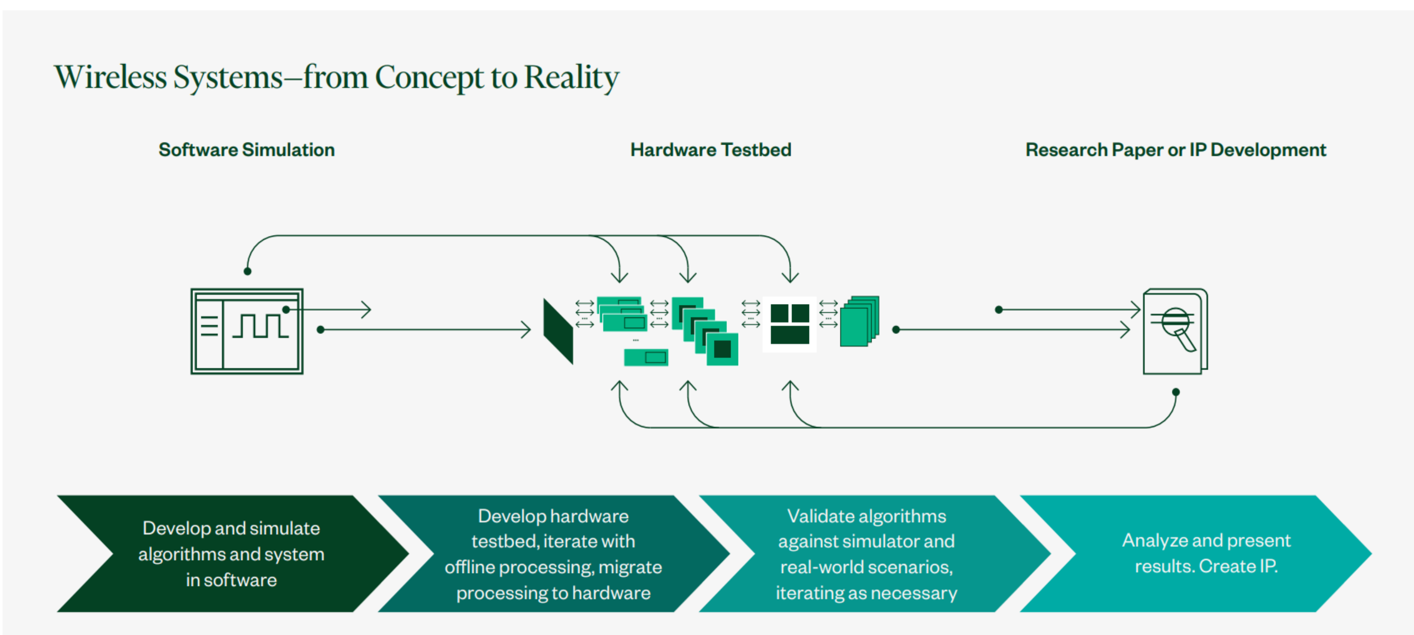


FIG 3 | From Concept to Reality

OAI Reference Architecture for 5G and 6G Research with the USRP Overview

Open Air Interface (OAI) is a fast-growing community and software assets in wireless domain with massive 5G enabled government, academic, and research use cases. It has the following advantages:

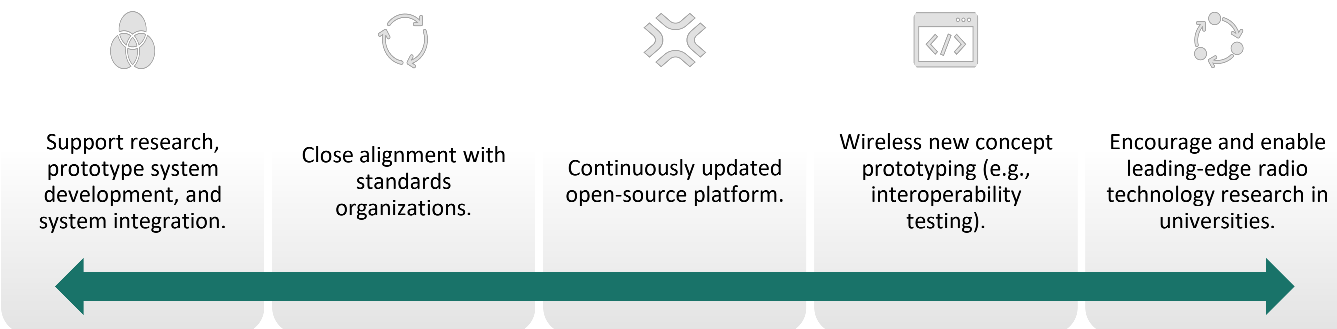


FIG 4 The advantage of OAI

The OAI Reference Architecture for 5G and 6G Research with the USRP is NI's blueprint for a system that meets key requirements of a hardware testbed for prototyping 5G/6G technology. It uses the very popular OAI 5G-NR protocol stack including 5G core network and outlines exactly how to create this extremely complex system setup and correctly configure all the parameters. It connects to wireless modem module user equipment (UE), commercial off-the-shelf (COTS) handset UE, and USRP based software UE. Follow NI's recommended solution to build up a real-time communication system as quickly as possible; this reference architecture has been validated by NI engineers to ensure it delivers the specified performance. Based on the standard hardware configuration and open-source software, this solution is ideal for rapidly transitioning wireless IP through its development lifecycle: from software simulation to proof-of-concept demonstration.

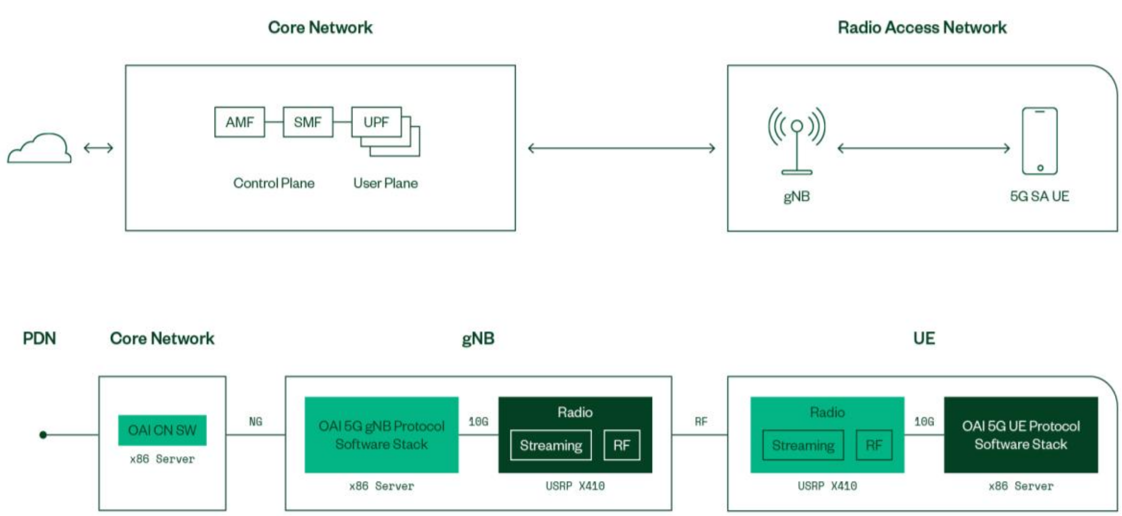


FIG 5 Architecture for Wireless System Prototyping

Solution Advantages

- Rich, open-source reference code for core network, gNB, and UE available on GitHub based on the popular OAI 5G-NR protocol stack
- Open architecture for real-time 5G end-to-end network to enable research and demonstration of 6G candidate technologies
- NI-validated system configuration including third-party components to ensure stable performance
- Detailed documentation, accelerating the set-up time for 5G end-to-end communication systems

Solution Details

A Validated Design Pattern

The following resources are available to users in the reference architecture:

01

Complete bill of materials including USRP, cables, and other hardware required for system assembly.

02

User manual including system set-up instructions and measured specifications.

03

Reference software code, built upon an open-source stack, can be easily accessed on GitLab.

Note: To access referenced code link as well as more technical details, please browse the link *OAI Reference Architecture Application Note*.

System Overview

The OAI Reference Architecture for 5G and 6G Research with the USRP provides hardware, software, and documentation that accelerates the path from concept to prototype.

OAI Reference Architecture for 5G System Prototyping with NI USRP

Bridging the gap between theoretical and practical issues around 5G system deployment
and implementation for enabling engineers and researchers to rapidly develop and test novel use cases.

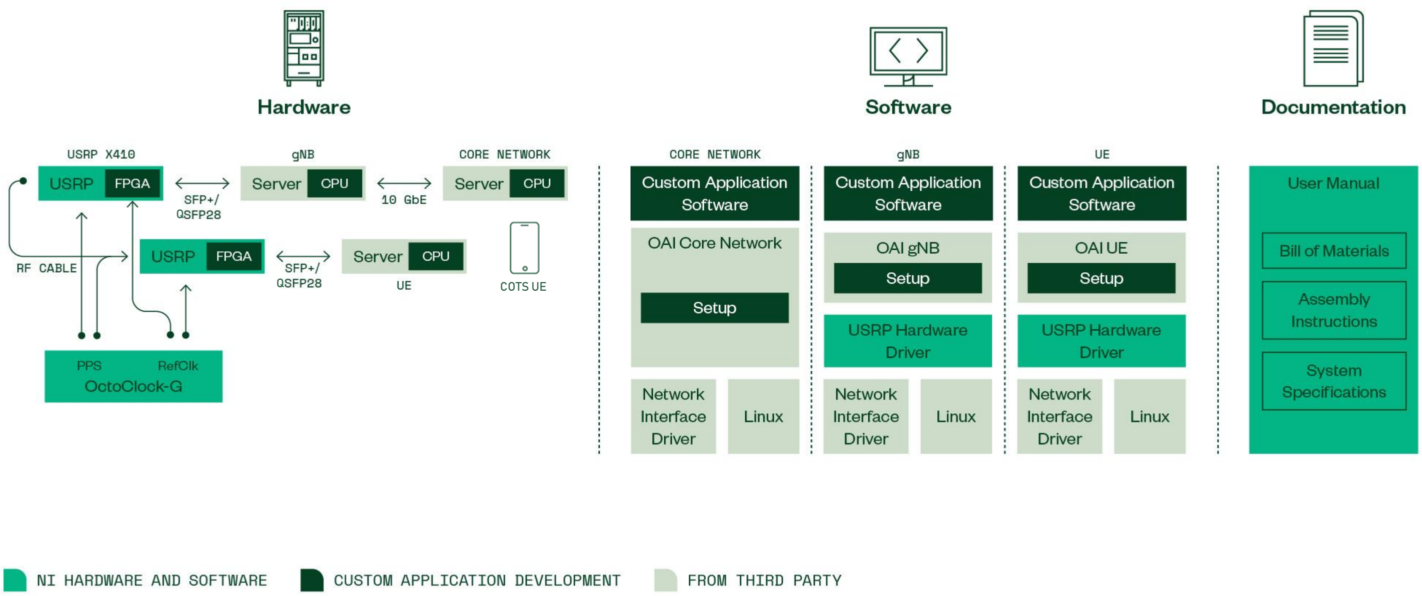


FIG 6 | OAI Reference Architecture Overview

"With this new relationship, we will bring this collaboration to a new level and make sure that OAI will get the best out of current and future platforms from NI."

—Florian Kaltenberger—EURECOM

Key Specifications

- Full end-to-end setup for 5G SA wireless research and prototyping.
- OpenAirInterface (OAI) 5G stack and USRP Hardware Driver (UHD) are open source.
- Connects to wireless modem module UE, COTS handset UE, and USRP based software UE.
- User applications like video streaming and connection to the internet are possible.
- Supports multiple bands in FR1, including n77 (3330-4200 MHz) and n78 (3300-3800 MHz).
- Support for dual 10 Gbps Ethernet connectivity
- External clock distribution module (OctoClock-G) with GPSDO and can be used for 1 PPS and 10 MHz reference signals.
- Scalable to multi-channel MIMO (Please check with OAI for the latest supported features).
- Allows both over-the-air (OTA) and cabled operation.

Hardware Components

USRP X410 Software Defined Radio

The NI Ettus USRP X410 is the most powerful, multi-channel software-defined radio specially designed for prototyping high-performance wireless systems and performing over-the-air signal generation and analysis. The SDR is designed for frequencies from 1 MHz to 7.2 GHz and features a two-stage superheterodyne architecture with four independent TX and RX channels capable of 400 MHz of instantaneous bandwidth each.

Digital interfaces for data offload and control include two QSFP28 interfaces capable of 100 GbE, a PCIe Gen3 x8 interface. There are also standard command, control, and debug interfaces: USB-C JTAG, USB-C console, and Ethernet 10/100/1000. The USRP X410 is an all-in-one device built on the Xilinx Zynq UltraScale+ ZU28DR RF System on Chip (RFSoC) with built-in digital up-and-down conversion and onboard Soft-Decision Forward Error Correction (SD-FEC) IP.

FIG 7 | NI Ettus USRP X410

USRP N320 Software Defined Radio

The USRP N320 is networked software defined radio that provides reliability and fault-tolerance for deployment in large-scale and distributed wireless systems. It is the high-performance SDR that uses a unique RF design by Ettus Research to provide 2 Rx and 2 Tx channels in a half-wide RU form factor. Each channel provides up to 200 MHz of instantaneous bandwidth and covers a frequency range from 3 MHz to 6 GHz. The baseband processor uses the Xilinx Zynq-7100 SoC to deliver a large user-programmable FPGA for real-time, low latency processing and a dual-core ARM CPU for stand-alone operation.

Support for 1 GbE, 10 GbE, and Aurora interfaces over two SFP+ ports and 1 QSFP+ port enables high throughput IQ streaming to a host PC or FPGA coprocessor. A flexible synchronization architecture with support for LO sharing for TX and RX, 10 MHz clock reference, PPS time reference, GPSDO, and White Rabbit enables the implementation of phase-coherent MIMO configurations.

FIG 8 | NI Ettus USRP N320

USRP X310 Software Defined Radio

The USRP N310 is a networked software defined radio (SDR) that provides reliability and fault-tolerance for deployment in large-scale and distributed wireless systems. The USRP N310 device simplifies control and management of a network of radios by introducing the unique capability to remotely perform tasks such as updating software, rebooting, factory resetting, self-testing, and host PC/ARM debugging and monitoring system health. The USRP N310 is one of the highest channel density devices in the SDR market, offering four RX and four TX channels in a half-wide RU form factor. The RF front end uses two AD9371 transceivers, the latest RFIC technology from Analog Devices. Each channel provides up to 100 MHz of instantaneous bandwidth and covers an extended frequency range from 10 MHz to 6 GHz.

FIG 9 | NI Ettus USRP N310

CDA-2990 Clock Distribution Device with GPSDO (OctoClock-G)

The CDA-2990 is an 8-Channel, 10 MHz Clock Distribution Device that helps you synchronize systems that include USRP Software Defined Radio Devices. It accepts both external 10 MHz and pulse-per-second (PPS) input signals and amplifies and distributes the signals to eight output ports. The CDA2990 is available in a configuration for distributing externally supplied signals. In the OAI Reference Architecture for 5G and 6G Research with the USRP, NI recommends the GPS-disciplined oscillator (GPSDO)-enabled option, which integrates a GPS-disciplined oven-controlled crystal oscillator (OCXO) that generates the 10 MHz and PPS signals internally.

FIG 10 | NI Ettus CDA-2990

Validated Third-Party Components

The OAI Reference Architecture for 5G and 6G Research incorporates hardware from third-party vendors. NI has tested with the selected third-party host computer, ethernet network card, UE, etc. Refer to the *OAI Reference Architecture Application Note* for more details.

NI Services and Support

NI offers a variety of solution integration options customized to your application-specific requirements. You can use your own internal integration teams for full system control or leverage the expertise of our worldwide network of Alliance Partners to obtain a turnkey system.

Contact your account manager or call or email us to learn more about how NI can help you increase product quality and accelerate timelines at (888) 280-7645 or info@ni.com

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