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Explore End-to-End 5G and 6G System Performance

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xRAN Testbed for 5G and 6G Research and Prototyping

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Trends in Wireless Communications

Networks for 5G and beyond are continuing to move away from monolithic base stations, toward a disaggregated open radio access network (open RAN or ORAN) architecture with separate, interoperable components. More capabilities are being deployed in software compared to previous generations, which relied on dedicated hardware implementations. At the same time, the push to achieve higher data rates, for more users, across a more diverse set of use cases continues. Researchers need to understand end-to-end link performance in real-world scenarios as they explore cutting-edge wireless technology.

Real-time, prototyping testbeds are becoming more critical tools for researchers as systems become more complex. These platforms enable researchers to move from simulation to real-world experiments where they can develop and demonstrate novel UE and gNB technology. Modular, upgradable hardware and software architectures enable solutions that can evolve with wireless technology and be leveraged for future project needs.

xRAN Testbed Overview

Explore Beyond 5G System Performance

The xRAN Testbed integrates hardware and software to deliver an end-to-end, 3GPP-compliant full stack solution for 5G and 6G network research and prototyping. NI's real-time, software-defined approach provides the flexibility to prototype and evaluate UE and gNB performance for next-generation wireless communications research. The xRAN Testbed end-to-end configuration is comprised of a 5G NR core network, along with a gNB and UE, each with a real-time physical layer and a commercial-grade protocol stack. Signal parameters like modulation and coding scheme (MCS) can be adjusted to assess overall performance impact. The future-ready, modular hardware and software architecture is designed to evolve beyond 5G.

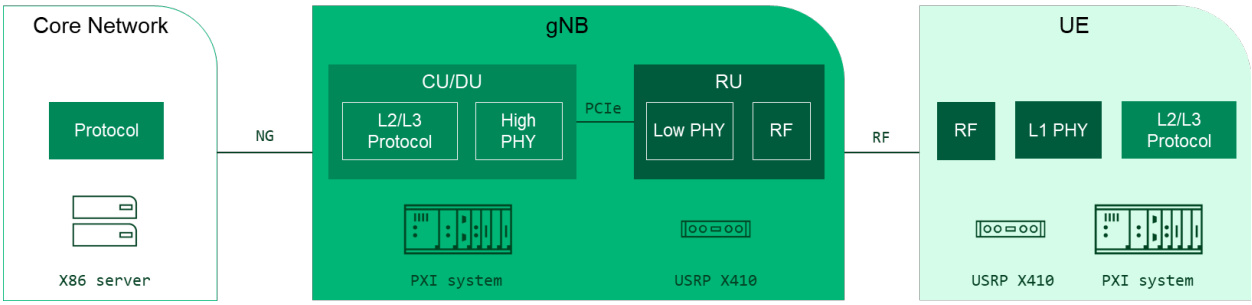

FIGURE 01

Simplified Block Diagram of the End-to-End xRAN Testbed

Solution Details

Hardware Components with Modular Flexibility

The xRAN Testbed is built on the NI Ettus USRP X410 software defined radio (SDR) which offers 7.2 GHz frequency coverage, 400 MHz bandwidth, and 4 TX and 4 RX channels. Combined with PXI FlexRIO coprocessor module and high-speed serial instruments, this solution provides a high-throughput, FPGA-accelerated L1. The gNB and the UE are based on the same hardware configuration, with the complete end-to-end system requiring two sets of hardware and the core network server.

HARDWARE COMPONENTS			QTY FOR E2E SYSTEM
UE or gNB	USRP X410	Software Defined Radio (SDR) for RF front-end and low PHY processing	2
	PXIe-7902	High-speed serial instrument for FPGA co-processing for L1	6
	PXIe-7915	FlexRIO coprocessor module for L1 coprocessing	2
	PXIe-8394	Bus extension module for connecting USRP X410	2
	PXIe-8238	Ethernet interface module	2
	PXIe-8880	PXI controller	2
	PXIe-1095	PXI chassis	2
	CDA-2990	Clock for timing/synchronization	2
Core Network	X86 server		1

FIGURE 02

End-to-end xRAN Testbed with gNB with core network on the left and UE on the right.

Software Components

The high-performance 5G NR Standalone (SA) reference IP implementation provides a 3GPP-compliant starting point for an E2E full-stack link with commercial-grade protocol stack for core network, gNB, and UE. With a real-time PHY, the system achieves up to 900 Mbps DL and 40 Mbps UL E2E throughput. Configurable FR1 TDD signal parameters allow users to evaluate various link scenarios, using the gNB and UE GUIs for analysis and troubleshooting.

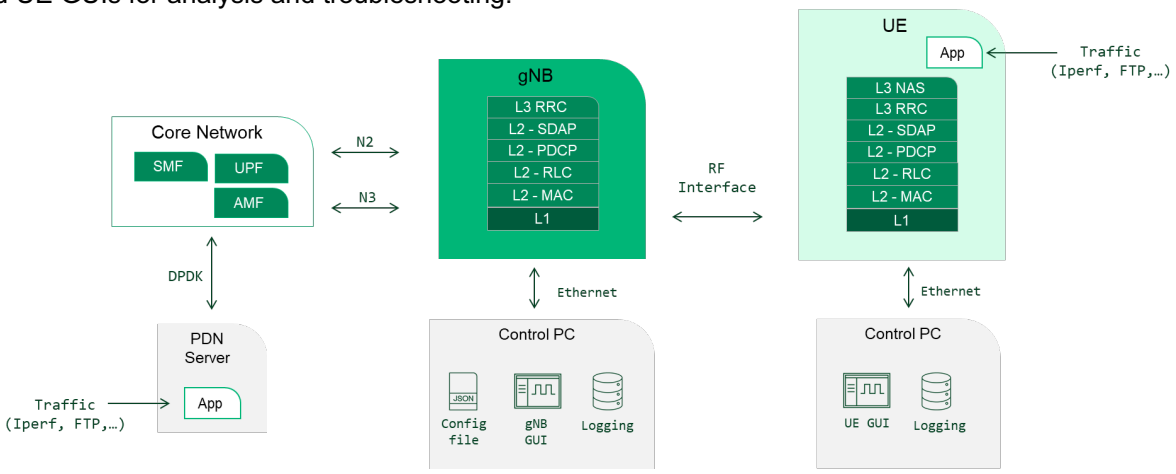

FIGURE 03

Data flow diagram showing 5G NR stack and software interface components.

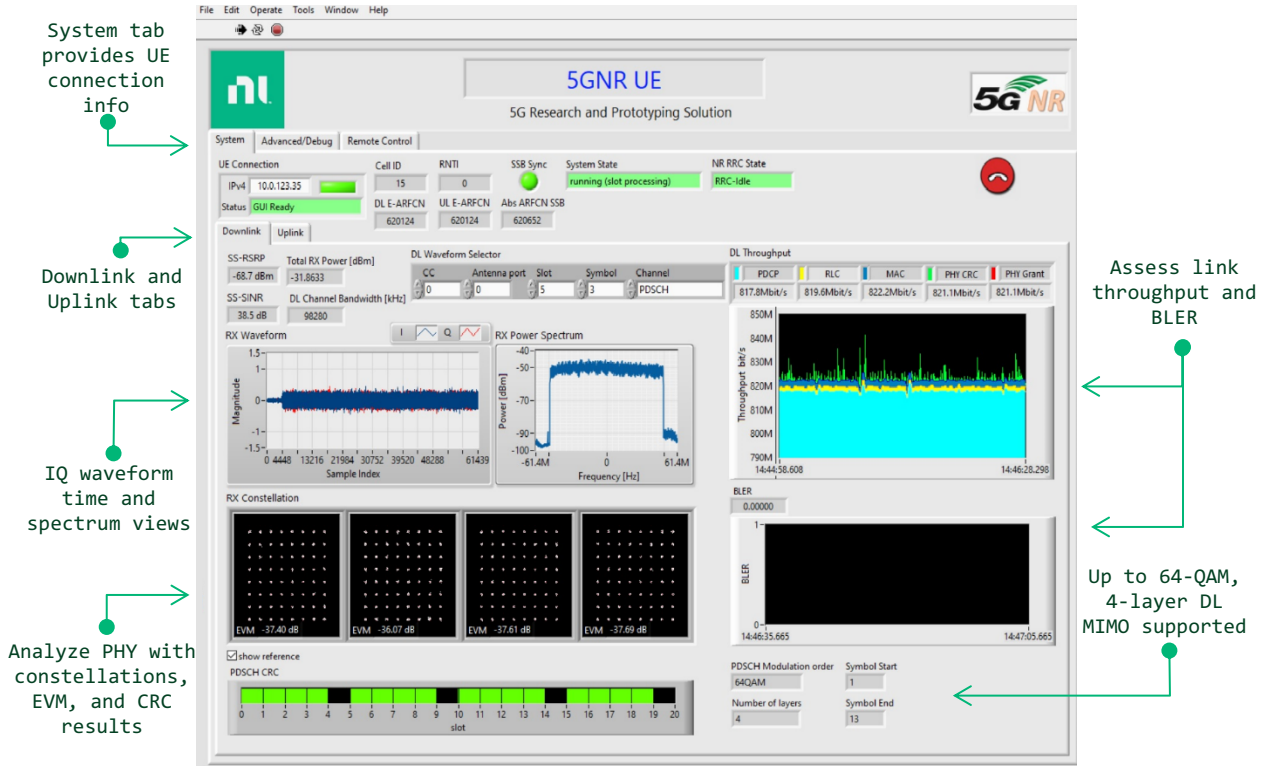

FIGURE 04

Overview of xRAN Testbed UE GUI Features

Specifications Overview

L1 FEATURES	
Operation mode	Standalone (SA), FR1
Duplex mode	TDD, DDDSU
Frequency, bandwidth	Band n78 (3.5 GHz), 100 MHz
Subcarrier spacing	30 kHz
Modulation (shared channels)	Up to 64QAM
Support physical channels	DL: PDSCH, PDCCH, PBCH, PSS, SSS, DMRS UL: PUSCH, PUCCH, PRACH, DMRS
FEC encoding/decoding	LDPC, Polar
MIMO	Single user MIMO; DL static 4 layers, UL static 1 layer
Multi-UE support	2 UEs per slot
3GPP specification	15.7 (Sep 2019)
L2/L3 FEATURES	
NAS	Registration
RRC	RRC connection establishment/reconfiguration, initial security activation, UE capability transfer, and DL/UL information transfer
SDAP	QoS flow to DRB mapping
PDCP	Transfer of user and control plane data; duplicate discarding
RLC	Acknowledged Mode (AM), Unacknowledged Mode (UM), and Transparent Mode (TM); segmentation/reassembly/reordering
MAC	HARQ/RA/SR procedures; CE: BSR

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