Introduction & Overview

- Provides a reference system architecture based open-source software and open standards
  - Step-by-step guide, from start to finish, that clearly illustrates how to implement the system
  - Help accelerate getting started on 5G projects with USRP
- Several USRP devices supported
  - USRP N300, N310, N320, N321, X410
- Several UE implementations supported
  - USRP, Quectel RM500Q-GL module, Google Pixel 5A handset
  - Additional devices will be tested and added in the future
    - Samsung Galaxy, Sierra Wireless modules
- Both over-the-cable (OTC) and over-the-air (OTA) connections
- Connection scenarios:
  - Within the 5G network
  - Between the 5G wireless network and the public internet
Introduction & Overview

• Detailed USRP and Host System configuration
  ○ Performance tuning settings, system parameters, configuration files, etc.
• Operation with multiple simultaneous UEs
• Operation on additional 3GPP bands
• Integrate and test different core network software:
  ○ Magma Core, Free5GC, Open5GS, ONF SD-Core
• 1x1 and 2x2 configurations for the gNB
• Data throughput results for various configurations
• Real-time DL and UL spectrum monitoring with USRP devices
• Application Note published on the Ettus Research Knowledge Base (KB)
  ○ Free & open-access
Example Reference System Configuration

• Initial system implementation:
  ○ Hardware:
    ■ USRP X410 for the gNB
    ■ Quectel RM500Q-GL 5G wireless modem module for the UE
      ● SIM cards from Open-Cells.com
    ■ Commercial Intel Core i7 and i9 CPU systems for the gNB, UE, CN host systems
  ○ Software:
    ■ Ubuntu 20.04.5
    ■ Linux kernel 5.15
    ■ UHD version 4.2.0.0
    ■ OAI version 2022.w33
    ■ Quectel firmware
Example Reference System Configuration

- 5G-NR Stand-Alone (SA) operation
- 40 MHz channel bandwidth
- 61.44 Msps USRP sampling rate
- 30 KHz SCS
- 64 QAM DL
- SISO (1x1)
- FR1 Band n78 (3.361 GHz)
- TDD Duplexing
Example Reference System Diagram

OAI Core Network
OS: Ubuntu 20.04
CPU: Intel Core i7-4770, 4 cores, 3.40 GHz
Generic Kernel: 5.15.0-50-generic
OAI CN Version: v1.3

OAI gNB (monolithic)
UHD: 4.2.0.0
OS: Ubuntu 20.04
Low-Latency Kernel: 5.4.0-128
CPU: Intel Core i9-10940X, 14 cores, 3.30 GHz
OAI gNB branch: 2022.w33

Public Internet

Quectel RM500Q-GL (COTS UE)
OS: Ubuntu 20.04
Low-Latency Kernel: 5.13.0-40-lowlatency
CPU: Intel Core i7-4790, 4 cores, 3.60 GHz
Quectel Firmware: RM500QGLABR11A06M4G

USRP X410
UHD 4.2.0.0

Ethernet
10 Gbps SFP+ Ethernet (x2)

RF Coax Cable

USB / M.2
Photos of the System
Photos of the System
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Photos of the System

Quectel Module UE
Photos of the System

Quectel Module UE
Photos of the System
Photos of the Quectel Module

- Pigtail MHF4-to-SMA RF Cables
- USB 3.0 / M.2 Carrier Board
- SIM Card Reader/Writer
- Quectel Module
Photos of the Quectel Module

Quectel Module

USB 3.0 / M.2 Carrier Board
Resources

• Application Note on the Ettus Research Knowledge Base (KB):
  ○ https://kb.ettus.com/

• Mailing Lists:
  ○ usrp-users
  ○ openair5g-nr
  ○ openair5g-user
  ○ https://kb.ettus.com/Mailing_Lists

• Email:
  ○ support@ettus.com