OpenAirInterface: An Open LTE Network in a PC

N. Nikaein, R. Knopp, F. Kaltenberger, L. Gauthier, C. Bonnet, D. Nussbaum, R. Ghaddab

EURECOM, Mobile Communication Department
Cellular systems are expected to converge from a proprietary and expensive HW/SW platforms towards an open SW platforms over commodity HW

- Happened already for cloud service
- Happened already for handsets
- Happened already for 2G

To foster the innovation in wireless world, there is a need for an open cellular ecosystem for 4G towards 5G
OpenAirInterface in a Nutshell

- Open-source (hardware and software) wireless technology platforms for deployment of mock network with high level of realism
  - Soft modem: SDR architecture and full GPP
  - System approach with high level of realism
  - Part of FIRE facility: remote access

- Current focus
  - 3GPP LTE (unicast and multicast), and a subset of LTE-A features
  - IEEE 802.11p and 802.21
  - LTE meshing extension and relay node
OpenAirInterface Objectives

- Open and integrated development environment under the control of the experimenters

- Flexibility to architect, instantiate, and configure the network components (at the edge, core, or cloud)

- Fully software-based network functions spanning all the layers

- Rapid prototyping of 3GPP compliant and non-compliant use-cases

- Instrumental in the development of the key 5G technologies
  - Examples: M2M/IoT, SDN, cloud- RAN and massive MIMO
OAI Wireless technology Platforms

- Link-level
- System-level

- EXMIMO 2
- USRP
- EMOS

- EXMIMO 1
- SoC Arch.

- C implementation under realtime Linux optimized for x86
- Rich R&D environment
  - Aeroflex-Geisler LEON/GRLIB,
  - RTAI/RE-PRREMPPT/LOW LATENCY Kernel
  - Linux and GNU
- Development and integration methodology
  - Tight interaction between the system emulation and soft modem
OpenAirInterface Software Architecture

**ExpressMIMO2 (LEON)**

**PCIexpress**

**Kernel Space**

**Linux network driver (nas_driver.ko)**

**Linux driver (openair_rf.ko)**

**User Space**

**Application**

**Control / Monitoring**

**Using real-time Linux extension (RTAI, Xenomai, RT-preemt)**

**Modem control and sync. (lte-softmodem)**

**Octave**

**OpenAir2/NAS/Driver/Mesh**

**OpenAir2/NAS/Driver/Lite**

**OpenAir2/NAS/Driver/Cellular**

**targets/ARCH/EXMIMO/Driver/eurecom**

**targets/ARCH/EXMIMO/USERSPACE/LIB**

**targets/ARCH/EXMIMO/USERSPACE/LIB**

**targets/ARCH/EXMIMO/USERSPACE/OCTAVE**

**targets/RTAI/USER**
OpenAirInterface Software platforms

- Supported tools
  - Configuration templates
  - Wireshark interface (L2 and above),
  - Protocol analyzer
  - Timing measurement and profiler
  - Soft Scope and performance monitoring
Supported Physical Layer features

- LTE release 8.6 compliant, with a subset of release 10;
- FDD and TDD configurations in 5, 10, and 20 MHz bandwidth;
- Transmission mode: 1 (SISO), and 2, 4, 5, and 6 (MIMO 2x2);
- CQI/PMI reporting;
- All DL channels are supported: PSS, SSS, PBCH, PCFICH, PHICH, PDCCH, PDSCH, PMCH;
- All UL channels are supported: PRACH, PUSCH, PUCCH, SRS, DRS;
- HARQ support (UL and DL);
- Highly optimized base band processing (including turbo decoder).
Supported Access Layer Features

- LTE release 8.6 compliant and a subset of release 10 features;
- Implements the MAC, RLC, PDCP and RRC layers
- Protocol service for Rel10 eMBMS (MCH, MCCH, MTCH)
- Priority-based MAC scheduler with dynamic MCS selection
- Fully reconfigurable protocol stack
- Integrity check and encryption using the AES algorithm
- Support of RRC measurement with measurement gap
- Standard S1AP and GTP-U interfaces to the Core Network
- IPv4 and IPv6 support
**Supported EPC Features**

- MME, SGW, PGW and HSS implementations.
- NAS integrity and encryption using the AES algorithm;
- UE procedures handling
  - attach, authentication, service access, radio bearer establishment;
- Transparent access to the IP network
  - Configurable access point name, IP range, DNS and E-RAB QoS;
- IPv4 and IPv6 support
Hardware Targets for Openair4G

- **ExpressMIMO2**
  - Designed and maintained by EURECOM
  - Used by many academia/industrial partners
  - 1.5/5/10/20 MHz, FDD/TDD (MIMO)

- **USRP B210**
  - Commercial Ettus/National Instruments board
  - Supported by OAI software platform

- **USRP X300**
  - Coming soon
OpenAirInterface Hardware Platforms

- RF RX (4 way)
- RF TX (4 way)
- PCIe (1 or 4 way)
- 4xLMS6002D RF ASICs: 250 MHz – 3.8 GHz
- GPIO for external RF control
- Spartan 6 LX150T
- 12V from ATX power supply
ExpressMIMO2 FPGA design architecture

- Use an AHB bus to interface a Leon3 processor with the other blocks (data transfer, memory management, ...)

![Diagram of ExpressMIMO2 FPGA design architecture]
Built-in System Emulator and Tools

Web Portal / Interface

- **Input:**
  - Description of application scenario
  - Initialization and configuration of all the blocks

- **Execution:**
  - PHY procedures, L2 protocols, traffic generator
  - PHY abstraction, channel model, and mobility model
  - Emulation medium: shared memory

- **Output:**
  - Execution logs
  - System/protocol operation
  - Key performance indicators: latency, jitter, throughput/goodput
DEMO SETUP
Demo Setup

- Usage of commodity hardware to run LTE network
- Reconfigurability, support of various use cases
- Flexibility in deployment
Various Network Experimentation setup

- OAI UE ↔ OAI eNB + OAI EPC
- OAI UE ↔ OAI eNB + Commercial EPC
- OAI UE ↔ Commercial eNB + OAI EPC
- OAI UE ↔ Commercial eNB + Commercial EPC
- Commercial UE ↔ Commercial eNB + OAI EPC
- Commercial UE ↔ OAI eNB + Commercial EPC
- Commercial UE ↔ OAI eNB + OAI EPC
Example use case

- Public safety networks
- Small cells
- Relay node
- Test/sniffer equipment
- Measurement Compiegne and field trials
- Network and/or application/service performance test
Research avenues

- 5G evolution path of OAI soft-modem supported by EU/industrial projects
  - Machine type communication and IoT
  - Cloudification of radio networks (RAN+EPC)
  - Massive MIMO, and COMP
  - Cognitive networking
  - Software-defined networking and network function virtualization support
  - Support of machine type communications
  - Mesh extension in support of multihop operation
  - Cooperative transmission and MAC
  - Caching strategy at the eNB or S/P-GW
  - Cooperative eMBMS, proximity networking
  - Scalable system experimentation and evaluation
  - RRM policies, handover logic and performance, MIMO performance, traffic scheduling policy
Conclusion

- OpenAirInterface
  - Suitably flexible platform for an open cellular ecosystem both for 4G experimentation as well as for 5G research
  - Open-source reference software implementation of 3GPP-compliant LTE system and a subset of LTE-A features
  - Real-time indoor/outdoor experimentation and demonstration

- Promote the development, distribution and adoption of the open-source hardware and software open cellular ecosystem
Contacts Information

- **URL:**
  - www.openairinterface.org
  - https://twiki.eurecom.fr/twiki/bin/view/OpenAirInterface

- **Partnership and collaboration:**
  - openair_admin@eurecom.fr

- **Technical Support:**
  - openair_tech@eurecom.fr

- **Developer support:**
  - openair4G-devel@eurecom.fr
  - To subscribe, send an email to majordomo@eurecom.fr with the content "subscribe openair4G-devel"