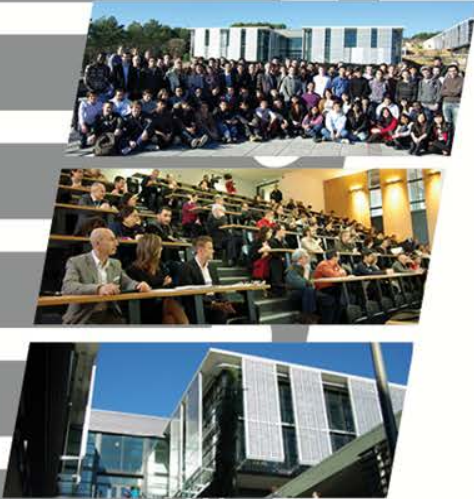# OpenAirInterface: An Open LTE Network in a PC

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

EURECOM, Mobile Communication Department

Toward Open 4G/5G Ecosystem

- **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
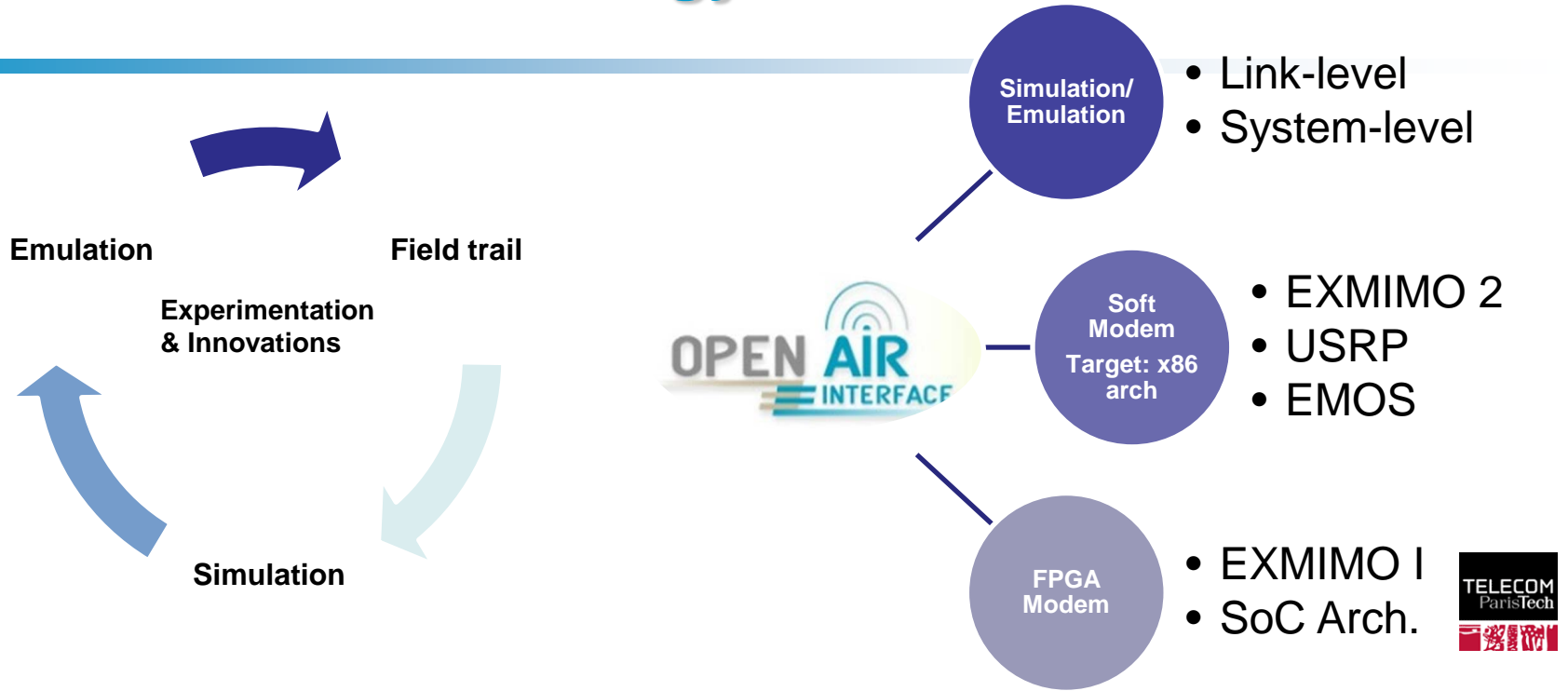 - Part of FIRE facility: remote access

- **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
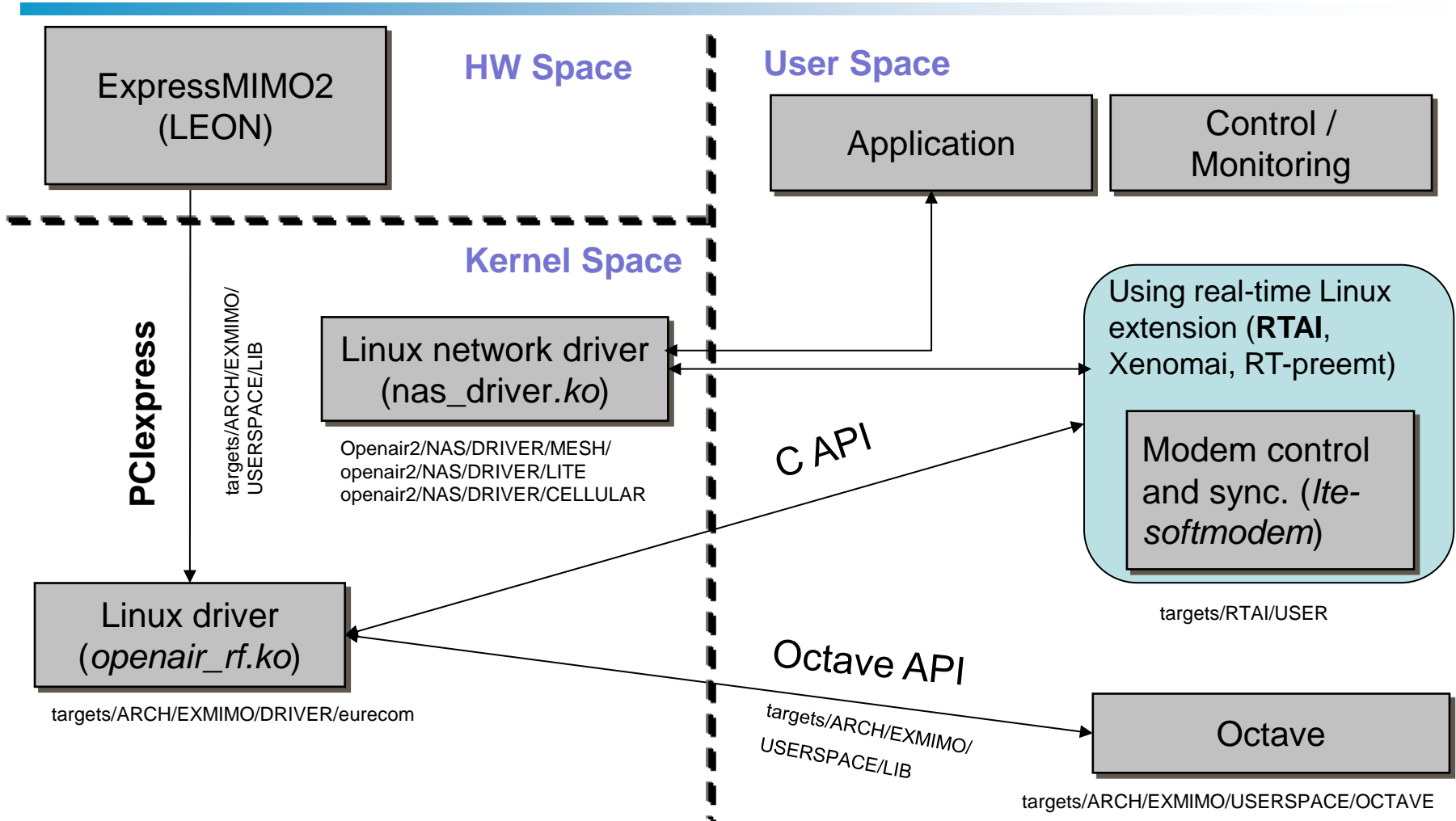
OpenAirInterface Objectives

- **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

OPEN AIR INTERFACE

EURECOM

OAI Wireless technology Platforms

Simulation/Emulation
- Link-level
- System-level

Soft Modem Target: x86 arch
- EXMIMO 2
- USRP
- EMOS

FPGA Modem
- EXMIMO I
- SoC Arch.

Emulation — Field trail — Experimentation & Innovations — Simulation

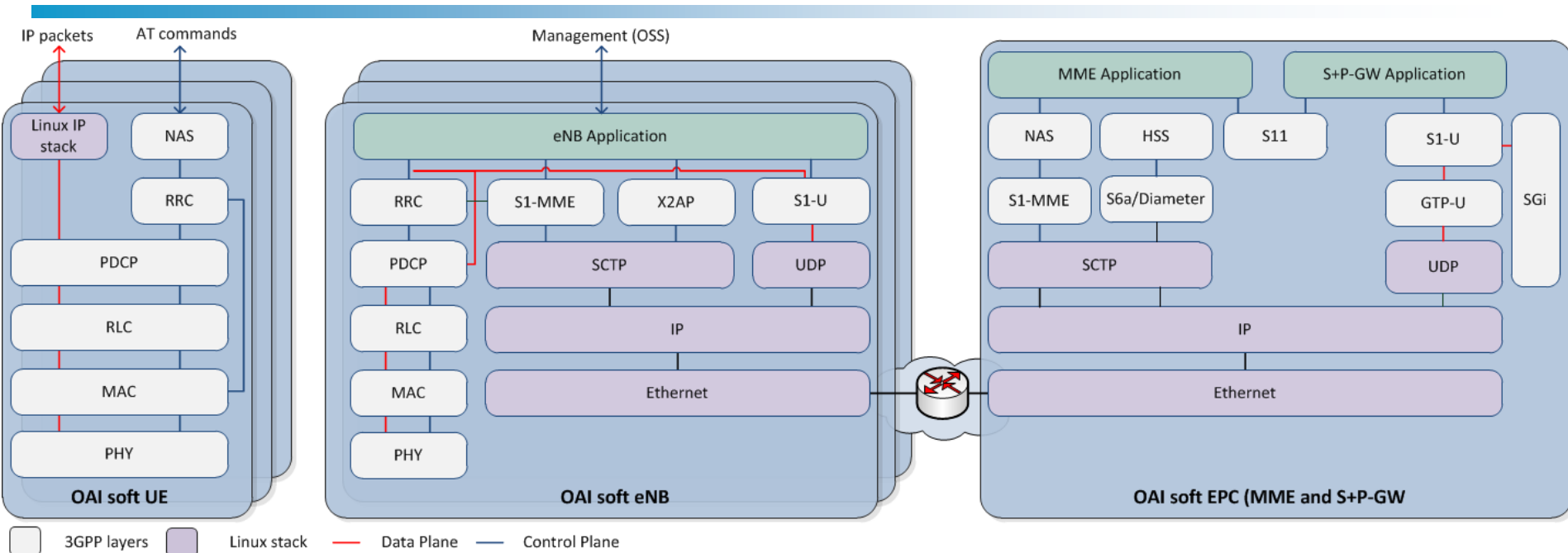OPEN AIR INTERFACE

TELECOM ParisTech

- **C implementation under realtime Linux optimized for x86**

- **Rich R&D environment**
  - ➢ Aeroflex-Geisler LEON/GRLIB,
  - ➢ RTAI/RE-PRREMPT/LOW LATENCY Kernel
  - ➢ Linux and GNU

- **Development and integration methodology**
  - ➢ Tight interaction between the system emulation and soft modem

Openairinterface Software Architecture

HW Space

User Space

ExpressMIMO2
(LEON)

Application

Control /
Monitoring

Kernel Space

PCIexpress

targets/ARCH/EXMIMO/
USERSPACE/LIB

Linux network driver
(nas_driver.*ko*)

Openair2/NAS/DRIVER/MESH/
openair2/NAS/DRIVER/LITE
openair2/NAS/DRIVER/CELLULAR

C API

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

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

targets/RTAI/USER

Linux driver
(*openair_rf.ko*)

targets/ARCH/EXMIMO/DRIVER/eurecom

Octave API

targets/ARCH/EXMIMO/
USERSPACE/LIB

Octave

targets/ARCH/EXMIMO/USERSPACE/OCTAVE

OPEN AIR
INTERFACE

EURECOM

OpenAirInterface Software platforms

- **Supported tools**
  - ➢ Configuration templates
  - ➢ Wireshark interface (L2 and above),
  - ➢ Pprotocol 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**

OPEN AIR INTERFACE

EURECOM

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
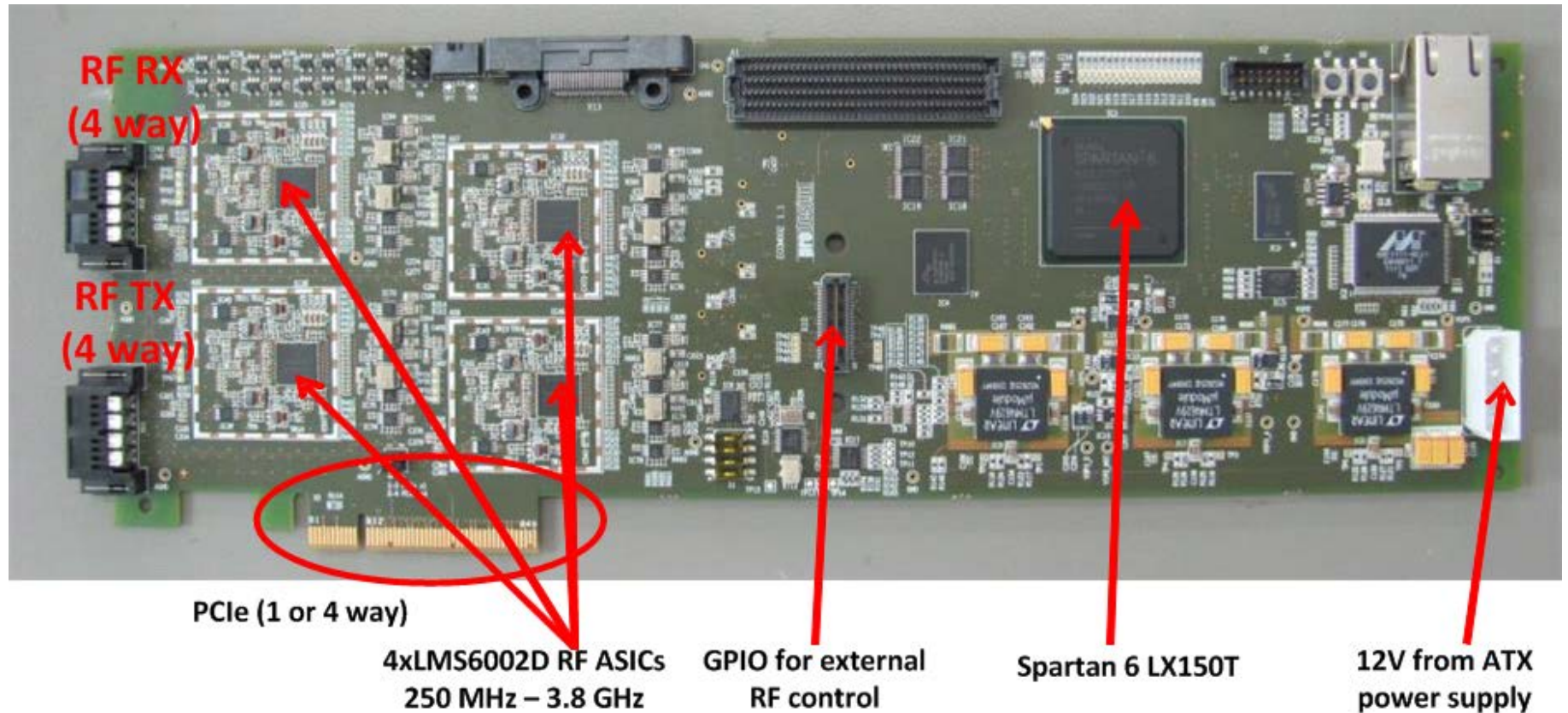 - Supported by OAI software platform

- **USRP X300**
  - Coming soon

EURECOM

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

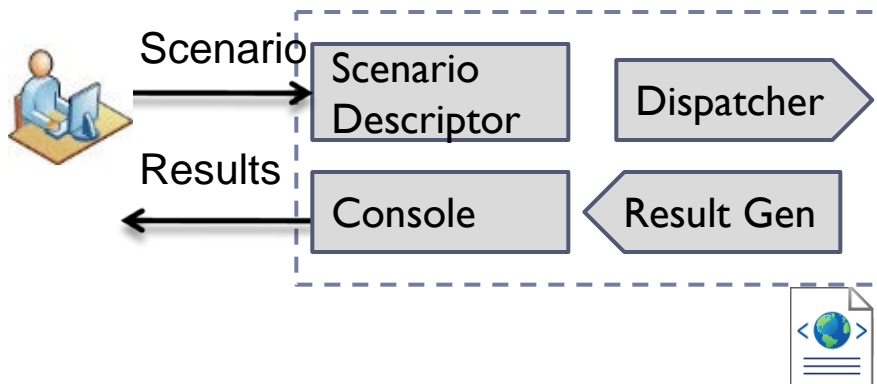**12V from ATX power supply**

OPEN AIR INTERFACE

EURECOM

ExpressMIMO2 FPGA design architecture

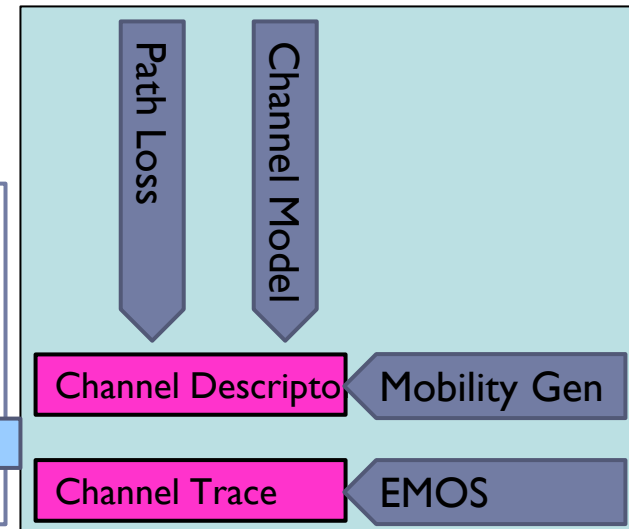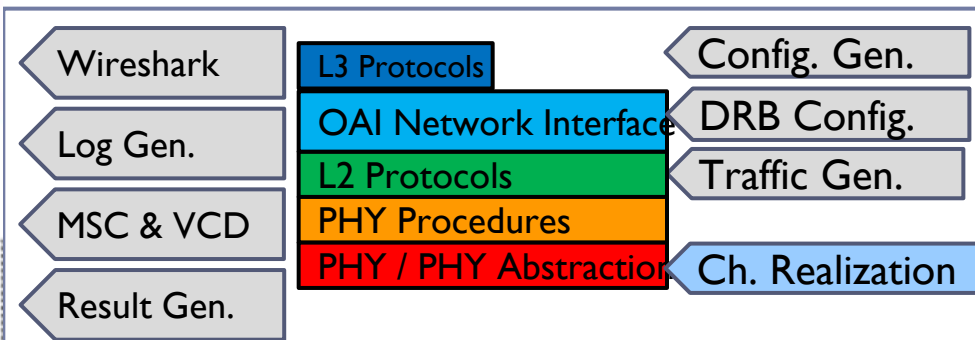- **Use an AHB bus to interface a Leon3 processor with the other blocks (data transfer, memory management, …)**
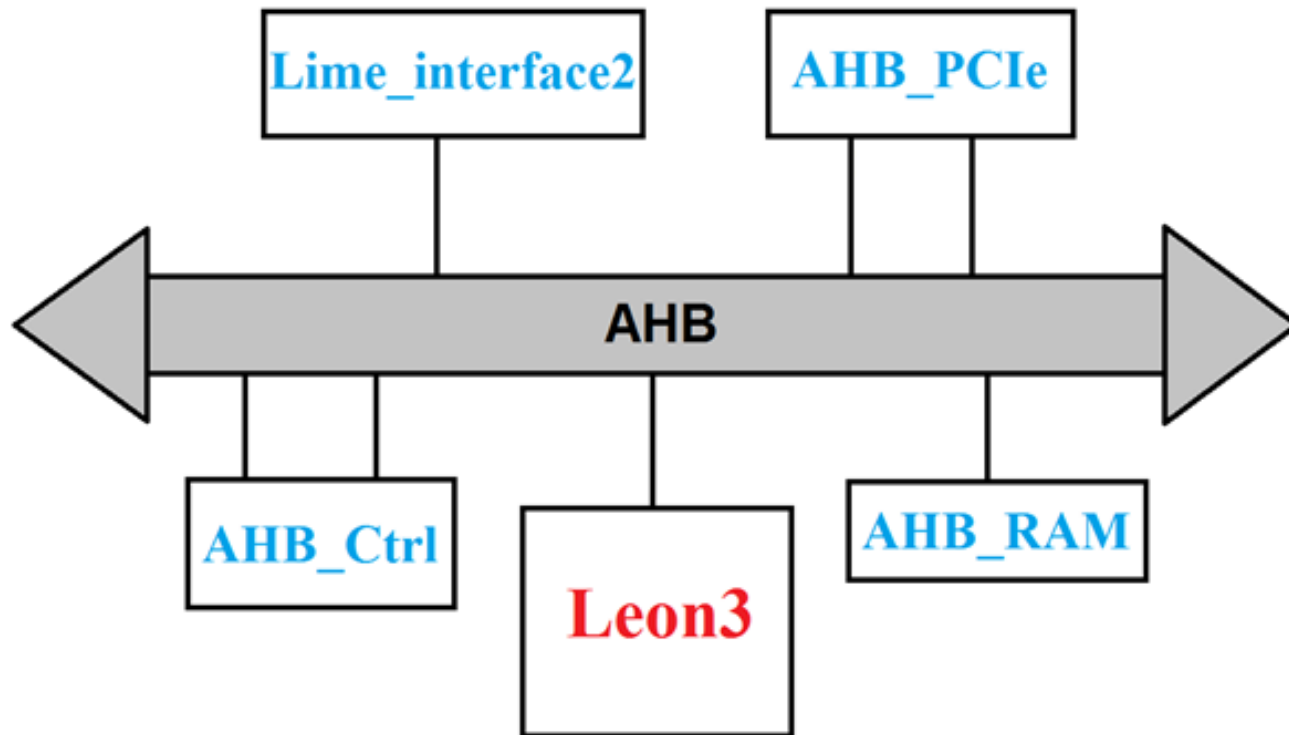
Built-in System Emulator and Tools

Web Portal / Interface

Scenario

Scenario Descriptor

Dispatcher

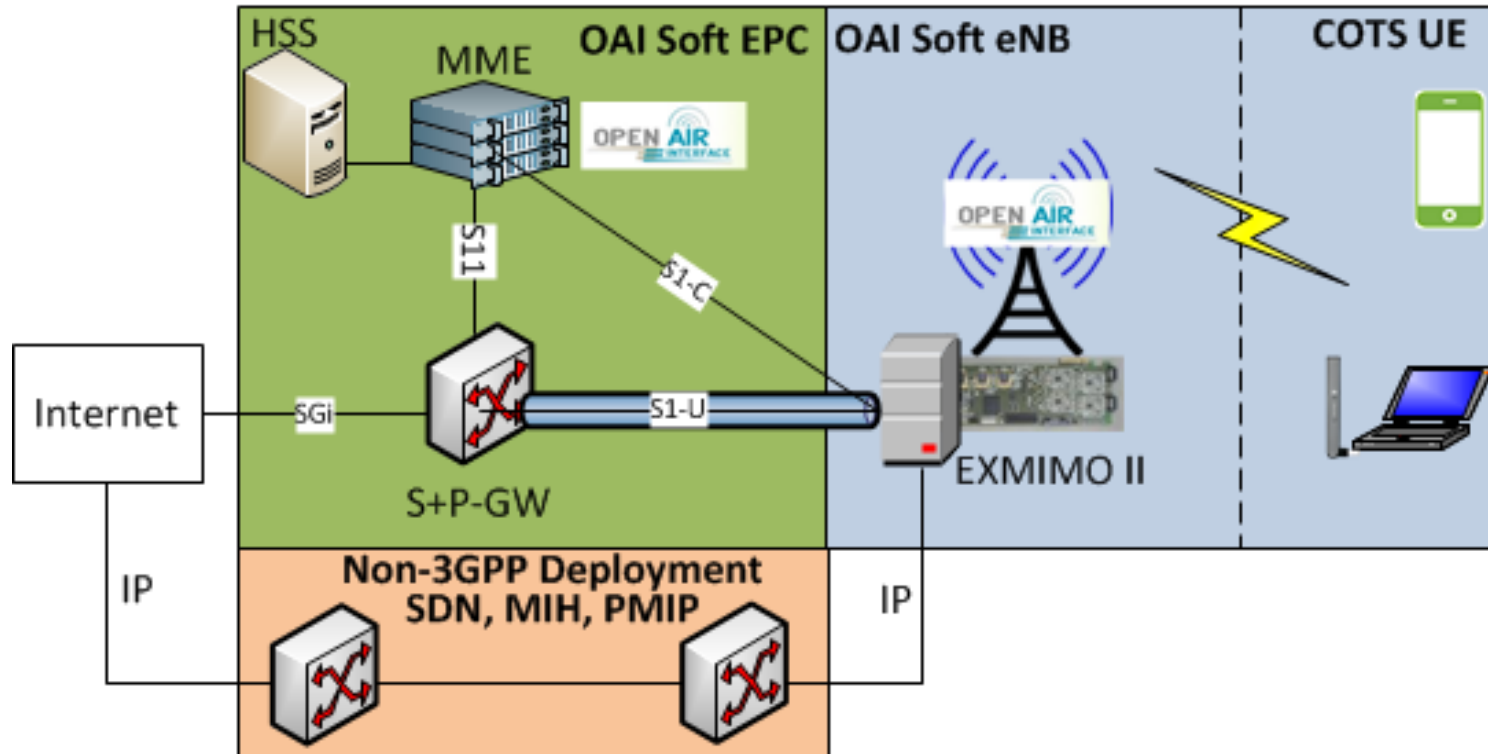Results

Console

Result Gen

- **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

Application | Traffic Gen

Wireshark | L3 Protocols | Config. Gen.
Log Gen. | OAI Network Interface | DRB Config.
L2 Protocols | Traffic Gen.
MSC & VCD | PHY Procedures
PHY / PHY Abstraction | Ch. Realization
Result Gen.

Path Loss | Channel Model

Channel Descriptor | Mobility Gen

Channel Trace | EMOS

OPEN AIR INTERFACE

EURECOM

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**

OPEN AIR INTERFACE

EURECOM

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**

OPEN AIR INTERFACE

EURECOM

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

OPEN AIR INTERFACE

EURECOM

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 opensource 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 and email to majordomo@eurecom.fr with the content "subscribe openair4G-devel"

EURECOM MEMBERS