OpenAirInterface and Agile Spectrum Access

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Abstract— **This demonstration[1] highlights the capabilities of the OpenAirInterface platform in terms of Agile RF spectrum-access and rapidly-deployable networking technologies. With respect to application scenarios, the latter target broadband public-safety communications. We demonstrate the real-time baseband and RF capabilities of the platform components as well as the methodologies used for large-scale system emulation on PC-based computing platforms.**

Keywords—Broadband communication platforms, Agile radio-frequency architectures, scalable emulation methodologies.

I. OVERVIEW

OpenAirInterface provides open-source hardware and software solutions for experimental radio network experimentation. The activity makes use of broadband and spectrally agile hardware platforms, in addition to high-performance emulation software for generic PC computers. Earlier reports on the air-interface development platform can be found in [1] and of the emulation platform in [2].

The software-based platform currently aligns its air-interface development with the evolving LTE standard but provides extensions for mesh networking, particularly in the MAC and Layer 3 protocol stack, in addition to Layer 1 extensions for distributed network synchronization. It can be can be seen as a mock standard for experimenting with real-time radio resources which retains the salient features of a real radio system, without all the required mechanisms for large-scale network deployment. Networking with tens of nodes using two-way real-time communication in both cellular and mesh topologies has been demonstrated in the context of several collaborative projects. The aim is to study practical aspects in modern radio systems such as distributed/cooperative processing, distributed synchronization, interference coordination and cancelation, spectrum aggregation. OpenAirInterface features an open-source software modem written in C comprising physical and link layer functionalities for cellular and mesh network topologies. This software modem can be used either for extensive computer simulations using different channel models or it can be used for real-time operation with the available hardware. In the latter case, it is run under the control of the real-time application interface (RTAI) which is an extension of the Linux operating system.

The purpose of this demonstration is twofold. Firstly, it will highlight the newest hardware platforms offered by OpenAirInterface comprising the ExpressMIMO baseband engine which can manage up to 4 40-MHz radio channels, and the AgileRF RF front-end used for synthesizing and processing 20MHz channels from 150 MHz to 8 GHz. To avoid regulatory issues, demonstration in the context of DYSPAN 2011 will be limited to 15dBm transmission in ISM bands (433.9 MHz, 2.45 GHz and 5.8 GHz) and multi-band RF sensing. A key aspect will be to show the capacity of the hardware to occupy spectral holes in ISM bands and perform sparse spectrum aggregation. This demonstration was developed and implemented as part of the the European FP7 collaborative project SENDORA (sensor network for dynamic and cognitive radio access) [3]. At least three fully functional radio nodes with dual-band TDD operation will be showcased.

The second aspect of the demonstration aims to highlight OpenAirInterface's performance evaluation methodology allowing for scalable emulated real-time deployment of radio networks on generic PC-based computers. The methodology makes use of a combination of a full access-layer protocol stack used for rapidly-deployable public-safety networks with physical-layer abstraction methods providing computationally-efficient performance evaluation with real applications and traffic sources.

The rest of the paper is organized as follows. In Section II we will describe the demonstration architecture. Section III provides some detail regarding the hardware that is proposed for demonstration.

II. DEMONSTRATION ARCHITECTURE DESCRIPTION

Two real-time system demonstration scenarios and associated trials have been defined. The first system demonstration scenario shall demonstrate a secondary network providing the users with a cognitive nomadic broadband access using a sensor network (SN) aided cognitive radio (CR) technology based on an independent SN. The secondary network shall receive transmission opportunities from the Fusion Centre (FC) and adapt its communications to take advantage of these opportunities. The objective is to take advantage of unused spectrum in an optimized way, in order to propose to the secondary users (SUs) a broadband access on a best

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[1] This work was supported by the European projects: SACRA (spectrum and energy efficiency through multi-band cognitive radio), ACROPOLIS (advanced coexistence technologies for radio optimization and unlicensed spectrum), and CROWN (cognitive radio oriented wireless networks).

effort basis. The FC is able to provide such information by computing sensing information provided by a dedicated SN. This SN is made of sensor nodes with detection and transmission capabilities.

The primary system is a WiFi system and WiFi communications are considered as primary user (PU) communications. A SN is deployed in the area to detect the spectrum usage in the corresponding frequency band. Three sensor nodes have detection capability and communicate their detection results through a wired connection to a FC entity that aggregates the information coming from the different sensors and proposes an interface with global spectrum monitoring. A secondary network (BS + SUs), deployed in the area, takes advantage from this interface provided by the FC entity to perform communications in an opportunistic manner. If PU transmissions are detected by the SN in the corresponding band, the FC shall receive the information and forward it to the Secondary Network. The secondary nodes shall adapt their transmissions to avoid harmful interferences generated to the PU.

The second system demonstration scenario shall demonstrate a secondary network providing the users with a cognitive nomadic broadband access using a WSN aided CR technology. In this scenario, the secondary network integrates the wireless SN: secondary communicating nodes have sensing capabilities, they perform the spectrum sensing in a distributed manner, compute transmission opportunities and adapt their communications to take advantage of these opportunities without interfering harmfully with the primary technologies.

III. HARDWARE DESCRIPTION

Hardware development efforts for setting the proposed demonstrator were mainly focusing on adapting EURECOM platform for the implementation of WSN aided CR concept. EURECOM hardware platform is composed of AgileRF and ExpressMIMO cards described in the following sections.

A. *AgileRF Radio Subsystem*

AgileRF is an RF front-end prototype for broadband radio-access. An example configuration is shown in Fig. 1 consisting of a single TDD transceiver operating over the 150MHz-8GHz frequency range. The AgileRF boards comprise the following subsystems:

1) RX: This is a generic broadband receiver board (200MHz-8GHz, 20MHz channels), Quadrature (I/Q) output.
2) TX: This is a generic quadrature transmitter board operating in the frequency range of 200MHz-8GHz.
3) Synth 1: 8.2GHz local oscillator (used for systems below 4GHz, e.g. DAB/DMB, LTE/GSM/WCDMA/HSPA).
4) Synth 2: 4-8GHz local oscillator.

The receiver is comprised of a broadband LNA followed by a band-selection filter network. A direct conversion quadrature mixer is used for inputs in the range 4-8GHz. An additional upconverter to 4-8GHz is used for input signals in the 150MHz-4GHz range. The band-selection filters and RF gain levels are controllable via a digital interface (controlled here by ExpressMIMO). Baseband outputs are provided via differential quadrature (I/Q) signals from the baseband engine. The baseband section has maximal baseband channel bandwidth of 20MHz and a sharp DC block for RF carrier leakage removal. Baseband amplifiers provide 60dB of gain, which when combined with variable RF attenuators allow for 70dB of gain control.

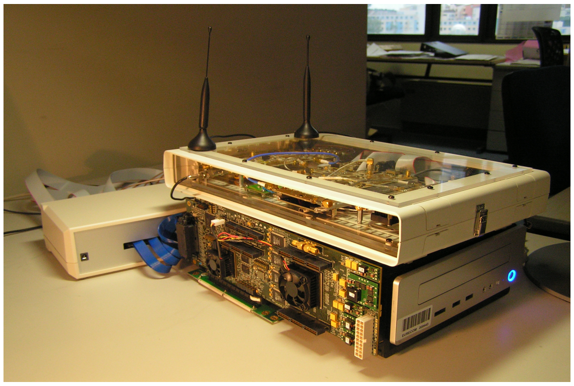

Fig. 1. AgileRF Prototype and ExpressMIMO Baseband Engine.

The transmitter has maximal baseband channel bandwidth of 20MHz. Baseband inputs are provided via differential quadrature (I/Q) signals from the baseband engine. Band-selection filters are provided to guarantee image-free outputs in all target bands. The bands are, DC-200MHz, 200-400MHz. 400-600MHz, 600-1000MHz, 1-2GHz, 2-3GHz, 3-5GHz, 5-8GHz.

B. *ExpressMIMO Baseband Engine*

ExpressMIMO is an 8-way signal processing engine comprising one Xilinx Virtex 5 LX110T embedded system (8x PCIexpress, 1Gbit/s Ethernet, SystemACE Flash, 128kByte DDR memory, LVDS expansion) and one Xilinx Virtex 5 LX330 computational engine (2Gbyte 64-bit DDR2 memory 4 AD9862 Mixed Signal Front-Ends, 1 AD9510 Precision PLL + VCO programmable clock source, Custom RF interface). It is powered by a standard 430W PC ATX power supply.

Air interface applications are based on a software-radio description in C-language running on the ExpressMIMO embedded system and the host PC. Example C-language implementations currently being integrated on ExpressMIMO include wideband RF sensing, 802.11a/g/p PHY and release 8 3GPP/LTE. The demonstration will make use of an adapted LTE-PHY for rapidly-deployable networks and wideband RF sensing functionality in support of sparse spectrum aggregation.

REFERENCES

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