Project CREaTION - Workshop Program

Cognitive Radio Transceiver Design for Energy Efficient Data Transmission (2013-2016)
Sala do Senado da Reitoria da Universidade de Aveiro
5 of February 2016

10h00 – Opening Session

10h10 – Project Research Outcomes

- **10h10** – Prof. João Canas Ferreira, Inesc-Tec and FEUP Universidade do Porto
- **10h30** – Prof. Fernando J. Velez, "Research on Carrier Aggregation in LTE-Advanced in IT-Covilhã," IT Covilhã and Universidade da Beira Interior
- **10h50** – Prof. José Vieira, IEETA and Universidade de Aveiro
- **11h10** – Prof. Nuno Borges de Carvalho, IT Aveiro and Universidade de Aveiro

11h30 – Prof. Roberto Gomez-Garcia, "Recent Advances on Multi-Functional RF/Microwave Passive Components with Static and Reconfigurable Single/Multi-Band Operation", University of Alcala, Madrid, Spain.

12h30 – Lunch at the Aveiro University restaurant

14h30 – Prof. Markku Renfors, "Filter Banks for Flexible Communication Waveforms, Spectrum Sensing , and Software Defined Radio", Tampere University of Technology (TUT), Tampere, Finland.

15h30 – Poster and demonstration session

Several posters and demonstrators of the research performed during the project CREaTION will be shown.

17h00 – Round table "The future of Cognitive Radio"

In this round table is open to the public participation and the following researchers: Prof. Nuno Borges de Carvalho, Prof. José Vieira,Prof. Fernando Velez, Prof. João Canas, Prof. Arnaldo Oliveira.

17h30 – Closing Session

Workshop CREaTION details

Talk 1 – 11h30

Title: “Recent Advances on Multi-Functional RF/Microwave Passive Components with Static and Reconfigurable Single/Multi-Band Operation”

Speaker: Prof Roberto Gomez-Garcia.

Affiliation: University of Alcala, Madrid, Spain

Abstract: The purpose of this talk is to present recent research findings in the field of multi-functional RF/microwave passive components. Specifically, power-distribution and impedance-transformation planar networks with added bandpass filtering capability, as well as filters that integrate several filtering functionalities (e.g., bandpass filtering and dynamic notch filtering for in-band interference mitigation) are reviewed. Two different design philosophies are expounded for the realization of these dual-function devices: i) the embedding of transversal signal-interference filtering sections to incorporate high-selectivity single/multi-band bandpass filtering capabilities for frequency-static applications, and ii) the inclusion of fully-adaptive single/multi-band quasi-bandpass filtering stages for frequency-adaptive systems. The theoretical and design foundations of these approaches, as well as their comparison with their conventional counterparts based on simple cascades of mono-function blocks, are described. Moreover, the experimental results of several microstrip proof-of-concept prototypes will be shown as practical verification of the engineered multi-functional components.

Short Bio: Roberto Gómez-García received theTelecommunication Engineer and Ph.D. degrees from the Polytechnic University of Madrid, Madrid, Spain, in 2001 and 2006, respectively. Since April 2006, he has been an Associate Professor with the Department of Signal Theory and Communications, University of Alcalá, Alcalá de Henares, Madrid, Spain. He has been for several research stays in the C2S2 Department of the XLIM Research Institute (formerly IRCOM), University of Limoges, France, Telecommunications Institute of the University of Aveiro, Portugal, the U. S. Naval Research Laboratory (NRL), Microwave Technology Branch, Washington, DC, USA, and Purdue University, West Lafayette, IN, USA. His current research interests include the design of fixed/tunable high-frequency filters and multiplexers in planar, hybrid and MMIC technologies, multi-function circuits and systems, and software-defined radio and radar architectures for telecommunications, remote sensing, and biomedical applications. Dr. Gómez-García is an Associate Editor for the IEEE TRANSACTIONS OF MICROWAVE THEORY AND TECHNIQUES, IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS I: REGULAR PAPERS, and IET Microwaves, Antennas and Propagation.

Talk 2 – 14h30

Title: Filter Banks for Flexible Communication Waveforms, Spectrum Sensing , and Software Defined Radio

Speaker: Prof. Markku Renfors

Affiliation: Tampere University of Technology (TUT), Tampere, Finland.

Abstract: This presentation focuses on the use of multirate filter banks for generating spectrally well-contained and flexible waveforms for challenging communication scenarios, like cognitive radio. Also the application of filter banks for wideband multichannel, multimode spectrum sensing will be discussed. Special emphasis on a filter bank implementation scheme which is based on fast-convolution (FC) processing. The basic idea of fast convolution is that a high-order filter can be implemented effectively through multiplication of sequences in frequency domain, after taking DFT's of the input sequence and the filter impulse response. Eventually, the time domain output is obtained by IDFT. The application of FC to multirate filters is rather well known in the literature and FC implementations of channelization filters for wireless communication systems have been considered in a few papers. The idea of FC-implementation of nearly perfect-reconstruction filter bank systems, with applications in filter bank multicarrier waveforms, has been introduced only recently. This fast-convolution filter bank (FC-FB) idea appears competitive in terms of computational complexity when compared to the polyphase and other traditional implementation structures of uniform filter banks. Furthermore, FC-FB offers increased degree of flexibility to support simultaneous processing of different or differently parameterized single-carrier and multicarrier communication waveforms, both for communication and spectrum sensing purposes.

Biography: Markku Renfors received M.Sc. and Dr. Tech. degrees from Tampere University of Technology (TUT), Tampere, Finland, in 1978 and 1982, respectively. Since 1992, he has been a Professor with the Department of Electronics and Communications Engineering, TUT, where he was Department Head from 1992 to 2010. Dr. Renfors is a Fellow of IEEE and recipient of the 1987 IEEE Circuits and Systems Society's Guillemin-Cauer Award (together with Tapio Saramäki). He has authored 70 papers in refereed journals, 300+ papers in conferences with review practice, and two patents. He has supervised 16 doctoral dissertations. Dr. Renfors was an Associate Editor of IEEE Signal Processing Letters in 2006-2010. Currently he is a Senior Area Editor of IEEE Transactions on Signal processing and a member of the Editorial Board of EURASIP Signal Processing journal. His research interests include multirate filtering and filter banks, especially with applications in advanced multicarrier and single-carrier waveforms, software defined radio, and algorithms for flexible communications receivers and transmitters. He has actively participated in the EU FP7 projects PHYDYAS and EMPhAtiC developing FBMC techniques especially for cognitive radio and heterogeneous fragmented spectrum use scenarios. His research interests include also digitally enhanced radio techniques

targeting at using advanced DSP techniques for mitigating the effects of analog imperfections in communications receiver and transmitter implementations.

Posters

Poster 1

Title: Reconfigurable FPGA-Based FFT Processor for Cognitive Radio Applications

Presenters: Mário Lopes Ferreira, Amin Barahimi, João Canas Ferreira

Affiliation: INESC TEC and FEUP.

Abstract: Cognitive Radios (CR) are viewed as a solution for spectrum utilization and management in next generation wireless networks. In order to adapt themselves to the actual communications environment, CR devices require highly flexible baseband processing engines. One of the most relevant operations involved in radio baseband processing is the FFT. This work presents a reconfigurable FFT processor supporting FFT sizes and throughputs required by the most used wireless communication standards. By employing Dynamic Partial Reconfiguration (DPR), the implemented design can adapt the FFT size at run-time and specialize its operation to the immediate communication demands. This translates to hardware savings, enhanced resource usage efficiency and possible power savings. The results obtained for reconfiguration times suggest that DPR techniques are a viable option for designing flexible and adaptable baseband processing components for CR devices.

Poster 2 + Demonstration

Title: FPGA-Based RFID Reader Architectures

Presenters: João Borges dos Santos, André Prata, Arnaldo S. R. Oliveira, Nuno Borges de Carvalho

Affiliation: Instituto de Telecomunicações - Aveiro

Abstract: Functional RFID Readers based on FPGA technology

Poster 3

Title: Passive Wireless Sensor Network using Backscatter with WPT

Presenters: Ricardo Correia, Nuno Borges Carvalho

Affiliation: Instituto de Telecomunicações - Aveiro

Abstract: We propose a system that combines a backscatter system and a WPT system for two different frequencies. Our goal is to modulate the signal emitted by the reader at one frequency and simultaneously harvest energy at the other frequency.

Poster 4

Title: Channel utilization analysis based on EM algorithm for 5G Spectrum Management

Presenters: Daniel Malafaia, José Vieira, Ana Tomé

Affiliation: IEETA

Abstract: We address a novel method, based on the expectation maximization algorithm, that allows the estimation of several parameters like the number of

active users in a given frequency band, the power received from each user, the occupied time slots and the front-end noise floor. The method takes advantage of the behavior from a signal under an estimator, which allows to model the analyzed data from users and system noise floor as a Gaussian mixture. The number of different Gaussian distributions allows us to determine the number of users in the channel, as well as associate the occupation to a given user. The lowest mean Gaussian give us an estimation for the noise floor.

Poster 5

Title: Software Defined Radio based Bio-Radar for remote heartbeat and breathing detection

Presenters: Daniel Malafaia, José Vieira, Ana Tomé

Affiliation: IEETA

Abstract: We present a continuous wave radar created using a software defined radio platform that uses Doppler effect to measure the heart-rate and breathing. We demonstrate that the bio-radar can indeed detect the breathing pattern and can follow the data acquired by validated research equipment. Also it's proven that the heartbeat frequency is present and can be extracted when the patient is at rest.

Poster 6 + Demonstration

Title: Passive-backscatter radio systems

Presenters: Alírio Boaventura, Nuno Borges Carvalho

Affiliation: Instituto de Telecomunicações - Aveiro

Abstract: RFID reader based on software defined radio and remote control system without batteries.

Poster 7 + Demonstration

Title: SDR-based RFID Reader

Presenters: João Santos, André Prata, Rui Fiel Cordeiro, Arnaldo S. R. Oliveira, Nuno Borges de Carvalho

Affiliation: Instituto de Telecomunicações - Aveiro

Abstract: Flexible multiband/multiprotocol RFID reader.

Poster 8 + Demonstration

Title: SDR-based LTE Small Cell

Presenters: Jorge Santos, Rui Fiel Cordeiro, André Prata, Daniel Costa Dinis, Daniel Belo, Arnaldo S. R. Oliveira, Nuno Borges de Carvalho, José Neto Vieira

Affiliation: Instituto de Telecomunicações - Aveiro

Abstract: Digital implementation of an LTE small cell based on an FPGA architecture.

Poster 9 + Demonstration

Title: Usage of electrical coupling for wirelessly transferring power across non-negligible distances

Presenters: Ricardo Fernandes

Affiliation: Instituto de Telecomunicações - Aveiro

Abstract: The purpose of this demo is to demonstrate the wireless transfer of power based on resonant electrical coupling. A sine wave produced by a signal generator (or equivalent) is sent to a transmitter device. Power is wirelessly transferred from that transmitter to a receiver (physically identical to the transmitter), as shown in the first figure. An RF-to-DC converter is connected to the receiver. At the end of the converter is an LED that glows more or less depending on the received power. The efficiency of the power transfer is maximized when the frequency of the signal generator matches the resonant frequency of the two devices.

Poster 10

Title: Coverage, Co-channel Interference and System Capacity Trade-off in Future LTE-Advanced Networks Operating in the Millimetre Wavebands

Presenters: Fernando J. Velez, Emanuel Teixeira, Fardin Derogarian

Affiliation: Instituto de Telecomunicações - Lisboa

Abstract: Millimetre Wavebands are able to provide high bit/data rates for short range applications, including micro/pico/femtocellular communications and Very High Throughput Wireless Sensor Networks. In real mobile environments, wireless/cellular connections are simultaneously affected by noise and co-channel interference. Also in cell planning and optimization process values of the of carrier-to-noise-plus-interference rate for mobile communications are utmost importance. In order to study the contribution of these factors some comparisons have been made of the equivalent supported throughput between different frequency bands, for different values of the reuse pattern, assuming the use of LTE/LTE-Advanced. Cell coverage and propagation models have been implemented while analysing the influence of oxygen and rain attenuation in path loss, at 60 GHz, as well a detailed study was made of carrier-to-noise-plus-interference ratio. From the comparison we have concluded that, although coverage is more demanding at 60 GHz (shorter range), the lower values of the interference justify higher bit rates at lower values for the reuse factor. Oxygen attenuation at 60 GHz band facilitates the reduction of interference between channels of neighbouring cells.

Poster 11

Title: Practical Implementation of Energy Efficient MAC Protocols with Cognitive Radio Capabilities for WSNs

Presenters: Fardin Derogarian, Fernando J. Velez and João Canas Ferreira

Affiliation: Instituto de Telecomunicações - Lisboa

Abstract: The continuous increase in the number of wireless devices, causes to more use of the radio spectrum and thus increase the problems due to large numbers of users. Now a days, almost in all areas, wireless sensors are applicable. Such a wide use, requires special attention in the allocation of shared radio channels. Most of WSN have designed to work in ISM band. These free license bands are utilized by many other applications such as Wi-Fi, Bluetooth. On the other hand, parts of the radio spectrum have been allocated for specific applications such as cellular mobile communication. But it should be noted that they have not always occupied that it leads to the possibly of using free times of licensed radio spectrum for other uses such as WSN. Cognitive radio is one of the techniques that it can be used for opportunistic spectrum access. A MAC protocol plays major role in monitoring the activities of primary users of a licensed band and allocating the radio spectrum for the secondary users. A large number of MAC protocols for WSN have been designed for a variety of applications. In this report, implementation of energy efficient WSN MACs in TinyOS with considering cognitive operation is presented. The idea is evaluation of MAC protocols performance to access to radio spectrum in the presence of primary users. As a cognitive radio communication scenario, two primary users communicate each other and randomly exchange messages. Secondary users monitor the activity of the primary users. They start to communicate whenever primary users are not active. One of the secondary users is connected to the computer via USB to send collected information about the communication.

Poster 12

Title: Basic Limits for Radio and Heterogeneous Network Optimization in LTE-Advanced with Carrier Aggregation

Presenters: Fernando J. Velez, and Sofia Sousa

Affiliation: Instituto de Telecomunicações - Lisboa

Abstract: In cellular optimization, the UL and DL the values from carrier-to-noise-plus-interference ratio (CNIR) from/at the mobile station are very important parameters. From a detailed analysis of its variation with the coverage and reuse distances for different values of the Channel Quality Indicator (CQI) and given ITU-R propagation models, an evaluation of the possible range for the reuse factor, r_{cc}, of LTE-A is performed for the DL. By considering CQI and reference CNIR requirements recommended by 3GPP, DL peak bit rates along with the Transport Block Size assumed for single stream and bandwidths of 10 and 20 MHz, PHY and supported throughputs are analysed. HetNets with Carrier Aggregation (CA) are considered, where macro cells operating at 800 MHz provide coverage and small cells (SCs) operating at 2.6 GHz provide throughput enhancement at hotspots. A clear decrease of the supported throughput for the highest coverage distances in NLoS propagation conditions is shown. Besides, owing to existence of a breakpoint

distance, d_{BP}, in the two slope model for LoS propagation, with SCs, a maximum occurs for system capacity for coverage distances, R, in the range between d_{BP}/r_{cc} and d_{BP}.

Poster 13 + Demonstration

Title: WBANs with Radio Frequency Energy Harvesting

Presenters: Fernando J. Velez, Emanuel Teixeira, Fardin Derogarian

Affiliation: Instituto de Telecomunicações - Lisboa

Abstract: Research on WBANs with RF Energy Harvesting includes the creation of a multi-band radio frequency EH system with super-capacitor storing and wearable antenna, for self-sustainable CR networks within health monitoring applications. Together with EH, wearable flex and piezoelectric sensor belts aims at monitoring foetal movement in the last four weeks of pregnancy. In addition, a 4G communication network employing carrier aggregation (CA) allows for the delivery of the collected data to the remote health professional.