BESTCOM meeting

KU Leuven, October 16, 2015

Venue: KU Leuven Faculty Club
Groot Begijnhof 14
B-3000 Leuven

Program

- 09h00-09h15: Welcome coffee

- 09h15-09h30: Opening by L. Vandendorpe (BESTCOM coordinator)

- 09h30-10h00: Oral presentation 1

Title: Multiobjective Game Theory for Signal Processing in Wireless Communications: Tradeoffs, Scalarisation and Distributed Algorithms

Author: I. Stupia (UCL), Luc Vandendorpe (UCL)

Abstract: The ambitious goals targeted for 5G networks changed radically the traditional view of wireless communication systems that are merely designed to support high data rates. In particular, the need of cellular networks supporting large populations of autonomous and self-adaptive communicating devices is delineating a new playing field in which paradigms like *multicriterion design* and *decentralisation of the decision making processes* are of paramount importance. In this perspective, the natural mathematical tool to analyse and solve optimisation problems with multiple conflicting objectives in wireless networks equipped with a common knowledge signaling system, is the multiobjective optimisation (MOO) framework. In contrast, decentralisation of decision making processes in communication systems usually relies on the analysis of strategic interactions between competing agents, which has its foundation in game theory. It is worth mentioning that MOO and game theory are often considered two distinct and mutually exclusive approaches. The main reason behind this established conviction is that in game theory each competing player focuses on the maximisation of his/her own objective, while MOO aims (in principle) at maximising all the objectives simultaneously. The mathematical modelling tool named multiobjective game theory (MOGT) lies across this dividing line, making possible the definition of solution concepts for noncooperative games in which the agents' payoffs are vector functions.

In the field of wireless communications, one possible application of the MOGT is the study of multipoint-to-multipoint networks in which each transmit and receiver pair (TRP) aims to simultaneously optimise multiple objective functions by dynamically adapting its transmit power. In this work, we take advantage of the multiobjective game (MOG) approach to predict the behaviour of each TRP, analyse tradeoffs between conflicting objectives and develop flexible and power allocation algorithms without the need for any centralised process. To achieve this goal, we apply the quasi variational inequality (QVI) modelling to transform the original multiobjective game into a set of equivalent problems with scalar payoffs and variable sets of strategies. This approach allows us to overcome the main limitations of existing scalarisation techniques, like scalarisation through weighted sum of the user's payoffs, which may involve the study of games with non-convex objective functions, making difficult (if not even impossible) the analysis of the set of possible solutions and the development of iterative solutions to achieve the equilibrium point corresponding to a desired tradeoff.

- 10h00-10h30: Oral presentation 2

Title: Blind Interference Alignment for Heterogeneous Cellular Networks.

Authors: Máximo Morales-Céspedes (UCL) and Jorge Plata-Chaves (KU Leuven).

Abstract: Achieving the optimal Degrees of Freedom (DoF), also known as multiplexing gain, in cellular networks has attracted a lot of research interests during the last decade. Unfortunately, perfect knowledge of the Channel State Information at the Transmitter (CSIT) is required by the transmission schemes able that are able to attain this goal (e.g., Interference Alignment (IA) or Linear Zero Forcing Beamforming (LZFB). Obtaining accurate real-time CSIT is quite challenging in a realistic implementation. As a result, optimal DoF schemes are handicapped. Recently, Blind Interference Alignment (BIA) was proposed as a means to achieve the optimal DoF without CSIT for the Multiple-Input Multiple-Output Broadcast Channel. Clearly BIA seems an attractive transmission scheme for cellular systems. However, its application to heterogeneous cellular networks is not straightforward. In this presentation, we initially describe the DoF region in the absence of CSIT for homogeneous cellular networks as well as the sum-DoF achieved by different existing techniques. By using this DoF region, we will show that the presence of small cells in heterogeneous networks introduces a new paradigm in cellular networks where the interaction between tiers has to be taken into consideration. First, we show that the existing network BIA (nBIA) scheme is not necessarily optimal for heterogeneous networks with a large number of femto cells, although it is sum-DoF optimal for homogeneous networks. Later, as an alternative to the nBIA scheme for heterogeneous networks, we propose a cognitive BIA scheme that is able to fully cancel the femto and macro intra-cell interference as well as the macro-femto interference without CSIT. Unlike the cooperative schemes where macro and femto BSs jointly transmit data to femto users (e.g. nBIA), the overall sum-DoF achieved by the proposed cognitive scheme increases with the number of femto cells. Moreover, we show that the proposed scheme allows the femto cells to achieve the optimal linear DoF subject to the maximization of the sum-DoF of the macro tier. Finally, simulation results are provided to show that the proposed cognitive BIA scheme overcomes traditional approaches such as resource division between both tiers or the application of nBIA to heterogeneous networks.

-10h30-11h00: Coffee break

-11h00-11h30: Oral presentation 3

Title: Goodput-maximizing Resource Allocation in Cognitive Radio BIC-OFDM systems with DF Relay

Authors: Jeroen Van Hecke (UGent-TELIN), Paolo Del Fiorentino (UPisa), Riccardo Andreotti (UPisa), Vincenzo Lottici (UPisa), Filippo Giannetti (UPisa), Luc Vandendorpe (UCL), and Marc Moeneclaey (UGent-TELIN)

Abstract: We propose a novel resource allocation (RA) strategy for a cognitive radio packet-oriented bit-interleaved coded orthogonal frequency division multiplexing (BIC-OFDM) system with decode-and-forward (DF) relays. The aim of the RA is maximizing the goodput (GP) of the source-relay-destination link, which is the number of information bits correctly received at the destination node per unit of time. Therefore, we derive a novel analytic expression for this figure of merit, which allows us to find the optimum constellation size, code rate and energy allocation per subcarrier. Further, this expression also serves as a novel relay selection criterion. Finally, we validate the proposed RA method, and compare its performance to capacity-maximizing algorithms through numerical simulations.

-11h30-12h00: Oral presentation 4

Title: Stochastic Analysis of Textile Antennas: from Production Uncertainties to Variability On-body

Authors: Marco Rossi (UGent-INTEC), Freek Boeykens (UGent-INTEC), Luigi Vallozzi (UGent-INTEC), Sam Agneessens (UGent-INTEC), Dries Vande Ginste (UGent-INTEC), Hendrik Rogier (UGent-INTEC)

Abstract: Given the growing importance that devices in wearable technology have acquired over the last years, the possibility to rigorously assess the impact of production uncertainties and variability due to on-body deployment on textile antennas' figures of merit is of paramount importance. To this end, we propose a stochastic framework based on a generalized polynomial chaos technique and Hermite-Padé approximations. More specifically, starting from experimentally estimated probability distributions of the design parameters, the effects of fabrication tolerances, substrate bending and compression on the input impedance, the return loss and the circular axial-ratio of textile antennas are quantified. The benefits of this approach with respect to traditional methods, such as Monte Carlo, are discussed.

- 12h00-12h30: Poster spotlight presentation: each poster presenter will have one minute to introduce his/her poster by means of a single slide

-12h30-13h30: Lunch

- 13h30-14h00: BESTCOM PI meeting

- 13h30-15h00: Coffee break and Poster session (all posters)

- 15h00-15h45: Keynote presentation

Title: Cloud Radio Access Networks: System Model, Capacity Analysis, and Optimization Algorithms

Author: Prof. Wei Yu, Electrical and Computer Engineering Department, University of Toronto, IEEE Communications Society Distinguished Lecturer

Abstract: Cloud radio access network (C-RAN) is an emerging wireless cellullar architecture in which the base-stations (BSs) take advantage of high-capacity backhaul links to upload signal processing and computation to a cloud-computing based central processor. The C-RAN architecture offers an enabling platform for the centralized joint encoding and joint decoding of user messages and a capability for intercell interference mitigation across the BSs. In this talk, we address the capacity analysis and optimization technique for C-RAN while specifically taking into account the finite capacity constraint on the backhaul links. In the uplink, the C-RAN architecture can be modeled as a multiple-access relay channel. We show that a compress-and-forward scheme in which the BSs quantize the received signals and send the quantized signals to the central processor using Wyner–Ziv coding is sum-capacity achieving to within a constant gap. We also propose a successive convex optimization approach for optimizing the quantization noise covariance matrix. In the downlink, the C-RAN architecture can be modeled as a broadcast relay channel. We compare the message-sharing strategy versus compression-based strategy for this setting, and show how compressive sensing and weighted minimum mean-squared error (WMMSE) techniques can be used to solve a network utility maximization problem involving joint user scheduling, BS clustering and beamforming in a user-centric message-sharing C-RAN design.

-15h45-16h15 Coffee break

-16h15-17h00 Keynote presentation

Title: Interference Mitigation using Device-to-Device Link

Author: Prof. Wei Yu, Electrical and Computer Engineering Department, University of Toronto, IEEE Communications Society Distinguished Lecturer

Abstract: In this talk, we consider the use of device-to-device link for cooperative communication in a cellular environment, where a nearby user terminal acts as a relay in enabling both signal enhancement and common interference rejection at the destination. Assuming Gaussian transmission and Gaussian test-channel in the compress-and-forward relaying strategy for a multiple-input multiple-output (MIMO) relay channel with a finite-capacity out-of-band relay-destination link and with arbitrarily correlated noises, we suggest an algorithm for joint optimization of the transmission strategy at the source and compression strategy at the relay. A coordinate ascent approach is employed to iteratively optimize the transmit covariance matrix for reception at both relay and destination, and for optimizing the quantization noise covariance matrix using a simultaneous diagonalization approach. Assuming uniqueness of the optimal solution in iterations, the algorithm converges to a stationary point of the overall problem. We further introduce the concept of antenna pooling, and illustrate that the optimized use of the device-to-device relay link is capable of significantly improving the user throughput in an interfering cellular environment. The relay link can enhance the overall transmission degree-of-freedom by enabling not only joint reception but also interference rejection across the user terminals.

-17h00 End

POSTERS

(P1) Title: Efficient Modeling of the Wireless Power Transfer Efficiency for Varying Positions and Orientations between Transmitter and Receiver

Authors: Gert-Jan Stockman, Dries Vande Ginste and Hendrik Rogier

Abstract: In this work, a method that efficiently calculates the Power Transfer Efficiency (PTE) of a Wireless Power Transfer (WPT) system is described. It allows for arbitrary relative positions and orientations between devices in the WPT system, both in far-field and radiative near-field configurations. The method uses a single simulation or measurement of the radiation patterns of the antennas employed in the WPT system, from which the interaction between devices at any relative position and orientation can be modeled. A spherical harmonics decomposition, together with Wigner-D rotation matrices, is applied to perform efficient translations and rotations of the devices used in the WPT system. The computational complexity of the method is low since it only relies on the free space radiation patterns of the antennas used. After this initial computational cost, any relative position or orientation of the devices is efficiently calculated with very low computational complexity.

(P2) Title: An Indoor Localization Technique Based on Ultra-Wideband AoD/AoA/ToA Estimation

Authors: Brecht Hanssens, David Plets, Emmeric Tanghe, Claude Oestges, Davy P. Gaillot, Martine Liénard, Luc Martens, and Wout Joseph

Abstract: This work presents a novel localization scheme based on Ultra-Wideband (UWB) channel sounding, employing a triangulation method that makes use of the geometrical properties of propagation paths, such as time of arrival (ToA), angle of departure (AoD) and angle of arrival (AoA). In order to extract these parameters from the sounding data, an extension to the well known high-resolution RiMAX algorithm was developed, facilitating the analysis of frequency-dependent propagation parameters. This framework was then tested by performing indoor measurements with a vector network analyzer and virtual antenna arrays. Several multipath parameters (ToA, AoD, AoA and power) were estimated from these measurements, and tracked as a function of frequency. These were subsequently used in a new location estimation scheme, allowing for the localization of a target node in Line-of-Sight (LoS), Obstructed-LoS (OLoS), and Non-LoS (NLoS) scenarios. The novelty of our approach is that we consider the existence of multiple possible target locations, after which we employ a clustering algorithm resulting in a more robust estimation of the target location. Measurements reveal that this newly proposed technique achieves a median accuracy of 0.42m, 0.59m and 1.22m in LoS, OLoS, and NLoS scenarios respectively, and this with only one single beacon node.

(P3) Title: Improved Tracking by Mitigating the Influence of the Human Body

Authors: Jens Trogh, David Plets, Luc Martens and Wout Joseph

Abstract: This paper presents a location tracking system that improves its performance by mitigating the influence caused by the human body of the user being tracked. The presence of such a user will influence the signal path between a body-worn mobile device and a receiving node. This influence will vary with the user's location and orientation and, as a result, the performance will deteriorate. By making use of the user's orientation towards the fixed infrastructure nodes, the influence of the body can be explicitly compensated, hereby improving the tracking accuracy. The overall system performance is extensively verified with experiments on a building-wide testbed. Compensating for this human body shadowing results in a relative improvement of 23.6%.

(P4) Title: Design of a Time-Division-Duplexing Wireless Off-Body Communication System with Low Data Rate Channel Feedback

Authors: Irven Aelbrecht, Hendrik Rogier, Marc Moeneclaey

Abstract: In the current society the necessity to be connected to the internet has become a basic requirement in which the maximization of user-convenience has always played a central role. This has led to an increase in, amongst other things, the development of textile integrated electronics. Together with this necessity, a demand for power efficient, high-throughput wireless communication to and from these devices, or in the specific case of textile integrated electronics, to and from the person wearing the integrated electronics, has arisen. Given the time-varying nature of the channel between transmitter and receiver, it is naïve to transmit using constant power and only one constellation. A better approach consists of adapting these parameters based on the current channel characteristics. However, this is not always possible due to hardware and/or bandwidth restrictions. Yet, by relying on the distribution of the measured channel, a performance improvement can still be realized. Therefore, an adaptive communication system is implemented on a software defined radio testbed. This enables to evaluate the performance of adaptive wireless communication by measurements in real-life scenarios.

(P5) Title: LTE as Potential Standard for Public Safety Indoor Body-to-Body Networks

Authors: Thijs Castel, Sam Lemey, Sam Agneessens, Patrick Van Torre, Hendrik Rogier, Claude Oestges

Abstract: A real-life rescue operation, performed by the Rapid Intervention Team looking for potential victims, is replicated by means of a body-to-body indoor channel sounder measurements. These channel sounder measurements, which provide high-resolution power delay profiles, enable us to characterize the indoor, wideband body-to-body channel using the RMS delay spread and the 50% correlation bandwidth. Both firefighters, who were simultaneously moving around in the vicinity of each other according to commonly used “two-in, two-out” principle, were equipped with two cavity-backed Substrate Integrated Waveguide textile antenna unobtrusively integrated in the front and back section of their rescue workers jackets, allowing us to characterize four independent wideband body-to-body links. Furthermore, we prove that the Long Term Evolution and, by extension, the non-cellular based LTE - Device to Device, standard is suitable for this indoor body-to-body environment. This could provide high data rate, real-time indoor communication between rescuers, enabling multimedia broadcast and efficient communication of up-to-date on-body sensor data in public safety networks.

(P6) Title: Modulo loss reduction in spatial multiplexing systems with Tomlinson-Harashima precoding

Authors: Erica Debels (UGent-TELIN), Adriaan Suls (UGent-TELIN), Marc Moeneclaey (UGent-TELIN)

Abstract: When a multi-user communication system over a block-fading MIMO channel utilizes Tomlinson-Harashima precoding in the downstream direction to eliminate the interference between the spatially multiplexed data streams, the conventional detection, involving a modulo operation at the receiving terminals, is known to yield a performance degradation that becomes considerable at low SNR. In this contribution, we propose a novel detection method that exploits sending one bit of extra information per user and per frame to the receiver, which indicates whether or not the considered user can detect all its data within the frame without performing a modulo operation. Moreover, in the case of M-PAM transmission it is possible to optimize the rotation of the constellations at the transmitter in order to maximize for each frame the number of users for which no modulo operation is required. Numerical results show that in the case of 2-PAM the novel detection algorithm is able to completely recover the modulo loss experienced by the

conventional detection method without an increase in transmit power, and to outperform 4-QAM (with conventional or novel detection) in terms of mutual information at low SNR.

(P7) Title: Mind the gap: void-creating algorithms for optical switching

Authors: Kurt Van Hautegem (UGent-TELIN), Wouter Rogiest (UGent-TELIN), Herwig Bruneel (UGent-TELIN)

Abstract: With ever-increasing demand for bandwidth, optical packet/burst switching is proposed to utilize more of the available capacity of optical networks in the future. In these packet-based switching techniques, packet contention on a single wavelength is resolved effectively by means of Fiber Delay Lines. The involved scheduling algorithms are typically designed to minimize packet loss and/or packet delay. By filling so-called voids, void-filling algorithms are known to outperform their non-void-filling counterparts. This however comes at a large computational cost as the void-filling algorithms have to keep track of beginnings and endings of all voids. This is opposed to the non-void-filling algorithms which only have to keep track of a single system state variable. We therefore propose a new type of algorithm that selectively creates voids that are larger than strictly needed, only when these will likely be filled. Results obtained by Monte Carlo simulation show that selective void creation can jointly reduce packet loss by 50% and packet delay by 18%, without imposing a high computational cost.

(P8) Title: Numerical Analysis of Eigen-modes on a Chipless Passive RFID System

Authors: D. Oueslati, S. Nath Jha, C. Craeye, and T Aguilli

Abstract: A numerical analysis method is proposed to study a chipless passive Radio Frequency Identification (RFID) system using the characteristic modes analysis. The approach is based on the SVD decomposition of the Method-of-Moments impedance matrix of a printed scatterer. Besides, a methodology is devised to selectively excite certain modes using multiple excitations, and to minimize the effect of unwanted eigen-modes using multiple receivers. Specific frequency responses which characterize the printed scatterer are presented to demonstrate the proposed method.

(P9) Title: Cramér Rao Bound for Location Estimation of Fixed Service Terrestrial Microwave Transmitter and Receiver Based on TDOA and Hybrid TOA and AOA.

Authors: Jeevan Shrestha, Luc Vandendorpe

Abstract: Cognitive satellite communication can be an alluring solution to relieve the conventional spectrum scarcity and improve the efficiency of the existing underutilized spectrum. It would been interesting to investigate if cognitive radio networks can used to estimate position of primary transmitter and the receiver. If the location of primary transmitter and receiver can be estimated, the cognitive satellite communication network can take decision whether to switch to given unlicensed band or not. The location of primary transmitter is estimated through collaborative effort of multiple cognitive radio nodes places accordingly in the certain geographical area of interest. We derive the CRBs (Cramér Rao bound) for the position based on hybrid method using both AOA and TOA (time of arrival) information and method based on time difference of arrival. We assume line of sight propagation model between sensor and primary transmitter and AWGN noise. The location estimation process proposed is two step estimation process. The analytical results obtained for the CRBs are illustrated by numerical results for typical scenarios. The effect of number of cognitive radio nodes, number of antenna elements in each node, geometry of antenna element, and total sensing time for the accuracy of location estimate is provided

(P10) Title: Optimal Precoder Design for MIMO-OFDM with Non-Linear Distortion Noise

Authors: Zijian Wang, I. Stupia, L. Vandendorpe

Abstract: This paper studies the design of precoders and power allocation for multiple-input-multiple-output (MIMO) orthogonal frequency-division multiplexing (OFDM) systems with nonlinear distortion due to the clipping effect of the amplifiers. By modeling the signal in time domain using Bussgang theory, we derive the rate expression in frequency domain. We show that the power allocation is the water filling strategy. We also give a sufficient condition of concavity of the rate function. The numerical results show our algorithm outperforms other input back-off (IBO) which maximize the rate.

(P11) Title: Optimal Zero Forcing Precoder and Decoder Design for Multi-User MIMO FBMC Under Strong Channel Selectivity

Authors: François Rottenberg, Xavier Mestre (CTTC), Jérôme Louveaux

Abstract: This paper investigates the optimal design of precoders or decoders under a channel inversion criterion for multi-user (MU) MIMO filterbank multicarrier (FBMC) modulations. The base station (BS) is assumed to use a single tap precoding/decoding matrix at each subcarrier in the downlink/uplink, resulting in a low complexity of implementation. The expression of the asymptotic mean squared error (MSE) for this precoding/decoding design in the case of strong channel selectivity is recalled and simplified. Optimizing the MSE under a channel inversion constraint, the expression of the optimal precoding/decoding matrix is found. It is shown that as long as the number of BS antennas is larger than the number of users, the optimized precoder and decoder can compensate the channel frequency selectivity and even restore the system orthogonality for a large enough number of BS antennas.

(P12) Title: Doppler Radar for vehicle monitoring: analysis, implementation and optimisation

Authors: Thomas Feuillen, Thomas Pairon, Achraf Mallat, Luc Vandendorpe, Christophe Craeye

Abstract: A modulation for radars based on the "Step Frequency" modulation is introduced. It allows for an estimation of the speed, angle of arrival as well as the distance between the target and the radar. This modulation consists in sending different frequencies periodically, thus forming a "frequency stairs". The two main advantages of this modulation are : on the one hand, a sound choice of frequencies results in a longer distance where a target can be uniquely localised; on the other hand, the proposed estimator gives an estimation of both the speed and the distance simultaneously. This allows for an enhanced estimation of these parameters in a multi-target environment. This work focuses mainly in the proposed estimator as well as the different algorithms used for the optimisation of the different frequencies forming the "frequency stairs". With this modulation, one can extend the maximal distance of detection up to hundreds of metres. Furthermore, the low complexity of the estimator yields a real time target detection coupled with an 1 km/h speed accuracy, a centimetre precision in distance as well as an average 1o degree error on the angle of arrival.

(P13) Title: Accelerated near-field Physical Optics using an inhomogeneous plane-wave method

Authors: Quentin Gueuning, C. Craeye, C. Oestges

Abstract: A spectral domain formulation of the near-field physical optics radiation integral from planar faces is presented. We exploit the decreasing degrees of freedom of the scattered field with respect to the observation distance through a low linear contour deformation and an adaptive integration scheme. For the

back-scattered field from a single plate, we observe a substantial speed-up factor while preserving a 2-digits accuracy compared to the brute force spatial integration.

(P14) Title: Double Relay Communication Protocol for Bandwidth Management in Cellular Systems

Authors: R. Torrea-Duran, F. Rosas, Z.K.Z.Khan, S. Pollin, P. Tsiaflakis, and M. Moonen

Abstract: The continuously growing demand for wireless connectivity has turned bandwidth into a scarce resource that should be carefully managed. A common solution is to assign disjoint portions of the bandwidth to different users, but the portion size decreases as the number of users grows. An alternative solution is to introduce spatial diversity through coordinated base stations, but such systems are very sensitive to timing and frequency synchronization offsets. To tackle these problems, we use principles of network coding for bandwidth management in a double relay cellular system of two base stations and two users. We propose a three-time-slot transmission strategy and a MMSE reception strategy. It avoids the need of tight frequency or timing synchronization through a simple communication protocol without using additional bandwidth or infrastructure. By finding a balance between spatial diversity and transmission time, our approach achieves the system capacity and fairness in all SNR conditions.

(P15) Title: Real-Time Spectrum Optimization Algorithm for Downstream DSL with a Diagonalizing Precoder

Authors: Jeroen Verdyck, Marc Moonen

Abstract: In multi-user multi-carrier networks, dynamic spectrum management (DSM) is a key technique to handle interference. As existing DSM algorithms might not be suitable when computation time and power are limited, a new paradigm of real-time DSM algorithms has been introduced. Real-time DSM algorithms have the defining property that they can be stopped after an arbitrary number of iterations and will deliver a solution that is both an improvement and guaranteed to be feasible. In this poster, we present a real-time spectrum optimization algorithm for downstream DSL with a diagonalizing precoder, which is a generalization of the existing IPDB algorithm for real-time spectrum coordination.