BSC'16

2016 28th Biennial Symposium on Communications Program

Time	ADM121-Sunroom	EME0050	EME1101	UNC200-Ballroom
Sunday, June 5				
08:30-12:00			*Tutorial 1: Cloud Radio Access Networks*	
12:00-14:00			*Lunch Break*	
14:00-17:30			*Tutorial 2: Non-Orthogonal Multiple Access*	
18:00-20:30	*Welcome Reception*			
Monday, June 6				
09:20-09:25		*Opening Remarks*		
09:25-10:25		*Plenary Talk: Predictive Pre-adaptive Information Processing for Cognitive Risk Control*		
10:25-10:55		*Coffee Break*		
10:55-11:35		*Cognitive Systems*		
11:35-13:35		*Lunch Break*		
13:35-15:15		*Invited Talks: Molecular Communication Systems*		
15:15-15:45		*Coffee Break*		
15:45-17:05		*Communication Systems*		
17:35-18:15		*CSIT Annual Meeting*		
Tuesday, June 7				
08:30-09:30		*Plenary Talk: Location, Location, and Location!*		
09:30-10:00		*Coffee Break*		
10:00-11:00		*Plenary Talk: Media-based Modulation: Higher Spectral Efficiency and Improved Security for Future Wireless Systems*		
11:00-11:20		*Modulation Techniques*		
11:20-12:20		*Coding Theory*		

12:20-14:20	*Lunch Break*	
14:20-15:20	*Data Networks*	
15:20-15:50	*Coffee Break*	
15:50-17:10	*Optical Communications*	
18:00-20:00		*Conference Banquet*

Wednesday, June 8

08:30-12:00		*Tutorial 3: Quadrature Spatial Modulation*
12:00-12:05		*Closing Remarks*

Sunday, June 5, 08:30 - 12:00

Tutorial 1: Cloud Radio Access Networks

Prof. Wei Yu, University of Toronto

Room: EME1101

Chair: Julian Cheng (University of British Columbia, Canada)

Abstract: Cloud radio access network (C-RAN) is an emerging wireless cellullar architecture, in which the base-stations (BSs) take advantage of high-capacity fronthaul 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 a cluster of BSs. In this tutorial, we address both the information theory and signal processing challenges in C-RAN design. The tutorial begins by presenting capacity analysis and optimization technique for C-RAN, specifically accounting the finite capacity constraints of the fronthaul links. In the uplink, we focus on the compression scheme in which the BSs quantize the received signals and send the quantized signals to the central processor. We show a strategy based on Wyner-Ziv coding is approximately sum-capacity achieving. In the downlink, we analyze both the message-sharing strategy and 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. The tutorial further addresses system-level analysis of the C-RAN using tools from stochastic geometry with an aim of quantifying the capacity benefit of cooperative communication as a function of the cluster size.

Sunday, June 5, 12:00 - 14:00

Lunch Break

Room: EME1101

Sunday, June 5, 14:00 - 17:30

Tutorial 2: Non-Orthogonal Multiple Access

Prof. Zhiguo Ding, Lancaster University

Room: EME1101

Chair: Julian Cheng (University of British Columbia, Canada)

Abstract: Multiple access in 5G mobile networks is an emerging research topic, since it is key for the next generation network to keep pace with the exponential growth of mobile data and multimedia traffic. Non-

orthogonal multiple access (NOMA) has recently received considerable attention as a promising candidate for 5G multiple access. The key idea of NOMA is to exploit the power domain for multiple access, which means multiple users can be served concurrently at the same time, frequency, and spreading code. Instead of using water-filling power allocation strategies, NOMA allocates more power to the users with poorer channel conditions, with the aim to facilitate a balanced tradeoff between system throughput and user fairness. Recent industrial demonstrations show that the use of NOMA can significantly improve the spectral efficiency of mobile networks. Because of such a superior performance, NOMA has been also recently proposed for downlink scenarios in 3rd generation partnership project long-term evolution (3GPP-LTE) systems, and the considering technique was termed multiuser superposition transmission (MUST). In this tutorial, we will provide a progress review for NOMA, including an information theoretic perspective of NOMA, the interaction between cognitive radio and NOMA, the design of MIMO and cooperative NOMA, and the impact of practical constraints, such as imperfect channel state information and limited feedback, on the performance of NOMA.

Sunday, June 5, 18:00 - 20:30

Welcome Reception

Room: ADM121-Sunroom

Monday, June 6, 09:20 - 09:25

Opening Remarks

Room: EME0050
Chair: Andrew Eckford (York University, Canada)

Monday, June 6, 09:25 - 10:25

Plenary Talk: Predictive Pre-adaptive Information Processing for Cognitive Risk Control

Prof. Simon Haykin, McMaster University

Room: EME0050
Chair: Andrew Eckford (York University, Canada)

Abstract: It was in 1990 that I presented a lecture on Radar Vision at the IEEE International Radar Conference, Arlington VA; it was at that conference I spoke about radar vision as an intelligent remote-sensing device that is capable of "cognition'' of the surrounding environment. From then on, I took it upon myself to learn more and more about human cognition as a new way of thinking about engineering applications. In 1999, Mitola and Maguire went on to present a paper on Cognitive Radio as a novel way of making software radios more personal. It was Mitola's paper that prompted me to publish the paper entitled Cognitive Radio: Brain-empowered wireless communications, followed in 2006 by Cognitive Radar: A way of the future. Putting it altogether, in an IEEE point-of-view article, I introduced Cognitive Dynamic Systems (CDS) as the umbrella that includes Cognitive Radio and Cognitive Radar as special cases of CDS. Turning next to Cognitive Control as a new addition to CDS, it was found to be highly challenging for the simple reason: Unlike traditional control, Cognitive Control operates on the environment indirectly via the preceptor, the function of which is to model the observables to set the stage for estimating the state of the environment. It was in 2009, that Cognitive Control was published for the first time; a more refined version of it was published in 2012. With this brief background, I will describe the expansion of cognitive control to formulate Cognitive Risk Control, the essence of which is based on the principle of Predictive Pre-adaptation that is well-known in cognitive neuroscience. This new way of thinking in control theory will appear in a new edited book entitled Cognitive Dynamic Systems. Currently, we are working on the formulation of Hierarchical CDS to bring it that much closer to the Brain. One last comment is in order: In one form or another, Cognition is spreading rapidly in different ways around the world. Most importantly, the Hierarchical CDS will be the basis for the construction of a new generation of Truly Smart Products. I am therefore emboldened to say that Hierarchical CDS will establish itself as an important element in the Fourth Industrial Revolution.

Monday, June 6, 10:25 - 10:55

Coffee Break

Room: EME0050

Monday, June 6, 10:55 - 11:35

Cognitive Systems

Room: EME0050
Chair: Christian Senger (University of Stuttgart, Germany)

Space Shift Keying in MIMO Cognitive Radio Systems with Limited Feedback and Channel Estimation Errors
Islam Abu Mahady and Ali Afana (Lakehead University, Canada); Salama Said Ikki (Lakehead University & Electrical Engineering Department, Canada)
In this paper, the performance of space modulation known as space shift keying (SSK) in multiple-input multiple-output (MIMO) cognitive radio systems is addressed. In particular, this work considers a MIMO secondary system adopts SSK at the transmitter side and a maximum likelihood detection at the receiver side in the presence of multiple primary receivers. The secondary system error performance is investigated in the presence of estimation errors at the receiver and statistical channel state information feedback at the transmitter. Closed-form expression for the average bit error probability (ABEP) over Rayleigh fading channels is derived in two transmit antennas case. For the general number of transmit antennas, a tight upper bounded ABEP is presented. Moreover, simple approximate expressions are introduced to evaluate the system diversity. Numerical results, which corporate with simulations, show the efficacy of SSK in enhancing the secondary system performance.

A Two-Level Authentication Scheme in Cognitive Radio Networks
Mahmoud Khasawneh and Anjali Agarwal (Concordia University, Canada)
In this paper, a two-level authentication scheme for communication in cognitive radio networks (CRN) is proposed. Before joining the network, a CR node is validated by obtaining security credentials from an authorized point. The proposed scheme relies on public and symmetric key cryptography instead of digital signature based approach to encrypt data between the communicating nodes in order to reduce the authentication time and to improve network security in terms of resource availability and accessibility. The scheme has been evaluated and verified in terms of security functionality, the correctness and the performance which shows less computation and communication requirements.

Monday, June 6, 11:35 - 13:35

Lunch Break

Room: EME0050

Monday, June 6, 13:35 - 15:15

Invited Talks: Molecular Communication Systems

Room: EME0050
Chair: Raviraj Adve (University of Toronto, Canada)

Talk 1: Andrew Eckford (York University), "Finite-State Channel Models for Signal Transduction in Neural Systems"; Talk 2. Ravi Adve (University of Toronto), "Information Rates in ASK-Based Molecular Communications: ISI and Feedback"; Talk 3. Nariman Farsad (Stanford University), "Capacity Limits of Diffusion-Based Molecular Timing Channels"; Talk 4. Adam Noel (Université de Montréal), "Channel Impulse Responses in Diffusive Molecular Communication with Spherical Transmitters"

Channel Impulse Responses in Diffusive Molecular Communication with Spherical Transmitters
Adam Noel and Dimitrios Makrakis (University of Ottawa, Canada); Abdelhakim Hafid (University of Montreal, Canada)
Molecular communication is an emerging paradigm for systems that rely on the release of molecules as information carriers. Communication via molecular diffusion is a popular strategy that is ubiquitous in nature and very fast over distances on the order of a micron or less. Existing closed-form analysis of the diffusing channel impulse response generally assumes that the transmitter is a point source. In this paper, channel impulse responses are derived for volume transmitters, which are much more accurate when the distance between a transmitter and its receiver are small relative to the size of the transmitter. The analytical results are verified in the

new molecular communication simulation platform AcCoRD (Actor-based Communication via Reaction-Diffusion).

Monday, June 6, 15:15 - 15:45

Coffee Break

Room: EME0050

Monday, June 6, 15:45 - 17:05

Communication Systems

Room: EME0050
Chair: Chintha Tellambura (University of Alberta, Canada)

Gaussian Two-Way Channels With Discrete Inputs and Quantized Outputs
Ershad Banijamali (University of Waterloo, Canada)
In this paper, Gaussian two-way channel with uniform output quantization is studied. For Gaussian inputs, the optimum uniform finite-level quantizer is determined numerically for different values of Signal-to-Noise Ratio (SNR). The two-way channel with constellation-based transmitters is then investigated. A formulation for the so-called Shannon achievable region of this channel is developed and numerical computations of this region are presented for particular constellations. It is shown that if one transmitter utilizes a rotated version of the constellation used at the other transmitter, the Shannon achievable region can be enlarged.

Serving Distance and Coverage in a Closed Access PHP-Based Heterogeneous Cellular Network
Zeinab Yazdanshenasan (Nanyang Technological University, Singapore); Harpreet S Dhillon (Virginia Tech, USA); Peter Han Joo Chong (Auckland University of Technology, New Zealand)
Heterogeneous cellular networks (HCNs) usually exhibit spatial separation amongst base stations (BSs) of different types (termed tiers in this paper). For instance, operators will usually not deploy a picocell in close proximity to a macrocell, thus inducing separation amongst the locations of pico and macrocells. This separation has recently been captured by modeling the small cell locations by a Poisson Hole Process (PHP) with the hole centers being the locations of the macrocells. Due to the presence of exclusion zones, the analysis of the resulting model is significantly more complex compared to the more popular Poisson Point Process (PPP) based models. In this paper, we derive a tight bound on the distribution of the distance of a typical user to the closest point of a PHP. Since the exact distribution of this distance is not known, it is often approximated in the literature. For this model, we then provide tight characterization of the downlink coverage probability for a typical user in a two-tier closed-access HCN under two cases: (i) typical user is served by the closest macrocell, and (ii) typical user is served by its closest small cell. The proposed approach can be extended to analyze other relevant cases of interest, e.g., coverage in a PHP-based open access HCN.

Achievable throughput of an opportunistic spectrum access scheme under a frame structure
Jagadeeshchandra Shetty (Indian Institute of Science, India)
One of the approaches in cognitive radio is the opportunistic spectrum access(OSA), which enables secondary users (SUs) to access the licensed frequency bands that are detected to be idle. Though there have been a few updates on the throughput aspects of SUs in OSA not much work has been done taking into account the sensing errors, spectrum occupancy probabilities as well as the transmission frame structure. In particular, it'll be interesting to investigate what happens if there is a change in the spectrum occupancy status during SU transmission period(status transition). In this short paper, we provide expressions for the achievable throughputs from these perspectives (assuming both the scenarios of no channel status transition and a status transition) for a SU. We consider a multiband channel structure. Simulation results are presented to verify our analysis.

Monday, June 6, 17:35 - 18:15

CSIT Annual Meeting

Room: EME0050
Chair: Andrew Eckford (York University, Canada)

Tuesday, June 7, 08:30 - 09:30

Plenary Talk: Location, Location, and Location!

Prof. Moe Z. Win, Massachusetts Institute of Technology

Room: EME0050
Chair: Julian Cheng (University of British Columbia, Canada)

Abstract: The availability of positional information is of extreme importance in numerous wireless applications. The coming years will see the emergence of location-aware networks with sub-meter localization accuracy, minimal infrastructure, and robustness in harsh (GPS challenged) environments. To reach this goal we advocate network localization and navigation, a new paradigm that exploits a combination of wideband transmission and spatiotemporal cooperation. Our work has addressed this problem from three perspectives: theoretical framework, cooperative algorithms, and network experimentation. We will give an overview of our recent research results in this exciting field.

Tuesday, June 7, 09:30 - 10:00

Coffee Break

Room: EME0050

Tuesday, June 7, 10:00 - 11:00

Plenary Talk: Media-based Modulation: Higher Spectral Efficiency and Improved Security for Future Wireless Systems

Prof. Amir Khandani, University of Waterloo

Room: EME0050
Chair: Chen Feng (University of British Columbia, Canada)

Abstract: The idea of Media-based Modulation (MBM) is based on embedding information in the variations of the transmission media (channel states). This is in contrast to conventional wireless systems where data is embedded in a Radio Frequency (RF) source prior to the transmit antenna. MBM offers several advantages vs. conventional systems, including "additivity of information over multiple receive antennas", and "inherent diversity when operating over a static fading channel". MBM is particularly suitable for transmitting high data rates using a single transmit and multiple receive antennas (Single Input-Multiple Output Media-Based Modulation, or SIMO-MBM). It is shown that a 1xK SIMO-MBM over a static multi-path channel asymptotically achieves the capacity of K parallel Additive White Gaussian Noise (AWGN) channels, where for one unit of energy sent over the single transmit antenna, the effective energy for each of the K AWGN channels is equal to one (the statistical average of channel/fading gain). Complexity issues limit the amount of data that can be embedded in the channel state using a single transmit unit in SIMO-MBM. To address this shortcoming, this presentation also presents the idea of Layered Multiple Input-Multiple Output Media-Based Modulation (LMIMO-MBM). LMIMO-MBM enables forming a high-rate constellation as the superposition of constituent vectors due to separate transmit units. Relying on such a layered structure, LMIMO-MBM can significantly reduce hardware and algorithmic complexities, as well as the training overhead, vs. SIMO-MBM. Exploiting the layered constellation structure, a fast iterative algorithm is proposed for signal detection. Simulation results show excellent performance in terms of Symbol Error Rate (SER) vs. Signal-to-Noise Ratio (SNR). For example, a 4X16 LMIMO-MBM is capable of transmitting 32 bits of information per (complex) channel-use, with SER~10-5 at Eb/N0~-3.5dB (or SER~10-4 at Eb/N0~-4.5dB). This performance is achieved using a single transmission (no extension in time/frequency), and without adding any redundancy for Forward-Error-Correction (FEC). This means, in addition to its excellent SER vs. energy/rate performance, MBM relaxes the need for complex FEC structures used in conventional wireless systems, and thereby minimizes the transmission delay and overhead. Application of FEC can further improve the performance. For example, applying Reed-Solomon codes enables transmitting 30 bits of information per (complex) channel-use with a Frame Error Rate (FER)~10-5 at Eb/N0~-6dB. It is shown that, under a set of mild conditions, by applying FEC with error correction capability t, the slope of the error rate vs. SNR (with hard decision decoding) will asymptotically increase by a factor of t+1. A practical (small size and low complexity) RF configuration is presented for embedding information in the channel state. For this purpose, periodic RF constructions are used which can act as on-off RF mirrors. The on-off operation relies on simple RF switches, and can support very fast switching for high bandwidth applications. It is also shown that a proper RF implementation allows implementing an NxK MIMO-MBM using a single transmit chain (instead of N). It is shown that the same antenna configuration can be used to provide unconditional security in wireless. This is based on using a

wireless channel to establish a secret key (one-time pad) between two legitimate parties. Wireless channel enables providing a reference of phase between the two legitimate parties, which in turn is used to extract a common phase value. Each such phase value can completely mask a phase-shift-keying (PSK) symbol (zero information leakage). The shared phase depends on the propagation environment between legitimate parties and will be impossible to guess even by an eavesdropper that is located in close vicinity, has unlimited processing power, and enjoys multiple antennas and high signal-to-noise ratio. It is shown that the same antenna configuration used for media-based modulation can perturb the wireless channel such that a number of such common phase values can be generated, together providing a longer secure key.

Tuesday, June 7, 11:00 - 11:20

Modulation Techniques

Room: EME0050
Chair: Chen Feng (University of British Columbia, Canada)

Performance Evaluation of Media-based Modulation in Comparison with Spatial Modulation and Legacy SISO/MIMO
Ehsan Seifi, Mehran Atamanesh and Amir K. Khandani (University of Waterloo, Canada)
The idea of Media-based Modulation (MBM), introduced in [1] [2], is based on embedding information in the variations of the transmission media (channel states). This is in contrast to legacy wireless systems where data is embedded in a Radio-Frequency (RF) source prior to the transmit antenna. MBM offers several advantages vs. legacy systems, including "additivity of information over multiple receive antennas", and "inherent diversity over a static fading channel". MBM is particularly suitable for transmitting high data rates using a single transmit and multiple receive antennas (Single Input-Multiple Output Media-Based Modulation, or SIMO-MBM). Furthermore, to address complexity issues (hardware and algorithmic complexities, as well as the training overhead) that limit the amount of data that can be embedded in channel states using a single transmit unit, Layered Multiple Input- Multiple Output Media-Based Modulation (LMIMO-MBM) is introduced in [3]. Current articles compares performance of MBM and LMIMO-MBM vs. legacy Multiple Input-Multiple Output (MIMO), and a recently introduced modulation scheme called Spatial Modulation (SM) and its generalization called Generalized Spatial Modulation (GSM). These comparisons demonstrate significant performance gains for MBM and LMIMO- MBM vs. these known techniques.

Tuesday, June 7, 11:20 - 12:20

Coding Theory

Room: EME0050
Chair: Masoud Ardakani (University of Alberta, Canada)

Multiplicative Gap Minimization Over BEC Channel Using Combined Genetic Algorithm and Linear Programming
Ahmadreza Amirzadeh, Mohammad Amin Haji Bagheri Fard, Mohamed Haj Taieb and Jean-Yves Chouinard (Laval University, Canada)
In the design of LDPC codes, there is a difference between the design rate which can be achieved with variable node and check node degree distribution optimization and Shannon capacity. In other words, a designed degree distribution ensemble can achieve a 1-δ fraction of the Shannon capacity, where δ is called the Multiplicative Gap (MG). In order to minimize MG, the check node and variable node degree distributions should be jointly optimized. This joint optimization process is typically very complex and maybe unfeasible to implement in practice. To solve this problem, in this paper we limit the size of the check node degree distribution to degrees of one or two, and design capacity approaching (small MG) irregular LDPC code ensembles over the Binary Erasure Channel (BEC). In the proposed method, we minimize δ by iterating between variable node degree distribution optimization using a Genetic Algorithm (GA) and check node degree distribution optimization using Linear Programming (LP). Our results show improvement in the minimization of δ compared to other degree distribution optimization methods.

Syndrome-based Decoding of Polynomial Evaluation Codes without Chien Search
Christian Senger (University of Stuttgart, Germany); Frank R. Kschischang (University of Toronto, Canada)
A new interpretation of Bose-Chaudhuri-Hocquenghem codes is given, based on the imposition of certain conjugacy constraints on the message polynomials of their cyclic generalized Reed-Solomon

(GRS) parent codes. This interpretation facilitates a merging of interpolation-based and syndrome-based decoders for GRS codes, resulting in syndrome-based decoders that do not require the computationally expensive Chien search and error evaluation steps.

Variable-length Constrained Sequence Codes for Mitigating Inter-cell Interference in All-bit-line Flash Memory with Multi-page Programming

Congzhe Cao and Ivan Fair (University of Alberta, Canada)

We propose using variable-length constrained sequence codes to mitigate inter-cell interference (ICI) in all-bit-line flash memory with multi-page programming for single-level cell (SLC), multi-level cell (MLC), and triple-level cell (TLC) flash memory structures. We outline constraints that mitigate ICI in these systems based on an observation of the Gray mapping of data symbols. The capacity of each constraint is then derived. Based on a finite state machine representation of each constraint, we construct variable-length constrained sequence codes with code rates very close to capacity to mitigate or completely remove ICI in these flash memories.

Tuesday, June 7, 12:20 - 14:20

Lunch Break

Room: EME0050

Tuesday, June 7, 14:20 - 15:20

Data Networks

Room: EME0050

Chair: Chen Feng (University of British Columbia, Canada)

Online Code Rate Adaptation in Cloud Storage Systems with Multiple Erasure Codes

Rui Zhu and Di Niu (University of Alberta, Canada); Zongpeng Li (University of Calgary, Canada)

Erasure codes have been adopted for cloud storage systems. While achieving higher reliability at lower storage overhead as compared to replication, erasure codes usually incur high reading cost when recovering an unavailable block. Although local reconstruction coding constructions have been proposed to reduce recovery cost, additional benefits can be achieved by adopting erasure codes with different code rates for data blocks with different popularity. In this paper, we study the problem of code rate selection and adaptation in cloud storage systems that adopt multiple erasure codes via online learning. Unlike offline optimization, which requires the knowledge or estimation of future demands, the online learning algorithms can make decisions only based on past observations and dynamically adapt to demand changes. To avoid solving a hard integer program, we perform a stochastic relaxation to the formulated online learning problem and solve it using a exponentiated gradient algorithm, resulting in sparse solutions. We show a regret bound of $O(\sqrt{T})$ of the proposed algorithm by showing that our algorithm is a special case of the FTRL online learning framework. Through trace-driven simulations based on real request traces from Windows Azure Storage, we show that our online algorithm performs close to the best fixed offline policy, and trades off between recovery cost during degraded reads and storage overhead.

On the Capacity Region of ALOHA Protocol for the Internet of Things

Moslem Noori, Samira Rahimian and Masoud Ardakani (University of Alberta, Canada)

Accommodating the needs of a large number of diverse users in the Internet of Things (IoT), notably managing how the users access the common channel, has posed unique challenges to the network designers. In this paper, we study a heterogeneous IoT network consisting of multiple classes of users who may have different service requirements. For this network, we consider the application of irregular repetition slotted ALOHA (IRSA) that is shown to offer large throughput for single-class networks. Then, we focus on finding the network performance boundaries by studying the set of feasible throughput values for each class, called the capacity region. To this end, we first introduce the concept of dual network of a multi-class network meaning a homogeneous network with the same number of users. We then prove that finding the capacity region of the assumed multi-class network boils down to finding the maximum achievable throughput of its dual network. Using this finding, we then discuss how any given point of the capacity region can be achieved. Further, a delay performance study is conducted to evaluate the average and maximum packet transmission delay experienced by the users of each class.

A Clustering-Based Approach for Low-Complexity Adaptive Profile Selection in DOCSIS 3.1

Mahdi Ben Ghorbel (University of British Columbia, Okanagan); Ebrahim Bedeer (Carleton University, Canada); Md. Jahangir Hossain (Universtiy of British Columbia, Okanagan,

Canada); Colin Howlett (Veima Networks, Canada); Brian Berscheid (Vecima Networks, Canada); Julian Cheng (University of British Columbia, Canada)

We introduce a low complexity downlink bit-loading for each subcarrier of a large number of cable modems (CMs) in DOCSIS 3.1. Although different modulations between subcarriers are allowed in DOCSIS 3.1, the number of different bit-loading per subcarrier assignments, called profiles, is limited for computational complexity. Thus, an efficient method of determining the best profile to be used by each CM is needed. The proposed approach is based on a two-step algorithm. In the first step, users are clustered into groups based on their signal-to-noise ratio (SNR), while in the second step, the profile per group (i.e., the bit-loading per sub-carrier) is selected. Two different criteria are investigated for this step. The first one considers the average SNR among the users in the cluster to determine the bit-loading, while the second one is more conservative and considers the worst SNR among the users in order to guarantee the targeted BER for all the users in the cluster. Through numerical results, we show the efficiency of the two-step approach and compare the two proposed criteria for bit-loading.

Tuesday, June 7, 15:20 - 15:50

Coffee Break

Room: EME0050

Tuesday, June 7, 15:50 - 17:10

Optical Communications

Room: EME0050

Chair: Frank R. Kschischang (University of Toronto, Canada)

Concatenated LDGM-Staircase Codes for Long-Haul Optical-Transport Networks

Lei Zhang and Frank R. Kschischang (University of Toronto, Canada)

We propose a concatenated coding scheme based on inner low-density generator matrix codes and outer hard-decision decodable spatially-coupled staircase codes for long-haul optical-transport networks. The concatenated scheme operates on soft-decision channel outputs and provides an output bit-error probability below 10^{-15}. The inner LDGM code is optimized based on a simple convex program, which minimizes the number of inner decoding iterations. The structure of the outer code allows the overall error floor to be easily predicted. Based on example (and sub-optimal) concatenated scheme designs, we find that the decoding complexity and coding gains of the concatenated scheme are competitive with the best available soft-decision forward error-correction schemes for the same application. At 20.0% overhead, an instance of the concatenated scheme achieved a net-coding-gain of 11.0 dB, with at most 6 decoding iterations per inner code block.

Priority MAC Scheme For Dual-Link Vehicular Visible Light Communication Networks

Sameera Siddiqui and Dimitrios Makrakis (University of Ottawa, Canada)

With extensively increasing usage of energy-efficient light emitting diodes (LEDs) in traffic lights, lamp posts, headlights, and taillights of vehicles, visible light communication (VLC) stands as the most reasonable and realistic choice for carrying out data transfer in vehicular environment. With the availability of rapidly switching LEDs, vehicular visible light communication (VVLC) networks are capable to perform not only low latency safety information transfer but are also appropriate to support quality of service (QoS) bounded high speed real time data transfer. The design and implementation of a unique medium access control (MAC) protocol is critical for vehicular visible light communication (VVLC) networks due to their dissimilarities from radio frequency (RF) based vehicular networks. This paper proposes an efficient medium access control scheme for dual-link VVLC systems. In dual-link VLC systems the wide beam links maintain connectivity at low data rate while the more focused narrow beams enable high rate data transfer. This scheme is capable of supporting fast and prioritized handover and safety critical message transfer as well as QoS based dissemination of traffic management information and infotainment application data by varying back-off durations. The simulation results demonstrate the remarkable performance of the proposed protocol in term of packet delivery rate (PDR).

On Spectral Efficiency of First Order Soliton-Based Optical Communications

Alexander Span and Stephan ten Brink (University of Stuttgart, Germany)

The success of coherent communication over fiber optic channels during the past decade was enabled by digital signal processing combating linear effects such as chromatic and polarization mode dispersion. With higher data rates, increasing launch powers, and farther reaches nonlinear effects also have to be taken into account. Recently, the Nonlinear Fourier Transform (NFT) has been shown to be a viable tool for mitigating nonlinear channel properties induced by the Kerr-effect. However, compared to classic Nyquist-signaling based methods, spectral efficiencies with aspects like bandwidth and impulse duration for defining symbol rate have less been studied. In

this paper, we illustrate the degrees of freedom for modulating the nonlinear spectrum of NFT-based communication using first order solitons. We first restrict ourselves to simple 1-out-of- N eigenvalue modulation and explore the general impact of modulating the eigenvalue real and imaginary parts on the time-bandwidth product, respectively. Then, modulating the discrete spectral amplitude is also considered. We show some limiting factors for achieving good constellation spectral efficiencies and provide an overview of the most important parameters.

Performance Analysis of Subcarrier QPSK Systems With Transmitter I/Q Imbalance Over Gamma-Gamma Fading Channels

Changle Zhu and Julian Cheng (University of British Columbia, Canada)

The impacts of the transmitter in-phase and quadrature (I/Q) imbalance on the performance of a subcarrier quadrature phase shift keying system over Gamma-Gamma fading channels are studied. The signals transmitted are distorted by I/Q imbalance which is unavoidable at the analog front-end due to the imperfection of circuit implementation. The fluctuation of irradiance due to the Gamma-Gamma fading channels can cause a further performance degradation. Closed-form symbol error rate expression is derived by taking into account of both transmitter I/Q imbalance and fading. Truncation error is analyzed to support the asymptotic analysis.

Tuesday, June 7, 18:00 - 20:00

Conference Banquet

Malcolm Metcalfe, Founder and CTO of ENBALA Power Networks

Room: UNC200-Ballroom

Wednesday, June 8, 08:30 - 12:00

Tutorial 3: Quadrature Spatial Modulation

Dr. Ali Afana, Prof. Salama S. Ikki, Prof. Raed Mesleh

Room: EME1101

Chair: Julian Cheng (University of British Columbia, Canada)

Abstract: Wireless technologies have proliferated every aspect of human activity, playing an integral role in national infrastructures and enabling pervasive mobile computing, e-commerce, multimedia communications, health monitoring, and others. To this end, several maturing technologies have been emerged in recent years to enhance the capacity of wireless networks, particularly cellular networks. Quadrature Spatial modulation (QSM) has been recently proposed as a promising multiple-input multiple-output (MIMO) technique that utilizes the spatial information in a novel fashion. At each time instance, only a single transmit antenna is activated among the set of existing transmit antennas and the activated antenna index is implicitly used to convey information beside the well-known M-ary modulation schemes. As compared to other conventional MIMO techniques, QSM is shown to have several advantages among of which are, complete avoidance of inter-channel interference (ICI), relaxed inter-antenna synchronization requirements, low receiver complexity, use of a single RF chain at the transmitter, and enhanced error performance with moderate number of transmit antennas. It has been shown that QSM increases the spectral efficiency of conventional spatial modulation (SM) system while retaining all SM inherent advantages. This tutorial will cover the basic concepts as well as the benefits, challenges and complexity issues of QSM in order to gain a deeper insight into the operation, performance and feasibility of QSM in practice.

Wednesday, June 8, 12:00 - 12:05

Closing Remarks

Room: EME1101

Chair: Julian Cheng (University of British Columbia, Canada)