Antennas and Propagation Session

High-Efficiency Ferrite Meander Antenna (HEMA) for LTE Applications

1569578335

This paper introduces a ferrite half-cycle meander antenna that can be used to realize a 2x2 MIMO communication system.

Chandana Jayasooriya
Wichita State University, USA

Novel Quadrifilar Helix Antenna Combining GNSS, Iridium, and a UHF Communications Monopole

1569603231

This paper describes an antenna system combining Global Navigation Satellite System (GNSS) with Iridium satellite communications and UHF 225-512 MHz communications on a handset to provide an integrated Communications - Navigation (Comm/Nav) antenna. The GPS/GNSS/Iridium antenna is a folded Quadrifilar Helix Antenna (QHA) with novel features which improve frequency coverage compared to existing QHA designs. This QHA antenna can be co-located concentrically (co-axially) around a UHF monopole which increases the gain of the monopole by several dB over most of the UHF communications band 225 - 512 MHz. Co-locating the QHA and monopole also reduces the area needed on the transceiver. The GNSS frequencies covered by the QHA include modernized GPS (L1, L2, L5), GLONASS, Galileo, and Beidou (Compass), spanning from 1164 to 1300 MHz and 1559 to 1611 MHz. The Iridium communications transmit and receive band (1611-1626 MHz) is also covered. The primary design goal for the QHA was to maximize Right-Hand Circularly Polarized (RHCP) gain at all GNSS frequencies and Iridium at angles from zenith down to 10 degrees above the horizon. A QHA is well suited to this application since it provides excellent RHCP coverage at all azimuth and elevation angles, as well as low crosspolarization to reduce multipath. The antenna patterns and gain are affected by the transceiver handset box upon which the antenna is mounted; for purposes of demonstration, the antennas were optimized and tested on a conductive handset box which was 8" long x 4" wide by 1.5" thick; no other ground plane was used. The diameter of the QHAs ranged from 0.75" to 1.5", so that each could fit on top of a handset. A 10-inch long UHF monopole or sleeve was included co-axially through the center of each QHA.

Paul Elliot
MITRE Corporation, USA
Experimental Validation of Stochastic Wireless Urban Channel Model: Estimation and Prediction

1569605215

Stochastic differential equations (SDE) can be used to describe the time-varying nature of wireless channels. This paper validates a long-term fading channel model for estimation and prediction from solely using measured received signal strength measurements. Such channel models can be used for optimizing wireless networks deployed for industrial automation, public access, and communication. This paper uses two different sets of received signal measurement data to estimate and predict the signal strength based on past measurements. The real-world performance of the estimation and prediction algorithm is demonstrated.

Phani Kuruganti
Oak Ridge National Laboratory, USA

MPTA: Modified Polymer Textile Antennas for Green Symbiotic Cloud Communications

1569612061

We propose a completely metal gratis antenna, developed from modified polymer textile. The antenna operating in the UWB range is light weight, low cost, rugged and can be ambidextrously positioned in dismounted military operations. The judiciously designed antenna can be easily amalgamated or sewn into military garb suggesting its strong candidature in secretive and investigative communications. The short pulse UWB transmission capabilities of designed antenna provides benefits such as low probability of intercept, good resistance to multipath fading in addition to its low visual profile. A tensile strength of about 60 mPa and a high operating temperature of 300°C allow the antenna to be soldier mounted under frequent physical abrasion. With a VSWR less than 2 and an operational efficiency of about 55%, in the 7.5 - 9.5 GHz range, the proposed modified polymer textile antenna (MPTA) validates its usage as a viable option in a plethora of military applications.

Hd Mustafa
IIT Bombay, India

Event-based Transmission Line Matrix Method for Simulating Site-Specific Multipath Propagation Characteristics

1569612739

Accurate radio channel modeling is essential for deploying advanced wireless sensors in harsh industrial and urban environments. Site-specific propagation modeling tools are required to understand the channel parameters within these environments. Multipath delay spread determines the frequency-selective fading characteristics of the channel. This paper describes a novel computationally inexpensive technique to determine multipath delay spread. Event-based transmission line matrix-based method is used to simulate the channel.

Phani Kuruganti
Oak Ridge National Laboratory, USA

Modeling of Radiowave Propagation in Tunnels

1569613061

We investigated propagation of radio frequency (RF) waves in tunnels. An understanding of RF propagation in tunnels is needed to plan for optimal radio communication system performance. We considered tunnels with a square cross section and right-angle junctions. We developed an analytic model of tunnel propagation by considering multiple reflections from tunnel walls and diffraction around junction corners. A comparison of model results with measurements shows a strong
correlation between model predictions and measured data. Finally, we briefly describe a software tool that helps users visualize field strength of the propagating field in tunnels.

Jeffrey Boksiner
US Army RDECOM CERDEC S&TCD, USA
Channel Coding Session

Adaptive-Rate Channel Coding for Packet Radio Systems with Higher Layer Fountain Coding

1569599317

We present a low-complexity protocol for adaptive-rate channel coding in tactical packet radio systems that employ higher layer fountain codes for correction of packet erasures and must communicate over wireless channels that experience fading and other time-varying propagation losses. The protocol responds to variations in channel conditions by adapting the rate of the channel code that is applied to the fountain-encoded packets. The protocol relies solely on a simple statistic from the receiver for its operation. It requires no channel measurements, parameter estimates, pilot symbols, or training. The throughput performance for the protocol is evaluated for Rayleigh fading channels modeled by finite-state Markov chains. We show that our adaptive-rate coding protocol in tandem with higher layer fountain coding outperforms systems with fixed-rate channel coding. We also compare the performance of our protocol to the performance of a hypothetical ideal protocol that is given perfect channel state information. We demonstrate that our protocol performs nearly as well as the ideal protocol even though sophisticated channel estimation techniques are not required.

Jason Ellis
Clemson University, USA

PER Prediction for Convolutionally Coded MIMO OFDM Systems — an Analytical Approach

1569599393

Packet error rate (PER) prediction for multiple-input multiple-output (MIMO) orthogonal frequency-division multiplexing (OFDM) systems is important to link adaptation. However, since the existing prediction methods require curve fitting and parameter calibration for each transmission scheme, they are actually not practical as the number of scheme increases. This paper presents a purely analytical approach to PER prediction for rate-compatible punctured convolutional (RCPC) with bit-interleaved coded modulation (BICM) MIMO OFDM systems based on the analysis of pairwise error probability (PEP) and the transfer functions of the codes. The accuracy of the proposed method is comparable with which resulting from other heuristic methods.

Chung-Yu Lou
University of California, Los Angeles, USA

A Low-Complexity Multicarrier Scheme with LDPC Coding for Mobile-to-Mobile Environment

1569599877

In this paper, we consider a mobile ad-hoc radio network in an urban area. The propagation environment between two endpoints can be modeled by a double-Rayleigh fading multipath channel. Such a mobile scenario justifies the use of filter bank based multicarrier (FBMC) transmission systems. This technique generalizes traditional cyclic prefix orthogonal frequency-division multiplexing (CP-OFDM), allowing the design of non-rectangular pulse shape filters. We show that this approach leads to a better interference mitigation in time-variant channels. We restrict our study to short filters and single-tap per sub-channel equalization in order to preserve a low-complexity transmultiplexer. In this study, we compare FBMC with short filters to CP-OFDM in terms of coded bit-error-rate performances, using a realistic mobile-to-mobile channel model.

Damien Roque
GIPSA-lab, France
Practical Implementation of Hybrid DLT Codes for Cooperative Relay Communications

1569599887

Forward error correction codes are commonly adopted in dual-hop relay communications to ensure the link-layer communication reliability. Among all FEC codes, Luby Transform (LT) codes are favorable because of their low decoder complexity and rate adaptability to channel dynamic fading. To alleviate the high computation cost in the primitive LT-based cooperative communications, hybrid decomposed LT (h-DLT) codes are proposed in our recent work. Theoretical analyses show that reduced energy consumption and latency can be achieved for h-DLT codes assisted cooperative relay communications. In this paper, the practical implementation of h-DLT codes in cooperative relay communications with limited storage capability is investigated. We first design a new type of h-DLT codes that enables energy-efficient reliable cooperative communications. Then, the code construction algorithms are provided and the corresponding communication protocol is devised. Finally, simulations are conducted to manifest the performance and benefits of the cooperative relay system with the newly proposed h-DLT codes and the effects of multiple design factors, such as the storage size at relays, the number of relays, and etc.

Xilin Cheng
Colorado State Univ, USA

Scrambled Code Multiple Access Waveform for Micro Satellite terminals

1569602439

This paper introduces a novel waveform based on very low-rate coding and a family of new multiple access techniques named Scrambled Code Multiple Access (SCMA). It allows different users of a communications system to efficiently share the same bandwidth by using specific scramblers to separate timeslots. The SCMA technology is especially well-suited for satellite communications with extremely small antenna micro satellite terminals (MICROSAT) for potential applications such as tactical communications on the move, asset tracking, sensor networking, and smart grid. With SCMA such applications can now be supported with cost-efficient Ku and Ka bands. We will discuss two types of receiver structure, several ways of using them, their respective performance, covertness features, and results from a prototype implementation that has been field tested.

Lin-Nan Lee
Hughes Network Systems, USA

Quasi-Cyclic Low-Density Parity-Check Stabilizer Codes

1569612931

Quantum error correction codes are needed to protect quantum systems from interference. An important family of quantum error correction codes are stabilizer codes. Most stabilizer codes in the literature belong to a subclass of stabilizer codes, referred to as CSS codes since they are based on the so-called CSS formalism. CSS codes have received significant attention because the CSS formalism is easy to satisfy and also because it is easy to adapt classical error correction codes to CSS codes. However, stabilizer codes promise superior error correction performance than CSS codes. The existing stabilizer codes in the literature are based on binary low-density parity-check (LDPC) codes. Since it has been shown that CSS codes based on nonbinary LDPC codes have good performance over binary quantum channels, in this paper we investigate stabilizer codes based on nonbinary LDPC codes. In particular, we propose two constructions of stabilizer codes based on nonbinary quasi-cyclic low-density parity-check (QC-LDPC) codes for binary quantum channels. The simulation results show that our QC-LDPC stabilizer codes decoded by a nonbinary sum-product algorithm have better performance than their binary counterparts.

Feng Shi
Lehigh University, USA
Channel Estimation and Receiver Design Session

The Cramer-Rao Bound for Data-Aided Synchronization of SOQPSK

1569582071

In this paper, we derive the Cramer-Rao bound (CRB) for shaped offset quadrature phase keying (SOQPSK) signals. We consider a situation where the carrier phase, frequency offset and symbol timing have to be estimated based on a known training sequence. The goal is to find the optimum training sequence for which the joint CRBs are minimized. It is shown that the proposed training sequence minimizes the CRBs for all three estimation parameters simultaneously. The presented results can be used in designing preambles for burst-mode SOQPSK transmissions.

Ehsan Hosseini
University of Kansas, USA

Cramer-Rao Bound for Channel Estimation in Amplify-and-Forward Relaying Networks

1569598543

In this paper, we consider a three-node amplify-and-forward (AF) relaying network, consisting of a source S, a destination D and a half-duplex relay node R, where only D is equipped with channel estimator. For a block flat fading channel model, we derive the Bayesian Cramer-Rao lower bound (CRLB) and the mean-squared error (MSE) of the linear minimum mean square error (LMMSE) channel estimate. For a fixed transmission block length and a total transmit power constraint, we investigate the optimal power allotment between S and R, such that Bayesian CRLB and the MSE of the LMMSE channel estimate are optimized.

Yupeng Jia
National Instruments, USA

Time-Domain Preamble-Based SNR Estimation for OFDM Systems in Doubly Selective Channels

1569603877

In wireless orthogonal frequency division multiplexing (OFDM) systems, the knowledge of signal-to-noise ratio (SNR) plays an important role for system optimization. Most of the exiting literatures have studied the SNR estimation for perfect synchronization in additive white Gaussian noise (AWGN) channels, or in frequency selective channels. However, the realistic channels are always doubly selective, and there may exist some residual symbol timing offset (STO) and carrier frequency offset (CFO) after coarse synchronization in the time domain. In this paper, we take these into account and propose a time-domain average SNR estimation scheme using one OFDM training symbol (preamble) which has been divided into multiple parts with equal length. Compared with the time-domain low-complexity SNR estimator (TLSE), our proposed time-domain preamble-based SNR estimator (TPSE) can not only be implemented in the presence of STO and CFO, but also generate more accurate SNR estimation for the channels with large Doppler shift. The estimated SNR value based on our scheme in time-domain can be further used to improve the forthcoming CFO estimation and fine synchronization efficiently.

Fan Yang
University of Electronic Science and Technology of China, P.R. China
Iterative Channel Estimation for Time-Varying Relay Networks with Optimal Energy Allocation

1569609885

Estimation of time-varying relay channels together with optimal energy allocation is considered. In the proposed frame structure, a priori known pilot symbols multiplexed with the data symbols are employed together with the decisions on the data symbols in an iterative fashion. This scheme is shown to achieve bit error rate (BER) off the known channel bound by 1.5 dB in signal-to-noise ratio (SNR) and the advantage over the conventional pilot only case can be as large as 3 dB. This attractive performance is shown to be achieved by a single-tap bidirectional least-mean-algorithm (BiLMS) at a very low complexity as compared to the minimum mean-square error (MMSE) filter with multiple taps. Under a fixed energy budget, the optimal energy allocation is also shown through an allocation factor for which a closed form expression under a suboptimal operation is computed and evaluated in various realistic scenarios to have a satisfactory performance.

Yavuz Yapıcı
Defence Technologies Engineering Inc. (STM), Turkey

Frequency-Domain Receiver Design for Fast Varying Channels

1569611723

Conventional frequency-domain receivers require a fixed channel within the block duration being the performance severely affected in presence of strong Doppler effects. In this paper we propose an iterative receiver for SC-FDE schemes (Single Carrier with Frequency-Domain Equalization) that is able to mitigate strong Doppler effects. This receiver can be regarded as a modified turbo equalizer, implemented in the frequency domain, able to compensate the Doppler effects associated to different groups of multipath components while performing the equalization procedure. Our performance results show significant improvements over the turbo-FDE, even when different multipath components have substantially different Doppler effects.

Fábio Silva
Instituto de Telecomunicações, Portugal

Blind Frequency Offset Estimation and Intercarrier Interference Cancelation for FD-MC-CDMA Systems in Aerial Vehicle Communication

1569612869

FD-MC-CDMA is an attractive candidate for next generation high speed aerial vehicle communication for its high spectrum efficiency and excellent BER performance. Similar to other multi-carrier transmission technologies, FD-MC-CDMA suffers significant performance degradation resulting from intercarrier interference (ICI) in high mobility environments. Particularly, because of the ICI is observed from all other subcarriers, the benefit of decomposing subcarriers into non-contiguous sets diminishes. In this paper, we propose a parallel processing based blind frequency offset estimation and ICI cancelation method for FD-MC-CDMA system to significantly improve the BER performance in high mobility environment. Specifically, by exploiting frequency offset quantization, the proposed scheme takes advantage of the orthogonality of the ICI matrix and offers perfect ICI cancelation and significant BER improvement. More importantly, the proposed scheme does not lower the transmission rate or reduce the network capacity. It is also important to note that the proposed ICI cancelation scheme maintains the low complexity of optimum multi-user detection (MUD) receiver and achieves the superb performance at linearly growing cost. Simulation results in AWGN channel and multipath fading channel confirm the excellent performance of the proposed scheme in the presence of frequency offset or time variations in the channel.

John Ellinger
Air Force Research Laboratory, USA
Cognitive Radio Session

**Distributed Energy-based Spectrum Sensing with Opportunistic Cooperative Diversity for Cognitive Radio Networks over Non-Identical Fading Channels**

156959763

Cognitive Radio Network (CRN) provides a promising method to expand usage of the underutilized spectrum resources. Spectrum sensing is a key functionality for the operation of secondary overlay CRN systems without causing harmful interference to the licensed primary users. Through the collaboration among spatially distributed CR users, spectrum sensing can provide reliable decisions. However, CRN is not a static network but a dynamic network such that the number of available spatial diversity is time-varying. The performance of cooperative spectrum sensing is thus dynamically changing. Furthermore, the distributed CRs may experience a variety of fading conditions, so identically distributed fading model adopted in most spectrum sensing literatures does not fully characterize the practical CRN application scenarios. Thus, in this paper, we study the cooperative spectrum sensing with opportunistic spatial diversity over non-identical fading channels. We derive the exact closed form expressions for the probabilities of detection and false alarm. These expressions are analytical tractable and hence provide the framework to apply optimization tools to efficiently guarantee the global optimality without computationally costly exhaustive search. Quick efficient performance evaluation is crucial for CRN to perform online adaptation to the wireless links, the primary users’ activities, and the CR dynamics simultaneously.

Chihkai Chen
University of California, Los Angeles, USA

**Cooperative Spectrum Sensing Based on Generalized Likelihood Ratio Test Under Impulsive Noise Circumstances**

1569597955

We propose nonlinear schemes for the spectrum sensing in cooperative cognitive radio networks under impulsive noise circumstances. By jointly employing the order statistics, generalized likelihood ratio test, and counting rule in the framework of spectrum sensing, the proposed scheme exhibits a better performance than the conventional counterparts. From simulation results, it is confirmed that the proposed scheme provides significant performance improvements over the conventional schemes.

Taehun An
KAIST, Korea

**A Combination of Quickest Detection with Oracle Approximating Shrinkage Estimation and Its Application to Spectrum Sensing in Cognitive Radio**

1569602233

Spectrum sensing is a fundamental problem in cognitive radio. How to sense the presence of primary user promptly in order to avoid the unexpected interference is a key issue to the system. The motivation of our work is to detect the primary user signal using small size data in short time. In this paper, a quickest detection based approach is proposed for spectrum sensing. This approach employs covariance matrix estimation instead of sample covariance matrix as the first step, then the core idea of sequential detection or quickest detection is borrowed and utilized here to improve the performance of traditional eigenvalue based MME and AGM detectors. The main advantage of the proposed approach is that it requires short data to detect quickly and it works at lower SNR environments. A performance comparison between the proposed approach and other traditional methods is provided, by the simulation on captured digital TV (DTV) signal. The simulation results show this proposed approach exhibits performance improvement while the threshold keeps robust.

Feng Lin
Tennessee Tech University, USA
Performance Analysis of Spectrum Monitoring for Cognitive Radios

1569602863

In-band spectrum sensing protocols require that the secondary users (SU's) periodically suspend their transmission periods and sense the channel in order to determine whether the primary user (PU) has emerged or not. There is a tradeoff between the spectrum sensing period and the throughput of the SU, often referred to as sensing-throughput tradeoff. In this paper, using the receiver error count, we introduce a decision statistic to enable the SU to detect the emergence of the PU without having to interrupt its own communication. We derive closed form formulas for channel utilization of the SU and detection delay of the PU using two Markov chain models. The limits of performance for a system using the proposed decision statistic is derived and an optimization problem is solved to maximize channel utilization with a constraint on detection delay. Numerical results are presented from analysis and simulation which show the accuracy of the analysis and the proficiency of the proposed algorithm.

Mahdi Orooji
Louisiana State University, USA

Spectrum Monitoring for Cognitive Radios in Rayleigh Fading Channel

1569610227

In-band spectrum sensing requires that the secondary users (SU) periodically suspend their communication in order to determine whether the primary user (PU) has started to utilize the channel or not. In contrast, in spectrum monitoring the SU can detect the emergence of the PU from its own receiver statistics such as receiver error count (REC). Previously it is shown that in AWGN channels, a hybrid spectrum sensing/spectrum monitoring system significantly improves channel utilization of the SUs and detection delay for the PUs. In this paper we investigate the problem of spectrum monitoring in the presence of fading where the SU employs diversity combining to mitigate the channel fading effects. We show that a decision statistic based on the REC alone does not provide a good performance. Next we introduce new decision statistics based on the REC and the combiner coefficients. Simulation results are presented that show significant improvement in system performance.

Erfan Soltanmohammadi
Louisiana State University, USA

The False Positive Congestion Problem and Probabilistic Spectrum Sensing

1569612465

We assess the formidable problem of band congestion due to spectrum sensing false positives combined with a guard-band policy. We calculate the distribution of spectral white spaces to find that large fractions of a band can be wasted even for small probabilities of false positives. To ameliorate this problem, we propose an algorithm consisting of random bin sampling followed by density clustering. A substantial reduction in sensing time is afforded by the fact that the number of randomly sampled bins need only be a small fraction of the total number of bins. Simultaneously, the clustering algorithm yields a dramatic enhancement of the false positive rejection rate due to large differences between the densities of true and false detections. We explain the theory behind this method, compare to simulation, and derive heuristic guidelines for its implementation.

Andrew Robertson
Naval Research Laboratory, USA
Compressive Sensing Session

Analysis and Design of QAPM Modulation using Compressive Sensing for Low Power Communication

1569609133

In this paper, we propose a QAPM (quadrature amplitude position modulation) modulation using compressive sensing for the purpose of power efficiency improvement. QAPM modulation is a combination technique of QAM (quadrature amplitude modulation) and PPM (pulse position modulation). Therefore, it can decrease the transmission power and improve BER performance. Moreover, even if the bandwidth are widened when the number of positions is increased, high sparsity characteristic caused by position number can be applied to compressive sensing technique. Compressive sensing has recently studied as a method that can be successfully reconstructed from the small number of measurements for sparse signal. Therefore, the proposed system can lower price of receiver by reducing sampling rate and has performance improved by using QAPM modulation. And the results are confirmed through simulations.

So-Ra Kim
Chungbuk National University, Korea

Spread Spectrum Wireless Passive Surface Acoustic Wave Sensor System

1569612369

This paper will discuss the recent results on orthogonal frequency coded (OFC) SAW sensor system development, which uses both frequency diversity, and pulse position reflectors, to encode the device ID. Post processing and correlation techniques of the received signal are then used to extract the sensor information. Some of the most difficult and critical parameters addressed are encoding approaches, operational range predictions, SAW device parameters of frequency and bandwidth, sensor post processing, and antenna-SAW device integration. Devices were successfully developed for ultra-wide-band (UWB) operation and also narrower fractional bandwidths of less than 10%. Device processing gains have varied from 9 to over 50. A fully operational 915 MHz OFC SAW multi-sensor system is developed, under evaluation, and recent results will be presented. The system is based on a software radio approach that provides great flexibility for future enhancements and diverse sensor applications. The most ubiquitous sensor requirement is for temperature, which is the first application demonstrated for the devices and system. The system has demonstrated various performance limits with a range of approximately 60 meters with a single sensor, and over 5 meters with 8 sensors. This paper's focus will be on the key SAW device technology development to date, addressing the critical device and system parameters, and will present operational 915 MHz OFC device system results. We believe this is the first 8-RFID-temperature sensor system capable of this range, with demonstrated measurements of ± 130C.

Donald Malocha
University of Central Florida, USA

Scalable Spectrum Situational Awareness Using Devices of Opportunity

1569612469

We present a solution that addresses the problem of providing scalable dynamic spectrum awareness for military (and commercial) applications opportunistically using RF devices that are deployed for tasks other than spectrum mapping. We consider challenging urban environments with a large heterogeneous mix of devices and signals. Additional challenges we address include sparsely distributed receivers and the requirement for a system that can be scaled based on the mission and the number of users that must be supported. In order to address these challenges in a scalable distributed fashion, we put forward a solution that uses the following three techniques we have developed: (1) Sparse signal reconstruction techniques to fill in the spatial gaps from limited receiver measurements; (2) Kanerva Sparse Distributed Memory (SDM) to store and retrieve large amounts of data and perform anomaly detection; (3) Feature extraction algorithms to allow for the use of different radio devices that are able to provide varying levels of information.
Jeffrey Connor  
Argon ST, USA  

**Output Compression for IC Fault Detection Using Compressive Sensing**  
1569612593

The process of detecting logical faults in integrated circuits (ICs) due to manufacturing variations is bottlenecked by the I/O cost of scanning in test vectors and offloading test results. Traditionally, the output bottleneck is alleviated by reducing the number of bits in output responses using XOR networks, or computing signatures from the responses of multiple tests. However, these many-to-one computations improve I/O time at the cost of higher detection failure rates, and lower test granularity. In this paper, we propose an output compression approach that uses compressive sensing to exploit the redundancy of correlated circuit outputs, when input test vectors are ordered appropriately. Compressive sensing's simple encoding method makes our approach attractive because it can be implemented on-chip using only a small number of accumulators. On several benchmark circuits, we show that our method can reduce the output I/O bottleneck without increasing failure rates, and can reconstruct higher granularity results off-chip.

Stephen Tarsa  
Harvard University, USA  

**Chemical Plume Detection in Hyperspectral Imagery via Joint Sparse Representation**  
1569613391

In this paper, we propose a new spatial-temporal joint sparsity method for the identification and detection of chemical plume in hyperspectral imagery. The proposed algorithm relies on two key observations: 1. each hyperspectral pixel can be approximately represented by a sparse linear combination of the training samples; and 2. neighborhood pixels from the same hyperspectral image as well as consecutive hyperspectral frames usually have similar spectral characteristics. By grouping these pixels into a joint structure and force them to have the same sparsity support of the training samples, we have effectively exclude the correlation of not only spatial but also time domain of the HSI data. Before the presence of this paper, almost no methods have made use of the temporal information for the detection of chemical plume in hyperspectral video data. Furthermore, the proposed method shows very competitive results with the Adaptive Matched Subspace Detector (AMSD) algorithm where the chemical types are predefined.

Minh Dao  
Johns Hopkins University, USA  

**BCS: Compressive Sensing for Binary Sparse Signals**  
1569613951

Model based Compressive Sensing (CS) for signal specific applications is of particular interest in the sparse signal approximation. In this paper, we deal with special class of sparse signal with binary entries. Unlike in conventional CS approaches based on l1 minimization, we model the CS process with bi-partite graph. We design a sampling matrix for binary sparse signal with unique sum property, which can be universally applied to any binary signal. Moreover a novel Binary CS decoding algorithm (BCS) based on graph and unique sum table which does not need complex optimization process is proposed. Proposed method is verified and compared with existing solutions through mathematical analysis and numerical simulations.

Ukash Nakarmi  
Oklahoma State University, USA
Cooperative Communications Session

Implementation of Distributed Time Exchange Based Cooperative Forwarding

1569611341

In this paper, we design and implement time exchange (TE) based cooperative forwarding where nodes use transmission time slots as incentives for relaying. We focus on distributed joint time slot exchange and relay selection in the sum goodput maximization of the overall network. We formulate the design objective as a mixed integer nonlinear programming (MINLP) problem and provide a polynomial time distributed solution of the MINLP. We implement the designed algorithm in the software defined radio enabled USRP nodes of the ORBIT indoor wireless testbed. The ORBIT grid is used as a global control plane for exchange of control information between the USRP nodes. Experimental results suggest that TE can significantly increase the sum goodput of the network. We also demonstrate the performance of a goodput optimization algorithm that is proportionally fair.

Muhammad Islam
WINLAB, Rutgers University, USA

Relay Selection for AF SISO Wireless Relay Networks under Jamming Environment with Relay Power Constraint

1569611353

This paper proposes a noncooperative wireless relay network consisting of a one-source-one-destination node pair and N relay nodes. The objective of this paper is to analytically derive the exact optimal noncooperative amplify-and-forward (AF) wireless relay vectors (or matrices) under both jamming and no-jamming environments with the power constraint at the relay nodes based on the minimum mean square error (MMSE) criterion. The MMSE cost function behaviors will be analytically and numerically investigated using the relay amplifying vectors derived. Finally, the relay selection scheme for the noncooperative AF wireless relay network is investigated using the maximum signal-to-noise (SNR) ratio criterion under both jamming and no-jamming environments. The Monte-Carlo simulation results with respect to the bit error rate (BER) will be presented using the derived optimal relay amplifying vectors to verify the analytical results based on the cost function.

Kanghee Lee
Wichita State University, USA

Multi-Group Multiuser Two-Way Relay with Superposition Coding

1569611645

In this paper, we investigate the application of superposition coding to multi-group multiuser two-way relay channel. A novel scheme combining network coding and superposition coding is proposed. In the two-phase communication scenario considered, single-antenna users of each group wish to exchange information with their corresponding partners with the assistance of the relay node (RN) which is equipped with multiple antennas. Decode-and-Forward (DF) strategy is employed by RN. Network coding is used to handle intra-group interference while superposition coding is deployed to cope with inter-group interference. We make explicit analysis of ergodic sum rate and outage probability which are chosen as the metrics to evaluate the performance of the proposed scheme. Space-time coding (STC) adopted by the multi-antenna RN enables the users to achieve spatial diversity gain. It shows that the proposed scheme outperforms other existing comparable approaches in terms of sum rate and outage probability. Simulation results are provided to verify our analysis and demonstrate the performance of the proposed scheme.

Renju Wu
Beijing University of Posts and Telecommunications, P.R. China
Enhanced Algebraic Error Control for Random Linear Network Coding

1569612899

Error control is significant to network coding, since when unchecked, errors greatly deteriorate the throughput gains of network coding and seriously undermine both reliability and security of data. Two families of codes, subspace and rank metric codes, have been used to provide error control for random linear network coding. In this paper, we enhance the error correction capability of these two families of codes by using a novel two-tier decoding scheme. While the decoding of subspace and rank metric codes serves a second-tier decoding, we propose to perform a first-tier decoding on the packet level by taking advantage of Hamming distance properties of subspace and rank metric codes. This packet-level decoding can also be implemented by intermediate nodes to reduce error propagation. To support the first-tier decoding, we also investigate Hamming distance properties of three important families of subspace and rank metric codes, Gabidulin codes, Koetter-Kschischang codes, and Mahdavifar-Vardy codes. Both the two-tier decoding scheme and the Hamming distance properties of these codes are novel to the best of our knowledge.

Zhiyuan Yan
Lehigh University, USA

Spectrum and Energy Efficiency in Two-Way Multi-Relay Networks with Selective Relaying

1569612949

In this paper, we study two-way multi-relay networks (TWMRNs) in which two nodes exchange information indirectly via an optimal relay node in Rayleigh fading channels. An amplify-and-forward (AF) scheme has been employed and the network mechanism is investigated in depth using a Markov chain model. Automatic Repeat-reQuest (ARQ) retransmission has been applied to guarantee successful packet delivery. The bit energy consumption and goodput are analyzed as functions of the signal-to-noise ratio and transmission rate. Through numerical results, it is demonstrated that selective relaying in TWMRNs can potentially increase the network reliability and achieve higher spectrum and energy efficiency than two-way networks with a single relay.

Qing Chen
University of Nebraska-Lincoln, USA

Novel Energy Efficient Relaying Schemes for Wireless Sensor Networks

1569613921

This paper proposes novel relaying schemes based on Modified Alamouti Codes and Time-Switched Space Time Coding for homogeneous sensor network architecture. With recent advancement in the areas of embedded / hardware technology like MEMS, it has been possible to fabricate a smart antenna based sensor prototype which contains dual antenna within single radio transceiver architecture. Exploiting this recent development, new relaying schemes based on the incorporation of such prototype in a Sensor Network framework is considered. Total energy consumption and delay characteristics are used as performance metrics for an exhaustive quantification of the stand alone and clustered sensor networking scenarios. Variable Rate M-QAM modulation schemes are considered for varying gateway distances. It is observed that for standalone scenario in presence of both single and dual gateway, m-Alamouti and TS-STC based relaying outperforms non cooperative and c-Alamouti mode by a significant margin all throughout the long haul distances. For clustered case, in presence of single antenna gateway only m-Alamouti starts to outperform c-Alamouti only beyond a certain threshold distance of 360m providing an energy efficiency of around 16% when the gateway distance from the source is 500m. For AS at the gateway, c-Alamouti turns out to be the most efficient scheme. Similar trend is observed when the distance between the clusters is increased from 100 to 200m. The Energy Efficiency of all the proposed schemes with respect to non cooperative mode with single antenna gateway falls typically within a window of 60 to 90% for distances beyond 250m.

Chitradeep Majumdar
Indian Institute of Technology, Bombay, India
Interference Mitigation Session

Guard Zones and the Near-Far Problem in DS-CDMA Ad Hoc Networks

1569588375

The central issue in direct-sequence code-division multiple-access (DS-CDMA) ad hoc networks is the prevention of a near-far problem. This paper considers two types of guard zones that may be used to control the near-far problem: a fundamental exclusion zone and an additional CSMA guard zone that may be established by the carrier-sense multiple-access (CSMA) protocol. In the exclusion zone, no mobiles are physically present, reflecting the fact that mobiles will always have a minimum physical separation in actual networks. Potentially interfering mobiles beyond the exclusion zone, but within the CSMA guard zone, can be deactivated by the protocol. This paper provides an analysis of DS-CSMA networks with either or both types of guard zones. Unlike the related literature, which requires infinite networks, a network of finite extent with a finite number of mobiles and uniform clustering as the spatial distribution is modeled, and a closed-form expression for the outage probability of a network with fixed geometry and Nakagami fading is used. It is shown that the outage probability is very sensitive to the exclusion-zone size, particularly when the processing gain is low or nonexistent, whereas the transmission capacity is sensitive to the deactivations caused by the CSMA protocol.

Don Torrieri
US Army Research Laboratory, USA

Focusing a radio signal and simultaneously nulling it at another location using time-reversal: Experimental results

1569598451

The time-reversal beam-forming technique utilizes the multipath in a cluttered environment to focus beyond the Rayleigh limit. This method makes use of the reciprocity of wireless propagation channels.

Time-reversal can also be used to null signals, either to reduce unintentional interference or to prevent eavesdropping.

Previous analytical work has also shown the ability to focus a signal at a location while simultaneously nulling it at a different location.

We now present experimental results showing time-reversal focus and nulling in a cluttered environment.

Ratish Punnoose
Sandia National Laboratories, USA
Joint Quantization Strategy for Uplink Cooperative Cellular Interference Alignment with Limited Feedback

1569610831

We consider the uplink three-cell single-user cellular systems with limited feedback interference alignment (IA). Considering the exchange of channel state information (CSI) between base stations (BSs), IA solution can be done at the BSs followed by feeding back the quantized version of precoding vectors to each user. A joint quantization strategy, which quantizes the precoding vectors for different users jointly, is proposed. The proposed quantization scheme enlarges the codebooks and quantizes precoding vectors jointly through the exchange of codebook information between BSs. Only one of the three BSs is appointed to feed back the same index of the precoding vectors to all the users in the systems so that the total cost of feedback bits would not be increased. With the proposed quantization scheme, the quantization errors become smaller and the systems sum rate gets higher. A quantization criterion, which we refer to as the maximum sum rate criterion, is also proposed. Compared with the general minimum chordal distance metric, the proposed quantization criterion can bring out a higher sum rate. Performance improvement of the proposed scheme is analyzed. Simulations also confirm the effectiveness of the proposed scheme.

Di Fang
Beijing University of Posts and Telecommunications, P.R. China

Addressing IQ Mismatch in Spatial Interference Suppression systems

1569611153

Second order statistic based Spatial Interference Suppression has been shown effective in suppressing strong interference from jammers or concurrent transmissions. However, hardware impairments in the RF front end can be a major impediment to the design of such systems since the interference can be several orders of magnitude stronger than the signal. IQ mismatch is found to limit the interference suppression ability due to the creation of additional interference eigen modes from the image band of the interference source. We show how the concept of expanding the received signal sub-space can be used to mitigate this effect, and present an architecture for interference suppression in the presence of IQ mismatch. Simulation results indicate 12 dB more interference suppression when using the proposed architecture to compensate for IQ mismatch in indoor environments.

Gaelen Pereira
University of California, Los Angeles, USA

Leveraging Mobile Grid Computing for Interference Alignment and Cancelation

1569612923

Interference Alignment and Cancelation (IAC) technique is aimed at significantly improving the wireless channel capacity. Existing algorithms for IAC are computationally intensive, which may lead to long execution times. Practical implementation of IAC is infeasible for fast-varying channels (when the coherence time is small, e.g., less than 0.5s). This is because a significant amount of time has to be spent on channel estimation as IAC techniques are extremely sensitive to the degree of accuracy of channel estimates thus leaving a very small portion of time for actual data transmission. The collective computational capabilities of nodes in the neighborhood can be exploited (for parallelism) to facilitate the practical realization of compute-intensive IAC techniques. A novel resource provisioning framework, which organizes the mobile devices in the neighborhood to form an elastic resource pool -- a heterogeneous mobile computing grid -- is presented. This framework enables distributed execution of compute-intensive communication algorithms like IAC. The effectiveness of the proposed approach is studied in detail under different operational scenarios.

Parul Pandey
Rutgers University, USA
Iterative FDE Receivers for UWB Systems with Strong Interference Levels

1569589729

Since UWB (Ultra Wideband) signals usually share the spectrum with other transmissions, they tend to be subject to strong interference levels. The proposed iterative receiver combined with SC-FDE (Single-Carrier with Frequency-Domain Equalization) block transmission technique is an effective mechanism to mitigate such impairment of UWB signals. In order to further improve the performance through the exploitation of diversity, the proposed receiver implements an ARQ (Automatic Repeat ReQuest) error control technique. The combined technique results in a system able to face strong interference levels as well as deep fadings, even for fixed channels conditions.

Mario da Silva
Instituto de Telecomunicações, Portugal
Jamming and Communications Security Session

**Design of a Multitone Firefly Time Synchronization Scheme for Responsive Vehicle-Protection Jammers**

1569598093

We address the problem of time synchronization between responsive communications jammers employed for vehicle protection against radio-controlled improvised explosive devices. Unlike barrage jammers, which continuously transmit jamming signals on pre-defined frequency bands, responsive jammers periodically perform fast wideband scans of the radio spectrum and are thus able to react to observed threat signals. In order to avoid a ring-around effect when multiple responsive jammers are active during a common mission, we present a fully distributed time synchronization scheme, which is based on the 'firefly' synchronization mechanism known from the area of wireless communication networks. In particular, a rigorous design of the underlying phase response function is proposed. Simulation results complement our analytical findings and illustrate the excellent performance of the proposed synchronization scheme.

Patrick Loos
Universitaet der Bundeswehr Munich, Germany

**Anti-Jamming Defense Mechanism in Cognitive Radios Networks**

1569599875

Cognitive Radio is a technology that enables the spectrum sharing in an opportunistic fashion. However, as the development of cognitive radio technology occurs, its security problems like jamming arise. In this paper, the jamming attack in cognitive radio networks is studied. A scenario comprised by a primary user, a secondary user, and a spectrum jammer (namely attacker) is sketched. Since the legitimate secondary user needs to transmit control messages and data in the available channels, it is derived the best combinations of the number of control and data channels to the legitimate secondary user in face of different data applications considering the quality of service requirements reliability and throughput. It is also considered the device with and without power constraints.

Marcelo Camilo
Instituto Militar de Engenharia, Brazil

**Jamming Attacks Against OFDM Timing Synchronization and Signal Acquisition**

1569611429

Orthogonal Frequency Division Multiplexing (OFDM) is used in many modern communications systems. Timing and frequency synchronization in an OFDM system are critical to performance and must be carried out early and often. Current synchronization methods, such as those developed by Schmidl and Cox, were not designed to be robust to adversarial signals. A series of attacks against the preamble synchronization stage have been developed and demonstrated to debilitate OFDM receivers. Multiple attacks against the symbol timing estimation stage are discussed, and some possible improvements to OFDM synchronization algorithms are suggested.

Matthew Pan
Virginia Tech, USA

**Design and Simulation of a High Frequency Exact Solvable Chaotic Oscillator**

1569612575

It has been shown that the performance of communication systems based on low dimensional chaotic systems with exact analytic solutions containing a single fixed basis function may exhibit performance comparable to that of nonchaotic systems. Previously, novel low frequency (LF) oscillators exhibiting solvable, chaotic behavior have been proposed, although the generation of low frequency signals has limited applicability in the field of communications. These limitations
motivate the development of similarly solvable, chaotic oscillators that operate in high frequency (HF) bands (>1MHz). The design and simulation of a HF exactly solvable chaotic oscillator has been submitted. The behavior of this oscillator, although solvable, is chaotic; giving rise to encoding or encryption applications. This oscillator may be encoded by means of small perturbation control known as Hayes type chaos communications. Furthermore, it has been shown that symbolic information encoded with oscillators of this topology may be extracted accurately and elegantly through means of matched filter decoding.

Aubrey Beal
Auburn University, USA

An LPI Design for Secure OFDM Systems

1569612833

Traditional OFDM systems present some embedded features that may be exploited in order to intercept the wireless transmitted signal. However, such a possibility is not accepted in military applications where security is a very important issue. Cyclic prefix is one of the most obvious OFDM parameters that induce cyclostationarity features. Aiming to suppress these features, some classical solutions in literature propose to entirely remove the cyclic extension so that additional processing is needed to eliminate the inter-symbol interference. In this paper we propose two techniques that, when combined, allow to eliminate cyclostationary and spectral features of the OFDM waveform, while maintaining the cyclic prefix advantages. The cyclic-prefix size in each OFDM symbol is varied pseudo-randomly so that cyclostationary features are suppressed. Moreover, a pseudo-random frequency jitter is introduced to the carrier frequency in order to mask subcarrier spectral lines. Once these techniques are applied, the designed system is said to generate a low-probability-of-intercept waveform. Finally, Performance in multipath channels is investigated and shown to be effective.

Marwen Bouanen
École de Technologie Supérieure, Canada

Optimal Jamming with Codewords

1569614011

In this paper, based on a noise forwarding (NF) scheme, the joint design of the optimal covariance matrices of a source's and a helper's signals that maximize the secret rate is studied. Under general power constraints, it is shown that the non-convex design problem can be converted into a quasiconvex optimization problem composed of convex subproblems. The properties of the optimal covariance matrices are examined. Under the individual power constraint, beamforming is shown to be optimal, and the design problem is reduced to a problem with two variables. The performance of the NF scheme and the artificial noise (AN) scheme is compared. The design of hybrid scheme consisting of the NF and AN techniques is also addressed.

Han-Ting Chiang
Purdue University, USA
MIMO Communications Session

A Low Complexity Algorithm for Linear Precoder Design with Finite Alphabet Inputs

1569601581

A low complexity precoding method is proposed for practical multiple-input multiple-output (MIMO) systems. Based on the two-step optimal precoder design algorithm that maximizes the lower bound of the mutual information with finite-alphabet inputs, the proposed method simplifies the precoder design by fixing the right singular vectors of the precoder matrix to be the modulation diversity matrix, eliminating the iterative optimization between the two steps, and discretizing the search space of the power allocation vector. The modulation diversity matrices are designed for different modulations, which outperform the existing maximum diversity for BPSK and 8PSK inputs. For a 4-by-4 channel, the computational complexity of the proposed precoder design is reduced to 3% and 6% of that required by the original two-step algorithm with Quadrature Phase Shift Keying (QPSK) and 8PSK, respectively. The proposed method achieves nearly the same mutual information as the two-step iterative algorithm for a large range of SNR region.

Mingxi Wang
Missouri University of Science and Technology, USA

Mobile MIMO Capacity In Network Interference: Informed and Uninformed Transmitters

1569610181

An optimal MIMO receiver implicitly achieves the best balance between enhancing signal power and interference suppression to maximize link throughput, making MIMO a good candidate for mobile ad-hoc networks (MANETs) with potentially severe network interference. It is confirmed that MIMO achieves higher throughput in severe interference if transmitters reduce the number of transmit antennas or modes (data streams) used, using a more realistic model than previous results. A policy of reducing the number of transmit antennas or modes in interference requires some enforcement mechanism to implement, as individual links are optimized by using all available antennas, or a number of modes selected by water-filling. Informed Transmitter (IT-) MIMO links with CSI optimize single-link performance in severe interference by reducing the number of transmit modes, and concentrating available power in the strongest modes. It is shown here that this reduction in IT-MIMO signal complexity results in network performance close to that of network-optimized UT-MIMO, without the need for network coordination. Results were obtained using expressions for MIMO capacity in a simulated environment, with a large number of randomly located interferers, and more realistic propagation than previous work. The propagation model included Rice fading, log-normal shadowing, and range-loss exponents and shadowing standard deviations that grow with range.

Bruce McGuffin
MIT Lincoln Laboratory, USA
Spectral Efficiency of Signal Processing Radios in Interference Limited Environments: Array Processing, MIMO, and MUD

1569610207

Array processing, MIMO with and without CSI feedback, and MUD were all compared to baseline SISO communications links to estimate the achievable improvements to area spectral efficiency using these techniques in interference. Two scenarios were investigated, a MANET with random transmitter locations, and Air-to-Ground (ATG) links with interference located on a hexagonal grid. Results were found using spectral efficiency bounds in a propagation simulation with Rice fading, log-normal shadowing, and a range-loss coefficient that increases with range. Area spectral efficiency in the MANET scenario with 90% link reliability improved by a factor of 10 to 34, using 4-element arrays, and without network optimization. The ATG scenario with 99% link reliability showed improvement by a factor of 2 to 6.

Bruce McGuffin
MIT Lincoln Laboratory, USA

Bounding The Ergodic Capacity of Asymmetric 2x2 Dual-Polarized Channels

1569612569

We consider asymmetric MIMO channel models in an analysis of ergodic capacity for multi-polarized MIMO systems. Using Jensen's inequality we derive an upper bound for various asymmetric channel realizations that are parameterized by the co-polarized power ratio, cross-polarization discrimination measures, and sub-channel Rician K-factors. Computation of a lower bound is complicated by the inherent asymmetry in the model, which prevents use of existing random matrix theories developed for Wishart matrices and Quadratic forms of Gaussian vectors. A lower bound is derived based on Minkowski's inequality and an approximation is also proposed that is shown numerically to be close to the lower bound.

Farzad Talebi
University of Notre Dame, USA

High-Rate Ultrasonic Communication Through Metallic Barriers Using MIMO-OFDM Techniques

1569612861

This paper presents methods to achieve high data transmission rates through metallic barriers using ultrasonic signalling techniques. Due to the frequency selective nature of acoustic-electric channels, orthogonal frequency division multiplexing (OFDM) is employed which achieves high spectral efficiency. Multiple parallel channels are used to further increase data rates. Multiple-input multiple-output (MIMO) techniques are used to reduce crosstalk that would otherwise greatly limit performance and achievable data rates. Several crosstalk cancellation structures are investigated and their theoretical capacity performances are determined for the general case of $A$ transmitters and $A$ receivers (i.e. $A$x$A$ MIMO). A physical 7x7 MIMO acoustic-electric channel array is formed using a 40 mm (1.575 in) thick steel barrier with seven pairs of 4 MHz nominal resonant frequency piezoelectric disk transducers, each with 10 mm (0.394 in) diameter. To investigate the effects of crosstalk, the transducers are closely spaced, and each transmitter-receiver pair is coaxially aligned on opposing sides of the metallic barrier. It is shown that, with the use of crosstalk cancellation techniques, the aggregate multichannel capacity performance scales linearly with the number of channels used and approaches 700 Mbps at high average signal-to-noise ratio (SNR) levels. Finally, the use of bit-loading techniques are explored using several levels of rectangular quadrature amplitude modulation (QAM), and the achievable data rates are compared with each other and to the multichannel theoretical capacity performances.

Jonathan Ashdown
Rensselaer Polytechnic Institute, USA
Branch and Bound with M Algorithm for Near Optimal MIMO

In this paper, an efficient Multiple-input multiple-output (MIMO) detection scheme with low complexity is proposed. The proposed scheme is based on combining Branch and Bound algorithm (which solves an integer quadratic programming (IQP) problem in each node of the search tree) with M-Algorithm (which chooses M reliable candidates nodes out of the available nodes, in each stage of the search tree, and retain them). The basic idea is analogous to the conventional QRD-M that presented in the literature, but the internal procedures of the algorithm is different, as the proposed algorithm uses the IQP based on BB algorithm. Not just that but also the M value in BBM is proved to be less than M in QRDM. Furthermore, the performance of our algorithm is far better than the QRD-M in terms of BER and computational complexity especially for higher order modulation (e.g. 64 QAM and 256 QAM). Simulation results show that the proposed detection scheme provides comparable performance to the ML detection at small M with fixed complexity exponent regardless of the SNR. This scheme can significantly reduce the computational complexity compared with the ML and QRD-M, hence, it is a promising scheme for optimal and near optimal performance of MIMO systems using higher order QAM modulation.

Ali Elghariani
Purdue University, USA
Modulation Session

Partitioned Cyclic Code Shift Keying for JTIDS

1569586291

In this paper, we propose partitioned cyclic code shift keying (PCCSK) for the Joint Tactical Information Distribution System (JTIDS) by combining a Hadamard matrix and modified maximal length sequences (MMLS). The proposed approach adaptively increases the transmission data rate within a limited transmission range in the battlefield. By exploiting a new code set as a spreading code and by adopting code selection, the system is easily able to achieve higher spectral efficiency. For additional performance enhancement, we apply adaptive channel coding with PCCSK, and we derive the appropriate code pairs. Monte Carlo simulations are conducted to show the transmission ranges of the proposed scheme, and the results show that PCCSK with adaptive coding can support a higher data rate with a reasonable transmission range.

Hong Jun Noh
Ajou University, Korea

Synchronization Performance using Scale Time Offset Robust Modulation

1569591471

Scale Time Offset Robust Modulation (STORM) is a waveform design technique involving the simultaneous transmission of a base waveform as well as a time-scaled and time-delayed copy of that waveform. For some applications this technique is attractive as a possible candidate to enhance synchronization performance, due to the different tradeoffs of its performance properties. This paper first presents background for the STORM technique. From there, a theoretical analysis of the performance of STORM as a possible timing synchronization mechanism is presented.

John Windish
The Pennsylvania State University, USA

Signal Recovery for CPM in Frequency Flat Fast Fading Channels

1569599963

A channel estimation scheme applicable to nonlinear modulation over frequency flat fast fading channels is presented. It is shown that the use of local B-splines for channel estimation results in excellent error rate performance and also low complexity compared to more traditional approaches.

Colin Brown
CRC, Canada

Analysis of M-ary UWB FSK Detected Using Two Passband Filters Considering Antenna and Multipath Effects

1569600081

We study ultra wideband (UWB) communications over dense multipath channels with M-ary frequency shift keying (FSK) data modulation and low complexity receivers. We model the signal transmission-reception taking into account the effects of both the frequency response of the antenna system and the frequency selectivity of the multipath channel. We derive an expression for the bit error rate (BER) when detection is achieved using a pair of passband filters. While other low complexity binary receivers reported in the literature present a large signal-to-noise ratio (SNR) degradation with respect to the binary coherent detection, using our signal design and filter-based detection the loss with respect to the binary coherent detection is only $3.5$ dB using a binary receiver with no channel estimation.
Some Remarks on the Dirac Delta Function Approximation for ASER Analysis of Digital Modulations over Fading Channels

1569614025

In this article, we apply two different approaches to obtain approximation for integer power probability of error of digital modulation schemes over fading channels. Firstly, we utilized the sampling property of Dirac delta function on three tight approximations for the Gaussian probability integral $Q(.)$ to obtain the integer power probability of error over fading channels. This approach reduces the integration to a sampling with framework also facilitating the derivation of simple and tight approximation formula for the average symbol error probability (ASEP) for a wide range of digital modulation schemes over generalised fading channels. Secondly, another approach for deriving asymptotic ASEP which involves use of moment generating function (MGF) was also investigated. Numerical results show that the Dirac delta function approximation performs poorly at different channel conditions while the MGF method is more helpful as it give error rates that are indistinguishable from the exact results obtained by numerical integration.

Efficient Receivers for SC-FDE with Offset Modulations

1569609405

Offset QAM signals (Quadrature Amplitude Modulation) allow good power-bandwidth trade-offs, making them good candidates for broadband wireless systems, especially when combined with SC-FDE schemes (Single-Carrier with Frequency-Domain Equalization). However, FDE receivers designed for non-offset modulations have poor performance when employed with offset modulations and even FDE receivers specially designed for offset modulations have poor performance when large offset QAM constellations are employed. This is especially serious for non-uniform constellations. In this paper we study the reason behind the poor performance of offset modulations with conventional FDE schemes and present pragmatic FDE receivers for offset modulations that have low complexity but allow excellent performance, even for large and highly non-uniform offset QAM constellations.

Miguel Luzio
Instituto de Telecomunicações/UNINOVA/FCT-UNL, Portugal
OFDM Session

An OFDM-Based Distributed Transmission Scheme for Uncoordinated Transmitters Without Carrier Frequency and Timing Synchronization

1569599293

Distributed transmission involving multiple uncoordinated transmitters has become a popular subject in wireless communications, such as cooperative transmissions, relaying, distributed MIMO, network coding, multi-access and multi-user detection. One of the major challenges for implementing distributed transmissions is the difficulty of synchronizing carrier frequency and timing of the distributed transmitters. In this paper we propose a new OFDM-based transmission scheme that does not require carrier frequency and timing synchronization. Specifically, by exploiting jointly OFDM cyclic prefix (CP), spreading and scrambling techniques, the receiver can cancel multiple carrier frequency offsets and timing offsets completely. This comes at no loss of bandwidth efficiency or power efficiency. In contrast, by allowing multiple OFDM symbols to share a CP, the bandwidth efficiency can even be higher than that of conventional OFDM. This scheme can support most of the existing distributed or cooperative transmission frameworks.

Xiaohua (Edward) Li
State University of New York at Binghamton, USA

Robust Receiver Algorithms to Mitigate Partial-Band and Partial-Time Interference in LDPC-coded OFDM Systems

1569600061

Orthogonal frequency division multiplexing (OFDM) systems are vulnerable to narrow-band jamming signals. We jointly tackle two problems: channel estimation in the presence of unknown interference, and decoding with imperfect channel knowledge. In this paper, we propose robust, yet simple, receiver algorithms consisting of both channel estimation and information decoding. The receiver conducts threshold tests to detect interference followed by pilot erasure and channel estimation. Then, channel estimation error and unknown interference statistics are dealt with by the robust log-likelihood ratio (LLR) calculations for soft iterative decoding. The proposed receiver algorithm does not require any statistical knowledge of interference and its complexity is linear against the length of codewords. Simulation results show that the bit-error-rate (BER) performance of the proposed system is 2 dB away from a genie system where channel information and interference parameters are perfectly known. We also demonstrate that soft decision feedback from a decoder to enhance channel estimation achieves additional 1 dB improvement.

Liangbin Li
University of California, Irvine, USA

Multi-Cycle Cyclostationary-based Spectrum Sensing Algorithm for OFDM Signals with Noise Uncertainty in Cognitive Radio Networks

1569608301

This paper proposes a simple multi-cycle cyclostationary based signal detection (spectrum sensing) algorithm for Orthogonal Frequency Division Multiplexed (OFDM) signals in cognitive radio networks. We assume that the noise samples are independent and identically distributed (i.i.d) random variables all with unknown (imperfect) variance. Our detection algorithm employ the following three steps. First, we formulate the test statistics as a ratio of two quadratic cyclic autocorrelation functions. Second, we derive a closed form expression for the false alarm probability. Third, we evaluate the detection probability of our algorithm for a given false alarm probability. The derived probability of false alarm expression fits to that of the simulation result. Moreover, we demonstrate that the proposed multi-cycle algorithm yields significantly superior probability of detection compared to the existing low complexity cyclostationary based and the well known energy detection algorithms.
Subcarrier-based Threshold Performance Enhancement in Constant Envelope OFDM

1569610761

Constant Envelope OFDM (CE-OFDM) addresses the major issue of a high peak-to-average power ratio (PAPR) in OFDM. However, since CE-OFDM is based on angle modulation, it suffers from the well known threshold effect which results in a large performance degradation at low carrier-to-noise ratios (CNRs). In this paper, we study the impact of the threshold effect induced phase cycle slips on the underlying phase modulated OFDM subcarriers in CE-OFDM. We study both the signal-to-noise ratio (SNR) as well as the bit error rate (BER) performance on a subcarrier basis and show that the performance degradation due to the threshold effect is much more significant at lower frequency subcarriers. Finally we develop a low complexity subcarrier based technique to mitigate the effect of the phase cycle slips for significant performance improvement.

Ahsen Ahmed
SPAWAR Systems Center Pacific, USA

Interference Analysis of Interleaved and Localized Mapping Schemes in OFDMA System with Carrier Frequency Offset

1569612333

In this paper, we analyze the effect of Carrier Frequency Offset (CFO) of multiple users on the SINR of a single user in OFDMA based uplink communication receiver. We have computed an explicit SINR expression for two types of mapping strategies used in uplink OFDMA systems namely Interleaved Frequency Division Multiple access (IFDMA) and Localized Frequency Division Multiple access (LFDMA). SINR expressions in case of carrier frequency offset correction are also computed. Based on the analytical expression and simulation, it is shown that Interleaved mapping in general results in more interference than Localized mapping. In addition, the interference due to interleaved mapping is almost constant for all subcarriers of the desired user while that of localized mapping is variable with minimum interference at the center of the allocated band and it increases as we move towards the subcarriers at the band edges.

Bilal Ranjha
The Pennsylvania State University, USA

Detection of Code Spread OFDM Based on 0-1 Integer

1569612955

In this paper we introduce Integer Quadratic Programming (MIQP) approach to optimally detect QPSK Code Spread OFDM (CS-OFDM) by formulating the problem as a combinatorial optimization problem. The Branch and Bound (BB) algorithm is utilized to solve this integer quadratic programming problem. Furthermore, we propose combined preprocessing steps that can be applied prior to BB so that the computational complexity of the optimum receiver is reduced. The first step in this combination is to detect as much as possible symbols using procedures presented in [9], which is basically based on the gradient of quadratic function. The second step detects the undetected symbols from the first step using MMSE estimator. The result of the latter step will be used to predict the initial upper bound of the BB algorithm. Simulation results show that the proposed preprocessing combination when applied prior to BB provides optimal performance with a significantly reduced computational complexity.

Ali Elghariani
Purdue University, USA
Direction Finding of a Compromised Node in a Spread-Spectrum Network

1569588381

When a spread-spectrum receiver in a network discovers that it is processing a jamming signal transmitted by a compromised node, its first response is to attempt to identify the compromised node. In this paper, an adaptive array is used to find the direction to the jamming source despite the presence of interference signals transmitted by both legitimate network nodes and external sources. Unlike other direction-finding algorithms, the desired-signal classification (DESIC) algorithm requires no information or special assumptions about the interference signals to effectively cancel them and find the desired direction. Simulation experiments show that the DESIC algorithm provides an excellent performance in many scenarios, even when the received signals cannot be resolved by the widely used MUSIC algorithm.

Don Torrieri
US Army Research Laboratory, USA

The Ambiguity Function of XM Radio Applied to False Target Detection in a Passive Radar

1569600849

Passive coherent location utilizing non-cooperating spaceborne illuminators can enable the detection and tracking of aircraft utilizing a low-cost, non-transmitting ground station. The strong S-band downlinks from the geostationary digital audio broadcast satellites of XM Radio are good illuminators for such work. This paper presents an analysis of the measured ambiguity function of the 2.332 GHz channel of the XM-3 satellite. Although the ambiguity function is generally well-behaved, it is shown that correlation peaks on the level of 1% exist at delay and Doppler combinations of potential target aircraft. These peaks can cause the false indications of targets in bistatic radar data.

William Barott
Embry-Riddle Aeronautical University, USA

Experimental Demonstration of Cognitive Radar for Target Localization under Strong Interference

1569605755

One of the major objectives of cognitive radar is to form a dynamic closed feedback loop to adapt the spectrum of transmit waveforms to avoid certain interference. In this paper, we build an automatic closed-loop cognitive radar to support experimental study of the radar system in real-world situations. Convex optimization is applied to jointly design sounding waveforms and the matched filters with spectral power suppressed in arbitrary bands and with low correlation sidelobes as well. Target localization is demonstrated under strong interferences. Experimental results are provided to evaluate the performance of the cognitive radar system.

Xia Li
Tennessee Technological University, USA

Enhanced Monopulse MIMO Radar using Reliable $\alpha\beta$ Filtering

1569610305

Typically, the radar systems are put into the two categories: phased array radar with closely spaced antenna elements, and multiple-input multiple-output (MIMO) radar with widely separated antennas. In this paper, we first review the detection performance of each of scheme and investigate the compromised scheme, so called directional MIMO radar. Then, we also proposed a enhanced MIMO radar system as a special case of directional MIMO radar. We show that the localization...
performance is significantly improved, by applying the $\alpha\beta$ filter. We also propose a tracking algorithm that involved with filtering process. Using numerical simulations, we demonstrate that the proposed scheme can improve the localization performance while reducing the feedback from each receivers.

Chan-ho An
Yonsei University, Korea

Estimation 2D DOA of Coherent Signals Using a New Antenna Array Configuration

1569612693

This paper presents an efficient scheme for a two-dimensional (2-D) direction of arrival angle estimation (DOA) for multiple incident sources in the presence of coherent signals. A new antenna array configuration and innovative signal processing technique are presented. Compared with the well-known classical subspace schemes such as MUSIC and ESPRIT, the proposed method has several advantages. First, the proposed method can accurately estimate 2D DOA using a single snapshot data, whereas existing schemes need multiple snapshots. Second, it does not require forward/backward spatial smoothing of the covariance matrix or 2D iterative searching; however, existing schemes do. These advantages guarantee that the proposed scheme has a lower computational complexity and is more appropriate for high-speed wireless communication applications. The simulation results verify that the proposed method provides a better performance than the well-known ESPRIT method and L-shaped array with less computational complexity.

Nizar Tayem
Prince Mohammad Bin Fahd University, Saudi Arabia)
Radio Resource Management Session

Optimal Resource Allocation in HARQ-based OFDMA Wireless Networks

1569590791

This paper deals with multiuser resource allocation (power, bandwidth, constellation size, and code rate) for an OFDMA system using HARQ in the context of Rayleigh distributed channel. We assume that the resource manager (base station or cluster head) only knows the channel statistics of the active links. Then, an optimal algorithm for minimizing the total transmitted power under per user goodput constraints is proposed. Extension to imperfect feedback on HARQ scheme is also performed. This algorithm can be especially applied to military ad hoc wireless networks.

Sébastien Marcille
Telecom Paristech, France

Online Learning in Decentralized Multi-user Spectrum Access with Synchronized Explorations

1569605273

In this paper we consider decentralized multi-user online learning of unused spectrum bands as an opportunistic spectrum access (OSA) problem. There is a set of M secondary users exploiting the spectrum opportunities in K channels. We develop a distributed algorithm for the secondary users that will learn the optimal allocation with logarithmic regret. Thus, our algorithm achieves the fastest convergence rate to the optimal allocation. In a more general framework, our algorithm gives an order optimal solution to the decentralized multi-player multi-armed bandit problem with general reward functions.

Cem Tekin
University of Michigan, USA

A Bipartite Matching Based User Grouping Method for Grouped OFDM-IDMA Systems

1569612677

In this paper, we present a novel user grouping method for grouped OFDM-IDMA systems. Aiming at maximizing the system capacity, we adaptively distribute the users among the pre-allocated subcarrier groups according to their respective channel conditions. We analyze the achievable capacity of the system and formulate the optimization problem as a weighted bipartite matching problem. Kuhn-Munkres method is employed to solve the problem. The performance of the proposed scheme is evaluated through both theoretical analysis and simulation. It shows that with our proposed algorithm, the system throughput is greatly improved and is very close to the theoretical upper bound.

Xiaotian Zhou
Shandong University, P.R. China
The Sub-channel Allocation Algorithm in Femtocell Networks Based on Ant Colony Optimization

1569613931

Femtocells are an effective technology to improve the system performance. In this paper, we address the problem of sub-channels allocation in OFDMA two-tier femtocell networks. Our objective is to maximize the rate sum of multiple femtocells with consideration of cross-tier interference between macrocell and multiple femtocells. A resource optimization approach based on Ant Colony Algorithm is proposed to implement the solution process of system. Simulation results show that the proposed algorithms not only improve the capacity of the femtocell system but also provide good proportional fairness among the femtocell users, as compared with the traditional algorithm.

Deli Liu
Beijing University of Posts and Telecommunications, P.R. China
High Throughput Farrow Resamplers Utilizing Reduced Complexity FIR Filters

New VLSI high throughput parallel structures for arbitrary rate non-integer ratio sample rate conversion are presented in the paper. High throughput Sample Rate Converters (SRC) find application in high data rate Software Defined Radio (SDR) where a large degree of flexibility is required to support varied sample rates. Parallel Signal Processing implementations offer higher throughput for lower clock speeds. This makes them ideal for high data rate modem implementations on FPGA's or in power limited ASIC designs. The Farrow structure offers unique advantages ideal for parallel implementation. These unique qualities allow the utilization of novel reduced complexity parallel finite-length impulse response (FIR) filters. The structures presented in this paper are suitable for implementation on application specific integrated circuits (ASIC) or field programmable gate arrays (FPGA). Results shown here are for implementation on FPGAs with varying orders of parallelization.

Jeffrey Long
The MITRE Corporation, USA

Quickest Change Point Identification Across a Sensor Array

The problem of quickly detecting a statistical change and identifying the change source is considered. In the problem studied, there are multiple sensors. A change can first occur at any one of these sensors and propagate to other sensors. One is required to detect the presence of such change with a minimal delay and furthermore identify the sensor that first observes the change. Three performance metrics, namely detection delay, false alarm probability and false identification probability, are of interest. The optimal stopping rule, determining when one should stop sampling and claim a change has occurred, and the optimal terminal decision rule, determining which sensor first observes the change, that minimize a weighted sum of these three performance metrics are characterized. We obtain the optimal solution by first converting the problem at hand to a Markovian stopping time problem and then solving the problem using tools from the optimal stopping theory.

Lifeng Lai
Worcester Polytechnic Institute, USA

Signal Processing Advances for the MUTE sEMG-Based Silent Speech Recognition System

Military speech communication often needs to be conducted in very high noise environments. On the other hand, it is beneficial to have covert voice communications, such as anti-terror special ops. To enable both capabilities, we have developed the MUTE (Mouthed-speech Understanding and Transcription Engine) system, which bypasses the limitations of traditional acoustic speech communication by measuring and interpreting muscle activity of the facial and neck musculature involved in silent speech production. This article details our recent progress on automatic sEMG speech activity detection, feature parameterization, multi-task sEMG corpus development, context dependent sub-word sEMG modeling, discriminative phoneme model training, and flexible vocabulary continuous silent speech recognition. Our current system achieved recognition accuracy at developable level for a pre-defined special ops task.

Yunbin Deng
BAE Systems, USA
Surgical telementoring can prove very effective in a military surgical paradigm where less experienced surgeons deployed at forward sites can be mentored by more experienced specialists from a rearward remote site, thus enhancing in-theater surgical options by bringing scarce expertise into play. However, lack of sufficient bandwidth in active military theaters limit the ability to implement real-time video communication capability, and hence render such clinically beneficial programs undeliverable. Region-of-interest (ROI) video-coding presents a possible solution to this problem. By allocating more bits to the ROI as compared to the rest of the frame (also known as background (BG)), ROI encoding of surgical videos can increase the bandwidth perceived by the telementoring application. In this paper, we introduce a flexible and interactive ROI in a low-complexity, H.264-compliant and diagnostically lossless (DL) fashion to enable remote mentoring of surgical procedures in very low-bandwidth scenarios. Further, subjective evaluations by surgeons indicate that ROI-encoded videos are preferred over the uniformly-encoded videos for the purpose of surgical evaluation and mentoring.

Sourabh Khire
Georgia Institute of Technology, USA
Signal Detection and Classification Session

Improved Modulation Classification using a Factor-Graph-based Iterative Receiver

1569610753

We bring together two research topics which have been the focus of significant research individually: modulation classification and iterative receiver design. In this work, these topics are joined within the framework of factor graphs which provide a unified approach to representing a variety of algorithms, especially iterative algorithms. Specifically, in this paper we present a factor graph which incorporates modulation classification into the iterative receiver structure. The proposed iterative receiver applies message passing on the factor graph to approximate the optimal solution to joint modulation classification, demodulation, and decoding. This results in a classifier which treats feedback from the decoder as a priori probabilities for the coded bits. We show that the proposed receiver is able to achieve significant performance gains over a receiver which performs maximum likelihood classification separately from demodulation and decoding.

Daniel Jakubisin
Virginia Tech, USA

Properization of Second-Order Cyclostationary Random Processes and Its Application to Signal Presence Detection

1569611417

In this paper, we show that a second-order cyclostationarity (SOCS) random process, whether it is proper or improper, can always be converted to an equivalent proper-complex SOCS random process with twice the cycle period. A simple linear-conjugate linear periodically time-varying operator called a FREquency SHift (FRESH) properizer is proposed to perform this conversion. As an application, we consider the presence detection of an improper-complex SOCS random process, which well models the complex envelopes of digitally modulated signals such as pulse amplitude modulation (PAM), staggered quaternary phase-shift keying (SQPSK), Gaussian minimum shift keying (GMSK), etc. In particular, the optimal presence detector that utilizes the FRESH properizer is derived for improper-complex SOCS Gaussian random processes, which provides the lower bound on the detection error probabilities. The derived optimal detector, which has the structural advantage in that it consists of a FRESH properizer followed by single linear filter, achieves the same performance as the conventional detector that consists of parallel-connected linear and conjugate-linear filters. Numerical results are also provided.

Jeong Yeo
Pohang University of Science and Technology (POSTECH), Korea
Template Matching for Signal Identification in Cognitive Radio Systems

1569612279

Spectrum sensing feature of cognitive radio systems introduces methods to improve the spectrum utilization. The unique signatures or specific features of wireless signals can be utilized to improve the performance of spectrum sensing by identifying the signals. Moreover, spectral efficiency can be improved by achieving signal orthogonality in different domains such as code, polarization and location beside the frequency and time. However, such methods assumes the types of the signals of interest to be known. In this paper, template matching method is proposed as a new spectrum sensing technique to identify the wireless signals based on the spectral signatures in the spectrum. In contrary to the original template matching approach, the number of templates to be kept in the database is limited to one abstract signal for each signal type. The templates are constructed from the abstracts and scaled based on the template matching parameters. Two new metrics are introduced for signal identification method proposed. The performance of proposed metrics are also compared with that of energy detection for wireless fading channels. Identification of the signals with the similar signatures are discussed as well.

Ali Gorcin
USF, USA

Cumulant-Based Channel Estimation Algorithm for Modulation Classification in Frequency-Selective Fading Channels

1569612319

Due to the lack of sufficient channel state information, modulation classification in frequency-selective fading channels is a challenging task. This is mainly because the complexity of the pre-processing stage, where the required channel state information for (optimal) likelihood-based classification is estimated, can be relatively high. For this reason, we propose in this paper a low-complexity cumulant-based channel estimation algorithm that enables the reliable classification of digital amplitude-phase modulated signals in frequency-selective fading channels. Numerical results are presented which show that the proposed algorithm outperforms a commonly used channel estimation algorithm for modulation classification, especially at low signal-to-noise ratio values. Using the proposed algorithm, it is also shown that the performance of a practical modulation classification method can approach that of a clairvoyant classifier assumed to have perfect channel knowledge.

SaiDhiraj Amuru
Virginia Tech, USA

A New DFT-Based Frequency Estimator for Single-Tone Complex Sinusoidal Signals

1569612673

Frequency estimation for single-tone complex sinusoidal signals under additive white Gaussian noise is a classical and fundamental problem in many applications, such as communications, radar, sonar and power systems. In this paper, we propose a new algorithm by interpolating discrete Fourier transform (DFT) samples. Different from other existing interpolation methods for frequency estimation, our algorithm is based on a much simpler expression and has mathematically tractable bias expression in closed form, which can potentially assist future bias correction. Simulations confirm that our proposed algorithm outperforms all existing alternatives in the literature with comparable complexity.

Luoyang Fang
Colorado State University, USA
Identification of OFDM Signals Under Multipath Fading Channels

1569612895

Modulation identification is an important part of adaptive communications systems and distinction of OFDM systems from single carrier systems is highly important from the aspects of adaptive receiver algorithms and blind receiver design. OFDM signals exhibit Gaussian characteristics in time domain in contrast with the single carrier signals. However, when the wireless communications considered, Gaussianity of the received samples is affected from the channel impairments along with the frequency and phase offsets. In this paper, we first analyzed how the time-domain Gaussianity of OFDM signals is affected under these conditions, and adapted a general a chi-square constant false alarm rate test which employs estimates of fourth order cumulants and their covariance estimates to the peculiar case of OFDM signals. A parametric analysis of the performance of the proposed method is provided depending on the parameters such as such as signal to noise ratio, number of symbols, and modulation order as well.

Ali Gorcin
USF, USA
Spread Spectrum

A Quick Pull-In Timing Recovery Technique for Frequency Hopped Systems

1569570611

In this paper we propose a quick pull-in timing recovery technique for coherent M-ary Phase Shift Keying (MPSK) receivers for frequency hopped systems. The pull-in technique approximates the maximum likelihood (ML) technique. It is achieved based on a set of six correlators spaced equally by a half symbol period (Tsym) and an interpolation filter. The interpolator is designed to exploit the property of the transmitting filter. It is chosen to satisfy the Nyquist zero-intersymbol interference (ISI) criterion. Computer Monte Carlo simulation is used to evaluate the performance of the pull-in technique against the ML technique. For Binary Phase Shift Keying (BPSK) signaling, we show that the performance of proposed technique tracks the ML technique.

Lan Nguyen
LinQuest Corporation, USA

Pulse Rotation Modulations for Spread Spectrum Communication Systems

1569598925

Spread spectrum communication systems excel in their ability to provide enhanced security and channel sharing, yet they do so at the expense of data throughput to each individual user. This paper presents an alternative mechanism for increasing the data throughput in wideband spread spectrum systems built on top of direct sequence or chaotic sequence modulations. The result is a low-cost mechanism for rotating the spread pulse within its own symbol duration, leading to higher data throughputs that can be throttled up/down as the channel and multiple access conditions change. Challenges with signal synchronization, spreading code orthogonality, and carrier-induced phase rotations are addressed. Simulated results for various cases of pulse rotation modulation (PRM) systems, extrapolated from a measured hardware prototype that has been used to demonstrate the PRM technique, are also presented.

Alan Michaels
Harris Corporation, USA


1569599359

In new paradigms of war, such as Network Centric Warfare (NCW), increasing flow of information is necessary in order to provide strategic superiority and, in consequence, increased combat power. As network-centric solutions started to be thought for military systems, increasing data rates showed to be necessary and Free Space Optics (FSO) technology appeared as a good solution. FSO uses modulated optical focused beams to establish atmospheric data transmission. This re-emerging technology combines high data rates (around 2.5 Gbps in commercial implementations), characteristic of optical medium, with short deployment time, an advantage of Radio Frequency (RF) systems. In addition, the convergent optical beam presented by FSO (divergence angles of up to 10 mrad), allows the optical links to provide significant degrees of security and immunity to interception. This characteristic, along with high network reconfigurability (provided by the short deployment time), license-free operation and low sensitivity to electromagnetic interference and jamming, makes FSO systems even more interesting for defense applications. Nevertheless, despite the good degree of physical security provided by the convergent beam, ON-OFF keying (OOK) modulation, used by most FSO systems, is not adequate to logically hide the information, if the beam is intercepted. This scenario should be considered, in the case of long-haul military mobile system with large divergence angles. Other disadvantage is that these systems are vulnerable to atmospheric phenomena, such as attenuation and scintillation. All these factors must be considered during the design of a new FSO system for military purposes. Code Division Multiple Access (CDMA) is a spread spectrum technique which provides efficient access to the channel, by allowing many users to access it asynchronously. The access is made through the assignment of unique signature codes, called Pseudo-Noise (PN) sequences, for each user. With these
codes, the signal becomes more difficult to be read or jammed by a possible intercepting receiver if the PN sequence used is not known. That is why the purposed system at this work uses the optical version of CDMA, OCDMA, to code the signals of multiple users sharing a common FSO system. However, OCDMA, being a spread spectrum technique, increases the bandwidth occupied by the transmitted signal. In addition, the signature sequences have to obey certain correlation properties in order to reduce the multiple-access interference (MAI) and provide good Bit Error Rate (BER) performance. Normally, these sequences are called optical orthogonal codes (OOC). The most common type of OCDMA system uses one-dimensional (1D) incoherent time domain encoding. Nevertheless, the number of users in a 1D temporal (also called Direct Sequence - DS) OCDMA network is limited. For this reason, two-dimensional (2D) codes started to be studied around 1990 achieving increased number of users and improved performance. 2D wavelength-hopping/time-spreading systems perform the coding in both time and frequency domain and can be designed starting from a usual 1D temporal system with different wavelengths being used in a coded way. An important and commonly proposed component for DS-OCDMA applications is the so called optical hard-limiter. It is a threshold element combined with optical feedback to achieve a bistability response. The hard-limiter stage can also be used in 2D system to equalize the power response between the different spectral components and increase the BER performance of each user. This work analyses the performance of a complete OCDMA system over FSO link under strong atmospheric turbulence. The system feasibility and performance is demonstrated through simulation with the commercial tool known as OptiSystem, from Optiwave, Inc. If a necessary component was not present in the software or its model did not correspond to the expectations, the desired device was created and programmed using the software MatLab. With the presented proposal, multiple users could share one unique optical wireless channel, transmitting coded information for defense mobile applications. A usual optical sequence, such as Prime Code, is used for both wavelength-hopping and time-spreading. The effects of variable number of users and strong turbulence are considered in terms of BER. In addition, differences of performance for single and double hard-limited architectures are demonstrated.

Vítor Carneiro
Instituto Militar de Engenharia, Brazil

Design and Implementation of a Multicarrier Spread Spectrum Communication System

1569606085

In this paper, we present a novel multicarrier spread spectrum (MC-SS) system based on filter bank theory. We refer to our system as filter bank MC-SS (FB-MC-SS). The system parameters that lend themselves to an efficient implementation are identified, and the relevant signal processing blocks are accordingly developed. The developed FB-MC-SS system is realized on a software radio platform and the experimental results are compared against those of its direct sequence spread spectrum (DS-SS) counterpart. Our experiments demonstrate a variety of jamming conditions where FB-MC-SS outperforms the conventional DS-SS by a significant margin.

Daryl Wasden
University of Utah, USA

Iterative Decoding in SFH Communications with Reed-Solomon Codes and Channel Estimation

1569611255

The performance of packet-level iterative decoding is examined for a slow-frequency-hop spread-spectrum system using interleaved Reed-Solomon code words and per-dwell differential encoding. It is shown that the use of per-dwell soft-output detection in conjunction with successive-erasures decoding results in much better performance than previously considered iterative decoding techniques for the same packet format, in particular with respect to the robustness of the system in the presence of partial-band interference. Several alternatives are considered for soft-output detection and the accompanying estimator of the per-dwell signal-to-interference-plus-noise ratio.

Madhabi Manandhar
Clemson University, USA
A frequency-hopping ad hoc network with a fixed number of mobiles and finite spatial extent is analyzed and optimized. The channel model accounts for shadowing and path-loss, and allows a Nakagami-m parameter that can vary among the inter-mobile channels. A closed-form expression is found for the outage probability conditioned on the locations of the mobiles and the shadowing factors. The conditioning is removed by averaging over the spatial distribution and the distribution of the shadowing. Using the outage probability, the modulation-constrained transmission capacity is found, which is a measure of the spatial spectral efficiency when the system is assumed to use noncoherent continuous-phase frequency shift keying and a capacity approaching code. Using modulation-constrained transmission capacity as an objective function, the system is optimized with respect to the code rate, modulation index, and number of frequency hopping channels.

Matthew Valenti
West Virginia University, USA
Underwater Communications

Time Reversal Multicarrier Communications over Long Multipath Fading Channels

1569545677

Time-reversed orthogonal frequency division multiplexing (TR-OFDM) has recently received attention as a promising scheme for supporting single-input multiple-output (SIMO) communications over time-dispersive fading channels. In TR-OFDM, the time reversal processing cleverly converts multiple time-dispersive fading channels associated with SIMO-OFDM into a single channel with generally smaller time dispersion and less fading. As a result, a moderate cyclic-prefix (CP) length can be used without inducing much inter-block interference (IBI) even when the original channels are long. This paper tackles a technical challenge critical to the success of TR-OFDM, that is, how to minimize the CP length while satisfying certain performance requirements. Based on a data model derived for TR-OFDM, a quantitative relationship between the CP length and error performance is first established and a design procedure is then proposed. Our design reveals that the optimal CP length depends on the power delay profiles of underlying channels. Both theoretical analysis and numerical simulations confirm the merits of our design.

Zhiqiang Liu
Naval Research Laboratory, USA

An Overview of Channel Coding For Underwater Acoustic Communications

1569567525

Since a few years, GESMA (Groupe d’Etudes Sous-Marines de l’Atlantique) has been managing a project named TRIDENT (TRansmission d’Images et de Données EN Temps réel). GESMA aims at building a multiple rate acoustic link, that would be able to transmit different kinds of data (text, images, speech) through the Underwater Acoustic (UWA) channel, with a view to provide Autonomous Underwater Vehicles (AUV) with a wireless communication link.

A real-time platform receiver [1], based on a space-time equalizer previously developed by Telecom Bretagne, has been design to reduce the various perturbations brought by the underwater acoustic channel. So far the acoustic link scheme did not use channel coding. In spite of its reliability, residual errors can be observed, even at high Signal to Noise Ratio (SNR). In order to correct them and provide a strongly protected transmission link, the channel coding option is analysed in this paper. In first, Two kinds of error correcting schemes has been tested, namely Convolutional Codes (CC) and Reed Solomon(RS) block code [2][3]. These two tested channel coding schemes have a low code rate (0.5 for the CC and 0.7 for the RS). In order, to improve the symbol correction and obtain a higher code rate, Reed Solomon Block Turbo Codes (RS BTC) [4] has also been tested. The iterative decoding process that we used is a soft version of the Chase algorithm. For the soft decoding process we also considered Berlekamp and Chien algorithms.

The sea trials were carried out in the bay of Brest in moving conditions and up to 3500 meters range. The objectives of these trials were to check both transmitter and receiver operating in moving and realistic conditions. Most of the sea trials have showed the equalizer robustness for both stationary and moving conditions. The first trials in October 2007 were performed to evaluate Convolutional Codes (CC) and Reed Solomon (RS) block code. Second trials were carried out in November 2009 to assess the Reed Solomon Block Turbo Codes (RS BTC).

This paper provides an overview of this project. First, the multiple data rate acoustic link is presented. The different kinds of channel coding strategies are introduced. Then, we describe the sea trials mainly applied to images and low bit rate speech (2400 bps) transmission. The last section supplies the acoustic communication results obtained when using the channel coders. Individual evaluation and comparison of the different channel coding strategies are presented.


Joël Trubuil
Télécom Bretagne, France

**ML-Based Receivers for Underwater Networks Using OFDM Signals with Strong Nonlinear Distortion Effects**

1569612073

Underwater networks present considerable opportunities as well as technical challenges. Due to severe nature of the underwater acoustic channel, the use of OFDM signals (Orthogonal Frequency Division Multiplexing) with reduced envelope fluctuations is strongly recommendable. Although iterative clipping and filtering techniques are the most efficient way of reducing the envelope fluctuations of OFDM signals, they introduce significant nonlinear distortion effects that lead to performance degradation.

In this paper we consider the ML (Maximum-Likelihood) detection of underwater OFDM signals with strong nonlinear distortion effects. It is shown that the nonlinear distortion does not necessarily mean significant performance degradation and, in fact, the ML performance could even be better than the performance with ideal, linear transmitters. We also present sub-optimum ML-based receivers that allow remarkable performance improvements, being able to reduce significantly the gap between the ML performance and the performance of conventional OFDM receivers.

João Guerreiro
FCT-UNL, Portugal

**Resource Allocation for OFDM Underwater Acoustic Cooperative Transmission with Limited Feedback**

1569612215

The underwater acoustic (UWA) communication has been regarded as one of the most challenging wireless communications due to the unique properties, such as limited bandwidth, extended multipath delay, medium inhomogeneities, rapid time-variation and large Doppler shifts. Cooperative relaying technique is a promising technique to provide high rate data transmission. However, literature on cooperative communications in UWA environments is very scarce. In this paper, we design a novel UWA cooperative communication system, which involves the wave cooperative (WC) transmission protocol, Orthogonal Frequency Division Multiplexing (OFDM) and the Lloyd algorithm-based limited feedback procedure for the first time. We take capacity criterion-based power allocation strategy as an example to demonstrate the performance of our proposed system. Simulation results show the system capacity performance based on uniform allocation (non-feedback), several bits of feedback and perfect feedback. Furthermore, simulation results compare the performance between the WC transmission protocol and the traditional amplify-and-forward (AF) transmission protocol. Additionally, simulation results show the effect of a relay's position on the system capacity.

Xiaopeng Huang
Stevens Institute of Technology, USA
Modulation Detection of Underwater Acoustic Communication Signals Through Cyclostationary Analysis

1569612825

Modulation detection is important to many military communication and electronic warfare applications. Cyclostationary analysis has been proven to be an effective means to detect and identify modulation types of radio frequency (RF) signals. It is highly desired to apply cyclostationary analysis to underwater acoustic communication signals to conduct modulation detection. However, due to the complex environment encountered by underwater acoustic communication, the cyclostationary features of such signals are significantly different from those of their RF counterparts. In this paper, we analyze the applicability of cyclostationary analysis in underwater acoustic communication signals for modulation detection purpose. Due to the severe and varying Doppler shift and phase noise, the cyclostationary features of underwater acoustic communication signals require very high resolution. We have developed a short-term dynamic multi-resolution cyclostationary analysis algorithm to obtain a meaningful spectrum correlation function (SCF) feature with sufficient resolution in the cyclic frequency range of interest. We then extract a simple parameter, namely the cyclic frequency/frequency peak ratio (CFFPR), to identify the modulation schemes of the signals. This feature proves to be statistically significant and stable in distinguishing BPSK modulation and QPSK modulation. Real experimental data collected at sea are used to validate the effectiveness of the proposed algorithm.

Zhiqiang Wu
Wright State University, USA
Wireless Sensor Networks Session

Detection of a Non-Cooperative Transmitter in Rayleigh Fading with Binary Observations

1569600579

The problem of distributed detection of an uncooperative target with non-coherent binary observations is considered. The propagation is assumed to be inversely proportional to a power of the distance from the target and the signal is assumed to be subject to Rayleigh fading and additive white Gaussian noise (AWGN). As the location and power of target are unknown, the probability of detection and probability of false alarm are also not known for each individual detectors. Thus, the optimum Chair-Varshney fusion rule does not apply. Instead, a two stage method based on a generalized likelihood ratio test (GLRT) is derived and proposed. Monte Carlo simulations have been performed to evaluate the performance of the global fusion rule. The results show that the performance of this fusion scheme is significantly better than the intuitive counting rule.

Arian Shoari
University of Rochester, USA

Energy-Efficient Spectrum Access for Ultra Low Power Sensor Networks

1569611555

This paper investigates a dynamic spectrum access (DSA) scheme for ultra low power sensor networks (ULPSN) in an open spectrum where multiple systems coexist and interfere with each other. Low transmission power and simple communication protocol are significant obstacles for ULPSN to operate in the open spectrum. The DSA has been researched to solve this problem by assuming that coexisting systems can perfectly detect each other. However, this assumption is limited for ULPSN because detection of ULPSN in coexisting system is difficult due to sensitivity limitation of spectrum sensing. As a result, available spectrum is more scarce for ULP system than other coexisting systems. Thus, we derive a new Markov chain model of open spectrum access. Based on the Markov chain mode, we design a DSA scheme to maximize the energy efficiency and investigate the channel access and switch policy of the proposed DSA within the framework of partially observable Markov decision process (POMDP). The simulation results demonstrate that the proposed DSA scheme yields improved energy efficiency and lifetime compared to a random channel selection for ULPSN.

Seokwon Lee
Yonsei University, Korea

Distributed Estimation of a Parametric Field Using Sparse Noisy Data

1569612675

The problem of distributed estimation of a parametric physical field is stated as a maximum likelihood estimation problem. Sensor observations are distorted by additive white Gaussian noise. Prior to data transmission, each sensor quantizes its observation to $M$ levels. The quantized data are then communicated over parallel additive white Gaussian channels to the fusion center for a joint estimation. An iterative expectation-maximization (EM) algorithm to estimate the unknown parameter is formulated, and its linearized version is adopted for numerical analysis. The numerical examples are provided for the case of the field modeled as a Gaussian bell. Dependance of the integrated mean-square error on the number of quantization levels, the number of sensors in the network and the SNR in observation and transmission channels is analyzed.

Natalia Schmid
West Virginia University, USA
Energy Minimization of Wireless Sensor Networks Based on Modulation and Coding Optimization Under Finite Frame Length Constraint

1569616139

Recent hardware advances allow more signal processing functionality to be integrated into a single chip. In sensor networks, the wireless nodes are typically operated with small batteries for which their replacement, when not impossible, is very difficult and expensive. Thus, minimizing the energy consumption of transmitting sensor nodes is an important issue on the design of such communication systems. The previous work in the literature proposes modulation as well as coding optimization considering uncoded and coded bit error rate (BER) of M-ary QAM as well as its average mutual information. However, these approaches do not address the coded case with finite frame length, which is always the case in practical systems. In this paper, we consider a design of coding and modulation that minimizes the transmit circuit energy under finite codeword length constraint of capacity-approaching channel codes and analyze its performance through simulation using low-density parity-check (LDPC) codes in a point-to-point communication link. The results are also compared with those of information-theoretic analysis based on the mutual information rate.

Kei Kinoshita
Yokohama National University, Japan