NJIT
New Jersey Institute of Technology

THE ELISHA YEGAL BAR-NESS
CENTER FOR WIRELESS COMMUNICATIONS
AND SIGNAL PROCESSING RESEARCH

The Elisha Yegal Bar-Ness

Center for Wireless Communications

and Signal Processing Research

Activity Report

AY2013/2014 to Present

About the Center

The Elisha Yegal Bar-Ness Center for Wireless Communications and Signal Processing Research (CWCSPR) engages in a broad range of research areas ranging from wireless communications, radar, sensor networks, cloud radio, information theory, and signal processing. A unifying theme of the Center's research is that of 5G wireless mobile networks.

There are six faculty members associated with the Center, 2 post-docs and over 20 graduate students, most of them pursuing their Doctor of Philosophy degree.

The Center routinely hosts visiting researchers, post-docs, and students from overseas. Several students pursue double PhD programs according to agreements between NJIT and other universities.

The Center seeks new collaborations with the wireless communications industry.

For more information, please contact Alexander Haimovich, Center Director, 973-596-3534 or alexander.m.haimovich@njit.edu.

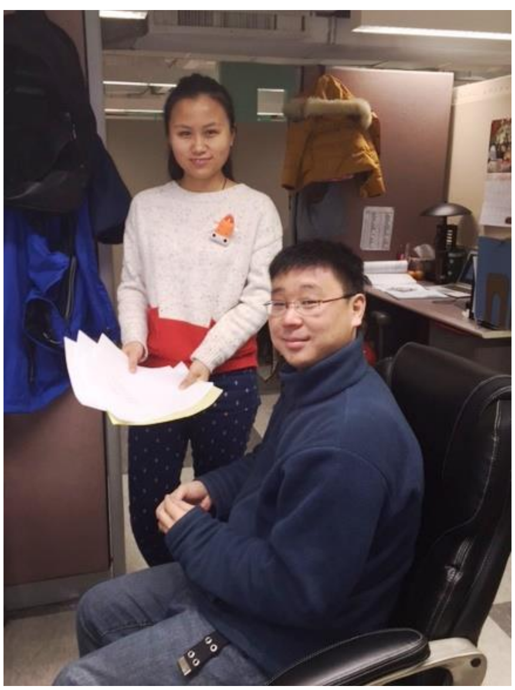
Vision of the Center

Primary Goal:

Serve as focal point in the Department of Electrical and Computer Engineering for research on wireless, communications and signal processing.

Activities carried out by participants:

- Initiate and pursue research in the fields of wireless, communications and signal processing.
- Search, collectively as well as individually, for possible sources of financial research support for themselves and their affiliates (graduate students or visiting faculty).
- Establish contacts in the electronics industry in the Newark-metropolitan area and New Jersey as a whole, learn about their needs, and suggest methods of collaboration.
- Assume responsibility for teaching graduate courses in the fields of communications and signal processing, propose and plan new courses, and monitor graduate courses taught by adjunct faculty.
- Undertake initiatives to recruit highly qualified graduate students, research associates and visiting faculty members, and support the efforts of the department chairman to recruit new faculty.
- Suggest, design, prepare, and deliver short courses as part of the New Jersey Institute of Technology's continuing education program.
- Organize seminars on topics of interest to Center members, the Department of Electrical and Computer Engineering, and local industry.

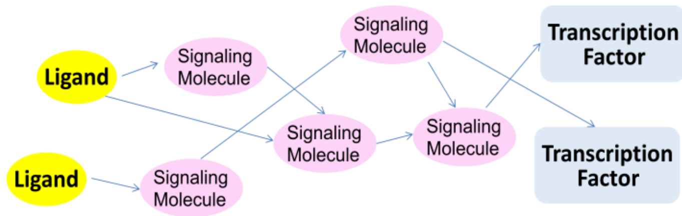


Research Interests of Center Faculty

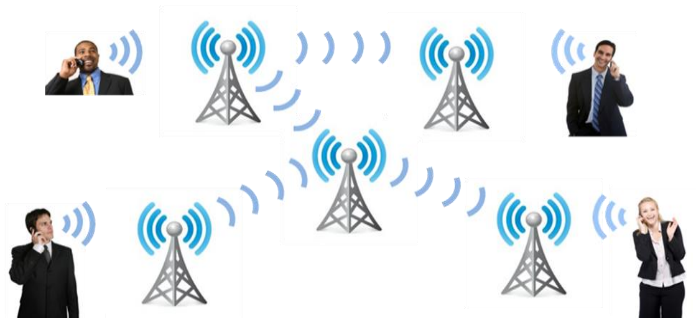
Molecular Communication and Signaling in Human Cells

Faculty: A. Abdi

PhD student: I. Habibi



(A) An intracellular molecular network where signaling molecules communicate input signals to some target proteins such as transcription factors.



(B) A man-made communication system where towers convey signals and information.

Image from I. Habibi, E. S. Emamian and A. Abdi, "Quantitative analysis of intracellular communication and signaling errors in signaling networks," BMC Syst. Biol., vol. 8, 89, 2014.

Each cell in the human body includes many biomolecules, which communicate with each other via biochemical reactions, through intracellular signaling networks, to transmit signals from inputs such as ligands to outputs, say, transcription factors. There are massive amounts of qualitative data regarding different individual communication mechanisms among various types of molecules in different cellular pathways. However, a systematic theory that can quantify intracellular communication processes is not available.

This research introduces an experimentally-verifiable quantitative and predictive theory for intracellular communication in complex molecular networks. It allows biologists to quantitatively model and analyze different types of molecular communication mechanisms and their impacts on cellular functions, using a generic set of concepts, metrics and methods. One important therapeutic application is identification of proper molecular targets at the drug discovery stage.

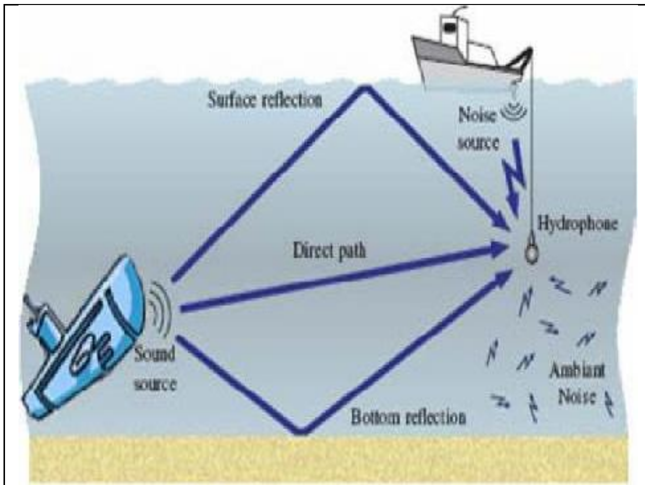
Data Communication via the Vector Components of the Acoustic Field:

Underwater Communication

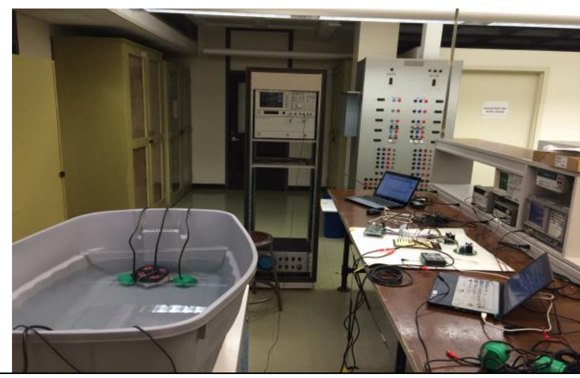
Faculty: A. Abdi

PhD student: E. Zhang

Sponsor: NSF



Innovative Communication and Signal Processing (iCASP) Lab setup at NJIT for underwater communication prototype test and develoment



Over 75% of the earth's surface is covered with water that overlays many resources upon which our lives depend. High speed wireless underwater data communication between underwater sensors, deepwater moored instruments, autonomous underwater vehicles, and surface vessels is of crucial importance in many applications of national interest. However, the achievable data rates by the conventional technologies are much smaller than what is needed for effective communication and management. To have high speed communication links in underwater environments, the transformative concept of communication via the vector components of the acoustic field was proposed and developed by A. Abdi in a prior NSF supported project.

In this new project, a prototype modem is going to be developed, based on the vector field concept. The key difference between the new modem and other existing modems is that it uses vector transducers, which are compact multichannel devices, to transmit several data streams via multiple particle velocity vector channels. This is while other modems use scalar transducers, which can modulate the data only on the scalar acoustic pressure.

The proposed concept to communicate via particle velocity vector channels is expected to have a major technological impact on underwater communication systems, which have solely used the acoustic pressure channel for decades. Development of a high speed vector acoustic modem will eventually allow the growth of many underwater systems and businesses whose operations have been constrained by low wireless data rates or very expensive undersea cables.

Data Communication via the Vector Components of the Acoustic Field:

Borehole Communication via Drill Strings in Oil Wells

Faculty: A. Abdi

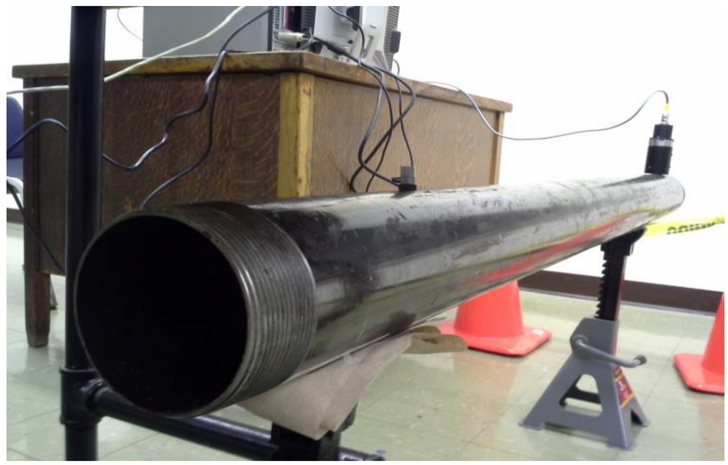
PhD student: A. Alenezi

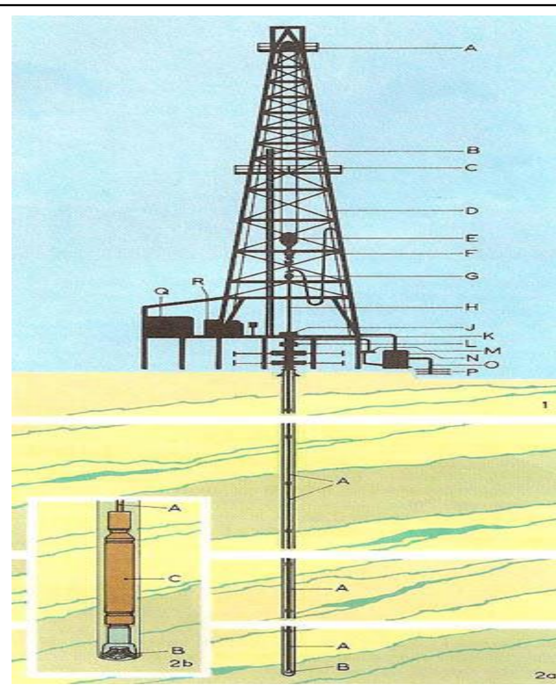
Sponsor: NSF

To extract oil from underground reservoirs, a well needs to be drilled using a long drill string. During the drilling process, real-time transmission of important data such as temperature, pressure, torque, drilling direction, etc., from downhole to the surface is of high importance. Such data allows the driller to closely monitor the process, change the drilling direction, adjust the penetration rate, etc., to minimize the failure chance of the costly operation and the machines.

Since boreholes are typically very deep, several thousand feet or more, wired communication is very expensive and prone to failure. On the other hand, wireless electromagnetic-based and mud-based methods can provide only very low data rates, typically few bits per second. Acoustic transmission, however, offers higher data rates. In this research, new high rate communication schemes are going to be developed, by utilizing the physics of sound propagation in steel pipes and drill strings.

Innovative Communication and Signal Processing (iCASP) Lab testbed at NJIT for communication via drill strings





Drill string underneath an oil rig

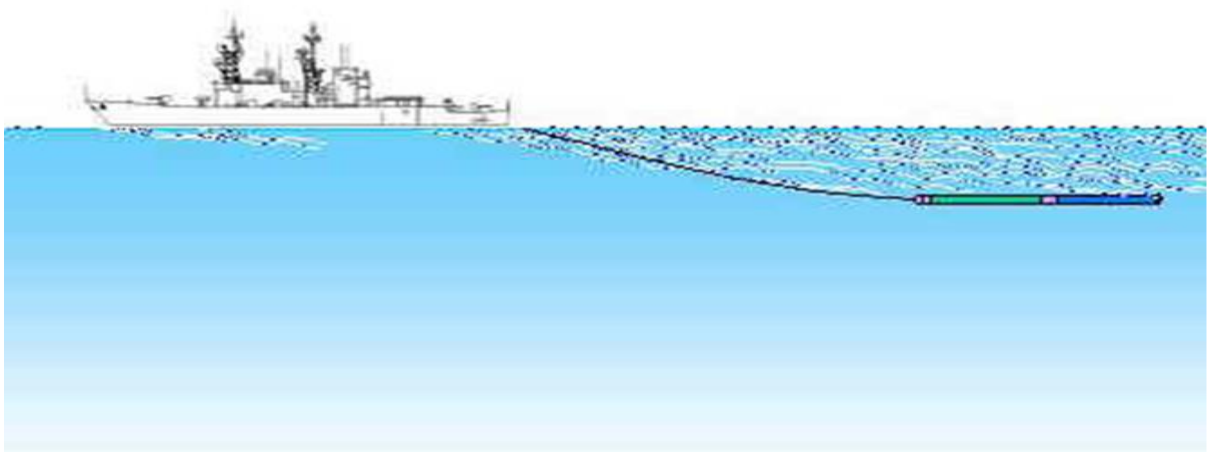
Image from http://www.daviddarling.info/encyclopedia/P/petroleum.html

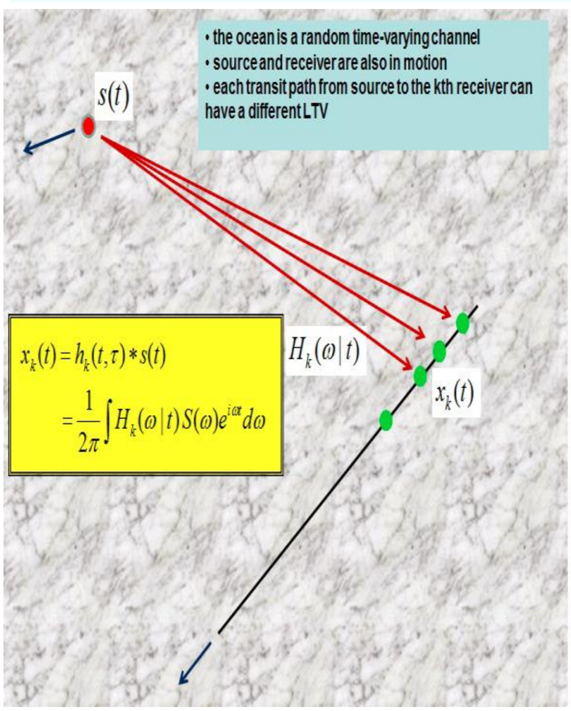
Passive Ranging using Distributed Arrays in Underwater Acoustic Environments subject to Spatial Coherence Loss

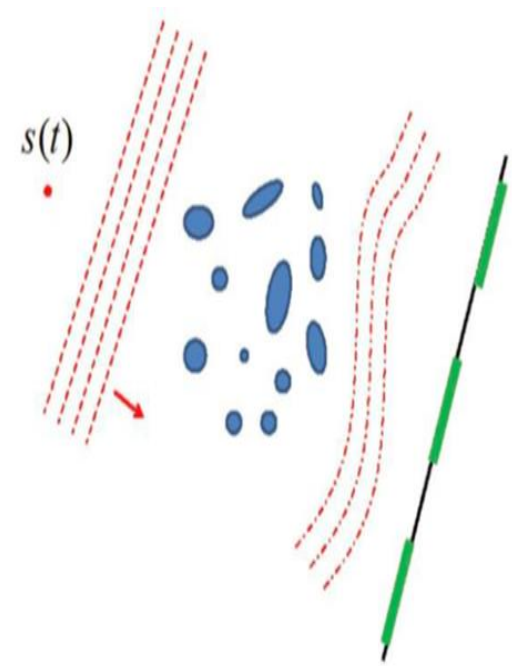
Faculty: Hongya Ge

Collaborators: Ivars P. Kirsteins (NUWC, Newport, RI)

Sponsor: US Office of Naval Research (ONR), NAYSEA and NUWC







Passive ranging in challenging underwater environments is an important problem in many naval applications, ranging from national defense to disaster recovery and environmental monitoring. Large aperture and/or moving aperture array systems has been designed and redesigned to enable the performance gain in passive methods to source detection, localization and tracking.

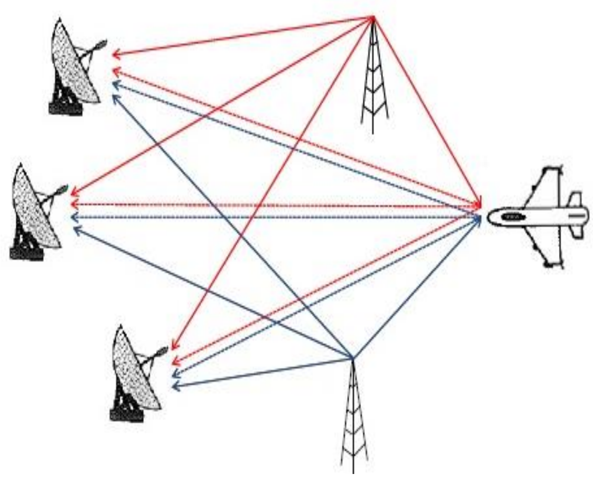
Through data-driven adaptive signal processing, our research explores statistical as well as tempo-spatial-spectral features of acoustic data collected by towed array systems comprised of multiple distributed volumetric array modules. The large amounts of space-time data are collected during different sea trials under the sponsorship of ONR, NAYSEA and NUWC. The goal is to design real-time solutions to passively localize (detection and estimation), classify and track distant emission sources undersea. Due to the turbulent nature and random media effects of underwater acoustic channels, an emission source's spherical or plane wavefronts are partially distorted when arriving at the receiving arrays of large/moving aperture. The relative motion between the source of interest and receiving arrays makes data and the associated parameters highly time varying (a typical high-dimension and sample poor scenario). All these will results in performance degradation to the wavefront curvature ranging systems equipped with very long aperture. We developed maximum likelihood multi-stage and multi-rank wavefront curvature passive ranging solutions to the problem of localizing and tracking distant source of interest.

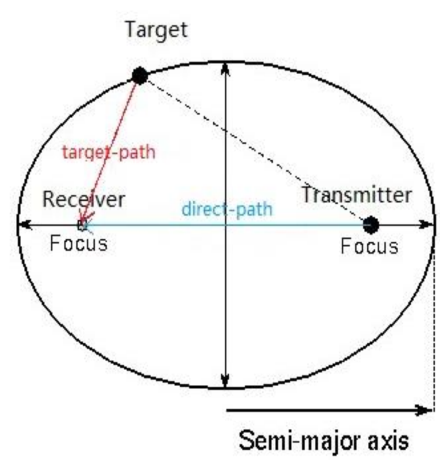
Passive MIMO-Radar for Target Detection

Faculty: Hongya Ge

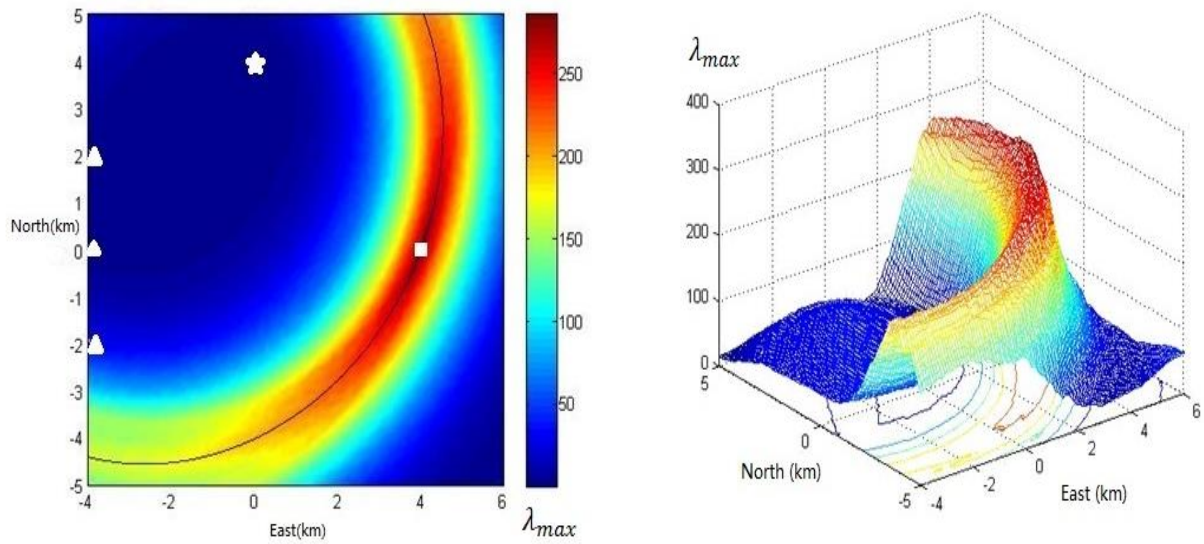
Graduate student: Enlong Hu

In passive MIMO-Radar system, the RF transmission from existing radio towers along with the reflected RF signals from a target are utilized by low-cost radar antennas. Such primary and secondary multi-channel data can be used to build low-cost MIMO radars for surveillance applications. We studied the performance gain in detection using multiple RF towers as well as reference channel data.

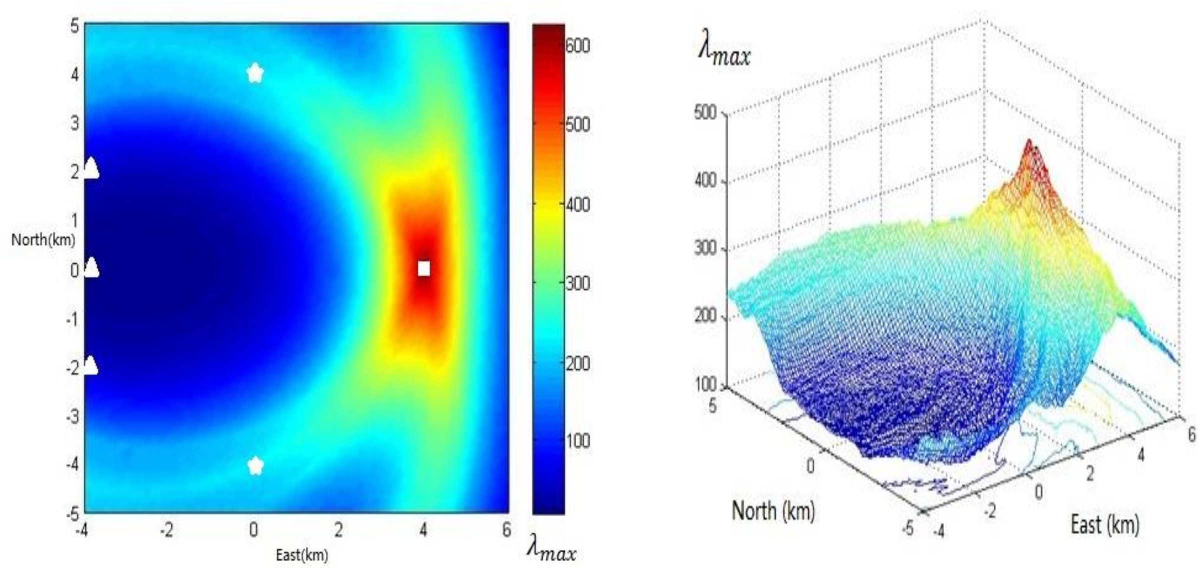




Results obtained by using the transmission from a single RF tower and the target reflection



Results obtained by the using transmissions from two RF towers and the target reflection



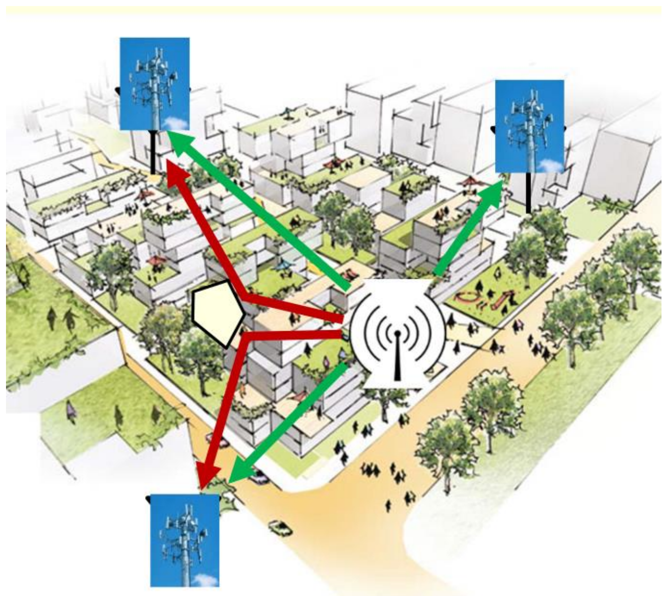
Direct Localization of RF Sources in Multipath Channels

Faculty: Alexander Haimovich

Graduate Students: Nil Garcia

Collaborators: Martial Coulon (Univ. of Toulouse), Jason Dabin (US Navy)

Sponsor; Battelle/ARO



The problem of localizing multiple emitters using widely spaced sensors is most commonly solved by estimating some parameters such as time of arrival (TOA), time difference of arrivals (TDOA) or received signal strengths (RSS). Subsequently, the emitters are located by multilateration. Such techniques estimate the intermediate parameters independently and therefore are suboptimal in comparison to direct localization techniques, in which emitter locations are estimated jointly. The literature on direct localization in the presence of frequency-selective multipath is scarce. To fill this gap, we propose a direct localization technique designed to work in the presence of flat or frequency-selective multipath, for known signals. A common approach in localization is to assume that the first arrival at each sensor corresponds to the line of sight (LOS) path, however, such approach can lead to large errors if the LOS path is blocked or confused with secondary lobes from other arrivals. Our approach divides the search area of the emitters in a grid of points. Since the number of emitters is sparse compared to the number of grid points, it leads naturally to a compressive sensing problem, which can be solved by sparse recovery techniques. Moreover, we show how such framework enables to distinguish between LOS and NLOS paths. Our technique has the advantage of direct localization techniques, i.e. superior accuracy, while being specially robust to strong NLOS signals, and to some extent, to sensors with blocked LOS. Subsequently, we will address the problem of localizing RF sources whose waveforms are unknown.

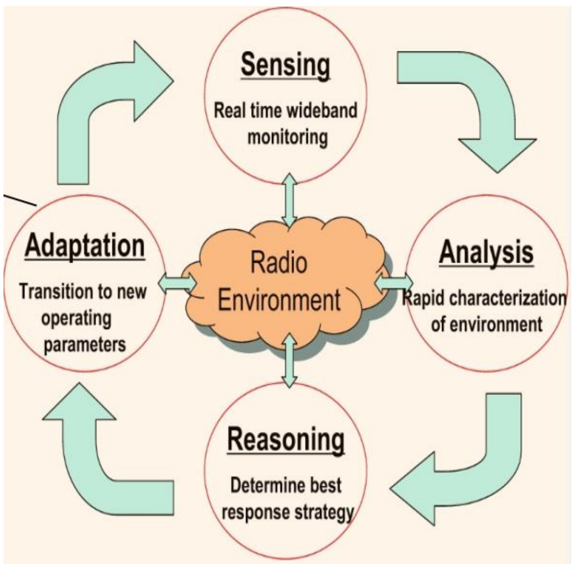
Modulation Classification of Signals in Multiple Antenna Systems

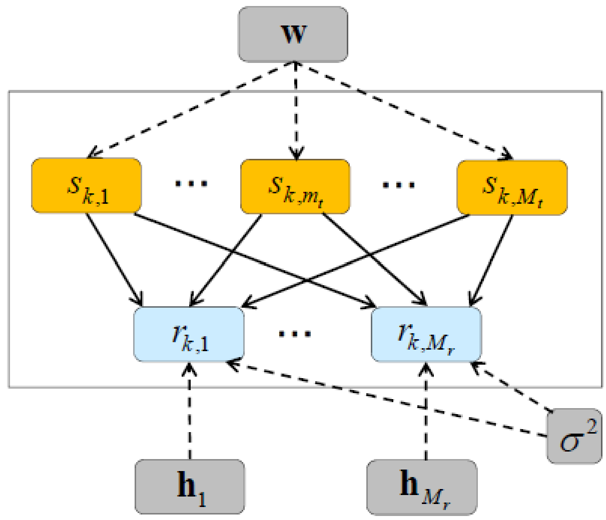
Faculty: Alexander Haimovich, Osvaldo Simeone

Graduate student: Yu Liu

Collaborators: Wei Su (US Army)

Sponsor: Aspen/US Army





Recognition of the modulation format of unknown received signals is an important functionality of intelligent, or cognitive, radios for both military and civilian applications. Much of the literature on modulation classification addresses single-input single-output (SISO) systems. Modulation classification of multiple-input multiple-output (MIMO) signals is considerably more challenging than the SISO problem due to the observed data being an unknown mixture of unknown signals. In this case, the modulation classification has to be preceded by blind signal separation, a difficult problem in its own right. In this project we develop Markov Chain Monte Carlo methods for modulation classification of single and multiple antenna systems.

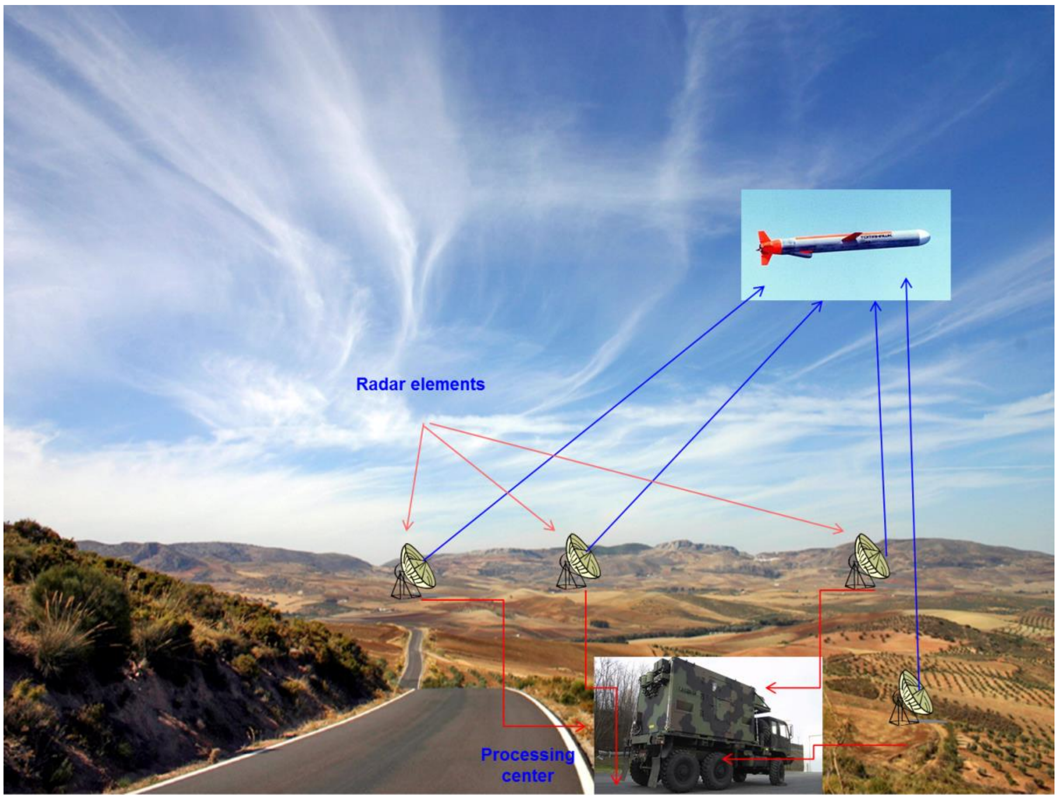
We also develop a theoretical bound on the accuracy of classification over unknown MIMO channels. We assume that the number of transmit antennas and signal to noise ratio (SNR) are known, and that MIMO channels are flat fading and unknown to the receiver. To develop the theoretical bound on performance, our approach is to first derive the Cramer-Rao bound (CRB) of the estimates of the MIMO channels. We then develop a bound on the probability of correct classification (PCC) based on the CRB.

MIMO radar: compressive sensing techniques for localization

Faculty: Alexander Haimovich

Graduate students: Haley Kim, Dong Annan

Sponsor: Air Force Office of Scientific Research



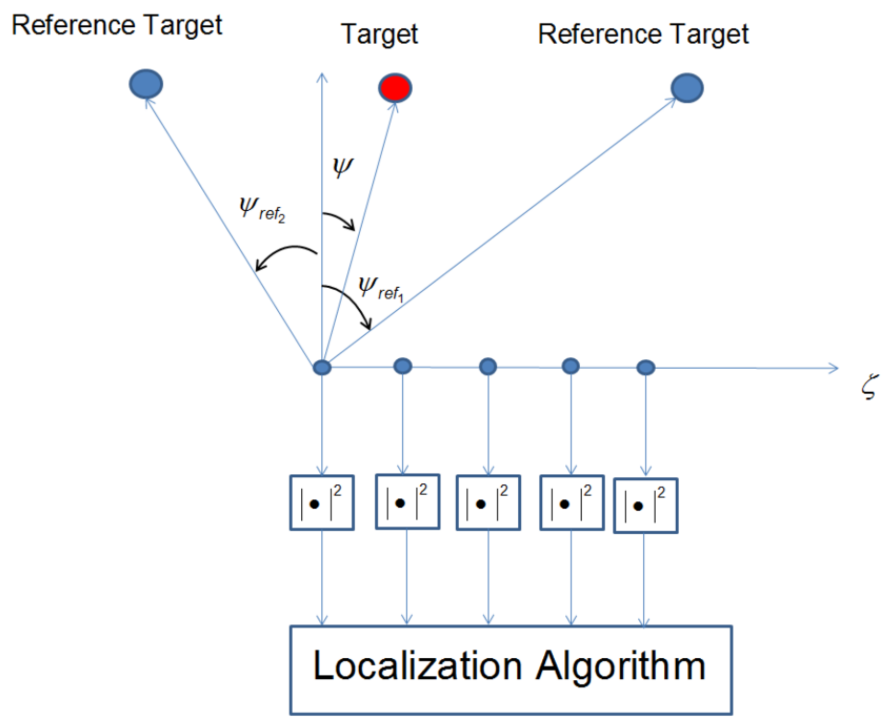
Multiple-input multiple-output (MIMO) radar is a sensing paradigm in which multiple transmitters and receivers have the ability to jointly plan transmissions and to process received signals in order to detect, localize and track targets. Compressive sensing is an emerging field in which performance of sensing systems is maintained even when observed signals are undersampled. Compressive sensing algorithms are designed to cope with ambiguities introduced by undersampling.

Large, random arrays are undersampled adaptive arrays that support improved angle-Doppler resolution and lower minimum detectable velocity (MDV), at the cost of higher sidelobes. Even though random arrays have been studied as early as the 1970's, new results reveal interesting links to the emerging field of compressive sensing. MIMO provides further improvements in angular resolution and MDV, while supporting waveform diversity and additional savings in the number of sensors. Compressive sensing algorithms are designed to cope with ambiguities introduced by undersampling. We develop methods involving MIMO radar and compressive sensing that enable to localize radar targets with high accuracy.

Non-coherent Direction of Arrival Estimation

Faculty: Alexander Haimovich

Graduate students: Haley Kim



We study the classical Direction of arrival (DOA) estimation problem in the presence of random sensor phase errors are present at each sensor. To eliminate the effect of these phase errors, we propose a DOA recovery technique that relies only on magnitude measurements. This approach is inspired by phase retrieval for applications in other fields. Ambiguities typically associated with phase retrieval methods are resolved by introducing reference targets with known DOA. The DOA estimation problem is formulated as a nonlinear optimization in a sparse framework, and is solved by the recently proposed GESPAR algorithm modified to accommodate multiple snapshots. Numerical results demonstrate good DOA estimation performance. For example, the probability of error in locating a single target within 2 degrees is less than 0.1 for SNR ≥ 15 dB and one snapshot, and negligible for SNR ≥ 10 dB and five snapshots.

Source Compression with Spatially Coupled Codes

Faculty: Joerg Kliewer

Graduate Student: Ali Shahini

Sponsor: NSF

Collaborators: David Mitchell (University of Notre Dame), Dan Costello (University of Notre Dame)

In the last ten to fifteen years, the area of channel coding has undergone a revolutionary change based on the combination of graph-based codes and iterative decoding algorithms. These coding methods, which include both turbo codes and LDPC codes, approach the capacity limits of channel coding performance promised by Shannon in his landmark 1948 paper. As a result, turbo and LDPC codes are replacing conventional error control techniques in numerous digital communication and storage applications, including deep-space digital transmission systems, next-generation digital wireless transmission, last-mile digital cable transmission, digital video broadcasting, high-density digital magnetic recording, and flash memories.

In a remarkable recent development, a new class of protograph-based LDPC convolutional codes, also referred to as *spatially coupled LDPC codes*, has been shown to possess an unique combination of desirable asymptotic properties – *capacity achieving* iterative decoding performance *plus* minimum distance growing linearly with block length. As a consequence, codes of practical lengths chosen from this class are the first to promise to achieve near-optimal performance at *both* low and high signal-to-noise ratios.

In this project we explore whether spatially coupled codes are also suitable for low-complexity source compression. In particular, we consider the duals of these codes, spatially coupled low density generator matrix (LDGM) codes. This is useful for example for applications as flash memory storage or low-complexity distributed video compression.

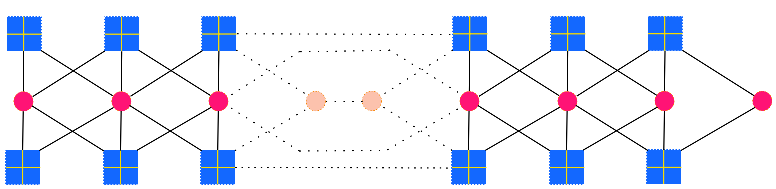


Figure: Protograph of a (3,6) spatially coupled LDGM ensemble

Measuring and Modeling Information Flow on the Brain-Response Channel

Faculty: Joerg Kliewer

Graduate Student: Ketan Mehta (NMSU)

Sponsor: NSF

Collaborators: Chuck Creusere (NMSU), Jim Kroeger (NMSU)

We use mutual information (MI) as a measure to quantify the subjective perception of audio quality by directly measuring the brainwave responses of human subjects using a high resolution electro-encephalogram (EEG). Specifically, we propose an information theoretic model to interpret the entire "transmission chain" comprising stimulus generation, brain processing by the human subject, and EEG measurements as a nonlinear, time-varying communication channel with memory. In the conducted experiments at NMSU, subjects were presented with audio whose quality varies between two quality levels. The recorded EEG measurements can be modeled as a multidimensional Gaussian mixture model (GMM). In order to make the computation of the MI feasible, we have derived a novel approximation technique for the differential entropy of the multidimensional GMM.

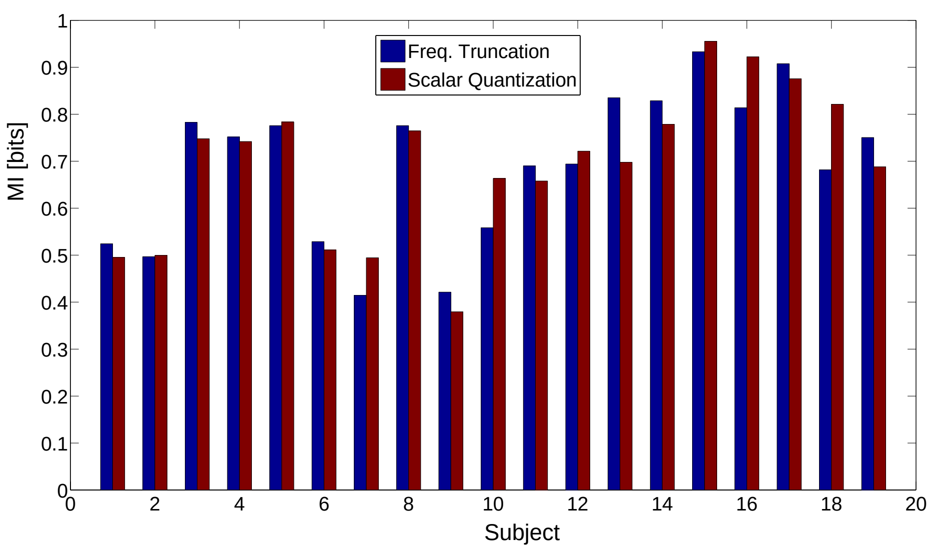


Figure: The median mutual information estimates for each of the 19 test subjects when presented with the same set of trial-sequences, across the two different distortion-types.

Future research focuses on blind classification of audio based on EEG measurements by modeling the brain-response channel with a hidden Markov model which can be trained by using the obtained MI results.

Low-Complexity Wireless Sensor Architectures Based on Asynchronous Processing

Faculty: Joerg Kliewer

Graduate Student: Yi Chen

Sponsor: NSF

Collaborators: Wei Tang (NMSU)

In recent years integrated wireless sensors have emerged in a wide range of applications including health care, surveillance, smart buildings, disaster mitigation, and environment monitoring, and therefore have significantly benefited society due to alleviating certain monitoring tasks associated with these applications. However, new applications as implantable biopotential sensors or submersible sensors for measuring mechanical stress require further miniaturization of existing state-of-the-art sensor hardware while having a significantly increased transmission data rate due to the need to perform multichannel processing, i.e., to aggregate the data of multiple single sensors on the same chip over a single communication link. Thus, these approaches require the design of very low-power sensor hardware architectures including novel low complexity modulation and coding schemes which can support reliable and secure transmission over these high speed data links.

The goal of this project is find and study novel designs and strategies that are tailored to this emerging class of low-power integrated wireless sensors nodes. We analyze a systematic solution for integrated wireless sensors by devising asynchronous delta modulation on the sensor interface in combination with asynchronous ultra wideband transmission on the wireless radio interface in order to significantly decrease the power consumption of the sensor hardware. Further, to ensure that the sensor operates with guaranteed reliability over the noisy communication link, new non-binary FEC schemes with a low complexity encoding are analyzed, whose data symbols consist of both asynchronous timing information and pulse signs.

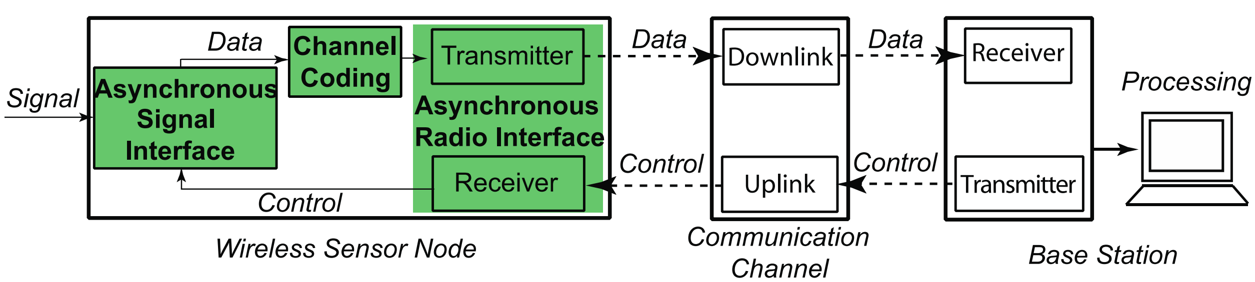
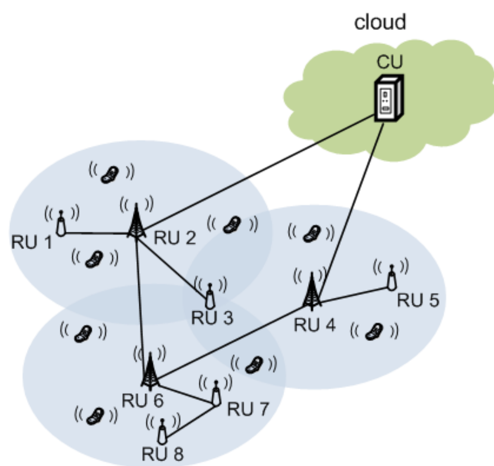


Figure: Block diagram of the wireless sensing system.

Cloud Radio Access Networks

Faculty: Osvaldo Simeone
Post-Doc: Seok-Hwan Park
Visiting Students: Jinkyu Kang (KAIST), Seongah Jeong (KAIST), Eunhye Heo (KAIST)
Collaborators: Shlomo Shamai (Technion), Onur Sahin (InterDigital), Joonhyuk Kang (KAIST)
Support: InterDigital, Vienna Science and Technology Fund



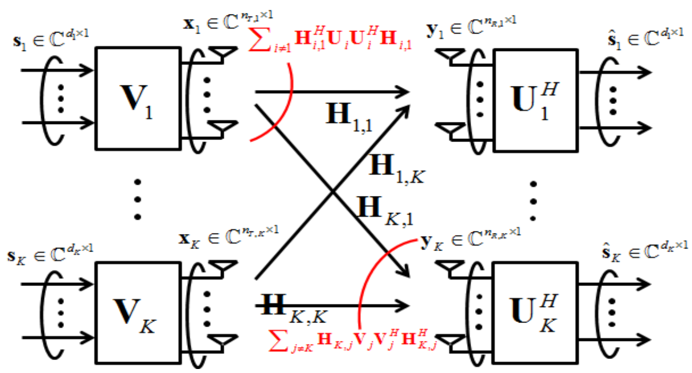
Next-generation wireless cellular systems are expected to undergo a radical paradigm shift, which is akin to the revolution brought forth by clouding computing in computer networks. As cloud computing prescribes the physical separation of user-centric data input/output and remote computing, cloud radio access networks (C-RANs) separate distributed and localized radio transmission/reception units from centralized information processing nodes.

In a basic C-RAN, radio units (RUs), such as macro-, pico- and home-base stations, provide the wireless interface between the operator's network and the mobile devices. However, unlike in conventional cellular systems, the RUs do not implement the information processing functionalities needed to encode and decode information on the wireless channel. Instead, information processing is carried out remotely within the "cloud" of the operator's network. This migration of computing to the cloud is enabled by a network of backhaul links that connect the radio units both among themselves and to control units (CUs) within the cloud.

The centralization of information processing afforded by C-RANs enables effective interference management at the geographical scale covered by the distributed radio units. Moreover, C-RANs in principle simplify the deployment of dense heterogeneous networks. Both advantages promise to be key components of the solution to the so called "spectrum crunch" problem. However, the main roadblock to the realization of the mentioned promises of C-RANs hinges on the effective integration of the wireless interface provided by the radio units with the backhaul network that links the radio units and information processing nodes within the cloud. The goal of this research is to investigate advanced integration strategies based on network information theoretic principles.

Robust Interference Alignment

Faculty: Osvaldo Simeone
Post-Doc: Tariq Elkourdi
Graduate Student: Ali Fouladgar
Sponsor: InterDigital

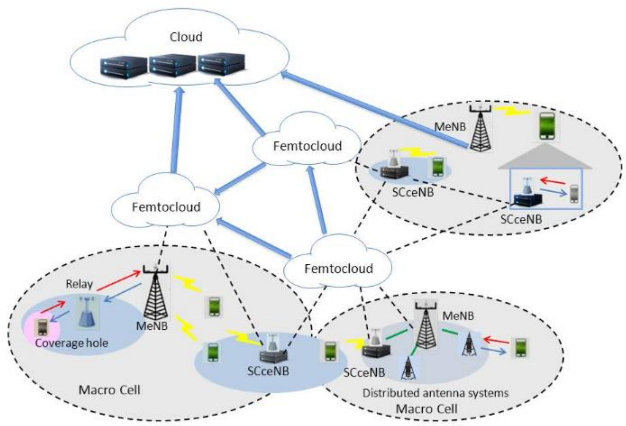


Interference alignment (IA) is a novel paradigm for the design of wireless networks that provides a radically different approach to interference management. Thanks to this paradigm shift, IA allows the capacity of wireless networks to be increased to levels that were previously thought to be theoretically out of reach. The key principle behind IA is the alignment of interference signals in a small subset of the "signal dimensions" occupied by the received signals at each interfered user. This alignment leaves a larger portion of the signal space available for the reception of information-bearing signals, hence increasing the capacity of the system.

In order to bridge the gap between theory and practice, this research aims at developing IA-based linear and non-linear transceivers that are robust to imperfections in the available channel state information and that can be implemented in a decentralized fashion.

Mobile Fog Computing

Faculty: Osvaldo Simeone
Graduate Student: Shahrouz Khalili
Collaborator: Gesualdo Scutari (Univ. of Buffalo)

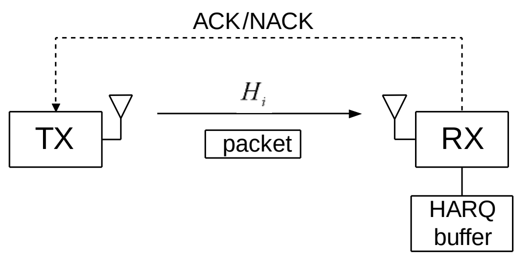


While the number of computation-intensive applications that users expect to run on mobile devices– including video processing, object recognition, gaming, automatic translation and medical monitoring– continues to grow, the devices' computing capabilities are ultimately limited by the battery lifetime. Barring breakthroughs in battery technology, the only potential solution to this challenge appears to be mobile cloud computing, that is, the offloading of computation-intensive tasks to a cloud service provider, such as for speech recognition with Google Voice Search and Apple Siri. However, accessing the cloud through a wireless network entails the energy and latency required for uplink and downlink transmissions, as well as the delay caused by routing on the backhaul network, hence potentially offsetting the gains of mobile cloud computing.

This project proposes to tackle the above problem by introducing the fog mobile computing architecture, in which the small-cell base stations of a cellular system are endowed with computing capabilities to offer proximate wireless access and computing. The key objective of the project is to develop effective, low-complexity, scalable and flexible offloading strategies based on the inter-layer optimization of computation and communication resources, with the aim of ensuring Quality of Experience (QoE) constraints in terms of minimal mobile energy expenditure and latency.

HARQ Buffer Management

Faculty: Osvaldo Simeone
Visiting Student: Wonju Lee (KAIST)
Collaborators: Sundeep Rangan (NYU-Poly) and Petar Popovski (Aalborg Univ.)



A key practical constraint on the design of hybrid automatic repeat request (HARQ) schemes is the modem chip area that needs to be allocated to store previously received packets. The fact that, in modern wireless standards such as LTE and LTE-Advanced, this area can amount to a large fraction of the overall chip has recently highlighted the importance of HARQ buffer management, that is, of the use of advanced compression policies for storage of received data. This work tackles the optimization and design of HARQ schemes, including adaptive rate control strategies at the transmitter and HARQ buffer management at the receiver, under the assumption of a finite-capacity HARQ for both multiple-access and broadcast scenarios.

Center PhD Students and Visiting Scholars:

First	Last	Advisor
Ali	Alenezi	Abdi
Iman	Habibi	Abdi
Erjian (Eric)	Zhang	Abdi
Yuewen	Wang	Akansu
Manan	Patel	Bar-Ness
Enlong	Hu	Ge
Annan	Dong	Haimovich
Nil	Garcia	Haimovich
Haley	Kim	Haimovich
Pelin	Salem	Haimovich
Phuoc	Vu	Haimovich
Nan	Wu	Haimovich
Minglei	Yang	Haimovich
Liu	Yu	Haimovich
Farshid	Mokhtarinezhad	Kliewer
Ali	Shanini	Kliewer
Chen	Yi	Kliewer
Bahar	Azari	Simeone
Ali Mohammad	Fouladgar	Simeone
David	Gomez-Barquero	Simeone
Shahrouz	Khalili	Simeone
Wonju	Lee	Simeone
Seok-Hwan	Park	Simeone

Center Masters and Undergraduate students working on projects:

Si	Yang	Abdi
Chih-yu	Chen	Abdi
Wei	Jiang	Abdi
Chizhong	Wang	Abdi
Mukesh Babu	Sundara Babu	Abdi
Diego	Agudelo	Abdi
Khoa	Dao	Abdi
Kleber	Solano	Abdi
Temilade	Afolabi	Abdi
Theo	Abavana	Abdi
Srinath	Yellepeddi	Abdi
Nasir	Younus	Abdi
Neel	Patel	Abdi
Niko	Ciccollela	Abdi
Surajit	Laik	Abdi

Polley	Bhunia	Abdi
Matthew	Ross	Abdi
Jonathan	Davila	Abdi
Kristopher	Perovic	Abdi

Center Faculty and Staff:

Ali	Abdi	Faculty
Ali	Akansu	Faculty
Yeheskel	Bar-Ness	Faculty Emeritus
Hongya	Ge	Faculty
Alexander	Haimovich	Faculty
Joerg	Kliewer	Faculty
Osvaldo	Simeone	Faculty
Angela	Retino	Staff

List of Projects and Funding

Abdi, Ali (PI), Ehrlich, Michael (Co-PI), "Data Communication via the Vector Components of the Acoustic Field," Sponsored by NSF (Directorate for Engineering, Federal, $50,000.00.(May 2013 - October 2014).

Ge, Hongya (PI), “Passive Ranging using Distributed Arrays in Underwater Acoustic Environment subject to Spatial Coherence Loss”, Sponsored by US Office of Naval Research (ONR), Jan. 1st, 2012—Sep. 30th, 2013, $80,000.00

Haimovich, Alexander M. (PI), Simeone, Osvaldo (Co-PI), "MIMO Signal Classification Models," Sponsored by Aspen Consulting, $115,000.00. (August 2014 - August 2015).

Haimovich, Alexander M. (PI), "Compressive Sensing for Target Localization with MIMO Radar and Passive Methods," Sponsored by AFOSR, Federal, $454,499.00. (August 1, 2012 - July 31, 2015).

Haimovich, Alexander (PI), "Precision Source Localization in Multipath Environment," Sponsored by US Army/Battelle Memorial, Federal, $149,998.00. (June 17, 2014 - May 26, 2015).

Zhou, Mengchu (PI), Haimovich, Alexander M. (Co-PI), Simeone, Osvaldo (Co-PI), "High-speed rail communication," Sponsored by CSR-ZIC, Private, $300,000.00. (July 2013 - December 2014).

Haimovich, Alexander M. (PI), "Sensing Compressive Methods for Precision Source Localization," Sponsored by US Army/Batelle, Federal, $149,981.00. (July 1, 2013 - June 24, 2014).

Haimovich, Alexander M. (PI), Simeone, Osvaldo (Co-PI), "Modulation Recognition Algorithms IAW," Sponsored by US Army/Aspen Consulting, Private, $64,000.00. (February 2013 - September 28, 2013).

Kliewer, Joerg (PI), “Collaborative Research: Coordination and Cooperation in Networked Multi-Agent Systems," Sponsored by U.S. National Science Foundation, Federal, $246,157. (Sept. 2014- Aug. 2017). Awarded to New Mexico State University, transferred to NJIT.

Kliewer, Joerg (PI),"Collaborative Research: Spatially Coupled Sparse Codes on Graphs – Theory, Practice, and Extensions," Sponsored by U.S. National Science Foundation, Federal, $153,989. (July 2012-June 2015). Awarded to New Mexico State University, transferred to NJIT.

Kliewer, Joerg (PI), "Collaborative Research: New Approaches to the Design of Jount-Source Channel Codes," Sponsored by U.S. National Science Foundation, Federal, $177,193. (Sep. 2011-Aug. 2015). Awarded to New Mexico State University, transferred to NJIT.

Kliewer, Joerg (PI), "Collaborative Research: Low-Complexity Wireless Sensor Architectures Based on Asynchronous Processing", NSF, Sept. 2014-Aug. 2017, $194,898

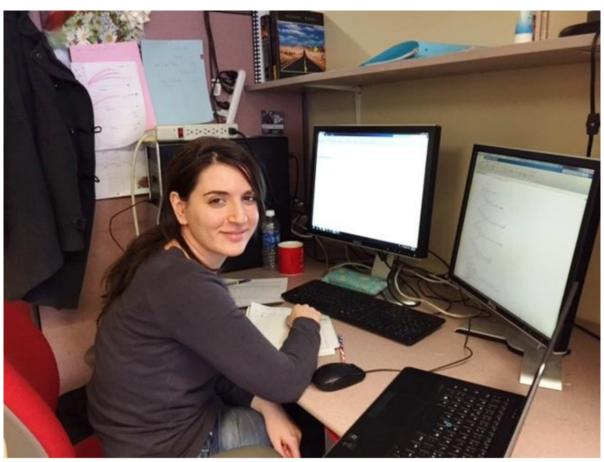
Kliewer, Joerg (PI), "Assessment and Modeling of Temporal Variation in Perceived Audio and Video Quality using Direct Brainwave Measurements", NSF (subaward from New Mexico State University), June 2014-May 2015, $53,741.

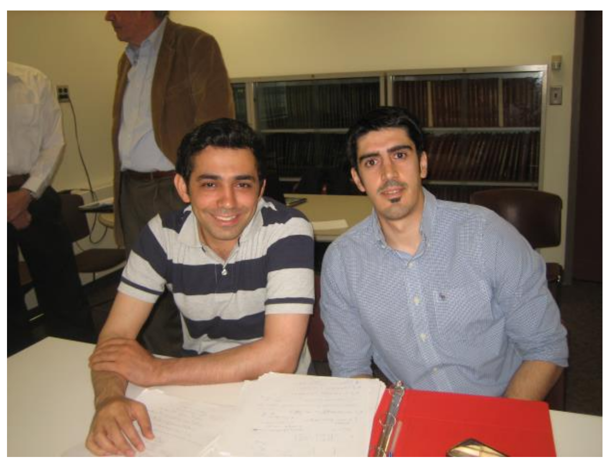
Simeone, Osvaldo (PI), "Delay-Tolerant Robust Coding for Green Networking," Sponsored by InterDigital LLC, Private, $87,096.00. (December 2012 - December 2013).

Simeone, Osvaldo (Co-PI), "TINCOIN," Sponsored by Vienna Science and Technology Fund, Other, $50,000.00. (November 2012 – Present).

Simeone, Osvaldo (PI), "Robust Compressed Interference Alignment for Cloud Radio Access Networks," InterDigital, Private, $90,000.00, November 2013 - November 2014.

Matz, G. (TU Wien) (PI), Simeone, Osvaldo (Co-PI), "TINCOIN," Vienna Science and Technology Fund, $40,000.00, March 2014 – March 2017.





Publications

Refereed Journal Articles Published:

Rossi, M., Haimovich, A. M., Eldar, Y. C. (2014). Spatial Compressive Sensing for MIMO Radar. *IEEE Transactions on Signal Processing, 62*(2), 419, 430.

Garcia, N., Haimovich, A. M., Lops, M., Coulon, M. (2014). Resource allocation in MIMO radar with multiple targets for non-coherent localization. *IEEE Transactions on Signal Processing, 62*(10), 2656,2666.

Y. Liu, O. Simeone, A. Haimovich and W. Su, "Modulation classification via Gibbs sampling based on a latent Dirichlet Bayesian network," IEEE Signal Proc. Letters, vol. 21, no. 9, pp. 1135-1139, Sep. 2014.

S.-H. Park, O. Simeone, O. Sahin and S. Shamai (Shitz), "Inter-Cluster Design of Precoding and Fronthaul Compression for Cloud Radio Access Networks," IEEE Wireless Commun. Letters, vol. 3, no. 4, pp. 369-372, Aug. 2014.

A. Fouladgar, O. Simeone, and E. Erkip, "Constrained Codes for Joint Energy and Information Transfer," IEEE Trans. Commun., vol. 62, no. 6, pp. 2121-2131, Jun. 2014.

J. Kang, O. Simeone, J. Kang and S. Shamai (Shitz), "Joint Signal and Channel State Information Compression for the Backhaul of Uplink Network MIMO Systems," IEEE Trans. Wireless Commun., vol. 13, no. 3, pp. 1555,1567, Mar. 2014.

S.-H. Park, O. Simeone, O. Sahin and S. Shamai (Shitz), "Joint Precoding and Multivariate Backhaul Compression for the Downlink of Cloud Radio Access Networks," IEEE Trans. Signal Processing., vol. 61, no. 22, pp.5646-5658, Nov. 2013.

R. Karasik, O. Simeone and S. Shamai (Shitz), "Robust Uplink Communications over Fading Channels with Variable Backhaul Connectivity," IEEE Trans. Wireless Commun., vol. 12, no. 11, pp. 5788-5799, Nov. 2013.

M. Li, O. Simeone and A. Yener, "Degraded Broadcast Diamond Channels with Non-Causal State Information at the Source," IEEE Trans. Inform. Theory, vol. 59, no. 12, pp. 8210-8223, Dec. 2013.

Xi Liu, O. Simeone and E. Erkip, "Lossy Computing of Correlated Sources with Fractional Sampling," IEEE Trans. Communications, vol. 61, no. 9, pp. 3685-3696, Sept. 2013.

S.-H. Park, O. Simeone, O. Sahin and S. Shamai (Shitz), "Multi-Layer Transmission and Hybrid Relaying for Relay Channels with Multiple Out-of-Band Relays," Transactions on Emerging Telecommunications Technologies, Aug. 2013.

C. Koller, M. Haenggi, J. Kliewer, D. J. Costello, Jr.: Joint channel and network coding for star networks connected by binary symmetric channels. *IEEE Transactions on Communications*, vol. 62, no. 1, January 2014, pp. 158-169
B. Amiri, J. Kliewer, L. Dolecek: Analysis and enumeration of absorbing sets for non-binary graph-based codes. *IEEE Transactions on Communications*, vol. 62, no. 2, February 2014, pp. 398-409.

D. J. Costello, Jr., L. Dolecek, T. E. Fuja, J. Kliewer, D. G. M. Mitchell, R. Smarandache: Spatially coupled sparse codes on graphs – theory and practice. *IEEE Communications Magazine*, vol. 52, no. 7, July 2014, pp. 168-176.

Refereed Journal Accepted for Publication:

K. Mehta, J. Kliewer: An information-theoretic approach towards assessing perceptual audio quality using EEG, *IEEE Journal on Selected Areas in Communications – Series on Molucular, Biological, and Multi-Scale Communications*

O. Simeone, E. Erkip and S. Shamai (Shitz), "Full-Duplex Cloud Radio Access Networks: An Information-Theoretic Viewpoint," to appear in IEEE Wireless Commun. Letters.

S. Jeong, O. Simeone, A. Haimovich, and J. Kang, "Beamforming Design for Joint Localization and Data Transmission in Distributed Antenna System," to appear in IEEE Trans. Veh. Techn

C. Tapparello, O. Simeone and M. Rossi, "Dynamic Compression-Transmission for Energy-Harvesting Multihop Networks with Correlated Sources," to appear in IEEE/ACM Trans. Networking.

B. Ahmadi, H. Asnani, O. Simeone and H. Permuter, "Information embedding on actions," to appear in IEEE Trans. Inform. Theory.

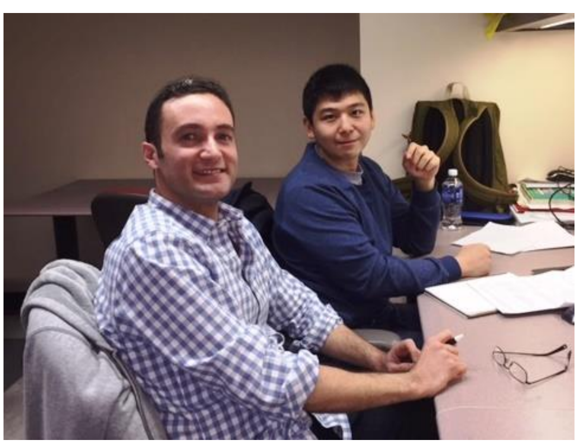
S. Khalili, O. Simeone and A. Haimovich, "Cloud Radio-Multistatic Radar: Joint Optimization of Code Vector and Backhaul Quantization" to appear in IEEE Signal Processing Letters.

A. M. Fouladgar, O. Simeone, S.-H. Park, O. Sahin and S. Shamai (Shitz), "Signal and Interference Alignment via Message Passing for MIMO Interference Channels," to appear in Transactions on Emerging Telecommunications Technologies.

B. Ahmadi, O. Simeone, C. Choudhuri and U. Mitra, "Cascade Source Coding with a Side Information "Vending Machine"," to appear in IEEE Trans. Inform. Theory.

Habibi, E. S. Emamian and A. Abdi, "Quantitative analysis of intracellular communication and signaling errors in signaling networks," BMC Systems Biology, accepted (July 2014).

Y. Sun and A.N. Akansu, ``Facial Expression Recognition with Regional Hidden Markov Models," IEE Electronics Letters, 2014.




Refereed Journal Submitted and under Review for Publication:

Khalili, S., Simeone, O., Haimovich, A. M. Cloud Radio-Multistatic Radar: Joint Optimization of Code Vector and Backhaul Quantization. *IEEE Signal Processing Letters, PP*(99), 1,1. Submitted August 24, 2014.

S. Jeong, O. Simeone, A. Haimovich, J. Kang, "Optimal Fronthaul Quantization for Cloud Radio Positioning," submitted to IEEE Transactions on Vehicular Technology.

S.-H. Park, A. M. Fouladgar, O. Simeone, O. Sahin and Sh. Shamai (Shitz), "Robust optimization of linear and non-linear transceivers for MIMO interference channels," submitted to IEEE Transactions on Vehicular Technology

K. Mehta, J. Kliewer: "An information-theoretic approach towards assessing perceptual audio quality using EEG", *IEEE Journal on Selected Areas in Communications – Series on Molucular, Biological, and Multi-Scale Communications*

O. Kosut, J. Kliewer: "Equivalence for networks with arbitrary states", *IEEE Transactions on Information Theory*

E. En Gad, Y. Li, J. Kliewer, M. Langberg, A. Jiang, J. Bruck, Asymmetric error correction and flash-memory rewriting using polar codes, *IEEE Transactions on Information Theory*

Papers Published in Conference Proceedings:

Jeong, S., Simeone, O., Haimovich, A. M., Kang, J. (2013). *Beamforming Design for Joint Localization and Data Transmission in Distributed Antenna Systems*. IEEE GlobalSIP 2013.

Chiriac, V. M., He, Q., Haimovich, A. M., Blum, R. S. (2013). *Ziv-zaikai bound for target location and velocity estimation using noncoherent MIMO radar* (pp. 1413-1417). Asilomar Conference on Signals, Systems and Computers.

S.-H. Park, O. Simeone, O. Sahin and S. Shamai (Shitz), “Multivariate Backhaul Compression for the Downlink of Cloud Radio Access Networks,” in Proc. IEEE Int. Symp. Inform. Theory (ISIT 2014), Honolulu, HI, Jun. 29-Jul. 4, 2014.

S.-H. Park, O. Simeone, O. Sahin and S. Shamai (Shitz), “Multihop Backhaul Compression for the Uplink of Cloud Radio Access Networks,” in Proc. IEEE Int. Symp. Inform. Theory (ISIT 2014), Honolulu, HI, Jun. 29-Jul. 4, 2014.

A. Fouladgar, O. Simeone and E. Erkip, “Constrained Codes for Joint Energy and Information Transfer with Receiver Energy Utilization Requirements,” in Proc. IEEE Int. Symp. Inform. Theory (ISIT 2014), Honolulu, HI, Jun. 29-Jul. 4, 2014.

S.-H. Park, O. Simeone, O. Sahin and S. Shamai (Shitz), “Performance Evaluation of Multiterminal Backhaul Compression for Cloud Radio Access Networks,” in Proc. Conference on Information Sciences and Systems (CISS), Princeton, NJ, March 19-21, 2014.

S.-H. Park, O. Simeone, O. Sahin and S. Shamai (Shitz), “On remote radio head selection for the downlink of backhaul constrained network MIMO systems,” in Proc. Conference on Information Sciences and Systems (CISS), Princeton, NJ, March 19-21, 2014.

J. Kang, O. Simeone, J. Kang, S. Shamai (Shitz), “Joint Signal and Channel State Information Compression for Uplink Network MIMO Systems,” in Proc. IEEE GlobalSIP 2013, Austin, TX, Dec. 3-5, 2013.

S. Jeong, O. Simeone, A. Haimovich, J. Kang, “Beamforming Design for Joint Localization and Data Transmission in Distributed Antenna Systems,” in Proc. IEEE GlobalSIP 2013, Austin, TX, Dec. 3-5, 2013.

S.-H. Park, O. Simeone, O. Sahin and S. Shamai (Shitz), “Multi-Layer Hybrid-ARQ for an Out-of-Band Relay Channel,” in Proc. IEEE PIMRC 2013, London, Sept. 8-11, 2013.

S.-H. Park, O. Simeone, O. Sahin and S. Shamai (Shitz), “Delay-Tolerant Robust Communication on an Out-of-Band Relay Channel with Fading Side Information,” in Proc. IEEE PIMRC 2013, London, Sept. 8-11, 2013.

K. Mehta, J. Kliewer: Assessing subjective perception of audio quality by measuring the information flow on the brain-response channel. *Proc. IEEE Int. Conf. Acoust., Speech, Signal Processing*, Florence, Italy, May 2014, pp. 5884-5888.

O Kosut, J. Kliewer: Equivalence for networks with adversarial state. *Proc. IEEE Int. Symp. on Information Theory*, Honululu, HI, July 2014, pp. 2252-2256.

W. Huang, T. Ho, M. Langberg, J. Kliewer: Reverse edge cut-set bounds for secure network coding. *Proc. IEEE Int. Symp. on Information Theory*, Honululu, HI, July 2014, pp. 106-110.

E. En Gad, Y. Li, J. Kliewer, M. Langberg, A. Jiang, J. Bruck: Polar coding for noisy write-once memories. *Proc. IEEE Int. Symp. on Information Theory*, Honululu, HI, July 2014, pp.1638-1642.

W. Huang, T. Ho, M. Langberg, J. Kliewer: Single source/sink network error correction is as hard as multiple unicast. *Proc. Fifty Second Annual Allerton Conference on Communication, Control, and Computing*, Monticello, IL, Oct. 2014.

M. Bloch, J. Kliewer: Strong coordination over a three-terminal relay network. *Proc. IEEE Information Theory Workshop*, Hobart, Australia, Nov. 2014, pp. 647-651.

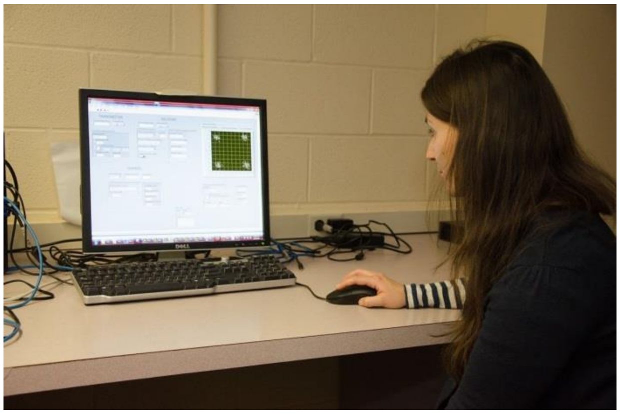
R. Chou, M. Bloch, J. Kliewer: Low-complexity channel resolvability for the symmetric multiple-access channel. *Proc. IEEE Information Theory Workshop*, Hobart, Australia, Nov. 2014, pp. 467-471.

Y. Sun, A.N. Akansu and J. Cicon, "The Power of Fear: Facial Emotion Analysis of CEOs to Forecast Firm Performance," 15th IEEE International Conference on Information Reuse and Integration, Aug. 2014.

Y. Sun and A.N. Akansu, "Automatic Inference of Mental States from Spontaneous Facial Expressions," IEEE ICASSP, May 2014.

News

Development of a Software Defined Radio undergraduate laboratory including purchasing lab equipment, developing experiments, and writing a lab manual. This is an ongoing collaboration with Prof. Haimovich and Prof. Simeone, ECE, 2012 – present.



NJIT Board of Overseers Honors Two Distinguished Professors For Pioneering Research [10/3/2014]

At NJIT's seventh annual celebration of research excellence, the Board of Overseers honored two eminent NJIT faculty members, Distinguished Professor Emeritus Yeheskel Bar-Ness and Distinguished Professor Somenath Mitra, for foundational contributions to their respective fields of wireless communications and nanotechnology. Bar-Ness received the 2014 Excellence in Research Lifetime Achievement Award for his groundbreaking work in electrical and computer engineering.

Eight Doctoral Students Present Research at Annual Elisha Yegal Bar-Ness CWCSPR Showcase [5/12/2014]

NJIT's Elisha Yegal Bar-Ness Center for Wireless Communications and Signal Processing Research showcased recently the research of eight doctoral students. The students' work was featured in presentations and posters displayed in the area. The annual event aims to give doctoral students and their professors from the center a chance to exchange information from a year's worth of work.

Patents Awarded/Filed

“15-004 Method and apparatus for signal and interference alignment”, O. Simeone, A. M. Fouladgar, invention disclosure.

“15-006 - Topology Discovery for Linear Wireless Networks with Application to Train Backbone Inauguration”, Y. Liu, O. Simeone, A. Haimovich M. Zhou, invention disclosure.

“Power Allocation for MIMO amplify-and forward relay channel”, N. Varanese, Y. Bar-Ness and O. Simeone, US Patent 8195089.

"Disclosure - Topology Discovery for Linear Wireless Networks with Application to Train Backbone Inauguration," Haimovich, Alexander M., Liu, Yu, Patent Type and Nationality: Regular, United States, Patent or Copyright Approved: August 21, 2014.

"Disclosure - Code-Aided EM Algorithm for Joint Channel Tracking and Decoding for Sparse Fast-Fading Multipath Channels," Haimovich, Alexander M., Khalili, Shahrouz, Patent Type and Nationality: Regular, United States, Patent or Copyright Approved: April 30, 2014.

“Asymmetric error correction and flash-memory rewriting using polar codes” E. En Gad, Y. Li, J. Kliewer, M. Langberg, A. Jiang, J. Bruck (full patent) Filed.