



2015 ANNUAL RESEARCH DAY

The Elisha Yegal Bar-Ness Center for Wireless Communications and Signal Processing Research

Tuesday, March 24, 2015

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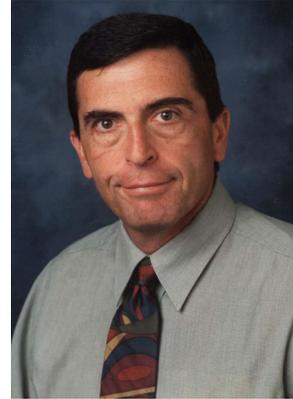




Welcome to the Center for Wireless Communications and Signal Processing Research (CWCSPR) Research Day 2015

5G Research at New Jersey Institute of Technology

The Elisha Yegal Bar-Ness Center for Wireless Communications and Signal Processing Research (CWCSPR) at New Jersey Institute of Technology (NJIT) was founded in 1985 by Professor Yeheskel Bar-Ness, who also served as its director until 2014. Since its inception, CWCSPR has contributed to technological advances in many areas of communications and signal processing. Research activity at the Center has grown over the years and diversified into new research fields. Current main areas of research are wireless networking, information theory, cloud radio access networks, radar, and sensor networks.



CWCSPR serves as a collaboration hub for faculty, visiting scholars, post-doctoral fellows, graduate, and undergraduate students. The Center routinely hosts international visiting scholars. Several current Ph.D. students pursue joint degrees because of agreements between NJIT and other universities.

The theme of the CWCSPR Research Day 2015 is “Towards 5G Mobile Networks: Research Trends.” The development of 5G wireless technologies is driven by convergent trends including the expected increase in the number of machine-to-machine wireless connections as the Internet of Things is taking shape; the proliferation of cloud-based services; the advancement in consumer electronics that will require ultra-high definition communication and high-definition multimedia interactions; vehicular connectivity; and more.

Research Day will feature presentations by faculty affiliated with the Center and other ECE faculty showcase research that addresses the challenges posed by the next generation of mobile networks. The presentations cover a broad range of topics such as error control strategies, cloud processing, geolocation, lightwave communications, data hiding and more. The Director of Wireless Communications Research Department at Bell Labs, Alcatel-Lucent, Dr. Reinaldo Valenzuela, is the keynote speaker.

I wish you a pleasant experience at NJIT.

Sincerely,



*Alexander M. Haimovich
Director, CWCSPR*



CWCSPR RESEARCH DAY 2015
TOWARDS 5G MOBILE NETWORKS: RESEARCH TRENDS
Tuesday, March 24, 2015
NJIT Campus Center Atrium, University Heights, Newark, NJ 07102

PROGRAM

9:30 - 9:40 a.m.	Welcoming Remarks
	Morning Session Faculty Presentations
9:40 - 10 a.m.	Advances in Error Control Strategies for 5G J. Kliewer
10 - 10:20 a.m.	Cloud Processing for 5G Systems O. Simeone
10:20 - 10:40 a.m.	Direct Methods for Geolocation Over Multipath Channels A. Haimovich
10:40 - 11 a.m.	5G is Man-Made Cells, 1G in Human Cells A. Abdi
11 - 11:20 a.m.	Visible-Light Enhanced 5G System A. Khreishah
11:20-11:30 a.m.	Break



11:30 a.m. to 12:30 p.m.

Keynote Speaker

5G Physical Layer Technologies: Challenges and Opportunities

Reinaldo Valenzuela

*Director, Wireless Communications Research Department,
Bell Labs, Alcatel-Lucent*

12:30–1:30 p.m.

Lunch

1:30-1:50 p.m.

Ultra-Short Pulse Antennas for Communication and Sensor Systems

H. Grebel

1:50-2:10 p.m.

Silicon-Germanium Nanotechnology for Wireless and Radar Applications

L. Tsybeskov

2:10-2:30 p.m.

Reversible Data Hiding

Y. Shi

2:30-2:50 p.m.

Expediting the Transmission of Data-Center Traffic

R. Rojas-Cessa

2:50-3:10 p.m.

**Event-Driven Signal Processing and Communications from
Time-Varying and Level Crossing Sampling Perspectives**

H. Ge





KEYNOTE SPEAKER



Reinaldo Valenzuela, Ph.D.

Director,

*Wireless Communications Research Department,
Bell Labs, Alcatel-Lucent*

Reinaldo Valenzuela received a B.S. degree from the University of Chile and a Ph.D. from Imperial College. He is currently Director of the Wireless Communications Research Department at Bell Laboratories and a Distinguished Member of Technical Staff. Dr. Valenzuela has been at the forefront of many recent advances in wireless systems. His research includes propagation measurements and models, MIMO/space time systems achieving high capacities using transmit and receive antenna arrays, HetNets, small cells, and next generation air interface techniques and architectures. The author of more than 185 papers, he has 44 issued patents and more than 20,000 citations in Google Scholar. Dr. Valenzuela is a “Highly Cited Author” in Thomson ISI, a Fulbright Senior Specialist, an IEEE Fellow and a Bell Labs Fellow. For his pioneering contributions to MIMO technology, he was awarded the 2010 IEEE Eric E. Sumner Award.



FACULTY RESEARCH PRESENTATIONS

Advances in Error Control Strategies for 5G

Joerg Kliewer

The significant increase in datarate, mobile data volume, and the number of connected devices predicted for future 5G cellular systems poses a significant constraint on the power consumption of mobile devices, which spark the demand for more efficient communication architectures. As error control codes are now able to approach the theoretical limit arbitrarily closely, in order to apply these coding schemes to 5G systems the focus is now on near optimal performance with low encoding and decoding complexity at the same time. This talk provides a brief overview about emerging low complexity error control schemes which are suitable for 5G systems and highlights some open questions along these lines.

Cloud Processing for 5G Systems

Oswaldo Simeone

Cloud processing enables the centralization of radio access network (RAN) functionalities and hence facilitates the deployment of dense heterogeneous networks. A key technical challenge of the resulting architecture, known as Cloud-RAN (C-RAN), is the integration of the wireless access channel and of the fronthaul network that transfers radio/baseband signals between the cloud and the radio units. In this talk, a novel baseband compression approach is presented for the C-RAN downlink. The main idea is that of viewing the quantization noise as a distributed source of interference whose impact on the signal space can be controlled by means of joint compression across the radio units.

Direct Methods for Geolocation over Multipath Channels

Alexander Haimovich

Source localization over multipath channels is a challenging problem with applications in defense, law enforcement, sensor networks and others. Traditional time-of-arrival (TOA)-based localization is a two-step process that is suboptimal at lower signal to noise ratios, and is challenged by scenarios with multiple sources. We propose a direct localization method (DLM) that exploits the sparsity of the emitters, as well as differences in properties of the line of sight (LOS) versus multipath components of the signals received at the sensors. It is shown that the proposed method has superior performance relative to other known localization techniques and is robust to sensors with blocked LOS.



5G is Man-Made Cells, 1G in Human Cells!

Ali Abdi

Intracellular signaling networks in human cells transmit signals from the cell membrane to the nucleus, via biochemical interactions. The goal is to regulate some target molecules, to properly control the cell function. Regulation of the target molecules occurs through the communication of several intermediate molecules that convey specific signals originated from the cell membrane to the specific target outputs. We propose to model intracellular signaling networks as communication channels. We define the fundamental concepts of transmission error and signaling capacity for intracellular signaling networks, and devise proper methods for computing these parameters. The developed systematic methodology quantitatively shows how the signals that ligands provide upon binding can be lost in a pathological signaling network, due to the presence of some dysfunctional molecules. We show the lost signals result in message transmission error, i.e., incorrect regulation of target proteins at the network output.

Furthermore, we show how dysfunctional molecules affect the signaling capacity of signaling networks and how the contributions of signaling molecules to the signaling capacity and signaling errors can be computed. The proposed approach can quantify the role of dysfunctional signaling molecules in the development of the pathology. We present experimental data on caspase3 and T cell signaling networks to demonstrate the biological relevance of the developed method and its predictions.

Visible-light Enhanced 5G System

Abdallah Khreishah

The demand for multimedia applications is expected to continue to grow over the coming decades. Therefore, current networking and Internet infrastructures must evolve to meet this growth. Wireless heterogeneous networks (HetNets) will play an important role toward the goal of using a diverse spectrum to provide high quality of service, especially in indoor environments where there is localized infrastructure supporting short-range directional wireless access. An additional tier in the wireless HetNets concept is envisioned using indoor gigabit small-cells (SCs) to offer additional wireless capacity where it is needed the most. The use of light as a new mobile access medium is considered promising. In this talk, we present our design of a visible-light enhanced 5G system. We first discuss the design and analysis of the hybrid system to enhance the throughput and delay of the system. After that, we present the joint lighting, power control and scheduling problem. We show that this problem is NP-hard and present two approximation algorithms for the problem. One of them is offline while the other is online. Several extensions of our system will also be discussed.



5G Physical Layer: Technology Opportunities and Challenges

Reinaldo A. Valenzuela

Director, Wireless Communications Research Department
Bell Labs, Alcatel-Lucent

The insatiable demand for media-rich content and the increasing availability of advanced devices such as smartphones, tablets, etc., is forcing the mobile communications ecosystem to start in earnest to consider the next generation solutions to address these needs. Some of the options being mentioned as ingredients for such 5th Generation mobile radio systems include Small Cells, HetNets, Carrier Aggregation, Machine-to-Machine, Internet-of-Things, Relays, Device-to-Device and operation in the millimeter wave spectrum range, among others. This talk will review some of the background trends driving the evolution of broadband wireless access that will impact the technology choices beyond 2020, as well as consider in detail some of the most intriguing options service providers may consider.

Ultra-short Pulse Antennas for Communication and Sensor Systems

Haim Grebel

Ultra-Wideband (UWB) systems have been the subject of intense research because they present an alternative physical layer to wireless systems. The essence of such links is the ability to transmit and receive Ultra-Short-Pulses (USP). USPs are also key to wired communication systems. With seamless information flow between wired and wireless links in mind, it is critical to develop an antenna structure which supports ultra-wideband wireless links. Here we describe an antenna array, capable of faithfully transmitting and receiving 100 psec pulses, namely, exhibiting a larger than 10 GHz frequency bandwidth. In addition, optical nano-antennas will be described.

Silicon-Germanium Nanotechnology for Wireless Systems and Radars

Leonid Tsybeskov

Silicon-Germanium (SiGe) technology became a driving force in emerging markets of low-cost/lightweight personal communication devices, high-speed data transmission, radars, Direct Broadcast Satellite (DBS) and automobile collision avoidance systems. In many aspects (like high-frequency noise, low power consumption, etc.), SiGe heterojunction bipolar transistors (HBTs) are advantageous over III/V-based devices. In addition, SiGe integrated circuits (ICs) are manufactured at high integration levels and low costs, and they are capable for realization of multipurpose RF building blocks. This talk is focused on novel SiGe nanoscale devices and their applications in wireless systems and radars.



Reversible Data Hiding

Yun Q. Shi

Reversible data hiding (RDH) is such a kind of data embedding technology that the original carrier can be recovered without any error once the hidden data are extracted. This technology has wide applications in our digital world from authentication to efficient data transmission for various applications. In this talk, a histogram-pair based image RDH scheme is to be presented, which can achieve optimal performance in terms of the highest PSNR (peak signal noise ratio) at a certain data embedding rate by adjusting four newly established thresholds. Finally, some other new developments in RDH will be briefly introduced.

Expediting the Transmission of Data-Center Traffic

Roberto Rojas-Cessa

The performance of a data center and some of the services it provides may be determined by the achievable response time. Users issue task requests and the data center provides a response within a deadline or as soon as possible. The traffic generated by the processes executing the task may contend for resources with traffic generated by maintenance and other task processes. In this talk, we discuss the different existing approaches to transport flows, or flow completion time, in a data center. In particular, we discuss an approach proposed by our Networking Research Laboratory where data center switches are adapted for achieving short flow completion times.

Event-Driven Signal Processing and Communications from Time-Varying and Level Crossing Sampling Perspectives

Hongya Ge

This work introduces a simple effective approach for recovering the time-domain information-bearing waveforms as well as identifying the spectral signatures of various broadband noise modulated hidden rhythmic signals. The proposed solution is based on the framework of multi-rate and level-crossing signal processing in combination with the principle of spread spectrum. Our approach enables a parallel scheme of compressive sampling based spectral analysis and diversity combining with improved SNR performance. Working on CD quality real acoustic datasets as well as simulated datasets, our solution can effectively filter out the hidden rhythmic signals of various harmonic features lying within relative limited bandwidths.



POSTER PRESENTATIONS

Modulation Classification for MIMO-OFDM Signals via Gibbs Sampling

Yu Liu, Ph.D. Student, Alexander Haimovich, and Osvaldo Simeone

The problem of modulation classification for a multiple-antenna (MIMO) system employing orthogonal frequency division multiplexing (OFDM) is investigated. The classification problem is formulated as a Bayesian inference task and a solution is proposed. The proposed Gibbs sampling method converges to the optimal Bayesian solution and the speed of convergence is shown to improve via annealing and random restarts. While most of the existing modulation classification techniques work under the assumptions that the channels are flat fading and that a large amount of observed data symbols is available, the proposed approach performs well under more general conditions.

Effect of MAC Type and Speed on Neighbor Discovery in Wireless Train Networks

Pelin Salem, Ph.D. Student, and Alexander Haimovich

In this paper, a wireless neighbor discovery (ND) process in a linear topology of a high-speed train backbone network is studied. A key step that enables communication in such a network is that of topology discovery (TD), or train inauguration, whereby nodes learn in a distributed fashion the physical topology of the backbone network. The first and key step in TD is ND, where each individual node discovers its right and left one-hop neighbors. While the current standard for train inauguration assumes wired links between adjacent backbone nodes, this paper investigates the more challenging scenario in which the nodes communicate in wireless-fashion based on IEEE 802.11 or slotted-ALOHA. The implementation of ND over wireless channels is made difficult by the broadcast nature of the wireless medium, which includes fading and interference. A network simulation using NS-2 software was developed for the 802.11-based (and slotted-ALOHA based) wireless ND. The network simulation was applied to analyze performance metrics, such as time to successful ND and ND success rate as a function of various parameters.

Direct Localization of Sources Using Widely Spaced Sensors in Multipath Environments

Nil Garcia, Ph.D. Student, and Alexander Haimovich

This work addresses the localization of sources with known waveforms in frequency-selective channels. Conventional localization by multilateration is an indirect approach that is suboptimal at lower SNR, and breaks down in the presence of multipath. We propose a direct localization method (DLM) that exploits the sparsity of the emitters, as well as differences in the properties of the line of sight (LOS) versus multipath components of the signals received at the sensors. It is shown that the proposed method has superior performance relative to other known localization techniques and is robust to sensors with blocked LOS.



Sparse Arrays, MIMO, and Compressive Sensing for GMTI Radar

Haley Kim, Ph.D. Student, and Alexander Haimovich

This work proposes a radar combining four synergistic elements: space-time adaptive processing (STAP), random arrays, multiple-input multiple-output (MIMO) radar, and compressive sensing. STAP supports joint space-time processing for detecting moving targets in ground clutter. Large, random arrays are under sampled arrays that support improved angle-Doppler resolution and lower minimum detectable velocity (MDV), at the cost of higher sidelobes. MIMO provides further improvements in angular resolution and MDV. Compressive sensing algorithms are designed to cope with ambiguities introduced by under sampling. We propose an algorithm for target detection and analyze its performance for detecting, slow ground targets.

Provably Efficient Online Collaborative Caching for Multicell-Coordinated Systems

Ammar Gharaibeh, Ph.D. Student and Abdallah Khreishah

Caching at the base stations brings the content closer to the users, reduces the traffic through the backhaul links, and reduces the delay experienced by the cellular users. The cellular network operator may charge the content providers for caching their content. Moreover, content providers may lose their users if the users are not getting their desired quality of service, such as maximum tolerable delay in Video on Demand services.

In this paper, we study the collaborative caching problem for a multicell-coordinated system from the point of view of minimizing the total cost paid by the content providers. We formulate the problem as an Integer Linear Program and prove its NP-completeness. We also provide an online caching algorithm that does not require any knowledge about the content popularities. We prove that the online algorithm achieves a competitive ratio of $\mathcal{O}(\log(n))$, and we show that the best competitive ratio that any online algorithm can achieve is $\Omega(\frac{\log(n)}{\log\log(n)})$. Therefore, our proposed caching algorithm is provably efficient. Through simulations, we show that our online algorithm performs very close to the optimal offline collaborative scheme, and can outperform it when content popularities are not properly estimated.



Visible-light Enhanced WiFi

Sihua Shao, Ph.D. Student and Abdallah Khreishah

In order to take the advantages of both WiFi and visible light communication (VLC), we propose and implement two heterogeneous systems with Internet access. One is the hybrid WiFi-VLC system, utilizing unidirectional VLC channel as downlink and reserving the WiFi back-channel as uplink. The asymmetric solution resolves the optical uplink challenges and benefits from the full-duplex communication based on VLC. To further enhance the robustness and increase throughput, the other system is presented, in which we aggregate WiFi and VLC in parallel by leveraging the bonding technique in the Linux operating system. Online experiment results reveal that the hybrid system outperforms the conventional WiFi for the crowded environments in terms of throughput and web page loading time, and also demonstrate the further improved performance of the aggregated system when considering the blocking duration and the distance between access point and user device.

A Novel Login Authentication Scheme Based on Dynamic Communication Delay Patterns

Zuochao Dou, Ph.D. Student and Abdallah Khreishah

Passwords have been proven to be an untrusted user login authentication method over the past decades. To overcome the weaknesses of passwords, a 2-factor authentication scheme is introduced. However, according to CustomerReport®, 3.1 million smartphones were stolen in 2013 in the U.S., which indicated a big threat for 2-factor authentication. To address these issues, we propose a novel login authentication mechanism based on the communication delay patterns (i.e., packet round trip delay and its variance). We design and implement novel network architecture to avoid the communication pattern forgery and perform mathematical analysis of the latency distribution reconstruction to verify that our work is feasible in real time. This is ongoing research; we plan to perform worldwide experiments to demonstrate that the false negative/positive rates are acceptable and the system robustness is guaranteed. Last but not least, mobility issue is also considered as a future research extension.

Low-Complexity Wireless Sensor Communication Based on Asynchronous Processing

Chen Yi, Ph.D. Student, and Joerg Kliewer

We study an asynchronous low-complexity wireless communication system, which is based on asynchronous sampling and asynchronous frequency shift keying modulation. The asynchronous sampling only triggers a transmit pulse if the source signal to be quantized has changes which exceed some threshold. Therefore, the transmitter only transmits pulses if the source signal is active, which reduces the power consumption significantly. Thus, this communication architecture is well suited for biosensor applications where sensor power consumption is a critical resource. An error analysis shows that the main error contribution are errors due to false detections of symbol timings and extra pulses erroneously inserted at the receiver, which however become small for moderate SNR.



Privacy-Constrained Lossy Compression Based on Polar Codes

Farshid Mokhtarinezhad, Ph.D. Student, and Joerg Kliewer

In this problem we consider two correlated discrete sources X and Y , where \hat{X} is reconstructed from only the source X by using a lossy source coding approach with rate R . Our objective is different from common rate-distortion optimal lossy source coding. In particular, we impose a privacy constraint on Y and quantify the amount of data that will be released about Y as equivocation Δ . This models the situation where a certain amount of source information X from one user is provided as utility to another user or the public, but some other part of the source information Y must be kept private to any outside party during the reconstruction process of X . We then show that polar codes achieve the optimal triple $(R; D; \Delta)$, thus providing a constructive solution for this problem.

Inter-Layer Per-Mobile Optimization of Cloud Mobile Computing: A Message-Passing Approach

Shahrouz Khalili, Ph.D. Student, and Osvaldo Simeone

Cloud mobile computing provides a promising solution for the problem of running computation intensive applications on battery-limited mobile devices. However, accessing the cloud through a wireless network entails the energy and latency required for uplink and downlink transmissions, potentially offsetting the gains of this technology. The management of the energy and latency associated with mobile-cloud communication calls for an inter-layer optimization approach that encompasses the physical layer, via power allocation, and the application layer, via the selection of which subtasks should be offloaded to the cloud.

In this paper, algorithmic solutions are proposed that tackle this problem in a principled fashion via message-passing strategies on the call graph of the application to be run at a mobile. Both serial and parallel implementations are considered, where, in the latter case, computations and communication tasks are allowed to run in parallel. Numerical results compare the performance of the two implementations and bring insight into the impact of the call graph on the performance of the system.--==

