

# KEDAR KULKARNI

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## Research Interests

Cognitive radio, Cooperative networks, Energy harvesting, Green communication, Queueing theory, Markov decision process

## Education

Year	Degree	Institute	CPI
2010-Present	Ph.D., Electrical Engineering	Indian Institute of Technology Kanpur	8.55 / 10
2006-10	B.Tech., Electronics & Telecommunications	College of Engineering Pune	8.96 / 10
2006	Higher School Certificate Examination	Vivekanand College, Kolhapur	91.5%
2004	Secondary School Certificate Examination	Tavanappa Patne Highschool, Kolhapur	91.33%

## Relevant Courses

Wireless Communications	Digital Communication Networks
Information Theory and Coding	Digital Switching
Communication Theory	Simulation of Communication Systems
Representation and Analysis of Random signals	Detection and Estimation Theory
Introduction to Signal Analysis	Mathematical Methods in Signal Processing
Topics in Cryptography and Coding Theory	

## Research Articles

### Journals (under review)

- K. Kulkarni and A. Banerjee, "On Stable Throughput of Cognitive Radio Networks With Cooperating Secondary Users," IEEE Transactions on Communications, **accepted**.  
Abstract: We propose novel cooperation protocols where multiple secondary users assist primary user in retransmission of its unsuccessful packets. We analyze users' packet throughput by modelling the protocols as signal flow graphs. Effect of imperfect sensing on stable throughput is examined for individual sensing as well as cooperative sensing cases.
- K. Kulkarni and A. Banerjee, "On Optimal Spectrum Access of Cognitive Relay With Finite Packet Buffer," Submitted to IEEE Transactions on Vehicular Technology.  
Abstract: We consider a scenario where secondary users acts as a relay for primary transmission. All packet queues are of finite size. Using discrete time Markov chain analysis, we propose an optimal access method under packet loss constraint of primary user. We also propose suboptimal methods that are good low complexity alternatives to the optimal method.
- K. Kulkarni and A. Banerjee, "Multi-channel Sensing And Resource Allocation in Energy Constrained Cognitive Radio Networks," Submitted to Elsevier Physical Communication.  
Abstract: We investigate energy constrained secondary users in a multi-channel environment where sensing can only be done one channel at a time. We model the problem of finding optimal sensing times and transmit powers as a non-linear Knapsack resource allocation problem and provide solution to maximize aggregate bit-throughput using greedy method.

### Conferences

- K. Kulkarni and A. Banerjee, "Stable Throughput Tradeoffs in Cognitive Radio Networks With Cooperating Rechargeable Nodes," in Proc. IEEE Wireless Commun. Netw. Conf. (WCNC), New Orleans, LA USA, vol., no., pp.1742-1747, 9-12 March 2015.  
Abstract: We consider a cognitive radio network employing cooperative relaying where all nodes are battery powered. Using principle of stochastic dominance, we characterize stable throughput region of the system and study effect of energy arrival and battery capacity on stable throughput region.

- K. Kulkarni and A. Banerjee, “Adaptive Transmission Strategies To Maximize Packet Throughput Of Cognitive Radio Under Primary User Queue Stability Constraint,” in Proc. Int. Conf. Signal Process. Commun. (SPCOM), IISc Bangalore, India, vol., no., pp.1-6, 22-25 July 2014.  
Abstract: We analyze and compare stable throughput of secondary user in two access modes-- interweave mode and joint interweave-underlay mode. We study effect of channel conditions on the packet throughput and find the crossover point where one mode performs better than the other.
- K. Kulkarni and A. Banerjee, “Maximizing Sum-Outage Capacity of OFDM-based Cognitive Radio Under Primary User Queue Stability Constraint,” in Proc. IEEE Wireless Commun. Netw. Conf. (WCNC), Istanbul, Turkey, vol., no., pp.1-6, 6-9 April 2014.  
Abstract: When primary user is a queue based system, secondary user must ensure queue stability of primary user while accessing its spectrum. We show that the queue stability constraint is equivalent to an interference constraint. Under this constraint, we propose power allocation to maximize sum-outage capacity of OFDM based secondary user.
- K. Kulkarni and A. Banerjee, “Power Allocation for OFDM-based Cognitive Radio Systems Under Average Interference Constraint,” in Proc. National Conf. Commun. (NCC), IIT Delhi, India, vol., no., pp.1-5, 15-17 Feb. 2013.  
Abstract: Primary users can arrive or depart at any time in the transmission period of secondary user. We model this dynamic activity of primary users by two-state Markov chain and propose a power allocation method to maximize transmission rate of secondary user under average interference constraint.

## Projects

- Resource Allocation And Stable Throughput Tradeoffs in Cognitive Radio Networks (Ph.D. Thesis, submitted, 2016)  
Supervisor: Dr. Adrish Banerjee, IIT Kanpur  
Abstract: We proposed power allocation methods to maximize secondary user capacity considering factors such as dynamic primary user activity, energy constrained users and sensing-throughput tradeoff. We also proposed novel cooperation protocols and optimal spectrum access methods for queue based cognitive radio systems. Focus of the thesis is on studying effect of cooperation and energy availability on user throughput.
- Multi-user Detection in DS-CDMA (Term paper, EE 670: Wireless Communications, 2011)  
Instructor: Dr. Aditya Jagannatham, IIT Kanpur  
In the term paper, I surveyed joint detection techniques in multi-user DS-CDMA systems. A performance comparison of sub-optimal linear receivers, decorrelating receiver and MMSE receiver was done.
- Automatic Vehicle Detection, Classification and Number Plate Recognition (B.Tech. Project, 2010)  
Supervisor: Dr. M. A. Joshi, COEP, Pune.  
Abstract: The idea of automation of toll plazas inspired this project. We used background subtraction and pixel-area based classification for vehicle detection and classification respectively. Number plate recognition was done using image segmentation and heuristics based optical character recognition.
- Multi-variable Expert Monitor System (MEMS) based soil moisture control (B.Tech. Mini-project, 2009)  
Abstract: I simulated an irrigation plant by varying speed of motor with changes in soil moisture using fuzzy logic based control. The control algorithm was implemented on AVR Atmega32 microcontroller.
- ROBOCON (National robotics competition, 2009)  
Abstract: I worked on navigation module of three fully autonomous robots assigned with the task of picking up another robot and traveling across an arena. The work included interfacing optical encoders and light sensors with AVR microcontroller boards for line tracing and implementing PID speed control.

## Talks

- Seminar on “Power Allocation for OFDM-based Cognitive Radio Systems Under Average Interference Constraint” (IEEE Student Seminar, Uttar Pradesh Section, IIT Kanpur, March 2013).
- Seminar on Architecture and Programming of AVR Atmega Microcontrollers (IET Design Course, COEP, Pune, 2009).
- Seminar on Introduction to Sensors and Use of Optical Sensors in Line Tracing (Line Follower Workshop, Robot Study Circle, COEP, Pune, 2008).

## Teaching Experience

- Tutor  
Course tutorship involved taking one lecture per week to solve numerical problems that will help students understand the theory taught in course and grading final examination of the course. In laboratory, tutorship involved designing experiments and conducting lab sessions.
  - ESC 201: Introduction to Electronics (Course), Fall 2014
  - ESC 201: Introduction to Electronics (Lab), Spring 2013
  
- Teaching assistant  
Assistant-ship involved preparing assignments and grading quizzes.
  - EE 381: Digital Circuits and Microprocessors (Lab), Spring 2012, Spring 2011.
  - EE 320: Principles of Communication (Course), Fall 2011, Fall 2010.

## Achievements

- Best Teaching Assistant Award in Spring Semester 2014 and Spring Semester 2012 at IIT Kanpur.
- Was awarded IEEE ComSoc Student Travel Grant for IEEE WCNC'15 and IEEE WCNC'14.
- 1<sup>st</sup> prize in Design Competition at IET Design Course 2008, COEP, Pune.
- 2<sup>nd</sup> prize in Circuit Debugging Competition at MindSpark 2007, COEP, Pune.

## Others

- Programming skills: MATLAB, Python, C, Assembly programming for AVR microcontrollers and 8051.
- Student member IEEE and student member IEICE.