

# Veeraruna Kavitha

## Curriculum Vitae

### Career Objective

To pursue learning and research in the field of stochastic analysis/optimization, networking, communication theory, statistical signal processing, information theory etc while improving the understanding of more sophisticated areas in applied mathematics like probability theory, optimal control, game theory. To develop better algorithms and thereby develop better communication systems.

### Personal Information

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### Brief Bio

I obtained my B.E. degree in Electronics from UVCE, Bangalore in 1994 and the M.Sc (Engg) and Ph.D. degree from Dept. of ECE, Indian Institute of Science (IISc), Bangalore in 2002 and 2007 respectively. From 1994-2000, I was involved in the design and development of GPS, CDMA and Voice band modems at Accord Software and Systems, Bangalore. I was an NBHM (National Board for Higher Mathematics) post doctoral fellow at Tata Institute of Fundamental Research (TIFR), Bangalore, during 2007-08. From 2008 onwards, I have been a post doctoral researcher with MAESTRO, INRIA, Sophia Antipolis, France and LIA, University of Avignon, France.

### Interests

Stochastic analysis, Stochastic optimal control, Wireless communications, Networking, Game theory, Statistical Signal Processing, Information Theory.

## Education

<u>Doctorate</u>	PhD
University	Indian Institute of Science, Bangalore.
Department	Electrical & Communication Engineering.
Specialization	Wireless communications, Channel Equalization.
Year	Sept 2007.
<u>MastersDegree</u>	MSc (Engg.)
University	Indian Institute of Science, Bangalore.
Department	Electrical Engineering.
Specialization	Blind Equalization, OFDM systems
Year	2002.
<u>BachelorsDegree</u>	B.E.(Electronics & Communication Engg.)
University	UVCE, Bangalore University.
Department	Electronics .
Year	1994.

## CourseWork

<u>Engineering</u>	Advanced Digital Communications, Estimation & Detection Theory, Information Theory, Adaptive Signal Processing, Stochastic Models and Applications, Stochastic Processes and Queuing Theory.
<u>Mathematics</u>	Topology, ODEs, Complex Analysis, Real Analysis, Functional Analysis, Advanced Calculus, Non linear Functional Analysis and applications to Differential equations Part I, Advanced Probability Theory.

## Achievements

1. Accord recognition award in 1996. This is an annual award presented to few outstanding employees (about 2 to 3).
2. I was awarded the NBHM (National Board for Higher Mathematics) Fellowship for the year 2007-2008 by the Government of India to carry out Post doctoral research in any of the esteemed mathematical centres within India (for example, TIFR (Tata Institute of Fundamental Research)).

## Current Employment (From August 2008)

I am currently working as a Postdoctoral Fellow under the supervision of Prof. Eitan Altman. I am a part of the MASTERO group of INRIA, Sophia Antipolis that is located together with Eitan Altman in University of Avignon. Major on going activities during this period :

- Stationary expected workload derivation for various continuous polling models via discretization approach.
- Optimal Control of Delay Tolerant Networks using Risk Sensitive MDP tools.
- Adversarial control of Delay Tolerant Networks in the presence of jammers.
- Opportunistic Scheduling in presence of noncooperation.
- Queuing in Space : Design of optimal message ferry routes.
- Mobility in Small Cell networks.
- Analysis of Non saturated slotted aloha channel.

## Post Doc at TIFR, Bangalore (August 2007 - July 2008)

The actual Post Doc started in April 2007. However my PhD defense took place only in July 2007 and hence during a part of this period I was parallely also a PhD student. In some countries, this period is not considered as a part of the Post Doc program. I worked as a Postdoctoral Fellow under NBHM Fellowship at TIFR (Tata Institute of Fundamental Research), Bangalore, India. Major activities during this period are:

- Learning stochastic control theory and viscosity solutions.
- Existence of value and a saddle point for zero sum stochastic differential games.
- Decentralized change detection at fusion center in a sensor network environment.

## PhD (August 2002 - September 2007)

**Topic :** Optimal Wireless Equalizers

**Res. Supervisor :** Professor Vinod Sharma, ECE Dept., IISc, Bangalore.

**Description :** The work addresses various issues related to equalizers in wireless channels.

In the first part of the thesis, using "channel" capacity as the performance measure, we obtain a systematic comparison of the blind, semi-blind and training equalizers. We approximate the blind/semi-blind CMA (Constant Modulus Algorithm) trajectories with the solution of an ODE, which facilitated the computation of the performance measure. We then obtain a tight easily computable lower bound on capacity and using this, we show that semi-blind equalizers perform best in any given wireless scenario.

The second part of the thesis focuses on convergence and tracking properties of the more commonly used training equalizers in a wireless environment. Towards this, we first obtain an ODE approximation for a general system whose components may depend on two previous values. This result facilitated us to obtain an ODE approximation for an LMS (Least Mean Square) Linear/ Decision feedback equalizer in training mode or an LMS linear equalizer in decision directed (DD) mode while tracking a wireless channel modeled by an AR (2) process. We conclude that a training based LMS linear equalizer tracks the instantaneous WF (Wiener filter). A decision directed LMS linear equalizer stays close to the instantaneous Wiener filter whenever the SNR (Signal to Noise Ratio) is high and when the equalizer is properly initialized. However, at low SNRs, the DD attractors are away from the Wiener filter. We also show that a training based LMS decision feedback equalizer stays close to the instantaneous Wiener filter at high SNRs.

Along the way, the thesis also attempts to solve some long standing issues in a fixed (also a quasi static) channel environment like, obtaining an MMSE DFE, convergence of an LMS-DFE and convergence of a DD-LMS-LE. For a fixed channel, using implicit function theorem for Banach spaces, we obtain the existence of DD-attractors close to the WF at high SNRs. We use similar techniques to obtain differentiability of the stationary density of a Markov chain with respect to the DFE in  $L_2$  norm and used the derivative to compare the LMS-DFE attractors with that of the DFE Wiener filters. We conclude that at least under high SNR, LMS can be used to obtain the MSE optimal DFE (the WF).

## MSc Research

**Topic :** Blind channel estimation and equalization for OFDM systems.

**Res. Supervisor :** Professor K R Ramakrishnan, EE Dept., IISc, Bangalore.

**Description :** We propose a blind channel estimator and a decision feedback equalizer for OFDM systems. The new blind channel estimator works even for OFDM systems with Cyclic Prefix length smaller than the channel length (e.g., DMT systems). The new DFE proposed can be used for any generic system, with "Block Decisions".

## Industrial Experience (Sep 1994 - Jul 2000)

During my tenure of 6 years at Accord, starting from Sep 1994, I held various positions contributing to Global Positioning System (GPS), Voice band modems and CDMA technology.

1. **First single chip DSP based GPS solution :** As a Research and Development Engineer, I developed several signal processing and navigation algorithms for GPS. We were one of the first companies in the world to build a single chip DSP (Digital Signal Processor) based GPS receiver on Analog Devices fixed and floating point DSPs. It was a national startup company and I was part of a small core group which developed the GPS. The work involved understanding state of art in research from scientific publications from ION (Institute of Navigation) and IEEE Signal Processing, Automatic Control and Communication Theory literature.
2. **More efficient and cost effective GPS solution :** The first solution illustrated only the basic functionality of GPS. As a Senior Engineer, I guided a team of enthusiastic engineers to develop more efficient and cost effective GPS solutions. This work involved the responsibility of handling the complete development life cycle of GPS products. We improved the code, carrier tracking algorithms and designed better signal processing algorithms to drastically improve the signal locking capabilities.
3. **DSP based Modems :** I was selected as a Project leader of a team to participate in Voice band Modem technology at Telindus, Belgium. As a part of the Telindus R&D group, I understood the underlying modem technology and was instrumental in developing and validating data and fax modems.
4. **High data rate CDMA based data link:** As a project leader, I lead another team which is involved in the design and development of high data rate CDMA links to be used in Mission control applications. The high data rates envisaged posed new dimension of problems, which involved robust carrier and code tracking algorithms. The prototypes were built to withstand high mobility land and air applications, Some of the principles used in the development of the high speed CDMA link technology was published in Analog Devices DSP conference in 2001.

## Publications

### Journals

1. Veeraruna Kavitha, Sreenath Ramanath and Eitan Altman, "Spatial queuing for analysis, design and dimensioning of Picocell networks with mobile users" accepted in Elsevier Performance Evaluation (special issue on selected papers from WiOpt 2010).

2. T. Banerjee, V. Sharma, V. Kavitha and A. K. JayaPrakasam, "Generalized Analysis of a Distributed Energy Efficient Algorithm for Change Detection", vol 10, pp. 91-101, IEEE Trans. on Wireless Communications, Jan 2011.

### **Journals under Revision**

1. V. Kavitha, E. Altman, R. Elazouzi and R. Sundareshan "Opportunistic scheduling in cellular systems in the presence of non-cooperative mobiles" under revision at IEEE Trans. Information Theory.
2. V. Kavitha, E. Altman, "Continuous Polling Models and Application to Ferry Assisted WLAN" under revision at Annals of Operations Research.

### **Journals Submitted**

1. Veeraruna Kavitha, Eitan Altman, Rachid Elazouzi, Rajesh Sundareshan, "Fair scheduling in cellular systems in the presence of noncooperative mobiles" submitted to IEEE Trans. Networking.
2. Veeraruna Kavitha "Continuous Polling with Rerouting: Theory and Application to Ferry aided Wireless LANs" submitted to Elsevier Computer Networks (Special issue on Complex Dynamic Networks).

### **Papers published in International Conferences**

1. Veeraruna Kavitha "Continuous Polling with Rerouting and Applications to Ferry Assisted Wireless LANs", accepted in 5th International ICST Conference on Performance Evaluation Methodologies and Tools, Value-Tools 2011.
2. Eitan Altman, Veeraruna Kavitha, Francesco De Pellegrini, Vijay Kamble and Vivek Borkar, "Risk sensitive optimal control framework applied to delay tolerant networks", accepted in IEEE InfoCom 2011
3. Sreenath Ramanath, Veeraruna Kavitha, Eitan Altman, "Open Loop Optimal Control of Base Station Activation for Green Networks", accepted in WiOpt 2011
4. Sreenath Ramanath, Veeraruna Kavitha, Merouane Debbah, "Satisfying Demands in a Multicellular Network: An Universal Power Allocation Algorithm", accepted in WiOpt 2011.
5. Veeraruna Kavitha, Eitan Altman, Rachid Elazouzi, Rajesh Sundareshan, "Fair scheduling in cellular systems in the presence of noncooperative mobiles", In Proc. InfoCom 2010, San Diego, USA.

6. Eitan Altman, Tamer Başar and Veeraruna Kavitha, "Adversarial Control in a Delay Tolerant Network", T. Alpcan, L. Buttyan, and J. Baras (Eds.): GameSec 2010, LNCS 6442, pp. 87-106.
7. Veeraruna Kavitha and Eitan Altman, "Analysis and Design of Message Ferry Routes in Sensor Networks using Polling Models", IEEE Proceedings of the 8th International Symposium on Modeling and Optimization in Mobile, Ad Hoc and Wireless Networks (WiOpt), pp. 247 - 255, May 31-Jun 04 2010, Avignon, France.
8. Sreenath Ramanath, Veeraruna Kavitha and Eitan Altman, "Spatial queuing analysis for mobility in pico cell networks", IEEE Proceedings of the 8th International Symposium on Modeling and Optimization in Mobile, Ad Hoc and Wireless Networks (WiOpt), pp. 152 - 159, May 31-Jun 04 2010, Avignon, France.
9. Sreenath Ramanath, Veeraruna Kavitha, Eitan Altman, "Impact of mobility on call block, call drops and optimal cell size in small cell networks", IEEE 21st International Symposium on Personal, Indoor and Mobile Radio Communications Workshops (PIMRC Workshops), pp. 157-162, 26-30 Sept. 2010, Istanbul, Turkey.
10. Veeraruna Kavitha, Eitan Altman, "Opportunistic Scheduling of a Message Ferry in Sensor Networks", Proceedings of the Second International Workshop on Mobile Opportunistic Networking (MobiOpp) 2010, Pisa, Italy.
11. Veeraruna Kavitha, Eitan Altman, Rachid Elazouzi, Rajesh Sundareshan, "Opportunistic scheduling in cellular systems in the presence of non-cooperative mobiles", Proceedings of 48th IEEE Conference on Decision and Control (CDC), pp. 8581 - 8587, 15-18 Dec. 2009, Shanghai, China.
12. Essaid Sabir, Rachid El-Azouzi, Veeraruna Kavitha, Yezekael Hayel and El-Houssine Bouyakhf, "Stochastic Learning Solution for Constrained Nash Equilibrium Throughput in Non Saturated Wireless Collision Channels", 3rd ICST/ACM International Workshop on Game Theory in Communication Networks, GameComm 2009, Pisa, Italy.
13. Veeraruna Kavitha, Eitan Altman, "Queueing in Space: design of Message Ferry Routes in sensor networks", 21st International Teletraffic Congress (ITC 21) 2009, Paris, France.
14. Sreenath Ramanath, Eitan Altman, Vinod Kumar, Veeraruna Kavitha, Laurent Thomas, "Fair assignment of base stations in cellular networks", 22nd World Wireless Research Forum (WWRF) Conference, May 5-7, 2009, Paris, France

15. T. Benerjee, V. Kavitha and V. Sharma, "Energy Efficient Change Detection over a MAC using Physical Layer Fusion", 33rd IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP), pp. 2501 - 2504 , March 31 2008-April 4 2008, Las Vegas, USA.
16. V. Kavitha and V. Sharma, "Tracking Analysis of an LMS Decision Feedback Equalizer for a Wireless Channel", 13th European Wireless Conference, Paris, France, April 2007.
17. V. Kavitha and V. Sharma, "Analysis of an LMS Linear Equalizer for Fading Channels in Decision Directed mode", 13th European Wireless Conference, Paris, France, April 2007.
18. V. Kavitha and V. Sharma, "Tracking performance of an LMS-Linear Equalizer for fading channels", 44th Annual Allerton Conference on Communication, Control and Computing, USA, September 2006.
19. V. Kavitha and V. Sharma, "LMS versus Wiener filter for a Decision Feedback Equalizer", 44th Annual Allerton Conference on Communication, Control and Computing, USA, September 2006.
20. V Kavitha and V Sharma, "Comparison of training, blind and semiblind equalizers in MIMO fading systems using capacity as measure", IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP '05), 18-23 March 2005 , pp. 589-592, USA.
21. V Kavitha and V Sharma, "Information theoretic comparison of training, blind and semiblind signal separation algorithms in MIMO systems", International Conference on Signal Processing and Communications, 2004. SPCOM '04, 11-14 Dec. 2004, pp. 407 - 411, Bangalore, India.
22. Amaranada Reddy, Archana Nayak, Gurucharan, Veeraruna Kavitha, Sreenath Ramanath, "Implementation of a Multi-Channel Baseband CDMA Receiver on a ADSP2189M Processor", International Digital Signal Processing Conference 2001, Boston, USA.

## Technical Reports

1. V. Kavitha and V. Sharma, "DD/Training-based Linear Equalizers for MIMO Fading channels: Tracking Performance", Technical report no: TR-PME-2007-01, DRDO-IISc program on mathematical engineering, ECE Dept., IISc, Bangalore, January 2007.  
(downloadable from [http://pal.ece.iisc.ernet.in/PAM/tech\\_rep07.html](http://pal.ece.iisc.ernet.in/PAM/tech_rep07.html))



2. V. Kavitha and V. Sharma, "Tracking Analysis of an LMS Decision Feedback Equalizer for a Wireless Channel", Technical report no: TR-PME-2006-19, DRDO-IISc program on mathematical engineering, ECE Dept., IISc, Bangalore, Oct 2006.  
(downloadable from [http://www.pal.ece.iisc.ernet.in/PAM/tech\\_rep06.html](http://www.pal.ece.iisc.ernet.in/PAM/tech_rep06.html)).
3. V. Kavitha and V. Sharma, "LMS Versus Wiener filter for a Decision feedback equalizer", Technical report no: TR-PME-2006-06, DRDO-IISc program on mathematical engineering, ECE Dept., IISc, Bangalore, June 2006.  
(downloadable from [http://www.pal.ece.iisc.ernet.in/PAM/tech\\_rep06.html](http://www.pal.ece.iisc.ernet.in/PAM/tech_rep06.html)).
4. V. Kavitha and V. Sharma, " Tracking performance of an LMS-Linear Equalizer for fading channels using ODE approach", Technical report no:TR-PME-2005-11, DRDO-IISc program on mathematical engineering, ECE Dept., IISc, Bangalore, Oct 2005.  
(downloadable from [http://pal.ece.iisc.ernet.in/PAM/tech\\_rep05.html](http://pal.ece.iisc.ernet.in/PAM/tech_rep05.html)).
5. V. Kavitha and V. Sharma, "Comparison of Training, Blind and Semi blind equalizers in MIMO fading systems using capacity as measure," Technical report no:TR-PME-2004-10, DRDO-IISc program on mathematical engineering, ECE Dept., IISc, Bangalore, Sept 2004.  
(downloadable from [http://pal.ece.iisc.ernet.in/PAM/tech\\_rep04.html](http://pal.ece.iisc.ernet.in/PAM/tech_rep04.html)).