Venkatesh Ramaiyan

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Research Interests

My research interests include performance modeling and analysis of wired and wireless networks (MAC, network, application and cross-layer), resource allocation and optimization in constrained networks, stochastic control, algorithm and protocol design, information theory and network coding. My current focus are in performance optimization in wireless sensor networks, modeling and analysis of distributed medium access protocols and performance analysis and provisioning of wireless access networks. My PhD work involves mathematical modeling, performance analysis, control, optimization and related analytics in the areas of communication networking, with a focus on wireless networking.

Education

- **Doctor of Philosophy (PhD) : Aug. 2003 – Jan 2009**
  Dept. of Electrical Communication Engineering (ECE)
  Indian Institute of Science, Bangalore, India
  Research advisor: Prof. Anurag Kumar
  Thesis topic: Topics in Modeling, Analysis and Optimization of Wireless Networks
  C.G.P.A : 7.3/8.0

- **Master of Engineering (M.E.) : Aug 2000 – Feb 2002**
  Dept. of Electrical Communication Engineering (ECE)
  Indian Institute of Science, Bangalore, India
  Research advisor: Prof. Anurag Kumar
  Thesis topic: Performance Analysis of Aggregates of Non-persistent TCP flows in very high speed networks
  C.G.P.A : 7.6/8.0
  Awards : Gold Medallist in the Division of Electrical Sciences

- **Bachelor of Engineering (B.E.) : Aug. 1996 – Jun 2000**
  Electronics and Communication Engineering (ECE)
  College of Engineering, Guindy,
  Anna University, Chennai, India.
  C.G.P.A : 9.2/10.0
  Awards : University Gold Medallist, Ramanujam Award for Excellence in Mathematics

Skill Set

Familiar Subjects : Communication Networks, Wireless Networks, Ad hoc and Sensor Networks, Coding Theory, Information Theory, Switching and Multiplexing, Fiber Optic Communication

Analytical Tools : Real Analysis, Linear Algebra, Random Processes, Measure Theory, Stochastic Control and Dynamic Programming, Optimization, Queueing Theory

Experience : Performance Modeling, Analysis and Optimization, Experimentation and Simulation, Protocol Design, Hardware and Software Implementation

Work Experience

- **Bell Labs Research, India : June 2007 – Aug 2007**
  Role : Summer Intern
  Work : Opportunistic Schedulers for WiMAX Relay Networks
- **Indian Institute of Science (Bangalore, India) : Dec 2002 – Jun 2003**
  Role : Project Associate
  Work : Fair Packet Scheduler for an Internet Bottleneck Link; Implemented in "C"
- **Tejas Networks (Bangalore, India) : Feb 2002 – Nov 2002**
  Role : Product Specialist
  Work : Cost-effective Optical Network Design, Futuristic Optical Switch Design

Projects Involved

- **Network Coding :** For a two link slotted wireless network employing a network coding strategy and with fading channels, we study the optimal power control and optimal exploitation of network coding opportunities that minimizes the average power required to support a given arrival rate. We also study the optimal power-delay tradeoff for the network and show that the minimum average queueing delay scales as $\Omega\left(\frac{1}{v}\right)$ for an average excess power of $O(v)$.
- **Power - Delay Tradeoffs in Wireless Networks :** For a single downlink fading wireless channel, we study a tradeoff between the long term time average transmission power and the long term time average queueing delay. We show that for an excess average power of $O(v)$, the average queueing delay scales as $\Omega\left(\frac{1}{\log(v)\sqrt{v}}\right)$.
- **Throughput and Delay Tradeoffs in Vehicular Networks :** We consider a vehicular network problem, where vehicles are used as relays to transfer data between a pair of stationary source and destination nodes. The source node has a file to transfer to the destination node and we are interested in the delay minimizing schedule for the vehicular network. We characterize the average queueing delay (at the source node) and the average transit delay of the packets (at the relay vehicles) in terms of the vehicular speeds and their interarrival times, and study the asymptotically optimal tradeoff between them.
- **Opportunistic Scheduling in a WiMAX frame :** A WiMAX frame comprises of f sub-channels and t slots which can be allotted among the competing links in the network. For a WiMAX relay network (IEEE 802.16j), we study an opportunistic scheduling strategy that achieves a proportional fair throughput among the competing nodes. We first show that the optimal

strategy is np-hard. We then obtain heuristic polynomial time algorithms that achieve within a fraction of the optimal throughput.

- **Scaling laws for Dense Wireless Networks :** For a dense wireless network, deployed over a small area, and with a network average power constraint, we show that single cell operation is throughput efficient in the asymptotic regime in which the network average power is made large. We show that, with a realistic path loss model and a physical interference model (SINR based), the maximum aggregate bit rate among arbitrary transmit-receive pairs scales only as $\Theta(\log(\bar{P}))$, where $\bar{P}$ is the network average power.

- **Optimal Routing and Power Control for Single Cell Wireless Networks :** We consider a densely deployed wireless network operating as a single cell. For a fading channel and a fixed transmission time strategy, we study the optimal hop length and power control that maximizes a measure of the transport capacity of the network for a given network average power constraint. Under certain conditions on the fading distribution, we characterize the optimal operating point of the network.

- **Performance Modeling of IEEE 802.11e WLANs :** Using a decoupling approximation, we study the performance of single cell IEEE 802.11e WLANs through a set of fixed point equations in terms of the average collision probabilities of the nodes. We study the impact of the backoff parameters of the nodes on the stability and fairness in the system. Then, for single cell IEEE 802.11e WLANs, we show that the fixed point equations have a unique solution. We also characterize the throughput differentiation achievable with the different backoff parameters specified in the IEEE 802.11e standard.

- **Modeling Capture in IEEE 802.11(e) WLANs :** The ability of a receiver to decode a transmission successfully in the presence of simultaneous interfering transmissions is called *capture*. We propose a general framework to model capture in IEEE 802.11(e) WLANs. We characterize the performance of the system through a set of fixed point equations in terms of the average collision probabilities of the nodes. We first show that capture can introduce multistability among the nodes even in single cell scenarios. Then, we obtain sufficient conditions to guarantee the existence of a unique solution to the fixed point equations representing the system behaviour.

- **Weighted Fair Scheduler for bottleneck links :** We developed a packet scheduler for a bottleneck link carrying Internet type traffic (e.g., TCP, UDP). Using a novel queueing and scheduling strategy, the scheduler isolates uplink and downlink traffic in the bottleneck link. The scheduler also supports multiple traffic classes, different scheduling priorities and minimum and maximum rate guarantees. Also, the scheduler minimizes delay among a class of packet schedulers.

- **Performance Modeling of TCP in High Speed WANs :** In high speed WANs, we observed that the performance of non-persistent TCP flows can be closely approximated by an open loop model. We then characterized the average packet delay and throughput performance of TCP in terms of the bandwidth-delay product of the route.

- **Telephone Answering Machine :** The final year B.E. project (2000) involved designing and developing a cost-effective telephone answering machine with handy features like caller-id recognition. Our contribution included designing and developing the hardware circuitry as well as writing the software code specific to the micro-processor.

Publications

- Journal Papers

  1. Venkatesh Ramaiyan, Anurag Kumar and Eitan Altman, "*Fixed Point Analysis of Single Cell IEEE 802.11e WLANs: Uniqueness and Multistability*", IEEE/ACM Transactions on Networking, October, 2008.

- Conference Papers

  1. Supratim Deb, Vivek Mhatre and Venkatesh Ramaiyan, "*WiMAX Relay Networks: Opportunistic Scheduling to exploit Multiuser Diversity and Frequency Selectivity*," MobiCom 2008, San Francisco, USA, September 2008.
  2. Venkatesh Ramaiyan and Anurag Kumar, "*On the Limits of Spatial Reuse and Cooperative Communication for Dense Wireless Networks*," IEEE Information Theory Workshop 2007, Bergen, Norway, July 2007.
  3. Venkatesh Ramaiyan, Anurag Kumar and Eitan Altman, "*Jointly Optimal Routing and Power Control for a Single Cell, Dense, Ad hoc wireless network*," IEEE WiOpt'07, Symposium on Modeling and Optimization in Mobile, Ad Hoc, and Wireless Networks, Limassol, Cyprus, April 2007.
  4. Ashish Sangwan, Venkatesh Ramaiyan and Rajeev Shorey, "*A Reliable Multihop Broadcast Protocol for Inter-Vehicular Communication in a Fading Channel*," IEEE COMSWARE, International Conference on Communication System Software and Middleware, Bangalore, India, 2007.
  5. Dinesh Kumar, Venkatesh Ramaiyan, Anurag Kumar and Eitan Altman, "*Capacity Optimizing Hop Distance in a Mobile Ad Hoc Network with Power Control*," IEEE WiOpt'06, Symposium on Modeling and Optimization in Mobile, Ad Hoc, and Wireless Networks, Boston, Massachusetts, April 2006.
  6. Venkatesh Ramaiyan, Anurag Kumar and Eitan Altman, "*Fixed Point Analysis of Single Cell IEEE 802.11e WLANs: Uniqueness, Multistability and Throughput Differentiation*," ACM Sigmetrics, International Conference on Measurement and Modeling of Computer Systems, Banff, Canada, June 2005.
  7. Venkatesh Ramaiyan, Anurag Kumar and Nandini Vasudevan, "*Fixed Point Analysis of the Saturation Throughput of IEEE 802.11 WLANs with Capture*," NCC'05, National Conference on Communications, IIT Kharagpur, January, 2005.

- In Preparation

  1. Venkatesh Ramaiyan and Anurag Kumar, "*Fixed Point Analysis of IEEE 802.11(e) WLANs with Capture*".
  2. Venkatesh Ramaiyan and Anurag Kumar, "*Optimal Network Coding and Power Control for a Two link Wireless Network with Bidirectional Traffic*".
  3. Venkatesh Ramaiyan, Eitan Altman and Anurag Kumar, "*Delay Optimal Scheduling in a Two-Hop Vehicular Relay Network*".

- Technical Report

  1. Venkatesh Ramaiyan, "*Fair Queueing for Data Switches*," Technical Report, June, 2003.

Awards

M.E. Gold Medallist in the Division of Electrical Sciences, IISc, Bangalore, India 2002
B.E. University Gold Medallist, CEG, Anna University, Chennai, India 2000
Ramanujam Award for excellence in Mathematics,
CEG, Anna University, Chennai, India 2000

Interests

Sports : Tennis, Badminton
Others : Yoga, Cinema

Reference

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