Aditya Ramamoorthy

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Education

12/02–06/05 **University of California**, Los Angeles, CA, USA
Research Area: Error Control Coding, Network Information Theory
Minors: Optimization and Applied Mathematics

09/01–12/02 **University of California**, Los Angeles, CA, USA
M.S. in Electrical Engineering

07/95–07/99 **Indian Institute of Technology**, Delhi, India
B. Tech. in Electrical Engineering

Research Interests

Network Coding, Distributed Source Coding and Error Control Coding.
Signal Processing for Nanotechnology and Storage Systems.

Professional Experience

Since 08/06 **Assistant Professor**
Dept. of Electrical and Computer Eng.
Iowa State University, Ames, IA.

08/05–08/06 **Senior Design Engineer**
Marvell Semiconductor Inc., Sunnyvale, CA

06/02–06/05 **Graduate Student Researcher**
University of California, Los Angeles, CA
Thesis work included results on the multicast capacity of large random networks, network coding for distributed compression and the design of irregular low-density parity-check codes.

10/04–06/05 **Visiting Student,**
Georgia Institute of Technology, Atlanta, GA
Collaborated with Prof. Steve McLaughlin's group on the design of irregular LDPC codes.

07/04–10/04 **Research Intern,**
Microsoft Research, Redmond, WA
Investigated the usage of network coding for the multicast of correlated sources.

06/00–08/01 **Systems Engineer**
Biomorphic VLSI Inc., Westlake Village, CA

11/99–05/00 **Systems Analyst**
Deloitte Consulting, Chicago, IL

Awards & Honors

- 2012 NSF CAREER Award.
- Associate Editor for *IEEE Transactions on Communications*, since Nov. 2011.
- Harpole-Pentair professor at Iowa State Univ. (ISU) for 2009 & 2010.
- Invited to serve as a faculty opponent for the doctoral thesis of Ming Xiao, Chalmers University of Technology, Gotebörg, Sweden.
- IEEE Turbo Codes conference 2006 paper chosen as one of the best papers at the conference and invited for publication to the European Transactions on Telecommunications.
- Awarded the Regents of the University of California Fellowship for Fall 2002 and 2004.
- Nominated for the best B. Tech. project in 1998 at IIT-Delhi.

Updated Jan. 2012.

Main Research Contributions

- **Network coding for distributed compression.**
  - Identified decoding complexity issues with joint source & network coding for multicasting correlated sources. Demonstrated that in general, from a capacity point of view, separate source and network codes are suboptimal, but for networks with two sources and two terminals separation is optimal.
  - Developed time and space efficient algorithms for flow and rate allocation for network coding based distributed compression. These are useful since for most distributed source coding problems, the feasible rate region is described by a number of inequalities that is exponential in the number of sources.
  - Considered the problem of replicated vs. coded source nodes, in distributed storage systems using network coding and developed strategies for reasoning about coding versus replication from an optimization standpoint. Our work allows us to upper bound the cost difference between solutions utilizing replication and coding at the source nodes.
- **Network coding based function computation.**
  - Derived necessary and sufficient conditions for multicasting finite-field sums (as opposed to actual messages) over directed acylic networks with unit-capacity links, when the number of source nodes or the number of terminal nodes is at most two.
  - Showed an alternate achievable region, and an efficient network code assignment for three-source, three-terminal networks. Developed a technique for performing a class decomposition of networks, that is useful in systematically reasoning about sum computation and potentially the multiple unicast problem. Our work explores the effect of network topology on function computation.
- **Network coding for protection.**
  - Demonstrated a simple, synchronization-free network coding based protocol for protection against network faults that needs significantly lower capacity resources than current techniques.
  - Obtained bounds on the spare capacity needed for a similar network coding based protocol for protection against a combination of adversarial errors and faults.
- **Signal Processing for Nanotechnology.**
  - Demonstrated that a communication systems perspective to the problem of nano-interrogation using dynamic mode atomic force microscopy can yield over four orders of magnitude improvement in detection fidelity as compared to conventional techniques.

Grants and Contracts Received

• **CAREER: Joint topographic imaging and materials characterization using atomic force microscopy - a systems approach**, National Science Foundation (CCF - Communication And Information Foundations), amount - $ 413,672. Sole PI.

• **ATD: Models for (Meta)Genome Identification from Next Generation Sequence Data with Errors**, Sep. 2011 - Sep. 2014, National Science Foundation (Division of Mathematical Sciences) & Defence Threat Reduction Agency, amount - $ 660,922. co-PI, with Prof. Srinivas Aluru and Prof. Bradley Blitvich. PI is Prof. Karin Dorman (ISU).

• **CIF: Small: Collaborative Research: Signal processing for enabling high speed probe based nanoimaging** , Jul. 2011 – Jul. 2014, National Science Foundation (CCF - Communication And Information Foundations), amount - $ 245,437. Sole PI from ISU. Collaborative with Prof. Murti Salapaka (Univ. of Minnesota).

• **An Algebraic Approach to Distributed Source Coding**, Sept. 2010 – Sept. 2013, National Science Foundation (CCF - Communication And Information Foundations), amount - $ 350,571. Sole PI.

• **Collaborative Research: Dynamic Mode High Density Probe Based Data Storage**, Apr. 2008 – Apr. 2011, National Science Foundation (ECCS - Integrative, Hybrid, Complex Systems), amount - $ 100,000. Sole PI from ISU. Collaborative with Prof. Murti Salapaka (Univ. of Minnesota).

• **Network Coding Based Protection**, Aug. 2007 - Aug. 2010, National Science Foundation (CISE - Computer and Network Systems - Nets - Networking Broadly Defined), amount - $ 306,700. co-PI (share $ 153,350). PI is Prof. Ahmed E. Kamal (ISU).
• **New Faculty Development Grant Award**, Jun. - Aug. 2007, Office of the Vice-Provost for Research, Iowa State University, amount - $ 12,000. Sole PI.

Formally Invited Lectures & and Invited Conference Presentations

• **Invited Papers and Talks**
  ◦ "*Channel Modeling and Detector Design for Dynamic Mode High Density Probe Storage and Nano-Imaging Applications*", 18th IFAC World Congress, Aug. 2011.
  ◦ "*An algebraic approach to Slepian-Wolf code design*", Workshop on Information Theory and its Applications (ITA), Univ. of California, San Diego, Feb. 2011.
  ◦ "*Communicating the sum of sources in a 3-sources/3-terminals network*", Workshop on Information Theory and its Applications (ITA), Univ. of California, San Diego, Feb. 2010.

• **Invited Talks**
  ◦ "*Networked Distributed Source Coding*", Electrical Communication Eng. Dept., Indian Institute of Science, Sept. 2011.
  ◦ "*Networked Distributed Source Coding*", Dept. of Electrical and Computer Eng., Univ. of Toronto, Apr. 2011.
  ◦ "*Networked Distributed Source Coding*", Dept. of Electrical and Computer Eng., Univ. of Minnesota, Twin Cities, Feb. 2011.
  ◦ "*Selfish Distributed Compression over Networks: Correlation Induces Anarchy*", Algorithmic Game Theory (AGT) Workshop, Institute for Pure and Applied Mathematics (IPAM), Los Angeles, CA, Jan. 2011.
  ◦ "*High-density data storage based on dynamic mode atomic force microscopy (AFM): a communications perspective*", Coordinated Science Laboratory (CSL), Univ. of Illinois, Urbana-Champaign, Oct. 2010.
  ◦ "*Network coding for distributed compression*", Dept. of Electrical and Computer Eng., Univ. of Iowa, Nov. 2007.

• **Talks at Universities and Companies**
  ◦ "*High-density data storage based on dynamic mode atomic force microscopy (AFM): a communications perspective*", Dept. of Electrical and Computer Eng., Univ. of Iowa, Apr. 2011.
  ◦ "*High-density data storage based on dynamic mode atomic force microscopy (AFM): a communications perspective*", Dept. of Electrical Eng., Univ. of California, Los Angeles, Jan. 2011.
  ◦ "*Network Coding for Function Computation*", Dept. of Electrical Eng. and Computer Sc., Massachusetts Inst. of Tech. (MIT), June 2010.
  ◦ "*Network Coding for Function Computation*", Dept. of Electrical and Computer Eng., Univ. of Illinois, Chicago (UIC), May 2010.
  ◦ "*Network Coding for Function Computation*", Dept. of Electrical and Computer Eng., Univ. of Wisconsin, Madison, Apr. 2010.
  ◦ "*Network coding for distributed compression*", Infosys Research Labs, Bangalore, India, Dec. 2010.
  ◦ "*Network coding for distributed compression*", Dept. of Computer Science., Univ. of Porto, Portugal, Nov. 2007.
  ◦ "*Network coding for distributed compression*", Dept. of Computer Eng., Chalmers Univ. of Tech., Gotebörg, Sweden, Nov. 2007.

Book Chapters

[1] S. Li* and A. Ramamoorthy, "Networked Distributed Source Coding," *Theoretical Aspects of Distributed Computing in Sensor Networks, Springer Verlag*, 2010 (**Invited**).

Journal Publications

[1] L. Ke, A. Ramamoorthy, Z. Wang, and H. Yin, "Degrees of freedom Region for an Interference Network with General Message Demands," *IEEE Transactions on Information Theory*, (to appear), 2011 [Online] Available: http://arxiv.org/abs/1101.3068.

[2] A. Ramamoorthy, V. P. Roychowdhury, and S. K. Singh, "Selfish Distributed Compression over Networks," *IEEE Transactions on Information Theory*, (to appear), [Online] Available: http://arxiv.org/abs/0804.1840.

[3] A. E. Kamal, A. Ramamoorthy, L. Long, and S. Li*, "Overlay Protection Against Link Failures Using Network Coding," *IEEE/ACM Transactions on Networking*, vol. 19, no. 2, pp. 1071–1084, 2011 [this or its conference versions cited 16 times].

[4] S. Huang*, A. Ramamoorthy, and M. Medard, "Minimum cost mirror sites using network coding: Replication versus coding at the source nodes," *IEEE Transactions on Information Theory*, vol. 57, no. 2, pp. 1080 –1091, 2011.

[5] S. Li* and A. Ramamoorthy, "Protection against link errors and failures using network coding in overlay networks," *IEEE Transactions on Communications*, vol. 59, no. 2, pp. 518–528, Feb. 2011.

[6] A. Ramamoorthy, "Minimum cost distributed source coding over a network," *IEEE Transactions on Information Theory*, vol. 57, no. 1, pp. 461–475, Jan. 2011. [this or its conference versions cited 15 times].

[7] S. Li* and A. Ramamoorthy, "Improved compression of network coding vectors using erasure decoding and list decoding," *IEEE Communications Letters*, vol. 14, no. 8, pp. 749–751, Aug. 2010.

[8] N. Kumar*, P. Agarwal, A. Ramamoorthy, and M. V. Salapaka, "Maximum-likelihood Sequence Detector for dynamic mode high-density probe storage," *IEEE Transactions on Communications*, vol. 58, no. 6, pp. 1686–1694, Jun. 2010.

[9] S. Li* and A. Ramamoorthy, "Rate and power allocation under the pairwise distributed source coding constraint," *IEEE Transactions on Communications*, vol. 57, no. 12, pp. 3771–3781, Dec. 2009.

[10] C. Shi* and A. Ramamoorthy, "Design and analysis of E2RC codes," *IEEE Journal on Selected Areas in Communications*, vol. 27, no. 6, pp. 889 –898, 2009.

[11] J. Kim, A. Ramamoorthy, and S. W. McLaughlin, "Design of Efficiently-Encodable Rate-Compatible LDPC Codes," *IEEE Transactions on Communications*, vol. 57, no. 2, pp. 365–375, Feb. 2009. [this or its conference versions cited 35 times].

[12] A. A. Somasundara, A. Ramamoorthy, and M. B. Srivastava, "Mobile element scheduling with dynamic deadlines," *IEEE Transactions on Mobile Computing,*, vol. 6, no. 4, pp. 395 –410, Apr. 2007 [this or its conference versions cited 236 times].

[13] A. Ramamoorthy, K. Jain, P. A. Chou, and M. Effros, "Separating Distributed Source Coding from Network Coding," *IEEE Transactions on Information Theory*, vol. 52, no. 6, pp. 2785–2795, Jun. 2006 [this or its conference versions cited 70 times].

[14] A. Ramamoorthy, J. Shi, and R. D. Wesel, "On the capacity of network coding for random networks," *IEEE Transactions on Information Theory,*, vol. 51, no. 8, pp. 2878 –2885, Aug. 2005 [this or its conference versions cited 69 times].

[15] A. Ramamoorthy, N. Vaswani, S. Chaudhury, and S. Banerjee, "Recognition of Dynamic Hand Gestures," *Pattern Recognition*, vol. 36, no. 9, pp. 2069–2081, 2003 [cited 63 times].

Citation information is given where appropriate from Google Scholar, and includes self citations. The symbol * indicates that the person is my student.

Journal Publications (Under Submission)

[1] S. Li* and A. Ramamoorthy, "Multiple-source Slepian-Wolf coding under a linear equation correlation model," *IEEE Transactions on Communications*, (under revision), 2011.

[2] A. Ramamoorthy and M. Langberg, "Communicating the sum of sources over a network," *IEEE Transactions on Information Theory*, submitted, 2010 [Online] Available: http://arxiv.org/abs/1001.5319 [this or its conference versions cited 31 times].

Conference Publications

[1] S. Huang* and A. Ramamoorthy. An achievable region for the double unicast problem based on a mimum cut analysis. In *IEEE Info. Th. Workshop*, 2011.

[2] L. Ke, A. Ramamoorthy, Z. Wang, and H. Yin. Degrees of freedom region for an interference network with general message demands. In *IEEE Intl. Symposium on Info. Th.*, 2011.

[3] S. Huang* and A. Ramamoorthy. A note on the multiple unicast capacity of directed acyclic networks. In *Proc. of the IEEE Conf. on Comm. (ICC)*, 2011.

[4] N. Kumar*, G. Saraswat, P. Agarwal, A. Ramamoorthy, and M. V. Salapaka. High-speed Nano-imaging using dynamic mode AFM: A MAP detection approach. In *44th Asilomar Conference on Signals, Systems and Computers*, 2010.

[5] N. Kumar*, A. Ramamoorthy, and M. V. Salapaka. Performance evaluation of ML sequence detection in ISI channels with Gauss Markov Noise. In *Proc. of the IEEE Global Telecommunications Conf. (GLOBECOM)*, 2010.

[6] C. Shi* and A. Ramamoorthy. Improved Combinatorial Algorithms for Wireless Information Flow. In *48th Allerton Conference on Communication, Control, and Computing*, 2010.

[7] M. Langberg and A. Ramamoorthy. Communicating the sum of sources in a 3-sources/3-terminals network; revisited. In *IEEE Intl. Symposium on Info. Th.*, pages 1853–1857, 2010.

[8] S. Huang*, A. Ramamoorthy, and M. Medard. Minimum cost content distribution using network coding: Replication vs. coding at the source nodes. In *IEEE Info. Th. Workshop*, pages 1–5, 2010.

[9] N. Kumar*, P. Agarwal, A. Ramamoorthy, and M. V. Salapaka. Maximum-likelihood sequence detector for dynamic mode high-density probe storage. In *Proc. of the IEEE Global Telecommunications Conf. (GLOBECOM)*, pages 1–6, 2009.

[10] M. Langberg and A. Ramamoorthy. Communicating the sum of sources in a 3-sources/3-terminals network. In *IEEE Intl. Symposium on Info. Th.*, pages 2121–2125, 2009.

[11] S. Li* and A. Ramamoorthy. Protection against link errors and failures using network coding in overlay networks. In *IEEE Intl. Symposium on Info. Th.*, pages 986–990, 2009.

[12] C. Shi* and A. Ramamoorthy. Design and Analysis of E^2RC Codes using EXIT Chart. In *Proc. of the IEEE Conf. on Comm. (ICC)*, pages 1–5, 2009.

[13] A. Ramamoorthy, V. P. Roychowdhury, and S. K. Singh. Selfish distributed compression over networks. In *IEEE INFOCOM 2009 Mini-Conference*, pages 3011 –3015, 2009.

[14] S. Li* and A. Ramamoorthy. Rate and power allocation under the pairwise distributed source coding constraint. In *IEEE Intl. Symposium on Info. Th.*, pages 2312–2316, 2008.

[15] A. Ramamoorthy. Communicating the sum of sources over a network. In *IEEE Intl. Symposium on Info. Th.*, pages 1646–1650, 2008.

[16] C. Shi* and A. Ramamoorthy. Protograph E^2RC Codes. In *Proc. of the IEEE Global Telecommunications Conf. (GLOBECOM)*, pages 1–5, 2008.

[17] N. Kumar*, P. Agarwal, A. Ramamoorthy, and M. V. Salapaka. Channel modeling and detector design for dynamic mode high density probe storage. In 42^{nd} *Annual Conf. on Info. Sc. and Sys. (CISS)*, pages 1273–1278, 2008.

[18] A. E. Kamal and A. Ramamoorthy. Overlay Protection Against Link Failures Using Network Coding. In 42^{nd} *Annual Conf. on Info. Sc. and Sys. (CISS)*, pages 527–533, 2008.

Citation information (from Google Scholar, including self-citations) is given where appropriate and only if a paper does not have a journal version. The symbol * indicates that the person is my student.

[19] A. Ramamoorthy. Minimum cost distributed source coding over a network. In *IEEE Intl. Symposium on Info. Th.*, pages 1761–1765, 2007.

[20] A. Ramamoorthy and N. Varnica. Error Floors of LDPC Coded BICM. In *Proc. of the IEEE Conf. on Comm. (ICC)*, pages 839–844, 2007.

[21] J. Kim, W. Hur, A. Ramamoorthy, and S. W. McLaughlin. Design of Rate-Compatible Irregular LDPC Codes for Incremental Redundancy Hybrid ARQ Systems. In *IEEE Intl. Symposium on Info. Th.*, pages 1139 –1143, 2006 [19 citations].

[22] J. Kim, A. Ramamoorthy, and S. W. McLaughlin. Design of Efficiently-Encodable Rate-Compatible Irregular LDPC Codes. In *Proc. of the IEEE Conf. on Comm. (ICC)*, pages 1131–1136, 2006.

[23] A. Ramamoorthy and R. D. Wesel. The Single Source Two Terminal Network with Network Coding. In *Proc. of the 9th Canadian Workshop on Info. Th.*, 2005 [7 citations].

[24] A. Kansal, A. Ramamoorthy, M. B. Srivastava, and G. J. Pottie. On sensor network lifetime and data distortion. In *IEEE Intl. Symposium on Info. Th.*, pages 6 –10, 2005 [21 citations].

[25] A. Ramamoorthy and R. D. Wesel. Construction of Short Block Length Irregular Low-Density Parity-Check Codes. In *Proc. of the IEEE Conf. on Comm. (ICC)*, pages 410–414, 2004 [61 citations].

[26] W. Weng, A. Ramamoorthy, and R. D. Wesel. Lowering the Error Floors of High-Rate LDPC Codes by Graph Conditioning . In *Vehicular Technology Conf.*, pages 2549–2553, 2004 [24 citations].

[27] A. Ramamoorthy, K. Jain, P. A. Chou, and M. Effros. Separating Distributed Source Coding from Network Coding. In *42nd Allerton Conference on Communication, Control, and Computing*, 2004.

[28] A. A. Somasundara, A. Ramamoorthy, and M. B. Srivastava. Mobile element scheduling for efficient data collection in wireless sensor networks with dynamic deadlines. In *Proc. of the 25th IEEE International Real-Time Systems Symposium*, pages 296 – 305, 2004.

[29] A. Ramamoorthy, J. Shi, and R. D. Wesel. On the Capacity of Network Coding for Random Networks. In *41st Allerton Conference on Communication, Control, and Computing*, 2003.

Patents

[1] A. E. Kamal and A. Ramamoorthy, "1+N Network Protection for Mesh Networks: Network Coding-Based Protection Using P-Cycles and Protection Paths," in *United States Patent 7,869,344*, granted Jan. 2011.

[2] A. Ramamoorthy, Z. Wu, and P. Sutardja, "Method and System for Error Correction in Flash Memory," in *United States Patent 7,844,879*, granted Nov. 2010.

[3] A. Ramamoorthy, G. Burd, and X. Yang, "Channel estimation for multi-level memories using pilot signals," in *United States Patent 7,649,793*, granted Jan. 2010.

[4] A. Matache, H. Tang, G. Burd, A. Ramamoorthy, J. Xu, and Z. Wu, "LDPC Codes and Expansion Method," in *United States Patent 7,774,675*, granted Aug. 2010.

[5] J. Kim, A. Ramamoorthy, S. W. McLaughlin, and D. Kim, "Rate-Compatible Encoding Methods and Apparatus," in *United States Patent*, pending.

[6] A. Ramamoorthy, "Multi-level signal memory with LDPC and Interleaving," in *United States Patent*, pending.

[7] P. Sutardja, Z. Wu, T. Doan, and A. Ramamoorthy, "High Density Multi-level Memory," in *United States Patent*, pending.

Instruction and Supervision

- **Graduate classes**
  - Special Topics on Communication: Network Coding.
  - Random Processes for Communications and Signal Processing.
- **Undergraduate classes**
  - Signals and Systems.
  - Communication Systems - II.
- **Curricular and Lab Development Activities**
  - Set up a Software Defined Radio Laboratory at ISU. Currently there are about twelve radios. The lab has been used to support senior design groups, conduct workshops for under-represented minorities, and will be used to offer lab components and standalone courses in the near future.
  - Developed a Special Topics Class on Network Coding.
- **Supervision of Graduate Students (All Ph.D.)**
  - Naveen Kumar (B. Tech/M. Tech. - IIT-Delhi) - graduated in Fall 2010.
    - Current affiliation - Link-a-Media Devices Inc.
    - *Winner of the ISU Research Excellence Award.*
  - Cuizhu Shi (M. S. - Shanghai Jiatong Univ.) - graduated in Spring 2011.
    - Current affiliation - Microsoft Corp.
  - Shizheng Li (B.S. - Southeast Univ.) - graduated in Summer 2011.
    - Current affiliation - JP Morgan
  - Shurui Huang (B.S. Tsinghua Univ.) - finished MS, currently in the Ph.D. program.
  - Wenyu Wang (B.S. Zhejiang Univ.) - currently in the Ph.D. program.

Professional Activities

- **Membership in Editorial Boards**
  Associate Editor, IEEE Transactions on Communications, since Nov. 2011.
- **Conference/Workshop Organizing**
  Publicity Chair, IEEE International Symposium on Information Theory (ISIT), 2012.
  Workshop Co-chair, International Workshop on Information Theory for Sensor Networks (WITS), 2008 held in conjunction with International Conference on Distributed Computing in Sensor Systems (DCOSS), 2008.
- **Technical Program Committees**
  IEEE International Symposium on Information Theory (ISIT) 2008.
  IEEE Global Telecommunications Conference (Globecom) 2008, 2010 & 2011.
- **Reviewing Activities**
  Reviewer for IEEE Trans. on Information Theory, IEEE Trans. on Comm., IEEE J. Sel. Areas in Comm., IEEE Trans. on Signal Proc., Eurasip J. on Wireless Comm. & Netw., IEEE Comm. Letters, Electronics and Telecommunication Research Institute (ETRI) Journal.
  IEEE InfoCom, IEEE Intl. Symp. on Info. Theory, IEEE Intl. Conf. on Comm. (ICC), IEEE GlobeCom, IEEE Info. Th. Workshop, IEEE Vehicular Tech. Conf.
- **Grant Reviewing Activities**
  National Science Foundation panelist in 2009 and 2011. Some invitations declined due to schedule conflicts.
  Israel Science Foundation reviewer in 2011.