

Prof. Lakshminarayanan Subramanian

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Areas of Interest

Networks, Distributed Systems, Security and Technologies for Developing Regions

Education

PhD in Computer Science, 1999- 2005
University of California at Berkeley
Thesis: Decentralized security mechanisms for Internet Routing
Advisors: Prof. Randy H. Katz, Prof. Scott Shenker, Prof. Ion Stoica

MS in Computer Science, 1999-2002
University of California at Berkeley

B.Tech in Computer Science, 1995-1999
Indian Institute of Technology, Madras

The Nurture program, a graduate program in Mathematics, 1995-1998
The Institute of Mathematical Sciences (IMSc), India

Professional Experience

Assistant Professor, New York University, 2006-Present
Researcher, Intel Research Berkeley, 2005-2006
Research Assistant, UC Berkeley, 1999-2005
Summer Intern, Microsoft Research, 2000
Summer Intern, EPFL – Switzerland, 1999
Summer Research Fellow, Indian Institute of Science, 1998

Awards and Honors

- ACM Doctoral Dissertation Nomination, 2005
- C.V. Ramamoorthy Award (2005) for outstanding contributions in a new research area in computer science.
- Best Student paper award, ACM/USENIX Networked Systems Design and Implementation (NSDI) 2004
- UC Regents Fellowship, 1999

- Silver Medalist, 36th International Mathematics Olympiad, Toronto, Canada, 1995
- All India First Rank, Roorkee University Entrance examination for which roughly 100,000 students appeared.

Ongoing Research Projects

I lead the Networks and Wide-Area Systems research group (<http://news.cs.nyu.edu>) jointly with Prof. Jinyang Li. I also lead the CATER research group (<http://cater.cs.nyu.edu>), a multidisciplinary initiative across different departments in NYU that focuses on developing appropriate Information and Communication Technologies (ICT) to address important problems in developing region contexts. I am involved in the following ongoing research efforts as a part of both these research groups:

Wireless Networks

1. **WiLDNet:** We have developed Wifi-based Long Distance Networks (WiLDNet), a low-cost wireless solution that can deliver over 7-10 Mbps over 100 kms for less than \$1000. WiLDNet has been deployed in over 10 developing countries and is currently used to provide telemedicine services in South India for 50000 patients/year. In 2007, we established the longest point-to-point wireless link spanning 384 kms.achieving over 6 Mbps. (Joint work with R. Patra, S. Nedevschi, S. Surana, A. Sheth, E. Brewer)
2. **Multi-radio Wireless Networks:** This project aims to build a high performance indoor multi-hop wireless network where every wireless node is equipped with multiple radios that operate in different channels. (Joint work with J. Li, A. Dhananjay, H. Zhang)
3. **WiRE architecture:** The Wifi-based Rural Extensions (WiRE) project aims to extend the WiLDNet project to build a comprehensive low-cost wireless architecture for rural network connectivity. The WiRE architecture uses a combination of point-to-point, point-to-multipoint and omni-directional networks. (Joint work with R. Patra, A. Dhananjay, E. Brewer)

Intermittent and Low-Bandwidth Networked Systems

1. **RuralCafe:** A system that provides enhanced web search and browsing capabilities over low-bandwidth and intermittent networks. This system is tailored to improve web search in Internet cafes in villages with minimal network connectivity. We have deployed RuralCafe in Amrita University in India which operates over low-bandwidth networks. (Joint work with J. Chen)
2. **ATMosphere:** A system that enables ATMs to operate in villages in the face of intermittent connectivity. To optimize operational costs, ATMosphere provides offline authentication as well as lazy consistency in updating records while maintaining high cash availability. (Joint work with M. Paik)
3. **Efficient Lightweight Mobile Records (ELMER):** A system that provides a practical and lightweight database access protocol for accessing and updating records remotely from mobile devices under an extremely bandwidth and cost-constrained Short Messaging Service channel. ELMER is designed for the context rural health-workers to fetch and update health records. (Joint work with A.Kumar, A. Purandare)
4. **SMSFind:** An SMS based contextual search engine that enables users to perform web search over SMS for arbitrary contexts. For arbitrary contexts, SMSFind outperforms GoogleSMS and Yahoo OneSearch. (Joint work with B. Linn, J. Chen)

Security and Information Privacy

1. **PaperSpeckle:** We have developed a new low-cost watermarking solution that can extract a unique watermark from any piece of paper using a pen and \$50 microscope. This work has several applications for low-cost paper-based authentication and preventing paper forgery in developing countries. (Joint work with A. Sharma, E. Brewer)
2. **Sybil Resilient Content Rating:** We have developed SumUp, a sybil-resilient online content rating system that leverages trust networks to rate online content in the face of Sybil adversaries casting bogus votes. (Joint work with T. Nguyen, B. Min, J. Li)
3. **TrickleDNS:** A decentralized architecture for securing the DNS without using a Public-Key Infrastructure (joint work with S. Sankaraman, V. Ramasubramanian)
4. **Bulk Document Leakage Detection:** This project aims to build a system that can automatically detect if sensitive data from enterprises has leaked and been published on the web. (Joint work with B. Krishnamurthy, A. Sharma, S. Kumar)
5. **Sensitive Data Leakage Prevention:** This project aims to build a deployable solution with minimal OS-level changes for preventing sensitive data from leaking out of an enterprise. (Joint work with B. Krishnamurthy, A. Sharma, S. Kumar)
6. **Privacy Preserving Query Computation Model:** A system that supports scalable privacy preserving queries in distributed databases using minimal cryptographic operations. (joint work with S. Chow, J. H. Lee)
7. **Access Control Routing (ACR):** A routing-based security solution aimed at simplifying access control configuration in routers and firewalls in large enterprise networks. (joint work C.T. Ee, D. Maltz, J. Lee, S. Shenker)

Students

- Jay Chen , PhD (intermittent networks, web search)
- Aditya Dhananjay, PhD (wireless networks) (co-advised with Jinyang Li)
- Tran Dinh Nguyen, PhD (trust networks and reputation systems) (co-advised with Jinyang Li)
- Michael Paik, PhD (mobile applications, mobile security)
- Ashlesh Sharma, PhD (paper authentication, leakage detection and prevention)
- Arvind Kumar, MS (mobile records)
- Brendan Linn, MS (SMS search)
- Amey Purandare, MS (mobile records)
- Nathan Silberman (working at Google NYC)

Alumni

- Saurabh Kumar, MS (working at Microsoft)
- Jie Han Lee, MS

I also closely work/have worked with the following students at UC Berkeley

- Rabin Patra, PhD (advised by Prof. Eric Brewer)
- Sergiu Nedeveschi, PhD (advised by Prof. Eric Brewer, now at Intel Research)
- Sonesh Surana, PhD (advised by Prof. Eric Brewer)
- Matthew Caesar (advised by Prof. Randy Katz, now an assistant professor at UIUC)

Courses

Networks and Distributed Systems, Spring 2009
Honors Operating Systems, Fall 2008
Information and Communication Technologies for Developing Regions, Fall 2007
What if a Computer Lies?, Spring 2007
Networks and Distributed Systems, (co-taught with Jinyang Li), Fall 2006,

Professional Activities

General Chair, Hotnets 2009
Organizing Committee, CCC Workshop on “ICTD: A New Grand Challenge for Computer Science Research”
Steering Committee: ACM SOSP Workshop on Networked Systems for Developing Regions (NSDR) 2009
Track Chair: WWW 2008 Track on “Technologies for Developing Regions”
Program Chair: ACM SIGCOMM Workshop on Networked Systems for Developing Regions, 2008
Track Chair: IEEE VTC 2009, “Low cost wireless access for under resources areas”
PC member: IEEE/ACM ICTD 2009, IwQoS 2009, ACM SIGCOMM 2008, SIGCOMM NSDR 2008, CoNext 2008, WWW 2008, ICDCN 2008, IwQoS 2008, IwQoS 2007, USENIX SRUTI 2007, ACM Electronic Commerce 2007, NPsec 2007, NPsec 2006
Publicity Chair: USENIX SRUTI 2006, NPsec 2006
Publication Chair: ACM CoNext 2007
Organizer, NY Systems/Networking Summit 2006

Grants

“Design of Intermittency Aware Networked Systems”, NSF NeTS NECO Project 0832153-0831934, Award amount: \$570,000. Joint with Prof. Eric Brewer, UC Berkeley. Sept 2008.

“SmartTrack: Design of Smartphone based Distributed Information Store”, Microsoft Grant. Cellphones for Healthcare RFP. Award amount: \$98,630. Jan 2008

“Cellphone based Distributed Information Systems”, NYU University Challenge Research Fund. Award Amount: \$10,000, June 2008.

NYU Startup Grant. Award Amount: \$270,000. Sept 2006

NYU Systems Startup Grant. Amount: \$65,000. Sept 2006

Journal Publications

Yong Xia, Lakshminarayanan Subramanian, Ion Stoica and Shivkumar Kalyananaraman. One More Bit is Enough. *IEEE/ACM Transactions on Networking*, Dec 2008 (Journal version of SIGCOMM 2005 paper)

Chen Nee Chuah, Lakshminarayanan Subramanian and Randy H. Katz. DCAP: Detecting Misbehaving flows via Collaborative Aggregate Policing, *ACM SIGCOMM Computer Communications Review*, October, 2003.

Lakshminarayanan Subramanian, Muralidhar Talupur, Kamala Krithivasan and C.Pandu Rangan. On the Generative Power of Simple H-Systems, *Journal of Automata, Languages and Combinatorics* , Volume 5 (2000), Number 4.

H. J. Wang, B. Raman, C-N. Chuah, R. Biswas, R. Gummadi, B. Hohlt, X. Hong, E. Kiciman, Z. Mao, J. S. Shih, L. Subramanian, B. Y. Zhao, A. D. Joseph, and R. H. Katz, ICEBERG: An Internet-core Network Architecture for Integrated Communications, *IEEE Personal Communications Special Issue on IP-based Mobile Telecommunications Networks*, August 2000.

Conference Proceedings

Jay Chen, Lakshminarayanan Subramanian and Jinyang Li. "RuralCafe: Web Search in the Rural Developing World". *World Wide Web Conference (WWW)* 2009.

Michael Paik and Lakshminarayanan Subramanian. "ATMosphere: A System for ATM Microdeposit Services in Rural Contexts". *IEEE/ACM Conference on Information and Communication Technologies and Development (ICTD)*, 2009.

Arthur Meacham, Ashlesh Sharma, Michael Paik, Giulio Quarta, Phil Smith, John Trahanas, Brian Levine, Mary Ann Hopkins, Barbara Rapchak and Lakshminarayanan Subramanian. "The Case for SmartTrack". *IEEE/ACM Conference on Information and Communication Technologies and Development (ICTD)*, 2009.

Jay Chen, Lakshminarayanan Subramanian and Kentaro Toyama. "Web Browsing Behavior under Poor Connectivity." *ACM Conference on Human Factors in Computing Systems (CHI)*, 2009. (Work in Progress Session).

Trandinh Nguyen, Bonan Min, Jinyang Li and Lakshminarayanan Subramanian. "Sybil Resilient Online Content Rating". *ACM/USENIX Networked Systems Design and Implementation (NSDI)* 2009.

Sherman Chow, Jie Han Lee and Lakshminarayanan Subramanian. "A Two-Party Computation Model for Privacy Preserving Queries over Distributed Databases." *Networks and Distributed Systems Security (NDSS)*, 2009.

Sergiu Nedeveschi, Rabin Patra, Sonesh Surana, Sylvia Ratnasamy, Lakshminarayanan Subramanian and Eric Brewer. "An Adaptive High-Performance MAC for Long-Distance Multihop Wireless Networks." *ACM MOBICOM*, 2008.

Ashlesh Sharma, Lakshminarayanan Subramanian and Eric Brewer. "Secure Rural Supply Chain Management using Low Cost paper Watermarking." *ACM SIGCOMM Workshop on Networked Systems for Developing Regions (NSDR)*, 2008.

Sonesh Surana, Rabin Patra, Sergiu Nedeveschi, Manuel Ramos, Lakshminarayanan Subramanian and Eric Brewer. "Beyond Pilots: Keeping Rural Wireless Networks Alive." *ACM/USENIX Networked Systems Design and Implementation (NSDI)*, 2008.

Rabin Patra, Sergiu Nedeveschi, Sonesh Surana, Anmol Sheth, Lakshminarayanan Subramanian and Eric Brewer. "WiLDNet: Design and Implementation of High-Performance Wifi-based Long Distance Wireless Networks." *ACM/USENIX Symposium on Networked Systems Design and Implementation (NSDI)*, 2007.

Anmol Sheth, Sergiu Nedeveschi, Rabin Patra, Sonesh Surana, Lakshminarayanan Subramanian and Eric Brewer. "Packet Loss Characterization in Wifi-based Long-Distance Networks," *IEEE INFOCOM 2007*.

Lakshminarayanan Subramanian, Sonesh Surana, Anmol Sheth, Sergiu Nedeveschi, Rabin Patra, Melissa Ho and Eric Brewer. "Rethinking Wireless for the Developing World." *ACM Hotnets 2006*.

Shridhar Mubaraq Mishra, John Hwang, Dick Filippini, Tom Du, Reza Moazzami, and Lakshminarayanan Subramanian. "Economic Analysis of Networking Technologies for Rural Developing Regions." *First Workshop on Internet and Network Economics*, Dec 2005.

Lakshminarayanan Subramanian, Randy H. Katz, Volker Roth, Scott Shenker and Ion Stoica. "Reliable Broadcast in Unknown Fixed-Identity Networks." *ACM Principles of Distributed Computing (PODC)*, July 2005.

Lakshminarayanan Subramanian, Matthew Caesar, Cheng Tien Ee, Mark Handley, Morley Mao, Scott Shenker and Ion Stoica. "HLP: A Next Generation Interdomain Routing Protocol." *ACM SIGCOMM 2005 Conference on Applications, Technologies, Architectures, and Protocols for Computer Communication*, Philadelphia, PA, August 2005.

Yong Xia, Lakshminarayanan Subramanian, Ion Stoica and Shivkumar Kalyanaraman. "One More Bit is Enough." *ACM SIGCOMM 2005 Conference on Applications, Technologies, Architectures, and Protocols for Computer Communication*, Philadelphia, PA, August 2005.

Jayanthkumar Kannan, Lakshminarayanan Subramanian, Ion Stoica and Randy H. Katz. "Analyzing Cooperative Containment of Fast-scanning Worms." *USENIX Workshop on Steps to Reduce Unwanted Traffic in the Internet (SRUTI)*, Cambridge, MA, July 2005.

Emre Kiciman and Lakshminarayanan Subramanian. "A Root-cause Localization Model for Large-scale Systems." *First Workshop on Hot Topics in Systems Dependability (HotDep)*, June 2005.

Matthew Caesar, Lakshminarayanan Subramanian and Randy H. Katz. "A Case for an Internet Health Monitoring System." *First Workshop on Hot Topics in Systems Dependability (HotDep)*, June 2005.

Lakshminarayanan Subramanian, Matthew Caesar, Cheng Tien Ee, Mark Handley, Morley Mao, Scott Shenker and Ion Stoica. "Towards a Next Generation Interdomain Routing Protocol." *Third Workshop on Hot Topics in Networks (HotNets-III)*, Nov, 2004.

Lakshminarayanan Subramanian, Volker Roth, Ion Stoica, Scott Shenker and Randy H. Katz. "Listen and Whisper: Security Mechanisms for BGP." *First Symposium on Networked Systems Design and Implementation (NSDI'04)*, March, 2004. (Awarded best student paper)

Lakshminarayanan Subramanian, Ion Stoica, Hari Balakrishnan and Randy H. Katz. "OverQoS: An Overlay based Architecture for Enhancing Internet QoS." *First Symposium on Networked Systems Design and Implementation (NSDI'04)*, March, 2004.

Lakshminarayanan Subramanian, Ion Stoica, Hari Balakrishnan and Randy H. Katz. "OverQoS: Offering QoS using Overlays." *First Workshop on Hop Topics in Networks (HotNets-I)*, October 28-29, 2002.

B. Raman, S. Agarwal, Y. Chen, M. Caesar, W. Cui, P. Johansson, K. Lai, T. Lavian, S. Machiraju, Z. M. Mao, G. Porter, T. Roscoe, M. Seshadri, J. Shih, K. Sklower, L. Subramanian, T. Suzuki, S. Zhuang, A. D. Joseph, R. H. Katz, I. Stoica. "The SAHARA Model for Service Composition Across Multiple Providers," *Proceedings of the International Conference on Pervasive Computing*, August 26-28, 2002.

Lakshminarayanan Subramanian, Venkata N. Padmanabhan and Randy H.Katz. "Geographic Properties of Internet Routing." *USENIX Annual Technical Conference*, Monterey, CA, June 2002.

Lakshminarayanan Subramanian, Sharad Agarwal, Jennifer Rexford and Randy H.Katz. "Characterizing the Internet Hierarchy from Multiple Vantage Points." *IEEE INFOCOM 2002*, New York, June 2002.

Venkata N. Padmanabhan and Lakshminarayanan Subramanian. "An Investigation of Geographic Mapping Techniques for Internet Hosts." *Proceedings of the ACM SIGCOMM 2001 Conference on Applications, Technologies, Architectures, and Protocols for Computer Communication*, San Diego, CA, August 2001. Also appeared as an extended abstract in *ACM SIGMETRICS 2001*.

Shivnath Babu, Lakshminarayanan Subramanian and Jennifer Widom. "A Data Stream Management System for Network Traffic Management." *ACM SIGMOD Workshop on Network Related Data Management (NRDM 2001)*, Santa Barbara, CA, May 2001.

Lakshminarayanan Subramanian and Randy H.Katz. "An Architecture for Building Self-Configurable Systems." *IEEE/ACM Mobile Ad Hoc Networking and Computing (MobiHoc 2000)*, Boston, August 2000.

Chen Nee Chuah, Lakshminarayanan Subramanian, Randy H.Katz and Anthony D.Joseph. "QoS Provisioning using a Clearing House Architecture." *Eighth International Workshop on Quality of Service (IwQoS 2000)*, Feb 2000.

Karthikeyan Mahesh, Lakshminarayanan Subramanian and S.V.Raghavan. "An Efficient Rerouting Mechanism for Dynamic Network Resource Management." *International Conference on Multimedia Computing and Systems (ICMCS 1999)*, Florence, June, 1999.

Lakshminarayanan Subramanian, S.S. Ghosh and N. Balakrishnan. "An Implementation of MPI over HTTP." *High Performance Computing and Networking, Europe (HPCN-Europe 1999)*, Amsterdam, April 1999. Appeared in *Lecture Notes in Computer Science*, Vol. 1593, Springer, pp 1299-1302.

Patents

Venkata N. Padmanabhan and Lakshminarayanan Subramanian. System and Method for Determining the Geographic Location of Internet Hosts. US Patent 11778490 - Filed Jul 16, 2007

Balachander Krishnamurthy, Saurabh Kumar and Lakshminarayanan Subramanian. Automatic Generation of Embedded Signatures for Duplicate Detection on a Public Network. Application No.: 12/156,370. Filed May 30 2008.

Balachander Krishnamurthy, Saurabh Kumar and Lakshminarayanan Subramanian. Unique Packet Identifiers for Preventing Sensitive Data Leakage. Application No.: 12/156,371; Filed: May 30, 2008

Ashlesh Sharma, Lakshminarayanan Subramanian and Eric Brewer. PaperSpeckle: Low-cost Paper Authentication. Provisional Patent Filed June 5, 2008.

Working Papers

Sriram Sankararaman, Venugopalan Ramasubramanian and Lakshminarayanan Subramanian. “TrickleDNS: A High Integrity Domain Name System.” NYU Technical Report.

Ashlesh Sharma, Lakshminarayanan Subramanian and Eric Brewer. “PaperSpeckle: A Low-cost Paper Authentication System.” NYU Technical Report

Balachander Krishnamurthy, Saurabh Kumar, Ashlesh Sharma and Lakshminarayanan Subramanian. “Bulk Document Leakage Detection.” NYU Technical Report

Lakshminarayanan Subramanian, Nicholas Economides, Ashlesh Sharma and Nathan Silberman. “An Economic Model for Internet Topology Evolution.” NYU Technical Report

Yair Sovran, Jinyang Li and Lakshminarayanan Subramanian. “Unblocking the Internet: Social Networks Foil Censors.” NYU Technical Report.

Aditya Dhananjay, Jinyang Li, Hui Zhang and Lakshminarayanan Subramanian. “Design and Implementation of High Performance Dual-radio Mesh Networks.” NYU Technical Report.

Brendan Linn, Jay Chen and Lakshminarayanan Subramanian. “SMSFind: SMS-based Contextual Web Search.” NYU Technical Report

Arvind Kumar, Amey Purandare, Arthur Meacham and Lakshminarayanan Subramanian. “ELMER: Efficient Lightweight Mobile Health Records.” NYU Technical Report

Jayanth Kumar Kannan, Ion Stoica and Lakshminarayanan Subramanian. “Cloak your Passwords from Third Party Honey Pots and Network Admins.” UC Berkeley Technical Report.

Cheng Tien Ee, John Lee, Dave Maltz, Scott Shenker and Lakshminarayanan Subramanian. “ACR: Simplifying Access Control in Enterprise Networks.” NYU Technical Report.