

Rajeev Koodli

SUMMARY: Technologist with a passion and proven track record in innovation, strategic and advanced technology development, and research. Architect, Program Manager and Inventor.

My background is in computer and communication systems with specialization in mobility, wireless and applications such as video. My work has spanned live and on-demand video, distributed computing, cellular network design using the Internet Protocol, Ad Hoc Networking, and Mobile Internetworking. As a **Senior Principal Scientist** at Nokia Research Center (08/97 – 03/07) and as a Senior Technologist at Nokia Siemens Network's Research Technology and Platforms (04/07 – 01/08), I have initiated, planned and executed strategic and longer-term projects in mobile and wireless systems and applications. I have managed projects with geographically distributed teams of engineers.

As an **Architect** with Starent Networks (since 03/08), I am involved in the design of 4G and 3G mobile internetworking (including Long-Term Evolution, CDMA, Wimax and WiFi).

Notables:

- Contributed to the creation of the mobility solution for IPv6 (which is the next-generation of the Internet Protocol), and led the development of real-time mobility management for the Internet Protocol.
- Specified protocols, designed system software, implemented protocols and led a team of engineers on projects. Worked with the platforms group leading to productization (http://press.nokia.com/PR/200411/969183_5.html).
- Led the development of solutions for autonomous networks, including network formation, power-conserving topology construction, resource discovery, and applications (Push-To-Talk, local Voice and Messaging), which are being incorporated into the technologies for “connecting the next billion”.
- Led and contributed to strategy and vision on the confluence of mobility and the Internet, next-generation mobility architecture (such as Long-Term Evolution and Wimax) and complementary mobile broadband access (i.e., WiFi).
- Designed solutions for application mobility between enterprise LAN and service provider WAN networks. Architected the system for real-time mobility (for applications such as VoIP and video) as well as secure mobility (for applications such as VPN). Evaluated the system performance and helped conduct trials, eventually leading to productization of the platform.
- Invented multiple patents (8 granted US patents, 2 European patents, many pending) including an essential 3G patent, authored the book “*Mobile Internetworking with IPv6: Concepts, Principles and Practices*” book, and authored numerous research papers and multiple IETF RFCs.

Project Snapshots: (Contact me for details)

Mobile Inter-networking:

Mobile Internetworking is all about building the necessary plumbing for millions of mobile devices to access and experience the Internet regardless of the access method and mobility. This includes providing an *always-on* and *best-connected* experience at the Internet Protocol.

I have been part of the original team that built the core mobility components for IPv6, including Mobile IPv6, Fast Mobile IP Handovers, and Network Mobility, and standardized them in IETF.

Mobile Applications and Services:

Designing suitable platforms for mobile applications in a diverse wireless world is crucial. I have architected solutions, and managed projects involving a team of engineers in developing applications and services. These have included mobile video, portable VoIP (with “virtually home” and “personal network” features), proximity mobile gaming, and localized Push-To-Talk and messaging.

Cellular Network design using IP:

Designed a cellular network architecture using IP for transport and application services while using evolved GPRS (General Packet Radio Service) for session and mobility management. Managed a Core Network IP QoS project. Designed header compression, service discovery and policy-based solutions. The project deliverables led to multiple standards contributions and inventions. Designed interworking solution between Wimax and CDMA (and between LTE and CDMA) based on Mobile IP (MIP) and Proxy Mobile IP (PMIP) protocols. Proposed solutions, evaluated the architectural choices between different mobility protocols for next-generation mobile networks including Wimax and LTE, and presented technical alternatives to customers.

Mobile Enterprise Infrastructure:

Our objective was to investigate problems and build solutions in mobilizing enterprise applications, especially VoIP and VPN over wireless networks. I was a manager providing leadership to the program, and a technical leader providing architecture, system design and implementation. I architected the mobility solutions for call handovers within a LAN, and between LAN and WAN, designed and managed the project on Firewall and NAT integration with the VoIP system. The system was trialed and components incorporated into Enterprise Solutions.

Connecting the Next Billion:

While the GSM system has been an unprecedented success in providing mobile voice and SMS, it has not been able to unify the Internet experience. This is especially acute in many underserved regions in the world, which present unique challenges in cost, infrastructure availability and management. There is a unique opportunity in unearthing hitherto unfamiliar Internet applications using mobile devices as the primary access means. I have proposed and led a power-conserving infrastructure project that could provide Internet access, localized rich-media applications and remote network management. The system being built is expected to be trialed in Asia.

Autonomous Ad hoc Networking:

Started the project to create ad hoc networks on-demand using IP. Designed and built *IP sub-network formation* (subsequent to radio connectivity establishment using Bluetooth and WLAN), *service*

discovery and *name resolution* in a fully infrastructure-less manner. These components enabled localized applications such as Push-To-Talk, instant messaging, multi-party conferencing and secure peer – peer communication. I was the Principal Investigator and the Manager.

Real-time Scheduling for Video:

As a graduate researcher in University of Massachusetts Amherst, I proposed and implemented scheduling algorithms to provide multi-tier Quality of Service (QoS) guarantees and VCR-like functions in Continuous Media applications such as Video. Proposed, implemented and validated a novel loss model based on noticeable loss using the REACT framework on the SGI Challenge multiprocessor. Implemented a distributed simulator to study the end-to-end behavior of real-time audio and video streams, and evaluated the performance in a video bridging application. Helped design a distributed, fault-tolerant testbed for investigating real-time recovery actions in a mission-critical, real-time application environment.

Multimedia Transport:

As a Visiting Researcher at (AT&T) Bell Labs (Holmdel, NJ), I worked on a Virtual Transport (VT) protocol for seamlessly accessing multimedia services in the Multimedia Communications Research Laboratory. Ported VT to MS Windows environment using Winsock. Designed and implemented an instance of VT for asynchronous communication using IPX/SPX. Researched QoS in the “Montage” video bridging system that resulted in a publication for International Workshop on QoS, 1997.

Distributed Computing:

Working as a graduate research assistant in Project Pilgrim at the University of Massachusetts Amherst, I designed and implemented distributed system tools using Open Software Foundation's Distributed Computing Environment (DCE), including RPC, POSIX Threads, Namespace and Motif. Designed and developed a tool for accessing and synchronizing information from multiple sources in a distributed environment using RPC and Threads. Researched the performance of user-level thread parallelism in the context of conventional operating systems support. Implemented a priority-based user-level thread scheduler. Improved a conferencing tool for heterogeneous distributed environments.

EDUCATION:

University of Massachusetts, Amherst, MA, USA

M.S., Ph.D. in Electrical and Computer Engineering
01/1991 to 08/1997

Ph.D. dissertation: "*Scheduling Support for Multi-tier Quality of Service (QoS) in Continuous Media Applications.*"

Proposed a scheduling framework for multi-tier Quality of Service (QoS) provisioning for Continuous Media applications (such as live or stored audio and video) in statistically shared environments such as the Internet. Introduced the concept of *noticeable loss* to capture the effect of loss distribution on QoS, and used this metric to evaluate a novel scheduling algorithm that supports disparate loss requirements while simultaneously providing predictable delay guarantees to

Continuous Media applications. Extended the scheduling algorithm to provide end-to-end delay support, and evaluated the system involving live video applications. Research work implemented in a Silicon Graphics Multiprocessor using the REACT framework and Berkeley Continuous Media Toolkit, and is available via refereed publications.

Karnataka University, Dharwad, India

BE in Electronics and Communications Engineering

07/1986 to 08/1990

First Class Honors

Senior year project "*Performance of coarse and fine grained algorithms in a distributed processing environment*" was selected for funding by the Indian Institute of Science.

PATENTS:

8 granted US patents, and 2 granted European patents; several others pending.

BOOK:

"Mobile Internetworking with IPo6: Concepts, Principles and Practices", published by John Wiley & Sons. Being translated to Korean language.

SELECTED RESEARCH PUBLICATIONS:

- With E. Kusmirek, "Flow Fairness using Aggregate Packet Marking for Wireless Mesh Networks", IEEE Comsware, Bangalore, India, January 2008.
- With A. Jardosh and T. Chan, "Best-Effort Call Handovers between WLAN and EVDO Networks", IEEE International Conference on Communications (ICC), Glasgow, Scotland, June 2007.
- With P. Engelstad et al., "Service Discovery Architectures for On-Demand Ad Hoc Networks", in Ad Hoc and Sensor Wireless Networks Journal, Vol 2, Number 1 2006.
- R. Koodli, V. Devarapalli, H. Flinck and C. E. Perkins, "Location Privacy with IP Mobility", in IEEE Securecomm 2005, Athens Greece.
- With Cedric Westphal, "Stateless IP Header Compression, IEEE ICC, Seoul Korea, May 2005.
- With R. Wakikawa et al., "Mobile Gateways for MANET Networks", Fifth International Conference on Networking (ICN), 2005. Also a short paper presentation at ACM Mobihoc Symposium, Tokyo, Japan, May 2004
- R. Koodli and C. E. Perkins, "Supporting IP Mobility in WLAN - WWAN Integration", Proceedings of Communications Design Conference, San Jose, CA, September 2003.
- C. Westphal and R. Koodli, "Header Compression: A Study of Context Establishment", Proceedings of IEEE WCNC conference, March 2003.
- R. Koodli and C.E. Perkins, "Fast Handovers and Context Transfers in Mobile Networks", in ACM CCR Special Issue on Wireless Extensions to the Internet, October 2001
- R. Koodli and M. Puuskari, "Supporting Packet Data QoS in Next-Generation Cellular Networks", IEEE Communications Magazine, February 2001.
- H. Chaskar and R. Koodli, "MPLS and DiffServ for UMTS QoS in GPRS Core Network Architecture", Internet Society's INET Conference, Stockholm, Sweden, June 2001
- H. Chaskar and R. Koodli, "A QoS Framework for Next-Generation Cellular Networks", IEEE Wireless 2000 conference, Calagary, Alberta Canada, June 2000

- S. Nananukul, R. Koodli and S. Dixit, "Controlling Short-Term Packet Loss Ratios using an Adaptive Pushout Scheme", IEEE Conference on High-performance Switching and Routing, Heidelberg, Germany, 2000
- J. Padhye, J. Kurose, D. Towsley and R. Koodli, "A TCP-friendly Rate Adjustment Protocol for Continuous Media Flows over Best-Effort Networks", NOSSDAV workshop, Basking Ridge, NJ, USA. June 1999. Also appeared as a short-paper in ACM SIGMETRICS, Atlanta, GA, USA. April 1999.
- S. Faccin, L. Hsu, R. Koodli, K. Le and R. Purnadi, "GPRS and IS-136 Integration for Flexible Network and Service Evolution", IEEE PCS Special Issue on Convergence of GPRS and IS-136. June 1999.
- R. Koodli and C. M. Krishna, "Noticeable Loss: A Metric for Capturing Loss Pattern in Continuous Media Applications", in Internet Routing and Quality of Service Conference, proceedings of SPIE's International Symposium on Voice, Video, and Data Communications, Boston, MA, November, 1998
- R. Koodli and C. M. Krishna, "A Loss Model for Supporting Disparate Quality of Service (QoS) in Multimedia Applications", in 13th ISCA International Conference on Computers and Their Applications, Honolulu, Hawaii, March 1998.
- R. Koodli and C. M. Krishna, "Supporting Multiple-tier QoS in a Video Bridging Application", in Fifth IEEE/IFIP International Workshop on Quality of Service, Columbia University, New York City, May 1997. Also appears in the book "Building QoS into Distributed Systems", Edited by A. Campbell and K. Nahrstedt, published by Chapman and Hall, 1997, pages 137-148.
- R. Koodli and C. M. Krishna, "Supporting End-to-end Deadlines for Soft Real-time Multimedia Applications", in IEEE International Performance, Computing and Communications Conference, Tempe, AZ, February 1997.

LIST OF Internet Engineering Task Force (IETF) PUBLICATIONS:

- R. Koodli (Editor), "Fast Handovers for Mobile IPv6", IETF RFC 5268, Updates RFC 4068
- J. Kempf and R. Koodli, "Distributing a Symmetric FMIPv6 Handover Key using SEND", RFC 5269
- R. Koodli and C. E. Perkins, "Mobile IPv4 Fast Handovers", RFC 4998
- R. Koodli, "IP Address Location Privacy and Mobile IPv6", RFC 4882
- Q. Ying, F. Zhao, and R. Koodli, "Solutions for Mobile IPv6 Location Privacy", IRTF MobOpts Research Group document
- J. Loughney, M. Nakhajiri, C.E. Perkins and R. Koodli, "Context Transfer Protocol", IETF RFC 4067
- R. Koodli and R. Ravikanth, "Loss Pattern Sample Metrics", IETF RFC 3357
- With J. Kempf (editor) et al. "Context Transfer Problem Statement", RFC 3374
- R. Koodli and C. E. Perkins. "A Context Transfer Framework for Seamless Mobility", (work in progress)
- R. Koodli and C. E. Perkins, "Service Discovery in Ad Hoc Networks", (work in progress)
- D. Forsberg, R. Koodli and C. E. Perkins, "Context Relocation of AAA Parameters in IP Networks", (work in progress)
- C. Westphal, R. Koodli and C. E. Perkins, "Context Relocation of QoS Parameters in IP Networks", (work in progress)
- R. Koodli, M. Tiwari and C. E. Perkins. "Header Compression Context Relocation in Mobile IPv6 Networks", (work in progress)

- R. Koodli and J. T. Malinen. "Idle-mode Context Transfers in Mobile Networks", (work in progress)
- R. Koodli, C. E. Perkins and J. Trostle. "Fast Handovers in Mobile IPv6", (work in progress)

PROFESSIONAL ACTIVITIES:

- Chair, Internet Research Task Force (IRTF) Research Group on IP Mobility Optimizations (MobOpts)
- Member, Internet Research Steering Group (IRSG)
- Member:
 - TPC IEEE SECON 2007, 2006, 2005, 2004, Executive Committee 2004
 - Executive Committee, IEEE Comsware 2007, 2008.
 - TPC IEEE Mobile P2P Workshop 2007
 - TPC IEEE/ACM Mobility in the Evolving Internet Architecture (Mobiarch), 2006, 2007, 2008
 - TPC IEEE Globecom Symposium on Wireless Networks, 2006
 - TPC VTC Fall 2005
 - TPC OpenSig 2003
 - TPC IEEE Network and Interop Broadband Wireless Summit, May 2001
- Invited Presenter, NSF's Mobility and Wireless Workshop, July 2007
- Invited Panelist, NSF project review panel
- Referee for IEEE Infocom 2000, Infocom 2003, ACM Mobicom 2002, IEEE Transactions on Vehicular Technology, Journal of Software Technology, International Workshop on QoS 98, International Conference on Computer Communications & Networks - IC3N, 1998
- Member, IEEE

SOME TALKS AND PRESENTATIONS:

- "Problem Solvers or Problem Formulators?" invited article at the International Conference on Higher Education, ICHE 2007, Bangalore, India
- "Mobility and Cross-Layer Design", at NSF Workshop on Mobility in Wireless Networks, Rutgers University, June 2007. Also a panel presentation in IEEE/ACM Workshop on Mobility in the Evolving Internet Architecture, December 2006
- "G(ee), Mesh or Max", wireless panel organizer and moderator, IEEE Comsware 2007, Bangalore, India
- "Advances in IP Mobility", presentation at Lucent Bell Labs, Bangalore January 2006
- "Next-generation Wireless Technologies", panelist presentation at IEEE LANMAN workshop, Mill Valley, CA USA, March 2004
- "IP Mobility for a Mobile Internet", presentations at the Indian Institute of Science and at Indian Institute of Information Technology, Bangalore, India, October 2003
- "Supporting IP Mobility in WLAN - WWAN Integration", presentation at Communications Design Conference, San Jose, CA October 2003
- "Supporting IP Mobility in a Mobile Internet", tutorial presentation at ACM Mobicom, San Diego, CA September 2003
- "IP Mobility: Recent Trends and Advances", tutorial presentation at Communications Design Conference, San Jose, CA September 2002
- "QoS and Mobility in IP Networks" presentation at UC Berkeley Computer Science Seminar course, March 2002

- Numerous IETF Presentations

SKILLS:

Unix, C, TCP/IP, IPv6, Mobile IP, Free BSD kernel, IPSO kernel, MPEG, Ad Hoc Routing Protocols, VoIP, POSIX Threads, RPC, SGI REACT scheduler, various workstations with Unix and Windows. Expert knowledge of mobile and wireless protocols and services. Strategic understanding of web applications and services.

HONORS:

- Inventor Royalty Award, 2007
- Nokia USA Inventor Award, 2004
- Joined Nokia Research Center as a Senior Research Engineer in August 1997. Promoted to Principal Scientist in February 2001. Promoted to Senior Principal Scientist in May 2005.
- Invited member of IEEE Wireless delegation to China in October 2000
- Graduate research funding from Bell Labs, 1995-96. Special honor from the University of Massachusetts Graduate School for receiving "Student Initiated External Research Grant".
- Research funding from the Indian Institute of Science for the senior year project titled "Performance of coarse and fine grained algorithms in a distributed processing environment".
- Secured fifth rank to the Karnataka state in secondary school graduation examination (1984). Subsequently awarded the National Merit Scholarship from the Ministry of Education and Culture, Government of India

CONTACT INFORMATION:

Email: Rajeev_Koodli@yahoo.com