Radhika Nagpal

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RESEARCH Robust multi-agent and distributed systems; Biologically-inspired approaches to engineering; Programming languages and global-to-local compilation; Self-assembly, robotics, sensor nets; Systems biology. **INTERESTS EDUCATION** Massachusetts Institute of TechnologyCambridge, MA Ph.D. in Electrical Engineering and Computer Science June 2001 Thesis: Programmable Self-Assembly using Biologically-Inspired Local Interactions Advisors: Prof. Gerald J. Sussman, Prof. Harold Abelson June 1994 S.M. and S.B. in Electrical Engineering and Computer Science Thesis: Store Buffering: Implementing Single-cycle Store Instructions **APPOINTMENTS** Assistant Professor of Computer Science Division of Engineering and Applied Sciences, Harvard University Sept 2004 Research Fellow, Dept. of Systems Biology, Harvard Medical School 2003-04 Postdoctoral Lecturer, Dept of Electrical Engineering and Computer Science, MIT 2001-03 Member of Technical Staff, Bell Laboratories, Murray Hill, NJ 1994-95 RESEARCH Harvard UniversityCambridge, MA Programming Myriads, Sept 2004 - present: Applying biologically-inspired programming paradigms for robust collective behavior to several application domains. Current projects include: (1) self-reconfiguration in modular robots (2) programming robot swarms for unmanned construction (3) self-maintaining algorithms for sensor network problems such as time synchronization. Continuing emphasis on methods for achieving self-organising/self-repairing behavior and on designing high-level goal-oriented languages that compile into

robust node level interactions.

Dissertation, completed June 2001: Developed a programming language for robust self-assembly of complex structures from locally-interacting agents, by combining techniques inspired by developmental biology with rules from geometry. The work uses a novel approach: the agent program is *directly compiled* from an abstract global specification. The resulting self-assembly process is extremely reliable in the face of random agent distributions, random agent death and varying agent numbers, and is also scale-independent.

Amorphous Computing, Jan 1996 – June 2001: Worked on the design and analysis of algorithms for massively distributed systems, such as sensor networks and smart materials, with emphasis on robust mechanisms that do not rely on specific network topologies, perfect reliability, access to global position, unique identifiers, or synchronous behavior. Jointly developed hardware prototype for sensor wall. Also worked on initial simulation experiments for engineering digital circuits in *E. coli* cells using genetic regulatory networks.

Hewlett-Packard LabPalo Alto, CA. *Self-organizing Adaptive Communication Network*, May – Aug 1997: Developed algorithms for ad-hoc communication infrastructure for large wireless sensor networks. Routing infrastructure emerges as a result of the communication pattern and adapts automatically to congestion and failures. Supervisors: Valery Kaneyevski, Wes Higaki.

Low-power Microprocessor Design (Master's Thesis), May 1993 – January 1994: Designed a RISC microprocessor geared towards low-power systems such as PDAs. For my thesis I devised a new technique for implementing pipelined store instructions in complex caches without stalling instruction execution or penalizing the clock speed. Advisors: Rae McLellan (Bell Labs) and Prof. Anant Agarwal (MIT).

Hobbit Microprocessor Architecture, May – Aug 1992: Worked on second version of the Hobbit, a low-power microprocessor for the EO pen-based handheld device, one of the first PDAs. Designed a set-associative data cache that operated in parallel to the stack cache. Designed a variable length floating-point pipeline in parallel with the integer pipeline. Supervisors: Rae McLellan, Alan Berenbaum.

TEACHING Harvard CS 263 *Biologically-inspired Distributed and Multi-agent Systems*, Fall 2004. Graduate course on biologically-inspired approaches to systems design, including swarm intelligence, amorphous computing, and immune-inspired systems. Covers both models of biology and applications; research projects.

MIT 6.033 *Computer Systems*, Spring 2003. (Recitation Instructor) Undergraduate course on engineering computer systems; covered operating systems, networking, fault-tolerant design, etc.

MIT 6.042 *Mathematics for Computer Scientists*, Fall 2001, Spring 2002, Fall 2002. Co-lecturer with Prof. Albert Meyer. Computer science undergraduate class on discrete math and discrete probability. In Spring 2002, we restructured the course to be taught in *lecture-studio style*, intermixing lecture and real-time problem-solving. Developed extensive in-class materials, now available on MIT OpenCourseware.

MIT 6.978 *Biologically-motivated Programming Technology for Robust Systems*, Fall 2002. Co-taught with Prof Harold Abelson and Prof. Gerald J. Sussman. Graduate research seminar on biologically-inspired algorithms for designing robust collective behavior. Supervised research projects.

Other: *Teaching Assistant*, MIT 6.001 Structure and Interpretation of Computer Programs, Spring 1994; *Mentor*, Research Science Institute summer program for exceptional high-school students, 1998.; *Mentor* for KEYS, MIT science program for middle school girls, 1996 – 1999.

GRANTS	"Robust Engineering Using Biologically-Inspired Models of Cell Differentiation and Morphogenesis",
RECEIVED	Radhika Nagpal, Gerald J. Sussman, NSF Grant on Quantum and Biologically-Inspired Computing (QuBIC),
	Sept 2001.

"Programming Technology for Molecular-Scale Computing", Harold Abelson, Gerald J. Sussman, Radhika Nagpal, Thomas F. Knight, *DARPA Long-Range Science and Technology Program*, May 2002.

PUBLICATIONS

INVITED CHAPTERS	Radhika Nagpal, Marco Mamei, "Engineering Amorphous Computing Systems", in <i>Methodologies and Software Engineering for Agent Systems</i> , editors Bergenti, Gleizes, and Zambonelli, Kluwer Academic Publishing, 2003.
Articles	Jonathan Bachrach, Radhika Nagpal, Micheal Salib, Howard Shrobe, "Experimental Results and Theoretical Analysis of a Self-Organizing Global Coordinate System for Ad Hoc Sensor Networks", <i>Telecommunications Systems Journal, Special Issue on Wireless System Networks</i> , Kluwer Academic Publishing, 2003.
	Harold Abelson, Don Allen, Daniel Coore, Chris Hanson, George Homsy, Thomas Knight, Radhika Nagpal, Erik Rauch, Gerald Sussman, and Ron Weiss, "Amorphous Computing", in <i>Communications of the ACM</i> , Volume 43, Number 5, May 2000.
CONFERENCES	Kasper Stoy, Radhika Nagpal, "Self-repair and Scale Independent Self-reconfiguration for a Modular Robot", <i>IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)</i> , Japan, Sept 2004.
	Kasper Stoy, Radhika Nagpal, "Self-reconfiguration Using Directed Growth", in International Symposium on Distributed Autonomous Robotic Systems (DARs), France, June 2004.
	Radhika Nagpal, Howard Shrobe, Jonathan Bachrach, "Organizing a Global Coordinate System from Local Information on an Ad Hoc Sensor Network", in <i>International Symposium on Information Processing in Sensor Networks (IPSN '03)</i> , Palo Alto, April 2003. Also as LNCS 2634.
	Radhika Nagpal, Attila Kondacs, Catherine Chang, "Programming Methodology for Biologically-Inspired Self-Assembling Systems", in <i>AAAI Spring Symposium</i> on Computational Synthesis: From Basic Building Blocks to High Level Functionality, Palo Alto, March 2003.
	Radhika Nagpal, "Programmable Self-Assembly Using Biologically-Inspired Multiagent Control", in Inter- national Joint Conference on Autonomous Agents and Multi-Agent Systems (AAMAS), Italy, July 2002.
	Radhika Nagpal, "Programmable Pattern-Formation and Scale-Independence", in <i>International Conference</i> on Complex Systems (ICCS), New Hampshire, June 2002.
	Radhika Nagpal, "Self-Assembling Global Shape, using Ideas from Biology and Origami", in <i>3rd Inter-</i> <i>national Meeting of Origami Science, Mathematics and Technology (3OSME)</i> , March 2001. Reprinted in <i>Origami</i> ³ , editor Thomas Hull, A.K. Peters, 2002.
	Radhika Nagpal, Daniel Coore, "An Algorithm for Group Formation in an Amorphous Computer", in <i>Proceedings of the 10th International Conference on Parallel and Distributed Computing Systems (PDCS'98)</i> , Nevada, Oct 1998.
	Radhika Nagpal, Hemant Kanakia, "Implementing Browsing Operations in MPEG", in <i>Proceedings of the</i> 7th International Workshop on Packet Video, Australia, March 1995.
WORKSHOPS	Radhika Nagpal,, "Towards a Catalog of Biologically-inspired Primitives", <i>Workshop on Engineering Self-organising Applications</i> , at the Intl. Joint Conf. on Autonomous Agents and Multiagents Systems Conference (AAMAS), 2003, LNAI 2977.

Radhika Nagpal, "Towards a Programming Methodology for Robust Collective Behavior", *Workshop on Collectives and the Design of Complex Systems*, Moffett Field (CA), August 2002.

Lauren Clement, Radhika Nagpal, "Self-Assembly and Self-Repairing Topologies", Workshop on Adaptability in Multi-Agent Systems, RoboCup Australian Open, January 2003.

	Ron Weiss, George Homsy, and Radhika Nagpal, "Programming Biological Cells", in Eighth International Conference on Architectural Support for Programming Languages and Operating Systems, Wild & Crazy Ideas Session, October 1998.
	Daniel Coore, Radhika Nagpal, "Implementing Reaction Diffusion on an Amorphous Computer", in <i>Proceedings of the MIT Student Workshop on High Performance Computing in Science and Engineering</i> , MIT/LCS TR-737, 1998.
TECHNICAL REPORTS	Radhika Nagpal, "Programmable Self-Assembly: Constructing Global Shape Using Biologically-Inspired Local Interactions and Origami Mathematics", PhD Thesis, <i>MIT Artificial Intelligence Laboratory Technical Report 2001-008</i> , June 2001.
	Radhika Nagpal, "Organizing a Global Coordinate System from Local Information on an Amorphous Computer", <i>MIT Artificial Intelligence Laboratory Memo 1666</i> , August 1999.
	Daniel Coore, Radhika Nagpal, and Ron Weiss, "Paradigms for Structure in an Amorphous Computer", <i>MIT Artificial Intelligence Laboratory Memo 1614</i> , Nov 1997.
	Radhika Nagpal, "Implementing Single-cycle Store Instructions in Write-through, Write-back and Set-associative Caches", <i>AT&T Technical Memo</i> , 1127-950117-01TM, 1994.
INVITED	(excluding conference and workshop presentations)
IALKS	Plenary talk, First International Meeting on Synthetic Biology, Cambridge, June 2004.
	DARPA and NSF PI meeting, April 2003.
	Job talks: University of Michigan (Ann Arbor), Stanford University, MIT Media Lab, Harvard University, Brandeis University, 2003.
	Colloquim, Mitsubishi Electric Research Laboratory (MERL), Cambridge Research Lab, MA, Sept 2002.
	Computer Science Colloquim, University of Virginia, Charlottesville, VA, 2002.
	"Emergence != Mysterious", Dangerous Ideas Seminar Series, MIT Artificial Intelligence Lab, 2002.
AWARDS	AT&T/Lucent Bell Labs Graduate Research Program for Women Fellowship (GRPW) 1995-2001. Honorable Mention NSF Fellowship, 1994 Invited to membership in Sigma Xi, Eta Kappa Nu and Tau Beta Pi. Quarterfinalist in 6.270 Lego Robot Contest, 1991 National Talent Search Scholarship (India), 1987
OTHER ACTIVITIES	Organising committee: Workshop on Engineering Self-Organising Applications, at the 3rd Intl. Joint Conf. on Autonomous Agent and Multiagent Systems Conference (AAMAS 2004).
	Co-organiser (with Prof. Welsh) of the Radcliffe Institute Workshop on "Programming Myriads: Investigat- ing Programming Abstractions and Language for Sensor Networks", Harvard University, June 2004.
	Program committee: Workshop on Engineering Self-Organising Applications, at the 2nd Intl. Joint Conf. on Autonomous Agent and Multiagent Systems Conference (AAMAS 2003).
	Reviewer: <i>IEEE Network Magazine</i> , special issue on ad-hoc networking:data communications and topology control (2004); <i>Telecommunications Systems Journal</i> , special issue on wireless sensor networks (2003); <i>International Symposium on Computer Architecture</i> (ISCA 2003).
	Participant: "Experimental Biology for Theoreticians", two week course at Harvard Summer School by Bauer Center for Genomics, July 2003.

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