Rahul Mangharam

Department of Electrical and Systems Engineering
University of Pennsylvania, Philadelphia, PA, USA 19104
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ACADEMIC EXPERIENCE

Director, Comcast Media Center at Penn — Dec 2013 – present
University of Pennsylvania, *Philadelphia, PA*
Collaborative Center between SEAS and PennDesign

Assistant Professor (Secondary Appointment) — May 2008 – present
University of Pennsylvania, *Philadelphia, PA*
Department of Computer and Information Science

Director, mLAB, Real-Time and Multimedia Laboratory — May 2008 – present
University of Pennsylvania, *Philadelphia, PA*
Department of Electrical and Systems Engineering

Stephen J. Angello Chair of Electrical & Systems Engineering — April 2008 – present
University of Pennsylvania, *Philadelphia, PA*
Department of Electrical and Systems Engineering

Assistant Professor — March 2008 – present
University of Pennsylvania, *Philadelphia, PA*
Department of Electrical and Systems Engineering

EDUCATION

Ph.D. in Electrical and Computer Engineering — March 2008
Carnegie Mellon University, *Pittsburgh, PA*
Dissertation: "Real-Time Embedded Wireless Networks: Algorithms and Experiences"
Advisor: Prof. Ragunathan (Raj) Rajkumar

M.S. in Electrical and Computer Engineering — August 2002
Carnegie Mellon University, *Pittsburgh, PA*
Thesis: "Size Matters: Size-based Scheduling for MPEG-4 over Wireless Channels"
Advisor: Prof. Ragunathan (Raj) Rajkumar

B.S. in Electrical and Computer Engineering — May 2000
Carnegie Mellon University, *Pittsburgh, PA*

RESEARCH INTERESTS

Real-Time and embedded systems, cyber-physical systems, formal analysis and verification, model-based design, with applications to wireless control networks, energy-efficient buildings, medical devices, & automotive systems.

RESEARCH AWARDS and HONORS

NSF CAREER Award — March 2013
Foundations of Medical Cyber-Physical Systems

Intel Early Faculty Career Honor — November 2012
Selected as one among top 20 academics internationally

National Academy of Engineers, US Frontiers of Engineering Symposium September 2012
Awarded to top 15 engineers under 45 years, nation-wide.

1st Prize in World Embedded Software Competition (Medical Devices), Korea November 2012
Korean Ministry of Knowledge Economy and Electronics and Telecommunications Research Institute (ETRI)

IEEE Best Student Paper Award, IEEE RTAS at CPS Week, Beijing. China (as advisor) April 2012

1st Prize in Honeywell User Group OneWireless Competition June 2011
Awarded for innovation in next-generation of wireless control for industrial automation

1st Prize in World Embedded Software Competition, Korea November 2010
Korean Ministry of Knowledge Economy and Electronics and Telecommunications Research Institute (ETRI)

Stephen J. Angello Term Chair in Electrical & Systems Engineering Fall 2008
University of Pennsylvania

Best Paper Award Summer 2006
IEEE Conference on Sensor, Mesh and Ah hoc Communications and Networks (SECON)

Sixth Annual Lockheed Martin ECE Project Award Spring 2006
ECE Department, Carnegie Mellon University

Sigma Xi Award Spring 2006
ECE Department, Carnegie Mellon University

Eta Kappa Nu Research Award Spring 2002
Meeting of the Minds University Research Award, Carnegie Mellon University

RESEARCH AWARDS and HONORS (with Students)

1. **ACM BuildSys Best Demonstration Award**, ACM Building Systems Symposium, Toronto. 2012.
2. **ACM Best Paper Presentation Award,** ACM IPSN Conference, Cyber-Physical Systems Week, Beijing. 2012
3. **9th World Embedded Systems Programming Contest,** Seoul, Korea – 3rd Prize for ProtoDrive Electric Vehicle Platform (William Price, Harsh Jain, Yash Pant). Nov 2012.
4. **1st Prize Winner of SEAS Senior Design Project** – Pacemaker Verification System (Varun Sampath, Shilpa Sarode and Sriram Radhakrishnan). May 2012.
5. **Intel Innovators $50K Award -** - Haptic belt for the blind (Eric Berdinis and Jeff Kiske, CE). 2012.
6. **IEEE President's Award**, Finalist - Pacemaker Verification System (Varun Sampath, Shilpa Sarode and Sriram Radhakrishnan). 2012.
7. **Honorable Harold Berger Award** for Best ESE Senior Design Project – Pacemaker Verification System (Varun Sampath, Shilpa Sarode and Sriram Radhakrishnan). 2012
8. **Intel/Cornell Embedded Systems Cup – People's Choice Award**. Haptic Belt for the Blind (Eric Berdinis and Jeff Kiske, CE). May 2012.
9. **Intel/Cornell Embedded Systems Cup – Project Award.** HAWK: Helicopter Aircraft Wielding Kinect (Kevin Conley, Matthew Hale, Paul Gurniak and Theodore Zhang, ESE). May 2012.
10. **Honorable Mention Award** for Senior Design Project – HAWK: Helicopter Aircraft Wielding Kinect (Kevin Conley, Matthew Hale, Paul Gurniak and Theodore Zhang, ESE). May 2012.
11. **Best Paper Award Nominee,** 18th International Conference on Tools and Algorithms for the Construction and Analysis of Systems (TACAS), 2012.
12. **Health 2.0 conference Winners** – viSparsh: Haptic belt for the blind (Jatin Sharma, Tushar Chugh, Rolly Seth, Young India Fellowship Program), 2012.
13. **Frederick Ketterer Memorial Award for Best Senior Design Project** – RAVEN: Remote Aerial Vehicle for Search and Rescue (Paul Martin and William Etter Jr., ESE). 2011.

14. **Winner of 1st Prize Senior Design Award**, CIS Department – AutoPlug: Automotive Architectures for Remote Vehicle Controls Testing (Gabriel Torres, Ross Boczar and Jason Suapengco, CIS). 2011.
15. **Google Zeitgeist Young Minds Award** - Haptic Belt for the Blind (Eric Berdinis and Jeff Kiske, CE). 2011.
16. **Accenture Innovation Jockeys** (Powered by Yahoo!) **Grand Finale Winner** – viSparsh – Haptic belt for the blind (Jatin Sharma, Tushar Chugh, Rolly Seth, Young India Fellowship Program), 2012.
17. **8th World Embedded Programming Competition**, **Grand Prize Winner** – AutoPlug: Plug-n-Play Architectures for Automotive Systems (Kevin Conley, ESE). 2010.
18. **Provost's Distinguished International Research Award**, University of Pennsylvania. 2010.
19. **Wharton Interactive Media Initiative Award**, University of Pennsylvania. 2009.
20. **University Research Foundation Award**, University of Pennsylvania. 2009.
21. **Honorable Harold Berger Award for Best ESE Senior Design Project** – Vehicle-to-Vehicle Communications Networks (Brandon Duick, Danny Lustig and Andrew Avrin, ESE). 2009.

PUBLICATIONS (JOURNALS)

(My students are underlined)

1. M. Pajic, Z. Jiang, I. Lee, O. Sokolsky and **R. Mangharam**. "Safety-critical Medical Device Development using the UPP2SF Model Translation Tool" *ACM Transactions of Embedded Computing Systems* (TECS). Special issue containing the best papers from RTAS 2012. Accepted, to be published in 2014.
2. **R. Mangharam** and M. Pajic. "Distributed Control for Cyber-Physical Systems" *Journal of the Indian Institute of Science, Special Issue on Cyber-Physical Systems,* Vol.93, No.3. September 2013.
3. Z. Jiang, M. Pajic, S. Moarref, R. Alur, and **R. Mangharam**, "Closed-loop Verification of Medical Devices with Model Abstraction and Refinement". *International Journal of Software Tools for Technology Transfer (STTT), Special Issue containing the Best Papers from TACAS 2012*. September 2013.
4. M. Pajic, **R. Mangharam**, G. J. Pappas, and S. Sundaram, "Topological Conditions for In-Network Stabilization of Dynamical Systems," *IEEE Journal on Selected Areas in Communications,* Volume:31, Issue:4. April 2013.
5. M. Pajic, A. Chernoguzov and **R. Mangharam**. "Robust Architectures for Embedded Wireless Network Control and Actuation" *ACM Transactions of Embedded Computing Systems* (TECS). Vol.11 Issue 4, Dec 2012.
6. M. Pajic, **R. Mangharam**, O. Sokolsky, D. Arney, J. M. Goldman and I. Lee "Model-Driven Safety Analysis of Closed-Loop Medical Systems", *IEEE Transactions of Industrial Informatics* (TII), *Special Section on Cyber-Physical Systems.* Vol.PP, Issue:99 October 2012.
7. Z. Jiang, M. Pajic, and **R. Mangharam**, "Cyber-Physical Modeling of Implantable Cardiac Medical Devices". *Proceedings of the* IEEE 100(1): 122-137. January 2012.
8. M. Pajic, S. Sundaram, G. J. Pappas and **R. Mangharam**. "The Wireless Control Network: A New Approach for Control over Networks" *IEEE Transactions in Automatic Control* (TAC), Vol.56, Issue:10. October 2011.
9. M. Pajic and **R. Mangharam**, "Spatio-Temporal Techniques for Anti-Jamming in Embedded Wireless Networks" *EURASIP Journal on Wireless Communications and Networking*, March 2010.
10. **R. Mangharam**, A. Rowe and R. Rajkumar, "FireFly: A Cross-Layer Platform for Wireless Sensor Networks", *Real Time Systems Journal, Sp. Issue on Real-Time Wireless Sensor Networks* (RTSJ). 2006.
11. A. Rowe, **R. Mangharam** and R. Rajkumar, ""Global Time-Synchronized Link Protocols for Energy Constrained Multi-hop Wireless Networks" *Elsevier Ad hoc Networks, Special Issue on Energy-efficient Design in Wireless Ad hoc and Sensor Networks*. 2007.
12. S. Pollin, **R. Mangharam**, B. Bougard, R. Rajkumar, F. Catthoor, L. Van der Perre, I. Moerman "MEERA: Cross-Layer Methodology for Energy-Efficient Resource Allocation for Wireless Networks", *IEEE Transactions in Wireless Communication.* Jan 2008.

13. S. Pollin, B. Bougard, **R. Mangharam**, F. Catthoor, R. Rajkumar, I. Moerman, L. Van der Perre "Optimizing transmission and shutdown for energy-efficient real-time packet scheduling in clustered ad hoc networks" *EURASIP Journal on Wireless Communications and Networking, Special Issue on Cross-layer Design for Ad Hoc Networks*, vol. 2005, no. 5, pp. 698-711, 2005.

PUBLICATIONS (JOURNALS, SUBMITTED)

14. T. Nghiem, M. Behl and **R. Mangharam**. "Green Scheduling of Control Systems". *IEEE Transactions on Automatic Control, Special Issue on Control of Cyber-Physical Systems*, (under review) Jan 2013.

PUBLICATIONS (CONFERENCES, SUBMITTED)

15. Y. Pant, T. Nghiem and **R. Mangharam**. "Peak Power Reduction in Hybrid Energy Systems with Limited Load Forecasts". *American Control Conference (ACC).* June 2014
16. M. Behl, T. Nghiem and **R. Mangharam**. "Model-IQ: Uncertainty Propagation from Sensing to Modeling and Control in Buildings". *ACM/IEEE International Conference on Cyber-Physical Systems* (ICCPS). April 2014.

PUBLICATIONS (CONFERENCES)

17. T. Nghiem, G. J. Pappas and **R. Mangharam**. "Event-based Green Scheduling of Radiant Systems in Buildings." *American Control Conference (ACC).* June 2013.
18. F. Miao, M. Pajic, **R. Mangharam** and G. J. Pappas. "Networked Realization of Discrete-Time Controllers." *American Control Conference (ACC).* June 2013.
19. Z. Jiang, S. Radhakrishnan, V. Sampath, S. Sarode, and **R. Mangharam**. "Heart-on-a-Chip: A Closed-loop Testing Platform for Implantable Pacemakers" Third Workshop on *Design, Modeling and Evaluation of Cyber Physical Systems (CyPhy'13) at CPSWeek*. Philadelphia, April 2013.
20. M. Pajic, O. Sokolsky, R. Alur, **R. Mangharam**, N. Michael, G. J. Pappas, P. Tabuada, S. Weirich and I. Lee, "SPARCS: Synthesis of Platform-aware Attack-Resilient Control Systems", *ACM International Conference on High Confidence Networked Systems (HiCoNS)*, 2013.
21. T. Nghiem, M. Behl, G. J. Pappas and **R. Mangharam**. "Green Scheduling for Radiant Systems in Buildings" *51st IEEE Conference on Decision and Control (CDC).* Maui, Hawaii, Dec 2012.
22. T. Nghiem, M. Behl and **R. Mangharam**. "Green Scheduling for Energy-Efficient Operation of Multiple Chiller Plants" *33rd IEEE Real-Time Systems Symposium (RTSS).* Puerto Rico, Dec 2012.
23. W. H. Bernal, M. Behl, T. Nghiem and **R. Mangharam**. "MLE+: A Tool for Integrated Design and Deployment of Energy Efficient Building Controls" *4th ACM BuildSys Workshop On Embedded Sensing Systems For Energy-Efficiency In Buildings.* Toronto, Canada, Nov 2012. **Best Demonstration Award.**
24. **R. Mangharam**. "The Car and The Cloud: Automotive Architectures for 2020" The Bridge on Frontiers of Engineering, National Academy of Engineering. Winter 2012, Vol 42. Number 4.
25. M. Pajic, S. Sundaram, J. L. Ny, G. J. Pappas and **R. Mangharam**. "Closing the Loop: A Simple Distributed Method for Control over Wireless Networks." *ACM International Conference on Information Processing in Sensor Networks* (IPSN). April 2012. (Acceptance rate 11/99). **Best Presentation Award.**
26. M. Pajic, Z. Jiang, I. Lee, O. Sokolsky, and **R. Mangharam**. "From Verification to Implementation: A Model Translation Tool and a Pacemaker Case Study". *18th IEEE Real-Time and Embedded Technology and Applications Symposium* (IEEE RTAS). April 2012. **Best Student Paper Award.**
27. Z. Jiang, M. Pajic, S. Moarref, R. Alur, and **R. Mangharam**, "Modeling and Verification of a Dual Chamber Implantable Pacemaker". *18th International Conference on Tools and Algorithms for the Construction and Analysis of Systems (TACAS)*. March 2012. **Best Paper Award Nominee.**

28. T. Nghiem, M. Behl, **R. Mangharam** and G. J. Pappas. "Scalable Scheduling of Building Control Systems for Peak Demand Reduction". *American Control Conference (ACC).* June 2012.

29. M. Pajic, S. Sundaram, G. J. Pappas and **R. Mangharam**, "Topological Conditions for Wireless Control Networks". *50th IEEE Conference on Decision and Control, (CDC).* Dec 2011.

30. M. Pajic, S. Sundaram, G. J. Pappas and **R. Mangharam**, "Network Synthesis for Dynamical System Stabilization." *The 45th Annual IEEE Asilomar Conference on Signals, Systems, and Computers*, 2011.

31. T. Nghiem, M. Behl, **R. Mangharam** and G. J. Pappas. "Green Scheduling of Control Systems for Peak Demand Reduction". *50th IEEE Conference on Decision and Control, (CDC).* Dec 2011.

32. **R. Mangharam** and A. A. Saba, "Anytime Algorithms for GPU Architectures", *IEEE Real-Time Systems Symposium* (IEEE RTSS), Vienna, Austria. Nov 2011.

33. Z. Li, P. C. Huang, A. Mok, T. Nghiem, M. Behl, G. J. Pappas and **R. Mangharam**. "On the Feasibility of Linear Discrete-Time Systems of the Green Scheduling Problem", *IEEE Real-Time Systems Symposium* (IEEE RTSS), Vienna, Austria. Nov 2011.

34. Z. Jiang and **R. Mangharam**, "Modeling Cardiac Pacemaker Malfunctions with the Virtual Heart Model", *33rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society (IEEE EMBC '11)*, 2011.

35. T. Nghiem, M. Behl, G. J. Pappas and **R. Mangharam**. "Green Scheduling: Scheduling of Control Systems for Peak Power Reduction". *2nd International Green Computing Conference*, July 2011.

36. Z. Jiang, M. Pajic, and **R. Mangharam**, "Model-based Closed-loop Testing of Implantable Pacemakers". *ACM/IEEE International Conference on Cyber-Physical Systems* (ICCPS). April 2011.

37. M. Pajic, S. Sundaram, G. J. Pappas and **R. Mangharam**, "A Simple Distributed Method for Control over Wireless Networks". *CPS Week Workshop on Real-Time Wireless for Industrial Applications, Real-WIN.* April 2011.

38. W. Etter, P. Martin, and **R. Mangharam**, "Cooperative Flight Guidance of Autonomous Unmanned Aerial Vehicles". *CPS Week Workshop on Networks of Cooperating Objects (CONET)*. April 2011.

39. U. Drolia, Z. Wang, Y. Pant and **R. Mangharam**. "AutoPlug: An Automotive Test-bed for Electronic Controller Unit Testing and Verification". *Intelligent Transportation Systems* (ITS). October 2011.

40. M. Pajic, S. Sundaram, J. Le Ny, G. J. Pappas and **R. Mangharam**, "The Wireless Control Network: Synthesis and Robustness." The *49th IEEE Conference on Decision and Control* (CDC), December 2010.

41. S. Sundaram, M. Pajic, C. N. Hadjicostis, **R. Mangharam** and G. J. Pappas, "The Wireless Control Network: Monitoring for Malicious Behavior." The *49th IEEE Conference on Decision and Control* (CDC), December 2010.

42. A. A. Saba and **R. Mangharam**, "Anytime Algorithms for GPU Architectures", *Analytic Virtual Integration of Cyber-Physical Systems Workshop*. Co-located with RTSS. December 2010.

43. Z. Jiang, A. T. Connolly and **R. Mangharam**. "Using the Virtual Heart Model to Validate the Mode-Switch Pacemaker Operation". *32nd Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*. August 2010.

44. Voyles, R.M., Povilus, S., **Mangharam, R**. and Kang Li; "RecoNode: A reconfigurable node for heterogeneous multi-robot search and rescue," *Safety Security and Rescue Robotics (SSRR), IEEE International Workshop on* , vol., no., pp.1-7, 26-30. July 2010

45. Z. Jiang, M. Pajic, A. T. Connolly, S. Dixit and **R. Mangharam**. "Real-time Heart Model for Implantable Cardiac Device Validation and Verification". *22nd Euromicro Conference on Real-Time Systems,* (IEEE ECRTS). July 2010.

46. D. Arney, M. Pajic, J. M. Goldman, I. Lee, **R. Mangharam** and O. Sokolsky. "Toward Patient Safety in Closed-Loop Medical Device Systems". *ACM/IEEE International Conference on Cyber-Physical Systems* (ICCPS). April 2010.

47. M. Pajic and **R. Mangharam**. "Embedded Virtual Machines for Robust Wireless Control and Actuation". *16th IEEE Real-Time and Embedded Technology and Applications Symposium* (IEEE RTAS). April 2010.

48. M. Pajic and **R. Mangharam**. "Anti-Jamming for Embedded Wireless Networks". *ACM International Conference on Information Processing in Sensor Networks* (IPSN'09). April 2009.

49. M. Pajic and **R. Mangharam**. "WisperNet: Anti-Jamming for Wireless Sensor Networks", *2nd Workshop on Embedded Systems Security (WESS), at Embedded Systems Week.* Atlanta, GA. October 2008.
50. **R. Mangharam**, R. Rajkumar, M. Hamilton, P. Mudalige and F. Bai, "Bounded-Latency Alerts in Vehicular Networks", *Mobile Networking for Vehicular Environments, IEEE INFOCOM*, 2007.
51. **R. Mangharam**, A. Rowe and R. Rajkumar, "Voice over Sensor Networks" *27th IEEE Real-Time Systems Symposium (IEEE RTSS).* Sao Paulo, Brazil. Dec 2006.
52. A. Rowe, **R. Mangharam** and R. Rajkumar, "RT-Link: A Time-Synchronized Link Protocol for Energy Constrained Multi-hop Wireless Networks" *IEEE International Conference on Sensors, Mesh and Ad Hoc Communications and Networks (IEEE SECON).* Reston, VA. Sept 2006. **Best Paper Award.**
53. **R. Mangharam** and R. Rajkumar, "MAX: A Maximal Transmission Concurrency MAC for Wireless Networks with Regular Structure" *IEEE Third International Conference on Broadband Communications, Networks and Systems (IEEE BROADNETS)*, San Jose, CA. Oct 2006.
54. **R. Mangharam**, D. S. Weller, R. Rajkumar, P. Mudalige and F. Bai, "GrooveNet: A Hybrid Simulator for Vehicle-to-Vehicle Networks", *Second International Workshop on Vehicle-to-Vehicle Communications (IEEE V2VCOM)*, San Jose, CA. July 2006.
55. **R. Mangharam**, D. S. Weller, D. D. Stancil, R. Rajkumar, "GrooveSim: A Topography-Accurate Simulator for Geographic Routing in Vehicular Networks" *ACM Mobicom/VANET,* Cologne, Germany. Sept. 2005.
56. **R. Mangharam**, J. Meyers, R. Rajkumar, D. Stancil, J. Parikh, H. Krishnan, and C. Kellum, "A Multi-hop Mobile Networking Test-bed for Telematics" *Society for Automotive Eng. World Congress*, Detroit, MI. August 2005.
57. **R. Mangharam**, S. Pollin, B. Bougard, R. Rajkumar, F. Catthoor, L. Van der Perre, "Optimal fixed and scalable energy management for wireless networks" *IEEE INFOCOM*, March 2005.
58. S. Pollin, B. Bougard, R**. Mangharam**, L. Van der Perre, F. Catthoor, R. Rajkumar, I. Moerman "Optimizing transmission and shutdown for energy-efficient packet scheduling in sensor networks" *European Workshop on Wireless Sensor Networks (EWSN)*. January 2005.
59. **R. Mangharam**, M. Demirhan, R. Rajkumar, and D. Raychaudhuri, "Size matters: Size-based scheduling for MPEG-4 over wireless channels" *SPIE & ACM Proceedings in Multimedia Computing and Networking (ACM MMCN)*. Vol. 3020 pp. 110-122. San Jose, CA, January 2004.

PUBLICATIONS (BOOK CHAPTERS)

60. A. Rowe, **R. Mangharam** and R. Rajkumar, "FireFly: A Time Synchronized Real-Time Sensor Networking Platform." *Wireless Ad Hoc Networking: Personal-Area, Local Area, and Sensor Networks, CRC Press. 2007.*

PUBLICATIONS (OTHER)

61. **R. Mangharam**. "Distributed Control-as-a-Service with Wireless Swarm Systems" *International Workshop on Swarm at the Edge of the Cloud, ESWeek*, Montreal, Canada, October 2013.
62. **R. Mangharam**. "Profiling Anytime Algorithms for Real-Time Computing" *Workshop on Benchmarking of Embedded Systems, ESWeek, Montreal*, Canada, October 2013.
63. Y. Pant, T. Nghiem and **R. Mangharam.** "Knock NOx: Model-based offline diagnostics of a Diesel Exhaust Control System" *IEEE Real-Time and Embedded Technology and Applications Symposium Work-in-Progress* (IEEE RTAS). April 2013.
64. S. Diaz, H. Jain, Y. Pant, W. Price and **R. Mangharam**. "ProtoDrive: An Experimental Platform for Electric Vehicle Energy Scheduling and Control" *33rd IEEE Real-Time Systems Symposium (RTSS@Work).* Puerto Rico, Dec 2012.
65. W. H. Bernal, M. Behl, T. Nghiem and **R. Mangharam**. "MLE+: A Tool for Integrated Design and Deployment of Energy Efficient Building Controls" *33rd IEEE Real-Time Systems Symposium (RTSS@Work).* Dec 2012.

66. V. Sampath, S. Sarode, S. Radhakrishnan, Z. Jiang, M. Pajic and **R. Mangharam**. "Pacemaker Verification System". Demo and Poster at *IEEE/ACM CPSWeek*. April 2012.
67. M. Pajic and **R. Mangharam**. "Architecture for a Fully Distributed Wireless Control Network". Demo, and Poster at *IEEE/ACM CPSWeek*. April 2011.
68. Z. Jiang, M. Pajic and **R. Mangharam**. "Closed-loop Testing for Implantable Cardiac Pacemakers". Demo and Poster at *IEEE/ACM CPSWeek*. April 2011.
69. M. Behl, M. Aneja, H. Jain and **R. Mangharam**. "EnRoute: An Energy Router for Energy-Efficient Buildings". Demo and Poster at *IEEE/ACM CPSWeek*. April 2011.
70. U. Drolia, Z. Wang, S. Vemuri, M. Behl and **R. Mangharam**. "AutoPlug - An Automotive Test-bed for ECU Testing, Validation and Verification". Demo and Poster at *IEEE/ACM CPSWeek*. April 2011.
71. P. Martin, W. Etter and **R. Mangharam**, "R.A.V.E.N. - Remote Autonomous Vehicle Explorer Network". Demo and Poster at *IEEE/ACM CPSWeek*. April 2011.
72. R. Mangharam, "AutoPlug: An Open Experimental Platform for Automotive ECU Testing, Updates and Verification". *NSF/USCAR Automotive CPS Workshop*, Troy, Michigan. March 2011.
73. W. H. Bernal and **R. Mangharam**, "From Control to Scheduling: an Elastic Execution Model" *IEEE Real-Time Systems Symposium (RTSS), Work-in-Progress*. Dec 2010.
74. M. Behl and **R. Mangharam**, "Pacer Cars: Real-Time Traffic Shockwave Suppression" *IEEE Real-Time Systems Symposium (RTSS), Work-in-Progress*. Dec 2010.
75. Z. Jiang, M. Pajic, A. T. Connolly and **R. Mangharam**. "A Platform for Implantable Medical Device Validation". Demo and Poster at *Wireless Health Conference*. October 2010.
76. M. Pajic and **R. Mangharam**. "Embedded Virtual Machines for Wireless Industrial Automation" *Demo and Poster at IEEE/ACM CPSWeek.* April 2009.
77. M. Pajic and **R. Mangharam**. "Runtime Approaches for Embedded Wireless Control-Actuator Networks" at *IEEE Real-Time Systems Symposium (RTSS), PhD Forum*. Dec 2009.
78. M. Pajic, Z. Jiang, A. T. Connolly and **R. Mangharam**. "A Framework for Validation of Implantable Medical Devices". Demo, Poster and Work-in-Progress paper at *IEEE/ACM CPSWeek*. April 2010.
79. A. A. Saba, S. Mohan and **R. Mangharam**. "Anytime Algorithms for Multicore Architectures" in *22nd Euromicro Conference on Real-Time Systems, Work-in-Progress Session, (IEEE ECRTS).* July 2010.
80. **R. Mangharam** and M. Pajic. "Embedded Virtual Machines for Robust Wireless Control Systems". Proc. of the 29th IEEE International Conference on Distributed Computing Systems Workshops. 2009.
81. **R. Mangharam**. "Real-Time Traffic Congestion Prediction". *NSF-NCO/NITRD National Workshop on High Confidence Transportation Cyber-Physical Systems.* Nov 2008.
82. **R. Mangharam**. "Mixed Reality, Now a Reality - Network Virtualization for Real-Time Automotive-CPS Networks". *NSF-NCO/NITRD National Workshop on High Confidence Automotive Cyber-Physical Systems*. April 2008.
83. **R. Mangharam** and M. Demirhan, "Performance and simulation analysis of 802.15.3 QoS" *IEEE 802.15.3 Standards Meeting*, Vancouver, Canada. Feb 2002.

HARDWARE and SOFTWARE ARTIFACTS

1. *MLE+:* A Tool for Integrated Design and Deployment of Energy Efficient Building Controls at http://mlab.seas.upenn.edu/mlep/ (2012-Present)
2. *ProtoDrive*: An Experimental Platform for Electric Vehicle Energy Scheduling and Control. http://mlab.seas.upenn.edu/protodrive/ (2012-Present)
3. *En-Route Energy Router:* Energy-Efficient Building Control and Scheduling Test-bed. 2010-Present

4. *Open-ISA100.11a*: Open software stack for standardized industrial wireless control automation. http://mlab.seas.upenn.edu/openisa/ (2011-Present)
5. *Pacemaker Verification System:* Platform for closed-loop testing and verification of medical devices. http://pvs.medcps.org/ (2012-Present.)
6. *HAWK:* Platform for Helicopter Aircraft Wielding Kinect for search and rescue in buildings (2012.)
7. *Haptic Belt for Blind:* Platform for indoor and outdoor guidance for blind persons (2011-Present.)
8. *AutoPlug*: Open Automotive Architecture for Plug-n-Play Services. Open-source software at http://www.autoplug.org/ (2011)
9. *AirHacks:* Open Unmanned Aerial Vehicle Platform (Quadrotor) at http://airhacks.org/ (2011)
10. *Penn Virtual Heart Model* and Closed-loop Implantable Device Models for medical device software validation and verification. Open-source Matlab/Simulink models (2011-Present)
11. *AutoMatrix:* Large-scale Traffic Congestion Simulator for estimating and predicting congestion with over 16 million vehicles (2011-Present.)
12. *GrooveNet 2.0:* Hybrid Network Simulator for Vehicle-to-Vehicle Networking. Both real and simulated vehicles can communicate. Over 65 research institutions have downloaded GrooveNet. http://mlab.seas.upenn.edu/groovenet/ (2011-Present)
13. *RT-Link* TDMA protocol for IEEE 802.15.4 sensor networks. Co-developed with Anthony Rowe. Graduate course taught using RT-Link on the FireFly sensor network platform. http://nano-rk.org/ (2006-Present.)
14. *IEEE 802.15 Link-layer Scheduling Framework* for ns-2 network simulator. Co-developed with Mustafa Demirhan. Over 40 research institutions have downloaded the software (2003-2006)

RESEARCH GROUP

Ph.D. Students

1. Paul Gurniak (Ph.D. Candidate, ESE) – Anytime Algorithms for Multi-core Architectures
2. Madhur Behl (Ph.D. Candidate, ESE) – Scheduling and Control for Energy-Efficient Buildings
3. Willy G. Bernal (Ph.D. Candidate, ESE) – Modeling and Tools for Energy-efficient Building Demand Response
4. Yash V. Pant (Ph.D. Candidate, ESE) – Anytime Control for Cyber-Physical Systems
5. Zhihao Jiang (Ph.D. Candidate, CIS) – High-Confidence Medical Device Software & Systems

Post-Doctoral Candidates

6. Truong X. Nghiem (Post-doc, ESE) – Green Scheduling of Control Systems

Graduated Ph.D. Students

1. Miroslav Pajic (ESE) – Network Controlled Cyber-Physical Systems. Sept. 2012.
2. Truong X. Nghiem (ESE) – Green Scheduling for Energy Systems (co-advised with George Pappas). Sept. 2012.

MS and Undergraduate students active in the lab:

1. Harsh Jain, MS, ESE. Wireless Control for Industrial Automation and ProtoDrive: Electric Vehicle Test-bed. Winner of Honeywell Wireless Control Automation Award, 2011. 3rd Prize in World Embedded Programming Competition, Korea. 2012. Distinguished Recognition Award in Intel/Cornell Embedded Systems Cup 2013.
2. William Price, Senior, EE & MEAM, ProtoDrive: Electric Vehicle Test-bed. 3rd Prize in World Embedded Programming Competition, Korea. 2012.
3. Tao Lei, MS, ESE. Traffic Signal Scheduling in Philadelphia. Also developed Cloud Services for MLE+ for energy-efficient building modeling and control. 2012-13.
4. Neel Shah, MS, Embedded Systems. En-Route 2.0 Energy Router Test-bed for Energy Efficient Buildings. 2012-13.

5. Praveen Pitchai, MS, Robotics. Vision Integrated Operating System for Comcast Cable Set-top box of the future. Computer vision and machine learning. 2012-13
6. Rajeev Kumar, MS, Robotics. Vision Integrated Operating System for Comcast Cable Set-top box of the future. Cloud-based interactive processing. 2012-13
7. Abhijeet Mulay, MS, Embedded Systems. ProtoDrive: Electric Vehicle Test-bed. Finalist for Intel/Cornell Cup for Embedded Systems. Developed ZipCare: a wearable wireless EKG heart-monitoring patch. 2012-13.
8. Shadhidhar Reddy, MS, EE. Vision Integrated Operating System for Comcast Cable Set-top box of the future. Platform architecture and immersive experience. 2012-13
9. Rajib Dutta, MS, Embedded Systems. ZipCare Wearable Heart and Activity Monitor. 2012-13.
10. Tanvir Ahmed, Junior, Computer Engineering. Vision Integrated Operating System for Comcast Cable Set-top box of the future. User interface and interaction. 2013.
11. Alfredo Muniz, Sophomore, Computer Engineering. ProtoDrive: Electric Vehicle Test-bed. 2013.
12. Parth Patel, Freshman, Electrical Engineering. ProtoDrive: Electric Vehicle Test-bed. 2013.

Undergraduate and Masters Thesis:

1. Azriel Samson, MS, Embedded Systems. Open-source ISA100.11a network stack for industrial automation. 2012-13.
2. Vignesh Anantha Subramanian, MS, Embedded Systems. Open-source ISA100.11a network stack for industrial automation. 2012-13.
3. Eric Berdinis, Senior, CE. Winner of Google Zeitgeist Award, Intel Innovators Award, Intel/Cornell Embedded Systems Cup – People's Choice Award.
4. Jeff Kiske, Senior, CE. Winner of Intel Innovators Award, Intel/Cornell Embedded Systems Cup – People's Choice Award.
5. Chen Zheng, MS EE. Electricity Controller Cloud Architecture. 2011-12.
6. Haofang Yuan, MS EE. SolarSkin for Energy Efficient Buildings. 2011-12.
7. Chenyan Sun, MS EE. Design and development of the ISA 100.11a Wireless Standard for Industrial Automation. 2011-12.
8. Varun Sampath, Senior, CE. Winner of SEAS 2012 Senior Design Competition. Winner of Honorable Harold Berger Senior Design Project Award, 2012. Finalist, World Embedded Competition, Korea.
9. Sriram Radhakrishnan, Senior, ESE. Winner of SEAS 2012 Senior Design Competition. Winner of Honorable Harold Berger Senior Design Project Award, 2012. Finalist, World Embedded Competition, Korea, 2012.
10. Shilpa Sarode, Senior, ESE. Winner of SEAS 2012 Senior Design Competition. Winner of Honorable Harold Berger Senior Design Project Award, 2012. Finalist, World Embedded Competition, Korea, 2012.
11. William Etter, Senior, ESE. Awarded Vagelos Undergraduate Research Grant. Winner of Frederick Ketterer Memorial Award for Best Senior Design Project 2011.
12. Theodore Zhang, Senior, ESE. Intel/Cornell Embedded Systems Cup Winner 2012. Honorable Mention Award, SEAS Senior Design Competition 2012.
13. Kevin Conley, Senior, ESE. Awarded Rachleff Scholar Scholarship. Awarded 1st Prize in World Embedded Software Competition, Korea, November 2010.
14. Teddy Zhang, Matthew Hale and Paul Gurniak, Senior Design Team.
15. Paul Martin, Senior, ESE. Awarded Vagelos Undergraduate Research Grant. Winner of Frederick Ketterer Memorial Award for Best Senior Design Project 2011.
16. Gabe Torres, Senior, CIS. Winner of 1st Prize Senior Design Award, CIS Department 2011.
17. Ross Boczar, Senior, ESE. Winner of 1st Prize Senior Design Award, CIS Department 2011.

18. Jason Suapengc, CIS. Winner of 1st Prize Senior Design Award, CIS Department 2011.
19. Anu Sukumaran, MS, ESE. First job at Lutron Electronics.
20. Utsav Drolia, MS, ESE. Now Ph.D. student at Carnegie Mellon University.
21. Danny Lustig, Winner of Harold Berger Senior Design Project Award, 2009. Ph.D. at Princeton University.
22. Andrew Avrin, Winner of Harold Berger Senior Design Project Award, 2009. Now at Google.
23. Steven Z. Wang, MS, ESE. First job at Motorola, Michigan
24. Srinivas Vemuri, MS, ESE. First job at GE Healthcare, Milwaukee
25. Mansimar Aneja, MS, Robotics. First job at BOSCH Research (Pittsburgh)
26. Brandon Duick (Boeing), Winner of Harold Berger Senior Design Project Award, 2009. Now at Lockheed Martin.
27. Jason DeLisser, 2010. Now at L3 Communications.
28. Avinash Rajput, 2009. First job at MERK, Automation Division.
29. Sunil Sadasivan (Cisco), 2010. CTO of Buffer.com
30. RoopKumar Kalimuthu (Penn), 2009
31. Malolan Shantanakrishnan (MathWorks), MS research on "*Dual Radio Platform for Sensor Networks*". 2006.
32. Mark Hamilton (CMU), BS Honors research on "*Safety Protocols in Vehicular Networks*" in Fall 2006.
33. Dan Weller, BS Honors Thesis on "*Vehicle Network Simulation*" in Spring 2006. Completed Ph.D. at MIT. Winner of Carnegie Institute of Technology Honors Research Competition.
34. Ryohei Suzuki (Tokyo University), Visiting Scholar with focus on "*Topology Discovery and Scheduling for TDMA Sensor Networks*" in Fall 2005.
35. Jalaja Kurubarahalli (Cisco), Masters Thesis on "*GeoRoute: An In-vehicle System for Geographic Routing in Vehicular Networks*" in Spring 2005.
36. Chih-Yuan Liao (Qualcomm), Masters Thesis on "*Network Tiles for Concurrent Transmission in Wireless Mesh Networks*" in Spring 2003.
37. Yoshisato Takeda (Mitsubishi Electric), Masters Thesis on "*PAQ-MAC: Power-Aware MAC Protocol for Wireless Networks with a 2-Packet Buffer*" in Spring 2002.

Undergraduate REU Students:

1. **George Chen**, Johns Hopkins University, Biomedical Engineering. 2013
   - *Won Best Summer Research Award in SEAS*.
   - Selected for CRA Engineering Education Awardees Conference, Oct 2013.
2. **Stephanie Diaz**, SUNY Binghamton, Electrical Engineering. 2012
   - Developed ProtoDrive: Electric Vehicle Platform.
   - *Published research* in *33rd IEEE Real-Time Systems Symposium, RTSS@Work, Puerto Rico, 2012.*
3. **Kevin Conley**, Penn, Electrical & Systems Engineering. 2012
   - Awarded Rachleff Scholar Scholarship.
   - *Won Best Summer Research Award in SEAS.*
   - Won 1st Prize in World Embedded Competition, Seoul, Korea in 2010 for the AutoPlug project.
   - Now pursuing Ph.D. in Stanford.
4. **Peter Malamas**, Johns Hopkins University, Biomedical Engineering. 2011
   - Developed 3D Electrophysiological Heart Model for Real-time Interaction with Pacemakers.
5. **Uchenna Kevin Anyanwu**, California State University at San Jose, Electrical Engineering. 2009.
   - Developed GrooveNet 3.0 Vehicular Network Simulator.
   - Now pursuing a Ph.D. at Virginia Tech.

6. **Allison Connolly**, Johns Hopkins University, Biomedical Engineering. 2009-10
   - Developed the Real-Time Heart Model.
   - Pursuing a Ph.D. at U. Minnesota, 2010.
   - Selected for NSF Engineering Education Awardees Conference, Jan 2010.
   - Co-authored three papers in IEEE ECRTS, IEEE EMBC and RTAS

PROFESSIONAL SERVICE

Conference Organization

1. Program Co-Chair, *4th MobileHealth Workshop at ACM MobiSys*, Philadelphia, August 2014
2. Program Co-Chair, *5th Medical Cyber-Physical Systems Workshop at CPSWeek*, Berlin. April 2014
3. Chair, CPS Industry Track, 19th *IEEE Real-Time and Embedded Technology and Applications Symposium* (**RTAS**), Philadelphia, April 2013
4. Program Co-Chair, *4th Medical Cyber-Physical Systems Workshop* at CPSWeek, Philadelphia. April 2013
5. Program Co-Chair, 18th *IEEE Real-Time and Embedded Technology and Applications Symposium (**RTAS**)*, Beijing, China. April 2012
6. Program Co-Chair, *2nd IEEE Analytic Virtual Integration of Cyber-Physical Systems Workshop*, Co-located with RTSS, Dec 2011
7. Program Chair, 3rd *IEEE Joint Workshop on High-Confidence Medical Devices Software and Systems*, Co-located with CPSweek Chicago, IL. April 2011

Conference Activities

Member of Organizing Committee

ACM IPSN (2014), IEEE Medical CPS (2014), AVICPS (2014), IEEE Medical CPS (2013), IEEE RTAS (2013), IEEE HCMDSS (2011), IEEE COMSNETS (2009, 2010), IEEE COMSWARE (2008), IEEE INFOCOM (2010), IEEE INSS (2009)

Member of Program Committee

1. ACM International Conference on High Confidence Networked Systems (HiCoNS), 2014
2. IEEE International Conference on Cyber-Physical Systems (ICCPS), 2014
3. ACM Workshop on Embedded Systems For Energy-Efficiency In Buildings (BuildSys), 2013
4. IEEE Real-Time Systems Symposium (RTSS), 2013
5. IEEE International Conference on Embedded Software (EMSOFT), 2013
6. IEEE International Conference on Cyber-Physical Systems, Networks, and Applications (CPSNA), 2013.
7. IEEE International Conference on Cyber-Physical Systems (ICCPS), 2013
8. ACM 2ND International Conference on High Confidence Networked Systems (HiCoNS), 2013
9. IEEE Real-Time Systems Symposium (RTSS), 2012
10. ACM International Conference on Information Processing in Sensor Networks (IPSN), 2012
11. IEEE Conference on Sensor, Mesh and Ad Hoc Communications and Networks (SECON), 2012.
12. IEEE Real-Time & Embedded Technology and Applications Symposium (RTAS), 2012
13. IEEE Real-Time & Embedded Technology and Applications Symposium (RTAS), 2011
14. IEEE RTSS, Work-in-Progress, 2010
15. IEEE Real-Time Systems Symposium (RTSS), Analytical Virtual Integration of CPS Workshop, 2010
16. IEEE Real-Time & Embedded Technology and Applications Symposium (RTAS), 2010
17. ACM INFOCOM, 2009
18. IEEE Real-Time Systems Symposium (RTSS), 2008

19. IEEE Real-Time & Embedded Technology and Applications Symposium (RTAS), 2008
20. IEEE International Symposium on Wireless Vehicular Communications, 2008
21. IEEE MoVeNet, 2nd International Workshop on Mobile Vehicular Networks, 2008
22. IEEE International Symposium on Vehicular Computing Systems, 2008
23. IEEE Workshop on Mobile Networks for Vehicular Environments, (INFOCOM/MOVE), 2008
24. IEEE Symposium on Selected Areas of Communication of ICC, 2009

Panelist and Session Chair

1. IEEE RTAS, CPSWeek, Philadelphia, PA. April, 2013. Industrial Session Chair.
2. IEEE ICCPS, CPSWeek, Philadelphia, PA. April, 2013. "CPS Applications" Session Chair.
3. Connected Vehicle Test-Bed Development & Integration Workshop, Buffalo, NY. Jun, 2012. Invited Speaker.
4. IEEE Analytic Virtual Integration of Cyber-Physical Systems Workshop, San Diego, CA. Co-located with RTSS, Dec 2010. Panelist.
5. IEEE RTAS, Stockholm, Sweden, April 2010. "Wireless Sensor Networks" Session Chair.
6. IEEE ICDCS, Montreal, Canada, June 2009. "Vehicular Ad hoc Networks" Session Chair.
7. IEEE International Workshop on Cyber-Physical Systems (WCPS), Montreal, Canada, June 2009. Panelist.
8. IEEE RTAS, St. Louis, MO, April 2008. "Quality of Service" Session Chair.
9. IEEE International Workshop on Mobile Vehicular Networks (MoVeNet), Atlanta, GA, September 2008. Panelist.

Conference Reviewer

- IEEE International Conference on Embedded Software (EMSOFT), 2010
- IEEE Intelligent Transportation Systems Magazine, 2010
- IEEE Vehicular Networking Conference, 2009
- IEEE International Conference on Embedded Software (EMSOFT), 2009
- IEEE/IFIP International Conference on Embedded and Ubiquitous Computing, 2009
- IEEE International Conference on Computer Communications and Networks, 2009
- IEEE ICC Symposium on Selected Areas in Communications, 2009
- IEEE Wireless Communication Magazine Special Issue on VANET, 2009
- IEEE INFOCOM, 2009
- IEEE Wireless Access in Vehicular Environments, 2008
- IEEE International Workshop on Mobile Vehicular Networks, 2008
- IEEE Communications Magazine, 2008
- IEEE Globecom, 2008
- IEEE Wireless Vehicular Communications, 2008
- IEEE International Symposium on Vehicular Computing Systems, 2008
- IEEE INFOCOM MOVE, 2008
- ACM SECON, 2008
- IEEE Communications Magazine, Automotive Networking Series, 2007
- IEEE RTAS 2007

Journal Editorial Boards

1. Guest Editor, *IEEE Transactions on Embedded Systems*, Special Issue on Best Papers from IEEE RTAS'13. 2014.
2. Guest Editor, *Journal of Real Time Systems*, Special Issue on Energy and Sustainability, 2014.
3. Guest Editor, *IEEE Transaction on Emerging Topics in Computing*, Sp. Issue on Wireless Health Comp., 2014.
4. Guest Editor, *IEEE Design & Test*, Special Issue on Cyber-Physical Systems for Medical Applications. 2014.

Journal Reviewer

- IEEE Transactions of Control, 2012, 2013
- IEEE Real-Time Systems Journal, 2012, 2013
- IEEE JSAC Special Issue on In-Network Processing, 2012

- ACM Transactions in Embedded Computing Systems (TECS), 2010
- ACM Computing Surveys Journal, 2010
- IEEE Network Special Issue on "Advances in Vehicular Communications Networks", 2009
- Elsevier Ad hoc Networks, 2009
- ACM Transactions on Sensor Networks, 2008
- IEEE Internet Computing, 2008
- ACM Transactions on Computers, 2008
- ACM Transactions on Mobile Computing, 2008
- ACM Transactions on Mobile Computing, 2007
- UBIROADS Workshop, 2007
- IEEE JSAC Special Issue on Vehicular Networks, 2007

Government Activities

1. NSF Panelist, 2009, 2010, 2011, 2012, 2013
2. NSF Workshop on Cloud Computing for Cyber-Physical Systems, Arlington, VA. March 2013. Break-out Session Chair
3. Cyber-physical Systems Panel at NIST Performance Metrics for Intelligent Systems, March 2012. Panelist
4. ARPA-E Energy-efficient Building Technology Workshop, Arlington, VA. December 2009
5. NSF-NCO/NITRD National Workshop on High Confidence Transportation Cyber-Physical Systems, Arlington, VA/. Nov 2008. Break-out Session Chair
6. NSF-NCO/NITRD National Workshop on High Confidence Automotive Cyber-Physical Systems, Detroit, MI. April 2008. Break-out Session Chair.
7. NSF-NCO/NITRD New Research Directions in Composable and Systems Technologies for High Confidence Cyber-Physical Systems, Arlington, VA. July 2007
8. NSF National Workshop on High Confidence Medical Device Software and Safety, Boston, MA. June 2007. Break-out Session Chair.

UNIVERSITY ACTIVITIES

Committees

1. Founding Committee Member, Undergraduate Program in Computer Engineering. 2009 – Present
2. Founding Committee Member, Masters Program in Embedded Systems. 2009 – Present
3. Founding Member, PRECISE Center, Penn Research in Embedded Computing Center. 2009 – Present

Outreach

1. Featured in Engineering Professor Video Project, Engineering Deans' Advisory Board (EDAB), Dec 2013
2. Dean's Student Advisory Council. Lecture on "Getting Involved in Undergraduate Research", Nov 2013
3. Guest lecture on Cyber-Physical Systems in Integrated Product Design course, Nov 2013.
4. Gave "Senior Design. Done Right" talk to seniors in ESE and CIS. September 2013.
5. SUNFEST NSF REU. Lecture on "Adventures in Cyber-Physical Systems", August 2013
6. Organized 3-session workshop for Toyota Engineers as part of the Penn English Language summer program, May 2012 and May-September 2013.
7. Women in Computer Science (WICS) High-school Day, Guide and Lecturer. May 2013.
8. Guest lecture on Cyber-Physical Systems in Integrated Product Design course, Nov 2012.
9. SUNFEST NSF REU. Lecture on "Automotive Embedded Systems", August 2012
10. Guest lecture on Cyber-Physical Systems in Architecture Department, Nov 2013.
11. Young India Fellowship: Mentored students on development of technologies for the blind. Team viSparsh won the Accenture Innovation Jockeys Award (France) for the development of a haptic navigation belt. Jan-Dec 2012.
12. Organized International Workshop on Mobile, Wireless and Pervasive Systems in collaboration with NIIT University, India. Jan 2012

13. Summer Academy in Applied Science and Technology. Master Lecture for High-School Students, July 2010
14. High-School Summer Mentorship Program, Faculty Organizer. July 2010
15. Women in Computer Science (WICS) High-school Day, Guide and Lecturer. May 2010.
16. SUNFEST NSF REU. Lecture on "Medical Cyber-Physical Systems", August 2010
17. High School Guidance Counselors and Teachers Day, Guide and Lecturer. November 2009

Ph.D. Thesis Committee Member

1. Alex Styler, Carnegie Mellon University, Jan 2014
2. David Arney, University of Pennsylvania, May 2012
3. Andrew Hilton, University of Pennsylvania, July 2010

Qualifier (WPE-II) Committee Member

1. Baek Gyu Kim, University of Pennsylvania, WPE-II, Dec 2013
2. Svilen Mihaylov, 2009

Instruction

1. Spring 2014 : ESE 350 Introduction to Embedded Systems
2. Fall 2013 : ESE 519 Real-Time and Embedded Systems
3. Spring 2013 : ESE 350 Introduction to Embedded Systems
4. Fall 2012 : ESE 519 Real-Time and Embedded Systems
5. Spring 2012 : ESE 350 Introduction to Embedded Systems
6. Fall 2011 : ESE 519 Real-Time and Embedded Systems
7. Spring 2011 : ESE 350 Introduction to Embedded Systems
8. Fall 2010 : ESE 519 Real-Time and Embedded Systems
9. Spring 2010 : ESE 350 Introduction to Embedded Systems
10. Spring 2009 : ESE 680 Wireless Embedded Networks
11. Fall 2006 : ECE 18848 Graduate Embedded Systems, Carnegie Mellon University
12. Spring 2001 : ECE 18-220 Fundamentals of Electrical Engineering, TA, Carnegie Mellon University

Teaching Workshops and Tutorials

1. Engineering Faculty Teaching Forum, Invited Speaker. "Active Learning in Lectures". Nov 2012
2. Tutorial at IEEE ICCAD. "Algorithms for Analysis and Optimization of Future Cyber Physical Systems", (with Radu Marculescu). San Jose, CA. Aug 2012
3. Organized International Workshop on Mobile, Wireless and Pervasive Systems in collaboration with NIIT University, India. Jan 2012.
4. Tutorial to Toyota engineers, Penn English Language Program. "Automotive Cyber-Physical Systems", May-August 2013
5. Tutorial to Toyota engineers, Penn English Language Program ."Vehicle to Vehicle Networks". May 2012
6. Sensor Network Workshop, Institute for Information Industry, Taipei, Taiwan. Nov 2005

RESEARCH EXPERIENCE

Visiting Scholar, Athens Information Technology**,** Athens, Greece Summer 2006

Invited to set up a Sensor Network lab with the FireFly platform and help design a course on sensor networks for the resident MS students. An experimental test-bed for tracking, sensing and multi-hop voice streaming was deployed. I conducted a 1-week workshop on network programming, time synchronization, logical topology control and design for predictable lifetime.

International Scholar, Inter-University Microelectronics Center (IMEC), Leuven, Belgium Fall 2003
I worked with Prof. Francky Catthoor on a cross-layer optimization methodology to improve the energy efficiency of next generation wireless transceivers. The scheme determines the lowest energy configuration, at run-time, of the physical layer, communications layer and link layer while delivering high quality video traffic over a fading wireless link. With actual channel measurements, a real power amplifier and turbo decoder, we were able to reduce the energy consumption by 2-5*x,* while streaming real MPEG-4 video for multiple users.

Visiting Researcher, Intel Labs, Hillsboro, OR Fall & Summer 2002
Ultra Wide-Band MAC Protocol: As part of the first design team on UWB, I designed and analyzed a link-layer protocol for multimedia across IEEE 802.15.3. We presented results at IEEE 802 Conference showing a 60% improvement in channel utilization for MPEG-4 streams and non real-time traffic with the addition of just one byte to the draft protocol.

INDUSTRY EXPERIENCE

Hardware Engineer, Apple Computer Inc., Cupertino, CA Summer 2000
As part of the first Gigabit Ethernet rollout, I developed a performance analysis tool to stress test the Ethernet MAC and PHY across a grid of machines. System programming involved PCI bus, MacOS internals, memory management, TCP/IP stack and the Gigabit Interface.

ASIC Engineer, Marconi Communications (FORE Systems), Warrendale, PA Spring & Summer 1999
As part of a 5-chip ASIC design team for a 250Gbps ATM/IP network switch, I worked on an ASIC. My work focused on implementing register control, state machine blocks and CRC.

Software Engineer, National Instruments Corporation, Austin, TX Summer 1997
Developed GPIB device-driver architecture using COM/DCOM middleware

SELECTED INVITED TALKS

1. *Cyber-Physical Systems Problems in Medical and Energy Domains* *Dec 2013*
   Cornell University, ECE Departmental Colloquium
2. *Closing the loop with Cyber-Physical Systems Modeling* *Nov 2013*
   University of California, San Diego. Computer Engineering Colloquium & **Distinguished Speaker Series**
3. *Closing the loop with Cyber-Physical Systems Modeling* *Nov 2013*
   University of Southern California (USC), Electrical Engineering Colloquium
4. *Vision Interactive Operating System* *Nov 2013*
   Penn Design Seminar, University of Pennsylvania
5. *Green Scheduling of Buildings for Peak Power Minimization* *Nov 2013*
   University of California, Berkeley**.** Software Defined Buildings Seminar
6. *Closing the loop with Cyber-Physical Systems Modeling* *Nov 2013*
   University of Illinois, Urbana-Champaign (UIUC), Computer Science Colloquium
7. *Green Scheduling of Buildings for Peak Power Minimization* *Oct 2013*
   Kansas State University. **Distinguished Lecture, Computer Engineering Colloquium**
8. *Closing-the-loop with CPS Modeling: Medical and Energy Systems* *Sep 2013*
   University of California, Los Angeles. Electrical Engineering Seminar
9. *Green Scheduling of Buildings for Peak Power Minimization* *Sep 2013*
   University of California, Merced. Electrical Engineering and Computer Science Seminar
10. *Medical and Energy Cyber-Physical Systems* *Sep 2013*
    Villanova University, Electrical Engineering and Computer Science Seminar

11. *Cyber-Physical Systems 2.0 -- Automotive, Medical, Energy and Industrial Automation* *Feb 2013*
Drexel University, Robotics Seminar Series

12. *Closing the loop with Medical Cyber-Physical Systems* *Oct 2012*
University of Berkeley, Design of Robotics and Embedded systems, Analysis, and Modeling Seminar

13. *The Car and the Cloud* *Sep 2012*
National Academy of Engineers, US Frontiers of Engineering, GM R&D Center, Michigan

14. *Closing-the-loop for Energy-Efficient Buildings* *Oct 2012*
Architecture Department Seminar, University of Pennsylvania

15. *Integrated Functional and Formal Modeling for Safety-Critical Medical Devices* *Jun 2012*
University of Oxford, UK. Formal Methods Seminar

16. *Cyber-Physical Systems 2.0 -- Automotive, Medical, Energy and Industrial Automation* *Jul 2012*
BOSCH Palo Alto Lab, California

17. *Automotive Cyber-Physical Systems – In vehicle, Vehicle-to-vehicle and Traffic Management* *Jul 2012*
Toyota Information Technology Center (ITC), Mountain View, California

18. *Cyber-Physical Systems and the Cloud* *Jul 2012*
CISCO Systems, Sunnyvale, California

19. *Physiological Control Systems for Networks of Medical Devices* *Jul 2012*
Invited Speaker, 5th annual workshop on "Numerical Software Verification" (NSV), co-located with the 24th International Conference on Computer Aided Verification (CAV 2012).

20. *Closing-the-loop with Medical Device Software and Systems* *Jul 2012*
Invited Speaker, Workshop on Formal Methods for Synthetic Biology, co-located with the 24th International Conference on Computer Aided Verification (CAV 2012).

21. *Automotive Cyber-Physical Systems – In vehicle, Vehicle-to-vehicle and Traffic Management* *Jun 2012*
Invited Speaker, Connected Vehicles Workshop (DoT UTRC), Buffalo, NY

22. *Network Cyber-Physical Systems* *May 2012*
Invited Speaker, Texas Instruments and Kilby Labs, Dallas, TX.

23. *Medical Cyber-Physical Systems: Closed-loop Medical Device Verification and Testing* *May 2012*
Invited Speaker, 15th Conference on Software Design for Medical Devices

24. *Closing the Loop with Cyber-Physical Modeling* *Oct 2011*
Vanderbilt University, Institute for Software Integrated Systems Seminar

25. *Medical Cyber-Physical Systems: Closed-loop Medical Device Verification and Testing* *Sep 2011*
FDA / NHLBI / NSF Workshop on Computer Methods for Medical Devices, Panelist

26. *Automotive Cyber-Physical Systems* *Sep 2011*
Wayne State University, Michigan, CS Departmental Seminar

27. *Closing the Loop with Wireless Control Networks* *Jun 2011*
EU-US Workshop on Networked Monitoring and Control, EU Commission, Brussels

28. *Closing the Loop with Cyber-Physical Modeling* *Apr 2011*
University of California, Irvine, ECE Departmental Seminar

29. *Automotive Cyber-Physical Systems* *Apr 2011*
University of Southern California, ECE Departmental Seminar

30. *Green Scheduling of Buildings for Peak Power Minimization* *Apr 2011*
ARPA-Energy Seminar

31. *Medical Cyber-Physical Systems: New Frontiers* *Mar 2011*
University of Illinois, Urbana-Champaign (UIUC)**, Distinguished Lecture**

32. *Closing the loop with Networked Cyber-Physical Systems* — *Dec 2010*
UCLA, Center for Embedded Networked Sensing

33. *Closing the loop with Networked Cyber-Physical Systems* — *Nov 2010*
University of Pennsylvania, CIS Departmental Seminar

34. *Networked Cyber-Physical Systems* — *Nov 2010*
Virginia Tech, Center for Embedded Systems for Critical Applications

35. *Generic Pacemaker Project: Closed-loop Software Testing, Validation and Verification* — *Nov 2010*
US. Food and Drug Administration (FDA), Special Topics Seminar

36. *Closing the loop with Networked Cyber-Physical Systems* — *Nov 2010*
University of Pittsburgh, ECE Departmental Seminar

37. *Closing the loop with Networked Cyber-Physical Systems* — *Oct 2010*
Cornell University, ECE Departmental Seminar

38. *Robust Architectures for Wireless Actuation and Control* — *Oct 2010*
Honeywell Technical Fellows Seminar

39. *Cyber-Physical Systems Research at Penn* — *Oct 2010*
University of Texas, Austin. ECE Colloquium

40. *Medical Cyber-Physical Systems* — *Oct 2010*
Temple University, ECE Departmental Colloquium

41. *Recent Research in Cyber-Physical Systems at mLAB-UPenn* — *Jul 2010*
IMEC, Leuven, Belgium. Special Speaker Seminar.

42. *Recent Research in Cyber-Physical Systems at mLAB-UPenn* — *Jul 2010*
Embedded Systems Institute, Eindhoven, Netherlands

43. *Medical Cyber-physical Systems* — *Aug 2009*
IMEC, Leuven, Belgium

44. *Automotive Cyber-Physical Systems* — *Jun 2009*
University of Waterloo, Ontario, Canada

45. *Distributed Wireless Control Grids* — *May 2009*
Honeywell Technical Symposium, Arizona

46. *Networked Cyber-Physical Systems* — *Mar 2009*
Indian Institute of Technology Bombay (IIT-B), Mumbai

47. *Networked Cyber-Physical Systems* — *Mar 2009*
Indian Institute of Technology Madras (IIT-M), Chennai

48. *Networked Cyber-Physical Systems* — *Mar 2009*
Veermata Jijabai Technological Institute (VJTI), Mumbai

49. *Research Activities at mLAB-UPenn* — *Mar 2009*
Infosys SET Labs, Bangalore

50. *Vehicular Wireless Networks for Safety and Congestion Prediction* — *Jan 2009*
Arada Systems, Bangalore

51. *Networked Automotive Cyber-Physical Systems* — *Dec 2008*
Keynote Speaker, Conference on Wireless Access in Vehicular Environments, U Michigan

52. *Vehicle to Vehicle Wireless Networks* — *Nov 2008*
WINLAB Wireless Seminar Series, Rutgers University. New Jersey

53. *Vehicle to Vehicle Wireless Networks* — *Nov 2008*
University of Delaware, Delaware

54. *FireFly: Real-Time Sensor Networking Platform* *Oct 2006*
Cornell University, New York

55. *Scalable Time Synchronization for Multi-hop Networks* *Sep 2006*
Microsoft Research – Silicon Valley Center

56. *Scalable Time Synchronization for Multi-hop Networks* *Sep 2006*
Intel Labs, Santa Clara

57. *GrooveNet: Hybrid Network Simulation for Vehicular Networks* *Jun 2006*
Imperial College, London

58. *MAX: Maximal Transmission Concurrency for Wireless Mesh Networks* *Jan 2005*
Microsoft Research, Redmond

59. *RT-Link: Predictable Lifetime in Embedded Wireless Networks* *Dec 2005*
Intel Labs, U.K.

60. *RT-Link: Predictable Lifetime in Embedded Wireless Networks* *Dec 2005*
Cambridge University, U.K.

61. *Tiling for Maximal Concurrency in Regular Wireless Networks'* *Aug 2005*
Bell Labs, New Jersey

62. *Real-Time Services for Multi-hop Wireless Networks* *Mar 2005*
University of York, U.K.

63. *Size-based Scheduling for MPEG-4 Streaming over Wireless Channels* *Mar 2002*
Intel Labs, Oregon

64. *An Architecture for QoS over IEEE 802.11e* *Feb 2002*
Philips Research, New York

RESEARCH FUNDING

Current

1. *Foundations of Medical Cyber-Physical Systems*
NSF CAREER Award
PI : Rahul Mangharam
$410,000; 3/1/2013-2/28/2018

2. *Heterogeneous, Autonomic Wireless Control Networks for Scalable Cyber-Physical Systems*
National Science Foundation, Major Research Instrumentation
Penn PI : Rahul Mangharam
$570,000; 2009-2015

3. *TERRASWARM Research Center*
Semiconductor Research Corporation and Department of Defense
SEAS PIs : Vijay Kumar, Rahul Mangharam and G. Pappas
$2,500,000; 1/1/2013 – 1/1/2018

4. *Greater Philadelphia Innovation Cluster (GPIC) - Energy-Efficient Building HUB*
Department of Energy (DoE), $169M total
SEAS PI : Rahul Mangharam; co-PI(s) : G. Pappas, S. Sarkar
$2,250,000; 2/1/2011- 3/31/2016.

5. *Media Lab at Penn*
Comcast Corporation, Industry Grant
PI : Rahul Mangharam
$160,000; 1/10/2014-12/31/2015 (with agreement to renew each year)

6. *T-SET University Transportation Center (2.0)*
   US Department of Transportation
   Penn PI : Dan Lee, co-PI(s): Rahul Mangharam, C. J. Taylor, K. Dandilis and I. Lee
   $5,900,00; 2013-2015

7. *Assuring the Safety, Security and Reliability of Medical Device Cyber Physical Systems*
   National Science Foundation CISE Cyber-Physical Systems (CPS)
   PI : I. Lee, co-PI(s) : R. Alur, O. Sokolsky, C. W. Hanson, G. J. Pappas, R. Mangharam
   $5,000,000; 9/1/2010-8/31/2015.

8. *Quantitative Analysis and Design of Control Networks*
   National Science Foundation CISE Cyber-Physical Systems (CPS)
   PI : G. J. Pappas, co-PI(s) : Rahul Mangharam, R. Alur, I. Lee, A. Ribeiro
   $1,500,000; 9/1/2009-8/31/2013.

9. *T-SET University Transportation Center (1.0)*
   US Department of Transportation
   Penn PI : Dan Lee, co-PI(s): Rahul Mangharam, C. J. Taylor, K. Dandilis and I. Lee
   $6,900,00; 2012-2104

10. *SPARCS: Synthesis of Platform-aware Attack-Resilient Control Systems*
    DARPA High Assurance Cyber Military Systems (HACMS)
    PI : I. Lee, co-PIs : R. Mangharam, N. Michael, G. Pappas, O. Sokoslky, S. Weirich (Penn) and P. Tabuada (UCLA)
    $4,700,000; 2012-2016

11. *Enhanced-Mobile Integrated Diagnostics and Data Analysis System (E-MIDDAS)*
    L3 Communications, Industry Grant
    PI : Rahul Mangharam
    $65,663; 2012-2013

12. *Robust Composition and Interoperability of CPS Components*
    National Science Foundation CISE Cyber-Physical Systems (CPS)
    PI : I. Lee, co-PIs: R. Mangharam, B. Loo and J. Goldman (Massachusetts General Hospital/Harvard University)
    $900,000; 2008–2013.

Previous

1. *Large-scale Test-bed and Real-Time Protocols for Vehicle-to-Vehicle Wireless Networks*
   National Science Foundation CISE Cyber-Physical Systems (CPS)
   PI : Rahul Mangharam
   $270,000; 2008-2012

2. *Distributed Control over Wireless Networks*
   DARPA, Multi-Scale Systems Center (MuSyC)
   PI : G. Pappas, co-PI : R. Mangharam
   $125,000; 2010

3. Distributed Wireless Controller Grids
   Honeywell Process Solutions, Industry Grant
   PI : Rahul Mangharam
   $130,000; 2008-2010

4. AutoMatrix: Large-scale Parallel Traffic Simulation
   NSF Research Experience for Undergraduates
   PI : Rahul Mangharam
   $9,200; 2010-2011

5. *Virtual Heart Model for Closed-loop Medical Device Testing*
   NSF Research Experience for Undergraduates
   PI : Rahul Mangharam (with I. Lee)
   $9,200; 2010-2011

6. *EnRoute - Test-bed for Energy-Efficient Building Controls*
   NSF Research Experience for Undergraduates
   PI : Rahul Mangharam (with G. Pappas)
   $6,000; 2010-2011

7. *Embedded Virtual Machines for Next-Generation Wireless Automation*
   University of Pennsylvania, University Research Foundation Award
   PI : Rahul Mangharam
   $9,200; 2010-2011

8. *Cyber-Physical Systems - Tapping into Physical World Analytics*
   Wharton Interactive Media Initiative
   PI : Rahul Mangharam
   $5,000; 2010-2011

9. *Collaboration between Penn and NIIT University, India*
   University of Pennsylvania, Provost International Award
   PI : Rahul Mangharam
   $5,000; 2010-2011