

Rahul Mangharam

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ACADEMIC EXPERIENCE

- Director, xLAB: Experience Design & Technology Lab** June 2014 – present
University of Pennsylvania, *Philadelphia, PA*
Collaborative Center between SEAS and PennDesign
- Associate Professor (Tenured)** May 2014 – present
University of Pennsylvania, *Philadelphia, PA*
Department of Electrical and Systems Engineering
Department of Computer and Information Science (Secondary)
- Assistant Professor (Secondary Appointment)** May 2008 – May 2014
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 Term Chair Assistant Professor** March 2008 – May 2014
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. Ragnathan (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. Ragnathan (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 medical devices, energy-efficient buildings, autonomous and automotive systems.

AWARDS and HONORS

- US Presidential Early Career Award for Scientists and Engineers (PECASE)** May 2016
Highest honor bestowed by the United States government on outstanding scientists and engineers in the early stages of their independent research careers. For developing techniques to make medical device software safe.
- Department of Energy's CLEANTECH \$50K Prize (Regional)** March 2016
For Data-driven modeling, control and tools for Demand Response

IEEE Benjamin Franklin Key Award For outstanding technical innovation and contributions that have had significant practical applications	April 2014
NSF CAREER Award Foundations of Medical Cyber-Physical Systems	March 2013
Intel Early Faculty Career Honor Selected as one among top 20 academics internationally	November 2012
National Academy of Engineers, US Frontiers of Engineering Symposium Awarded to top 15 engineers under 45 years, nation-wide.	September 2012
1st Prize in World Embedded Software Competition (Medical Devices), Korea Korean Ministry of Knowledge Economy and Electronics and Telecommunications Research Institute (ETRI)	November 2012
IEEE Best Student Paper Award, IEEE RTAS at CPS Week, Beijing, China (as advisor)	April 2012
1st Prize in Honeywell User Group OneWireless Competition Awarded for innovation in next-generation of wireless control for industrial automation	June 2011
1st Prize in World Embedded Software Competition, Korea Korean Ministry of Knowledge Economy and Electronics and Telecommunications Research Institute (ETRI)	November 2010
Stephen J. Angello Term Chair in Electrical & Systems Engineering University of Pennsylvania	Fall 2008
Best Paper Award IEEE Conference on Sensor, Mesh and Ad hoc Communications and Networks (SECON)	Summer 2006
Sixth Annual Lockheed Martin ECE Project Award ECE Department, Carnegie Mellon University	Spring 2006
Sigma Xi Award ECE Department, Carnegie Mellon University	Spring 2006
Eta Kappa Nu Research Award Meeting of the Minds University Research Award, Carnegie Mellon University	Spring 2002

RESEARCH AWARDS and HONORS (with Students)

- 1st Prize in World Embedded Software Competition, Korea**
Korean Ministry of Knowledge Economy and Electronics and Telecom Research Institute (ETRI) 2014
- ACM BuildSys Best Demonstration Award**, ACM Building Systems Symposium, Toronto. 2012.
- ACM Best Paper Presentation Award**, ACM IPSN Conference, Cyber-Physical Systems Week, Beijing. 2012
- 9th World Embedded Systems Programming Contest**, Seoul, Korea – 3rd Prize for ProtoDrive Electric Vehicle Platform (William Price, Harsh Jain, Yash Pant). Nov 2012.
- 1st Prize Winner of SEAS Senior Design Project** – Pacemaker Verification System (Varun Sampath, Shilpa Sarode and Sriram Radhakrishnan). May 2012.
- Intel Innovators \$50K Award** - - Haptic belt for the blind (Eric Berdinis and Jeff Kiske, CE). 2012.
- IEEE President's Award**, Finalist - Pacemaker Verification System (Varun Sampath, Shilpa Sarode and Sriram Radhakrishnan). 2012.
- Honorable Harold Berger Award** for Best ESE Senior Design Project – Pacemaker Verification System (Varun Sampath, Shilpa Sarode and Sriram Radhakrishnan). 2012
- Intel/Cornell Embedded Systems Cup – People's Choice Award**. Haptic Belt for the Blind (Eric Berdinis and Jeff Kiske, CE). May 2012.
- Intel/Cornell Embedded Systems Cup – Project Award**. HAWK: Helicopter Aircraft Welding Kinect (Kevin Conley, Matthew Hale, Paul Gurniak and Theodore Zhang, ESE). May 2012.

11. **Honorable Mention Award** for Senior Design Project – HAWK: Helicopter Aircraft Welding Kinect (Kevin Conley, Matthew Hale, Paul Gurniak and Theodore Zhang, ESE). May 2012.
12. **Best Paper Award Nominee**, 18th International Conference on Tools and Algorithms for the Construction and Analysis of Systems (TACAS), 2012.
13. **Health 2.0 conference Winners** – viSparsh: Haptic belt for the blind (Jatin Sharma, Tushar Chugh, Rolly Seth, Young India Fellowship Program), 2012.
14. **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.
15. **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.
16. **Google Zeitgeist Young Minds Award** - Haptic Belt for the Blind (Eric Berdinis and Jeff Kiske, CE). 2011.
17. **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.
18. **8th World Embedded Programming Competition, Grand Prize Winner** – AutoPlug: Plug-n-Play Architectures for Automotive Systems (Kevin Conley, ESE). 2010.
19. **Provost's Distinguished International Research Award**, University of Pennsylvania. 2010.
20. **Wharton Interactive Media Initiative Award**, University of Pennsylvania. 2009.
21. **University Research Foundation Award**, University of Pennsylvania. 2009.
22. **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. Madhur Behl, Francesco Smarra, and **Rahul Mangharam**, "DR-Advisor: A Data-Driven Demand Response Recommender System", *Journal of Applied Energy*. January 2016.
2. Z. Jiang and **R. Mangharam**. "High-Confidence Medical Device Software Development". *Foundations and Trends in Electronic Design Automation*, Vol. 9, No. 4 (2015) 309–391. December 2015
3. 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. January 2015.
4. 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.10, Issue:1 Feb 2014.
5. **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.
6. 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*. March 2013.
7. 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.
8. 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.
9. 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.

10. 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.
11. M. Pajic and **R. Mangharam**, "Spatio-Temporal Techniques for Anti-Jamming in Embedded Wireless Networks" *EURASIP Journal on Wireless Communications and Networking*, March 2010.
12. **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.
13. 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.
14. 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.
15. 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 (CONFERENCES)

1. Yash Pant, Houssam Abbas, and **Rahul Mangharam**, "Smooth Operator: Control Using the Smooth Robustness of Temporal Logic", *ACM/IEEE 8th International Conference on Cyber-Physical Systems (ICCPS)*. April 2017 (under review).
2. Achin Jain, Madhur Behl, and **Rahul Mangharam**, "Data predictive control for building energy management". *American Control Conference (ACC)*. June 2017 (under review).
3. Yash Pant, Houssam Abbas, and **Rahul Mangharam**, "Robust Model Predictive Control for Non-Linear Systems with Input and State Constraints Via Feedback Linearization", *IEEE Conference on Decision and Control (CDC)*. Las Vegas, USA, Dec 2016
4. Achin Jain, Madhur Behl, and **Rahul Mangharam**, "Data Predictive Control for Peak Power Reduction". *ACM International Conference on Embedded Systems for Energy-Efficient Built Environments (BUILDSYS)*. Nov 2016.
5. Zhihao Jiang, Houssam Abbas, Kuk Jin Jang, Marco Beccani and **Rahul Mangharam**, "Computer aided clinical trials for implantable cardiac devices", *Modeling, Design and Safety Analysis in Physiological Closed-Loop Systems Symposium at 53rd Society of Engineering Science Annual Technical Meeting*, U. Maryland. Oct 2016.
6. Zhihao Jiang, Houssam Abbas, Kuk Jin Jang, Marco Beccani and **Rahul Mangharam**, "In-silico Pre-clinical Trials for Implantable Cardioverter Defibrillators", *38th International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*. August 2016.
7. Zhihao Jiang, Houssam Abbas, Kuk Jin Jang, Marco Beccani and **Rahul Mangharam**, "Modeling and Simulation for In-silico Pre-clinical Trials for Implantable Cardiac Devices", *BMES/FDA Frontiers of Medical Devices Conference*. May 2016.
8. Houssam Abbas, Kuk Jin Jang, Zhihao Jiang, and **Rahul Mangharam**, "Towards Model Checking of Implantable Cardioverter Defibrillators", *19th ACM International Conference on Hybrid Systems: Computation and Control (HSCC)*. March 2016.
9. Houssam Abbas, Kuk Jin Jang, and **Rahul Mangharam**, "Benchmark: Nonlinear Hybrid Automata Model of Excitable Cardiac Tissue", *Applied Verification for Continuous and Hybrid Systems, Cyber-Physical Systems Week*. April 2016.
10. Madhur Behl, Achin Jain, and **Rahul Mangharam**, "Data-Driven Modeling, Control and Tools for Cyber-Physical Energy Systems", *ACM/IEEE 7th International Conference on Cyber-Physical Systems (ICCPS)*. April 2016.
11. Zhihao Jiang, Houssam Abbas, Pieter J. Mosterman, and **Rahul Mangharam**, "Automated Closed-Loop Model

Checking of Implantable Pacemakers using Abstraction Trees ", *IEEE Medical Cyber-Physical Systems*, CPS Week. April 2016.

12. Matthew O'Kelly, Houssam Abbas, Sicun Gao, Shin'ichi Shiraishi, Shnpei Kato, and **Rahul Mangharam**, "APEX: Autonomous Vehicle Plan Verification and Execution", SAE World Congress, April 2016.
13. **Rahul Mangharam**, Houssam Abbas, Madhur Behl, Kuk Jang, Miroslav Pajic and Zhihao Jiang, "Three challenges in cyber-physical systems," *8th International Conference on Communication Systems and Networks (COMSNETS)*, 2016.
14. Zhihao Jiang, Houssam Abbas, Kuk Jin Jang, and Rahul Mangharam, "Towards high confidence medical device software", *IEEE Computer*. January 2016.
15. Madhur Behl and **Rahul Mangharam**, "Sometimes, Money Does Grow On Trees: Data-Driven Demand Response with DR-Advisor", *ACM International Conference on Embedded Systems for Energy-Efficient Built Environments (BUILDSYS)*. November 2015.
16. Yash Pant, Houssam Abbas, Kartik Motha, Joseph Divetti and **Rahul Mangharam**, "Co-design of Anytime Computation and Control Systems", IEEE Real-Time Systems Symposium (RTSS), December 2015.
17. Yash Vardhan Pant, Houssam Abbas, K. N. Nischal, Paritosh Kelkar, Dhruva Kumar, Joseph Devietti and **Rahul Mangharam**, "Power-efficient algorithms for autonomous navigation", *IEEE Complex Systems Engineering (ICCSE)*, Nov 2016.
18. Madhur Behl, Truong Nghiem, Willy Bernal and Rahul Mangharam, "Campus-Wide Integrated Building Energy Simulation" 14th International Conference of the International Building Performance Simulation Association (IBPSA), Dec 2015.
19. Truong Nghiem and **Rahul Mangharam**, "Scalable Scheduling of Energy Control Systems," *Proceedings of the 12th International Conference on Embedded Software (EMSOFT)*, 137-146. October 2015.
20. Madhur Behl and **Rahul Mangharam**, "Sometimes money does grow on trees: Data Driven Demand Response With Regression Trees", *SRC TECHCON*. September 2015.
21. Madhur Behl, Truong Nghiem and **Rahul Mangharam**, "DR-Advisor: A Data Driven Demand Response Recommender System". *CISBAT International Building Simulation Association IBPSA*, Sept 2015.
22. Kuk Jang, Jungmin Ryoo, Orkan Telhan and **Rahul Mangharam**, "CloudMat: Context-aware Personalization of Fitness Content," *IEEE 12th International Conference on Services Computing (SCC)*, June 2015.
23. M. Behl, T. Nghiem and **R. Mangharam**. "IMpACT: Inverse Model Accuracy and Control Performance Toolbox for Buildings". *IEEE International Conference on Automation Science and Engineering (CASE)*, August 2014.
24. Y. Pant, T. Nghiem and **R. Mangharam**. "Peak Power Reduction in Hybrid Energy Systems with Limited Load Forecasts". *American Control Conference (ACC)*. June 2014
25. 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.
26. T. Nghiem, G. J. Pappas and **R. Mangharam**. "Event-based Green Scheduling of Radiant Systems in Buildings." *American Control Conference (ACC)*. June 2013.
27. F. Miao, M. Pajic, **R. Mangharam** and G. J. Pappas. "Networked Realization of Discrete-Time Controllers." *American Control Conference (ACC)*. June 2013.
28. 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.
29. 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)*, at CPSWeek. Philadelphia, April 2013.
30. 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.
31. 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.

32. 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.**
33. **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.
34. 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.**
35. 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.**
36. 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.**
37. 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.
38. 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.
39. 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.
40. 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.
41. **R. Mangharam** and A. A. Saba, "Anytime Algorithms for GPU Architectures", *IEEE Real-Time Systems Symposium (IEEE RTSS)*, Vienna, Austria. Nov 2011.
42. 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.
43. 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.
44. 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.
45. 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.
46. 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.
47. 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.
48. 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.
49. 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.
50. 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.
51. 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.

52. 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.
53. 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
54. 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.
55. 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 (ICCP)*. April 2010.
56. 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.
57. M. Pajic and **R. Mangharam**. "Anti-Jamming for Embedded Wireless Networks". *ACM International Conference on Information Processing in Sensor Networks (IPSN'09)*. April 2009.
58. 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.
59. **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.
60. **R. Mangharam**, A. Rowe and R. Rajkumar, "Voice over Sensor Networks" *27th IEEE Real-Time Systems Symposium (IEEE RTSS)*. Sao Paulo, Brazil. Dec 2006.
61. 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**.
62. **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.
63. **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.
64. **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.
65. **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.
66. **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.
67. 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.
68. **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)

84. 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)

85. **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.
86. **R. Mangharam**. "Profiling Anytime Algorithms for Real-Time Computing" *Workshop on Benchmarking of Embedded Systems, ESWeek*, Montreal, Canada, October 2013.
87. 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.
88. 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.
89. 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.
90. 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.
91. M. Pajic and **R. Mangharam**. "Architecture for a Fully Distributed Wireless Control Network". Demo, and Poster at *IEEE/ACM CPSWeek*. April 2011.
92. Z. Jiang, M. Pajic and **R. Mangharam**. "Closed-loop Testing for Implantable Cardiac Pacemakers". Demo and Poster at *IEEE/ACM CPSWeek*. April 2011.
93. 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.
94. 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.
95. 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.
96. **R. Mangharam**, "AutoPlug: An Open Experimental Platform for Automotive ECU Testing, Updates and Verification". *NSF/USCAR Automotive CPS Workshop*, Troy, Michigan. March 2011.
97. 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.
98. M. Behl and **R. Mangharam**, "Pacer Cars: Real-Time Traffic Shockwave Suppression" *IEEE Real-Time Systems Symposium (RTSS), Work-in-Progress*. Dec 2010.
99. 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.
100. M. Pajic and **R. Mangharam**. "Embedded Virtual Machines for Wireless Industrial Automation" *Demo and Poster at IEEE/ACM CPSWeek*. April 2009.
101. M. Pajic and **R. Mangharam**. "Runtime Approaches for Embedded Wireless Control-Actuator Networks" at *IEEE Real-Time Systems Symposium (RTSS), PhD Forum*. Dec 2009.
102. 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.

103. 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.
104. **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.
105. **R. Mangharam**. "Real-Time Traffic Congestion Prediction". *NSF-NCO/NITRD National Workshop on High Confidence Transportation Cyber-Physical Systems*. Nov 2008.
106. **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.
107. **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. F1/10: Autonomous Racing Cars (2016)
<http://f1tenth.org>
2. DR-Advisor: Data-driven Demand Response Recommender System (2015)
<http://mlab.seas.upenn.edu/dr-advisor>
3. *MLE+*: A Tool for Integrated Design and Deployment of Energy Efficient Building Controls at
<http://mlab.seas.upenn.edu/mlep/> (2012-Present)
4. *ProtoDrive*: An Experimental Platform for Electric Vehicle Energy Scheduling and Control.
<http://mlab.seas.upenn.edu/protodrive/> (2012-Present)
5. *En-Route Energy Router*: Energy-Efficient Building Control and Scheduling Test-bed. 2010-Present
6. *Open-ISA100.11a*: Open software stack for standardized industrial wireless control automation.
<http://mlab.seas.upenn.edu/openisa/> (2011-Present)
7. *Pacemaker Verification System*: Platform for closed-loop testing and verification of medical devices.
<http://pvs.medcps.org/> (2012-Present.)
8. *HAWK*: Platform for Helicopter Aircraft Wielding Kinect for search and rescue in buildings (2012.)
9. *Haptic Belt for Blind*: Platform for indoor and outdoor guidance for blind persons (2011-Present.)
10. *AutoPlug*: Open Automotive Architecture for Plug-n-Play Services. Open-source software at
<http://www.autoplug.org/> (2011)
11. *AirHacks*: Open Unmanned Aerial Vehicle Platform (Quadrotor) at <http://airhacks.org/> (2011)
12. *Penn Virtual Heart Model* and Closed-loop Implantable Device Models for medical device software validation and verification. Open-source Matlab/Simulink models (2011-Present)
13. *AutoMatrix*: Large-scale Traffic Congestion Simulator for estimating and predicting congestion with over 16 million vehicles (2011-Present.)
14. *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)
15. *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.)
16. *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)

Ph.D. Students

1. Matthew O'Kelly (Ph.D. Candidate, ESE) – Autonomous Vehicle Plan Verification and Execution
2. Kuk Jang (Ph.D. Candidate, ESE) – Medical Cyber-Physical Systems
3. Yash V. Pant (Ph.D. Candidate, ESE) – Anytime Computation and Control for Cyber-Physical Systems
4. Zhihao Jiang (Ph.D. Candidate, CIS) – High-Confidence Medical Device Software & Systems
5. Jiyue He (Ph.D. Candidate, ESE) - Medical Cyber-Physical Systems
6. Achin Jain (Ph.D. Candidate, ESE) – Data-driven Cyber-Physical Systems

Post-Doctoral Candidates

7. Houssam Abbas (Post-doc, ESE) – Hybrid Systems and Formal Verification
8. Marco Beccani (Post-doc, ESE) – Real-time and Embedded Systems
9. Madhur Behl (Post-doc, ESE) – Data-driven Modeling, Control and Tools for Energy Cyber-Physical Systems

Graduated Ph.D. Students

1. Madhur Behl (Post-doc, ESE) – Assistant Professor at University of Virginia (starting 2017)
2. Miroslav Pajic (ESE) – Network Controlled Cyber-Physical Systems. Sept. 2012. Assistant Professor at Duke.
3. Truong X. Nghiem (ESE) – Green Scheduling for Energy Systems (co-advised with George Pappas). Sept. 2012. Research faculty at EPFL.

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. Shashidhar 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, IEEE COMSNETS 9th International Conference on Communication Systems & Networks, January 2017
2. Program Co-Chair, ACM SIGBED International Conference on Embedded Software (EMSOFT), September 2016
3. Program Co-Chair, IEEE Real-Time Systems Symposium (RTSS), December 2015
4. Program Co-Chair, ACM Conference on Embedded Systems For Energy-Efficiency In Building Environments (BuildSys), November 2015
5. Program Co-Chair, 6th Medical Cyber-Physical Systems Workshop at CPSWeek, Seattle. April 2015
6. Program Chair (Demos and Posters), ACM Conference on Embedded Systems For Energy-Efficiency In Buildings (BuildSys), November 2014
7. Program Co-Chair, 4th MobileHealth Workshop at ACM MobiSys, Philadelphia, August 2014
8. Program Co-Chair, 5th Medical Cyber-Physical Systems Workshop at CPSWeek, Berlin. April 2014
9. Chair, CPS Industry Track, 19th IEEE Real-Time and Embedded Technology and Applications Symposium (RTAS), Philadelphia, April 2013
10. Program Co-Chair, 4th Medical Cyber-Physical Systems Workshop at CPSWeek, Philadelphia. April 2013
11. Program Co-Chair, 18th IEEE Real-Time and Embedded Technology and Applications Symposium (RTAS), Beijing, China. April 2012
12. Program Co-Chair, 2nd IEEE Analytic Virtual Integration of Cyber-Physical Systems Workshop, Co-located with RTSS, Dec 2011
13. 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

14. FORMATS'15, E-Energy'15, WFCS'15, LCTES'15, ICCPS'16
15. 12th European Conference on Wireless Sensor Networks (EWSN), 2015
16. ACM Conference on Future Energy Systems (E-Energy), 2015
17. ACM SIGPLAN Conference on Languages, Compilers, and Tools for Embedded Systems (LCTES), 2015
18. IEEE Symposium for Reliable Distributed Systems (SRDS), 2015
19. ACM International Conference on Information Processing in Sensor Networks (IPSN), 2015
20. IEEE International Conference on Cyber-Physical Systems (ICCPS), 2015
21. IEEE International Conference on Cyber-Physical Systems, Networks, and Applications (CPSNA), 2014
22. ACM Workshop on Embedded Systems For Energy-Efficiency In Buildings (BuildSys), 2014
23. ACM International Conference on High Confidence Networked Systems (HiCoNS), 2014
24. IEEE International Conference on Cyber-Physical Systems (ICCPS), 2014
25. ACM Workshop on Embedded Systems For Energy-Efficiency In Buildings (BuildSys), 2013
26. IEEE Real-Time Systems Symposium (RTSS), 2013

27. IEEE International Conference on Embedded Software (EMSOFT), 2013
28. IEEE International Conference on Cyber-Physical Systems, Networks, and Applications (CPSNA), 2013.
29. IEEE International Conference on Cyber-Physical Systems (ICCPS), 2013
30. ACM 2ND International Conference on High Confidence Networked Systems (HiCoNS), 2013
31. IEEE Real-Time Systems Symposium (RTSS), 2012
32. ACM International Conference on Information Processing in Sensor Networks (IPSN), 2012
33. IEEE Conference on Sensor, Mesh and Ad Hoc Communications and Networks (SECON), 2012.
34. IEEE Real-Time & Embedded Technology and Applications Symposium (RTAS), 2012
35. IEEE Real-Time & Embedded Technology and Applications Symposium (RTAS), 2011
36. IEEE RTSS, Work-in-Progress, 2010
37. IEEE Real-Time Systems Symposium (RTSS), Analytical Virtual Integration of CPS Workshop, 2010
38. IEEE Real-Time & Embedded Technology and Applications Symposium (RTAS), 2010
39. ACM INFOCOM, 2009
40. IEEE Real-Time Systems Symposium (RTSS), 2008
41. IEEE Real-Time & Embedded Technology and Applications Symposium (RTAS), 2008
42. IEEE International Symposium on Wireless Vehicular Communications, 2008
43. IEEE MoVeNet, 2nd International Workshop on Mobile Vehicular Networks, 2008
44. IEEE International Symposium on Vehicular Computing Systems, 2008
45. IEEE Workshop on Mobile Networks for Vehicular Environments, (INFOCOM/MOVE), 2008
46. 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, 2009-2015
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

Director, Embedded Systems Master Program

June 2015 – present

University of Pennsylvania, *Philadelphia, PA*

Program with 72 MS students - <http://www.cis.upenn.edu/prospective-students/graduate/embs.php>

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. Andrew King, University of Pennsylvania, January 2015
2. Alex Styler, Carnegie Mellon University, Jan 2014
3. David Arney, University of Pennsylvania, May 2012
4. 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, University of Pennsylvania, 2009

Instruction

1. Spring 2015 : ESE 350 Introduction to Embedded Systems
2. Spring 2014 : ESE 350 Introduction to Embedded Systems
3. Fall 2013 : ESE 519 Real-Time and Embedded Systems
4. Spring 2013 : ESE 350 Introduction to Embedded Systems
5. Fall 2012 : ESE 519 Real-Time and Embedded Systems
6. Spring 2012 : ESE 350 Introduction to Embedded Systems
7. Fall 2011 : ESE 519 Real-Time and Embedded Systems
8. Spring 2011 : ESE 350 Introduction to Embedded Systems
9. Fall 2010 : ESE 519 Real-Time and Embedded Systems

10. Spring 2010 : ESE 350 Introduction to Embedded Systems
11. Spring 2009 : ESE 680 Wireless Embedded Networks
12. Fall 2006 : ECE 18848 Graduate Embedded Systems, Carnegie Mellon University
13. Spring 2001 : ECE 18-220 Fundamentals of Electrical Engineering, TA, Carnegie Mellon University

Teaching Workshops and Tutorials

1. Tutorial to Toyota engineers, Penn English Language Program. "Automotive Cyber-Physical Systems", May-August 2013 and May-August 2014.
2. Engineering Faculty Teaching Forum, Invited Speaker. "Active Learning in Lectures". Nov 2012
3. Tutorial at IEEE ICCAD. "Algorithms for Analysis and Optimization of Future Cyber Physical Systems", (with Radu Marculescu). San Jose, CA. Aug 2012
4. Organized International Workshop on Mobile, Wireless and Pervasive Systems in collaboration with NIIT University, India. Jan 2012.
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 2-5x, 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

[Over 20 talks between 2015-2016. To be updated.]

1. *Model-IQ: Modeling, Control and Tools for Energy-efficient Buildings* Nov 2014
DIMACS Mathematics for Planet Earth 2013+ Workshop on Data-aware Energy Use, San Diego
2. *Cyber-Physical Systems Problems in Medical and Energy Domains* Sep 2014
IEEE Philadelphia Section, Invited Speaker
3. *Cyber-Physical Systems Problems in Medical and Energy Domains* Dec 2013
Cornell University, ECE Departmental Colloquium
4. *Closing the loop with Cyber-Physical Systems Modeling* Nov 2013
University of California, San Diego. Computer Engineering Colloquium & **Distinguished Speaker Series**
5. *Closing the loop with Cyber-Physical Systems Modeling* Nov 2013
University of Southern California (USC), Electrical Engineering Colloquium
6. *Vision Interactive Operating System* Nov 2013
Penn Design Seminar, University of Pennsylvania
7. *Green Scheduling of Buildings for Peak Power Minimization* Nov 2013
University of California, Berkeley. Software Defined Buildings Seminar
8. *Closing the loop with Cyber-Physical Systems Modeling* Nov 2013
University of Illinois, Urbana-Champaign (UIUC), Computer Science Colloquium
9. *Green Scheduling of Buildings for Peak Power Minimization* Oct 2013
Kansas State University. **Distinguished Lecture, Computer Engineering Colloquium**
10. *Closing-the-loop with CPS Modeling: Medical and Energy Systems* Sep 2013
University of California, Los Angeles. Electrical Engineering Seminar
11. *Green Scheduling of Buildings for Peak Power Minimization* Sep 2013
University of California, Merced. Electrical Engineering and Computer Science Seminar
12. *Medical and Energy Cyber-Physical Systems* Sep 2013
Villanova University, Electrical Engineering and Computer Science Seminar
13. *Cyber-Physical Systems 2.0 -- Automotive, Medical, Energy and Industrial Automation* Feb 2013
Drexel University, Robotics Seminar Series
14. *Closing the loop with Medical Cyber-Physical Systems* Oct 2012
University of Berkeley, Design of Robotics and Embedded systems, Analysis, and Modeling Seminar
15. *The Car and the Cloud* Sep 2012
National Academy of Engineers, US Frontiers of Engineering, GM R&D Center, Michigan
16. *Closing-the-loop for Energy-Efficient Buildings* Oct 2012
Architecture Department Seminar, University of Pennsylvania
17. *Integrated Functional and Formal Modeling for Safety-Critical Medical Devices* Jun 2012
University of Oxford, UK. Formal Methods Seminar
18. *Cyber-Physical Systems 2.0 -- Automotive, Medical, Energy and Industrial Automation* Jul 2012
BOSCH Palo Alto Lab, California
19. *Automotive Cyber-Physical Systems – In vehicle, Vehicle-to-vehicle and Traffic Management* Jul 2012
Toyota Information Technology Center (ITC), Mountain View, California
20. *Cyber-Physical Systems and the Cloud* Jul 2012
CISCO Systems, Sunnyvale, California
21. *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).
22. *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).
 23. *Automotive Cyber-Physical Systems – In vehicle, Vehicle-to-vehicle and Traffic Management* *Jun 2012*
Invited Speaker, Connected Vehicles Workshop (DoT UTRC), Buffalo, NY
 24. *Network Cyber-Physical Systems* *May 2012*
Invited Speaker, Texas Instruments and Kilby Labs, Dallas, TX.
 25. *Medical Cyber-Physical Systems: Closed-loop Medical Device Verification and Testing* *May 2012*
Invited Speaker, 15th Conference on Software Design for Medical Devices
 26. *Closing the Loop with Cyber-Physical Modeling* *Oct 2011*
Vanderbilt University, Institute for Software Integrated Systems Seminar
 27. *Medical Cyber-Physical Systems: Closed-loop Medical Device Verification and Testing* *Sep 2011*
FDA / NHLBI / NSF Workshop on Computer Methods for Medical Devices, Panelist
 28. *Automotive Cyber-Physical Systems* *Sep 2011*
Wayne State University, Michigan, CS Departmental Seminar
 29. *Closing the Loop with Wireless Control Networks* *Jun 2011*
EU-US Workshop on Networked Monitoring and Control, EU Commission, Brussels
 30. *Closing the Loop with Cyber-Physical Modeling* *Apr 2011*
University of California, Irvine, ECE Departmental Seminar
 31. *Automotive Cyber-Physical Systems* *Apr 2011*
University of Southern California, ECE Departmental Seminar
 32. *Green Scheduling of Buildings for Peak Power Minimization* *Apr 2011*
ARPA-Energy Seminar
 33. *Medical Cyber-Physical Systems: New Frontiers* *Mar 2011*
University of Illinois, Urbana-Champaign (UIUC), **Distinguished Lecture**
 34. *Closing the loop with Networked Cyber-Physical Systems* *Dec 2010*
UCLA, Center for Embedded Networked Sensing
 35. *Closing the loop with Networked Cyber-Physical Systems* *Nov 2010*
University of Pennsylvania, CIS Departmental Seminar
 36. *Networked Cyber-Physical Systems* *Nov 2010*
Virginia Tech, Center for Embedded Systems for Critical Applications
 37. *Generic Pacemaker Project: Closed-loop Software Testing, Validation and Verification* *Nov 2010*
US. Food and Drug Administration (FDA), Special Topics Seminar
 38. *Closing the loop with Networked Cyber-Physical Systems* *Nov 2010*
University of Pittsburgh, ECE Departmental Seminar
 39. *Closing the loop with Networked Cyber-Physical Systems* *Oct 2010*
Cornell University, ECE Departmental Seminar
 40. *Robust Architectures for Wireless Actuation and Control* *Oct 2010*
Honeywell Technical Fellows Seminar
 41. *Cyber-Physical Systems Research at Penn* *Oct 2010*
University of Texas, Austin. ECE Colloquium
 42. *Medical Cyber-Physical Systems* *Oct 2010*

Temple University, ECE Departmental Colloquium

43. *Recent Research in Cyber-Physical Systems at mLAB-UPenn*
IMEC, Leuven, Belgium. Special Speaker Seminar. Jul 2010
44. *Recent Research in Cyber-Physical Systems at mLAB-UPenn*
Embedded Systems Institute, Eindhoven, Netherlands Jul 2010
45. *Medical Cyber-physical Systems*
IMEC, Leuven, Belgium Aug 2009
46. *Automotive Cyber-Physical Systems*
University of Waterloo, Ontario, Canada Jun 2009
47. *Distributed Wireless Control Grids*
Honeywell Technical Symposium, Arizona May 2009
48. *Networked Cyber-Physical Systems*
Indian Institute of Technology Bombay (IIT-B), Mumbai Mar 2009
49. *Networked Cyber-Physical Systems*
Indian Institute of Technology Madras (IIT-M), Chennai Mar 2009
50. *Networked Cyber-Physical Systems*
Veermata Jijabai Technological Institute (VJTI), Mumbai Mar 2009
51. *Research Activities at mLAB-UPenn*
Infosys SET Labs, Bangalore Mar 2009
52. *Vehicular Wireless Networks for Safety and Congestion Prediction*
Arada Systems, Bangalore Jan 2009
53. *Networked Automotive Cyber-Physical Systems*
Keynote Speaker, Conference on Wireless Access in Vehicular Environments, U Michigan Dec 2008
54. *Vehicle to Vehicle Wireless Networks*
WINLAB Wireless Seminar Series, Rutgers University. New Jersey Nov 2008
55. *Vehicle to Vehicle Wireless Networks*
University of Delaware, Delaware Nov 2008
56. *FireFly: Real-Time Sensor Networking Platform*
Cornell University, New York Oct 2006
57. *Scalable Time Synchronization for Multi-hop Networks*
Microsoft Research – Silicon Valley Center Sep 2006
58. *Scalable Time Synchronization for Multi-hop Networks*
Intel Labs, Santa Clara Sep 2006
59. *GrooveNet: Hybrid Network Simulation for Vehicular Networks*
Imperial College, London Jun 2006
60. *MAX: Maximal Transmission Concurrency for Wireless Mesh Networks*
Microsoft Research, Redmond Jan 2005
61. *RT-Link: Predictable Lifetime in Embedded Wireless Networks*
Intel Labs, U.K. Dec 2005
62. *RT-Link: Predictable Lifetime in Embedded Wireless Networks*
Cambridge University, U.K. Dec 2005
63. *Tiling for Maximal Concurrency in Regular Wireless Networks'*
Bell Labs, New Jersey Aug 2005
64. *Real-Time Services for Multi-hop Wireless Networks*
Mar 2005

University of York, U.K.

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

Mar 2002

66. *An Architecture for QoS over IEEE 802.11e*
Philips Research, New York

Feb 2002