Xiaohui Liu

Wayne State University
Department of Computer Science
5057 Woodward Avenue, Suite 3209
Detroit, Michigan 48202, USA

Phone: +1 313-318-8421
xiaohui@wayne.edu
http://www.cs.wayne.edu/xliu

Research Interests

Wireless and Sensor Networks: MAC, routing, and cross-layer protocols

Wireless Networked Control Systems: predictable, reliable, and real-time wireless networking for sensing and control

Education

2008–2014 (Expected) **Wayne State University**, *Ph.D. in Computer Science*.

2004–2008 **Wuhan University, China**, *B.S. in Computer Science*.

Publications

Journals

Hongwei Zhang, Xin Che, Xiaohui Liu, Xi Ju.
Adaptive Instantiation of the Protocol Interference Model in Wireless Networked Sensing and Control.
In ***ACM Transactions on Sensor Networks (ToSN)***, *2014.*

Xiaohui Liu, Hongwei Zhang, Qiao Xiang, Xin Che, Xi Ju.
Taming Uncertainties in Real-Time Routing for Wireless Networked Sensing and Control.
In ***IEEE Transactions on Smart Grid (TSG)***, *special issue on "Smart Grid Communication Systems: Reliability, Dependability, and Performance", Vol. 4, No. 1, March 2013*

Qiao Xiang, Jinhong Xu, Xiaohui Liu, Hongwei Zhang, Loren J. Rittle.
When In-Network Processing Meets Time: Complexity and Effects of Joint Optimization in Wireless Sensor Networks.
In ***IEEE Transactions on Mobile Computing (TMC)***, *10(10), pp. 1488-1502, October 2011.*

Conferences & Workshops

Xiaohui Liu, Hongwei Zhang, Qiao Xiang, Xin Che, Xi Ju.
Taming Uncertainties in Real-Time Routing for Wireless Networked Sensing and Control.
In ***13th ACM International Symposium on Mobile Ad Hoc Networking and Computing (MobiHoc)***, *2012.*

Xiaohui Liu, Hongwei Zhang, Qiao Xiang.
Towards Predictable Real-Time Routing for Wireless Networked Sensing and Control.
In ***Cyber-Physical-Systems (CPS) Week Workshop on Real-Time Wireless for Industrial Applications (RealWin)***, *2011.*

Xin Che, Xiaohui Liu, Xi Ju, Hongwei Zhang.
Adaptive Instantiation of the Protocol Interference Model in Mission-Critical Wireless Networks.
In ***7th IEEE Communications Society Conference on Sensor, Mesh and Ad Hoc Communications and Networks (SECON)***, *2010.*

Qiao Xiang, Jinhong Xu, Xiaohui Liu, Hongwei Zhang, Loren J. Rittle.
When In-Network Processing Meets Time: Complexity and Effects of Joint Optimization in Wireless Sensor Networks.
In ***30th IEEE Real-Time Systems Symposium (RTSS)***, *2009*.

Posters & Demos

Hongwei Zhang, Xiaohui Liu, Chuan Li, Yu Chen, Xin Che, Feng Lin, Le Yi Wang, George Yin.
Poster Abstract: PRK-Based Scheduling for Predictable Link Reliability in Wireless Networked Sensing and Control.
In ***4th ACM/IEEE International Conference on Cyber-Physical Systems (ICCPS)***, *2013*

Technical Reports

H. Zhang, C. Li, X. Liu, Y. Chen, X. Che, F. Lin, L. Y. Wang, and G. Yin.
PRK-based scheduling for predictable link reliability in wireless networked sensing and control.
In ***Technical Report DNC-TR-14-01, Wayne State University***, *2014*.

H. Zhang, X. Che, X. Liu, and X. Ju.
Adaptive instantiation of the protocol interference model in wireless networked sensing and control.
In ***Technical Report WSU-CS-DNC-TR-12- 01, Wayne State University***, *2012*.

X. Liu, H. Zhang, Q. Xiang, X. Che, and X. Ju.
Taming uncertainties in real-time routing for wireless networked sensing and control.
In ***Technical Report DNC-TR-11-04, Wayne State University***, *2011*

Q. Xiang, J. Xu, X. Liu, H. Zhang, and L. J. Rittle.
When in-network processing meets time: Complexity and effects of joint optimization in wireless sensor networks.
In ***Technical Report DNC-TR-09-01, Wayne State University***, *2009*.

In Preparation

Hongwei Zhang, Xiaohui Liu, Chuan Li, Yu Chen, Xin Che, Feng Lin, Le Yi Wang, George Yin.
PRK-Based Scheduling for Predictable Link Reliability in Wireless Networked Sensing and Control.
In ***The 14th International Conference on Information Processing in Sensor Networks (IPSN)***, *2015*.

Xiaohui Liu, Hongwei Zhang.
A Maximal Concurrency and Low Latency Distributed Scheduling Protocol for Wireless Sensor Networks.
In ***IEEE Wireless Communications and Networking Conference (WCNC)***, *2015*.

Xiaohui Liu, Hongwei Zhang.
An Optimal Greedy Real-Time Convergecast Scheduling for Multi-hop Wireless Networks over Unreliable Links.
In ***The 21st IEEE Real-Time and Embedded Technology and Applications Symposium (RTAS)***, *2015*

Patent

Hongwei Zhang, Xiaohui Liu, Chuan Li, "PRK-Based Scheduling for Predictable Link Reliability", U.S. Provisional Application #61/788,445, International Application #PCT/US2014/27055

Selected Software Development

2014 **PRK-based Scheduling Protocol (PRKS)**.

PRKS guarantees the reliability of a wireless link is no less than requirement in the presence of interference while maximizing throughput. This is done by identifying the optimal parameter K in the PRK interference model, which in turn is formulated as a distributed control problem. **Numerous underpinnings of TinyOS, such as execution model and resource sharing mechanism, intend to shield programmers from many complexities of programming a concurrent system, which comes at the expense of nondeterministic execution. To cater to PRKS's needs of predictable timing, I tailor these fundamental underlying services.** More specifically, there are five primary challenges in implementation: (1) the controller is distributed, and nodes can have inconsistent view of plant states due to diffusion delay; (2) the protocol is based on TDMA and requires global time synchronization, but the de facto time synchronization protocol FTSP for TelosB is buggy and yields intolerable synchronization errors; (3) most protocol codes run in asynchronous mode, causing concurrency issues; (4) TinyOS' task execution model makes execution delay very nondeterministic; (5) many computations are intensive and highly varying. **I single-handedly tackled these challenges as well as other challenges posed by extreme memory constraints of TelosB motes using TinyOS. In addition to PRKS, I also implemented 4 other protocols for comparison from the ground up.** Through measurement study in sensor network testbed NetEye and Indriya, we observe that PRKS enables predictably high link reliability (e.g., 95%) in different network and environmental conditions without a priori knowledge of these conditions, and, through local distributed coordination, PRKS achieves a channel spatial reuse very close to what is enabled by the state-of-the-art centralized scheduler while ensuring the required link reliability, and improves substantially over all other protocols in terms of reliability, delay, and throughput.

2012 **Multi-Timescale Adaptation (MTA) Routing Protocol**.

MTA identifies minimal energy paths that can meet probabilistic deadlines of real-time traffic, given the notorious dynamics and uncertainties of path delays in wireless networks. **TinyOS is not designed with real-time support in mind, so it's not surprising to find many of its features detrimental to real-time routing, such as task and split-phase APIs, to name a few. Many core APIs are altered in a systematic way to enable real-time networking without devising an entirely new real-time OS.** More precisely, the following obstacles appear in realizing it on resource-scarce TelosB motes running TinyOS: (1) the standard TinyOS task queue is served in FIFO order so urgent tasks can be postponed by less urgent ones, causing deadline misses that can otherwise be avoided; (2) the default CC2420 radio stack is non-blocking and synchronous, making critical codes like packet transmission and reception susceptible to excessive delay; (3) tracking relative deadlines of traffic necessitates time synchronization across a link while there are bugs in the default packet-level time synchronization for TelosB, especially under heavy load; (4) the number of paths in a directed-acyclic-graph (DAG) maintained by MTA increases exponentially with the network diameter, making it impossible to store all of them in memory to choose the optimal path from. **Despite the aforementioned obstacles, I managed to implement the whole protocol independently. Besides MTA itself, I also implemented 4 other protocols and 7 MTA variants from scratch.** Two testbeds of 127+ motes have verified MTA's significant advantages over the state of the art for a variety of settings.

Technical Skills

Programming languages: nesC, C, C++, Java, LaTex, ASP, HTML, Javascript, PHP

Tools: TinyOS, Matlab, MySQL

Awards

2012 **Outstanding Graduate Research Assistant (GRA) Award**, Wayne State University

2009 **Microsoft Imagine Cup US Software Design Top 15 Finalist** (out of about 2,000 teams)

2005 **National Scholarship**, China

2008, 2011, 2012 Graduate Research Travel Award, Department of Computer Science, Wayne State University

2006 Second Prize of Mathematics Contest, Wuhan University, China

2005 Second Prize in 10th "Ziqiang Cup" Extracurricular Contest of Science and Academics, Wuhan University, China

2005, 2006 Second Class Academic Scholarship, Wuhan University, China

2007 Third Class Academic Scholarship, Wuhan University, China

Experience

Fall 2009 – Present **Research Assistant**, *Wayne State University*, Dr. Hongwei Zhang.

January 2010 – January 2012 **President**, *ACM Student Chapter at Wayne State University*.

Fall 2008 – Fall 2009 **Teaching Assistant**, *Wayne State University*.

December 2007 – March 2008 **Software Engineer**, *Wicresoft Company*.

May 2007 – December 2007 **Chief Development Officer**, *Trinity Studio*.

Professional Activities

Referee

ToN, ToSN, TPDS, TC, IPL, IJDSN, TPDS, JPDC

Sensys, MASS, SECON, WCNC, AHSN, ICCN, SAS, Globecom, SAC, ICC, MSWiM, NAS, CPNS, ADHOC, WMET, HiPC, QShine, TVT, MUE, WAVE

Reference

Hongwei Zhang.
Associate Professor
Department of Computer Science, Wayne State University
Suite 3010, 5057 Woodward Avenue, Detroit, Michigan 48202
+1 313 577 0731
hongwei@wayne.edu
http://www.cs.wayne.edu/~hzhang

Nathan Fisher.
Associate Professor
Department of Computer Science, Wayne State University
Suite 14200, 5057 Woodward Avenue, Detroit, Michigan 48202
+1 313 577 5421
fishern@wayne.edu
http://www.cs.wayne.edu/~fishern

Le Yi Wang.
Professor
Department of Electrical and Computer Engineering, Wayne State University
Room 3135, 5050 Anthony Wayne Drive, Detroit, Michigan 48202
+1 313 577 4715
lywang@wayne.edu
http://www.ece.eng.wayne.edu/~lywang