

Changbin Liu

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RESEARCH INTERESTS

My research centers around **cloud computing** and **wireless networking**, especially the use of data-centric techniques and declarative languages to manage and optimize complex networked systems. I enjoy building real and sophisticated systems, and have collaborated as the lead student on two interdisciplinary projects with industry (AT&T Labs Research and Raytheon BBN Technologies), resulting in deployed systems and publications across various sub-disciplines of computer science, such as networking, systems, database and cloud.

EDUCATION

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| Sept 2007 - Aug 2012 (expected) | University of Pennsylvania , Philadelphia, PA
Ph.D. in Computer and Information Science
Thesis: Transactional Automated Cloud Resource Orchestration
Advisor: Boon Thau Loo
GPA: 3.96/4.0 |
| Sept 2007 - May 2009 | University of Pennsylvania , Philadelphia, PA
M.S.E. in Computer and Information Science
Advisor: Boon Thau Loo |
| Sept 2003 - Jun 2007 | Tsinghua University , Beijing, China
B.S. in Computer Science and Technology |

SELECTED PUBLICATIONS

- **TROPIC: Transactional Resource Orchestration Platform In the Cloud.**
Changbin Liu, Yun Mao, Xu Chen, Mary Fernandez, Boon Thau Loo, and Jacobus Van der Merwe.
2012 USENIX Annual Technical Conference (ATC'12). (18.4% acceptance)
- **Cologne: A Declarative Distributed Constraint Optimization Platform.**
Changbin Liu, Lu Ren, Boon Thau Loo, Yun Mao, and Prithwish Basu.
38th International Conference on Very Large Databases (VLDB'12).
- **PUMA: Policy-based Unified Multi-radio Architecture for Agile Mesh Networking.**
Changbin Liu, Ricardo Correa, Harjot Gill, Tanveer Gill, Xiaozhou Li, Shivkumar Muthukumar, Taher Saeed, Boon Thau Loo, and Prithwish Basu.
4th International Conference on Communication Systems and Networks (COMSNETS), Jan 2012.
(27% acceptance)
- **Declarative Policy-based Adaptive Mobile Ad Hoc Networking.**
Changbin Liu, Richardo Correa, Xiaozhou Li, Prithwish Basu, Boon Thau Loo, and Yun Mao.
ACM/IEEE Transactions on Networking (TON), 2011.
- **Declarative Automated Cloud Resource Orchestration.**
Changbin Liu, Boon Thau Loo, and Yun Mao.
ACM Symposium on Cloud Computing (SOCC), Cascais, Portugal, Oct 2011. (16.9% acceptance)
- **Cloud Resource Orchestration: A Data-Centric Approach.**
Changbin Liu, Yun Mao, Jacobus Van der Merwe, and Mary Fernandez.
In Proceedings of the biennial Conference on Innovative Data Systems Research (CIDR), Asilomar, CA, Jan 2011. (about 20% acceptance)
- **Declarative Policy-based Adaptive MANET Routing.**
Changbin Liu, Rick Correa, Xiaozhou Li, Prithwish Basu, Boon Thau Loo, and Yun Mao.
17th IEEE International Conference on Network Protocols (ICNP 2009), Princeton, New Jersey, Oct, 2009. (18.3% acceptance)

OTHER PUBLICATIONS

- **Declarative Constraint Optimization in Distributed Systems.**
Changbin Liu, and Boon Thau Loo.
Workshop on Languages for Distributed Algorithms (LADA), co-located with POPL, Jan 2012.
- **Recent Advances in Declarative Networking.**
Boon Thau Loo, Harjot Gill, Changbin Liu, Yun Mao, William R. Marczak, Micah Sherr, Anduo Wang, and Wenchao Zhou.
Fourteenth International Symposium on Practical Aspects of Declarative Languages (PADL), co-located with POPL, Jan 2012. (invited paper)
- **A Policy-based Constraint-solving Platform Towards Extensible Wireless Channel Selection and Routing.**
Changbin Liu, Xiaozhou Li, Shivkumar C. Muthukumar, Harjot Gill, Taher Saeed, Boon Thau Loo, and Prithwish Basu.
ACM Workshop on Programmable Routers for Extensible Services of TOMorrow (PRESTO), in conjunction with ACM CoNEXT, Philadelphia, PA, Dec 2010.
- **Formally Verifiable Networking.**
Anduo Wang, Limin Jia, Changbin Liu, Boon Thau Loo, Oleg Sokolsky, and Prithwish Basu.
8th Workshop on Hot Topics in Networks (ACM SIGCOMM HotNets-VIII), New York, Oct 2009. (16.0% acceptance)
- **RapidMesh: Declarative Toolkit for Rapid Experimentation of Wireless Mesh Networks.**
Shivkumar C. Muthukumar, Xiaozhou Li, Changbin Liu, Joseph B. Kopena, Mihai Oprea, Richardo Correa, Boon Thau Loo, and Prithwish Basu.
4th ACM International Workshop on Wireless Network Testbeds, Experimental Evaluation and Characterization (WiNTECH 2009), in conjunction with ACM MobiCom, Beijing, China, Sept, 2009.
- **A Theorem Proving Approach Towards Declarative Networking.**
Anduo Wang, Boon Thau Loo, Changbin Liu, Oleg Sokolsky, and Prithwish Basu.
22nd International Conference on Theorem Proving in Higher Order Logics (TPHOLs) emerging trends proceedings, Munich, Germany, Aug 2009.
- **A Declarative Perspective on Adaptive MANET Routing.**
Changbin Liu, Yun Mao, Mihai Oprea, Prithwish Basu, and Boon Thau Loo.
ACM SIGCOMM Workshop on Programmable Routers for Extensible Services of TOMorrow (PRESTO), Seattle, WA, Aug 2008.
- **Network Utility Maximization for Triple-Play Services.**
Lei Shi, Changbin Liu, and Bin Liu.
Computer Communications, Volume 31, Number 10, Feb 2008, Pages 2257-2269.
- **Max-min Utility Fairness in Link Aggregated Systems.**
Satya R. Mohanty, Changbin Liu, Bin Liu, and Laxmi N. Bhuyan.
High Performance Switching and Routing (HPSR), New York, NY, May 2007.
- **Utility Based Bandwidth Allocation for Triple-Play Services.**
Changbin Liu, Lei Shi, and Bin Liu.
European Conference on Universal Multiservice Networks (ECUMN), Toulouse, France, Feb 2007.

PATENTS

- Yun Mao, Mary Fernandez, Changbin Liu, Jacobus Van Der Merwe, U.S. Patent Application filed September 2011, AT&T Docket Number 2010-1037 – “Cloud Infrastructure Services”.
- Yun Mao, Changbin Liu, Boon Thau Loo, Jacobus Van der Merwe, U.S. Patent Application filed October 2011, AT&T Docket Number 2011-0012 – “Systems, Methods, and Articles of Manufacture to Provide Cloud Resource Orchestration”.

PROTOTYPE DEMONSTRATIONS

- **PUMA: Policy-based Unified Multi-radio Architecture for Agile Mesh Networking**
Tanveer Gill, Changbin Liu, Lu Ren, Harjot Gill, Boon Thau Loo and Prithwish Basu.
Submitted to 4th International Conference on Communication Systems and Networks (COMSNETS) (demo), Jan 2012.
- **Towards Transactional Cloud Resource Orchestration.**
Changbin Liu, Yun Mao, Xu Chen, Mary Fernandez, Boon Thau Loo, and Jacobus Van der Merwe.
8th USENIX Symposium on Networked Systems Design and Implementation (NSDI'11) (poster and demo), Boston, USA, Mar 2011.
- **Declarative Toolkit for Rapid Network Protocol Simulation and Experimentation.**
Shivkumar C. Muthukumar, Xiaozhou Li, Changbin Liu, Joseph B. Kopena, Mihai Oprea, and Boon Thau Loo.
ACM SIGCOMM Conference on Data Communication (demo), Barcelona, Spain, Aug 2009.
- **A Demonstration of the RapidMesh Development Toolkit.**
Xiaozhou Li, Shivkumar C. Muthukumar, Changbin Liu, Joseph B. Kopena, Mihai Oprea, Richardo Correa, Boon Thau Loo, and Prithwish Basu.
4th ACM International Workshop on Wireless Network Testbeds, Experimental Evaluation and Characterization (WiNTECH 2009) demonstration, in conjunction with ACM MobiCom, Beijing, China, Sept, 2009.

RESEARCH EXPERIENCE

University of Pennsylvania, research assistant, Sept 2007 - Present

- **Transactional automated cloud resource orchestration:** Lead student in designing and implementing: (1) A highly available transactional resource orchestration platform for building Infrastructure-as-a-Service (IaaS) cloud. Transactional orchestration procedures automatically guarantee atomicity, consistency, isolation and durability (ACID) properties for cloud operations. Transactional semantics provide a clean abstraction which enables cloud operators to focus on developing high level cloud services without worrying about the complexities of accessing and managing underlying volatile distributed resources; and (2) An automated resource orchestration platform that allows cloud operators to declaratively specify optimization goals and constraints based on provider operational objectives and customer service level agreements. Based on these specifications, orchestration commands are automatically generated to optimize resource configurations and allocations within the cloud. We validate our system prototype using realistic scenarios and workloads derived from production cloud services that orchestrate compute, storage, and network resources within and across geographically distributed data centers for load balancing and consolidation. This work is joint UPenn-AT&T Labs Research project, and has been published at CIDR'11, SOCC'11, VLDB'12 and USENIX ATC'12. In addition, two related U.S. patent applications have been filed. Please see <http://netdb.cis.upenn.edu/dmf> for more information.
- **Declarative Adaptive Wireless Networks (DAWN):** Lead student on the DAWN project focusing on the use of declarative policy languages to: (1) Synthesize a large variety of wireless routing protocols, including proactive, reactive, and epidemic; (2) Develop highly customizable hybrid protocols which can easily adapt to network connectivity and data traffic patterns based on specified policies; and (3) Construct a novel declarative constraint-solving architecture that achieves efficient adaptive policy-based routing and channel selection for multi-radio wireless mesh networks. Our work has been extensively evaluated in a cluster-based emulation platform as well as the ORBIT wireless testbed. Results have been published at PRESTO'08 and PRESTO'10 workshop, ICNP'09, TON'11 and COMSNETS'12. This project is in collaboration with Raytheon BBN Technologies under the DARPA Wireless Networks After Next (WNaN) program. Please see <http://netdb.cis.upenn.edu/puma> for more information.
- **RapidNet declarative networking engine:** RapidNet is an open-source development toolkit which provides a unified platform for rapid implementation, simulation and experimentation of network protocols. RapidNet utilizes declarative networking to specify network behavior by integrating a declarative networking engine with the emerging network simulator 3 (ns-3) platform. RapidNet has been demonstrated at SIGCOMM'09 and presented at WiNTECH'09, and actually deployed on the ORBIT wireless testbed. Please see <http://netdb.cis.upenn.edu/rapidnet> for more information.

- **Formally Verifiable Networking (FVN):** FVN is a novel approach towards unifying the design, specification, implementation, and verification of networking protocols within a logic-based framework. FVN utilizes theorem proving, a well established verification technique where logic-based axioms that automatically capture network semantics are generated, and a user-driven proof process is used to establish network correctness properties. We validate various protocols such as Border Gateway Protocol (BGP) and Hybrid Link State protocol, using both PVS theorem prover and real implementation and experimentation. Results have been published at HotNets'09 and TPHOLs'09. Please see <http://netdb.cis.upenn.edu/fvn> for more information.

Tsinghua University, undergraduate student, Jul 2006 - Jun 2007

- **Network utility maximization:** In the context of Next Generation Internet (NGI), we divided network traffic into several categories and proposed their corresponding utility functions. Based on utility analysis, we found some significant traffic characteristics that had previously gone unnoticed, and further we proposed highly efficient algorithms to achieve network utility maximization for network router's traffic scheduling and bandwidth allocation. Results have been published at ECUMN'07, HPSR'08, and Computer Communications.

PROFESSIONAL SERVICES

- External reviewer, International Conference on Logic Programming (ICLP), 2012.
- External reviewer, ACM Transactions on Database Systems (TODS), 2011.
- External reviewer, ACM Symposium on Cloud Computing (SOCC), 2011.
- Reviewer, Journal of Computer Systems, Networks, and Communications, 2011.
- Reviewer, Simulation Modeling Practice and Theory, International Journal of the Federation of European Simulation Societies, 2011.
- Reviewer, Computer Networks, the International Journal of Computer and Telecommunications Networking, 2011.
- External reviewer, ACM SIGMOD Conference, 2011.
- External reviewer, Biennial Conference on Innovative Data Systems Research (CIDR), 2011.
- Student volunteer, The 6th International Conference on emerging Networking EXperiments and Technologies (CoNEXT), 2010.
- External reviewer, ACM Workshop on Programmable Routers for Extensible Services of TOmorrow (PRESTO), 2010.
- External reviewer, International Performance Computing and Communications Conference (IPCCC), 2010.
- External reviewer, Annual Conference of ITA (ACITA) 2010.
- External reviewer, International workshop on Peer-To-Peer Systems (IPTPS), 2010
- External reviewer, ACM International Conference on emerging Networking EXperiments and Technologies (CoNEXT), 2009
- External reviewer, IEEE Global Communications Conference (GLOBECOM), 2009
- External reviewer, International Conference on Very Large Data Bases (VLDB), 2008, 2009
- External reviewer, Conference on Computer Communications (INFOCOM), 2009
- External reviewer, International Conference on Data Engineering (ICDE), 2009

WORK EXPERIENCE

- Research intern, AT&T Labs Research, Florham Park, NJ, Summer 2011, Summer 2010.
- Teaching Assistant, CIS 553/TCOM 512 - Networked System, Computer and Information Science Department, University of Pennsylvania, Fall 2008, Fall 2009.
- Grader, CIS 505 - Software System, Computer and Information Science Department, University of Pennsylvania, Spring 2009.

PROGRAMMING SKILLS

- Highly proficient in C++, Python, Matlab
- Proficient in Java, Perl, SQL, Lingo
- Operating system: Linux, Windows

SELECTED AWARDS AND HONORS

- COMSNETS-ACM SIGCOMM Student Travel Grant, 2012.
- Graduate Fellowship, University of Pennsylvania, 2007 - Present.
- Department Fellowship, Tsinghua University, Beijing, China 2006
- General Electric (GE) Fellowship, Tsinghua University, Beijing, China 2005
- Dongfeng Motor Group Co. Fellowship, Tsinghua University, Beijing, China 2004.
- Second Prize, Beijing Physics Contest for University Students, China, 2004
- Second Prize, National Mathematics Contest for High School Students, China, 2002