Si Liu

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Research Interests

Si Liu's research interests encompass formal methods (FM), software engineering (SE), and distributed systems, with a particular emphasis on **applying FM and SE techniques to build reliable, secure, and high-performance distributed systems**. His current work focuses on verifying and validating the **designs & deployments** of databases and DNS, addressing both **qualitative** (e.g., reliability and security) **& quantitative** (e.g., availability and scalability) aspects. He has also recently developed an interest in verifying AI-powered systems.

Education

University of Illinois Urbana-Champaign (UIUC)
PHD IN COMPUTER SCIENCE   *Aug. 2012 – May 2019*
• Advisor: Prof. Dr. Jose Meseguer

East China Normal University (ECNU)
MASTER IN COMPUTER SCIENCE   *Sep. 2009 – May 2012*

East China Normal University (ECNU)
BACHELOR IN SOFTWARE ENGINEERING   *Sep. 2005 – Jun. 2009*

Professional Experience

May 2023 – Present	**Senior Researcher (Deutsch: Oberassistent)**, ETH Zurich
Aug. 2019 – May 2023	**Postdoc Researcher**, ETH Zurich
Oct. 2014 – Sep. 2018	**Research Assistant**, Assured Cloud Computing Center, UIUC
Jun. 2011 – Aug. 2011	**Research Intern**, National Cyber-Physical Systems Camp, USTC
Sep. 2009 – May 2012	**Research Assistant**, Danish-Chinese Research Center, ECNU
May 2008 – Feb. 2009	**Software Engineering Intern**, Dept. of Talent House, Hewlett-Packard Co. Ltd.

Awards & Honors

2024	**Official Project Partner on the grant for Project "Formal Verification of Isolation Guarantees in Database Systems"**, SNSF (Swiss National Science Foundation)	*CHF 181,099*
2024	**Career Seed Award**, ETH Zurich	*CHF 30,000*
2024	**The ETH Medal for supervised Master thesis (Top 2.5%)**, ETH Zurich	
2023	**The ETH Medal for supervised Master thesis (Top 2.5%)**, ETH Zurich	
2012	**Outstanding Graduate Award (Ranked 1st)**, East China Normal University	
2011	**Excellent Student Award (Ranked 1st)**, East China Normal University	

Publications

∗ I contributed equally as a co-first author   † indicates the students I supervised

● FM/SE x DATABASES

Under Submission:

[VLDB'25] Zijing Yin†, **Si Liu**, David Basin. Testing Graph Databases with Synthesized Queries
[—'25] **Si Liu**∗, Zhiheng Cai∗, Hengfeng Wei. Uniso: A Unified Framework for Checking Database Isolation Guarantees

[—'25] Shabnam Ghasemirad[†], Christoph Sprenger, **Si Liu**, Luca Multazzu, David Basin. Pushing the Limit: Verified Performance-Optimal Causally Consistent Database Transactions

[—'25] Jiang Xiao[†], **Si Liu**, Hengfeng Wei. Boosting Database Isolation Checking via Mini-Transactions

Under Revision:

[VLDB'25] Shabnam Ghasemirad[†], **Si Liu**, Luca Multazzu, Christoph Sprenger, David Basin. VerIso: Verifiable Isolation Guarantees for Database Transactions

Published:

[OOPSLA'24] **Si Liu**, Long Gu, Hengfeng Wei, David Basin. Plume: Efficient and Complete Black-box Checking of Weak Isolation Levels

[SIGMOD'24] **Si Liu**, Luca Multazzu, Hengfeng Wei, David Basin. NOC-NOC: Towards Performance-optimal Distributed Transactions

[VLDB'24] Long Gu[†], **Si Liu**, Tiancheng Xing, Hengfeng Wei, Yuxing Chen, David Basin. IsoVista: Black-box Checking Database Isolation Guarantees. **Demo Track**

[VLDB'23] **Si Liu**[*], Kaile Huang[*], Zhenge Chen, Hengfeng Wei, David Basin, Haixiang Li, Anqun Pan. Efficient Black-box Checking of Snapshot Isolation in Databases

[OSDI'23] Zu-Ming Jiang, **Si Liu**, Manuel Rigger, Zhendong Su. Detecting Transactional Bugs in Database Engines via Graph-Based Oracle Construction

[OOPSLA'22] **Si Liu**, Jose Meseguer, Peter Csaba Olveczky, Min Zhang, David Basin. Bridging the Semantic Gap between Qualitative and Quantitative Models of Distributed Systems

[TOSEM'22] **Si Liu**. All in One: Design, Verification, and Implementation of SNOW-Optimal Read Atomic Transactions

● FM x DNS (AND BEYOND)

[POPL'25] Dhruv Nevatia[†], **Si Liu**, David Basin. Reachability Analysis of the Domain Name System. (conditionally accepted)

[USENIX SEC'24] Huayi Duan, Marco Bearzi, Jodok Vieli, Adrian Perrig, David Basin, **Si Liu**, Bernhard Tellenbach. CAMP: Compositional Amplification Attacks against DNS

[SIGCOMM'23] **Si Liu**, Huayi Duan, Lukas Heimes, Marco Bearzi, Jodok Vieli, Adrian Perrig, David Basin. A Formal Framework for End-to-End DNS Resolution

[NSDI'23] Huayi Duan, Fischer Ruben, Lou Jie, **Si Liu**, David Basin, Adrian Perrig. RHINE: Robust and High-performance Internet Naming with E2E Authenticity

[CSF'22] **Si Liu**[*], Thilo Weghorn[*], Christoph Sprenger, Adrian Perrig, David Basin. N-Tube: Formally Verified Secure Bandwidth Reservation in Path-Aware Internet Architectures

[Book Chapter] David Basin, Tobias Klenze, **Si Liu**, Christoph Sprenger. *Design-Level Verification* in *The Complete Guide to SCION: From Design Principles to Formal Verification.* 2022

[Book Chapter] Giacomo Giuliari, Markus Legner, **Si Liu**, Adrian Perrig, Thilo Weghorn, Marc Wyss. *Extensions for the Data Plane* in *The Complete Guide to SCION: From Design Principles to Formal Verification.* 2022

● FM/SE x AI

Under Submission:

[—'25] Shi Peng, **Si Liu**, Peixin Wang, Chenyang Xu, Cheng Chen, Dapeng Zhi, Min Zhang. ATA: An Abstract-Train-Abstract Approach for Explanation-Friendly Deep Reinforcement Learning

Published:

[CAV'24] Dapeng Zhi, Peixin Wang, **Si Liu**, Luke Ong, Min Zhang. Unifying Qualitative and Quantitative Safety Verification of DNN-Controlled Systems

[VMCAI'24]	Jiaxu Tian, Dapeng Zhi, **Si Liu**, Peixin Wang, Guy Katz, Min Zhang. Taming Reachability Analysis of DNN-Controlled Systems via Abstraction-Based Training
[NeurIPS'23]	Jiaxu Tian, Dapeng Zhi, **Si Liu**, Peixin Wang, Cheng Chen, Min Zhang. Boosting Verification of Deep Reinforcement Learning via Piece-Wise Linear Decision Neural Networks
[CVPR'23]	Zhaodi Zhang, Zhiyi Xue, Yang Chen, **Si Liu**, Yueling Zhang, Jing Liu, Min Zhang. Boosting Verified Training for Robust Image Classifications via Abstraction
[ISSTA'23]	Zhiyi Xue, **Si Liu**, Zhaodi Zhang, Yiting Wu, Min Zhang. A Tale of Two Approximations: Tightening Over-Approximation for DNN Robustness Verification via Under-Approximation
[ASE'22]	Zhaodi Zhang, Yiting Wu, **Si Liu**, Jing Liu, Min Zhang. Provably Tightest Linear Approximation for Robustness Verification of Sigmoid-like Neural Networks

PRIOR TO 2022:

[TASE'21]	Lei Liang, **Si Liu**. Exploring Design Alternatives for Replicated RAMP Transactions Using Maude
[NFM'20]	**Si Liu**, Atul Sandur, Jose Meseguer, Peter Olveczky, Qi Wang. Generating Correct-by-Construction Distributed Implementations from Formal Maude Designs
[TACAS'19]	**Si Liu**, Peter Csaba Olveczky, Min Zhang, Qi Wang, Jose Meseguer. Automatic Analysis of Consistency Properties of Distributed Transaction Systems in Maude.
[FAoC'19]	**Si Liu**, Peter Csaba Ölveczky, Qi Wang, Indranil Gupta, José Meseguer. Read Atomic Transactions with Prevention of Lost Updates: ROLA and Its Formal Analysis. *Formal Aspects of Computing*
[CCS'19]	Qi Wang, Pubali Datta, Wei Yang, **Si Liu**, Carl Gunter, Adam Bates. Charting the Attack Surface of Trigger-Action IoT Platforms.
[FASE'18]	**Si Liu**, Peter Csaba Ölveczky, Keshav Santhanam, Qi Wang, Indranil Gupta, José Meseguer. ROLA: A New Distributed Transaction Protocol and Its Formal Analysis.
[LITES'17]	**Si Liu**, Jatin Ganhotra, Muntasir Raihan Rahman, Son Nguyen, Indranil Gupta, José Meseguer. Quantitative Analysis of Consistency in NoSQL Key-value Stores. *Leibniz Transactions on Embedded Systems*
[ICFEM'17]	**Si Liu**, Peter Csaba Ölveczky, Jatin Ganhotra, Indranil Gupta, José Meseguer. Exploring Design Alternatives for RAMP Transactions through Statistical Model Checking.
[JLAMP'16]	**Si Liu**, Peter Csaba Ölveczky, José Meseguer. Modeling and Analyzing Mobile Ad hoc Networks in Real-Time Maude. *Journal of Logical and Algebraic Methods in Programming*
[SAC'16]	**Si Liu**, Peter Csaba Ölveczky, Muntasir Raihan Rahman, Jatin Ganhotra, Indranil Gupta, José Meseguer. Formal Modeling and Analysis of Ramp Transaction Systems.
[QEST'15]	**Si Liu**, Son Nguyen, Jatin Ganhotra, Muntasir Raihan Rahman, Indranil Gupta, José Meseguer. Quantitative Analysis of Consistency in NoSQL Key-value Stores. *Nominated for Best Paper.*
[ICFEM'14]	**Si Liu**, Muntasir Raihan Rahman, Stephen Skeirik, Indranil Gupta, José Meseguer. Formal Modeling and Analysis of Cassandra in Maude.
[PRDC'14]	Xi Wu, **Si Liu**, Huibiao Zhu and Yongxin Zhao. Reasoning about Group-Based Mobility in MANETs.
[ComSIS'13]	Xi Wu, Huibiao Zhu, Yongxin Zhao, Zheng Wang, **Si Liu**. Modeling and verifying the Ariadne protocol using process algebra. *Computer Science and Information Systems Journal*
[ECBS'12]	Xi Wu, **Si Liu**, Huibiao Zhu, Yongxin Zhao, Lei Chen. Modeling and Verifying the Ariadne Protocol Using CSP.
[HASE'11]	**Si Liu**, Yongxin Zhao, Huibiao Zhu, Qin Li. A Calculus for Mobile Ad Hoc Networks from a Group Probabilistic Perspective.
[SSIRI'11]	**Si Liu**, Xiaofeng Wu, Qin Li, Huibiao Zhu, Qian Wang. Formal Approaches to Wireless Sensor Networks.
[TASE'11]	**Si Liu**, Yongxin Zhao, Huibiao Zhu, Qin Li. Towards a Probabilistic Calculus for Mobile Ad Hoc Networks.
[TASE'11]	Mengying Wang, Huibiao Zhu, Yongxin Zhao, **Si Liu**. Modeling and Analyzing the μTESLA Protocol Using CSP.

[ICECCS'11] Yongxin Zhao, Yanhong Huang, Jifeng He, **Si Liu**. Formal Model of Interrupt Program from a Probabilistic Perspective.

[UTP'10] Qin Li, Yongxin Zhao, Xiaofeng Wu, **Si Liu**. Promoting Models.

WORKSHOP PAPERS

[WRLA'18] **Si Liu**, Peter Csaba Ölveczky, Qi Wang, José Meseguer. Formal Modeling and Analysis of the Walter Transactional Data Store.

[SSS'15] **Si Liu**, Peter Csaba Ölveczky and José Meseguer. Formal analysis of Leader Election in MANETs Using Real-Time Maude.

[WRLA'14] **Si Liu**, Peter Csaba Ölveczky and José Meseguer. A Framework for Mobile Ad hoc Networks in Real-Time Maude.

[SSIRI'11] Han Zhu, Huibiao Zhu, **Si Liu**, Jian Guo. Towards Denotational Semantics for Verilog in PVS.

OTHER BOOK CHAPTERS

- Rakesh Bobba, Jon Grov, Indranil Gupta, **Si Liu**, José Meseguer, Peter Csaba Ölveczky, Stephen Skeirik. Survivability: Design, Formal Modeling, and Validation of Cloud Storage Systems using Maude. 2018.

PHD THESIS

- Design, Verification and Automatic Implementation of Correct-by-Construction Distributed Transaction Systems in Maude. University of Illinois Urbana-Champaign. 2019

Teaching Experience

Fall 2024	**Computer Systems**, Teaching Assistant	*ETH Zurich*
Spring 2024	**Data Modeling and Databases**, Teaching Assistant	*ETH Zurich*
Fall 2023	**Computer Systems**, Teaching Assistant	*ETH Zurich*
Spring 2023	**Data Modeling and Databases**, Teaching Assistant	*ETH Zurich*
Fall 2022	**Information Systems for Engineers**, Head Teaching Assistant	*ETH Zurich*
Spring 2022	**Data Modeling and Databases**, Teaching Assistant	*ETH Zurich*
Fall 2021	**Applied Security Lab**, Teaching Assistant	*ETH Zurich*
Spring 2021	**Data Modeling and Databases**, Teaching Assistant	*ETH Zurich*
Fall 2020	**Computer Systems**, Teaching Assistant	*ETH Zurich*
Spring 2020	**Data Modeling and Databases**, Teaching Assistant	*ETH Zurich*
Fall 2019	**Applied Security Lab**, Teaching Assistant	*ETH Zurich*
Fall 2016	**Distributed Systems**, Teaching Assistant	*UIUC*
Fall 2011	**Process Algebra**, Teaching Assistant	*ECNU*
Spring 2011	**Algorithms and Data Structures**, Teaching Assistant	*ECNU*
Fall 2010	**Discrete Mathematics**, Teaching Assistant	*ECNU*
Spring 2010	**Algorithms and Data Structures**, Teaching Assistant	*ECNU*

Mentoring

- **PhD students**

  – Dhruv Nevatia (co-supervised with Prof. David Basin), ETH Zurich

  – Shabnam Ghasemirad (co-supervised with Dr. Christoph Sprenger and Prof. David Basin), ETH Zurich

  – Zijing Yin (co-supervised with Prof. David Basin), ETH Zurich

  – Ziwei Zhou (co-supervised with Prof. Min Zhang), ECNU

  – Shi Peng (co-supervised with Prof. Min Zhang), ECNU

- – Zhaodi Zhang (co-supervised with Prof. Min Zhang; first employment: Chengdu Education Research Institute), ECNU

- **Graduate students**

  - – Theodor Moroianu, ETH Zurich

  - – Yunxin Sun, ETH Zurich

  - – Yufei Zhang, ETH Zurich

  - – Rolando Grave de Peralta, ETH Zurich

  - – Zhou Zhou, ECNU

  - – Long Gu, Nanjing University

  - – Qiuhuan Xiong, Nanjing University

  - – Luca Multazz (first employment: SICPA), ETH Zurich

    - * honoured with the ETH Medal for his Master thesis "NOCS-Optimal Distributed Transactions and Beyon" (top 2.5%)

  - – Lukas Heimes (first employment: SBB CFF FFS), ETH Zurich

    - * honoured with the ETH Medal for his Master thesis "A Formal Framework for End-to-End DNS Resolution" (top 2.5%)

  - – Jodok Vieli (graduated), ETH Zurich

  - – Marco Bearzi (graduated), ETH Zurich

  - – Shabnam Ghasemirad (now PhD at ETH Zurich), ETH Zurich

  - – Jiang Xiao (first employment: Agricultural Bank of China), Nanjing University

  - – Teng Wang (first employment: Alibaba Cloud), Nanjing University

  - – Jiaxu Tian (first employment: CITIC Securities), ECNU

  - – Zhiyi Xue (now PhD at ECNU), ECNU

- **Undergraduate students**

  - – Tiancheng Xing (graduated, now Master at NUS), Nanjing University

  - – Zhiheng Cai (graduated, now PhD at Tsinghua University), Nanjing University

  - – Long Gu (graduated, now Master at Nanjing University), Nanjing University

  - – Zhenge Chen (graduated, now Master at UCSD), Nanjing University

  - – Zhou Zhou (graduated, now Master at ECNU), ECNU

  - – Ziwei Zhou (graduated, now PhD at ECNU), ECNU

  - – Ruiyang Liu (graduated, now Master at JHU), ECNU

  - – Lei Liang (graduated, now at CITIC Securities), ECNU

  - – Plamen Stefanov (graduated, now Master at ETH Zurich), ETH Zurich

  - – Keshav Santhanam (graduated, now PhD at Stanford University), UIUC

Professional Activities

- **Program Committee:** NSDI'25, ICFEM'24, ICFEM'23
- **Journal Reviewer:** JLAMP, SCP, The VLDB Journal
- **Sub-Reviewer:** ICFEM ('22, '16, '14, '13, '12, '11, '10), FM ('21, '18), FASE'14, TASE ('12, '11)
- **Judge:** Student Research Competition (SPLASH 2024)
- **Dagstuhl Seminar:** "Ensuring the Reliability and Robustness of Database Management Systems (21442)" 2021 (participant)
- **Grant Proposal:** preparing proposal for NSF CNS 1409416 ($584,508; 2014–2018), Availability-Consistency Tradeoffs in Key-Value and NoSQL Storage Systems

Talks & Presentations

- NOC-NOC: Towards Performance-optimal Distributed Transactions. SIGMOD'24, Santiago, Chile, 2024.
- Generating Correct-by-Construction Distributed Implementations from Formal Maude Designs. NFM'20, Virtual, 2020.
- Design, Verification and Automatic Implementation of Correct-by-Construction Distributed Transaction Systems in Maude. University Paris Diderot, France, 2019.
- Design, Verification and Automatic Implementation of Correct-by-Construction Distributed Transaction Systems in Maude. ETH Zurich, Switzerland, 2019.
- Automatic Analysis of Consistency Properties of Distributed Transaction Systems in Maude. TACAS'19, Prague, Czech Republic, 2019.
- Exploring Design Alternatives for RAMP Transactions through Statistical Model Checking. ICFEM'17, Xi'an, China, 2017.
- Design, Formal Modeling, and Validation of Cloud Storage Systems using Maude. Huawei, Urbana-Champaign, USA, 2017.
- Exploring Design Alternatives for the RAMP Transaction System Through Statistical Model Checking. Assured Cloud Computing Center, Urbana-Champaign, USA, 2017.
- Formal Modeling and Analysis of Ramp Transaction Systems. SAC'16, Pisa, Italy, 2016.
- Formal Modeling and Analysis of Ramp Transaction Systems. Assured Cloud Computing Center, Urbana-Champaign, USA, 2016.
- Quantitative Analysis of Consistency in NoSQL Key-value Stores. QEST'15, Madrid, Spain, 2015.
- Quantitative Analysis of Consistency in NoSQL Key-value Stores. Assured Cloud Computing Center, Urbana-Champaign, USA, 2015.
- A Framework for Mobile Ad hoc Networks in Real-Time Maude. WRLA'14, Grenoble, France, 2014.
- Formal Modeling and Analysis of Cassandra in Maude. Assured Cloud Computing Center, Urbana-Champaign, USA, 2014.
- A Calculus for Mobile Ad Hoc Networks from a Group Probabilistic Perspective. HASE'11, Boca Raton, USA, 2011.
- Towards a Probabilistic Calculus for Mobile Ad Hoc Networks. USTC, Suzhou, China, 2011.
- Towards a Probabilistic Calculus for Mobile Ad Hoc Networks. TASE'11, Xi'an, China, 2011.

- Formal Approaches to Wireless Sensor Networks. SSIRI'11, Jeju Island, Korea, 2011.