# Si Liu

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## Research Interests

Si Liu's research lies at the intersection of **formal methods**, **systems**, and **security**, with a strong focus on **leveraging formal verification techniques to build reliable, secure, and performant distributed systems**. In recent years, he has worked on verifying and validating both the **designs and deployments** of **databases** and **DNS**, addressing not only **qualitative** (e.g., reliability and security) but also **quantitative** (e.g., availability and scalability) aspects. He is also interested in the intersection of these areas with AI: both in applying AI techniques to strengthen verification, and in developing rigorous methods for verifying AI-powered systems themselves.

## Education

**University of Illinois Urbana-Champaign (UIUC)**
PhD in Computer Science — *Aug. 2012 – May 2019*

**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

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|---|---|
| Aug. 2025 – present | **Tenure-track Assistant Professor**, Texas A&M University |
| May 2023 – July 2025 | **Senior Researcher (Deutsch: Oberassistent)**, ETH Zurich |
| Aug. 2019 – Apr. 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

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|---|---|---|
| Mar. 2024 – Mar. 2027 | **Official Project Partner on the grant for Project "Formal Verification of Isolation Guarantees in Database Systems"**, SNSF (Swiss National Science Foundation) | *CHF 181,099* |
| Aug. 2024 – July 2025 | **Career Seed Award**, ETH Zurich | *CHF 30,000* |
| 2024 | **Thesis supervisor for Luca Multazz, recipient of the ETH Medal for his Master thesis (Top 2.5%)**, ETH Zurich | |
| 2023 | **Thesis supervisor for Lukas Heimes, recipient of the ETH Medal for his 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 (recent)

**[FM'26]** **Si Liu**[*], Ziwei Zhou[*], Zhou Zhou, Peixin Wang, Min Zhang. A Formal Framework for Predicting Distributed System Performance under Faults

**[VLDB'26]** Zhiheng Cai[†], **Si Liu**, Hengfeng Wei, Yuxing Chen, Anqun Pan. Fast Verification of Strong Database Isolation

**[SIGMOD'26]** Zijing Yin[†], **Si Liu**, David Basin. Testing Graph Databases with Synthesized Queries

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

**[ICDE'25]** Hengfeng Wei, Jiang Xiao, Na Yang, **Si Liu**, Zijing Yin, Yuxing Chen, Anqun Pan. Boosting End-to-End Database Isolation Checking via Mini-Transactions

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

**[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 Security (DNS and beyond)

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

**[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

## • Other Publications

**[NN'25]** Shi Peng, **Si Liu**, Dapeng Zhi, Peixin Wang, Chenyang Xu, Cheng Chen, Min Zhang. ATA: An Abstract-Train-Abstract approach for explanation-friendly deep reinforcement learning. Neural Networks, 2025

**[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

**[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 $\mu$TESLA 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

- I am fortunate to have the opportunity to work with the following talented students:
- **PhD students (6 in total)**
  - Dhruv Nevatia (co-advising with Prof. David Basin), ETH Zurich
  - Shabnam Ghasemirad (co-advising with Dr. Christoph Sprenger and Prof. David Basin), ETH Zurich
  - Zijing Yin, ETH Zurich
  - Ziwei Zhou, ECNU
  - Shi Peng, ECNU
  - Zhaodi Zhang, ECNU

- **Graduate students (21 in total, including two who were awarded the ETH Medal)**
  - Kumaran Gowrisankar, Texas A&M University
  - Sahithi Duppati, Texas A&M University
  - Jaelen Dixon, Texas A&M University
  - Shashank Chandavarkar, Texas A&M University
  - Wenyuan Jiang, ETH Zurich
  - Rongchuan Liu, ETH Zurich
  - 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, ETH Zurich
    - **honoured with the ETH Medal for his Master thesis "NOCS-Optimal Distributed Transactions and Beyon" (top 2.5%)**
  - Lukas Heimes, 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, ETH Zurich
  - Marco Bearzi, ETH Zurich
  - Shabnam Ghasemirad (now PhD at ETH Zurich), ETH Zurich
  - Jiang Xiao, Nanjing University
  - Jiaxu Tian, ECNU
  - Zhiyi Xue, ECNU
- **Undergraduate students (11 in total)**
  - Bosheng Peng, Nanjing University
  - Tiancheng Xing, Nanjing University
  - Zhiheng Cai, Nanjing University
  - Long Gu, Nanjing University
  - Zhenge Chen, Nanjing University
  - Zhou Zhou, ECNU
  - Ziwei Zhou, ECNU

- Ruiyang Liu, ECNU
- Lei Liang, ECNU
- Plamen Stefanov, ETH Zurich
- Keshav Santhanam, UIUC

## Professional Activities

- **Program Committee:** DASFAA'26, NSDI'25, ICFEM'24, ICFEM'23, ICFEM'22
- **Journal Reviewer:** The VLDB Journal, Journal of Logical and Algebraic Methods in Programming, Autonomous Agents and Multi-Agent Systems, Theory of Computing Systems
- **Sub-Reviewer:** ICFEM ('16, '14, '13, '12, '11, '10), FM ('21, '18), FASE'14, TASE ('12, '11)
- **Judge:** Student Research Competition (SPLASH 2024), Texas Junior Academy of Science (TJAS) 2025
- **Dagstuhl Seminar:** "Ensuring the Reliability and Robustness of Database Management Systems (21442)" 2021 (participant)
- **Grant:**
  - Official Project Partner on the SNSF grant for Project "Formal Verification of Isolation Guarantees in Database Systems" (CHF 181,099; 2024–2027)
  - Preparing the proposal for NSF CNS 1409416 ($584,508; 2014–2018), Availability-Consistency Tradeoffs in Key-Value and NoSQL Storage Systems

## Invited Talks & Presentations

- Making Database Transactions Reliable and Performant: from Design to Deployment. Department of Computer Science, Aarhus University, 2025.
- Making Database Transactions Reliable and Performant: from Design to Deployment. Department of Computer Science, UC Irvine, 2025.
- Making Database Transactions Reliable and Performant: from Design to Deployment. Department of Computer Science and Engineering, Texas A&M University, 2025.
- Making Database Transactions Reliable and Performant: from Design to Deployment. Department of Computer Science, UT Dallas, 2025.
- Making Database Transactions Reliable and Performant: from Design to Deployment. School of Computer Science and Engineering, UNSW Sydney, 2025.
- Making Database Transactions Reliable and Performant: from Design to Deployment. School of Computer Science, University of Sydney, 2025.
- Making Database Transactions Reliable and Performant: from Design to Deployment. School of Data Science, The Chinese University of Hong Kong (Shenzhen), 2025.
- Making Distributed Systems Dependable and Performant: from Design to Deployment. School of Computer Science and Technology, Nanjing University, 2024.
- Plume: Efficient and Complete Black-box Checking of Weak Isolation Levels. OOPSLA'24, Pasadena, USA, 2024.
- 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.

## Referees

**Prof. José Meseguer**
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[1] Ms. Allison Mette is managing emails on behalf of Prof. José Meseguer, and this is her email address (along with her phone number).

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