Gengrui Zhang

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(Updated in July 2022)

RESEARCH INTERESTS

My research interests focus on the core problems in distributed systems, especially consensus algorithms and fault tolerance. My current research studies aim to develop algorithms and architectures that build up fault-tolerant, high-performance, highly scalable, and highly available distributed systems. I am especially interested in developing consensus algorithms binding efficiency and robustness under various fault-tolerant models including benign and Byzantine failures, and applying theoretical problems to real-world applications. Towards these objectives, I am also broadly interested in questions related to distributed computing theories, consistency models, blockchains, P2P systems, cloud/distributed databases, microservices, serverless computing, and systems for AI.

EDUCATION

University of Toronto — Toronto, ON, Canada
Ph.D. Candidate, Electrical & Computer Engineering — 2019 - present
Dissertation: *"Reputation-based Consensus Algorithms: Binding Efficiency and Robustness"*
Advisor: Prof. Hans-Arno Jacobsen (*IEEE Fellow*)

University of Chinese Academy of Sciences — Beijing & Shenzhen, China
Master of Applied Science, Computer Science — 2015 - 2018
Thesis: *"Digital Content Protection Using Blockchain Technologies"*
Advisor: Prof. Cheng-Zhong Xu (*IEEE Fellow*)

Hunan University (Talent Program) — Changsha, HN, China
Bachelor of Applied Science, Computer Science — 2011 - 2015
Thesis: *"Design and Implementation of GraphX Algorithms using Apache Spark"*
Advisor: Prof. Ken-Li Li

INDUSTRY EXPERIENCE

Tencent Technology Co. Ltd — Shenzhen, GD, China
Back-end System Development Engineer, Platform & Content Group (PCG) — 2018

▷ Job duties were responsible for designing and implementing production systems for the backend of advertising platforms, including proxy servers (interacting with the frontend), user profile matching, ads recommendation calculation, caches for fetching and storing ads from databases, second-price auctions for ads, and revenue monitoring systems.

FELLOWSHIPS & AWARDS

ECE Student Fellowship, University of Toronto 2019 - 2022

Research Fellowship, University of Toronto 2019 - 2022

Outstanding Student, University of Chinese Academy of Sciences 2017

University Individual Scholarship, Hunan University 2012 - 2014

Best Paper Award

- The 13th International Conference on Green, Pervasive and Cloud Computing 2018

Prize of Excellence, Asia SuperComputer Challenge 2014

Proud Team Award, Asia SuperComputer Challenge 2013

PROJECTS CONDUCTED

Reputation-based Consensus Algorithms. This project develops high-performance BFT consensus algorithms incorporating server reputation to suppress faulty servers from leading consensus. It generalizes a meta-consensus framework for calculating server reputation and adapting system configuration changes. It has the following major novel features. ▷ NSERC

- Behavior-aware server reputation calculation under Byzantine failures.
- Robust active view changes suppressing suspected faulty servers from gaining leadership.
- Increased system availability with long-term punitive mechanisms on faulty servers.

Fast replication for cloud/distributed databases. This project aims to develop fast state machine replication (SMR) protocols for cloud/distributed databases. It creates a logical quorum layer mapping to the participation of physical servers by assigning them different weights. It enables fast SMR replication in cloud/distributed databases with the following novelties. ▷ NSERC

- Weighted server participation creating logical quorums for reaching consensus.
- Enabling fast SMR replication with quorum sizes less than $2f+1$ under normal operation.

Blockchains for V2X networks. This project achieves security, privacy, and trust in blockchain-based V2X (5/6G) networks. It develops a permissioned blockchain (V-Guard) that breaks the data monopoly of centralized vehicular platforms with the following features. ▷ Huawei Canada

- Dynamic quorum constructors enabling consensus under intermittent on/off-line vehicles.
- Separation of ordering and consensus, achieving low-latency transaction ordering and high-throughput consensus.
- Efficient garbage collection in (vehicle) storage devices with a limited space.

Fast Leader Election in Consensus. This project attains a fast leader election protocol in leader-based consensus algorithms using voting-based election mechanisms. The protocol takes Raft as an example and fundamentally solves split votes by dynamically prioritizing servers based on their logs, electing the highest-priority server as a leader without suffering from competition. ▷ NSERC

- It dynamically assigns a higher priority to a more up-to-date server with the most recent logs.
- It prepares a pool of differently prioritized servers as future leaders where the highest-priority server becomes the next leader.

PUBLICATIONS

▷ Conference Papers:

- **Gengrui Zhang**, Fei Pan, Sofia Tijanic, and Hans-Arno Jacobsen. Prestige BFT: A Reputation-based Byzantine Fault-tolerant Consensus Algorithm. (*Under review*)
- **Gengrui Zhang**, Yunhao Mao, Shashank Motepalli, Shiquan Zhang and Hans-Arno Jacobsen. V-Guard: A High Performance Consensus Protocol for V2X Permissioned Blockchains. (*Under review*)
- **Gengrui Zhang** and Hans-Arno Jacobsen. Escape to Precaution against Leader Failures. *In 2022 IEEE 42nd International Conference on Distributed Computing Systems, 2022.* **(ICDCS'22)** (*Acceptance rate:* 19.9%)
- **Gengrui Zhang** and Hans-Arno Jacobsen. Prosecutor: An Efficient BFT Consensus Algorithm with Behavior-aware Penalization against Byzantine Attacks. *In Proceedings of the 22nd International Middleware Conference, 2021.* **(Middleware'21)** (*Acceptance rate:* 25.9%)
- James Meijers, Edward Au, Yuxi Cai, Hans-Arno Jacobsen, Shashank Motepalli, Robert Sun, Andreas Veneris, **Gengrui Zhang**, and Shiquan Zhang. Blockchain for V2X: A Taxonomy of Design Use Cases and System Requirements. *In 2021 3rd Conference on Blockchain Research & Applications for Innovative Networks and Services (BRAINS). IEEE, 2021* (*Author names in alphabetical order except the first author*)
- **Gengrui Zhang** and Chengzhong Xu. An Efficient Consensus Protocol for Real-time Permissioned Blockchains under non-Byzantine Conditions. *In International Conference on Green, Pervasive, and Cloud Computing. Springer, 2018* **(Best Paper Award)**

▷ Journal Articles:

- **Gengrui Zhang** and Hans-Arno Jacobsen. Prosecutor+: An Efficient BFT Consensus Algorithm with Behavior-aware Penalization and Proactive Recovery. (*Under review*)
- **Gengrui Zhang**, Fei Pan, Michael Dang'ana, Yunhao Mao, Shashank Motepalli, Shiquan Zhang, and Hans-Arno Jacobsen. Reaching Consensus in the Byzantine Empire: A Comprehensive Review of BFT Consensus Algorithms. *arXiv preprint arXiv:2204.03181, 2022* (*Under review*)
- James Meijers, Panagiotis Michalopoulos, Shashank Motepalli, **Gengrui Zhang**, Shiquan Zhang, Andreas Veneris, and Hans Arno Jacobsen. Blockchain for V2X: Applications and Architectures. *IEEE Open Journal of Vehicular Technology, 2022*

PATENT

- **Gengrui Zhang**, Hans-Arno Jacobsen, and Sheng Sun. Method and System for Creating a Distributed Ledger of Verified Vehicle Transactions (invention disclosure submission). 2022.
- **Gengrui Zhang**, Tongxin Bai, and Chengzhong Xu. A Second-hand Vehicle Transaction Method, Apparatus and System based on Blockchain Technology. CN 106897887 A[P]. 2017.

INVITED TALKS

"Fairness in Byzantine Consensus"

- Macau University, Macau SAR, China, 2021.04

"Scaling Byzantine Consensus"

- Blockchain ACM SACMAT, Toronto, Canada, 2019.06

"Optimizing Consensus Algorithms for Permissioned Blockchains"

- Blockchain Week, Toronto, Canada, 2019.04

"Untangling Blockchain Consensus Protocols from Blockchain 1.0 to 2.0"

- Tencent, Shenzhen, China, 2018.04

"High-level Comparisons between Permissionless and Permissioned Blockchains"

- SIAT-CAS, Shenzhen, China, 2017.11

TEACHING EXPERIENCE

▷ **Graduate level courses:**

- **ECE1770 Trends in Middleware: Blockchain Technology (*Winter*)** 2022
  Head TA, University of Toronto
- **ECE1770 Trends in Middleware: Blockchain Technology (*Winter*)** 2021
  Guest Lecture (Raft consensus algorithm), University of Toronto
- **ECE1762 Algorithms and Data Structures (*Winter*)** 2020 - 2021
  TA, University of Toronto

▷ **Undergrad level courses:**

- **ECE419 Distributed Systems (*Winter*)** 2019 - 2022
  Head TA, University of Toronto
- **ECE345 Algorithms and Data Structures (*Fall*)** 2019 - 2021
  TA, University of Toronto
- **ECE244 Programming Fundamentals (*Fall*)** 2019 - 2021
  TA, University of Toronto
- **CSC263 Data Structures and Analysis (*Winter*)** 2021
  TA, University of Toronto
- **CSC148 Introduction to Computer Science (*Winter*)** 2022
  TA, University of Toronto

SUPERVISION

Co-supervised design projects (4th-year capstone):

- AI-Enabled Traffic Camera Feed Transcription 2021
  Students: Andrew Lau, Chunqiu (Steven) Xia, Robert Dermarkar
- Consensus Protocol Visualization Engine 2020
  Github: https://github.com/ConsensusVisualization/protocols
  Students: Robert Fairley, Yannan (Walter) Lin, Abhishek Patil, and Daniel Hu
- Consensus Protocol Visualization Engine 2020
  Students: Jinzhuo (Sarah) Tang, Xian (Shirley) Zhou, Yichen Wang, Yuchen Wang

REVIEW AND SERVICE

Conferences:

- ACM/IFIP International Middleware Conference (Middleware) 2019 - 2022
- International Conference on Distributed Computing Systems (ICDCS) 2019
- IEEE International Conference on Blockchain (IEEE Blockchain) 2019

Journals:

- Journal of Parallel and Distributed Computing (JDBC) 2018