Kuo Zhao

CSIRO's Data61
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Qualifications

02/2018–03/2022 **Doctor of Philosophy**,
Faculty of Information Technology, Monash University

PhD thesis: Efficient Implementation Techniques for Lattice-based Cryptosystems
Supervisors: Associate Professor Ron Steinfeld and Dr. Amin Sakzad
Key Projects and Achievements:
Discrete Gaussian Sampling Algorithms **[1, 2]**

- I created *two new* discrete Gaussian sampling algorithms. Discrete Gaussian sampling is a crucial algorithm used by the post-quantum cryptography.
- My algorithms are *faster*, consuming *less* memory, and/or supporting a *wider* range of discrete Gaussian distributions, compared to previous techniques.
- My techniques have been adopted by the FALCON, a post-quantum digital signature scheme approved by the NIST.

Post-quantum Privacy Preserving Protocols **[3, 4, 5, 6]**

- I investigated the implementation aspects for post-quantum privacy preserving protocol primitives, in *ongoing* research collaborations with researchers in the Monash University. These protocols, including the Ring Confidential Transactions and the Verifiable Random Function, are crucial for cryptocurrencies such as the Monero and the Algorand.
- I developed *efficient* proof-of-concept implementations for these cryptography primitives. My implementations are *faster* than previous post-quantum solutions for the same protocol.
- Four media articles (1, 2, 3, 4) have been released by the CSIRO and/or the Monash University.

02/2016–12/2017 **Master of Networks and Security**,
Faculty of Information Technology, Monash University

Minor thesis: Efficient implementation techniques for lattice-based crypto
Achievements:

- Dux of Postgraduate (Master of Networks and Security), Cliff Bellamy Awards 2018, Monash University.

09/2011–06/2015 **Bachelor of Engineering**,
College of Computer Science & Technology, Zhejiang University, China

Employments

11/2022–now **Postdoctoral Fellow**,
Data61 Cybersecurity and Quantum Systems Group, CSIRO

Key Projects:

***GPU-accelerated Falcon Digital Signature Scheme* [7]**

- I *initiated* a research collaboration with researchers from the Gachon University, South Korea.
- I created *new* techniques to solve the unique challenges of efficiently implementing the Falcon, a post-quantum digital signature scheme approved by the NIST, on a GPU. My techniques increase the throughput of a crucial algorithm in Falcon by *ten times* on a GPU.
- We developed the *first* GPU-accelerated *high-throughput* implementation of Falcon.

eMLE-Sig 2.0 Digital Signature Scheme

- I developed an *efficient* software implementation of the eMLE-Sig 2.0, a new post-quantum digital signature scheme designed by the CSIRO. For the same cryptography security level, my implementation is *faster* than the NIST-approved post-quantum digital signature algorithms.
- I created *new* techniques to significantly *accelerate* the arithmetic computations in the eMLE-Sig 2.0.
- My implementation has been submitted to the Call for Additional Digital Signature Schemes for the Post-Quantum Cryptography Standardization Process by the NIST.

Achievements:

- I received the SCS Biannual Award May 2023 (Engineering and Technology Award), about *six months* after I joined CSIRO's Data61, for my *innovations* in the two key projects above.
- I was invited and served as a Program Committee member for the Asiacrypt 2023 conference.

08/2021–10/2022 **Research Assistant**,
Faculty of Information Technology, Monash University

Key Projects and Achievements:

***Latte Hierarchical Identity-based Encryption* [8]**

- I *initiated* a research collaboration with researchers from the University of Waterloo, Canada, and the Queen's University Belfast, United Kingdom.
- I developed the *first* complete optimized practical implementation of Latte, a post-quantum Hierarchical Identity-based Encryption scheme endorsed by the ETSI.
- I created *new* optimization techniques for the algorithms in Latte. My techniques significantly *accelerate* the algorithms, and *reduce* the key and ciphertext sizes. For one crucial algorithm, my techniques only take *less than a second* on a desktop computer, significantly *faster* than the order of minutes previously estimated by the ETSI.

Implementation of Post-Quantum Algorithms for Bouncy Castle Library

- I was a Chief Investigator for the project of post-quantum cryptography integration in the Bouncy Castle, an *Australian sovereign* software cryptography library.
- I was part of the supervision team, providing cryptography engineering insights and guidance to four student research assistants.
- My name has been listed on the Contributors of the Bouncy Castle.

02/2018–10/2022 **Teaching Associate**,
Faculty of Information Technology, Monash University

06/2017–11/2017 **Research Assistant**,
Faculty of Information Technology, Monash University

Key Projects and Achievements:

***Titanium Key Encapsulation Mechanism* [9]**

- I developed an *efficient* and *secure* software implementation of the Titanium, a new post-quantum Key Encapsulation Mechanism designed by the Monash University.
- I created *new* techniques to significantly *accelerate* the arithmetic computations in the Titanium.
- My implementation has been submitted to the Post-Quantum Cryptography Standardization Process by the NIST.

Referees

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Dr Amin Sakzad
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Monash University
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Publications

[1] Zhao, Raymond K. ; Steinfeld, Ron ; Sakzad, Amin: FACCT: FAst, Compact, and Constant-Time Discrete Gaussian Sampler over Integers. In: *IEEE Trans. Computers* 69 (2020), Nr. 1, S. 126–137

[2] Zhao, Raymond K. ; Steinfeld, Ron ; Sakzad, Amin: COSAC: COmpact and Scalable Arbitrary-Centered Discrete Gaussian Sampling over Integers. In: *PQCrypto* Bd. 12100, Springer, 2020 (Lecture Notes in Computer Science), S. 284–303

[3] Esgin, Muhammed F. ; Zhao, Raymond K. ; Steinfeld, Ron ; Liu, Joseph K. ; Liu, Dongxi: MatRiCT: Efficient, Scalable and Post-Quantum Blockchain Confidential Transactions Protocol. In: *CCS*, ACM, 2019, S. 567–584

[4] Esgin, Muhammed F. ; Steinfeld, Ron ; Zhao, Raymond K.: Efficient Verifiable Partially-Decryptable Commitments from Lattices and Applications. In: *Public Key Cryptography (1)* Bd. 13177, Springer, 2022 (Lecture Notes in Computer Science), S. 317–348

[5] Esgin, Muhammed F. ; Steinfeld, Ron ; Zhao, Raymond K.: MatRiCT+: More Efficient Post-Quantum Private Blockchain Payments. In: *IEEE Symposium on Security and Privacy*, IEEE, 2022, S. 560–577

[6] Esgin, Muhammed F. ; Ersoy, Oguzhan ; Kuchta, Veronika ; Loss, Julian ; Sakzad, Amin ; Steinfeld, Ron ; Yang, Xiangwen ; Zhao, Raymond K.: A New Look at Blockchain Leader Election: Simple, Efficient, Sustainable and Post-Quantum. In: *AsiaCCS*, ACM, 2023, S. 623–637

[7] Lee, Wai-Kong ; Zhao, Raymond K. ; Steinfeld, Ron ; Sakzad, Amin ; Hwang, Seong O.: High Throughput Lattice-based Signatures on GPUs: Comparing Falcon and Mitaka. In: *IEEE Transactions on Parallel and Distributed Systems* (2024), S. 1–18. http://dx.doi.org/10.1109/TPDS.2024.3367319. – DOI 10.1109/TPDS.2024.3367319

[8] Zhao, Raymond K. ; McCarthy, Sarah ; Steinfeld, Ron ; Sakzad, Amin ; O'Neill, Máire: Quantum-Safe HIBE: Does It Cost a Latte? In: *IEEE Trans. Inf. Forensics Secur.* 19 (2024), S. 2680–2695

[9] Steinfeld, Ron ; Sakzad, Amin ; Zhao, Raymond K.: Practical MP-LWE-based encryption balancing security-risk versus efficiency. In: *Des. Codes Cryptogr.* 87 (2019), Nr. 12, S. 2847–2884

[10] Tasopoulos, George ; Li, Jinhui ; Fournaris, Apostolos P. ; Zhao, Raymond K. ; Sakzad, Amin ; Steinfeld, Ron: Performance Evaluation of Post-Quantum TLS 1.3 on Resource-Constrained Embedded Systems. In: *ISPEC* Bd. 13620, Springer, 2022 (Lecture Notes in Computer Science), S. 432–451

[11] Tasopoulos, George ; Dimopoulos, Charis ; Fournaris, Apostolos P. ; Zhao, Raymond K. ; Sakzad, Amin ; Steinfeld, Ron: Energy Consumption Evaluation of Post-Quantum TLS 1.3 for Resource-Constrained Embedded Devices. In: *CF*, ACM, 2023, S. 366–374