

List of projects

1. Implement the **Identity-based Encryption** scheme of [BF01] based on pairings. Discuss similarities with BLS signature scheme [BLS01].
2. Implement one of the following from [GS08]: NIZK or NIWI.
3. **Verifiable Delay Functions**. Implement one of the following VDF's and discuss what are the applications of this primitive (see [BBBF18]):
 - Wesolowski VDF [Wes19].
 - Pietrzak VDF [Pie19b].
4. Implement (Partial) **Homomorphic Time-Lock Puzzles** [MT19]. Discuss its applications. How can you build a Fully-Homomorphic Time-Lock Puzzles?
5. Implement one of the following **Proof of retrievability**:
 - Shackam-Waters PoR [SW08].
 - Dodis-Vadhan-Wichs PoR [DVW09].
6. Implement one of the following:
 - **Proof of Replicated Storage** from [DGO19].
 - **Proof of Catalytic Space** from [Pie19a]
 - **Proof of Replicated Storage** from [Fis19].
7. Implement one of the following:
 - **Proof of Sequential Work** from [CP18].
 - **Incremental Proof of Sequential Work** from [DLM19].
 - **Reversible Proofs of Sequential Work** from [AKK⁺19]
 - **Proof of Storage** from [DFKP15].
 - Proof of Storage from [Fis19].
8. Implement **Oblivious Linear Evaluation** scheme from [CDI⁺19] based on the Pailler cryptosystem. How can you use this scheme to perform non-interactive MPC.
9. Implement the **Trapdoor hash function** from one of the following assumptions: DDH, QR or LWE. [DGI⁺19].
10. Implement the **LPN-based cryptosystem** from [Döt15]. What special security properties this scheme has?
11. Implement the **Oblivious Transfer** protocol from [PVW08] from one of the following assumptions: DDH, QR or LWE.
12. Implement **Lossy Functions** from [PW08]
13. Implement one of the **Trapdoor Function** from DDH from [GH18], [GGH19] or [DGH⁺19]

14. Implement the **GSW Encryption** scheme [GSW13] (no need to implement the bootstrap technique).
15. Implement the **Bideniable Encryption scheme** from [OPW11] (from any of the assumptions).
16. Implement the **Non-Committing encryption** scheme from [YKT19].
17. Implement the **PRF** from [BPR12].
18. Implement the **Private Set Intersection** protocol from [KS05].
19. Implement the **Unbalanced Private Set Intersection** from [CLR17].
20. Implement the **Rainbow** [DS05] or the **Unbalanced Oil and Vinegar** [KPG99] signature scheme.
21. Implement the **Key-Homomorphic Pseudorandom Function** from [BLMR13].
22. Implement the **Hybrid Key-Encapsulation Mechanism** from [BBF⁺19] (using your favourite classical and post-quantum cryptosystems).
23. Implement one of the following signature schemes based on RSA [HW09a, HW09b, HW18].
24. Implement the **Verifiable Random Function** of [DY05].
25. Implement the Non-Malleable Code of [DPW18].
26. Implement the authentication protocol of [CKT16] or the one from [LM13].
27. Implement the Mersenne Prime Cryptosystem from [AJPS18].

References

- [AJPS18] Divesh Aggarwal, Antoine Joux, Anupam Prakash, and Miklos Santha. A new public-key cryptosystem via Mersenne numbers. In Hovav Shacham and Alexandra Boldyreva, editors, *Advances in Cryptology – CRYPTO 2018, Part III*, volume 10993 of *Lecture Notes in Computer Science*, pages 459–482, Santa Barbara, CA, USA, August 19–23, 2018. Springer, Heidelberg, Germany.
- [AKK⁺19] Hamza Abusalah, Chethan Kamath, Karen Klein, Krzysztof Pietrzak, and Michael Walter. Reversible proofs of sequential work. In Yuval Ishai and Vincent Rijmen, editors, *Advances in Cryptology – EUROCRYPT 2019, Part II*, volume 11477 of *Lecture Notes in Computer Science*, pages 277–291, Darmstadt, Germany, May 19–23, 2019. Springer, Heidelberg, Germany.
- [BBBF18] Dan Boneh, Joseph Bonneau, Benedikt Bünz, and Ben Fisch. Verifiable delay functions. In Hovav Shacham and Alexandra Boldyreva, editors, *Advances in Cryptology – CRYPTO 2018, Part I*, volume 10991 of *Lecture Notes in Computer Science*, pages 757–788, Santa Barbara, CA, USA, August 19–23, 2018. Springer, Heidelberg, Germany.
- [BBF⁺19] Nina Bindel, Jacqueline Brendel, Marc Fischlin, Brian Goncalves, and Douglas Stebila. Hybrid key encapsulation mechanisms and authenticated key exchange. In Jintai Ding and Rainer Steinwandt, editors, *Post-Quantum Cryptography - 10th International Conference, PQCrypto 2019*, pages 206–226, Chongqing, China, May 8–10 2019. Springer, Heidelberg, Germany.

- [BF01] Dan Boneh and Matthew K. Franklin. Identity-based encryption from the Weil pairing. In Joe Kilian, editor, *Advances in Cryptology – CRYPTO 2001*, volume 2139 of *Lecture Notes in Computer Science*, pages 213–229, Santa Barbara, CA, USA, August 19–23, 2001. Springer, Heidelberg, Germany.
- [BLMR13] Dan Boneh, Kevin Lewi, Hart William Montgomery, and Ananth Raghunathan. Key homomorphic PRFs and their applications. In Ran Canetti and Juan A. Garay, editors, *Advances in Cryptology – CRYPTO 2013, Part I*, volume 8042 of *Lecture Notes in Computer Science*, pages 410–428, Santa Barbara, CA, USA, August 18–22, 2013. Springer, Heidelberg, Germany.
- [BLS01] Dan Boneh, Ben Lynn, and Hovav Shacham. Short signatures from the Weil pairing. In Colin Boyd, editor, *Advances in Cryptology – ASIACRYPT 2001*, volume 2248 of *Lecture Notes in Computer Science*, pages 514–532, Gold Coast, Australia, December 9–13, 2001. Springer, Heidelberg, Germany.
- [BPR12] Abhishek Banerjee, Chris Peikert, and Alon Rosen. Pseudorandom functions and lattices. In David Pointcheval and Thomas Johansson, editors, *Advances in Cryptology – EUROCRYPT 2012*, volume 7237 of *Lecture Notes in Computer Science*, pages 719–737, Cambridge, UK, April 15–19, 2012. Springer, Heidelberg, Germany.
- [CDI⁺19] Melissa Chase, Yevgeniy Dodis, Yuval Ishai, Daniel Kraschewski, Tianren Liu, Rafail Ostrovsky, and Vinod Vaikuntanathan. Reusable non-interactive secure computation. In Alexandra Boldyreva and Daniele Micciancio, editors, *Advances in Cryptology – CRYPTO 2019, Part III*, volume 11694 of *Lecture Notes in Computer Science*, pages 462–488, Santa Barbara, CA, USA, August 18–22, 2019. Springer, Heidelberg, Germany.
- [CKT16] David Cash, Eike Kiltz, and Stefano Tessaro. Two-round man-in-the-middle security from LPN. In Eyal Kushilevitz and Tal Malkin, editors, *TCC 2016-A: 13th Theory of Cryptography Conference, Part I*, volume 9562 of *Lecture Notes in Computer Science*, pages 225–248, Tel Aviv, Israel, January 10–13, 2016. Springer, Heidelberg, Germany.
- [CLR17] Hao Chen, Kim Laine, and Peter Rindal. Fast private set intersection from homomorphic encryption. In Bhavani M. Thuraisingham, David Evans, Tal Malkin, and Dongyan Xu, editors, *ACM CCS 2017: 24th Conference on Computer and Communications Security*, pages 1243–1255, Dallas, TX, USA, October 31 – November 2, 2017. ACM Press.
- [CP18] Bram Cohen and Krzysztof Pietrzak. Simple proofs of sequential work. In Jesper Buus Nielsen and Vincent Rijmen, editors, *Advances in Cryptology – EUROCRYPT 2018, Part II*, volume 10821 of *Lecture Notes in Computer Science*, pages 451–467, Tel Aviv, Israel, April 29 – May 3, 2018. Springer, Heidelberg, Germany.
- [DFKP15] Stefan Dziembowski, Sebastian Faust, Vladimir Kolmogorov, and Krzysztof Pietrzak. Proofs of space. In Rosario Gennaro and Matthew J. B. Robshaw, editors, *Advances in Cryptology – CRYPTO 2015, Part II*, volume 9216 of *Lecture Notes in Computer Science*, pages 585–605, Santa Barbara, CA, USA, August 16–20, 2015. Springer, Heidelberg, Germany.
- [DGH⁺19] Nico Döttling, Sanjam Garg, Mohammad Hajiabadi, Kevin Liu, and Giulio Malavolta. Rate-1 trapdoor functions from the Diffie-Hellman problem. In Steven D. Galbraith and Shiho Moriai, editors, *Advances in Cryptology – ASIACRYPT 2019, Part III*, volume 11923 of *Lecture Notes in Computer Science*, pages 585–606, Kobe, Japan, December 8–12, 2019. Springer, Heidelberg, Germany.

- [DGI⁺19] Nico Döttling, Sanjam Garg, Yuval Ishai, Giulio Malavolta, Tamer Mour, and Rafail Ostrovsky. Trapdoor hash functions and their applications. In Alexandra Boldyreva and Daniele Micciancio, editors, *Advances in Cryptology – CRYPTO 2019, Part III*, volume 11694 of *Lecture Notes in Computer Science*, pages 3–32, Santa Barbara, CA, USA, August 18–22, 2019. Springer, Heidelberg, Germany.
- [DGO19] Ivan Damgård, Chaya Ganesh, and Claudio Orlandi. Proofs of replicated storage without timing assumptions. In Alexandra Boldyreva and Daniele Micciancio, editors, *Advances in Cryptology – CRYPTO 2019, Part I*, volume 11692 of *Lecture Notes in Computer Science*, pages 355–380, Santa Barbara, CA, USA, August 18–22, 2019. Springer, Heidelberg, Germany.
- [DLM19] Nico Döttling, Russell W. F. Lai, and Giulio Malavolta. Incremental proofs of sequential work. In Yuval Ishai and Vincent Rijmen, editors, *Advances in Cryptology – EUROCRYPT 2019, Part II*, volume 11477 of *Lecture Notes in Computer Science*, pages 292–323, Darmstadt, Germany, May 19–23, 2019. Springer, Heidelberg, Germany.
- [Döt15] Nico Döttling. Low noise LPN: KDM secure public key encryption and sample amplification. In Jonathan Katz, editor, *PKC 2015: 18th International Conference on Theory and Practice of Public Key Cryptography*, volume 9020 of *Lecture Notes in Computer Science*, pages 604–626, Gaithersburg, MD, USA, March 30 – April 1, 2015. Springer, Heidelberg, Germany.
- [DPW18] Stefan Dziembowski, Krzysztof Pietrzak, and Daniel Wichs. Non-malleable codes. *J. ACM*, 65(4), April 2018.
- [DS05] Jintai Ding and Dieter Schmidt. Rainbow, a new multivariable polynomial signature scheme. In John Ioannidis, Angelos Keromytis, and Moti Yung, editors, *ACNS 05: 3rd International Conference on Applied Cryptography and Network Security*, volume 3531 of *Lecture Notes in Computer Science*, pages 164–175, New York, NY, USA, June 7–10, 2005. Springer, Heidelberg, Germany.
- [DVW09] Yevgeniy Dodis, Salil P. Vadhan, and Daniel Wichs. Proofs of retrievability via hardness amplification. In Omer Reingold, editor, *TCC 2009: 6th Theory of Cryptography Conference*, volume 5444 of *Lecture Notes in Computer Science*, pages 109–127. Springer, Heidelberg, Germany, March 15–17, 2009.
- [DY05] Yevgeniy Dodis and Aleksandr Yampolskiy. A verifiable random function with short proofs and keys. In Serge Vaudenay, editor, *PKC 2005: 8th International Workshop on Theory and Practice in Public Key Cryptography*, volume 3386 of *Lecture Notes in Computer Science*, pages 416–431, Les Diablerets, Switzerland, January 23–26, 2005. Springer, Heidelberg, Germany.
- [Fis19] Ben Fisch. Tight proofs of space and replication. In Yuval Ishai and Vincent Rijmen, editors, *Advances in Cryptology – EUROCRYPT 2019, Part II*, volume 11477 of *Lecture Notes in Computer Science*, pages 324–348, Darmstadt, Germany, May 19–23, 2019. Springer, Heidelberg, Germany.
- [GGH19] Sanjam Garg, Romain Gay, and Mohammad Hajiabadi. New techniques for efficient trapdoor functions and applications. In Yuval Ishai and Vincent Rijmen, editors, *Advances in Cryptology – EUROCRYPT 2019, Part III*, volume 11478 of *Lecture Notes in Computer Science*, pages 33–63, Darmstadt, Germany, May 19–23, 2019. Springer, Heidelberg, Germany.
- [GH18] Sanjam Garg and Mohammad Hajiabadi. Trapdoor functions from the computational Diffie-Hellman assumption. In Hovav Shacham and Alexandra Boldyreva, editors,

- Advances in Cryptology – CRYPTO 2018, Part II*, volume 10992 of *Lecture Notes in Computer Science*, pages 362–391, Santa Barbara, CA, USA, August 19–23, 2018. Springer, Heidelberg, Germany.
- [GS08] Jens Groth and Amit Sahai. Efficient non-interactive proof systems for bilinear groups. In Nigel P. Smart, editor, *Advances in Cryptology – EUROCRYPT 2008*, volume 4965 of *Lecture Notes in Computer Science*, pages 415–432, Istanbul, Turkey, April 13–17, 2008. Springer, Heidelberg, Germany.
 - [GSW13] Craig Gentry, Amit Sahai, and Brent Waters. Homomorphic encryption from learning with errors: Conceptually-simpler, asymptotically-faster, attribute-based. In Ran Canetti and Juan A. Garay, editors, *Advances in Cryptology – CRYPTO 2013, Part I*, volume 8042 of *Lecture Notes in Computer Science*, pages 75–92, Santa Barbara, CA, USA, August 18–22, 2013. Springer, Heidelberg, Germany.
 - [HW09a] Susan Hohenberger and Brent Waters. Realizing hash-and-sign signatures under standard assumptions. In Antoine Joux, editor, *Advances in Cryptology – EUROCRYPT 2009*, volume 5479 of *Lecture Notes in Computer Science*, pages 333–350, Cologne, Germany, April 26–30, 2009. Springer, Heidelberg, Germany.
 - [HW09b] Susan Hohenberger and Brent Waters. Short and stateless signatures from the RSA assumption. In Shai Halevi, editor, *Advances in Cryptology – CRYPTO 2009*, volume 5677 of *Lecture Notes in Computer Science*, pages 654–670, Santa Barbara, CA, USA, August 16–20, 2009. Springer, Heidelberg, Germany.
 - [HW18] Susan Hohenberger and Brent Waters. Synchronized aggregate signatures from the RSA assumption. In Jesper Buus Nielsen and Vincent Rijmen, editors, *Advances in Cryptology – EUROCRYPT 2018, Part II*, volume 10821 of *Lecture Notes in Computer Science*, pages 197–229, Tel Aviv, Israel, April 29 – May 3, 2018. Springer, Heidelberg, Germany.
 - [KPG99] Avi Kipnis, Jacques Patarin, and Louis Goubin. Unbalanced oil and vinegar signature schemes. In Jacques Stern, editor, *Advances in Cryptology – EUROCRYPT’99*, volume 1592 of *Lecture Notes in Computer Science*, pages 206–222, Prague, Czech Republic, May 2–6, 1999. Springer, Heidelberg, Germany.
 - [KS05] Lea Kissner and Dawn Xiaodong Song. Privacy-preserving set operations. In Victor Shoup, editor, *Advances in Cryptology – CRYPTO 2005*, volume 3621 of *Lecture Notes in Computer Science*, pages 241–257, Santa Barbara, CA, USA, August 14–18, 2005. Springer, Heidelberg, Germany.
 - [LM13] Vadim Lyubashevsky and Daniel Masny. Man-in-the-middle secure authentication schemes from LPN and weak PRFs. In Ran Canetti and Juan A. Garay, editors, *Advances in Cryptology – CRYPTO 2013, Part II*, volume 8043 of *Lecture Notes in Computer Science*, pages 308–325, Santa Barbara, CA, USA, August 18–22, 2013. Springer, Heidelberg, Germany.
 - [MT19] Giulio Malavolta and Sri Aravinda Krishnan Thyagarajan. Homomorphic time-lock puzzles and applications. In Alexandra Boldyreva and Daniele Micciancio, editors, *Advances in Cryptology – CRYPTO 2019, Part I*, volume 11692 of *Lecture Notes in Computer Science*, pages 620–649, Santa Barbara, CA, USA, August 18–22, 2019. Springer, Heidelberg, Germany.
 - [OPW11] Adam O’Neill, Chris Peikert, and Brent Waters. Bi-deniable public-key encryption. In Phillip Rogaway, editor, *Advances in Cryptology – CRYPTO 2011*, volume 6841 of *Lecture Notes in Computer Science*, pages 525–542, Santa Barbara, CA, USA, August 14–18, 2011. Springer, Heidelberg, Germany.

- [Pie19a] Krzysztof Pietrzak. Proofs of catalytic space. In Avrim Blum, editor, *ITCS 2019: 10th Innovations in Theoretical Computer Science Conference*, volume 124, pages 59:1–59:25, San Diego, CA, USA, January 10–12, 2019. LIPIcs.
- [Pie19b] Krzysztof Pietrzak. Simple verifiable delay functions. In Avrim Blum, editor, *ITCS 2019: 10th Innovations in Theoretical Computer Science Conference*, volume 124, pages 60:1–60:15, San Diego, CA, USA, January 10–12, 2019. LIPIcs.
- [PVW08] Chris Peikert, Vinod Vaikuntanathan, and Brent Waters. A framework for efficient and composable oblivious transfer. In David Wagner, editor, *Advances in Cryptology – CRYPTO 2008*, volume 5157 of *Lecture Notes in Computer Science*, pages 554–571, Santa Barbara, CA, USA, August 17–21, 2008. Springer, Heidelberg, Germany.
- [PW08] Chris Peikert and Brent Waters. Lossy trapdoor functions and their applications. In Richard E. Ladner and Cynthia Dwork, editors, *40th Annual ACM Symposium on Theory of Computing*, pages 187–196, Victoria, BC, Canada, May 17–20, 2008. ACM Press.
- [SW08] Hovav Shacham and Brent Waters. Compact proofs of retrievability. In Josef Pieprzyk, editor, *Advances in Cryptology – ASIACRYPT 2008*, volume 5350 of *Lecture Notes in Computer Science*, pages 90–107, Melbourne, Australia, December 7–11, 2008. Springer, Heidelberg, Germany.
- [Wes19] Benjamin Wesolowski. Efficient verifiable delay functions. In Yuval Ishai and Vincent Rijmen, editors, *Advances in Cryptology – EUROCRYPT 2019, Part III*, volume 11478 of *Lecture Notes in Computer Science*, pages 379–407, Darmstadt, Germany, May 19–23, 2019. Springer, Heidelberg, Germany.
- [YKT19] Yusuke Yoshida, Fuyuki Kitagawa, and Keisuke Tanaka. Non-committing encryption with quasi-optimal ciphertext-rate based on the DDH problem. In Steven D. Galbraith and Shihō Moriai, editors, *Advances in Cryptology – ASIACRYPT 2019, Part III*, volume 11923 of *Lecture Notes in Computer Science*, pages 128–158, Kobe, Japan, December 8–12, 2019. Springer, Heidelberg, Germany.