qFALL
Quantum-Resistant Fast Lattice Library

Laurens Porzenheim

Codes and Cryptography

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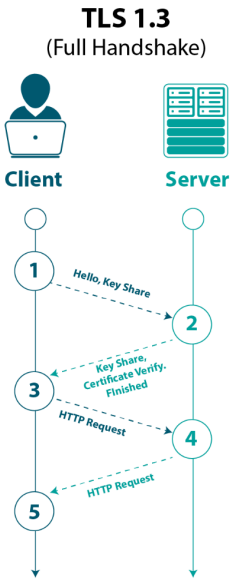
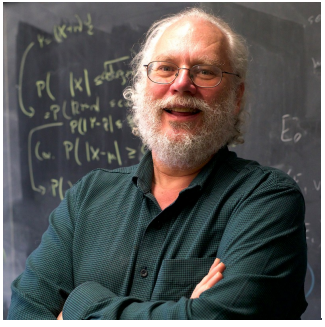
PADERBORN UNIVERSITY

A Post-Quantum World

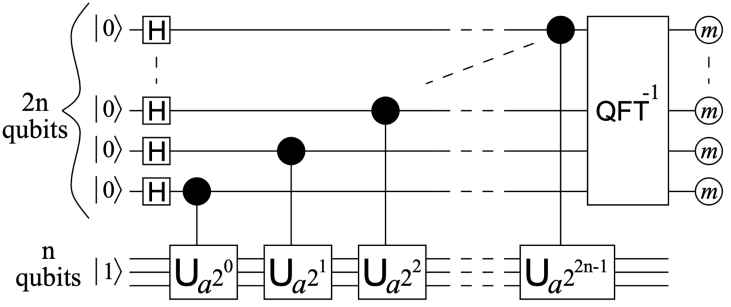
- Used by everyone daily for secure communication
- Relies on hardness of factoring, discrete logarithm
- Example: TLS, the 's' in https



- Bigger and better quantum computers are being developed
- They break current public key cryptography
- Shor's Algorithm is used to break factoring, discrete logarithm



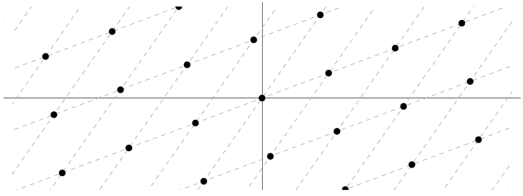
Peter Shor



Shor's Algorithm

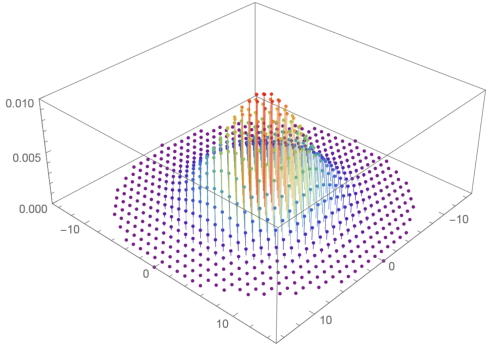
Lattices and Lattice Problems

- Lattice problems are conjectured to be quantum-resistant
  - E.g. finding a shortest vector in high-dimensional lattices
  - Learning With Errors
- Build new cryptography based on these problems
- The first constructions are being standardized by NIST



A Two-Dimensional Lattice

NIST
National Institute of Standards and Technology
U.S. Department of Commerce



A Discrete Gaussian Distribution

LWE:

- Choose a random matrix $A \in \mathbb{Z}_q^{m \times n}$ and random secret $s \in \mathbb{Z}_q^n$
- Choose a an error term e from distribution χ
- Compute $b = As + e$
- Then b looks indistinguishable from uniform, if an adversary only knows A
- We can build encryption schemes from this

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Things to implement:

- How to sample A, s?
- How to do matrix-vector multiplication?
- How to choose and implement χ?
  - E.g. discrete Gaussian
- Use more efficient base problems, such as Ring-LWE
  - In this case, $A \in \mathcal{R}_q^m$ with $\mathcal{R} = \mathbb{Z}_q[X] \backslash (X^n + 1)$

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I simply want to test my construction
$\Rightarrow$ much work for simple test

The Project Group

Our Goals

What we want:

- **Main Goal:** Open-source library for **prototyping** lattice cryptography
- Build it from the ground up (excluding number theory)
- Implementation of Basics and Schemes
  - E.g. Gaussian Sampling, Signatures, Encryption
- Implement one NIST candidate
- Somewhat optimized implementation
- Optional: write program to compute secure parameters

What is not the goal:

- Perfectly secure (we ignore side-channel attacks)
- Use every known optimization

What We Offer

- Meaningful project: will be used in the future for research (prototyping, sample implementations, teaching, ...)
- We set the first milestones, you decide how the PG will develop further depending on what interests you
- Experience in security related coding
- Short introduction, quick start, no long seminar phase
- You can use our lab (at main campus) next to our offices :)
  - → short question/answer times

Prerequisites / Nice to Have

- You like writing clean or efficient code (or would like to learn/improve it).
- Understand formal specifications
- Some background in security / cryptography preferred, for instance IT Sicherheit, Introduction to Cryptography (Bachelor) or Foundations of Cryptography, Real World Crypto Engineering (Master)
- Advanced Math knowledge, if you want to do more theoretical tasks