Cryptography and quantum computers: Where do we stand?

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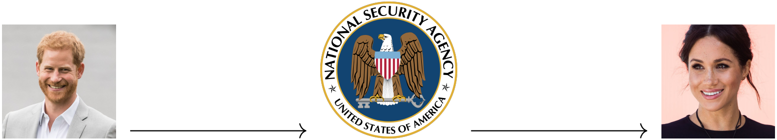
What is this all about?

Cryptography

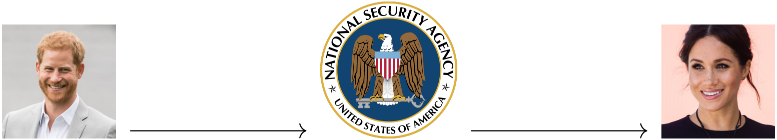


Sender

Channel with eavesdropper ‘Eve’

Receiver

Cryptography

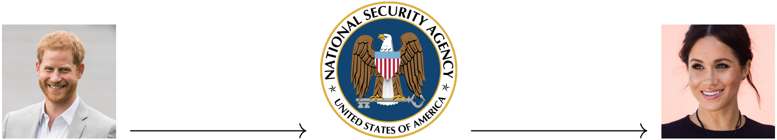


Sender Channel with eavesdropper ‘Eve’ Receiver

Problems:

- Communication channels store and spy on our data
- Communication channels are modifying our data

Cryptography



Sender | Channel with eavesdropper 'Eve' | Receiver

Problems:

- Communication channels store and spy on our data
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Goals:

- Confidentiality despite Eve's espionage.
- Integrity: recognising Eve's espionage.

(Slide mostly stolen from Tanja Lange)

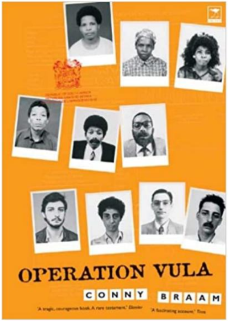
Example: encrypted messaging with one-time-pads

- Message: a bit string (e.g. $m = 1001100$)
- OTP: also a bit string (e.g. $k = 0111000$)
- Encrypted message: line up m and k, and flip the bit of m if the corresponding bit in k is 1:

$$\begin{array}{c} 1\,0\,0\,1\,1\,0\,0 \\ 0\,1\,1\,1\,0\,0\,0 \\ \downarrow \\ 1\,1\,1\,0\,1\,0\,0 \end{array}$$

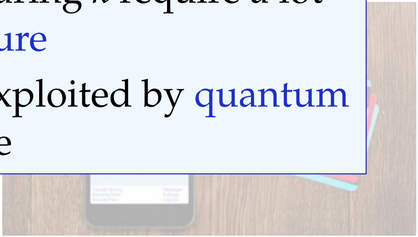
Anti-Apartheid
Movement

THE
VULA CONNECTION

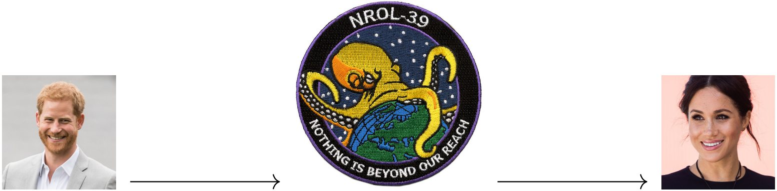

OPERATION VULA
CONNY BRAAM
'A tragic, courageous book. A rare testament.' Elsevier
'A fascinating account.' Trou

Online Banking
$ 304.02
Credit Card
1234 5678 9012 3456
CURRENT NAME

- All of these require sharing a key k securely
- Current methods of sharing k require a lot of mathematical structure
- This structure can be exploited by quantum computers in the future



My research: post-quantum cryptography



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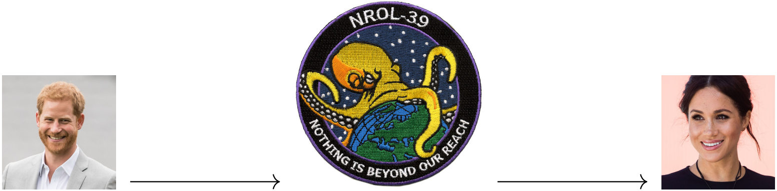
My research: post-quantum cryptography



Sender

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Receiver

- Eve has a quantum computer.
- Sender and receiver don’t have a quantum computer.

Where are we now?

- Post-quantum cryptography discussion dominated by NIST competition for standardization.

Where are we now?

- Post-quantum cryptography discussion dominated by NIST competition for standardization.
- This initiative comes after a US report with:

> **Key Finding 10:** Even if a quantum computer that can decrypt current cryptographic ciphers is more than a decade off, the hazard of such a machine is high enough—and the time frame for transitioning to a new security protocol is sufficiently long and uncertain—that prioritization of the development, standardization, and deployment of post-quantum cryptography is critical for minimizing the chance of a potential security and privacy disaster.

Where are we now (according to NIST)?

The NIST not-a-competition:

- Had 82 submissions in 2017.
- 69 were accepted.
- 15 submissions currently in 3rd round, aiming for a total of 4 rounds.
- Aiming for standardization in 2022.
- Only covers digital signatures and key encapsulation (c.f. “sharing k securely”).

Important open problems/research directions

Needed for many post-quantum candidates:

- Thorough cryptanalysis – classical and quantum.
- Secure and efficient implementation (especially considering hardware limitations).
- Meaningful comparison between candidates (must come from comparable implementations).
- More advanced protocols (e.g. for privacy, zero-knowledge etc).

Thank you! Questions?