DEV SEC OPS DAYS

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Carnegie Mellon University Software Engineering Institute

# Implementing Post-Quantum Cryptography in Industry

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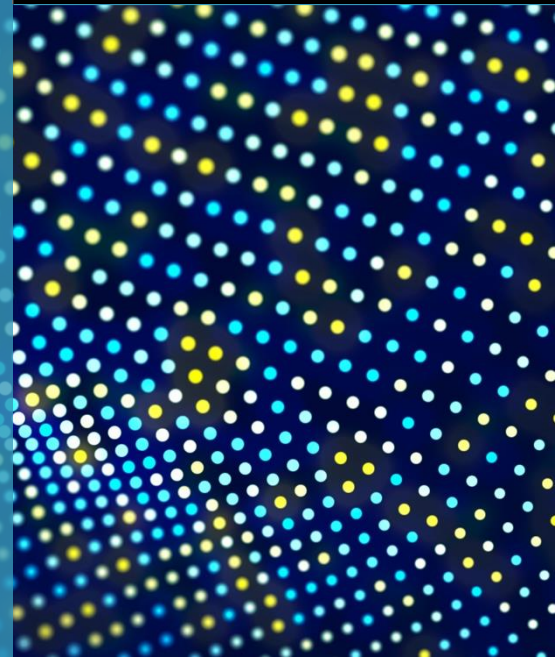
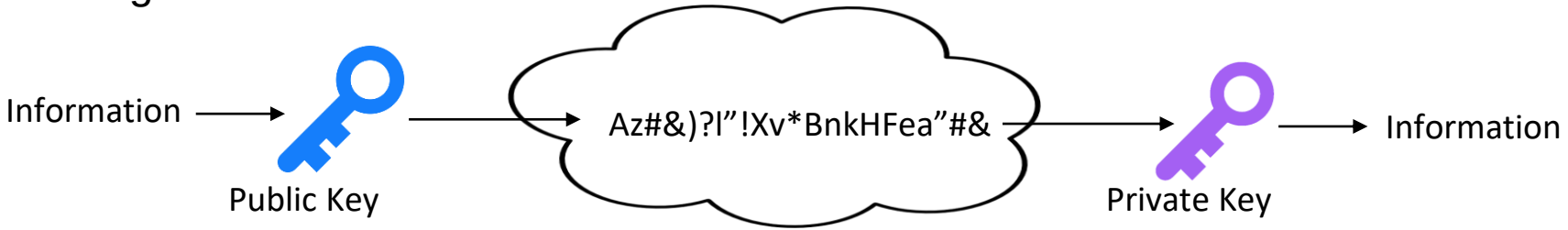


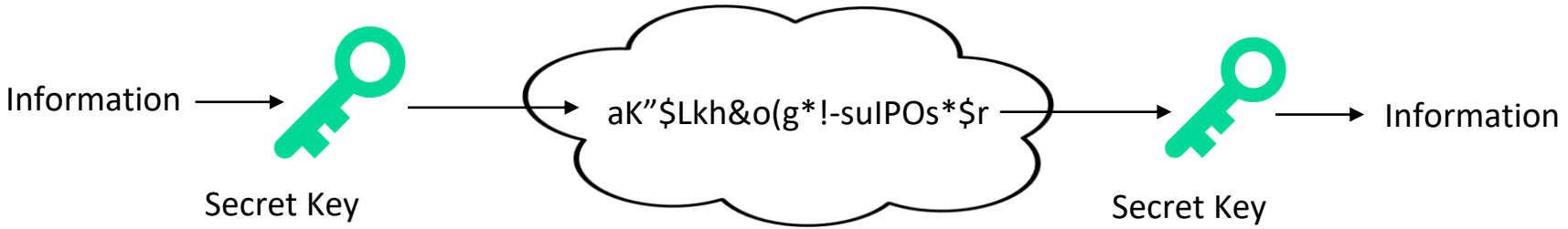
# Context of the problem



Current asymmetric crypto will be broken - RSA, ElGamal, ECC. Also, Diffie-Hellman key exchange



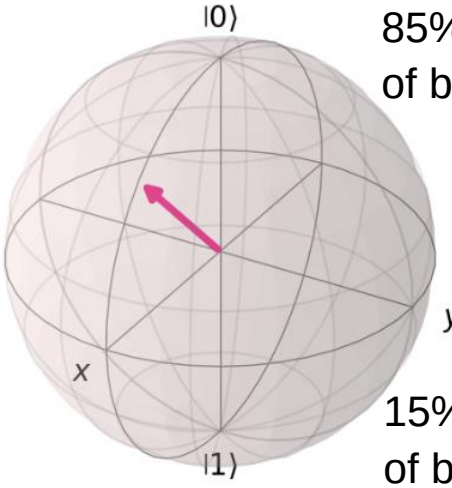

Current symmetric crypto will **not** be broken. Grover Quantum Algorithm used to attack, downgrades AES-256 to AES-128, which is still secure



# Why quantum computing can do this?



## Superposition




85% chance of being 0

15% chance of being 1

## Entanglement

(Image credit: MARK GARLICK/SCIENCE PHOTO LIBRARY via Getty Images)

Allows new kinds of algorithms due to these properties

Disadvantage example: you can't copy paste.

# Breaking RSA – Optimistic advancement of QC



Using a new a strategy published in Dec 2022, which claims to be a realistic alternative to Shor's Algorithm (some sceptics to this):

| RSA number | Qubits | Kn-depth | 2DSL-depth | LNN-depth |
|---|---|---|---|---|
| RSA-128 | 37 | 113 | 121 | 150 |
| RSA-256 | 64 | 194 | 204 | 258 |
| RSA-512 | 114 | 344 | 357 | 458 |
| RSA-1024 | 205 | 617 | 633 | 822 |
| RSA-2048 | 372 | 1118 | 1139 | 1490 |

"IBM Quantum systems scale up towards the stated goal of 4,000+ qubits by 2025 and beyond"[2]
**Today: 433 Qubits**
**Last year: 128 Qubits**

"We find that a quantum circuit with 372 physical qubits and a depth of thousands is necessary to challenge RSA-2048. Such a scale of quantum resources is most likely to be achieved on NISQ devices in the near future."[1]
(Bao, 2022, p. 5)

# Breaking RSA – Pessimistic advancement of QC



Senior director of data and security research at Fujitsu Dr Tetsuya Izu said: “Our research demonstrates that quantum computing doesn’t pose an **immediate** threat to existing cryptographic methods”[3]  2023

- They didn’t mention alternative algorithms
- They simulated 39 qubits in a super computer
- Many anecdotes of people predicting the future wrong. E.g. one week before chatGPT
- Not **immediate**, but, how long?

# After how long is it safe to leak some information?



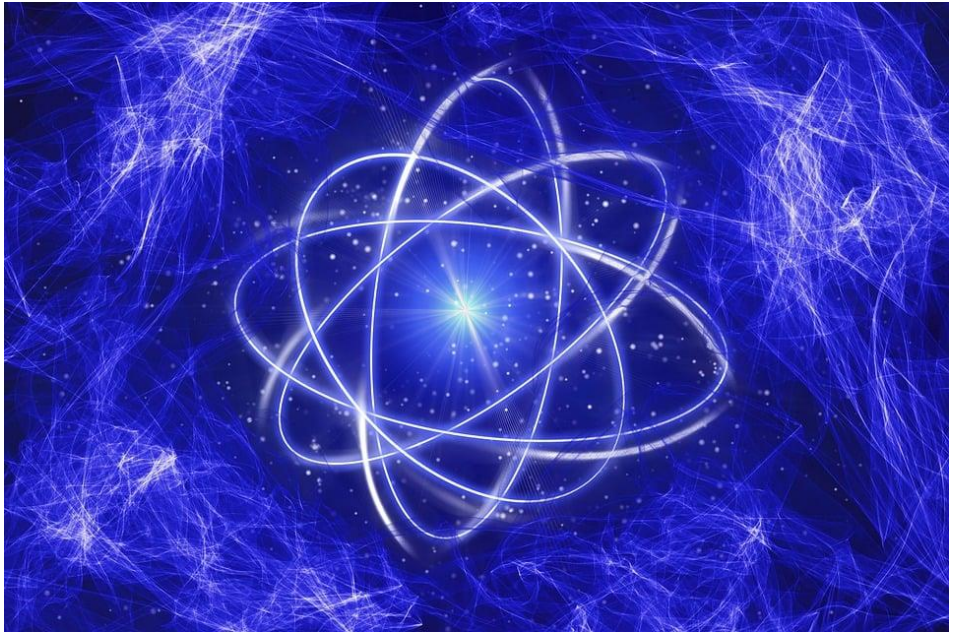
- Credit card expiration time: avg time: 3 to 5 years. Can be 10 years+
- Clinical history: a life span?
- Industrial secrets: generations?
- Military records: 40 years for top secret
- Source code: depends on the company. Some will open source it, other companies keep it undisclosed "eternally"

"harvest now, decrypt later" is a serious attack

# Protecting information for many years is needed



NIST
National Institute of Standards and Technology



**Post-Quantum Crypto to be a standard, NOT YET ONE**

**Public-key Encryption**

CRYSTALS-KYBER

**Digital Signature**

CRYSTALS-DILITHIUM

FALCON

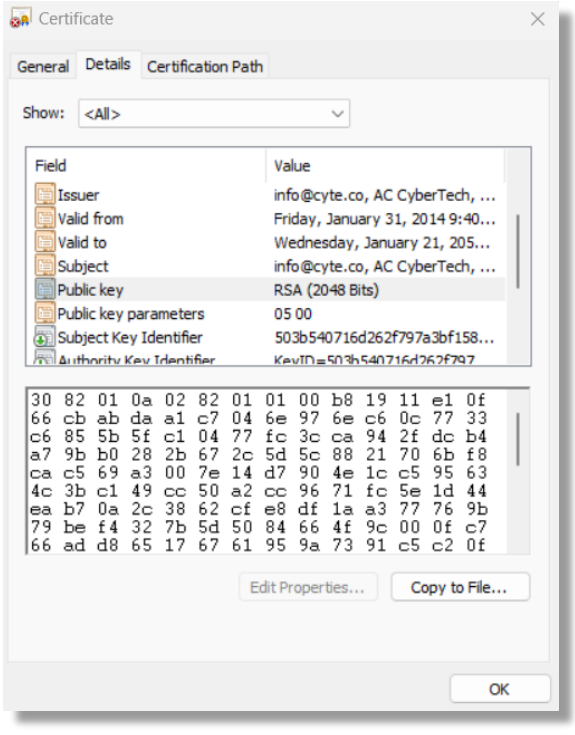
SPHINCS+

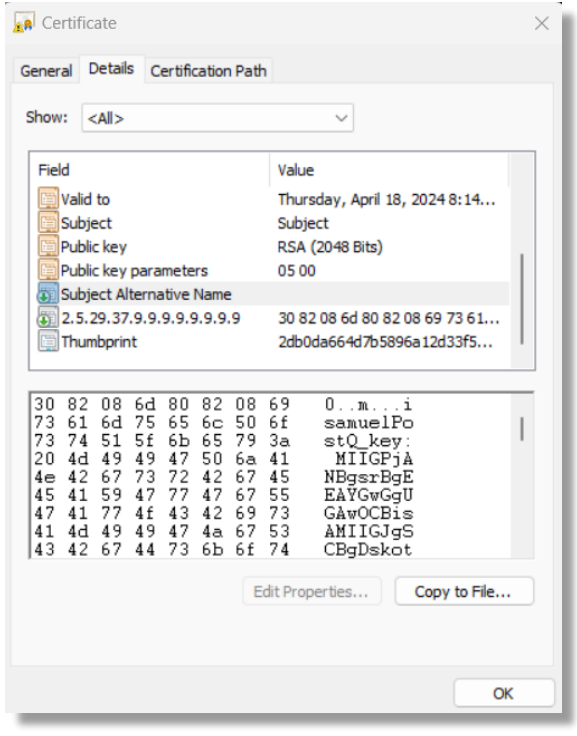
Any of these can be run in traditional computers. DON'T NEED QUANTUM COMPUTERS

# Hybrid, viable option today in custom software



Current PKI infrastructure can be used



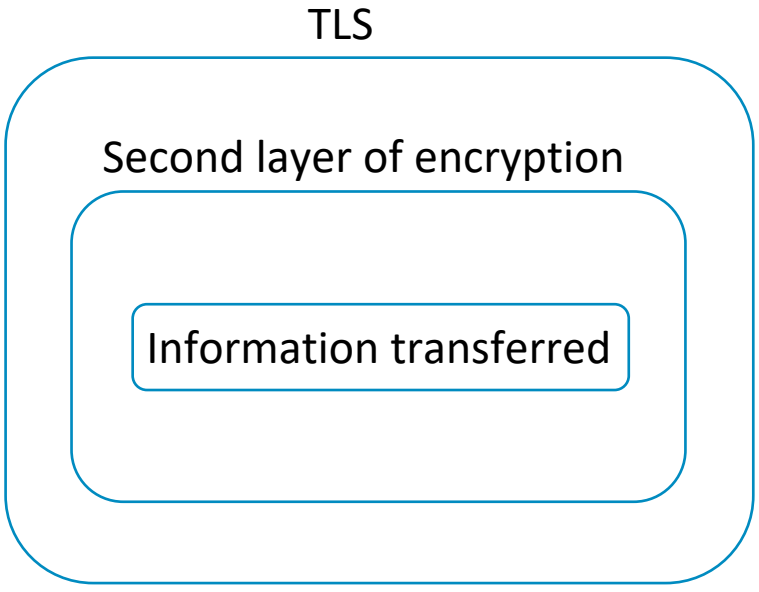


You can’t make a browser use this. Useful for sending sensitive files (today in use).

# Sensitive data transmitted from browser to server



**Security in depth:**




**The second layer was added in the past, because of:**

- Heartbleed: 64 kb are exposed taking advantage of the TLS heartbeat
- POODLE: Padding Oracle On Downgraded Legacy Encryption (to attack SSL 3.0)
- BEAST: CVE-2011-3389, allows “MITM”
- SWEET32: CVE-2016-2183, When a high number of data is encrypted, information can be leaked.
- …

A postquantum public key (CRYSTALS-KYBER) can be added, to transfer a session AES-256 key.

# What to do in DevOps

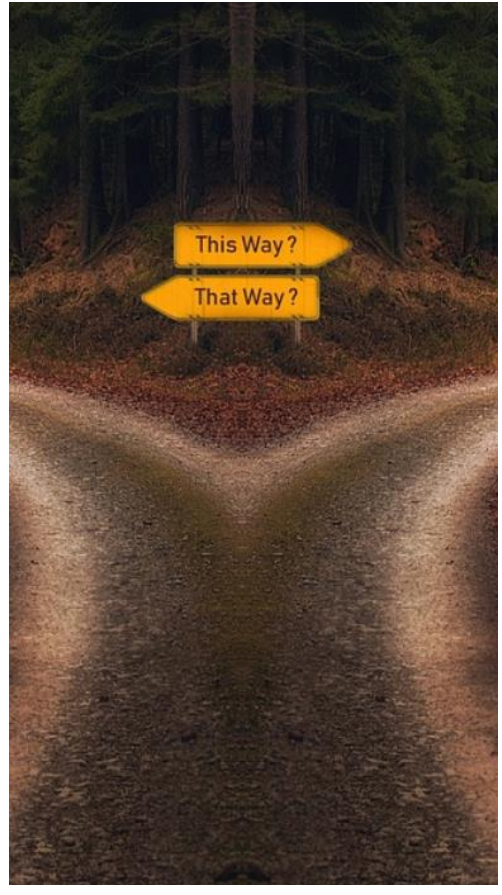


Alternatives to keep proprietary source code safe

- Keep everything in an internal network
  - Unlikely in post-pandemic, even in radical companies

- If your binaries are “public but obfuscated binaries”, you can push obfuscated code and push the mapping encrypted with AES
  - If that is the case, code can be reversed, so beware your code is not secret

- Push AES-256 encrypted source code and decrypt it in the CI server to then run tests etc.
  - Need to put manually the AES in the server and locally.
  - No browser features like navigation of code
  - You could not use github, that violates their terms.



# Breaking Asymmetric Crypto – cybersecurity perspective



- In cybersecurity we are not optimistic or pessimistic, we are paranoid!
- In fact, “Paranoia is our Profession”
- We should not take our chances and hope that quantum computing doesn’t advance
- Implement CRYSTALS-KYBER as soon NIST round 4 finishes. (don’t wait, like some still use SSL)
- If operating very sensitive information, might need one of the alternative approaches.
  - In git third party solutions, can be uncomfortable
  - In your own apps, it is easy to implement and works well

Remember: Better to err on the side of caution.

# Contacts



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# References

[1] Bao Yan. (2022). Factoring integers with sublinear resources on a superconducting quantum processor (https://arxiv.org/pdf/2212.12372.pdf)

[2] https://newsroom.ibm.com/2022-11-09-IBM-Unveils-400-Qubit-Plus-Quantum-Processor-and-Next-Generation-IBM-Quantum-System-Two

[3] https://www.itnews.com.au/news/quantum-computers-wont-break-rsa-encryption-any-time-soon-590115#:~:text=They%20found%20that%20to%20factor,104%20days%20to%20crack%20RSA.

Images from https://pixabay.com/