Adam Koltun

Marketing Manager

The Quantum Resistant Ledger

Agenda

Deploying

Winternitz OTS+ Signatures

in an

Extended Merkle Signature Scheme

(XMSS)

for the purpose of

Securing a Blockchain Network

Against

Quantum Computers

Why should I pay attention?

Bitcoin Is Not Quantum-Safe, And How We Can Fix It When Needed

by **Vitalik Buterin** Jul 30, 2013 11:42 PM EST

CCN BTC/USD 10:12 $9,593.14 Low $8,777.24 $9,

BITCOIN SECURITY OCTOBER 16, 2016 18:58

Quantum Computers Will Destroy Bitcoin, Scientists Warn

coindesk Blockchain 101 Technology Markets Business

Quantum Computers Could Jack Your Crypto Private Key in 10 Years, Researchers Say

ections

The Washington Post
Democracy Dies in Darkness

National Security

NSA seeks to build quantum computer that could crack most types of encryption

By Steven Rich and Barton Gellman January 2, 2014 Email the author

MIT Technology Review

Business Impact

Quantum Computers Pose Imminent Threat to Bitcoin Security

Agenda

Deploying

Winternitz OTS+ Signatures

in an

Extended Merkle Signature Scheme

(XMSS)

for the purpose of

Securing a Blockchain Network

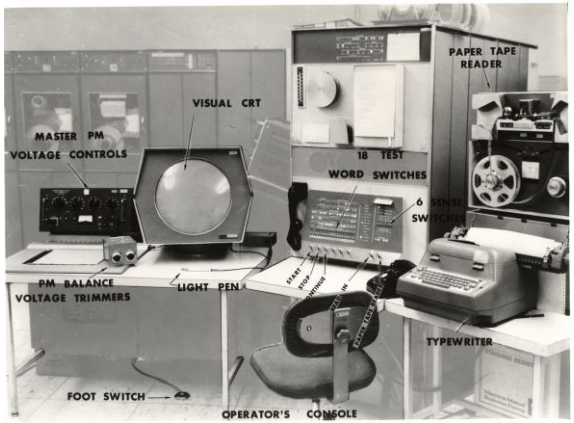
Against

Quantum Computers

What are QCs?

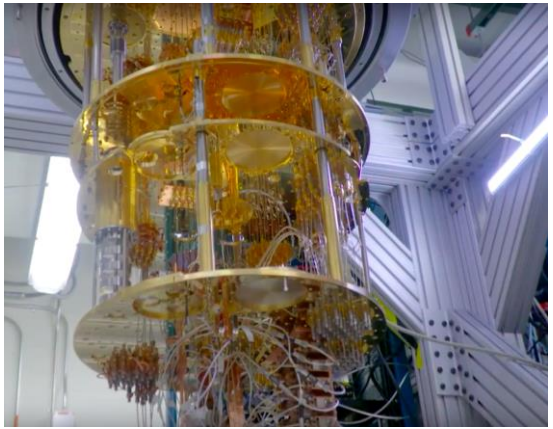
What are Quantum Computers?

Computers exploiting quantum mechanics



Traditional Computer

Circa 1961. PDP-1



Quantum Computer

Circa 2017

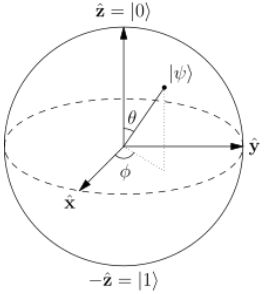
Google rigetti IBM intel Microsoft

Governments,
and many others..

0 1 Bits

- Can take two possible values - 0 or 1.
- Can be easily linked to one another.

0 1 Qubits

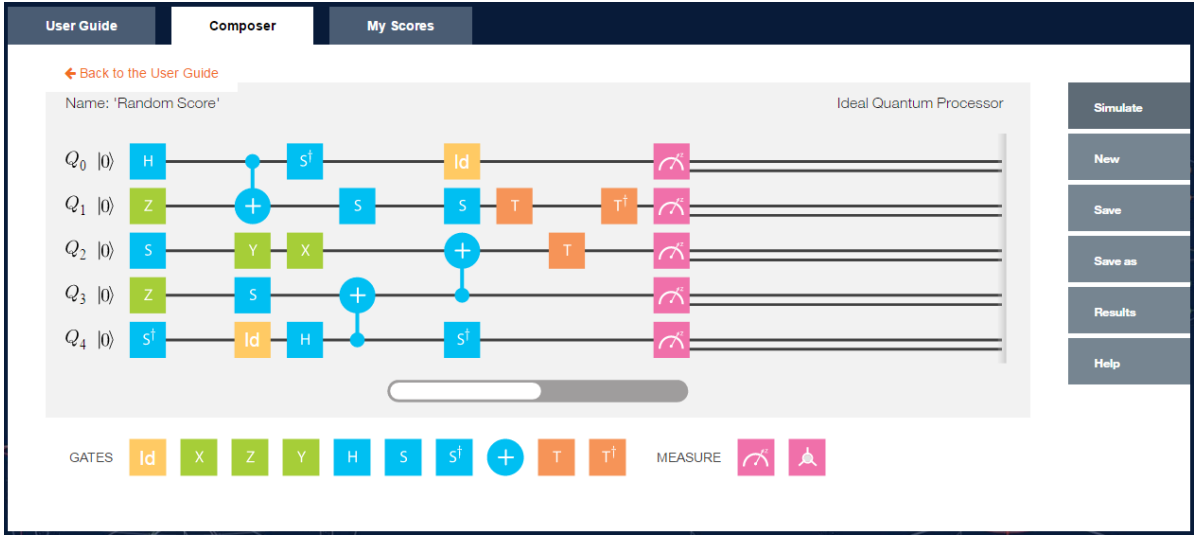


- Can be a **superposition** of both 0 and 1 at the same time.
- Every qubit doubles the amount of positions (1=2, 2=4, 3=8, etc.)
- Difficult to link to one another

What comprises a Quantum Computer?

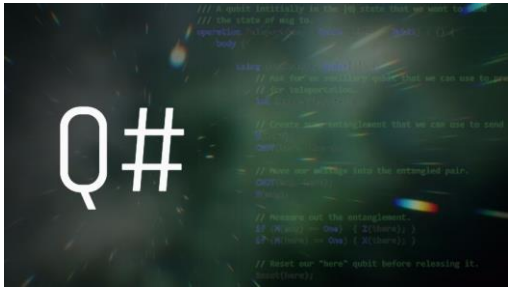
- Uses **qubits** instead of bits like a traditional computer
- A quantum computer with **n** qubits can be in an arbitrary superposition of up to 2^n different states **simultaneously!**
- Allows for **exponential increase in computational power**. For every qubit added to a system, the amount of alternatives that can be processed in parallel doubles. i.e. 3 qubits can compute 8 values, 4 qubits can compute 16 values *simultaneously*.

When can I use one?



IBM Q Experience

- For researchers & lay people to experiment on quantum computers



Q# from Microsoft

- Not for direct coding of quantum computers
- For writing sub programs that run on a quantum processor, under control of a traditional computer

Agenda

Deploying

Winternitz OTS+ Signatures

in an

Extended Merkle Signature Scheme

(XMSS)

for the purpose of

Securing a Blockchain Network

Against

Quantum Computers

What are QCs?

What is the issue?

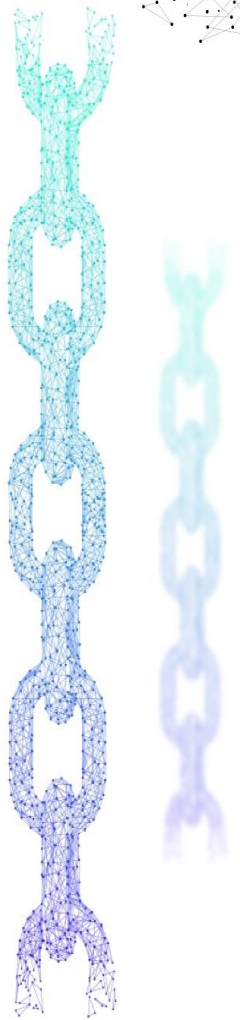
Cryptography Crash Course!

- *All cryptographic methods are based upon one or more assumptions*
- *More assumptions = more failure points*
- *If the assumption is broken, the crypto is broken*

A history of assumptions

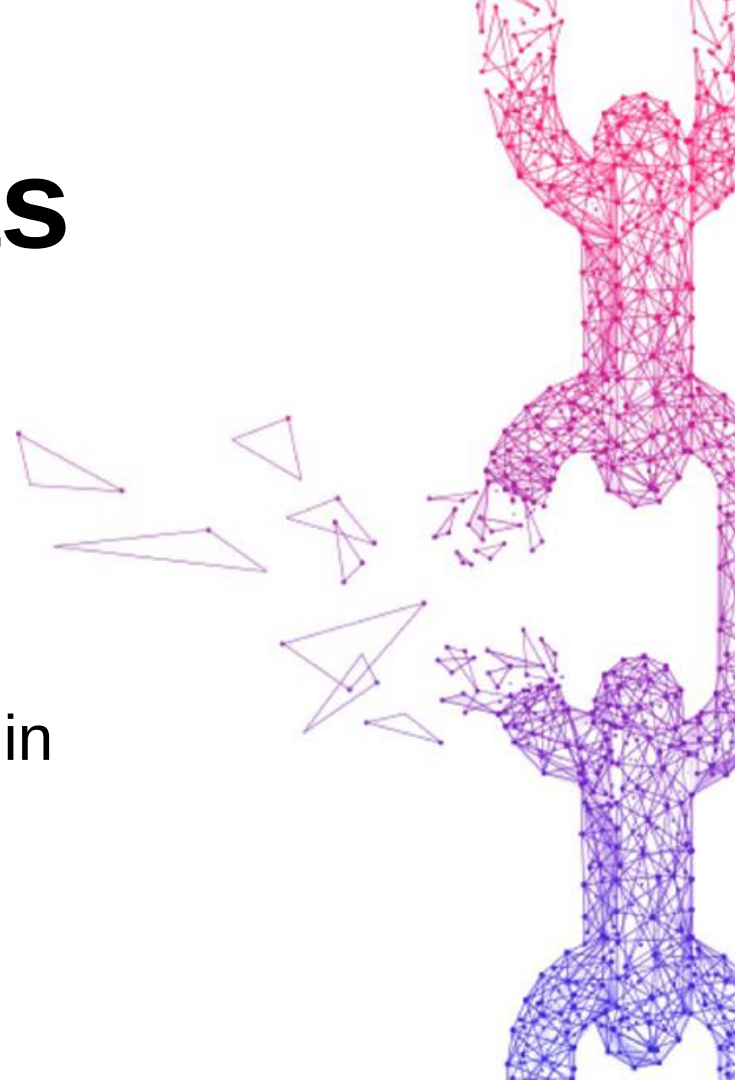
- *Walls were great at defending against medieval siege tech*

- *Assumption: the amount of time to breach them would take so long as to leave the walls functionally secure*



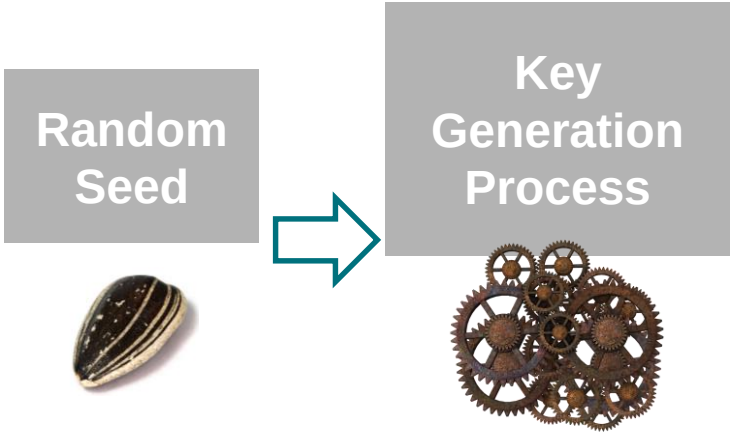
Then there was Dynamite!

Walls that used to be able to withstand years of abuse suddenly could be taken down in a matter of hours or days



Cryptography Crash Course! Signatures

- *When Bob wants to prove to the World that he approves something.*



Cryptography Crash Course!
Signatures pt.2

- *Bob shows the world his **Public Key***
- *Bob uses his **Secret Key** to sign*
- *Anyone can **Deposit,** only Bob can **Withdraw***

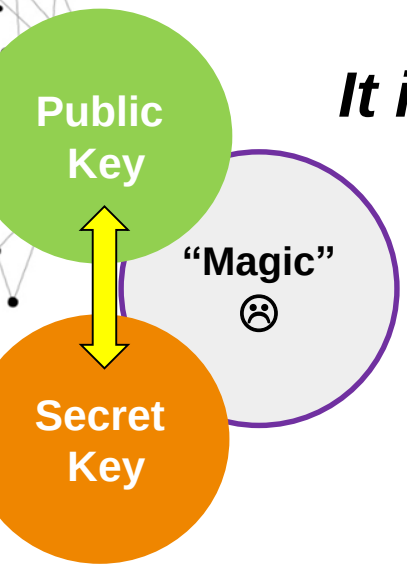
Cryptography Crash Course!

ECDSA

Used by Bitcoin, Ethereum, most cryptocurrencies

ASSUMPTION

It is hard for computers to factorize large numbers.



It is currently possible to crack ECDSA,

but takes too long to be worth it.

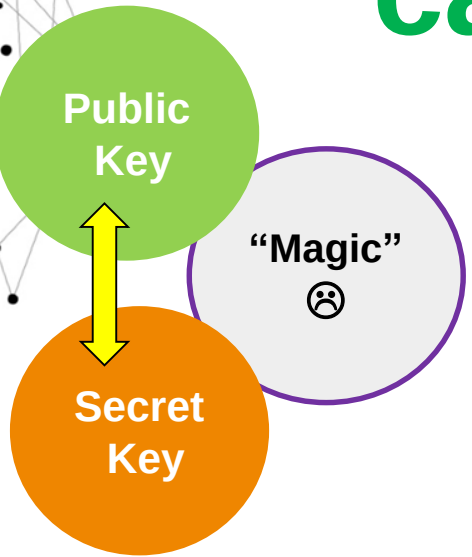
Cryptography Crash Course!

ECDSA pt.2

Quantum Computers

can factorize *easily*

(using Shor's algorithm)



Broken assumption

=

Broken cryptography

Agenda

Deploying

Winternitz OTS+ Signatures

in an

Extended Merkle Signature Scheme

(XMSS)

for the purpose of

Securing a Blockchain Network

Against

Quantum Computers

What are QCs?

What is the issue?

What can be done?

Post Quantum Cryptography!

A solution to resist both Traditional and Quantum Computers

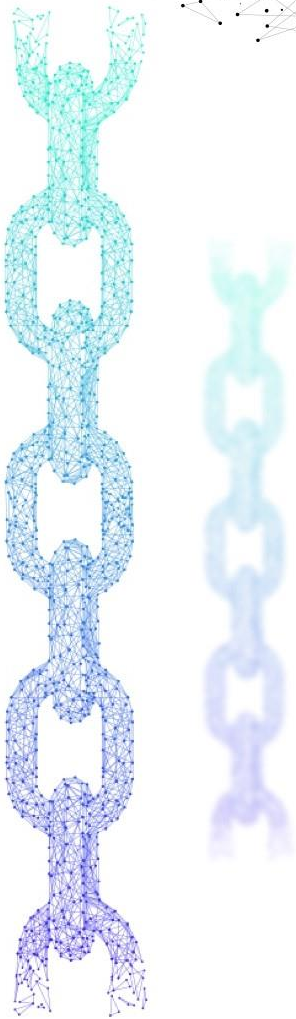
*But also applicable to a **Blockchain***

- *Can’t be too slow*
- *Can’t be too large (signature size)*
- *Must be provably secure*
- *Minimal failure points (assumptions)*
- *Has been peer-reviewed & scrutinized*

Post Quantum Cryptography!

Lots of research and many alternatives!

- *Lattice-based cryptography*
- *Multivariate cryptography*
- *Hash-based cryptography*
- *Code-based cryptography*
- *Super-singular elliptic curve isogeny cryptography*



Post Quantum Cryptography!

Lots of research and many alternatives!

- *Lattice-based cryptography*
- *Multivariate cryptography*
- ***Hash-based cryptography***
- *Code-based cryptography*
- *Supersingular elliptic curve isogeny cryptography*

Hash Based Cryptography

One-way functions

- *Like a cake - you cannot determine specific amounts of the individual ingredients post-bake*
- *Also, one cannot un-bake a cake back into its individual ingredients*

Advantages

- ***Simple*** *security assumptions (fewer failure points)*
- ***Fast*** *to compute, hard to crack*
- *Some examples:*
  - *Only rely on the security of one-way functions*
  - *Lamport One Time Signatures (OTS) (1979)*
  - *Winternitz OTS Signatures (1979)*
  - *Developed by Ralph Merkle, inspired by Robert Winternitz*

*Winternitz OTS+ = **O**ne **T**ime **S**ignature*

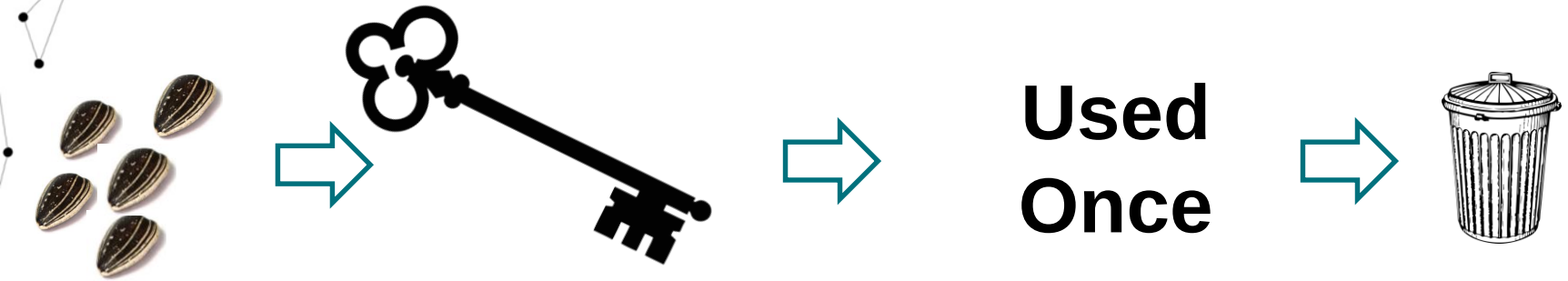
- *Quantum Computers struggle with hashes*
- *Signatures are relatively small*
- *Keysizes are relatively small*
- *Makes minimal security assumptions (minimal fail points)*

It is not all rainbows and unicorns

*Winternitz OTS+ = **O**ne **T**ime **S**ignature*

*Bob can only sign once, and he needs to change his Public Key **every time!***

*That means changing **wallet addresses** every time!*

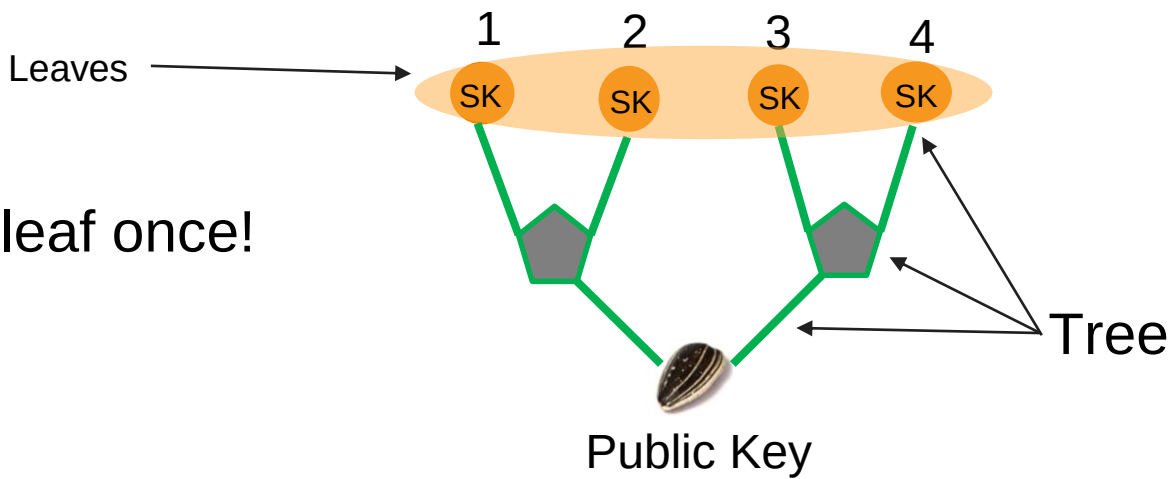


XMSS (Extended Merkle Signature Scheme)

Bob grows a tree full of secret keys!

All are linked to the same Public Key at the root

*BUT! He **must remember** the leaves he has used!*



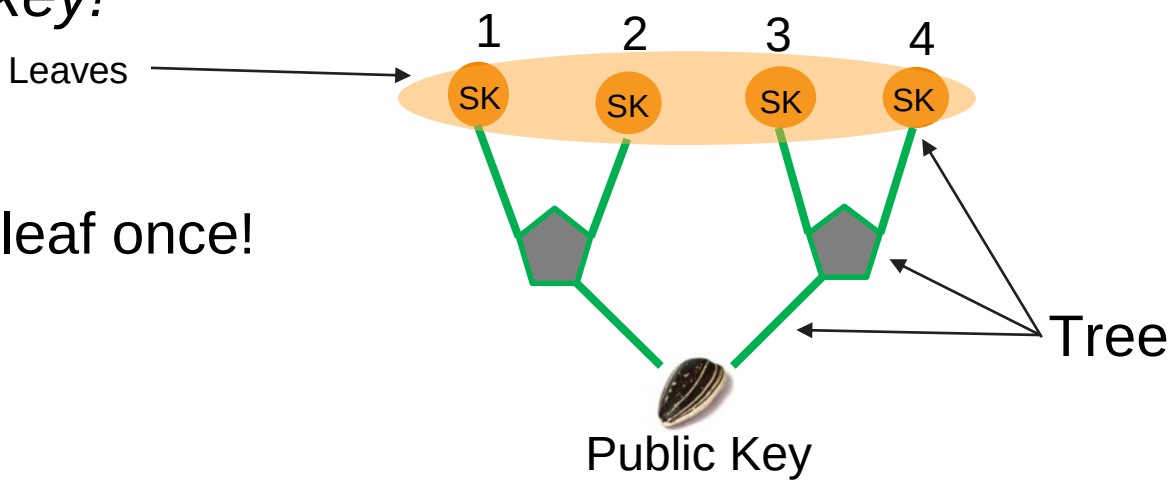
Only use each leaf once!

XMSS (Extended Merkle Signature Scheme)

The Good: *The tree can be VERY high and have many leaves*

The Danger: *Bob* ***must never*** *sign twice with the same secret key!*

Only use each leaf once!



Conclusion

- *We don’t need to wait for Quantum Supremacy.*
- *A single actor could disrupt the cryptocurrency economy*
- *Companies are making a lot of public progress*
- *Government programs have likely made more progress than they have publicized*

Conclusion

- *Upgrading in cryptocurrency is not easy. BTC is an example of political struggles with respect to upgrading.*
- *It is usually easier to implement changes in the initial codebase, than to add them in later*