Distributed HSM

Yeti Meeting - march 2020

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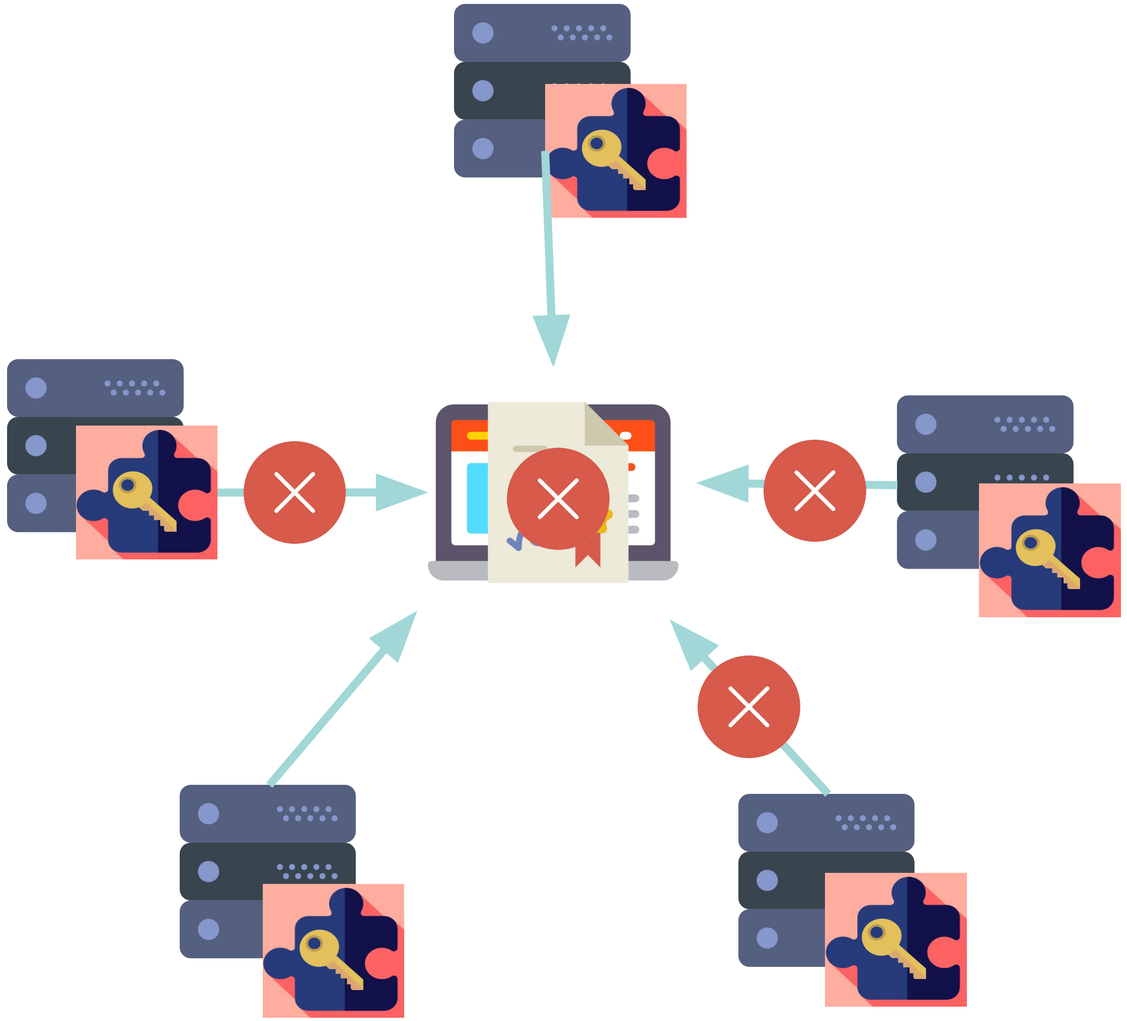
Threshold Cryptography

It allows to use a cryptographic key for signing, with a subset of distributed key shares.

The system is functional, even if not all the shares are retrieved. There is a minimum threshold of shares needed, usually **n/2+1**



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Some Threshold Cryptography Signing algorithms

RSA: *Practical Threshold Signatures*
(V. Shoup)

- 1 Round *(Keygen and signing)*
- Joining *k SigShares* allows us to generate an individual signature.
- RSA is a very common algorithm for signatures

ECDSA: *Using Level-1 Homomorphic Encryption To Improve Threshold DSA Signatures For Bitcoin Wallet Security*
(D. Boneh, R. Gennaro, S. Goldfeder)

- 2 rounds (*Keygen*) and 4 rounds (*signing*)
- *SK* is distributed and encrypted with *threshold homomorphic encryption*
- ECDSA Signatures are **smaller** and **more secure** than RSA signatures.

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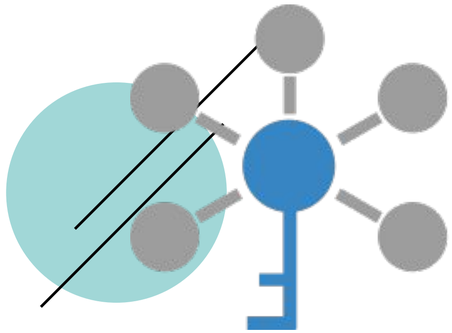

dHSM

Distributed Hardware Security Module

Collection of libraries that act like a HSM. They use threshold cryptography to sign documents and distribute the shares between a number of different devices

PKCS#11 API compilant
(OpenDNSSEC, KNOT)

Nodes communicate between them using ZMQ library

C++ and Go implementations

Cheaper deployment,
compared with real HSM.

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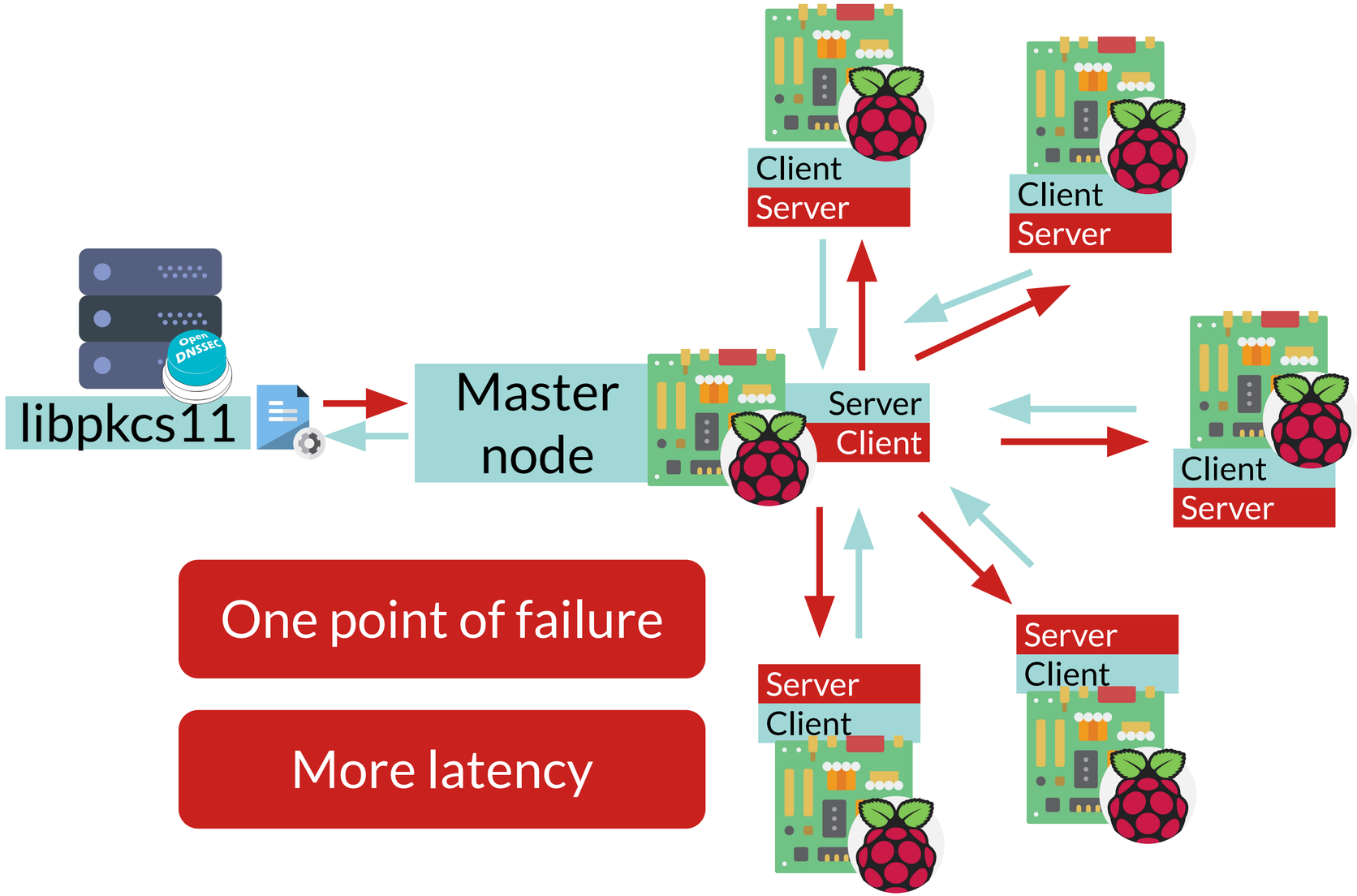
History

2014

C++ implementation with a separated master node



One point of failure

More latency

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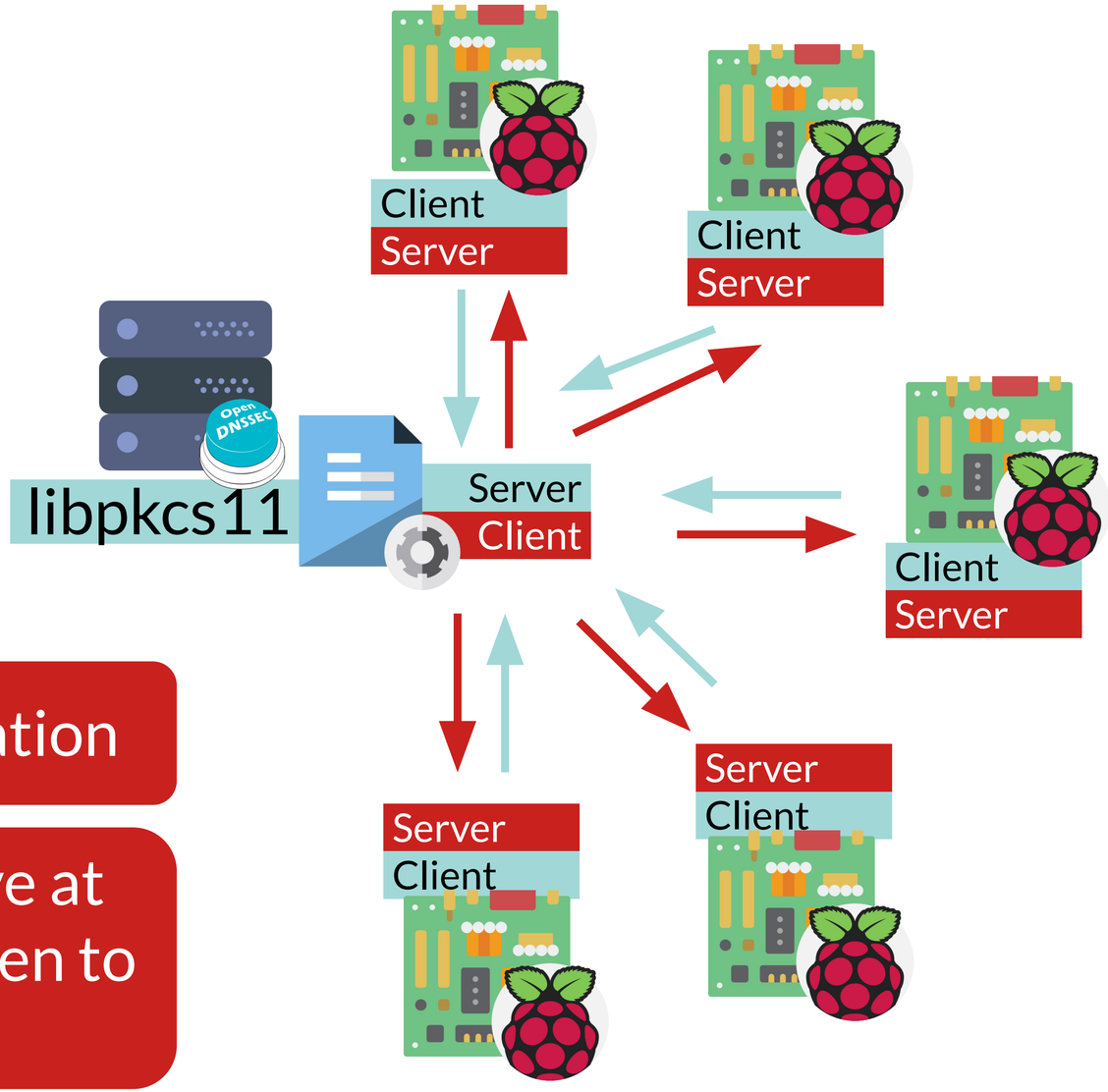
History

2016

C++ implementation without separated master node (client acts like the master node)

Complex installation

Signer must have at least one port open to nodes



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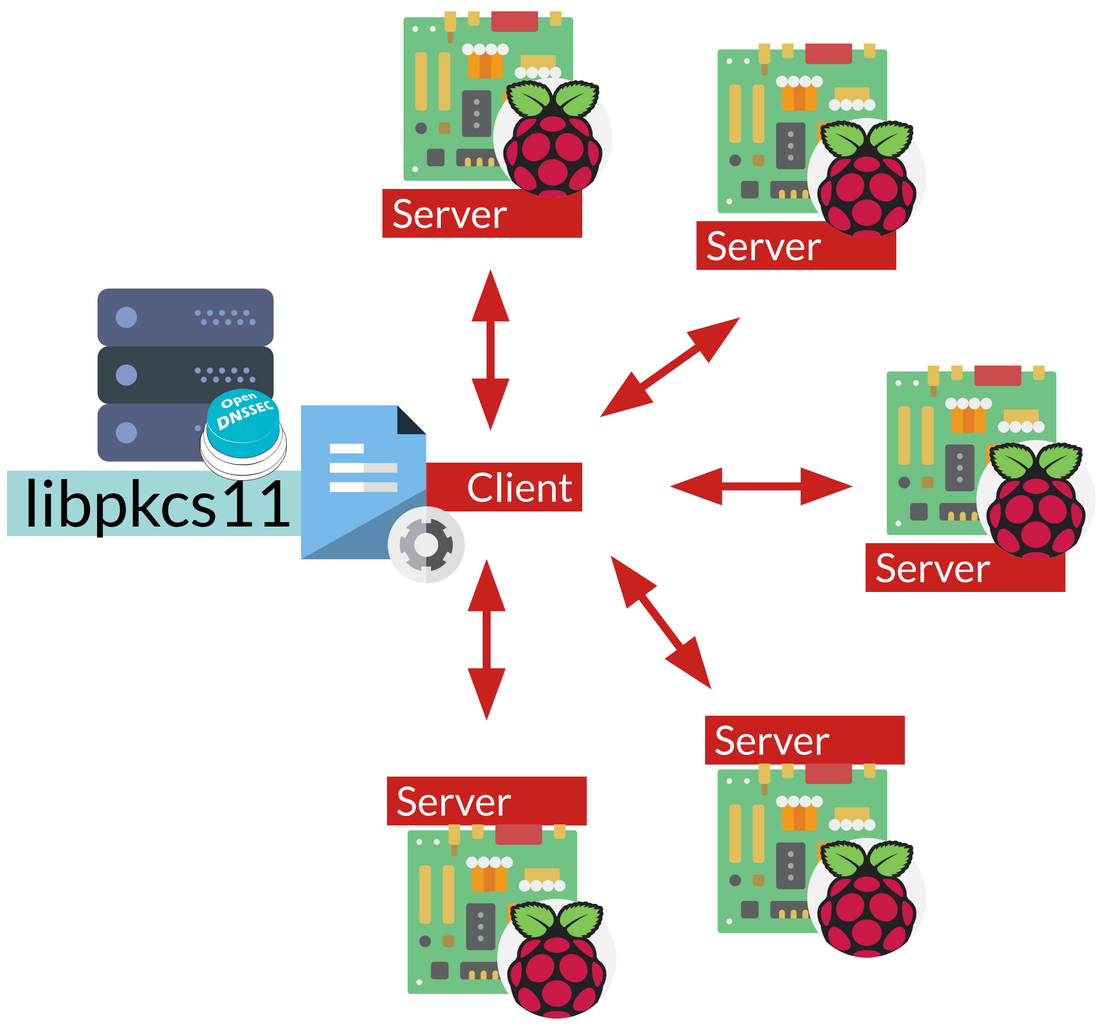
History

2019

Reimplemented in Go
Go Modules
installation.
Library server deleted
(no need of open port).
RSA and ECDSA
signatures
implementation



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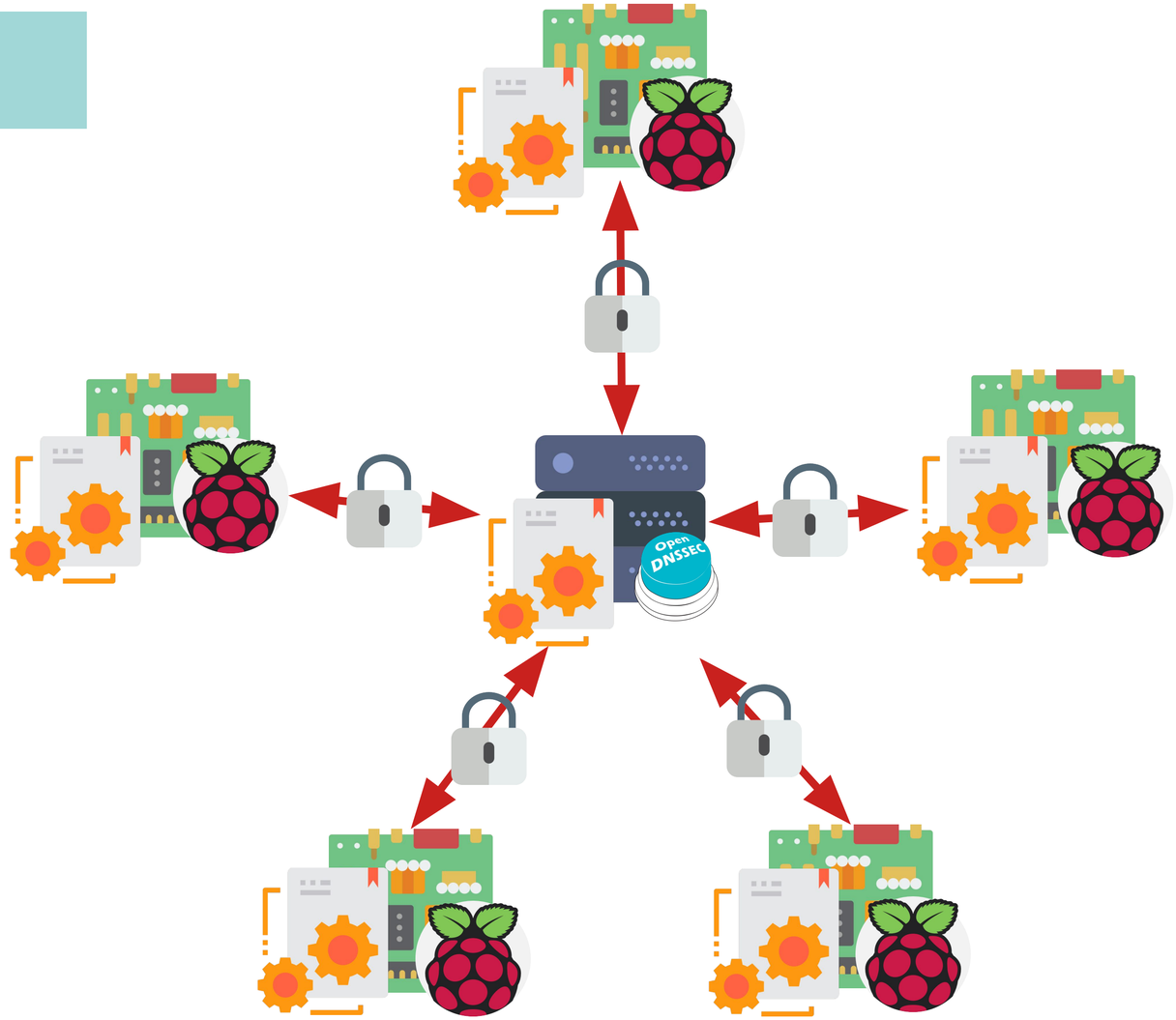
How does it work?

Initial Configuration

- Compile DTC library in server which has installed OpenDNSSEC
- Compile DTCNode in each participant node
- Create config files with communication keys
- Configure OpenDNSSEC to use DTC as PKCS#11 library



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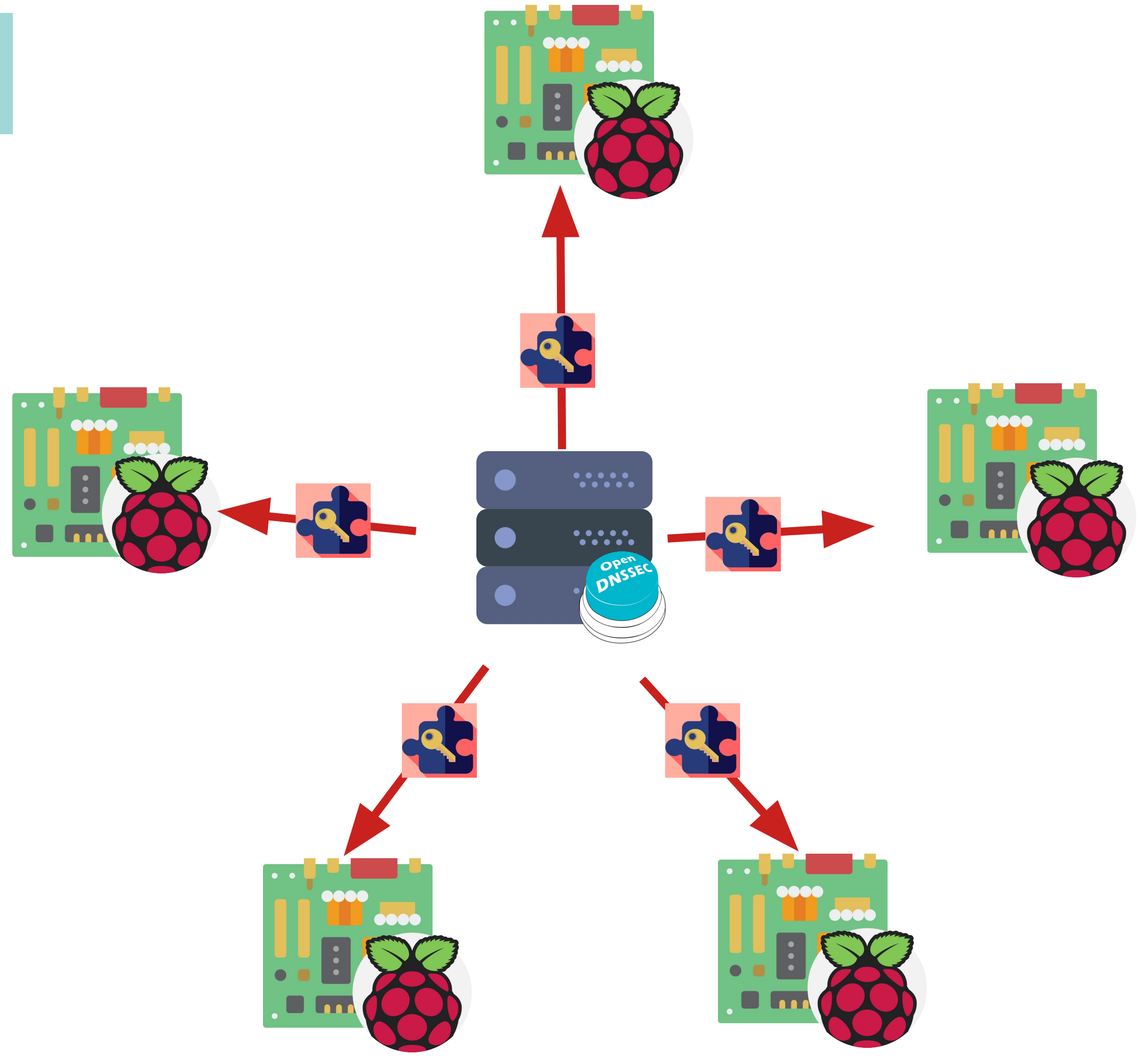
How does it work?

Key Creation (RSA Case)

- OPENDNSSEC asks to the library to create a KSK key pair
- Library creates KSK key with **t-of-n threshold** , delivering key shares to all the connected nodes



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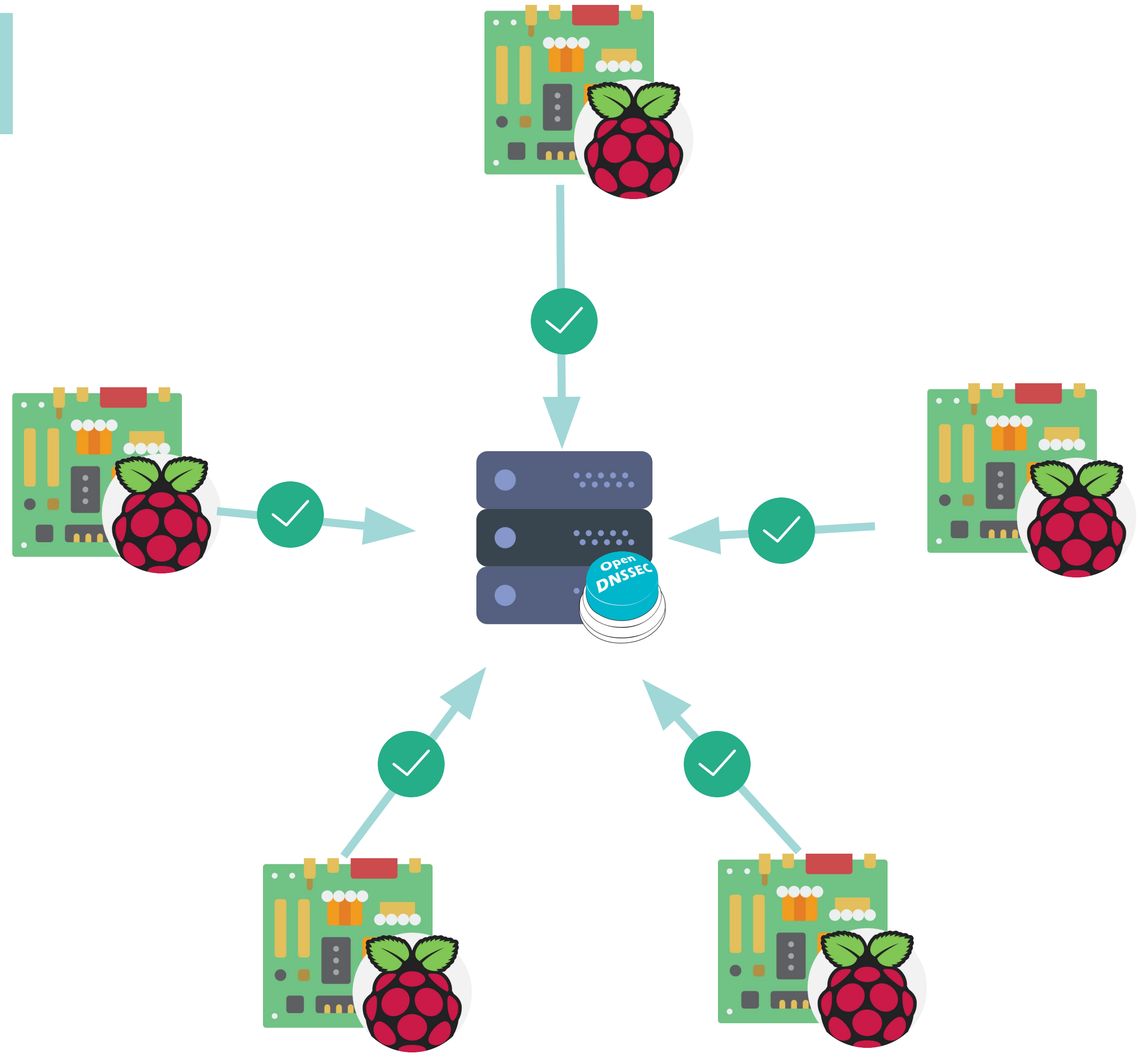
How does it work?

Key Creation (RSA Case)

- The connected nodes ACK the successful storage of key shares.



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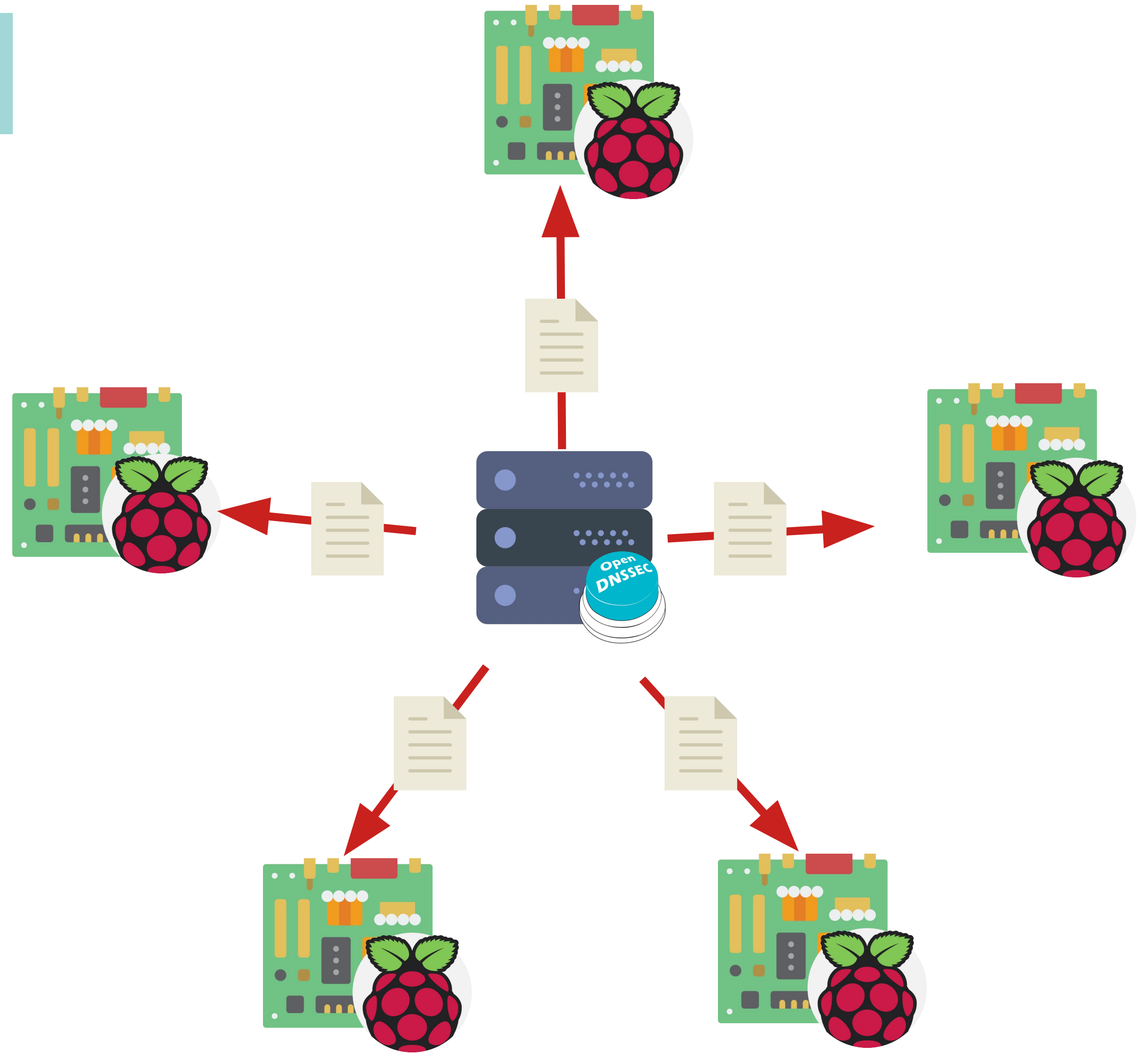
How does it work?

Signing Process (RSA Case)

- OPENDNSSEC asks to the library to sign a RR
- Library sends a RR to be signed to all the connected nodes.



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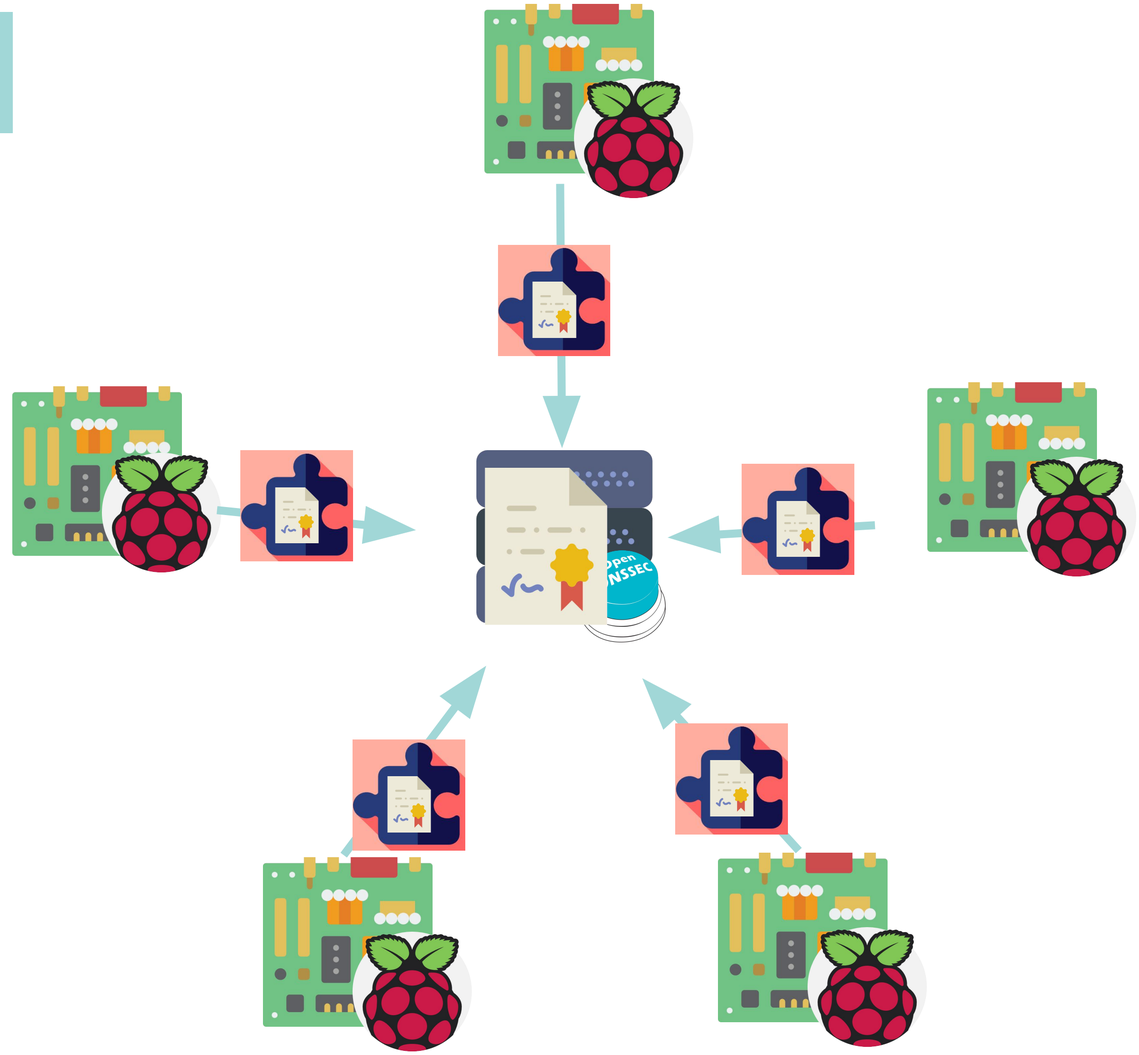
How does it work?

Signing Process (RSA Case)

- The nodes sign the zone and return their signature shares.
- The shares are joined by the client, generating a signature.



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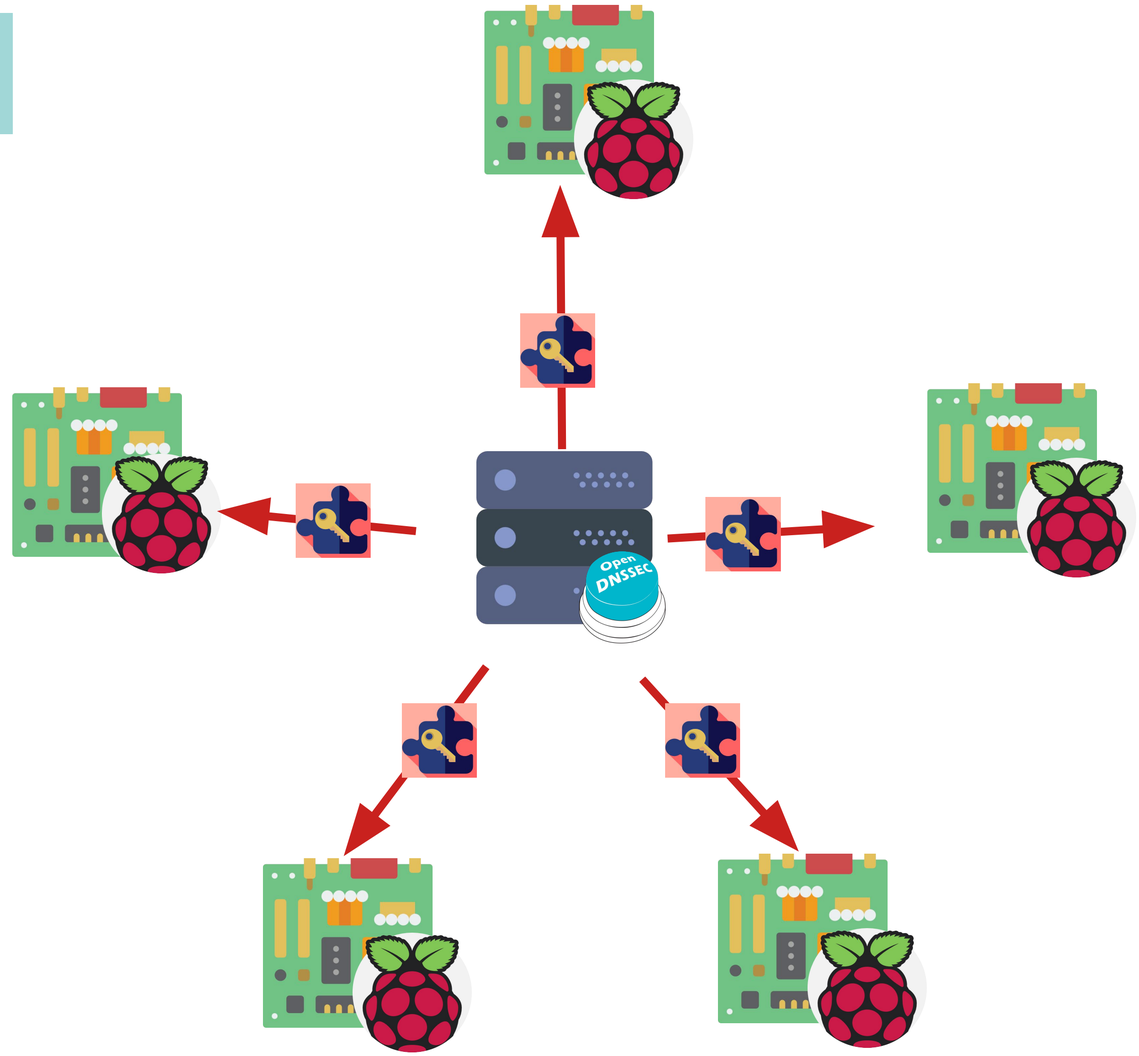
How does it work?

Key Creation (ECDSA Case)

- OPENDNSSEC asks to the library to create a KSK key pair.
- Library generates a threshold Paillier's encryption scheme keypair, and distributes a SK share and the PK to each node.



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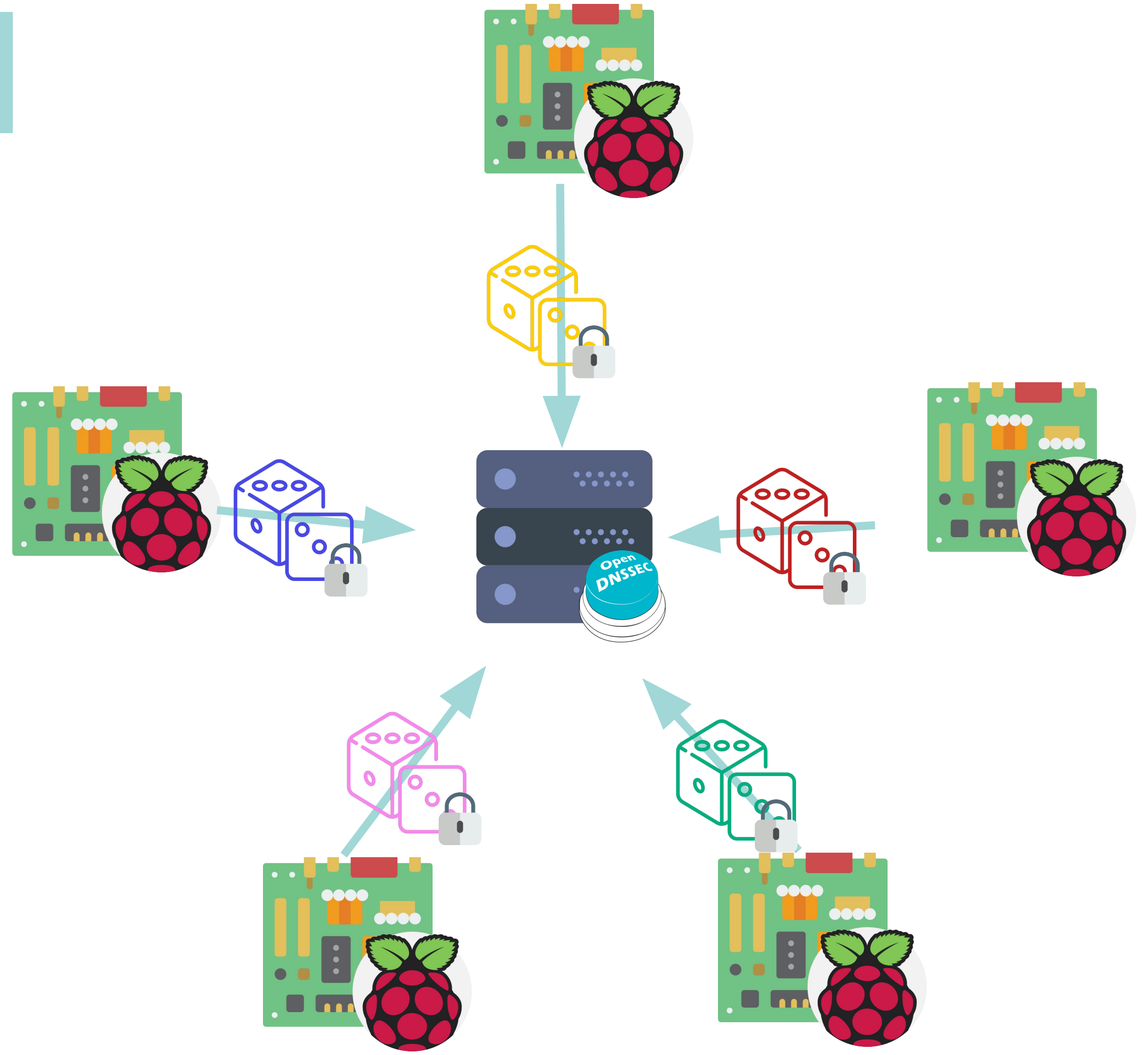
How does it work?

Key Creation (ECDSA Case)

- Each node encrypts a random value with Paillier's PK and sends it to the client.



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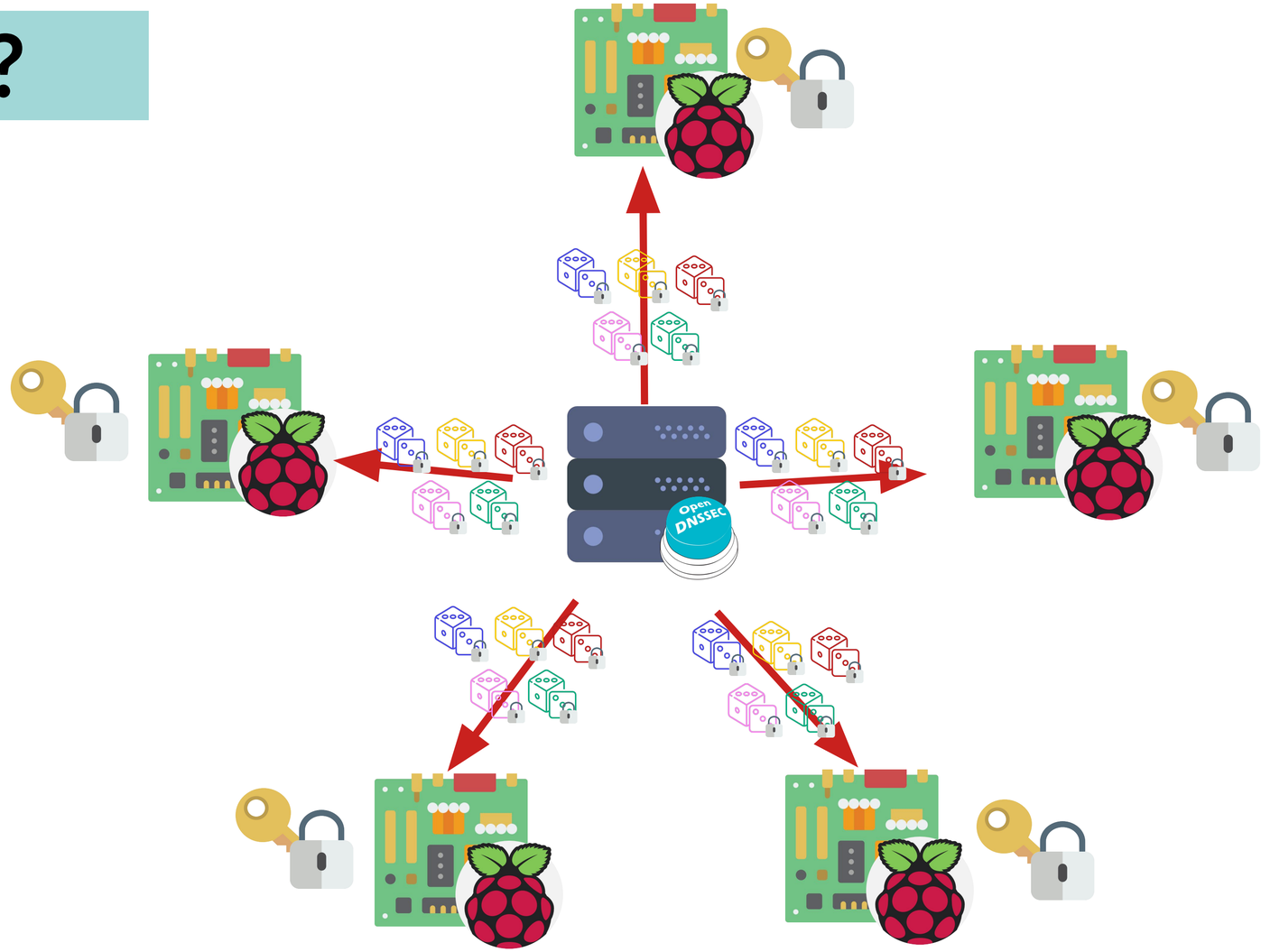
How does it work?

Key Creation (ECDSA Case)

- The values are broadcasted by the client to all nodes, and and each node joins them homomorphically to form a Paillier Encrypted SK.



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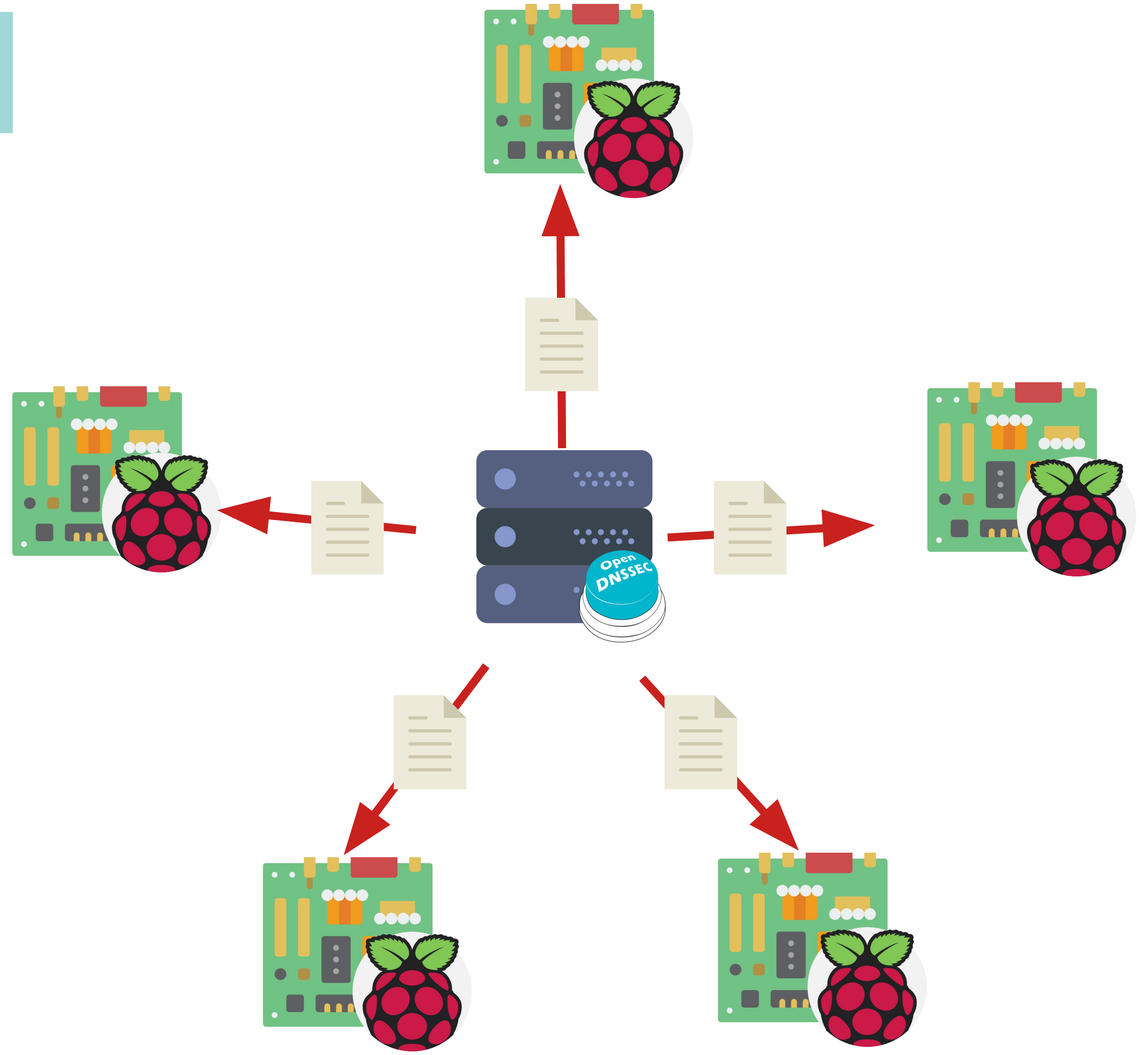
How does it work?

Signing Process (ECDSA Case)

- OPENDNSSEC asks to the library to sign a RR.
- Library sends the RR to each node.



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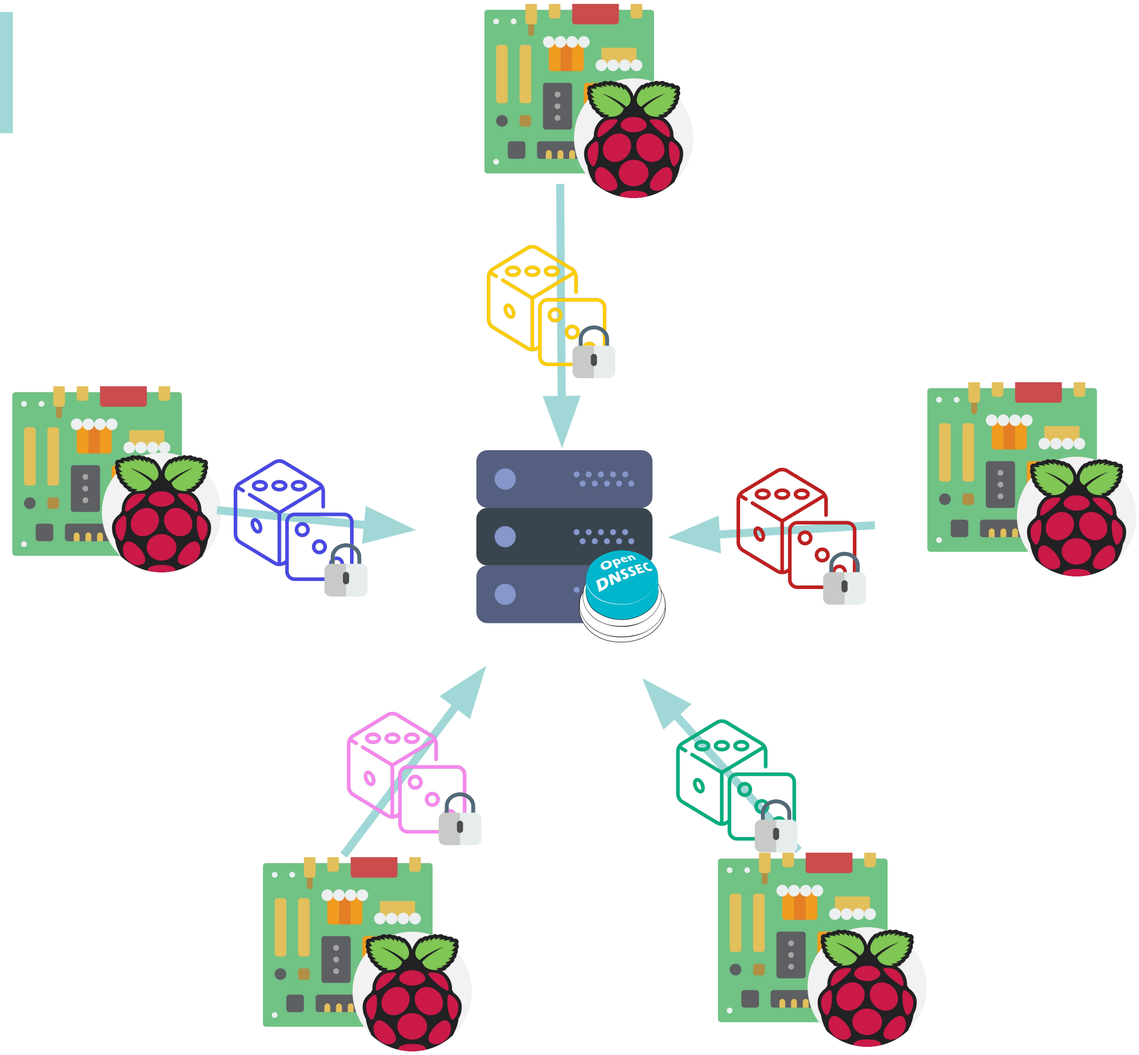
How does it work?

Signing Process (ECDSA Case)

- Each node returns its own encrypted randomness to be used in the process.



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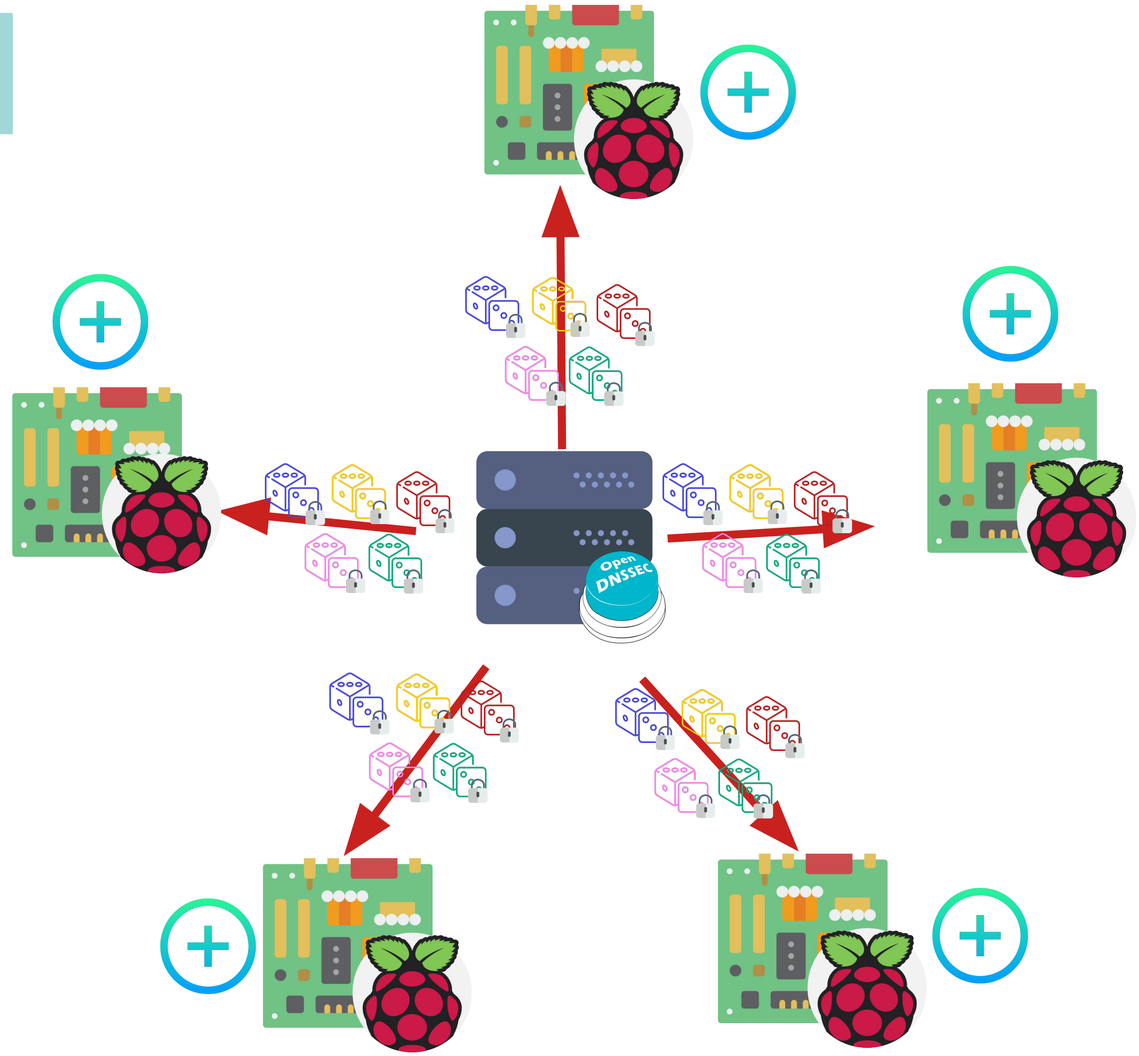
How does it work?

Signing Process (ECDSA Case)

- The values are broadcasted by the client to other nodes and aggregated using Level 2 Paillier-based homomorphic encryption in 4 rounds.



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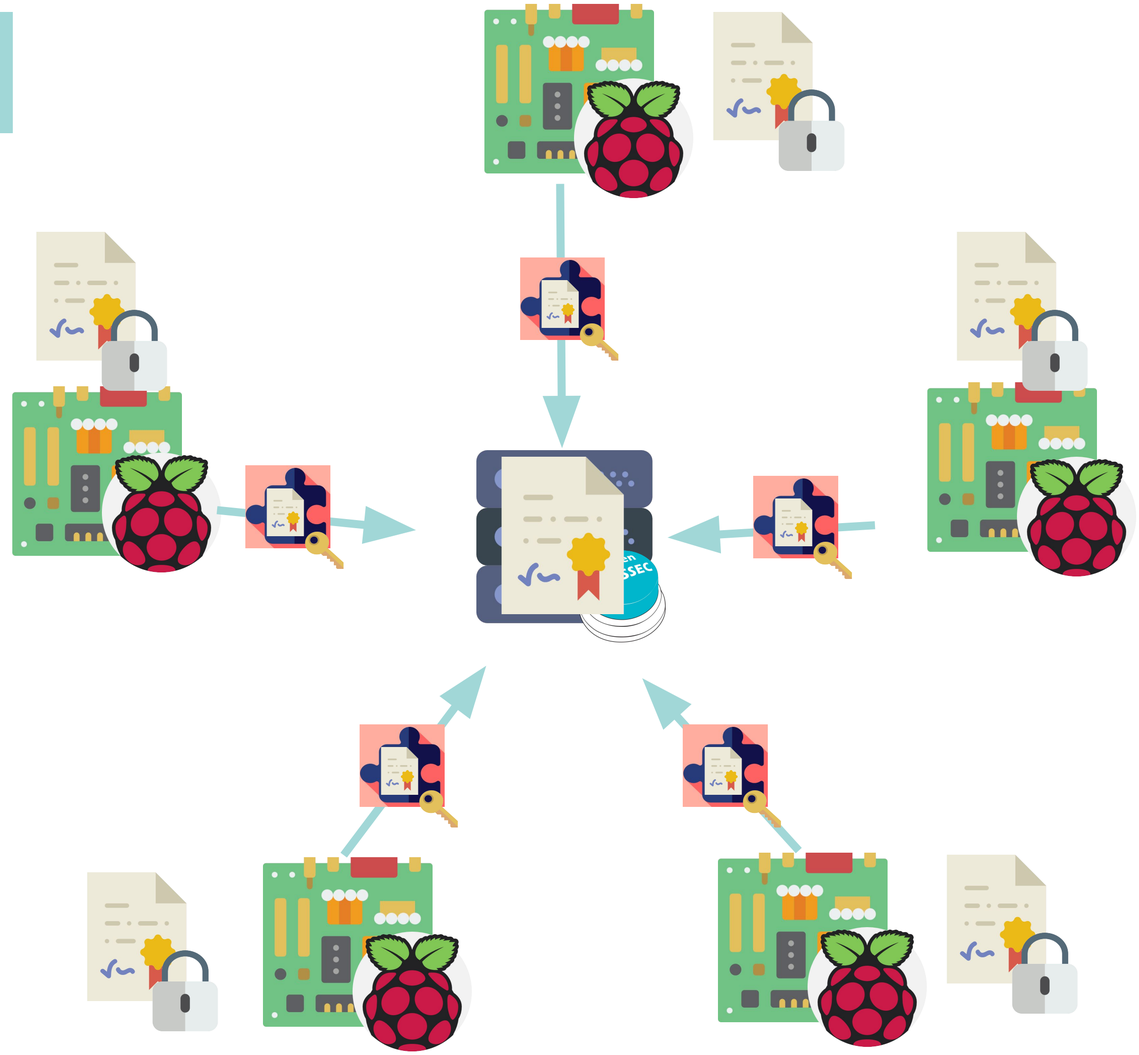
How does it work?

Signing Process (ECDSA Case)

- After the four rounds, the client and all the nodes generate a Paillier-encrypted signature.
- The Nodes send decryption shares to the client to decrypt the signature.



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Components

All of them are available at
https://niclabs.cl/tchsm

Wiki and Documentation:
https://github.com/niclabs/dtc/wiki

TCRSA

Uses Go native libraries only

DTCNODE

Process that runs on each node

TCPAILLIER

Threshold Paillier Cryptosystem impl.

TCECDSA

Threshold ECDSA Signing impl.

DTC

PKCS#11 library

HSM-SIGNER

Go implemented zone signer

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Features

Measurements on PC with seventh gen Intel Core i7 processor, Ubuntu 18.04 and 8 GB of RAM

Compile Time

~3 minutes

Key Generation

~10s RSA/1024
~3m RSA/2048
~3m ECDSA/256

Signing Time

~100 signatures/second RSA
~25 signatures/second ECDSA

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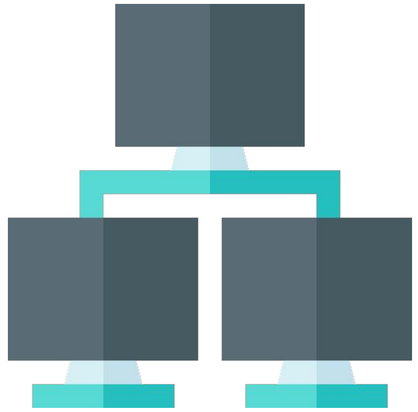
Future Work

Implement other cryptographic schemes

(That support threshold crypto)



Implement other communication and storage platforms

(Besides ZMQ and SQLite)

Try other uses for the library

(Apart from DNSSEC)

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Acknowledgements

Fco. Cifuentes y Fco. Montoto

Firsts designs and implementations of DTCHSM.

Eduardo Riveros

Implementation and design of current version of DTCHSM.

Flaticon

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Thanks

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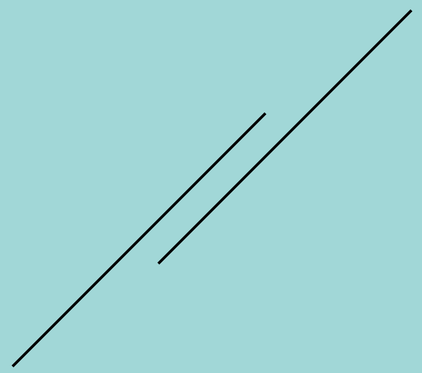

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