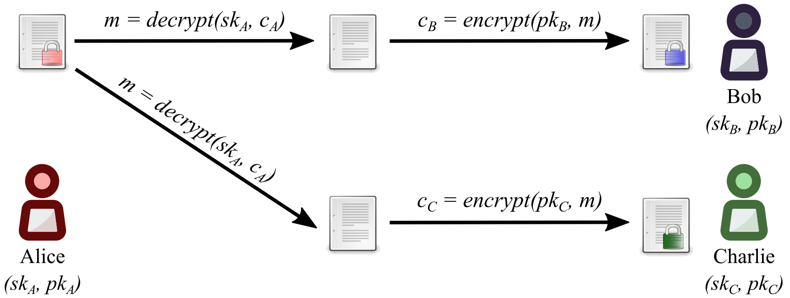
# NuCypher

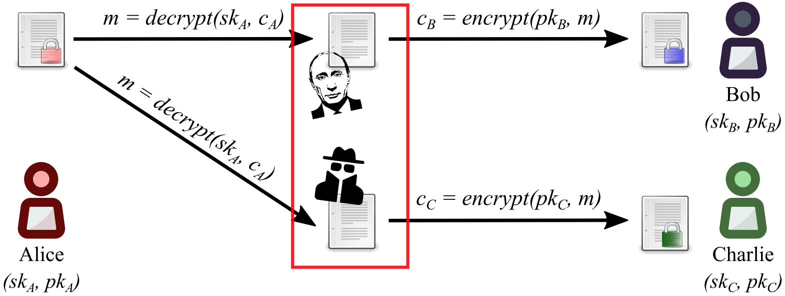
<presenter name(s), role(s)>

<event name>, <dd MMM yyyy>

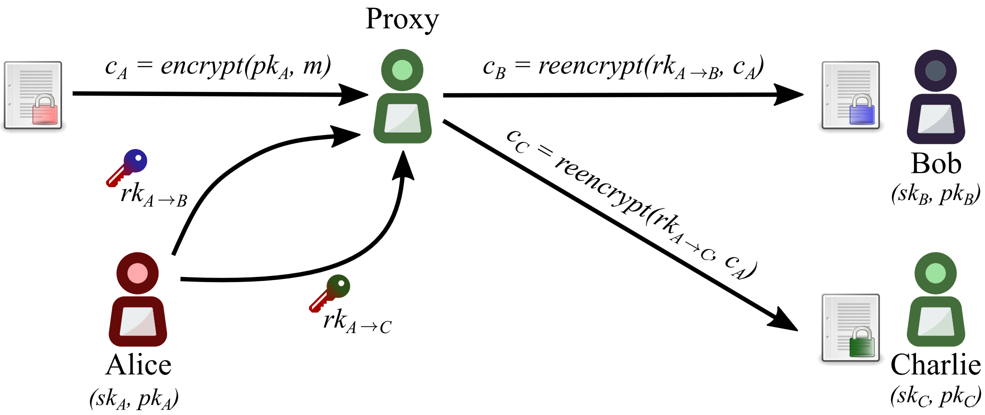
# Public Key Encryption (PKE)



# Public Key Encryption (PKE)

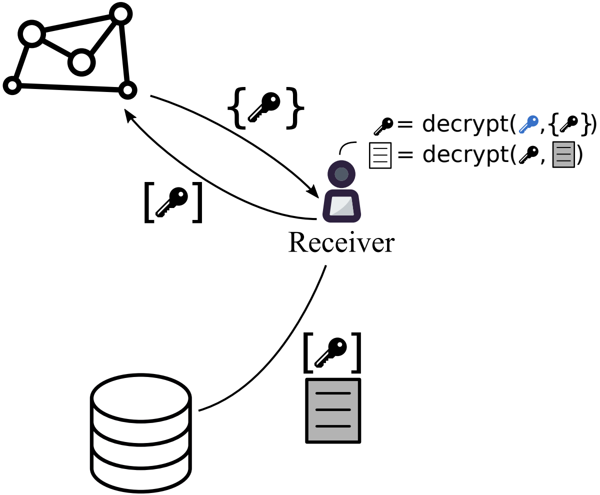


# What is proxy re-encryption (PRE)



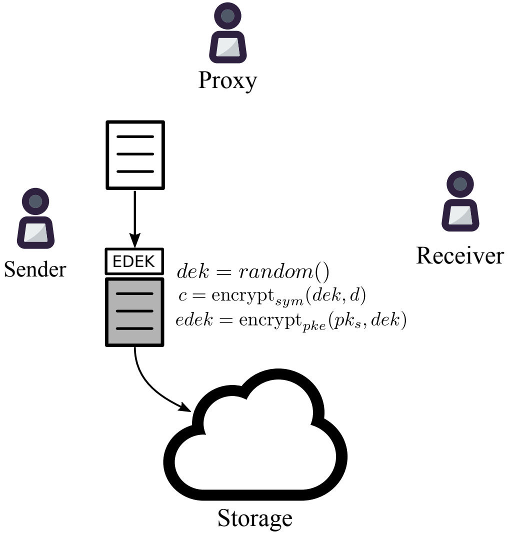
# Solution

## Proxy re-encryption + Key Management



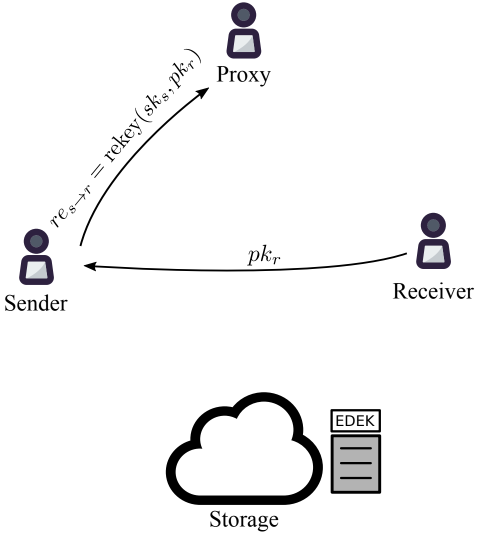
# Centralized KMS using PRE

## Encryption



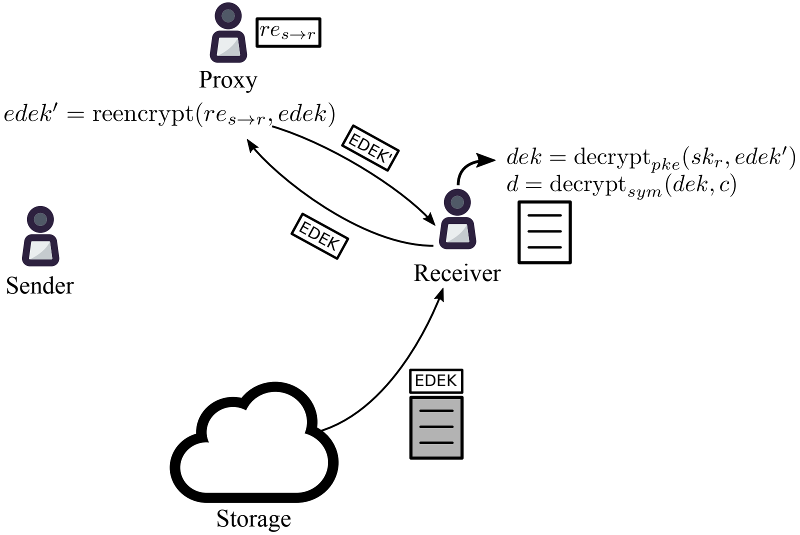
# Centralized KMS using PRE

## Access delegation



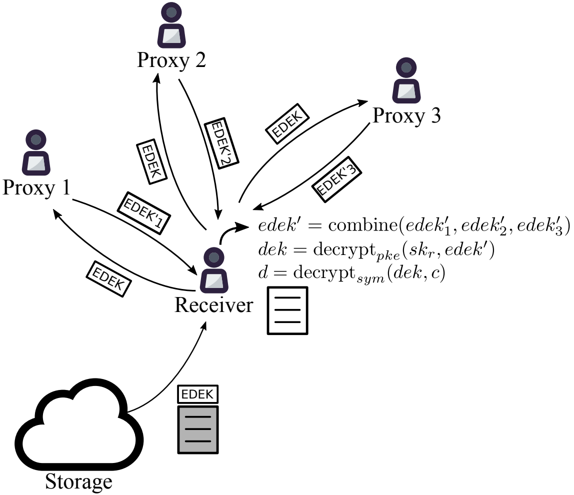
# Centralized KMS using PRE

## Decryption



# Decentralized Key Management

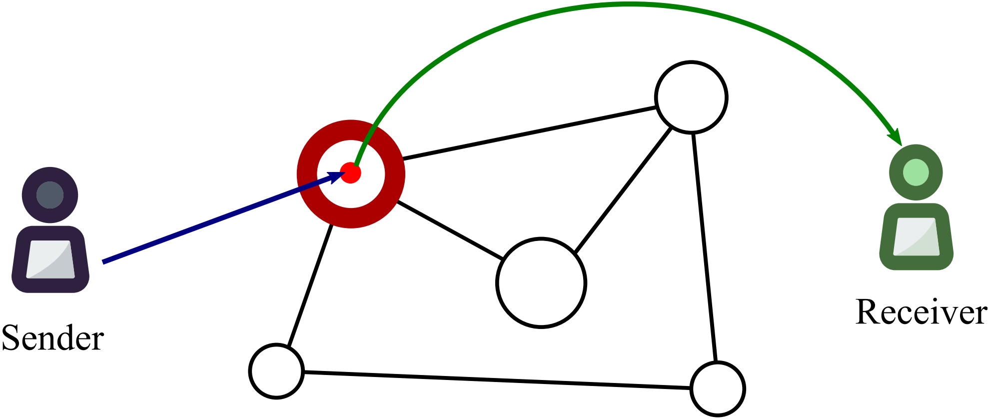
## Using threshold split-key re-encryption (Umbral)



# Umbral: Threshold Proxy Re-encryption

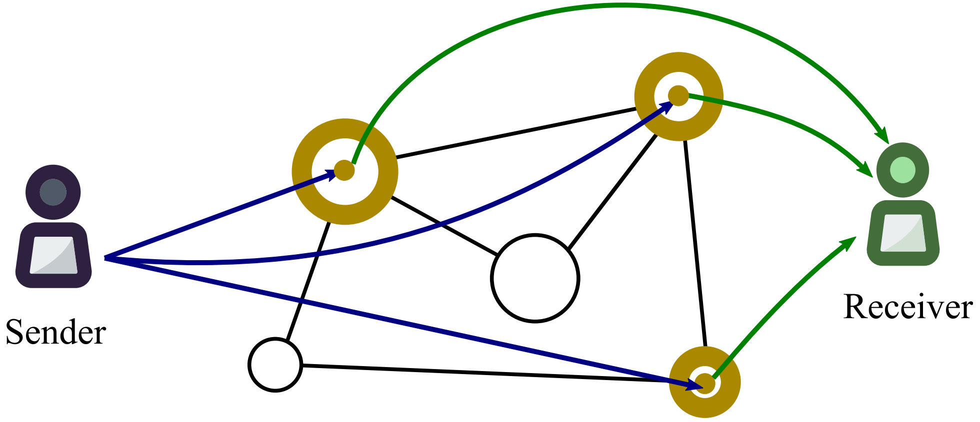
- "Umbral" is Spanish for "threshold"
- PRE properties: Unidirectional, single-hop, non-interactive
- Follows a KEM/DEM approach:
  - UmbralKEM provides the threshold re-encryption capability
  - Uses ECIES for key encapsulation with ZK proofs of correctness for verifiability on prime order curves (such as secp256k1)
  - DEM can be any authenticated encryption (currently ChaCha20-Poly1305)
- IND-PRE-CCA security
- Key splitting is analogous to Shamir Secret Sharing
- Verification of re-encryption correctness through Non-Interactive ZK Proofs
- Reference implementation: `https://github.com/nucypher/pyUmbral`
- Documentation: `https://github.com/nucypher/umbral-doc`

# KMS Network: Data Sharing + PKE



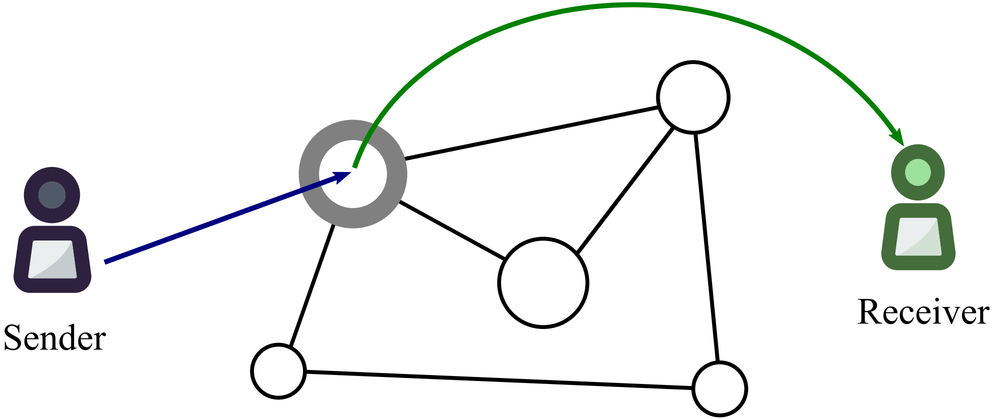

- Single node has access to data
- Single node can deny to do work

# KMS Network: Data Sharing + PKE + Shamir Secret Sharing



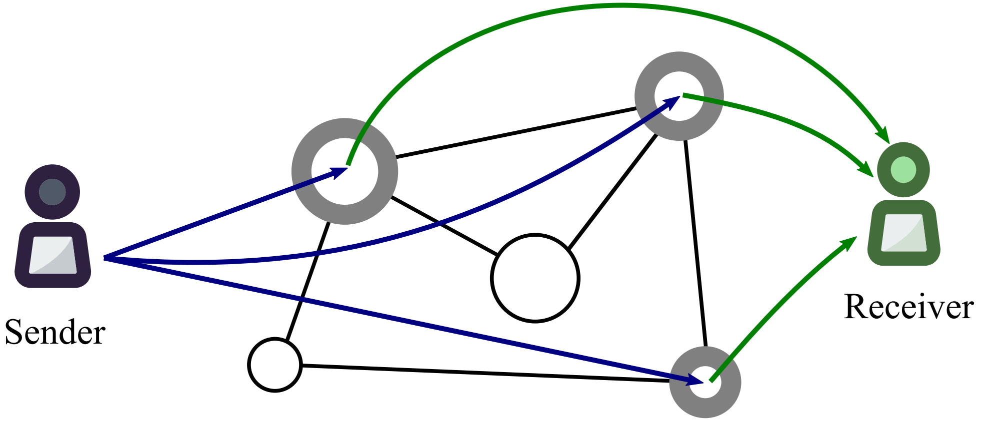

- Nodes can collude to gain access to data

# KMS Network: Data Sharing + PRE




- Single node collusion with receiver possible
- Single node can deny to do work

# KMS Network: Data Sharing + Threshold PRE (Umbral)




- Collusion now requires m nodes + receiver

# NU Token

## Purpose

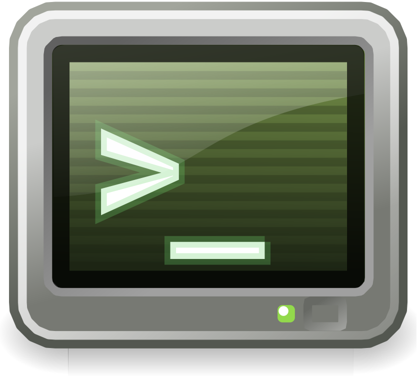
- Splitting trust across re-encryption nodes
  - More tokens = more trust, more work, and more compensation
- Proof of Stake for minting new coins according to the mining schedule
- Security deposit at stake against malicious behavior of nodes

# Data Sharing Policies

- Time-based
- Conditional on payment
  - “Grant access once paid, continue granting while paying”
- Smart contract (public) method

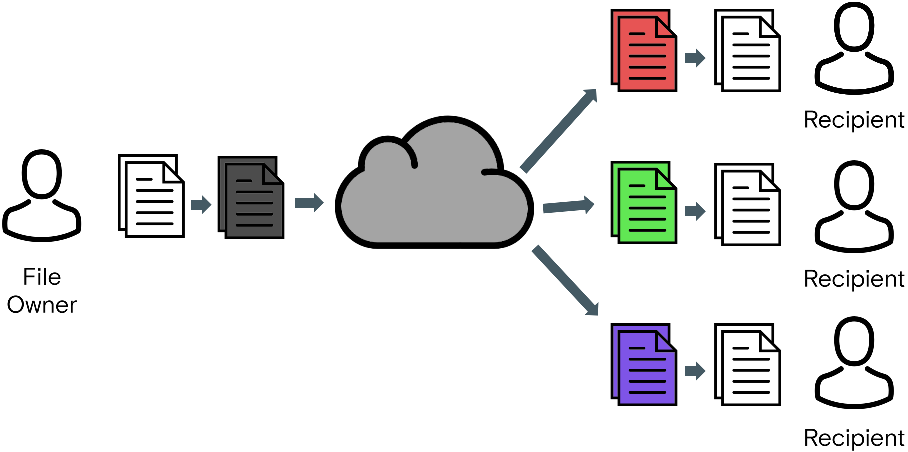
Decentralized re-encryption nodes (Ursulas) relied on to apply conditions without having the ability to decrypt data

# Demo



# Use Cases

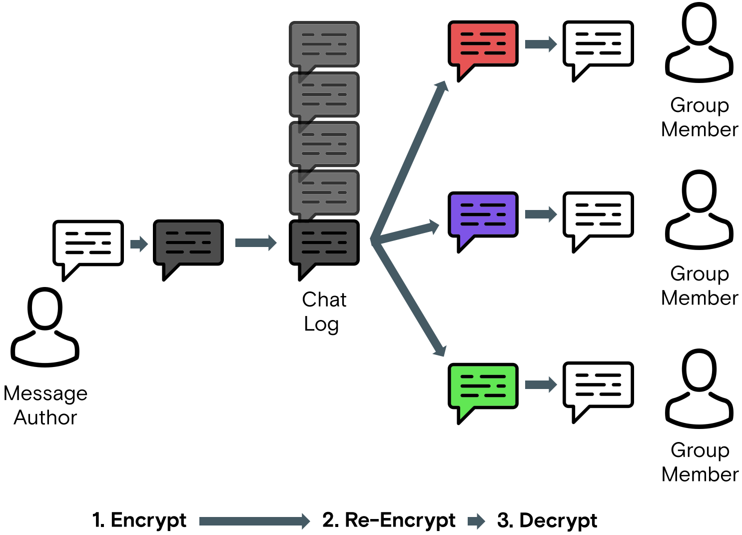
## Encrypted file sharing




**1. Encrypt** → **2. Re-Encrypt** → **3. Decrypt**

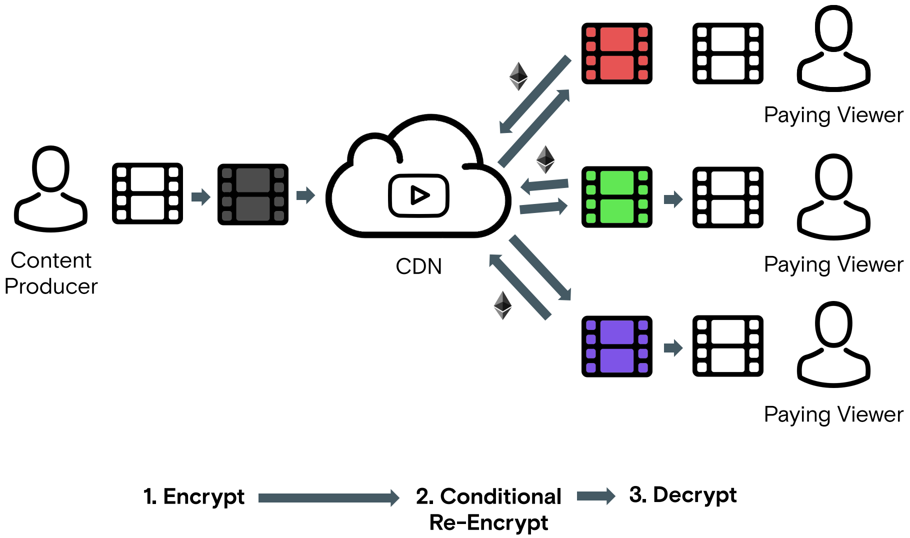
# Use Cases

## Encrypted multi-user chats



# Use Cases

## Decentralized access-controlled content



# Early Users

## Decentralized Application

**Medical & Biotech Data Platform**
- MEDIBLOC
- MedCredits
- medixain
- PointNurse
- wholesome BUSINESS-IN-A-BOX FOR DOCTORS
- IKU BIOTECH REDEFINED

**Key Management**
- EMBLEM

**Automobile Data**
- CarBlock

**Location Data**
- DATAEUM

**Genomics Data**
- 博士链 DOCTOR CHAIN

## NuCypher Ecosystem

## Protocol & Infrastructure

**Medical Data Protocol**
- IRYO
- HealthDex

**Decentralized Database**
- bluzelle
- fluence.ai
- WOLK

**Sharing Economy**
- ORIGIN

**Internet of Things**
- SPHERITY
- XAIN.

**User Data Monetization**
- SWIPE
- datum

# Competing Technology

Data Masking and Tokenization

- Less secure for data with underlying patterns
- Reduce the value of data by obfuscating it

Public Key Encryption

- Data must be decrypted before it is shared
- Not Scalable

Multi-Party Computation

- Interactive protocol
- Slow Performance

Fully Homomorphic Encryption

- Slow Peformance
  - NuCypher has developed a GPU-accelerated FHE library: nuFHE

# Fully Homomorphic Encryption

## nuFHE library

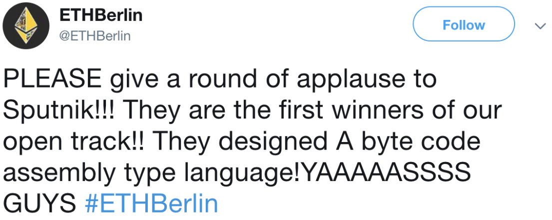
- GitHub: `https://github.com/nucypher/nufhe`
- GPU implementation of fully homomorphic encryption
- Uses either FFT or integer NTT
- Achieved 100x performance over TFHE benchmarks

| **Platform** | **Library** | **Performance (ms/bit)** | |
|---|---|---|---|
| | | **Binary Gate** | **MUX Gate** |
| **Single Core/Single GPU - FFT** | TFHE (CPU) | 13 | 26 |
| | nuFHE | 0.13 | 0.22 |
| | **Speedup** | **100.9** | **117.7** |
| **Single Core/Single GPU - NTT** | cuFHE | 0.35 | N/A |
| | nuFHE | 0.35 | 0.67 |
| | **Speedup** | **1.0** | **-** |

# FHE Proof of Concept

## Sputnik

- GitHub: `https://github.com/nucypher/sputnik`
- Assembly language and interpreter for FHE that uses nuFHE
- Commits a merkle root of computation to the blockchain for proof of logic flow
- Used to execute first homomorphic smart contract at ETHBerlin 2018

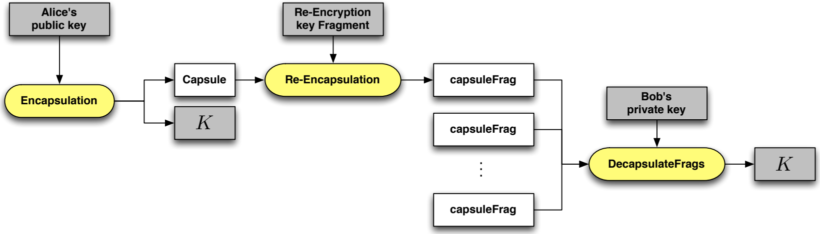


# More Information

NuCypher

**Website:** `https://www.nucypher.com`
**Whitepaper:** `https://www.nucypher.com/whitepapers/english.pdf`
**Proxy Re-encryption Network:** `https://github.com/nucypher/nucypher`
**Umbral Reference Implementation:** `https://github.com/nucypher/pyUmbral`
**nuFHE:** `https://github.com/nucypher/nufhe`
**Discord:** `https://discord.gg/7rmXa3S`
E-mail: <email_prefix>@nucypher.com
E-mail: hello@nucypher.com

# Appendix: Umbral Flow Diagram




- Reference implementation: `https://github.com/nucypher/pyUmbral`
- Documentation: `https://github.com/nucypher/umbral-doc`

# Appendix: Security Audits

TRAIL OF BITS

nccgroup

Least Authority
Freedom Matters

# Appendix: NU Token Metrics

## Mining

**Mining & Staking Economics:** `https://github.com/nucypher/mining-paper`

**Mining reward:**

$$\kappa = \left(0.5 + 0.5\frac{\min(\mathsf{T_i}, \mathsf{T}_1)}{\mathsf{T}_1}\right)$$

$$\mathsf{T_{i,initial}} \geq \mathsf{T}_{\min}$$

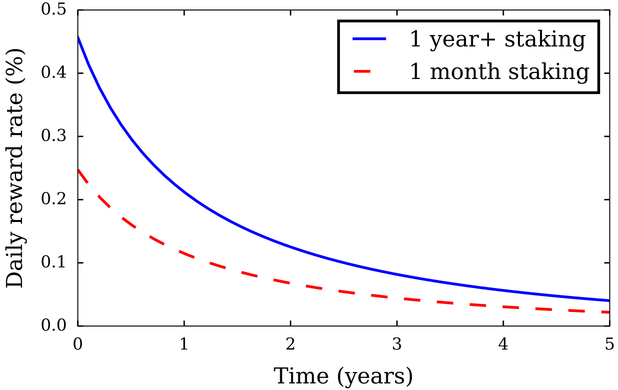
$$\delta \mathsf{s_{i,t}} = \kappa \frac{\mathsf{l_i}}{\sum \mathsf{l_j}} \frac{\ln 2}{\mathsf{T}_{1/2}} \left(\mathsf{S}_{\max} - \mathsf{S}_{\mathsf{t}-1}\right)$$

**Results into:**

$$\text{reward} \propto 2^{\frac{\mathsf{t}}{\mathsf{T}_{1/2}}}$$

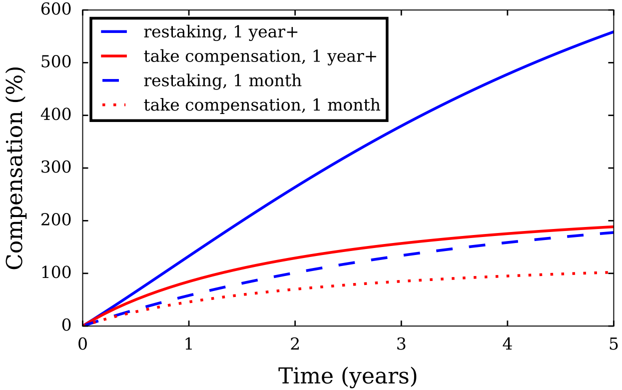
# Appendix: NU Token Metrics

## Graph of daily mining compensation



# Appendix: NU Token Metrics

## Relocking mining rewards



# Appendix: Team

## Founders

MacLane Wilkison
Co-founder and CEO

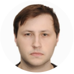
Michael Egorov, PhD
Co-founder and CTO

## Employees

David Nuñez, PhD
Cryptographer

John Pacific (tux)
Engineer

Justin Myles Holmes
Engineer



Sergey Zotov
Engineer

Kieran Prasch
Engineer

Bogdan Opanchuk, PhD
Engineer

Ryan Caruso
Community

Derek Pierre
Business Development

Arjun Hassard
Product & Partnerships

Keaton Bruce
Engineer

## Advisors

Prof. Dave Evans

Prof. Giuseppe Ateniese
Stevens Inst. of Technology

John Bantleman
Rainstor

Tony Bishop
Equinix