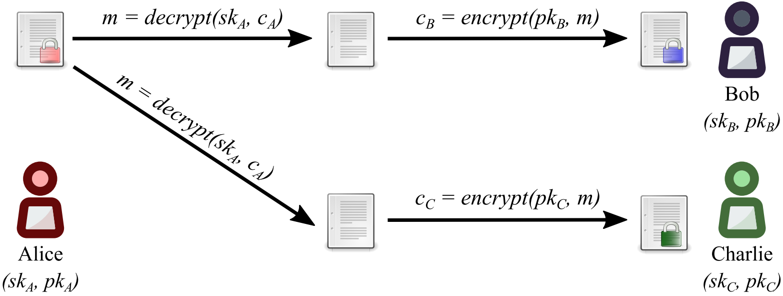
NuCypher

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

<event name>, <dd MMM yyyy>

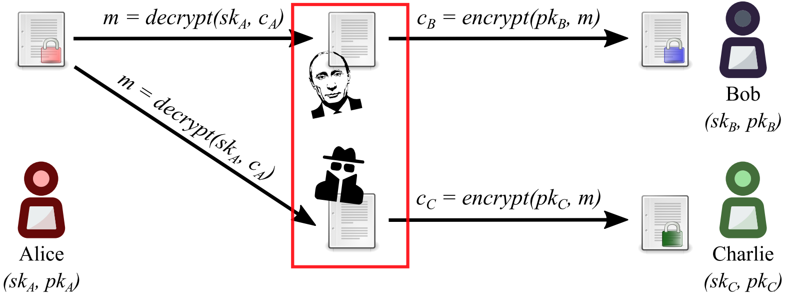
Public Key Encryption (PKE)



Limitations

- Decryption required before sharing
- Not scalable
- Complex access revocation

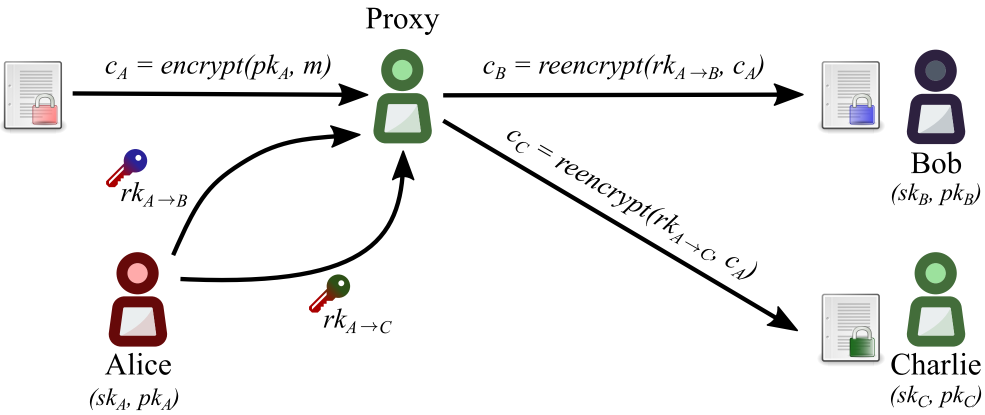
Public Key Encryption (PKE)



Limitations

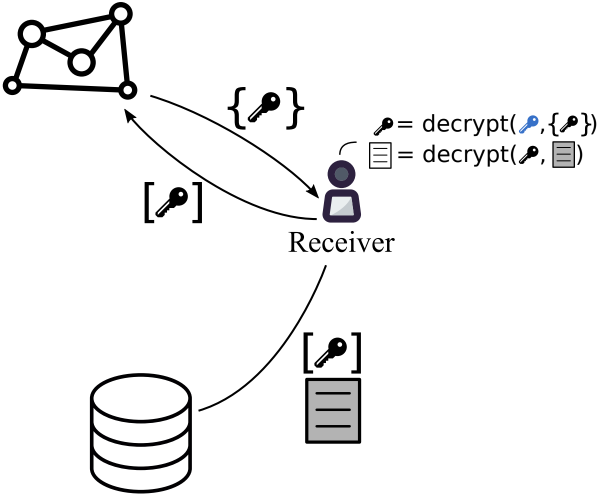
- Decryption required before sharing
- Not scalable
- Complex access revocation

What is proxy re-encryption (PRE)



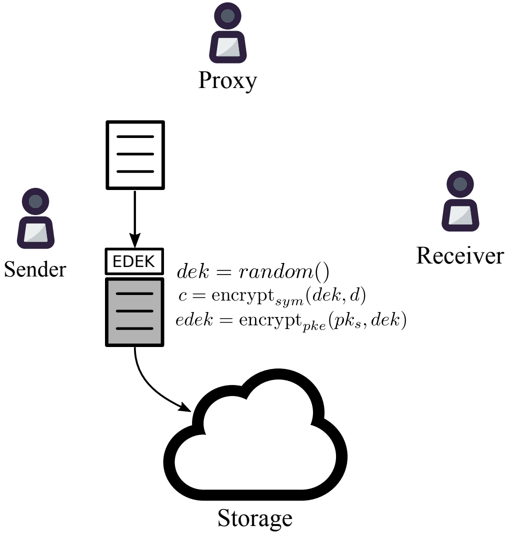
Solution

Proxy re-encryption + Key Management



Centralized KMS using PRE

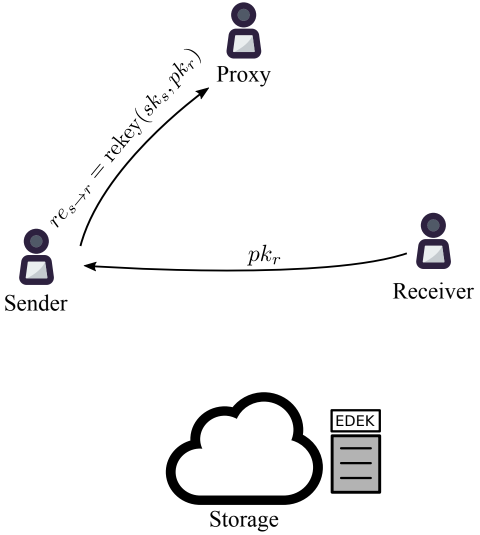
Encryption



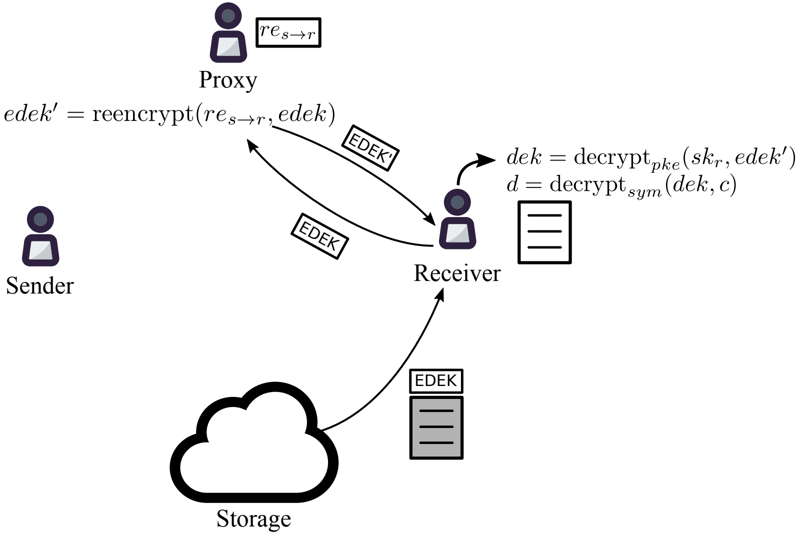
$$dek = random()$$
$$c = \text{encrypt}_{sym}(dek, d)$$
$$edek = \text{encrypt}_{pke}(pk_s, dek)$$

Centralized KMS using PRE

Access delegation

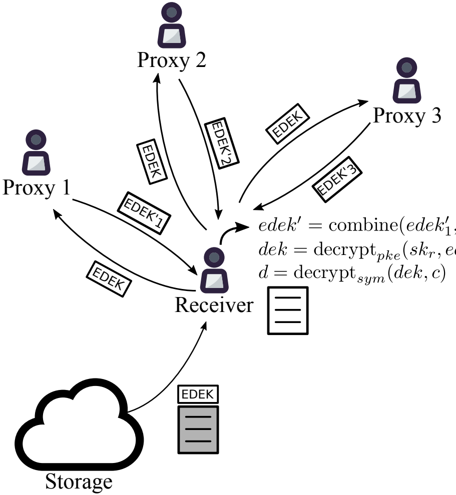


Centralized KMS using PRE
Decryption



Decentralized Key Management

Using threshold split-key re-encryption (Umbral)

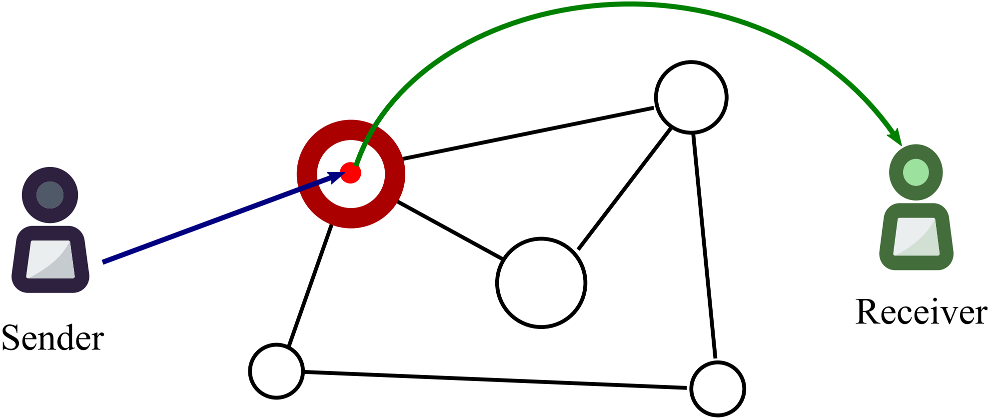


$edek' = \text{combine}(edek'_1, edek'_2, edek'_3)$
$dek = \text{decrypt}_{pke}(sk_r, edek')$
$d = \text{decrypt}_{sym}(dek, c)$

Umbral: Threshold Proxy Re-encryption

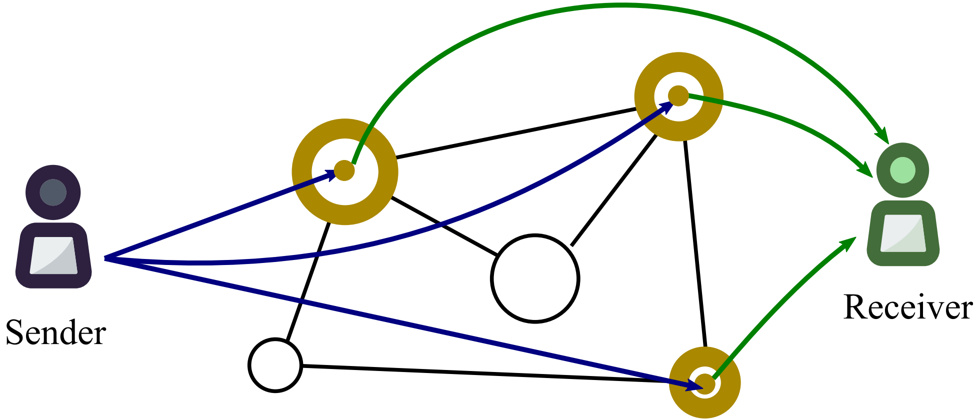
- “Umbral” is Spanish for “threshold”
- PRE properties: Unidirectional, single-hop, non-interactive
- It follows a KEM/DEM approach:
  - UmbralKEM provides the threshold re-encryption capability
  - Uses ECIES for key encapsulation with zero knowledge proofs of correctness for verifiability on prime order curves (such as secp256k1)
  - The 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 (WIP): `https://github.com/nucypher/umbral-doc`

Network: Data Sharing + PKE



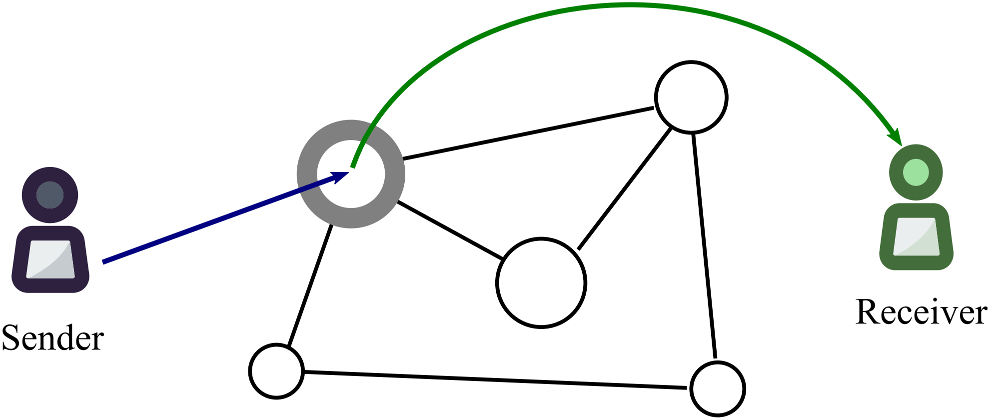
- Single node has access to data
- Single node can deny to do work

Network: Data Sharing + PKE + Shamir Secret Sharing



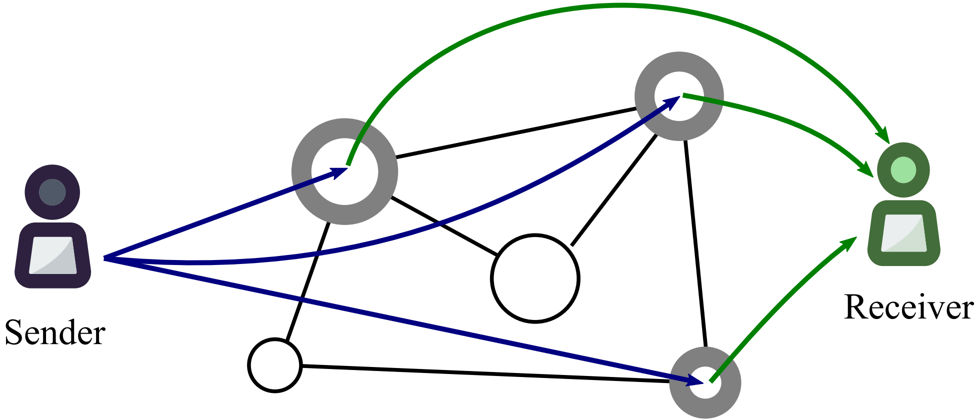
- Nodes can collude to gain access to data

Network: Data Sharing + PRE



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

Network: Data Sharing + Threshold PRE (Umbral)



- Collusion now requires m nodes + receiver

Data Sharing Policies

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

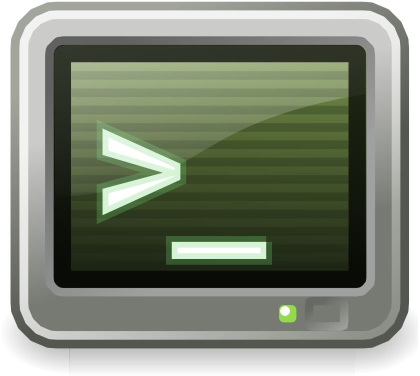
Decentralized proxies (Ursulas) are trusted to apply conditions without decrypting data

NU Token

Purpose

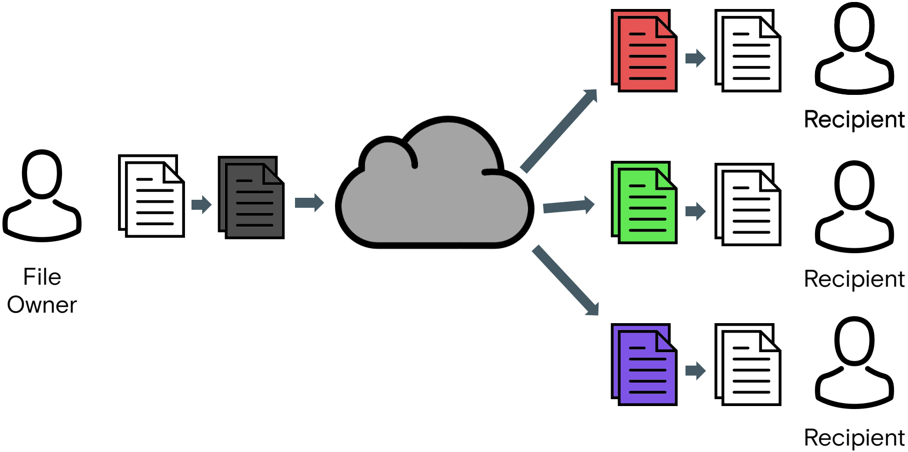
- Splitting trust between re-encryption nodes (more tokens = more trust and more work)
- Proof of Stake for minting new coins according to the mining schedule
- Security deposit to be at stake against malicious behavior of nodes

Demo



Use Cases

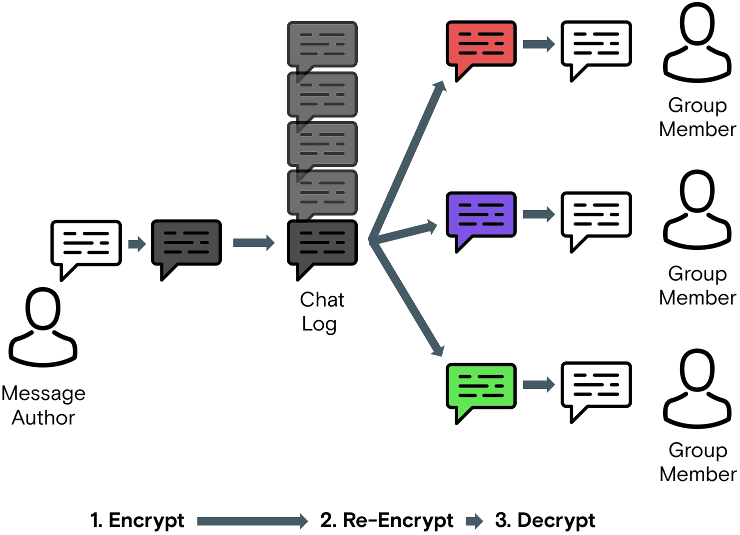
Encrypted file sharing



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

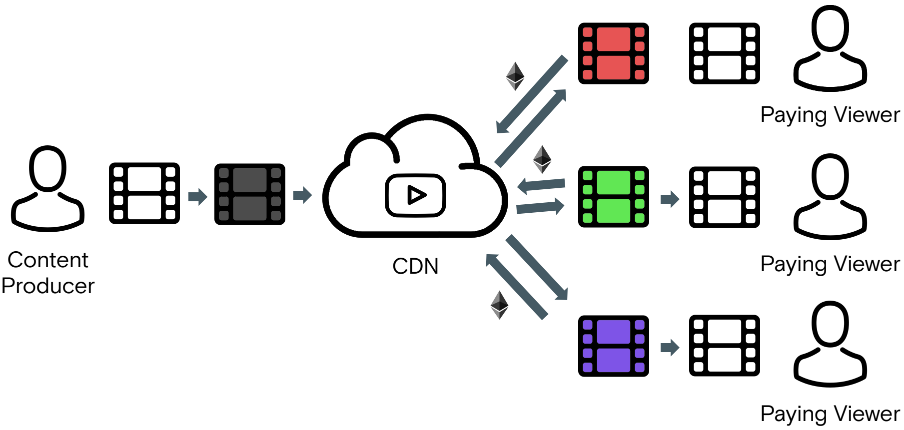
Use Cases

Encrypted multi-user chats



Use Cases

Decentralized Access-Controlled Content



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

Early Users

NuCypher Ecosystem

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

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

Multi-Party Computation

- Slow Performance

Fully Homomorphic Encryption

- Slow Peformance
  - NuCypher is investing efforts in this area

Fully Homomorphic Encryption

nuFHE Library

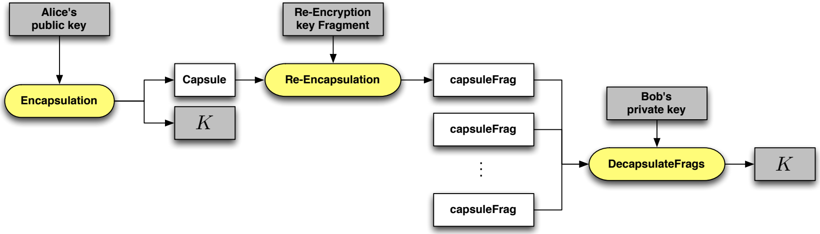
- GitHub: `https://github.com/nucypher/nufhe`
- GPU implementation of fully homomorphic encryption
- Uses either FFT or integer NTT
- Achieved 100x performance over TFHE benchmarks

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**	**-**

More Information

Website: `https://nucypher.com`
Github: `https://github.com/nucypher/`
PyUmbral: `https://github.com/nucypher/pyUmbral/`
GoUmbral: `https://github.com/nucypher/goUmbral/`
Mocknet: `https://github.com/nucypher/mock-net/`
Discord: `https://discord.gg/7rmXa3S`
Whitepaper: `https://www.nucypher.com/whitepapers/english.pdf`
E-mail: <email>@nucypher.com
E-mail: hello@nucypher.com

Appendix: Umbral Flow Diagram



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Appendix: Security Audits

TRAIL OF BITS

nccgroup

Least Authority
Freedom Matters

Appendix: NU Token Metrics

Mining

Mining reward:

$$\kappa = \left(0.5 + 0.5\frac{\min(\mathsf{T_i}, \mathsf{T}_1)}{\mathsf{T}_1}\right) \tag{1}$$

$$\mathsf{T_{i,initial}} \geq \mathsf{T}_{\min}, \tag{2}$$

$$\delta \mathsf{s_{i,t}} = \kappa \frac{\mathsf{l_i}}{\sum \mathsf{l_j}} \frac{\ln 2}{\mathsf{T}_{1/2}} \left(\mathsf{S}_{\max} - \mathsf{S_{t-1}}\right). \tag{3}$$

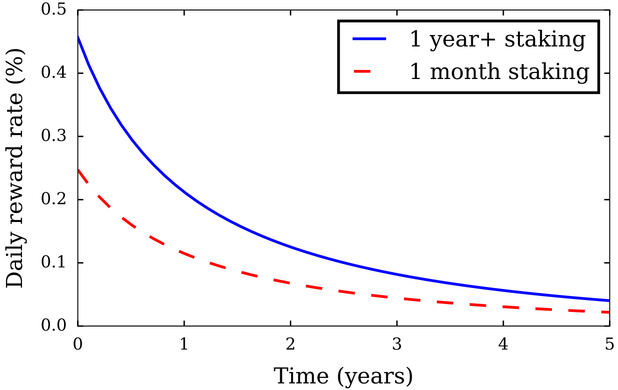
$$\tag{4}$$

Results into:

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

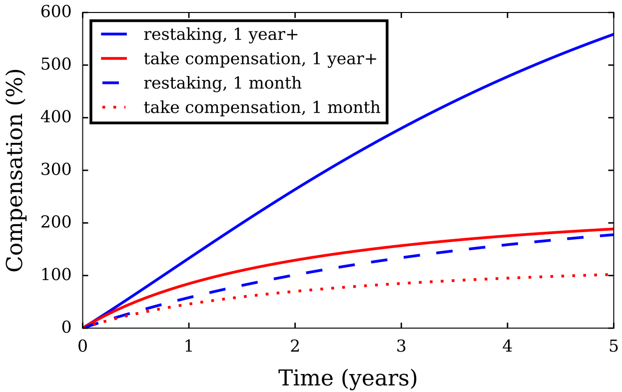
Appendix: NU Token Metrics

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

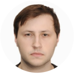
Cryptographer

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

Advisors

Prof. Dave Evans

Prof. Giuseppe Ateniese

Stevens Inst. of Technology

John Bantleman

Rainstor

Tony Bishop

Equinix