A Decentralized Data Sharing Scheme for IPFS

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1. Introduction

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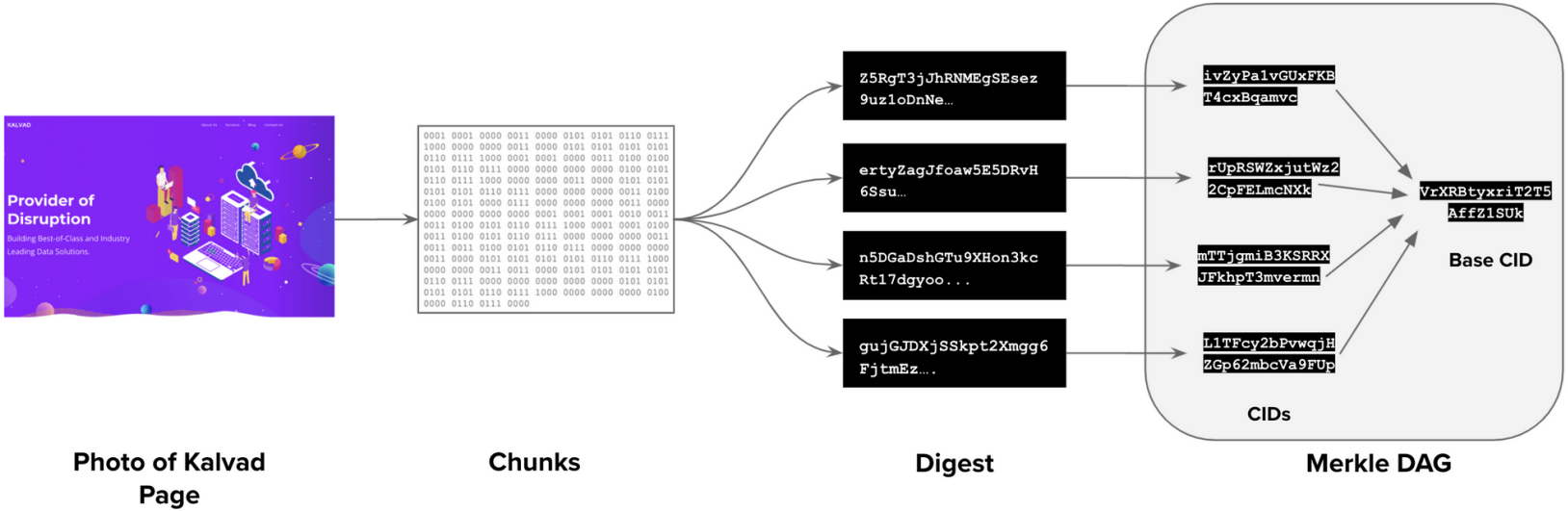
- IPFS is changing the way we store and retrieve data in a decentralized way.
- But we need a secure, flexible, and decentralized way to share data on IPFS



- Link: https://blog.kalvad.com/myths-about-ipfs/

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2. Related Work

2. Literature Review

- 1. Steichen at 2018 modified IPFS with **ACL** Ethereum smart contracts for efficient file sharing.

- 2. Sharma at 2021 added **ABE** technology to build a secure, efficient blockchain-based architecture for cloud storage systems.

- 3. BATTAH at 2020 proposed a decentralized blockchain system with **PRE** for multi-party access to encrypted IPFS data.

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3. Design Goals

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1. Data Confidentiality: Only the data owner and authorized data requester can access the content of files.

2. Efficiency and Cost-effectiveness: Core functions should be completed within a reasonable time.

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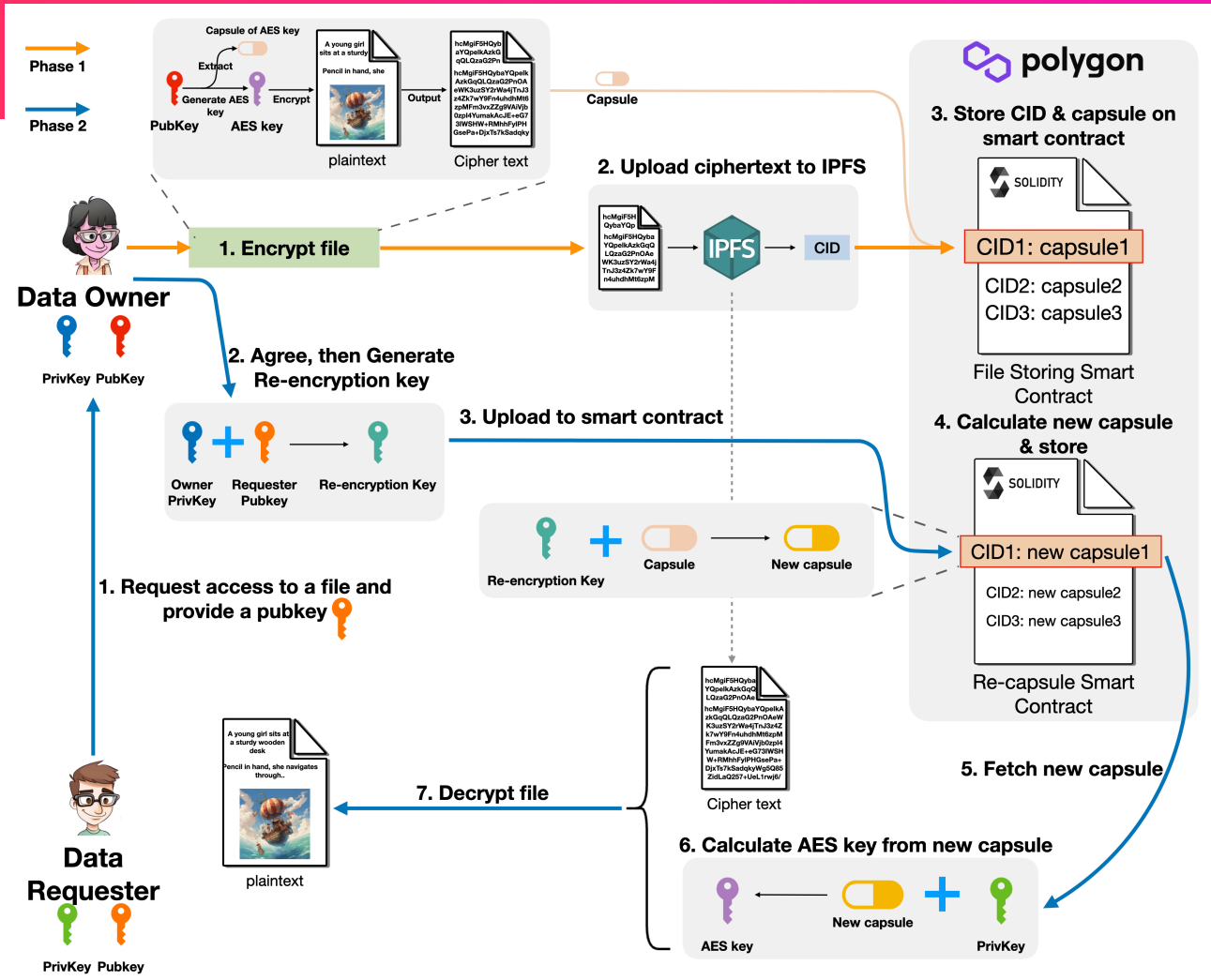
4. System Overview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polygon
3. Store CID & capsule on smart contract
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plaintext
6. Calculate AES key from new capsule
New capsule
AES key
PrivKey
Data Requester
PrivKey Pubkey

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5.1 File Encryption Algorithm

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Algorithm 1 File Encryption

Input: inputFilePath, outputFilePath, publickey
Output: CID, capsule

```
data ← ReadData(inputFilePath)
Generate AES key based on publickey:
    kp1 ← generate_key_pair()
    kp2 ← generate_key_pair()
    sk1 ← kp1.get_private_key()
    sk2 ← kp2.get_private_key()
    pk1 ← kp1.get_public_key()
    pk2 ← kp2.get_public_key()
    tmpHash ← [pk1, pk2]
    hash ← hash_to_scalar(tmpHash)
    partial_S ← sk1.add(sk2.mul(hash))
    pk_point ← publickey
    point_symmetric ← pk_point.mul(sk1.add(sk2))
    symmetric_key ← SHA256(point_symmetric)
encrypted_data ← Encrypt(data, symmetric_key)
Extract capsule information:
    E ← pk1
    V ← pk2
    S ← partial_S
    capsule ← newCapsule(E, V, S)
WriteData(outputFilePath, encrypted_data)
CID ← UploadToIPFS(outputFilePath)
return CID, capsule
```

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5.2 Re-Encryption Key Calculation

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Algorithm 3 Re-Encryption Key Calculation

Input: Owner privateKey, Requester publicKey
Output: re-encryption Key

1: $kp \leftarrow$ GenerateKeyPair()
2: $tmp\_sk \leftarrow kp$.get_private_key()
3: $tmp\_pk \leftarrow kp$.get_public_key()
4: $pk\_point \leftarrow (publicKey)$
5: $points\_for\_hash \leftarrow [tmp\_pk, pk\_point, pk\_point \times tmp\_sk]$
6: $hash \leftarrow$ hash_to_scalar($points\_for\_hash$)
7: $sk \leftarrow (privateKey)$
8: $hash\_inv \leftarrow$ inverse($hash$)
9: $rk \leftarrow sk \times hash\_inv$
10: $re\_key.\_private\_key \leftarrow rk$
11: $re\_key.\_public\_key \leftarrow tmp\_pk$
12: **return** re_key

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5.3 Re-capsule Smart Contract

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Algorithm 4 Re-capsule Smart Contract

Input: capsule, re-encryption Key
Output: new capsule

1: $rk \leftarrow$ (re-encryption Key)
2: $new\_E \leftarrow$ capsule.E $\times$ rk._private_key
3: $new\_V \leftarrow$ capsule.V $\times$ rk._private_key
4: $new\_S \leftarrow$ capsule.S
5: $new\_ec\_point \leftarrow rk.\_public\_key$
6: $new\_capsule \leftarrow$ new Capsule(new_E, new_V, new_S, new_ec_point)
7: **return** $new\_capsule$

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5.4 File Decryption Algorithm

5.4 File Decryption Algorithm

- Explain the File Decryption algorithm used in the file sharing phase.

Algorithm 5 File Decryption

Input: inputFilePath, outputFilePath, requester privateKey, new capsule
Output:

1: $data \leftarrow$ ReadData($inputFilePath$)
2: $priKey \leftarrow$ (requester privateKey)
3: $capsule \leftarrow$ (new capsule)
4: $new\_ECpoint \leftarrow$ capsule.new_ec_point
5: $new\_E \leftarrow$ capsule.new_E
6: $new\_V \leftarrow$ capsule.new_V
7: $public\_key \leftarrow$ priKey.public_key
8: $points\_for\_hash \leftarrow [new\_ECpoint, public\_key, new\_ECpoint \times priKey]$
9: $hash \leftarrow$ hash_to_scalar($points\_for\_hash$)
10: $tmp\_kdf\_point \leftarrow (new\_E + new\_V) \times hash$
11: $AES\_key \leftarrow$ SHA256(tmp_kdf_point)
12: $decrypted\_data \leftarrow$ decrypt(data, AES_Key)
13: WriteData($outputFilePath, decrypted\_data$)

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6. Experiment Results

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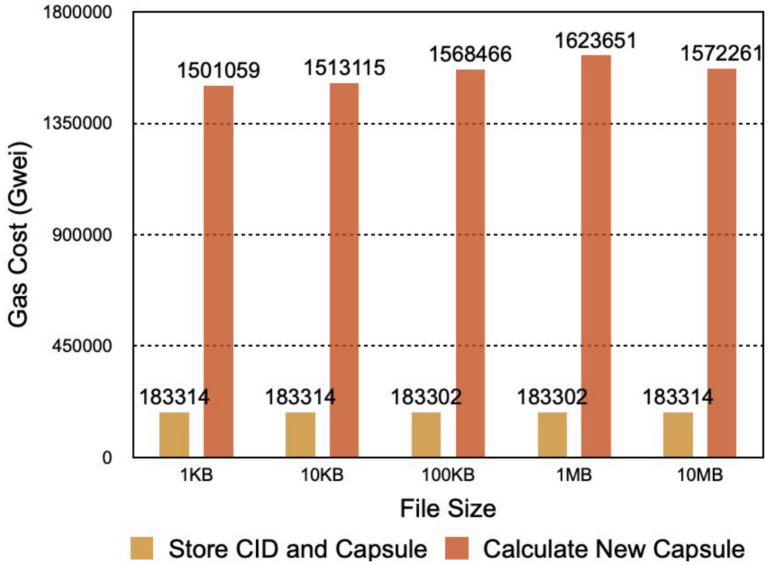
TABLE III
FUNCTIONALITY TESTS

Function	1KB	10KB	100KB	1MB	10MB
Encryption	✓	✓	✓	✓	✓
Proxy Re-Encryption	✓	✓	✓	✓	✓
Contract Integration	✓	✓	✓	✓	✓
File Retrieval	✓	✓	✓	✓	✓



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7. Future Work

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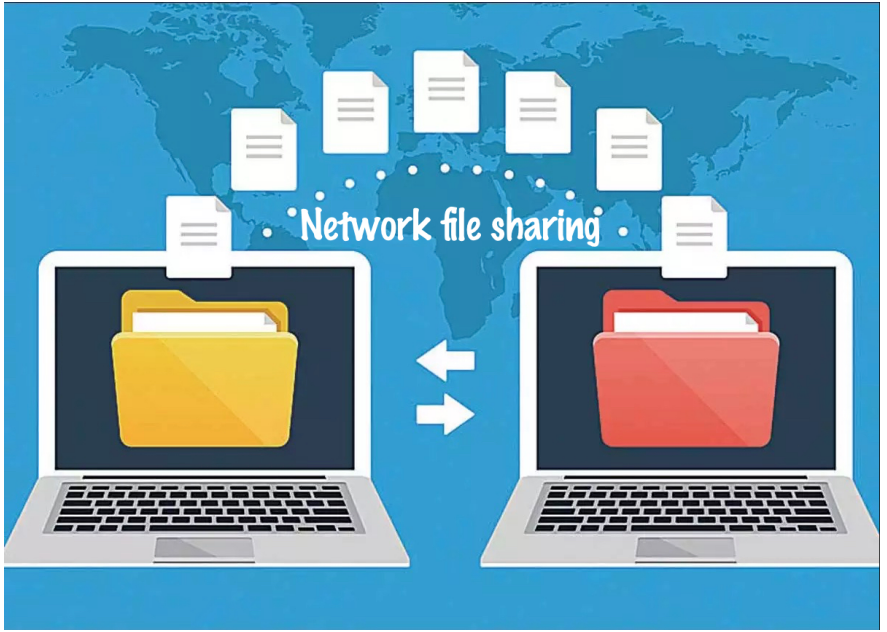
- Incorporation of time constraints within the proxy re-encryption scheme



- Link: https://zh.howtofix.guide/network-file-sharing/

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8. Conclusion

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- This work introduces a novel solution that combines blockchain technology, proxy re-encryption, and smart contracts to give a file sharing scheme for IPFS

THE END

THANKS