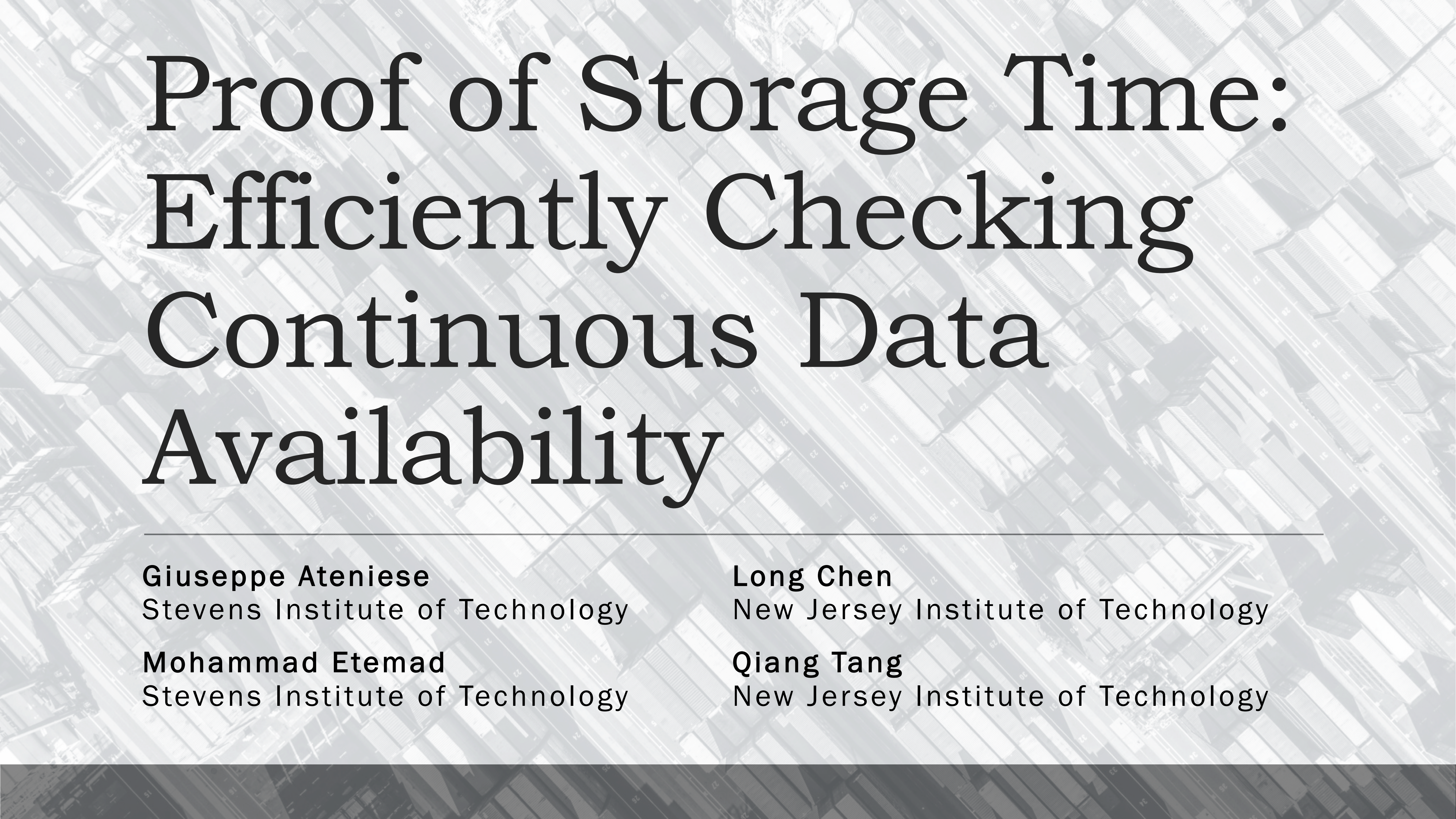

Proof of Storage Time: Efficiently Checking Continuous Data Availability

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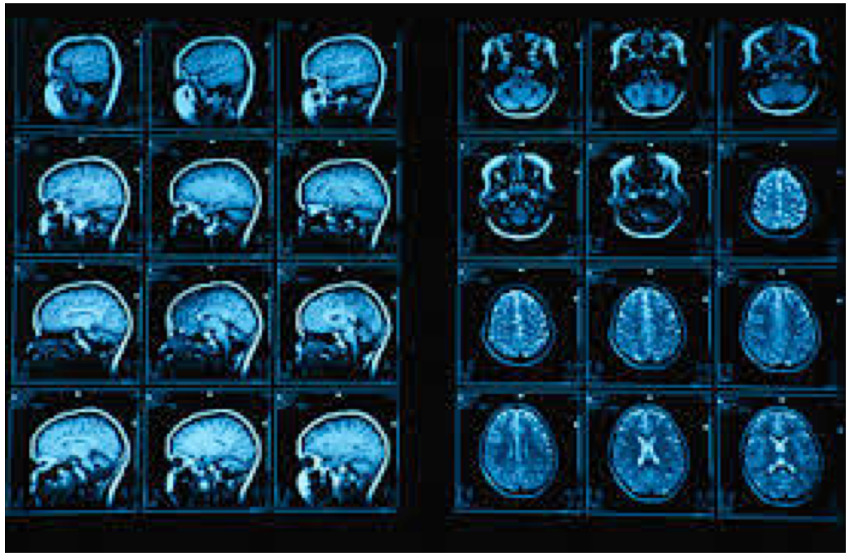
Outsourced Storage is a common practice

Backup

Data sharing

Saving Cost



Example Case

A hospital stores medical imaging data on the cloud

Surgeons will consult these data during an emergency surgery

A brief downtime will cause a serious medical accident!

Continuous data availability is crucial

Mission and Business Critical Applications

Brief downtime may lead to serious negative consequences

- Lost of productivity
- Financial pain
- Damages to the business’ reputation

Threats to Continuous Availability

Equipment failures

Power outrages

Malicious attackers

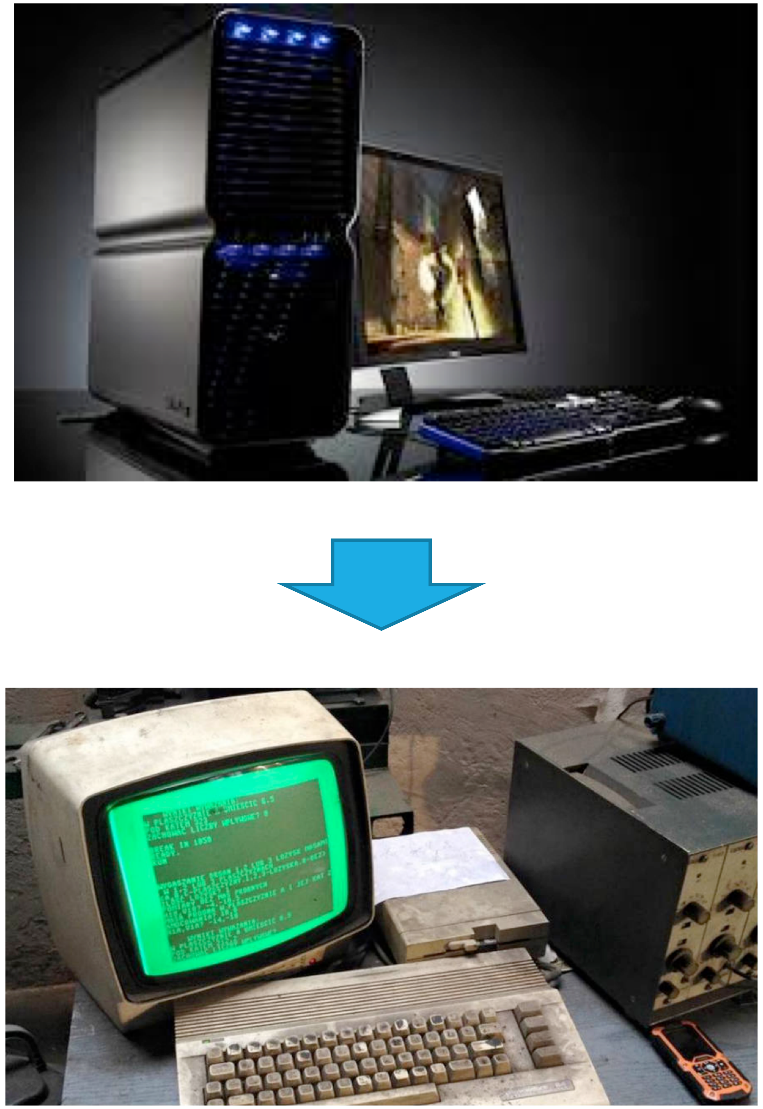
Cost of Continuous Availability

More replications

More hardware and software components

More complex administration

Continuous availability means a high price !

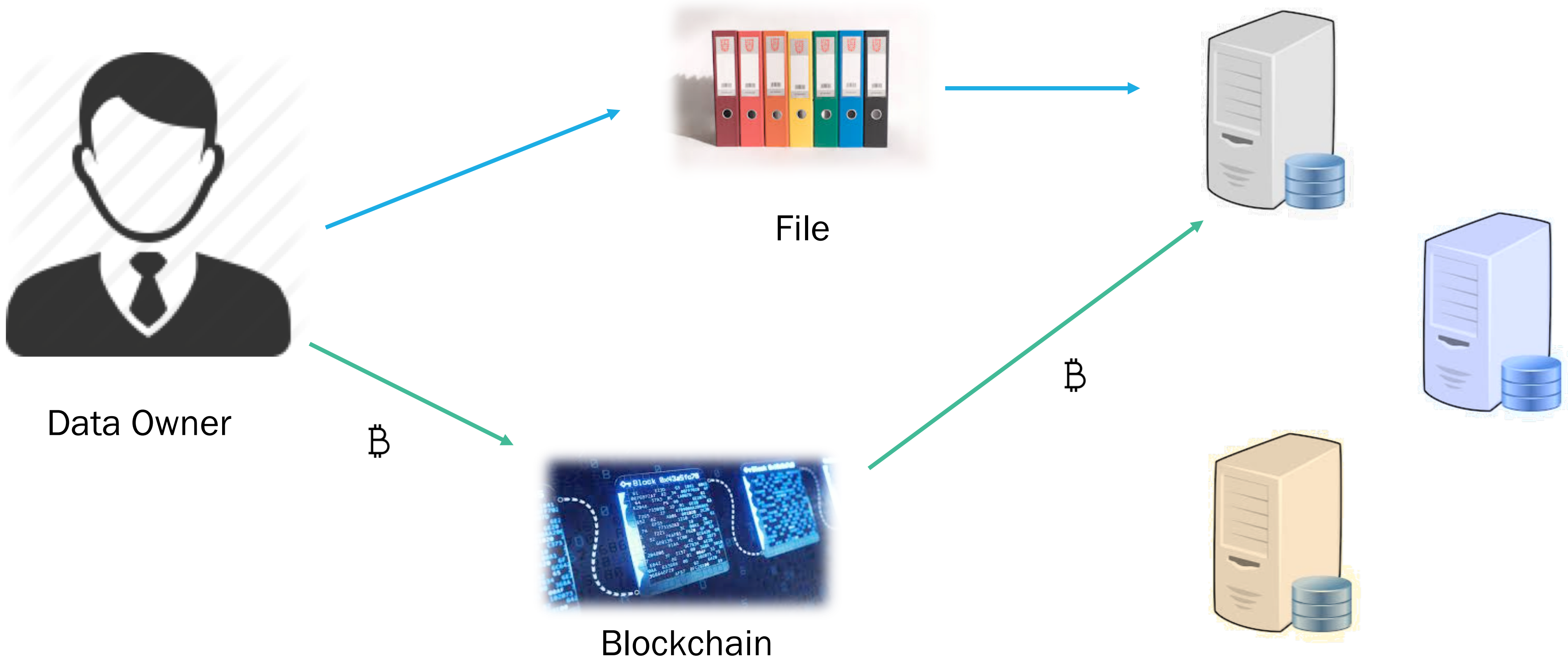


Verify Continuous Availability

A dishonest server would provide an inferior service

The client who paid a high price must verify the continuous availability

Decentralized Storage Market



File

Data Owner

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Blockchain

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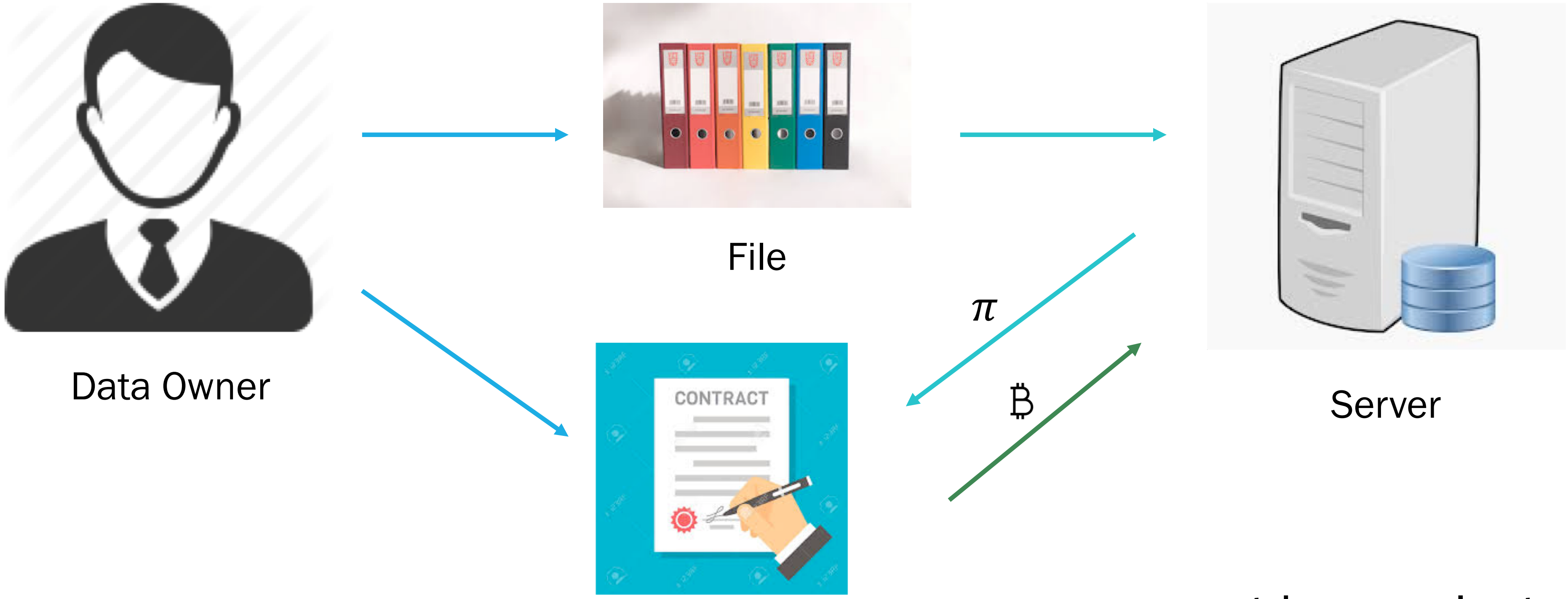
Decentralized Storage Market



Data Owner

File

Server

π

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Smart Contract

- π must be succinct
- Verification must be cheap

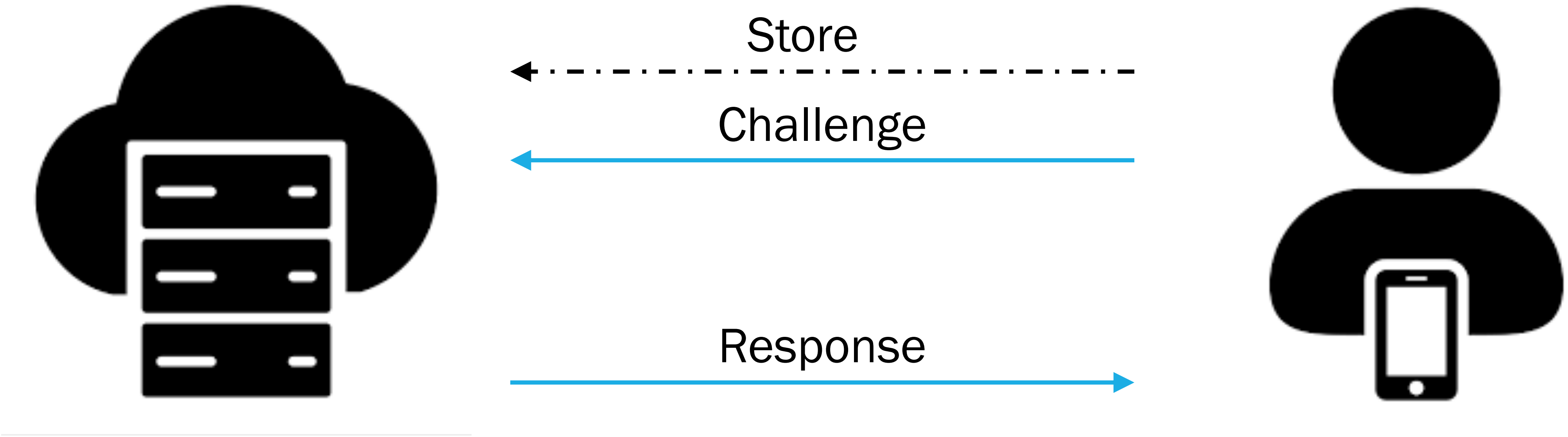
Proof of Storage-time

- Definition
- Construction
- Instantiation

Proof of Storage-time

- Definition
- Construction
- Instantiation

PoSt Framework



Store

Challenge

Response

Security Definition

Proof of Retrievability

□ **Goal:** Verify data availability

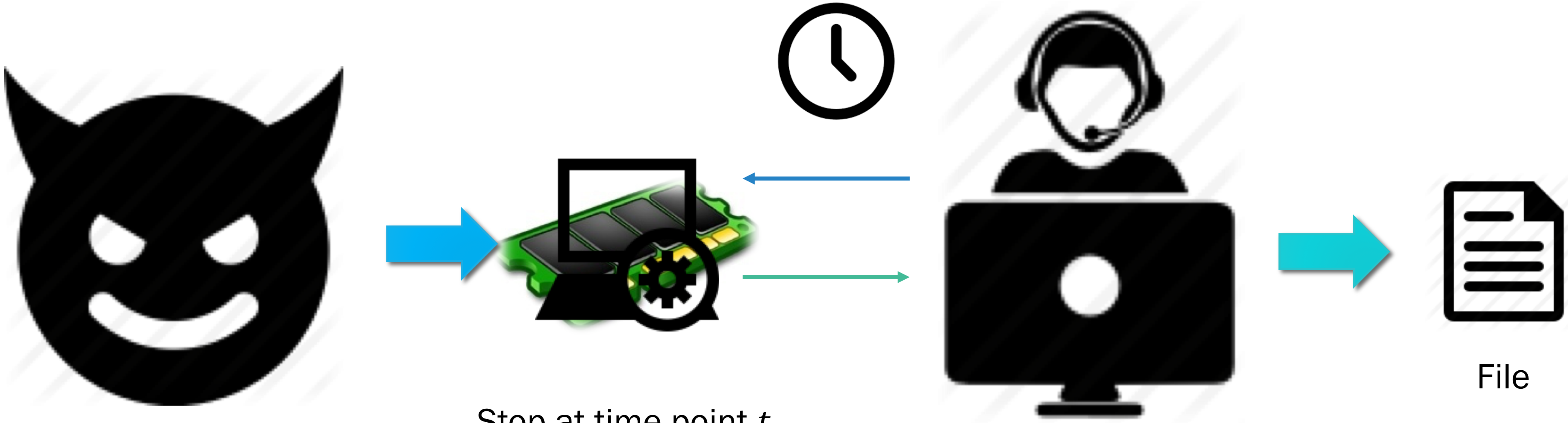
□ **Security:** Extractability

Proof of Storage-time

□ **Goal:** Verify *continuous* availability

□ **Security:** *Continuous* extractability

Continuous Extractability



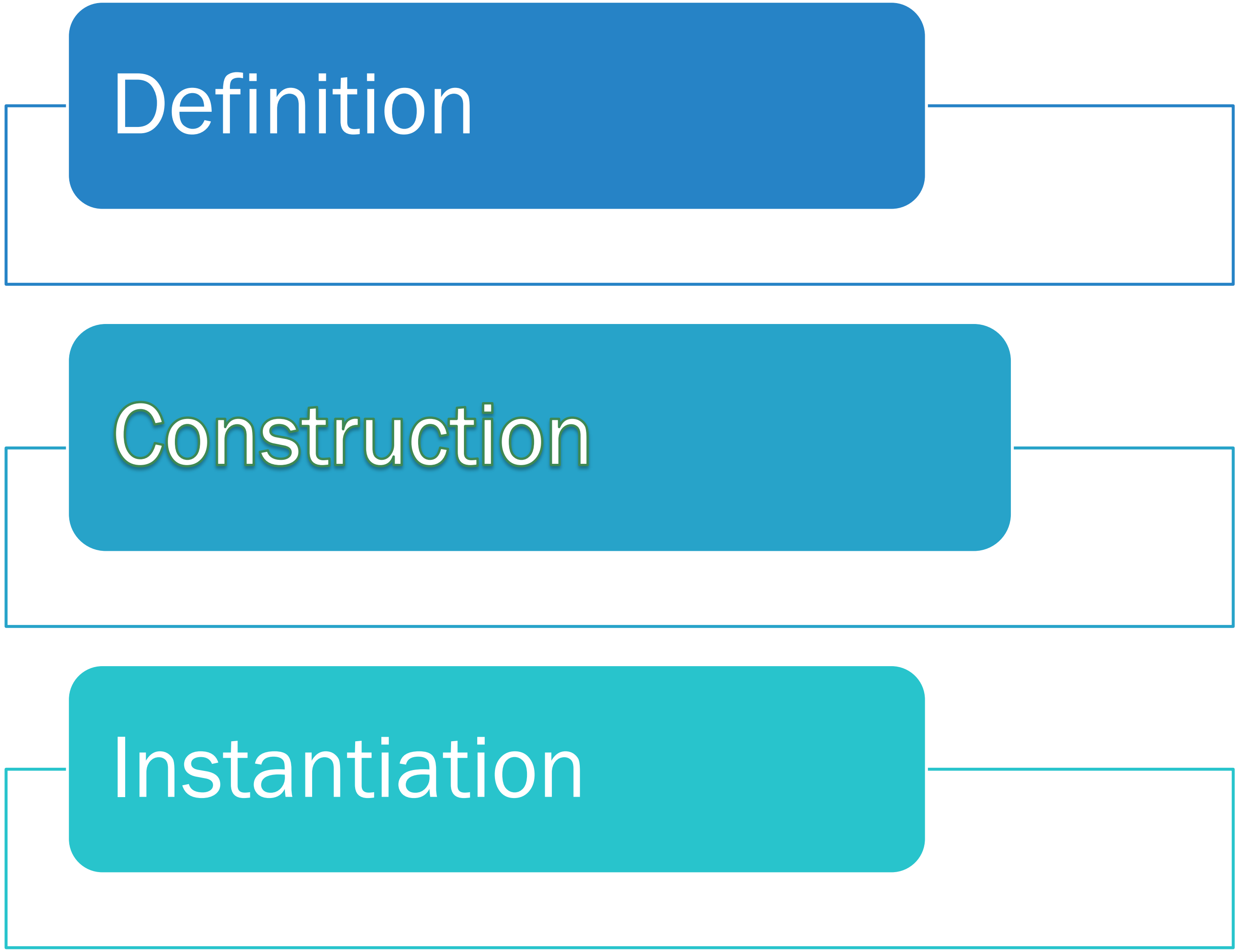
Adversary

Stop at time point t
Record the current state
in the memory

Extractor

File

Proof of Storage-time



Definition

Construction

Instantiation

Naïve Attempts

Proof of Retrievability

- A challenge and response protocol
- Only certify availability at the time a valid proof is processed

Frequent PoR

- Inefficient communication and verification
- The client needs to be always online

Unsuccessful Attempts

Send PoR challenges in advance

- The prover may compute all PORs rapidly and discard the data

Send PoR challenges in the end

- The prover could keep data offline and retrieve them at the last moment

Filecoin’s proposal

1. Send PoR challenge c_0
2. Compute the PoR proof p_0
3. Let $c_1 = Hash(p_0)$
4. Compute the PoR proof p_1
5. ……
6. Send back all c_i and p_i

Problem:

- *No concrete delay guarantee*
- *Verification is inefficient*

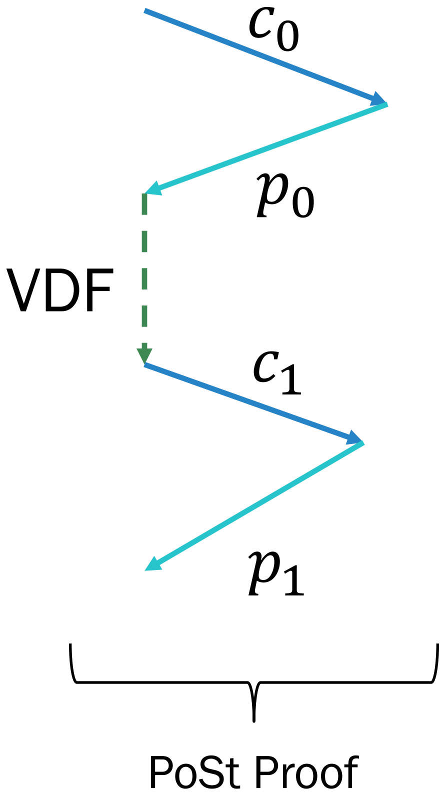
Verifiable Delay Function

$$F(x) = y \quad \pi$$

- To compute y for honest guys takes time almost T
- Malicious guy, even with parallel ability, can not get the result within time T
- Anyone can *efficiently* verify the correctness of the evaluation with a proof π

Warm-up Construction

1. Given a PoR challenge c_0
2. Generate the PoR p_0
3. Compute $(c_1, \pi_1) = VDF(p_0)$
4. Generates the PoR p_1
5. Etc.
6. Output all c_i, p_i, π_i



Problem

- The proof size is too large
- Verification is inefficient

Trapdoor Delay Function

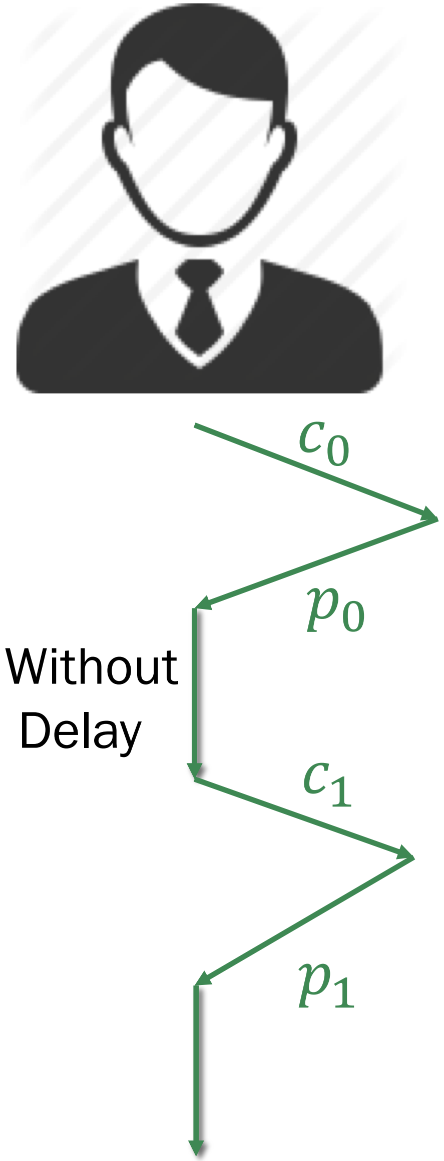
$$F(x) = y$$

- To compute y for honest guys takes time almost T
- Malicious guy can not get y within time T even with parallel computing

$$F(x, \textcolor{red}{trapdoor}) = y$$

- Anyone with trapdoor can compute y within time significantly smaller than T

Main Construction



Verification:

$$c_0, p_0, c_1, p_1, \ldots = c_0, p_0, c_1, p_1, \ldots$$

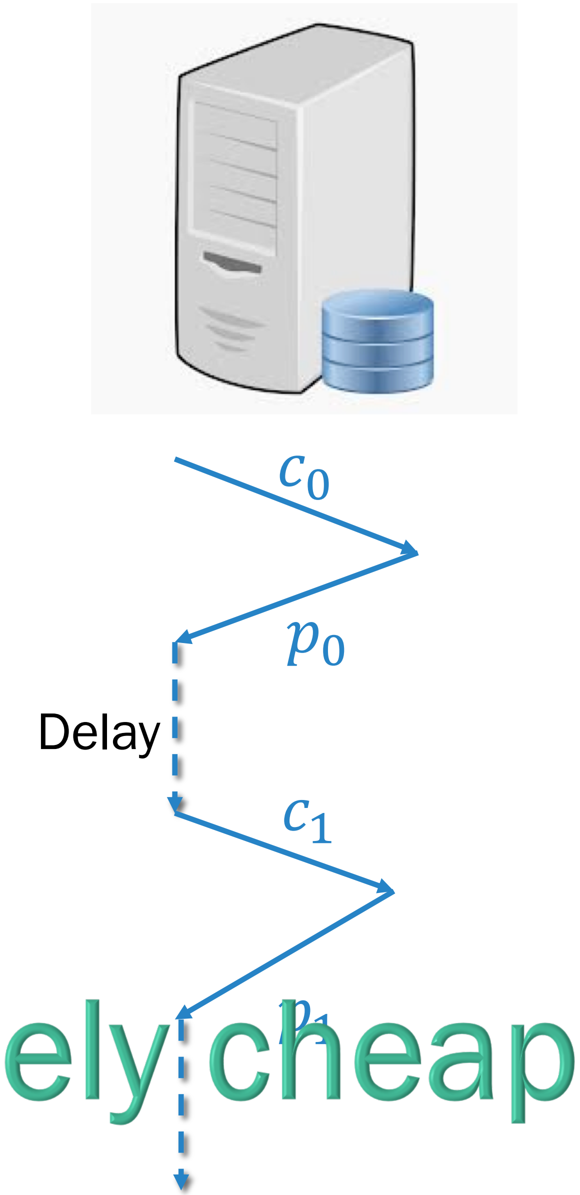
Aggregation

$$Hash(c_0, p_0, c_1, p_1, \ldots) = Hash(c_0, p_0, c_1, p_1, \ldots)$$

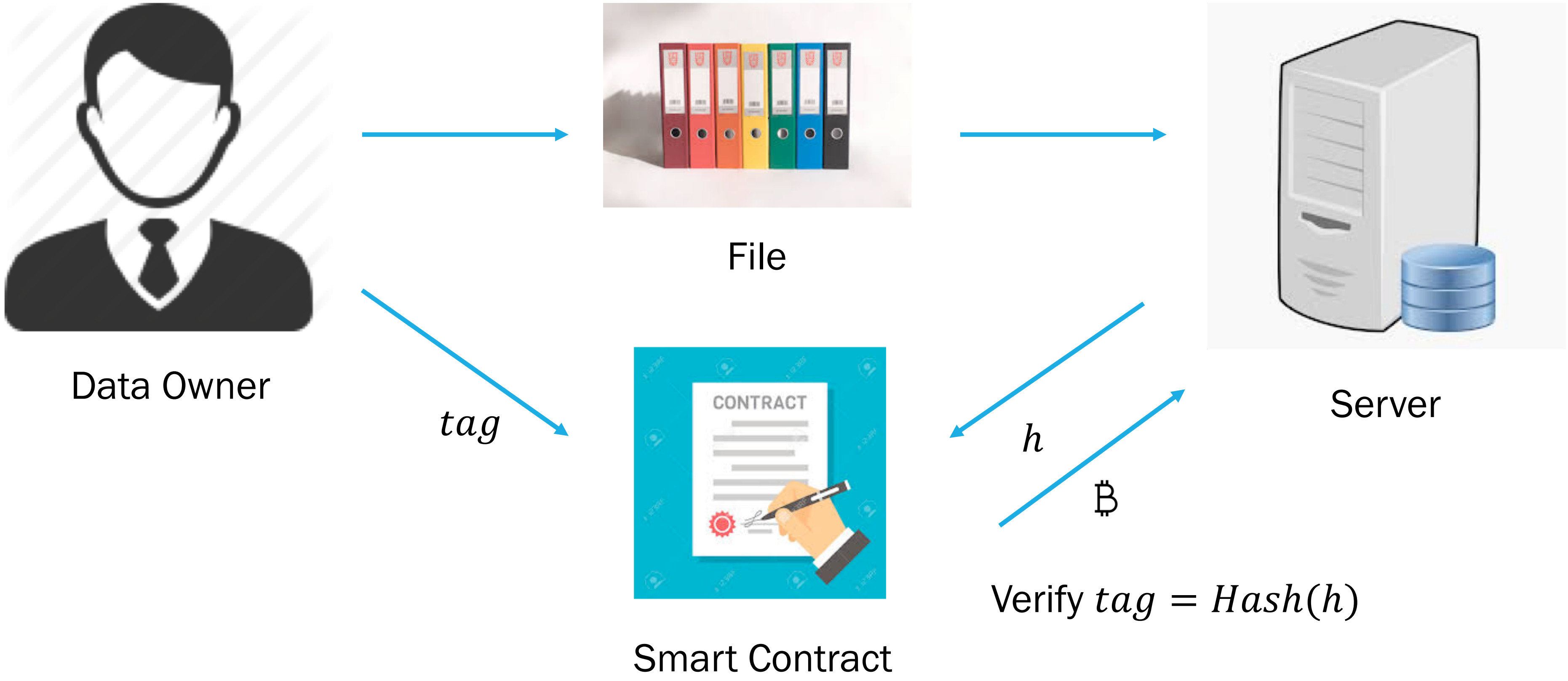
Public Validation

Extremely cheap

$$tag = Hash(Hash(c_0, p_0, c_1, p_1, \ldots))$$



Decentralized Storage Market



Data Owner

File

Server

tag

Smart Contract

h

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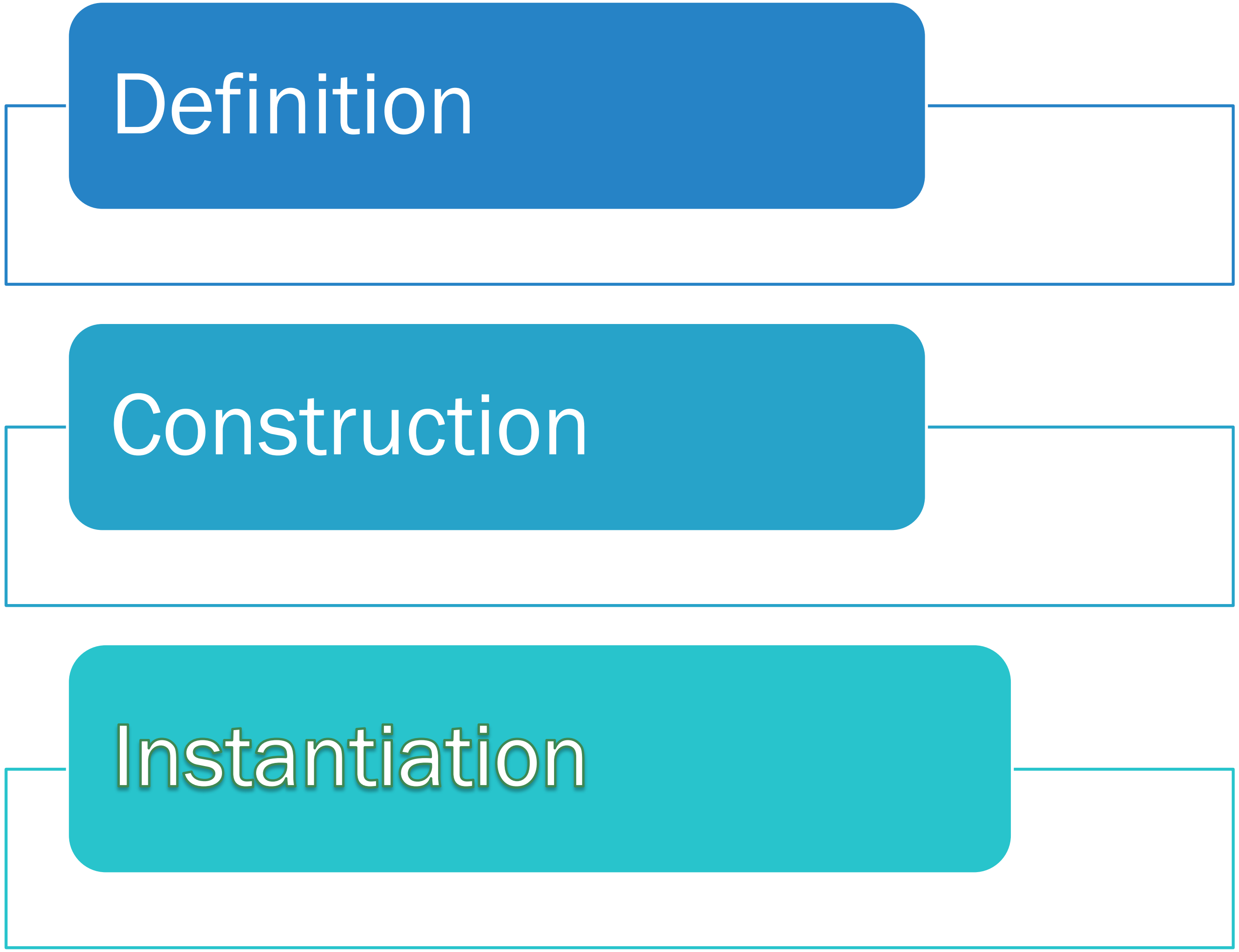
Verify $tag = Hash(h)$

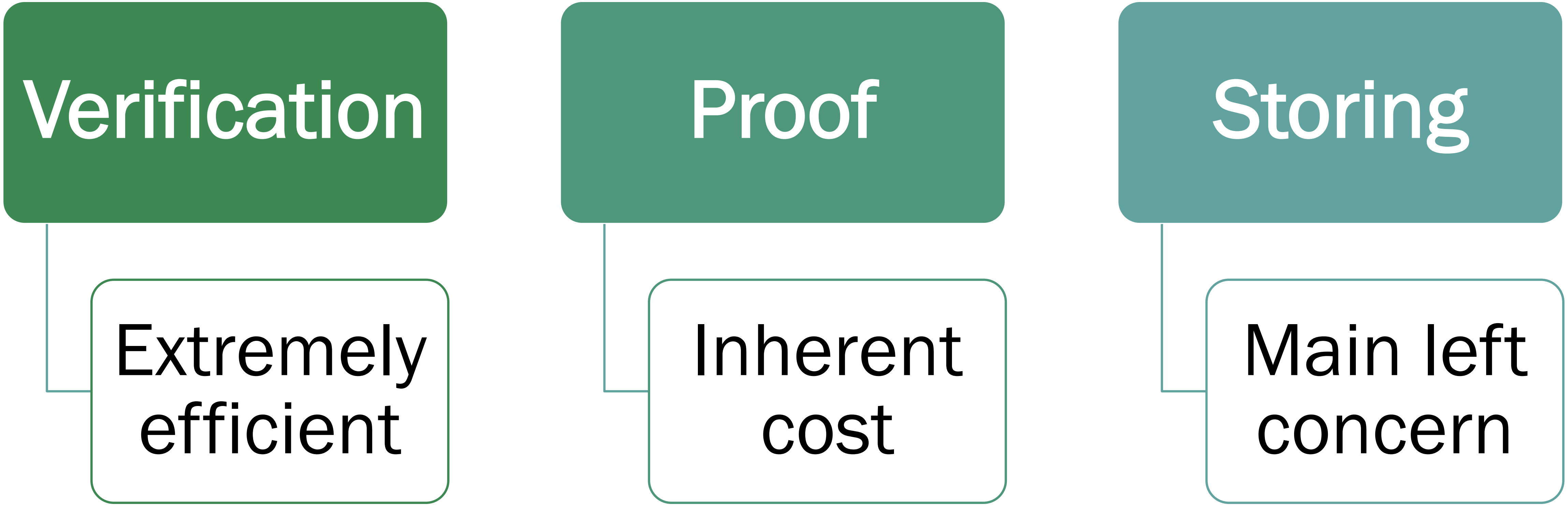
Proof of Storage-time



Definition

Construction

Instantiation



Verification

Extremely efficient

Proof

Inherent cost

Storing

Main left concern

Efficiency of Each Procedure

Storing Procedure Optimization

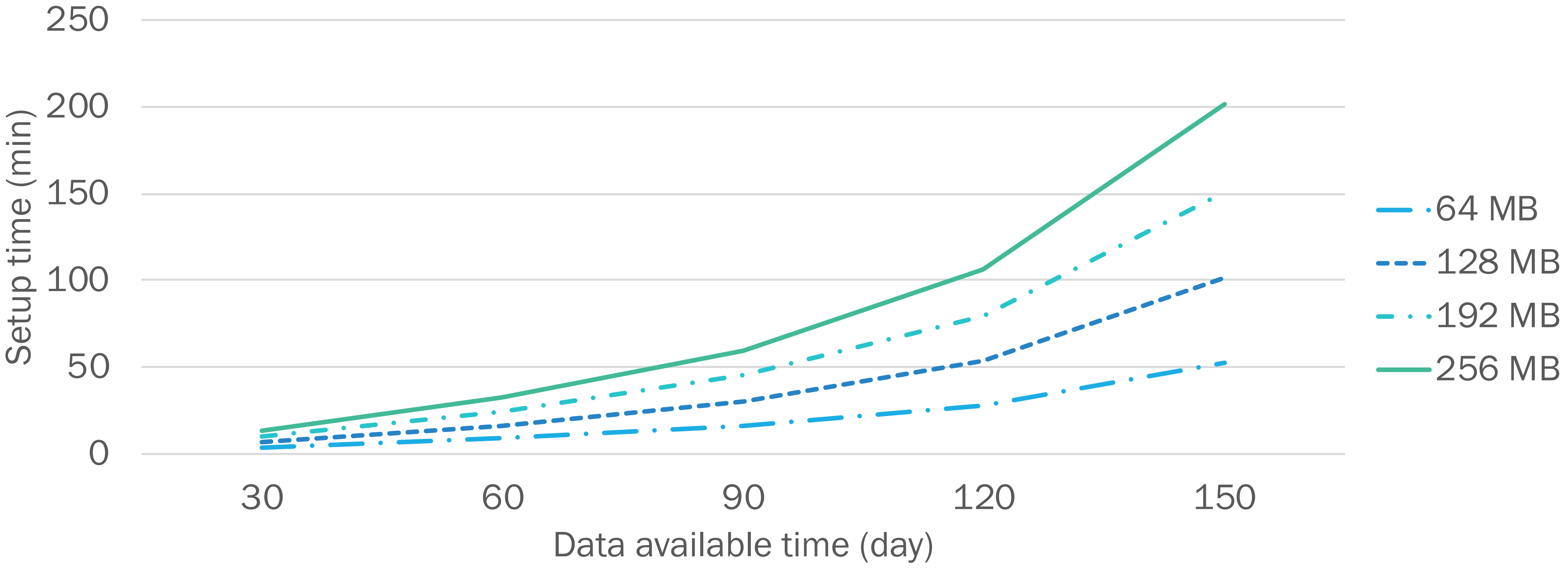
Adopting Hash based PoRs

Precomputation

Accelerate the PoR by Parallel Computation

Others...

Storing Benchmark



Hourly data check up

Summary

PoSt can verify continuous data availability

PoSt can be used to realize the decentralized storage market

Future work

- Optimization the storing procedure
- Make it stateless
- Achieve public verifiable
- More applications

Thank you for attention

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