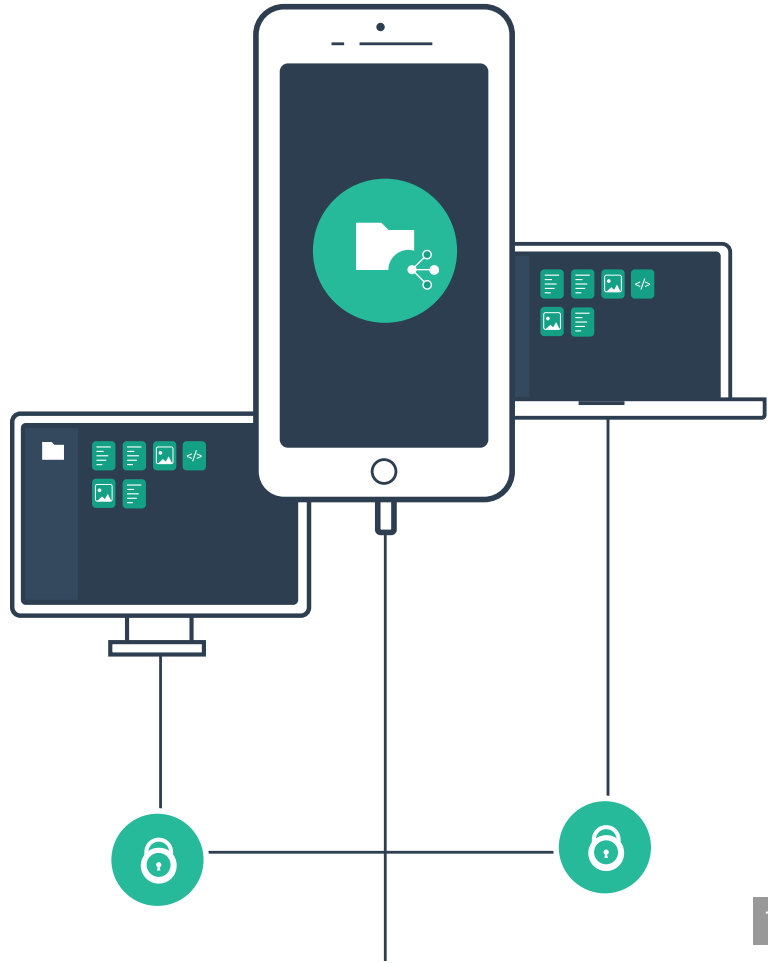
PEERGOS

Peergos: the architecture of privacy

Dr Ian Preston
Co-founder, CEO



"The defence of privacy will be the saviour of the future."

- Gus Hosein,

Executive Director Privacy International

Why is privacy so important?

- Fundamental human right

  "No one shall be subjected to arbitrary interference with his privacy, family, home or correspondence."
  The Universal Declaration of Human Rights

Necessary for democracy

Without privacy:

- Mass surveillance
- Monitoring and crushing dissent
- Voter manipulation from profiling
- Swinging elections

Most of our lives are **online**.

protect privacy → protect online privacy

What happens when you visit a website?

- DNS lookup
- TLS connection (trust 140 CAs)
- Arbitrary code from server
- Load 3rd party code
- Login to site?
- Send personal data to server?
- Manipulation by AI curated feed
- Subverted democracy, compromised consensus

Can a better design fix these problems?

Requirements

- Protect against 3rd and 1st party surveillance
- Remove incentives that resulted in surveillance capitalism
- Return data and identity ownership to users
- Take your data between hosts and apps
- Work in existing browsers

Enter Peergos protocol

- Global, E2EE filesystem
- Fine-grained access control
- Signed content-addressed (host independent)
- Automatic host migration (preserving links)
- Sandbox apps/sites
- Portable, self-sovereign identity

PEERGOS

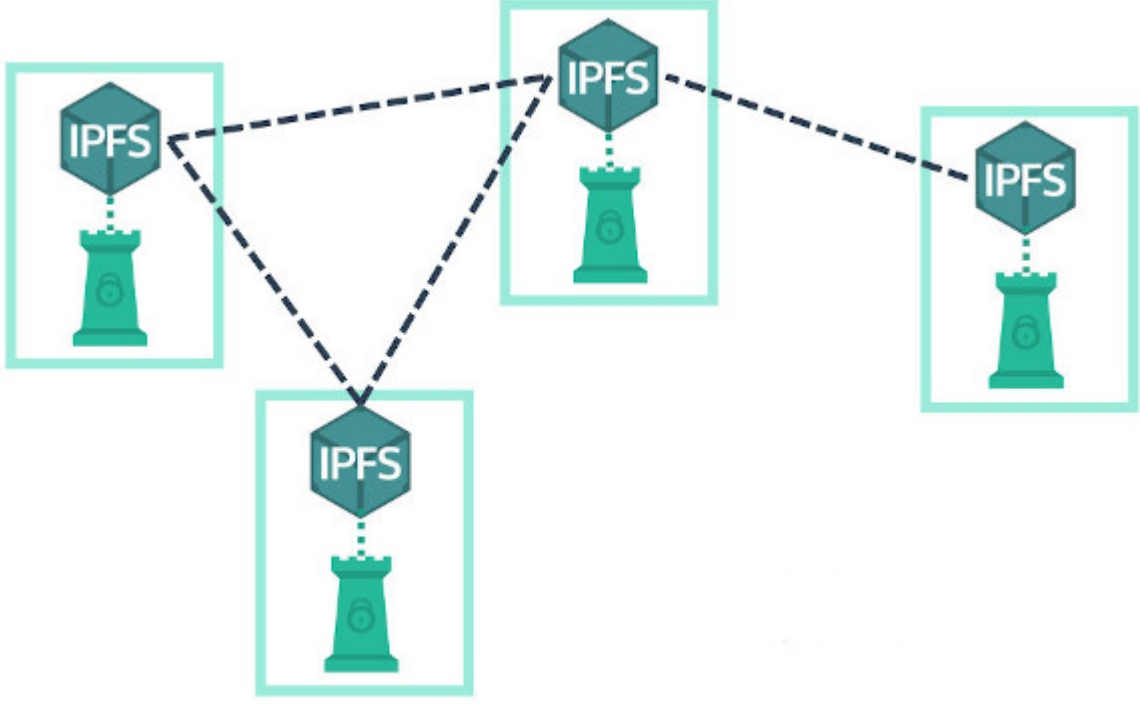
Who will run it?

- self hosters?
- storage providers?
- most people can't run their own server
- want no privacy improvement from self hosting

→ Encryption + trustless servers

Architecture

- trustless internode communication, TLS but no certificate authorities (CAs) or DNS!



Trustless servers

1. content-addressed data
2. signed updates
3. Public Key Infrastructure (PKI) for human-readable names

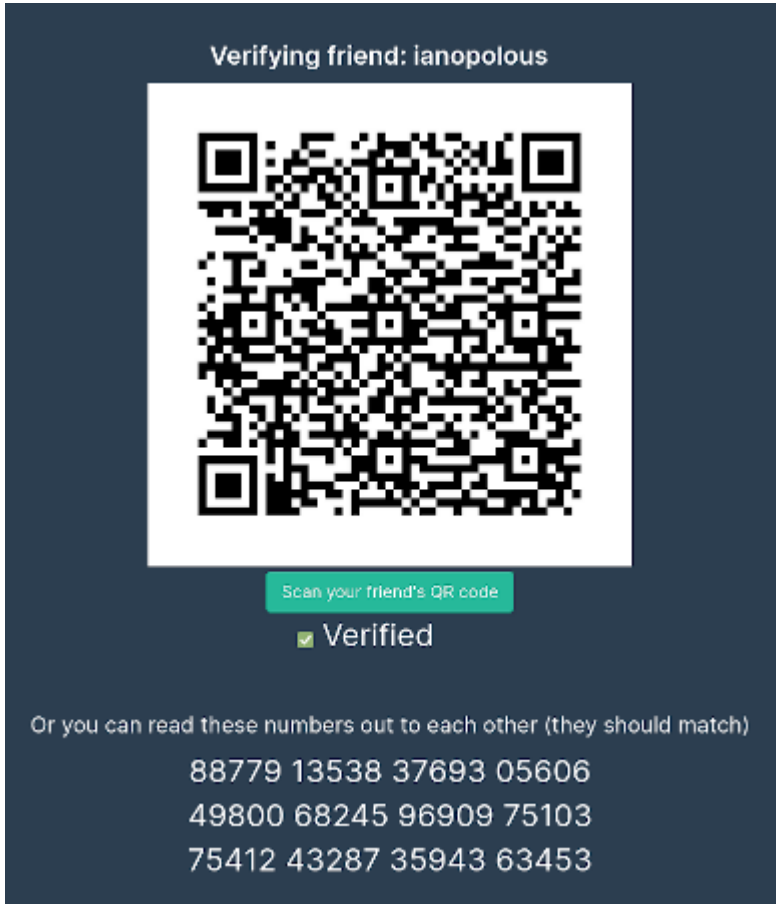
→ location independent addressing (server freedom)

Identity

- username → (identity, home server) public keys
- append-only merkle log of signed name claims
- similar to certificate transparency logs
- stored in a Compressed Hash Array Mapped Prefix-trie (CHAMP)

Identity properties

- host independent
- TOFU, but can also verify in person by QR code etc.



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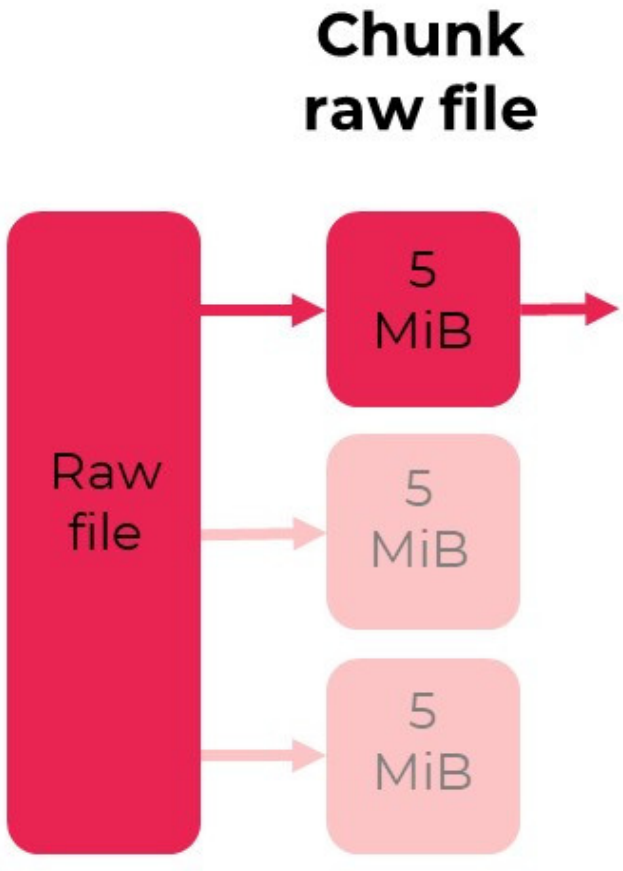

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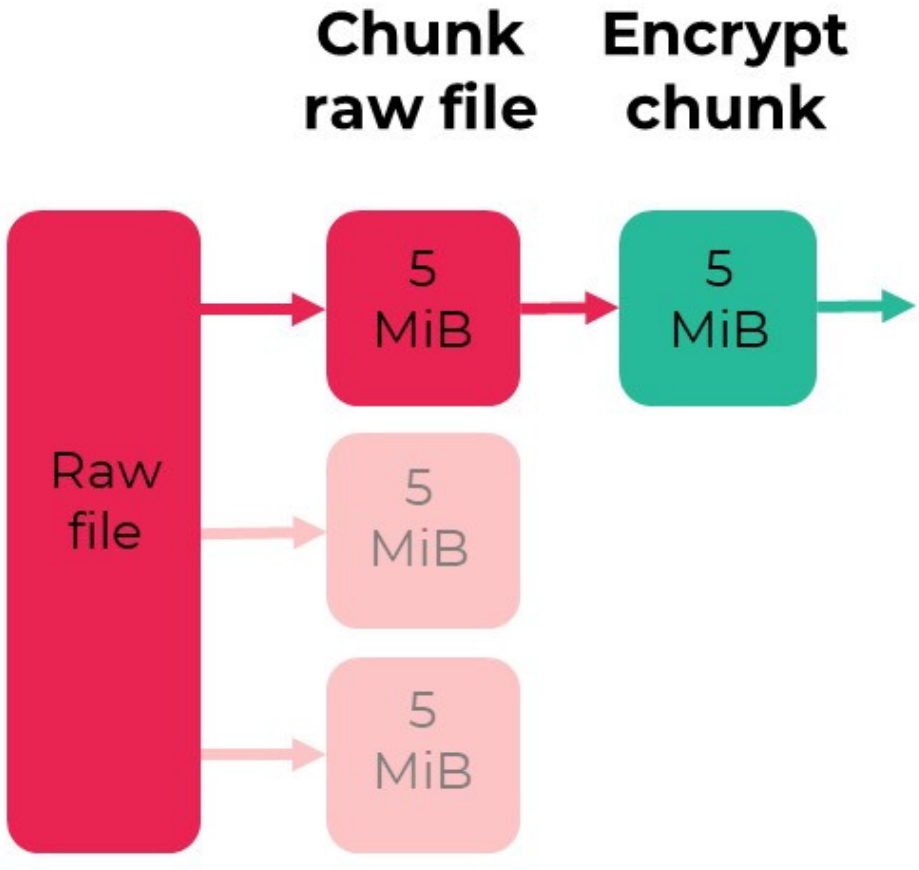

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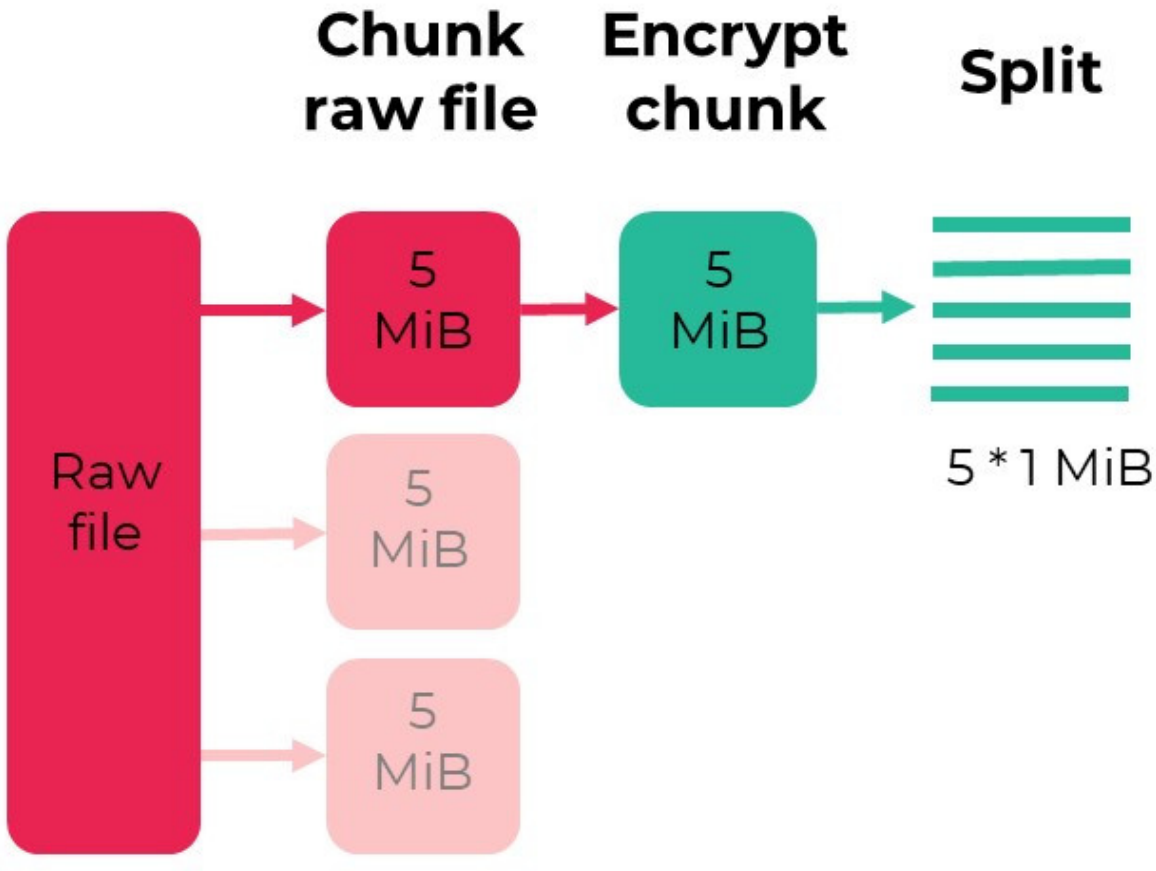
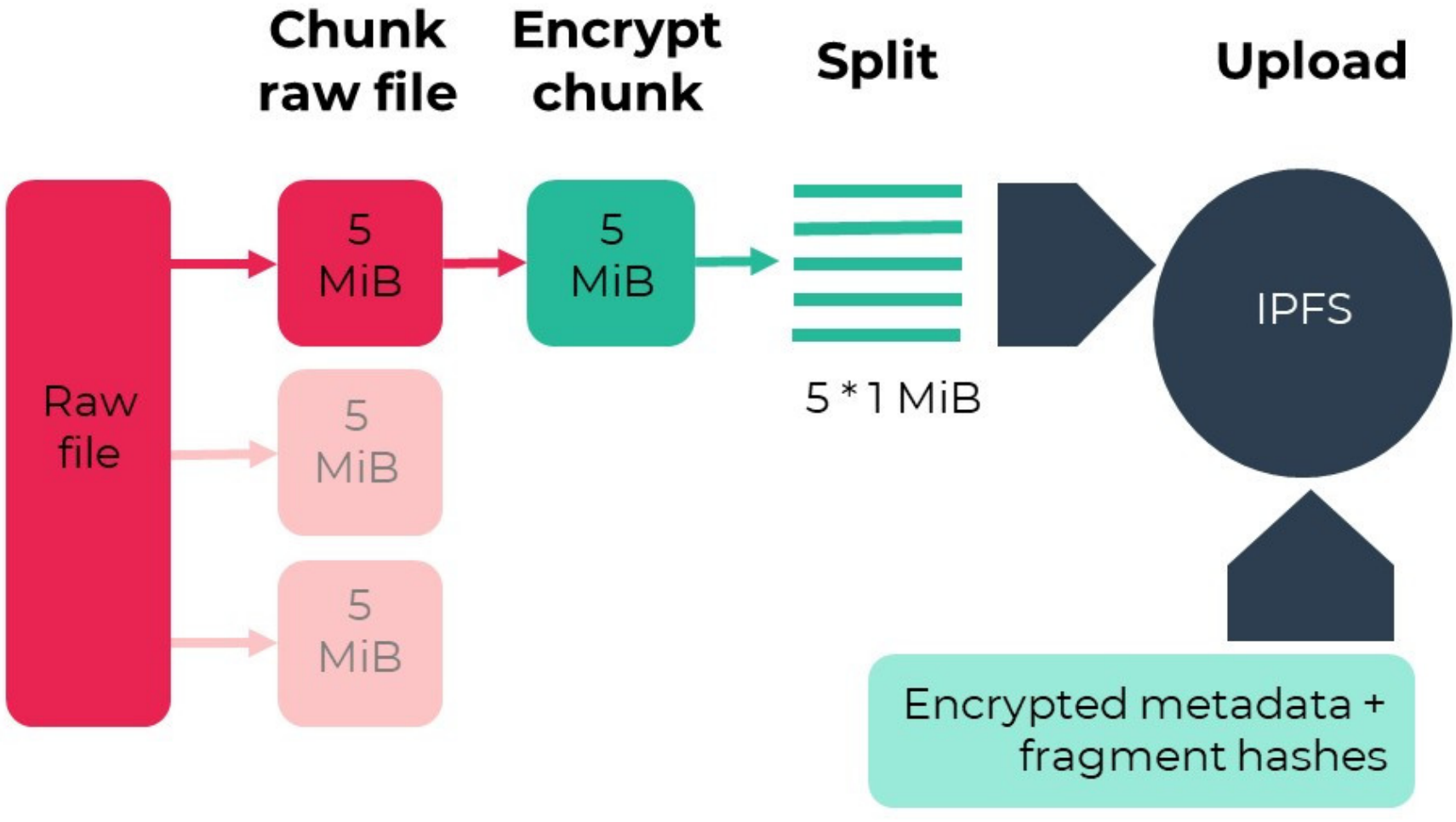

Chunk raw file
Encrypt chunk
Split
Raw file
5 MiB
5 MiB
5 MiB
5 MiB
5 * 1 MiB

File upload


Chunk raw file
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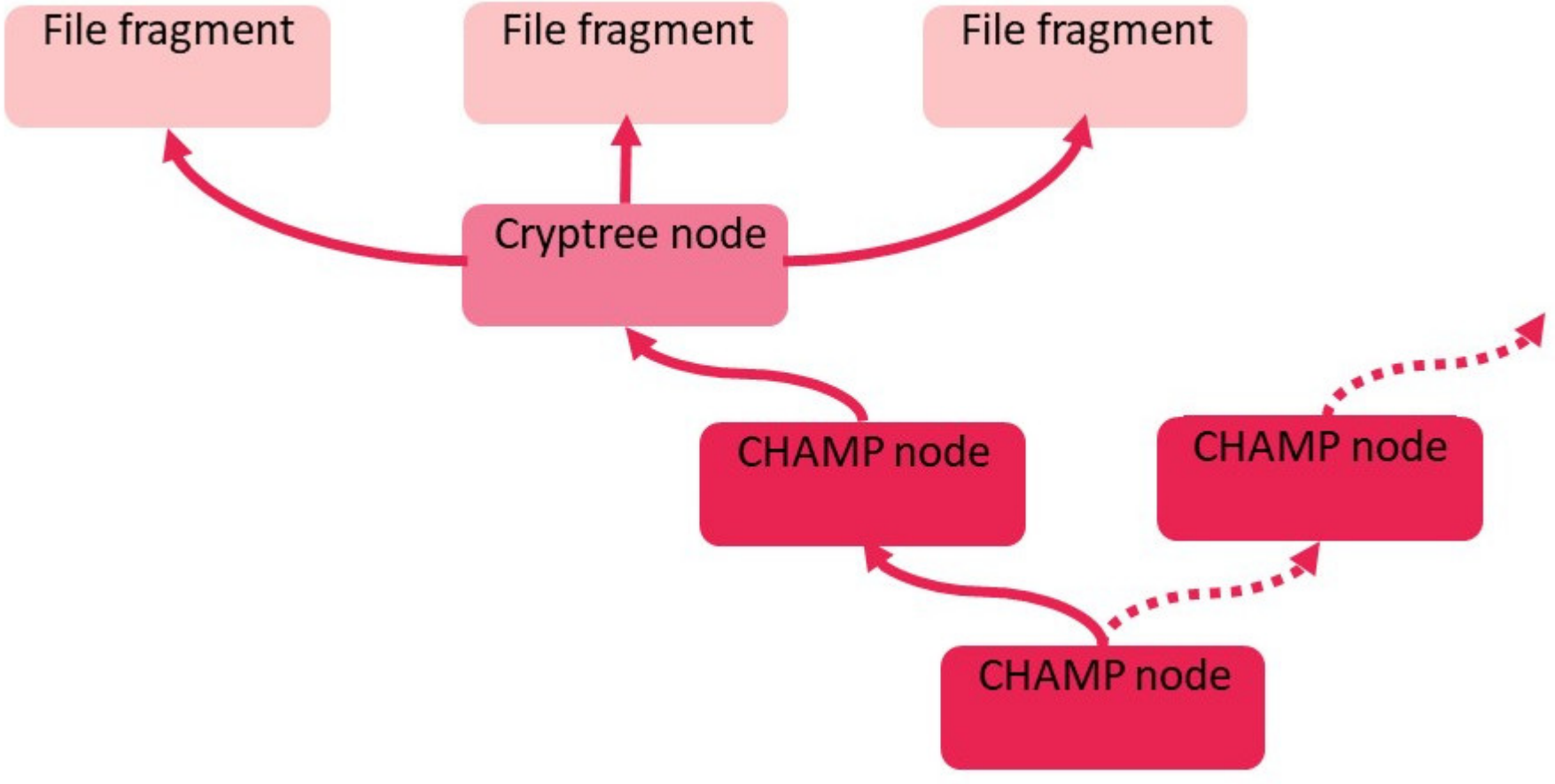
Upload
Raw file
5 MiB
5 MiB
5 MiB
5 MiB
5 * 1 MiB
IPFS
Encrypted metadata + fragment hashes

Immutable state - file system CHAMP



CHAMP

- compressed hash-array mapped prefix-trie
- key value store
- independent of insertion order (unlike btree)
- balanced

In the Peergos filesystem the champ keys are random 32 bytes, values are cryptree nodes. Each cryptree node can link to larger encrypted file fragments.

Cryptree metadata privacy

Host cannot see:

- file sizes
- file vs dir
- file/folder names
- folder topology
- social graph
- who or how many have access to a file/blob.

Cryptree format

BATs

fromBase
- SymmetricKey parentOrData
- Optional<SymmetricLinkToSigner> signer
- RelativeCapability nextChunk

64n

fromParent
- Optional<RelativeCapability> parentLink
- FileProperties properties

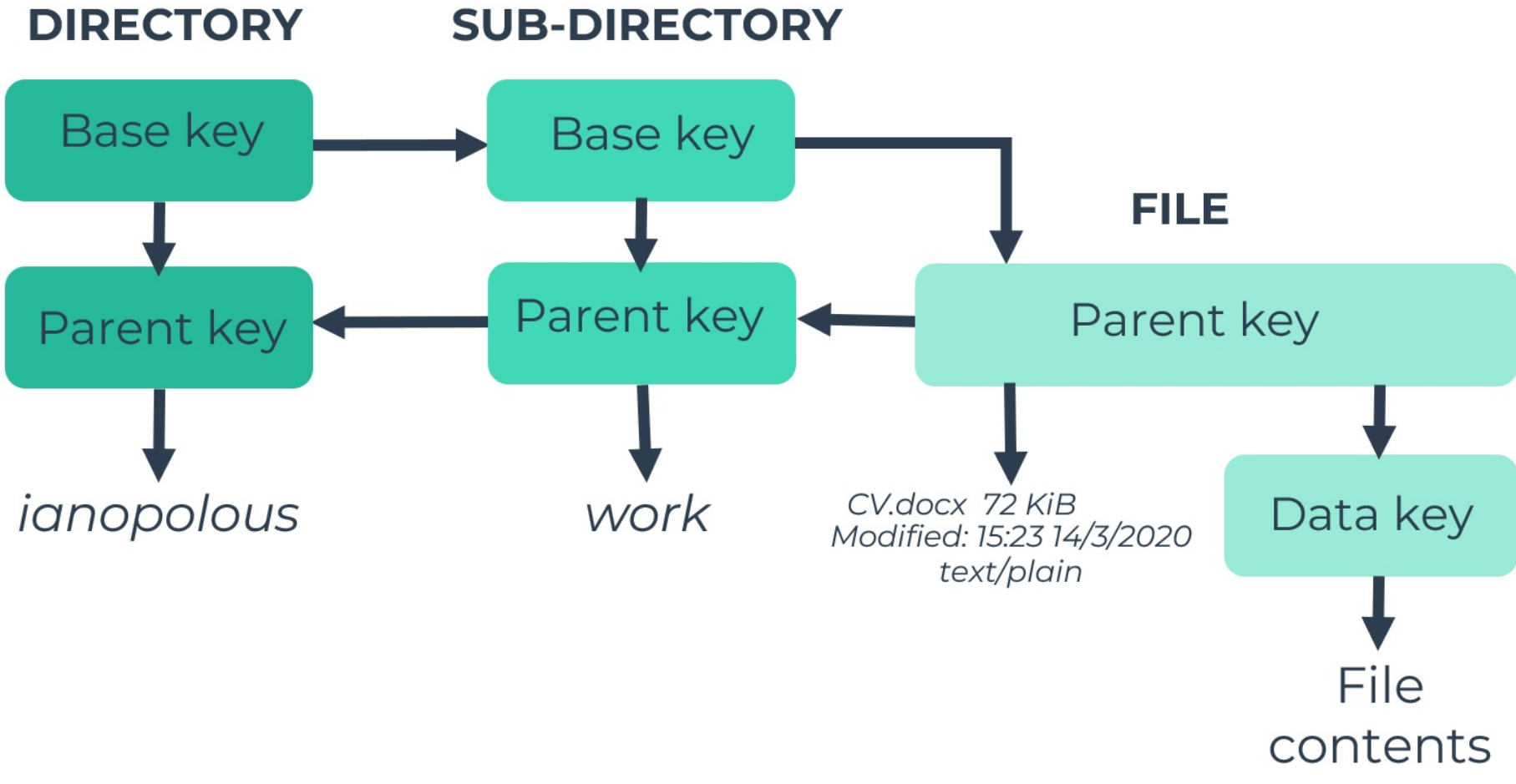
16n

Inline or List<Cid>, List<Bat>

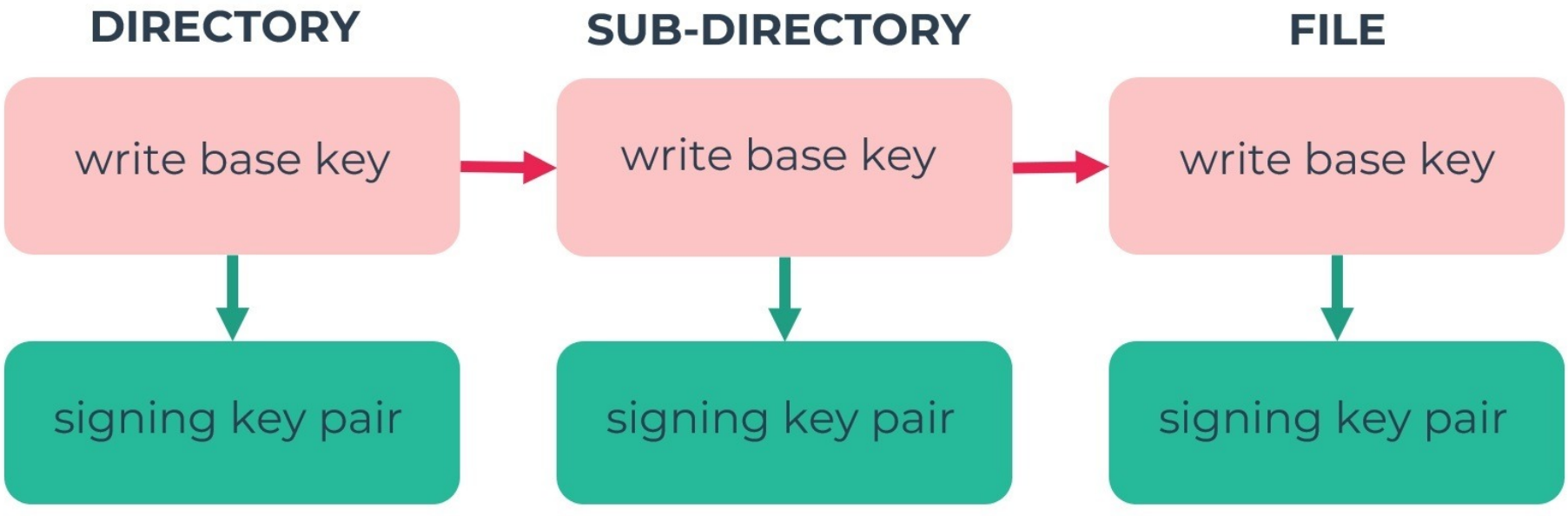
childrenOrData

4096n

Read Cryptree

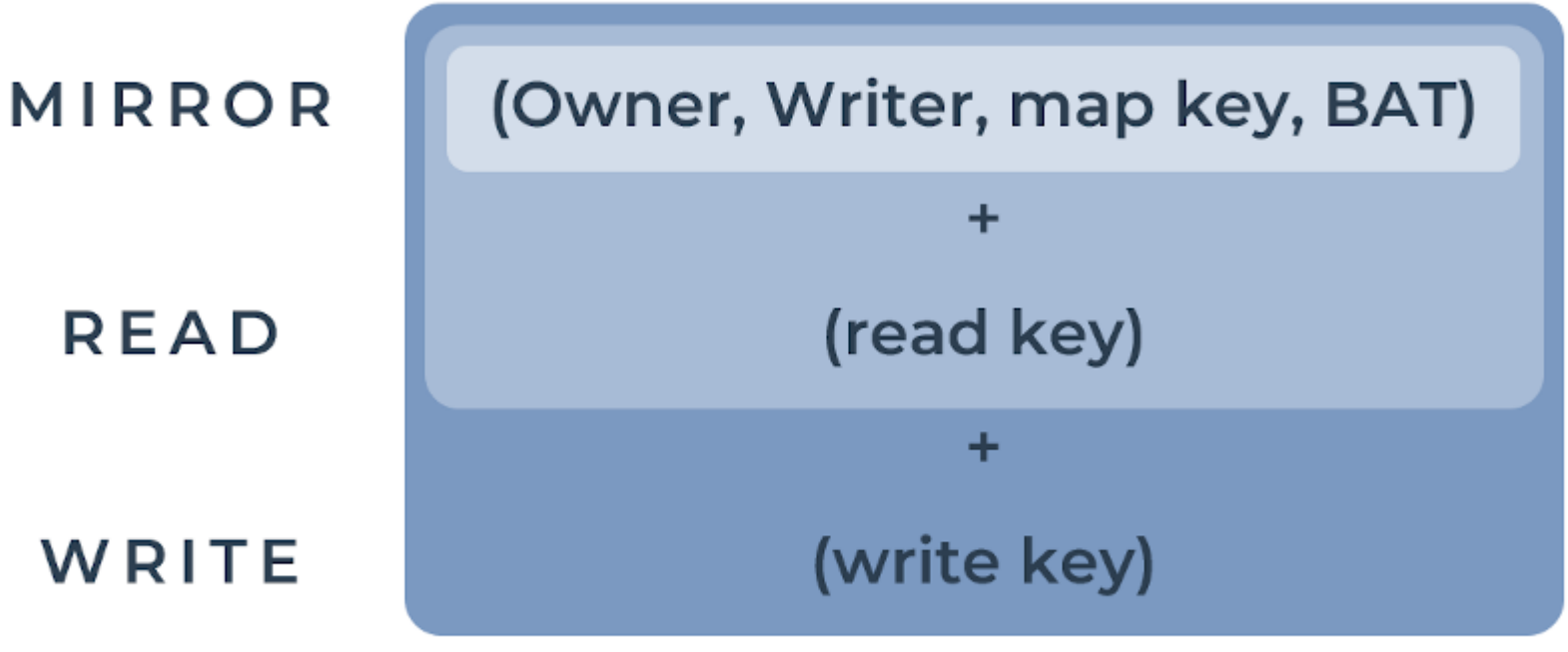


Write Cryptree



Capabilities (Caps)

- Pure information, not identity-based
- Works in secret links etc.
- Can be revoked



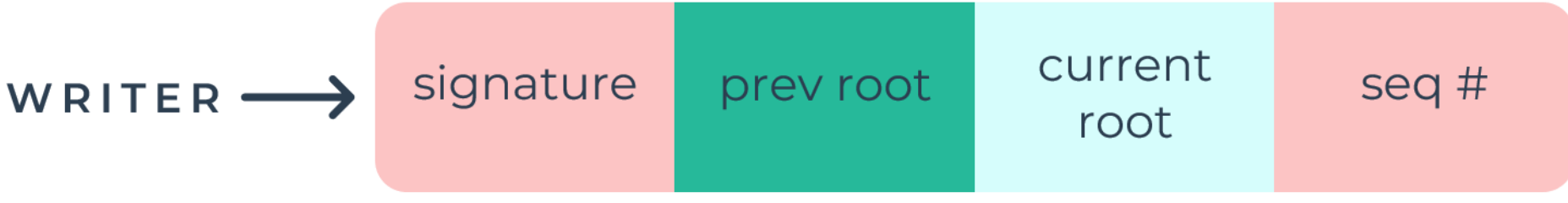
Retrieving a capability (PKI)

1. Use PKI (locally) to look up owner's host peer-id

PKI: username => signed(username, host, identity)

Retrieving a capability (mutable)

2. P2P HTTP request to host to get mutable pointer for writer
3. Verify signature and sequence for pointer
4. Get root hash from pointer



Retrieving a capability (immutable metadata)

5. champ.get(root, map key, BAT) => blocks
   (P2P HTTP request)
6. Repeat CHAMP lookup locally with returned blocks
7. Use read key to decrypt cryptree node, and get metadata

Retrieving a capability (immutable data)

8. Get blocks for any chunk fragments using BATs and hashes in cryptree node
9. Concat blocks and decrypt (max 5 MiB)
10. Calculate next chunk's map key =

    sha256(stream-secret + current chunk map key)
11. Repeat steps 5-10

Fast file seeking

How do we get cap to later chunks of a file?

mapkey => sha256(stream-secret + mapkey)

bat => sha256(stream-secret + bat)

1. local hashing
2. a single champ.get to retrieve the encrypted metadata
3. up to 5 block.get calls for fragments

DEMO

Fast seeking within a movie

Block Access Tokens (BATs)

- Don't put encryped data in public!
- Post-quantum ciphertext access control
- 2 BATs per block
- Send S3 V4 sig (89 bytes) with hash
- Tied to requesting peer-id and time
- Recipient verifies signature against requesting peer-id and the BAT

Inline BATs

- BAT = 32 random bytes

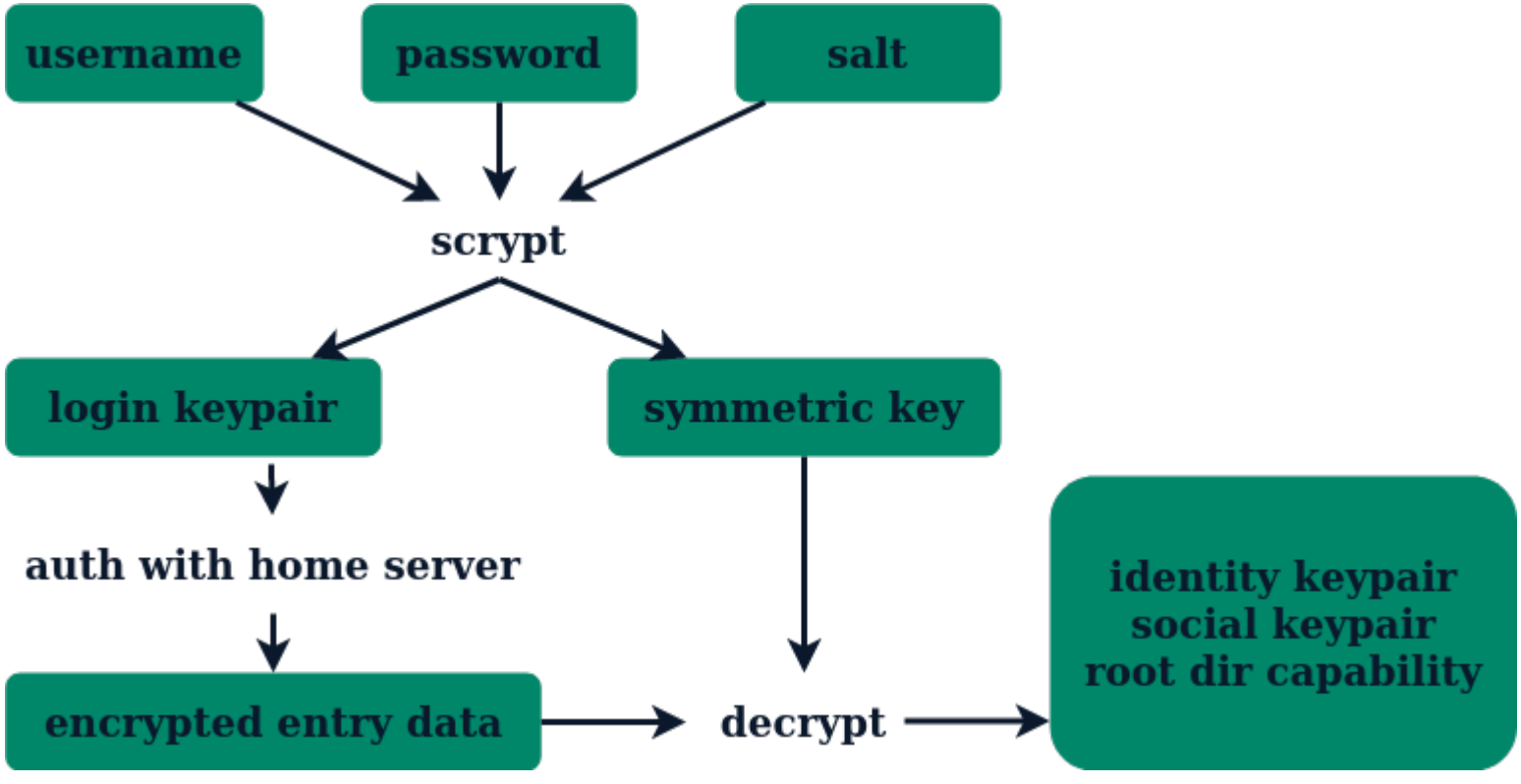
CBOR

```
{
   "bats" :  [inline BAT, mirror BAT ID],
   .
   .
   .
}
```

RAW

8 byte magic prefix	77 byte cbor list(inline BAT, mirror BAT ID)	8 KiB - 1 MiB block data

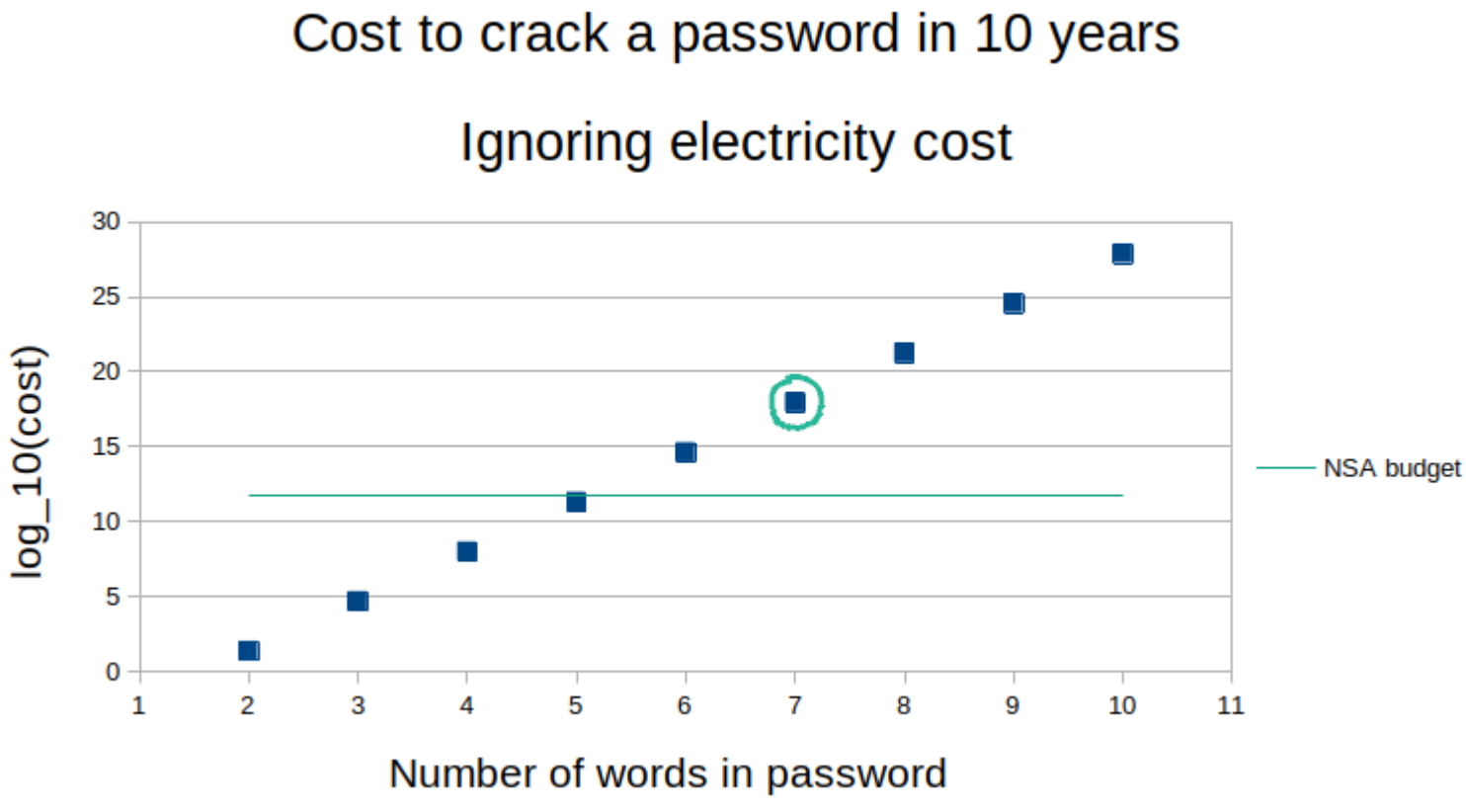
Login


username
password
salt
scrypt
login keypair
symmetric key
auth with home server
encrypted entry data
decrypt
identity keypair
social keypair
root dir capability

Login security

- humans shouldn't create passwords
- generate password - 7 words from 2048 word list
- generated passwords have 7*11 = 77 bits of entropy
- GPU can calculate ~1M scrypt hashes per second
- 1 GPU would take 5 billion years
- 1 million GPUs would take 5000 years

Brute forcing a login (after hacking server)



Social

- follow request to open encrypted channel
- encrypted inbox for follow requests

Application sandbox

- run untrusted code over private data
- an app can't exfiltrate data
- an app can't read anything it's not granted acess to
- works in existing browsers, without add-ons
- works offline
- simple REST API (without a server!)

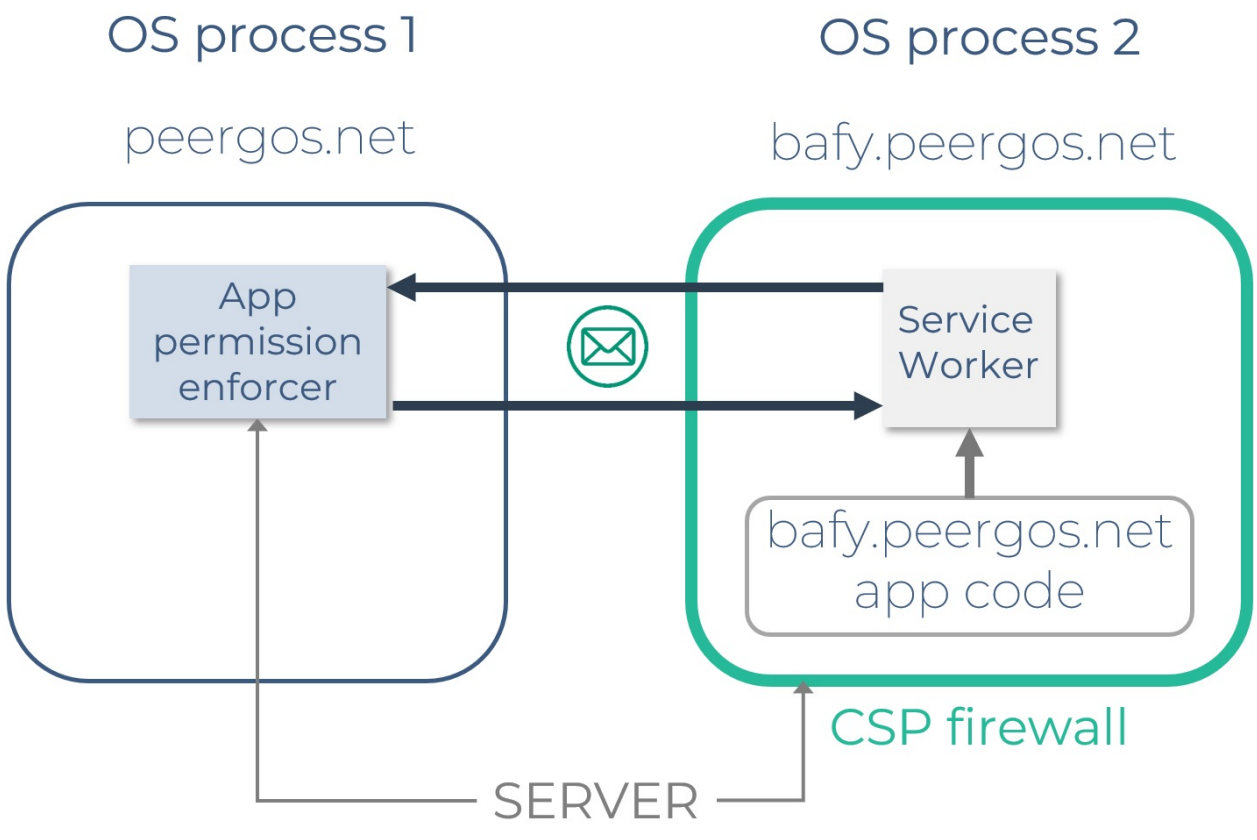
Application authoring

- just a folder of HTML5
- author controls visibility
- basic permissions (e.g. register for certain file types)
- frictionless publishing - drag and drop
- 0 permissions = private website

Browser app

- special app that renders folders of HTML
- isolates different folders
- internal links (relative)
- external links /peergos/username/path/to/file.html
- works in secret links!
- markdown pages work!

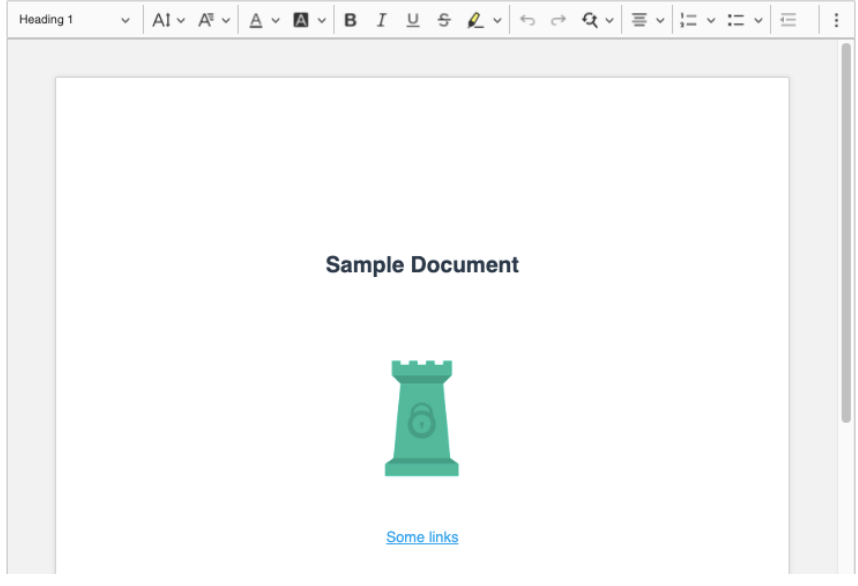
Application sandbox



What can an app do?

Edit files

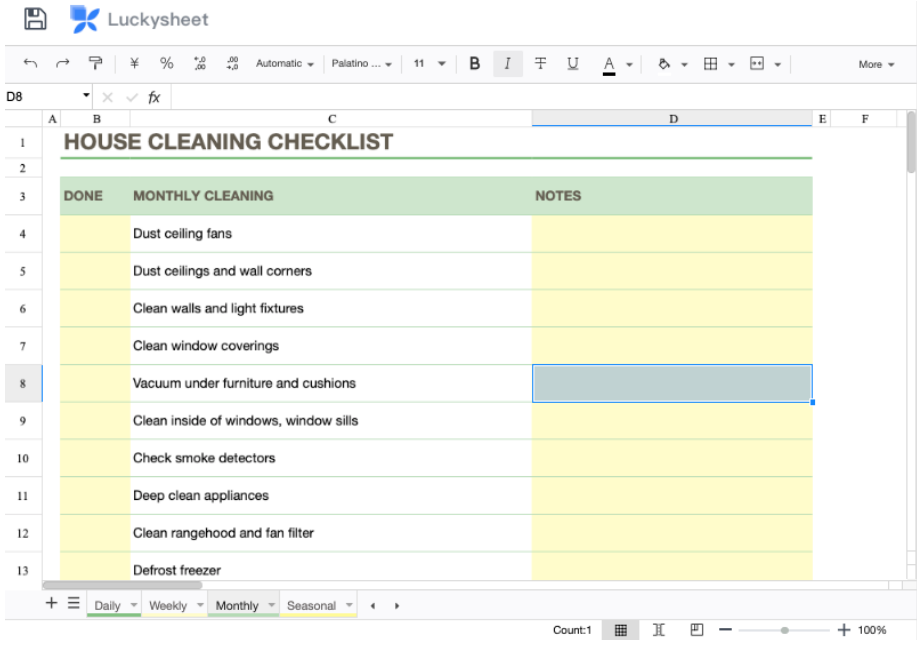
- Word processor



What can an app do?

Edit files

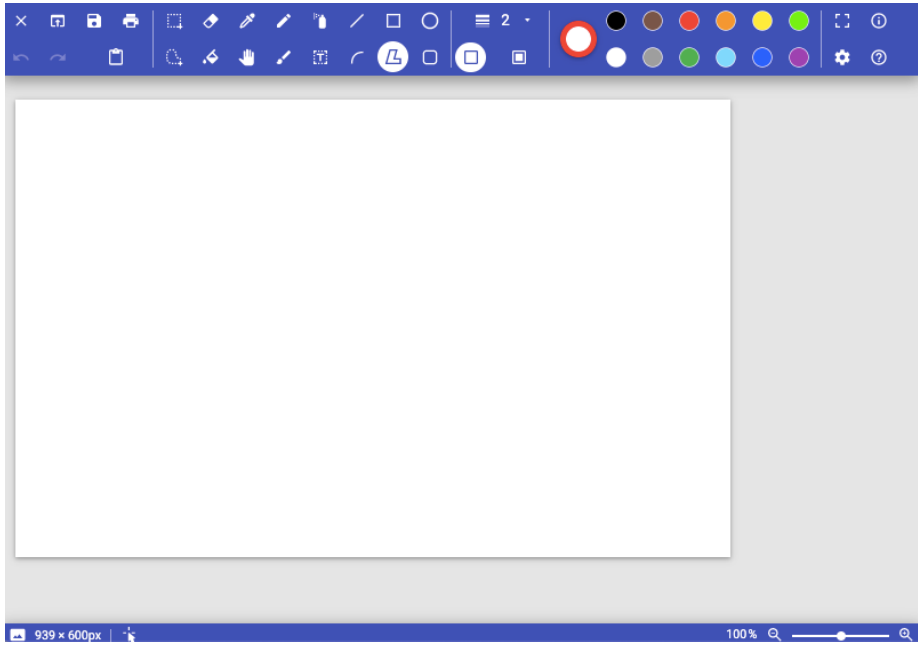
- Word processor
- Spreadsheets



What can an app do?

Edit files

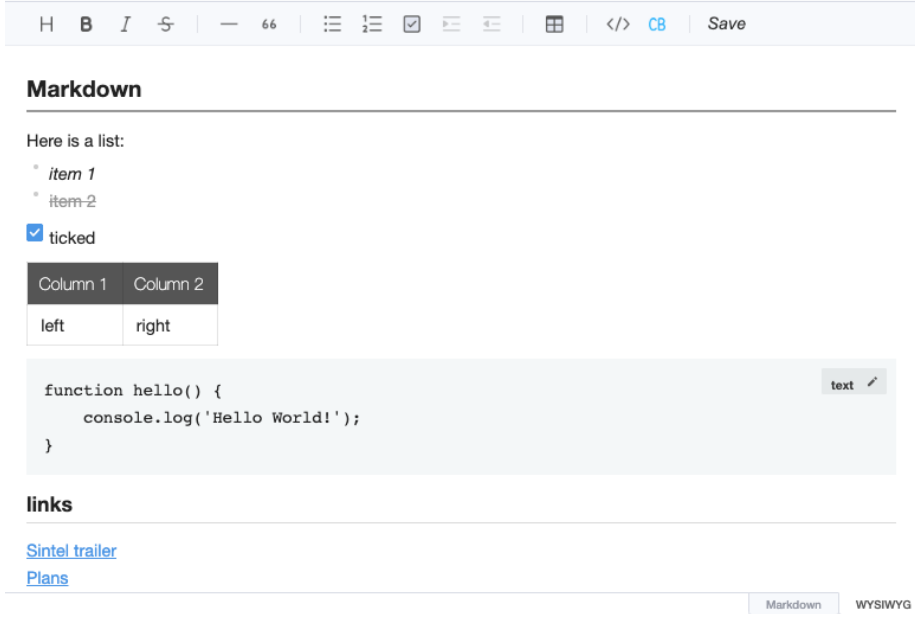
- Word processor
- Spreadsheets
- Image editor



What can an app do?

Edit files

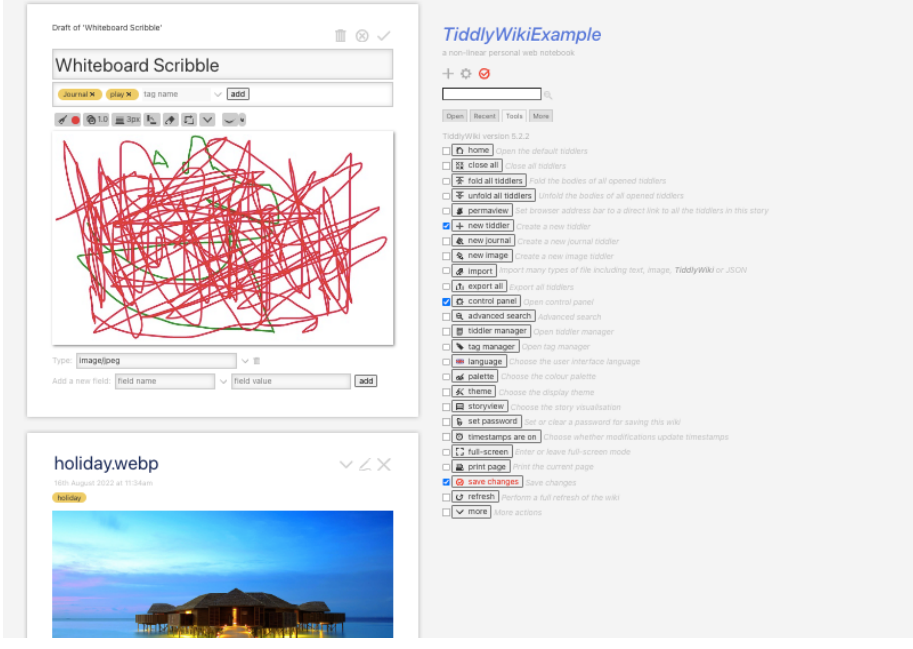
- Word processor
- Spreadsheets
- Image editor
- Markdown editor



What can an app do?

Edit files

- Word processor
- Spreadsheets
- Image editor
- Markdown editor
- Tiddlywiki notebooks

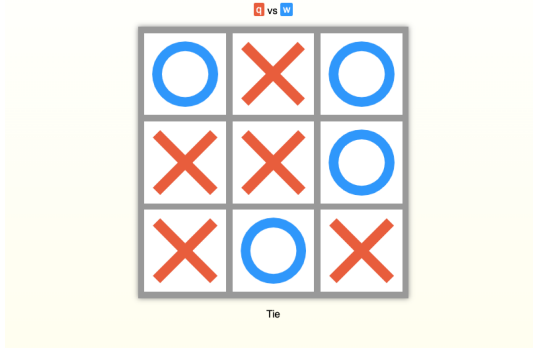


What else can an app do?

- Media player

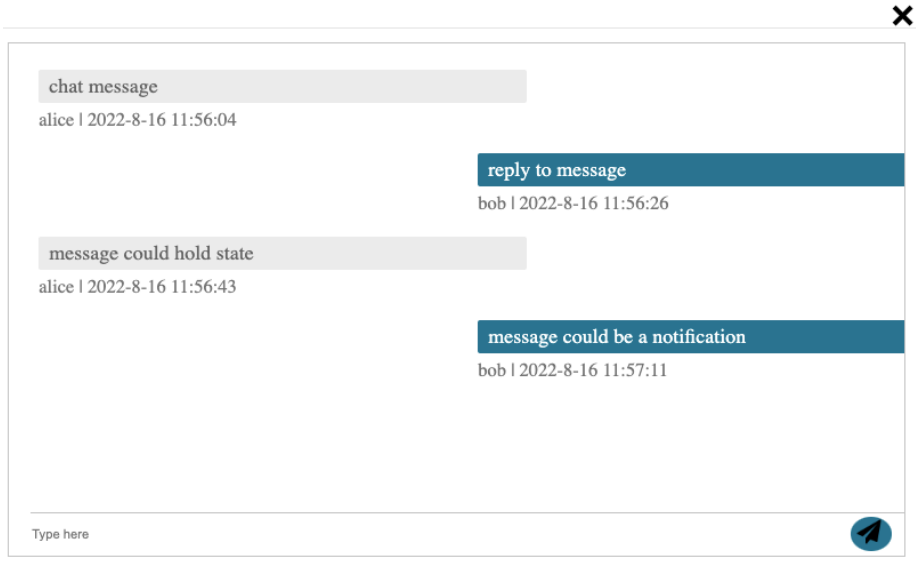
What else can an app do?

- Media player
- Multiplayer games



What else can an app do?

- Media player
- Multiplayer games
- Chat



What else can an app do?

- Media player
- Multiplayer games
- Chat
- Doom

More example apps: github.com/peergos/example-apps

App structure

- assets/index.html
- peergos-app.json

With STORE_APP_DATA permission

- data/

App manifest

```
{
    "displayName": "Painter",
    "description": "MS Paint clone,
    "version": "1.0.7",
    "author": "alice",
    "launchable": true,
    "folderAction": false,
    "appIcon": "icon.png",
    "fileExtensions": ["jpg","png"],
    "fileTypes":["image"],
    "permissions": ["EDIT_CHOSEN_FILE"]
}
```

- Open a file of a certain type
- fileExtensions, fileTypes and mimeTypes
- wildcard supported

Permissions

- STORE_APP_DATA
- EDIT_CHOSEN_FILE
- READ_CHOSEN_FOLDER
- EXCHANGE_MESSAGES_WITH_FRIENDS
- ACCESS_PROFILE_PHOTO

Run parameters

Passed via query parameters

- path
- isPathWritable
- theme

REST API

Write and get app-private data:
/peergos-api/v0/data/path.to.file

POST a HTML form and store the results:
/peergos-api/v0/form/path.to.file

Send async messages to friends:
/peergos-api/v0/chat/

Files REST HTTP API

- GET - get file or dir
- GET(?preview=true) - get thumbnail
- POST - create file
- PUT - update file
- DELETE - delete file
- PATCH - append to a file

Chat REST API

```
# list all chats created by this app (GET)
* /peergos-api/v0/chat/

# create chat (POST => chatId)
* /peergos-api/v0/chat/

# get messages by local index (GET)
* /peergos-api/v0/chat/:chatId?from=0&to=100

# send message (PUT - text: message)
* /peergos-api/v0/chat/:chatId
```

DEMO

Private websites

More cool features

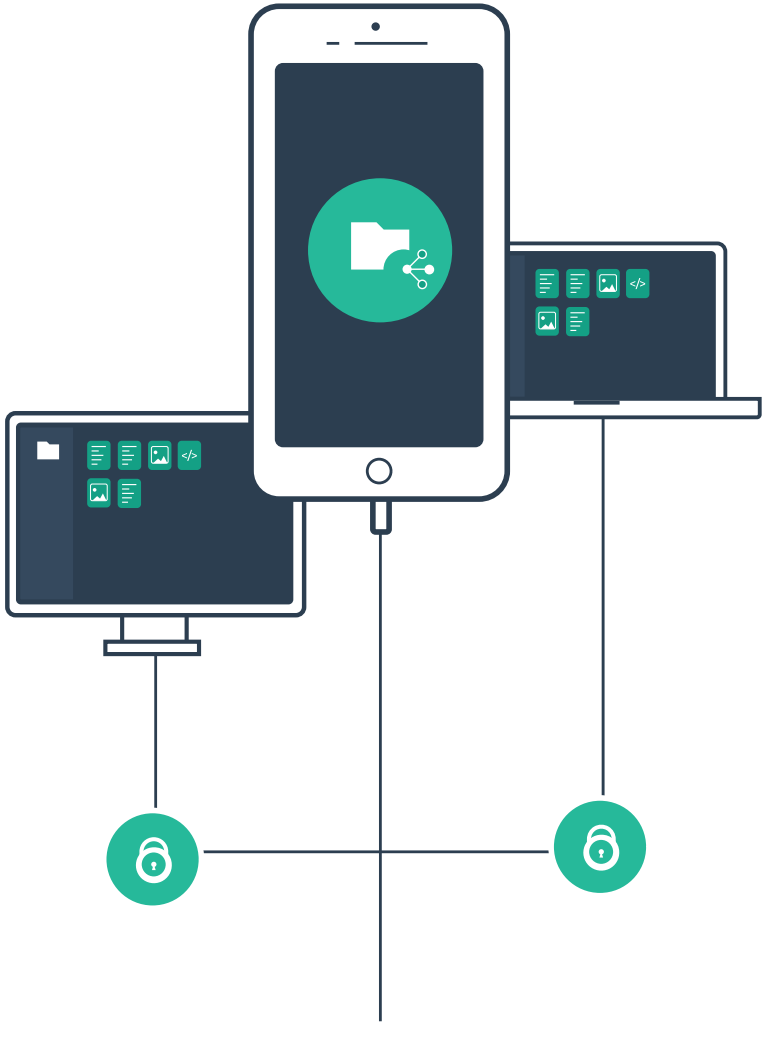
- Offline login and read access
- Encrypted history (deep links)

Social media

- public social media is bad for society
  - allows micro targeted political profiling
  - open to abuse
  - public ~ infinity (nobody understands it)
- normal in-person conversations are good for society
- Peergos social media is modelled on in-person conversations

Without privacy, there can be no democracy.

PEERGOS



Questions?

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book.peergos.org

@peergos

Workshop Part 1 - Create account

1. Download peergos from: https://peergos.net/public/peergos/releases
2. Install Java 17 or later from https://adoptium.net
3. Run with, *java -jar Peergos.jar daemon -generate-token true*
4. Wait for signup URL to be printed
5. Create a local account with username starting with "crete-"
6. Try it out, upload files, edit a markdown file etc.

Workshop Part 2 - Social

1. Restart peergos with "-log-to-console true" and wait for ".. finished updating pki mirror state."
2. Connect to "peergosdemo" wifi which has no internet
3. Restart peergos
4. Friend someone else in the room and share something with them 100% offline

Workshop Part 3 - Write a peergos app

Best app gets a free year of Pro

Details and API:
https://book.peergos.org/features/apps.html

Examples: https://github.com/Peergos/example-apps

Try adapting an existing webapp to use peergos for storage or sharing?

Concurrent GC

- Kubo GC with 1 TiB S3 blockstore takes ~24 hours whilst holding a global lock
- V1 of Peergos GC takes 2 hours on same size blockstore, fully concurrent (no locks)
- V2 takes 7 mins!

How does writing blocks work?

1. startTransaction => tid
2. write blocks tagged with tid
3. commit new root to mutable pointers
4. closeTransaction(tid)

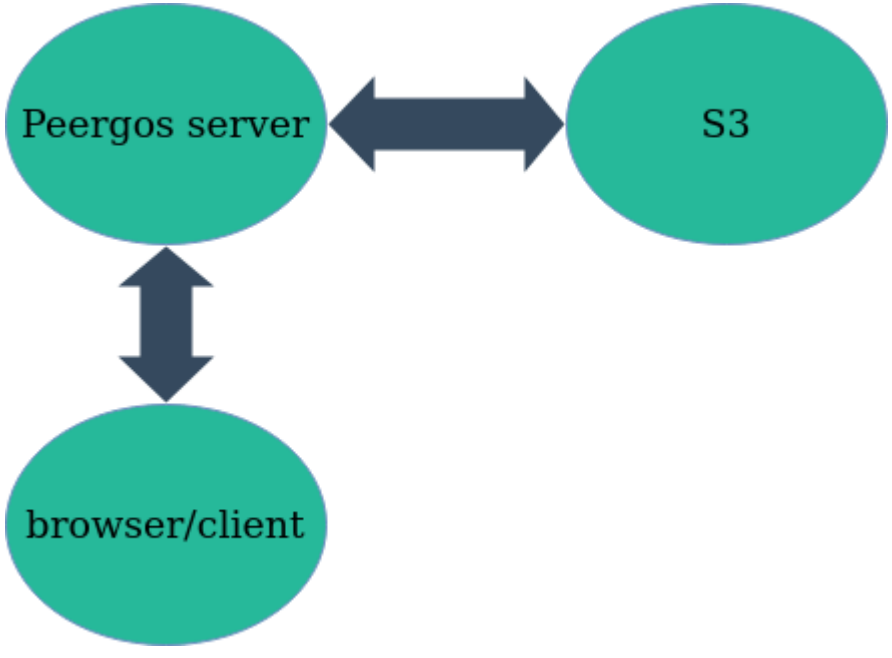
GC algorithm

1. List blockstore
2. List GC roots
3. List uncomitted writes (block writes are tagged with a tid)
4. Mark reachable (parallel) (skip raw blocks)
5. Delete unreachable (parallel)

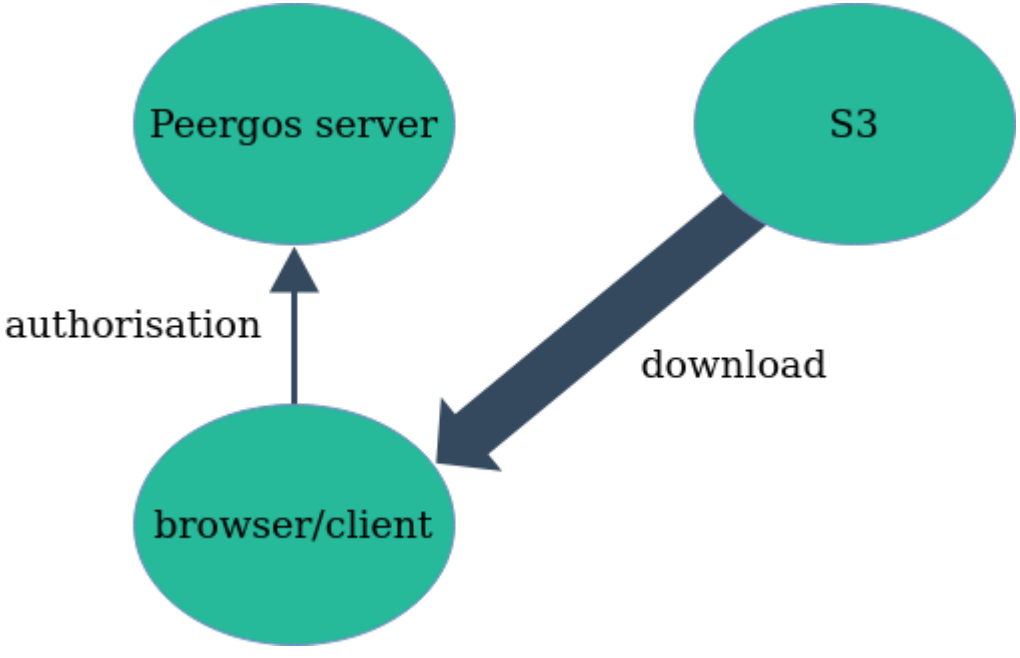
V2 - block metadata

- Store cid => links: list[cid], size in database
- total size ~0.05% of blockstore size
- avoid retrieving and parsing blocks during GC

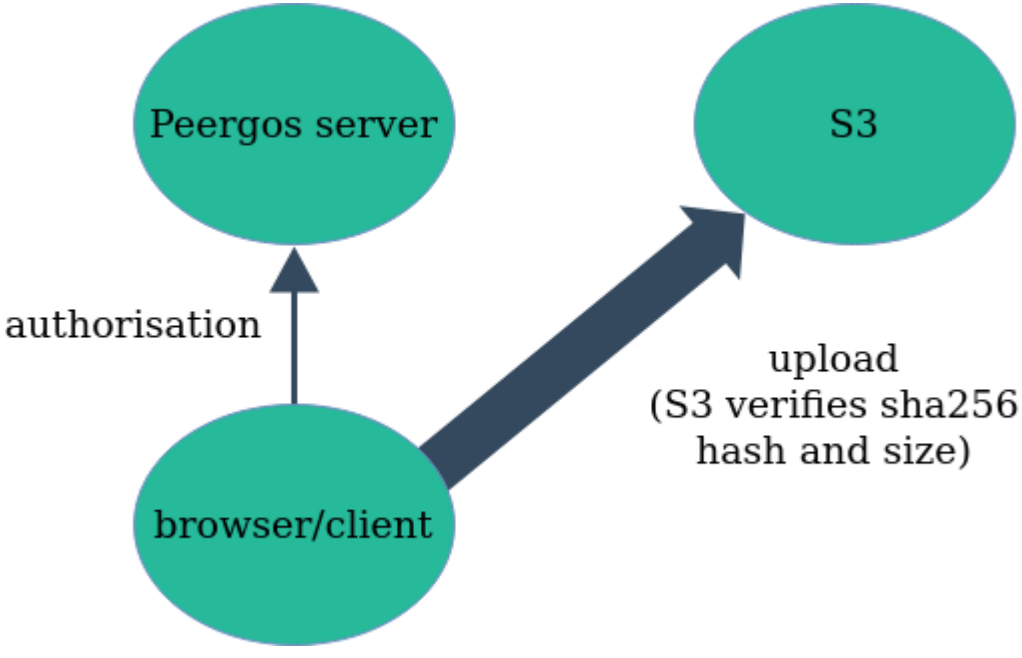
Bandwidth with S3 blockstore



Direct S3 blockstore reads



Direct S3 blockstore writes



What's in a directory?

Semantically a dir is list[children]

- list[cap]
- list[relative cap] ==> fast revocation
- list[named relative cap] ==> fast get-by-path

list[(name, [writer], map key, BAT, read key)]

Build security

- reproducible builds, both server and front end
- Don't use npm! Only 12 JS dependencies, all vendored
- Have our own simple, deterministic replacement for webpack
- self host all assets
- Most of the client code is written in a type-safe language (Java) and cross-compiled to JS