Git Is For Data

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Code collaboration

1st generation (versioning of individual files)
1972 – SCCS
1982 – RCS

2nd generation (centralized repository-level versioning)
1986 – CVS
1995 – Perforce
2000 –SVN

3rd generation (distributed version control model)
2005 – Git
2005 – Mercurial
2005 -- Bazaar

Code collaboration

1st generation (versioning of individual files)
1972 – S
1982 – R

2nd gene ning)
1986 – C
1995 – R
2000 –S

3rd gene
2005 – Git
2005 – Mercurial
2005 -- Bazaar

Data collaboration

Data: Any collection of bytes of value

While data storage has scaled with distributed filesystems, blobstores, etc.

Collaboration is still just

Build and share report?

Run some experiments?

Make a new version?

Make A Copy

Data is rarely standalone

Code With Data

- Games
- Interactive media
- Intelligent applications

Data With Code

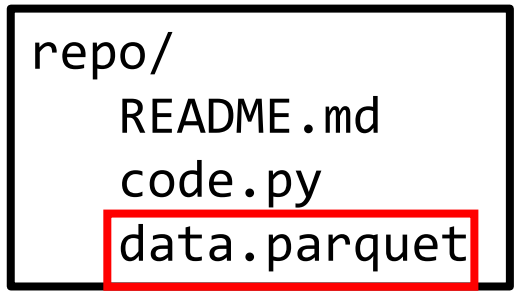
- ML modeling
- Reports / notebooks

How solutions work for code and data today?

Git LFS

```
> git lfs track *.parquet
```

User's Checkout



Git LFS

```
> git lfs track *.parquet
> git add *
```

User's Checkout

```
repo/
    README.md
    code.py
    data.parquet
```

Clean (dehydrate)

What Git Stores

```
repo/
    README.md
    code.py
    data.parquet
```

```
50415231 150415F4 CE2415E6 B4214C15 A2B40115 04120000 BAA71264 16000000 39794B7A 79395041
70656950 504F554A 45746E76 6B67011A 545A524A 77564C79 7A454A71 31564169 68446859 696F7701
1A54366F 52414334 75794A43 734A6C31 5830575A 70565341 011A505F 3151515A 7566347A 5A4F7946
43765863 306F3656 054E5036 6F7A7963 55315270 6B744E47 322D3142 726F5674 054E502D 79786642
59474236 53457173 7A6D784A 78643937 054E507A 70373133 714E6878 3864394B 434A4A6E 72773178
051A5068 57304E65 5F485448 45416747 46317241 646D522D 05684C77 4E556561 3349585A 57443633
62624F51 614F4809 1A506E4D 48687559 616E3865 33634F4E 6F33506F 726E4A05 4E544173 53437630
715F4257 71496533 6D58324A 71734F51 01D05065 396E4E34 58786A64 486A3471 744B434F 50715F76
```

Pointer file

```
version https://git-lfs.github.com/spec/v1
oid sha256:4d7a214614ab2935c...
size 12345
```

Git LFS

```
> git clone ...
```

User's Checkout

```
repo/
    README.md
    code.py
    data.parquet
```

What Git Stores

```
repo/
    README.md
    code.py
    data.parquet
```

Smudge (hydrate)

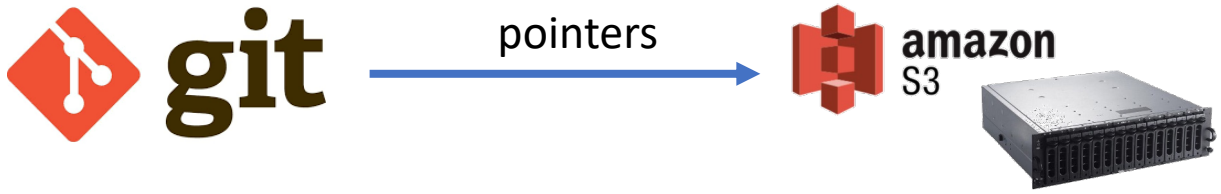
```
50415231 150415F4 CE2415E6 B4214C15 A2B40115 04120000 BAA71264 16000000 39794B7A 79395041
70656950 504F554A 45746E76 6B67011A 545A524A 77564C79 7A454A71 31564169 68446859 696F7701
1A54366F 52414334 75794A43 734A6C31 5830575A 70565341 011A505F 3151515A 7566347A 5A4F7946
43765863 306F3656 054E5036 6F7A7963 55315270 6B744E47 322D3142 726F5674 054E502D 79786642
59474236 53457173 7A6D784A 78643937 054E507A 70373133 714E6878 3864394B 434A4A6E 72773178
051A5068 57304E65 5F485448 45416747 46317241 646D522D 05684C77 4E556561 3349585A 57443633
62624F51 614F4809 1A506E4D 48687559 616E3865 33634F4E 6F33506F 726E4A05 4E544173 53437630
715F4257 71496533 6D58324A 71734F51 01D05065 396E4E34 58786A64 486A3471 744B434F 50715F76
```

Pointer file

```
version https://git-lfs.github.com/spec/v1
oid sha256:4d7a214614ab2935c...
size 12345
```

Git LFS, Git DVC, Git Annex, etc. are architecturally similar

"All problems in computer science can be solved by another level of indirection"

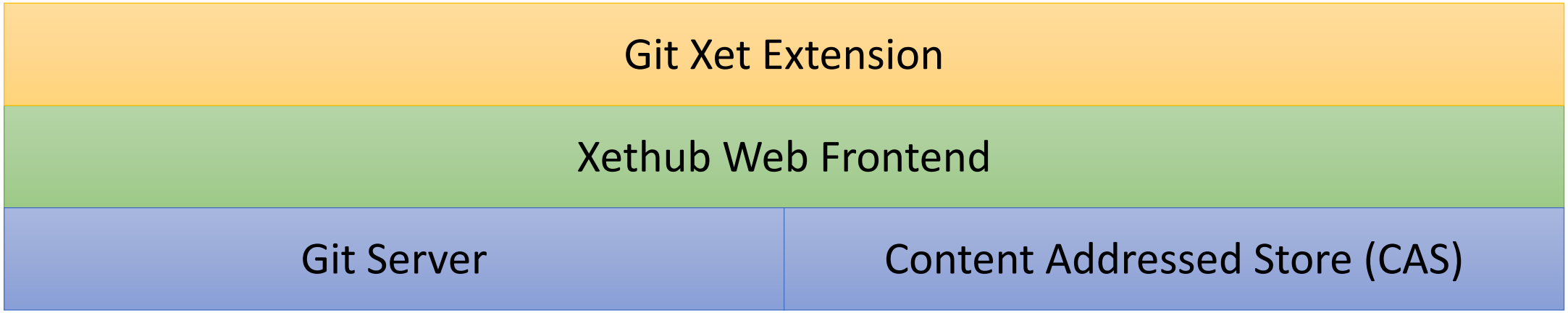


- Explicit storage decisions
- Frequently, no different than a download manifest + curl

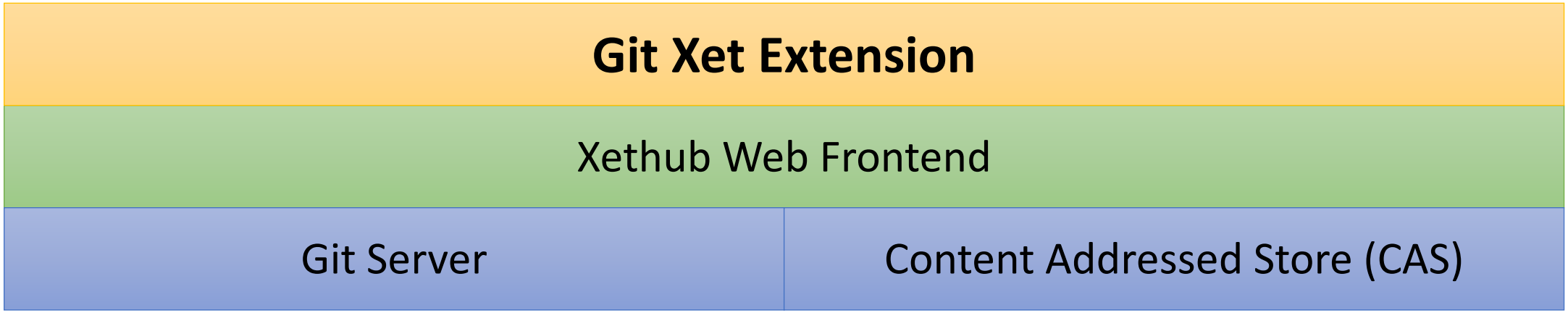
Data should be 1st class

xethub


xethub


Git Xet Extension
Xethub Web Frontend
Git Server
Content Addressed Store (CAS)


xethub


Git Xet Extension
Xethub Web Frontend
Git Server
Content Addressed Store (CAS)

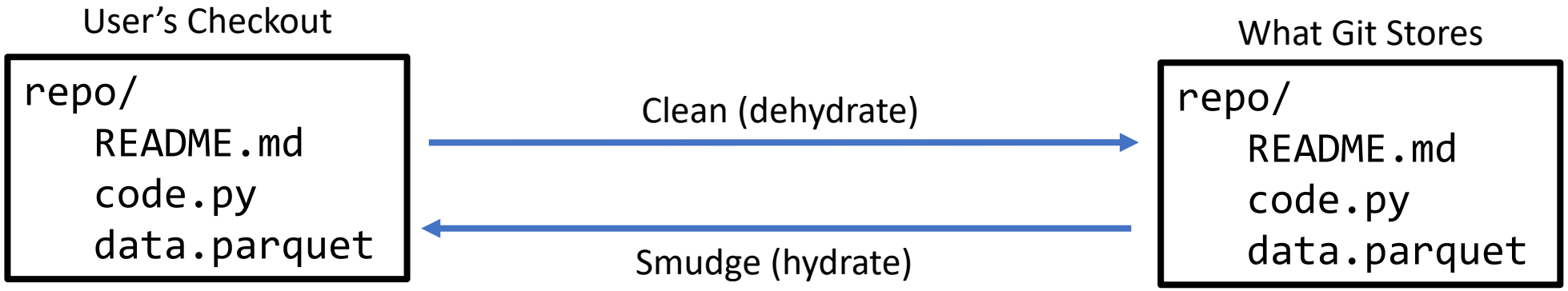
Git Xet Extension

Full Git Compatibility:

```
> git add dataset/*
> git commit -a -m “adding large files”
> git push
> [all esoteric git commands we have tested]
```

Uniform UX: Code and data files are treated the same.

Git Xet



Data-informed heuristic optimizes for
best performing storage location of each file.

git

Xethub CAS

Store a big binary file

Large_file.bin

Content Defined Chunking

Large_file.bin

Content Defined Chunking

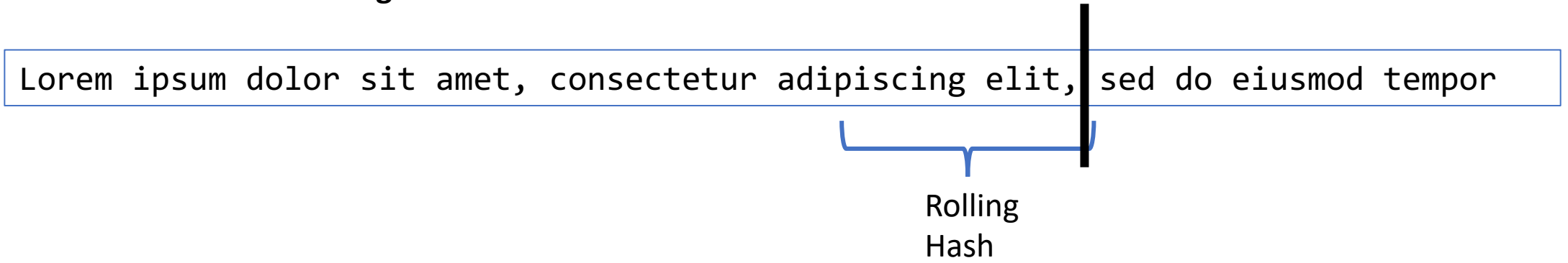
Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor

Rolling
Hash

Content Defined Chunking

Large_file.bin

Content Defined Chunking



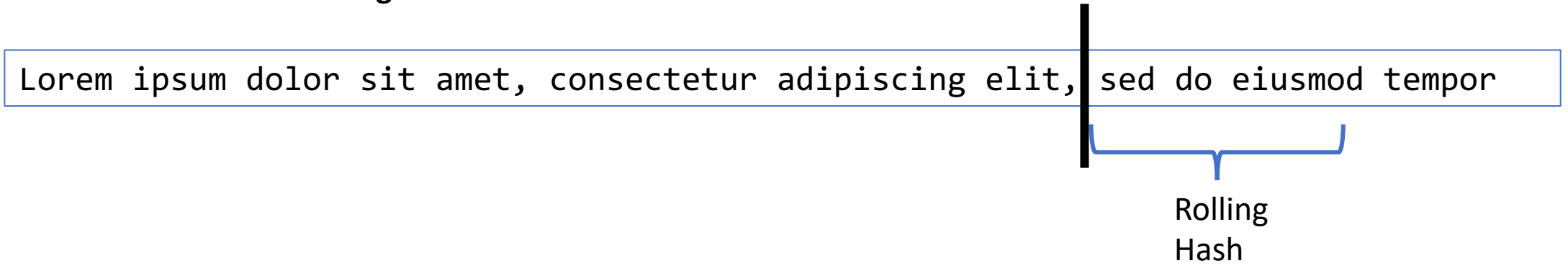
If Hash % 16384 == 0, this is a chunk boundary

Target average 16KB chunks

Content Defined Chunking

Large_file.bin

Content Defined Chunking

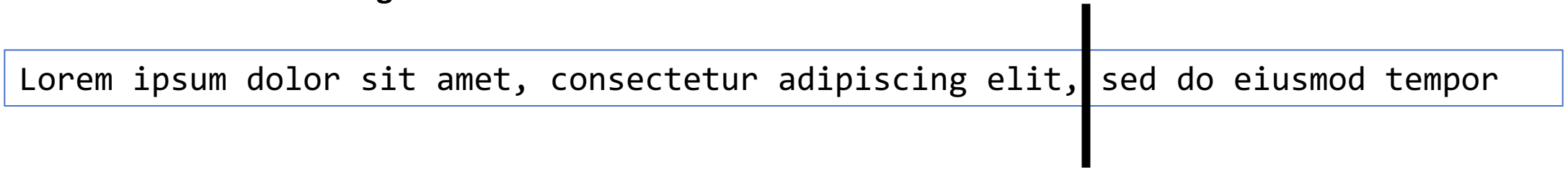


If Hash % 16384 == 0, this is a chunk boundary

Content Defined Chunking

Large_file.bin

Content Defined Chunking

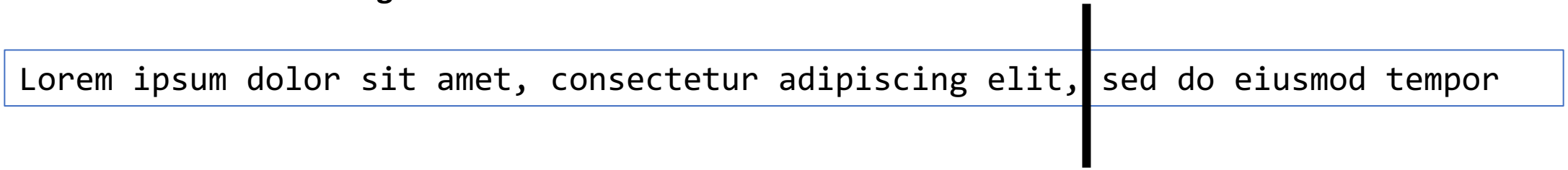


If Hash % 16384 == 0, this is a chunk boundary

Content Defined Chunking

Large_file.bin

Content Defined Chunking



CDC procedure is robust to insertions and deletions as chunk boundaries are decided based on the data.

If Hash % 16384 == 0, this is a chunk boundary

Content Defined Chunking

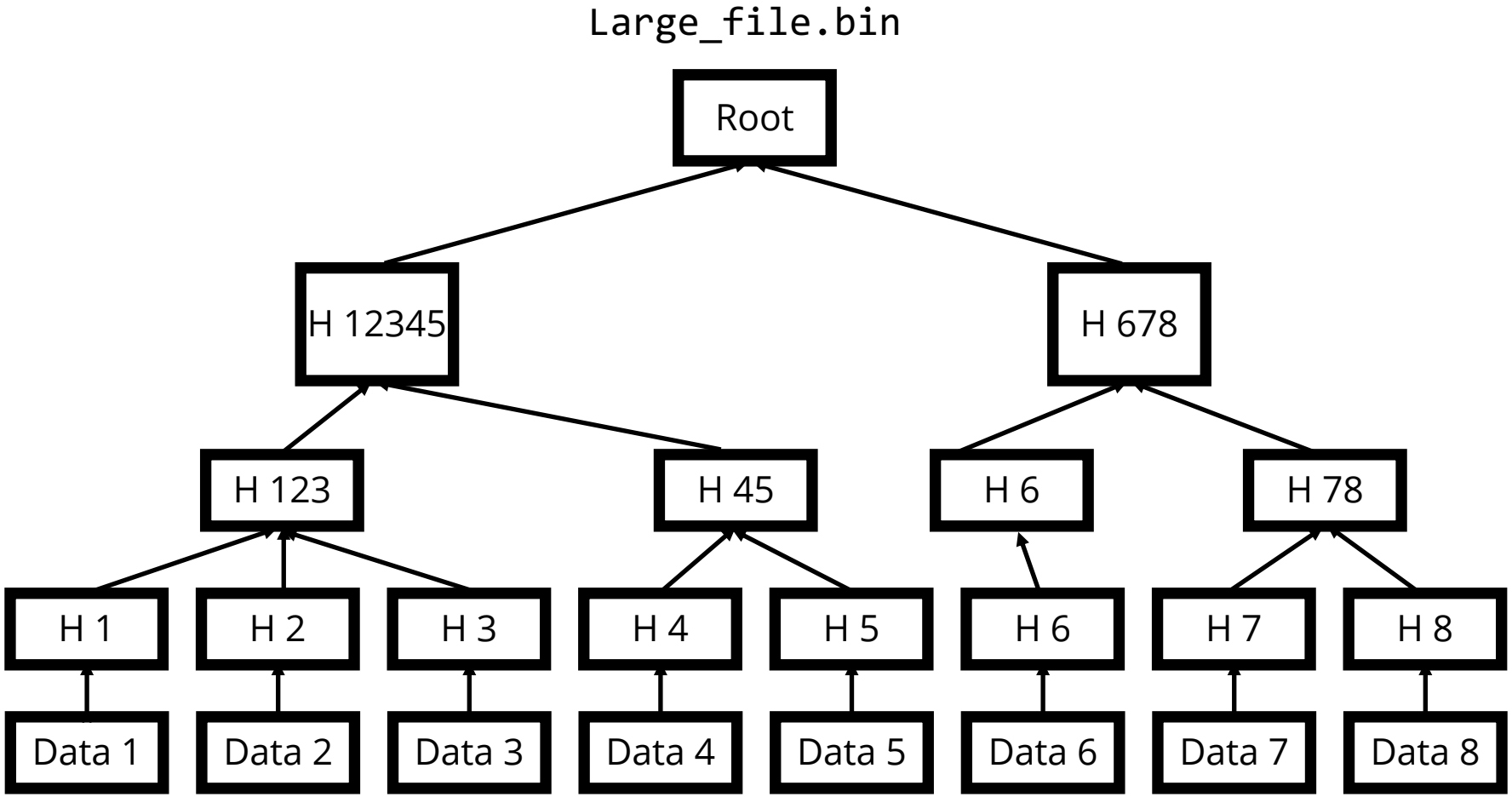
Large_file.bin

What is the target chunk size?

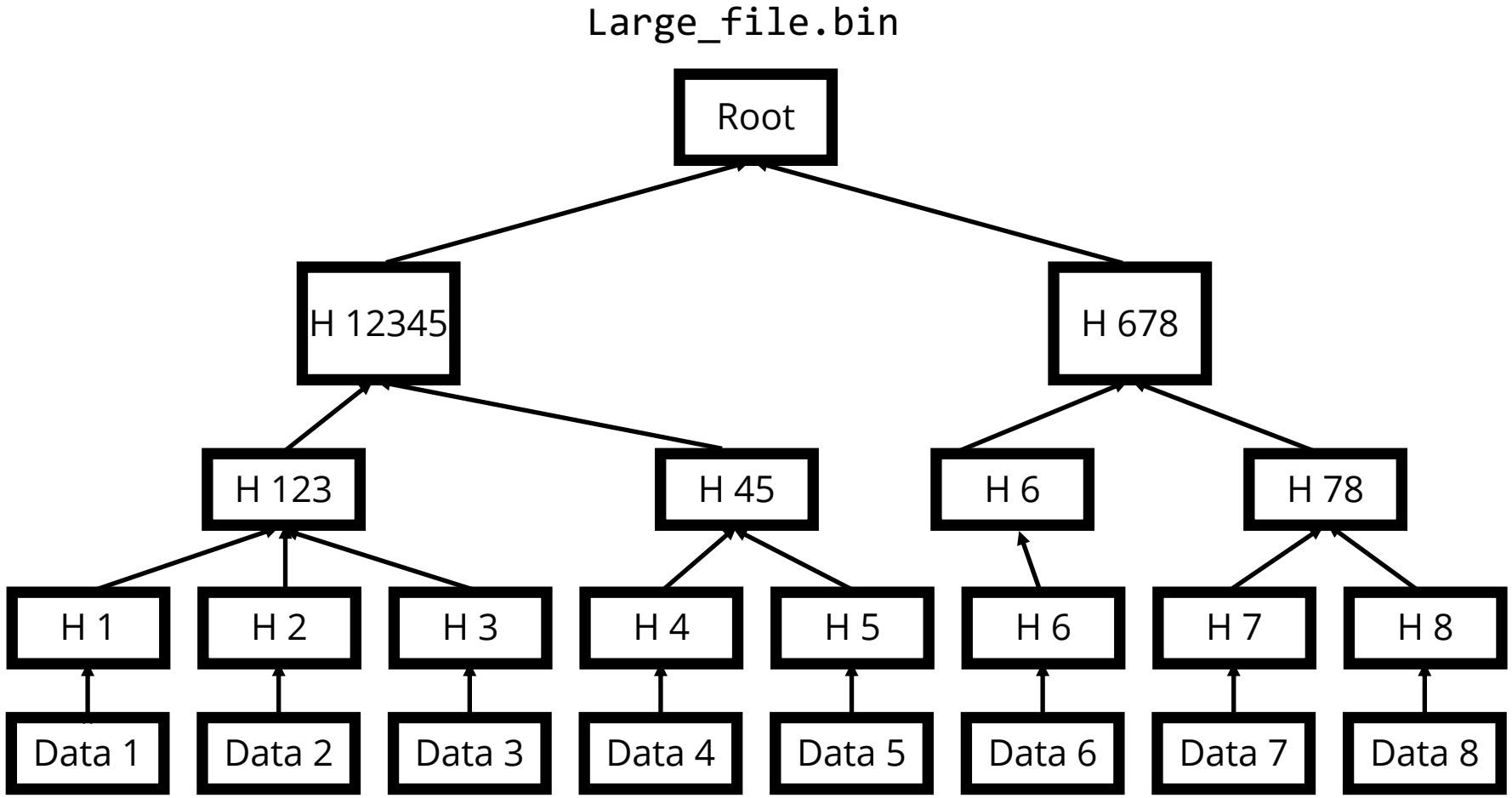
Small chunks ➔ better dedupe.
Large chunks ➔ more efficient to store

Can we get the best of both worlds?

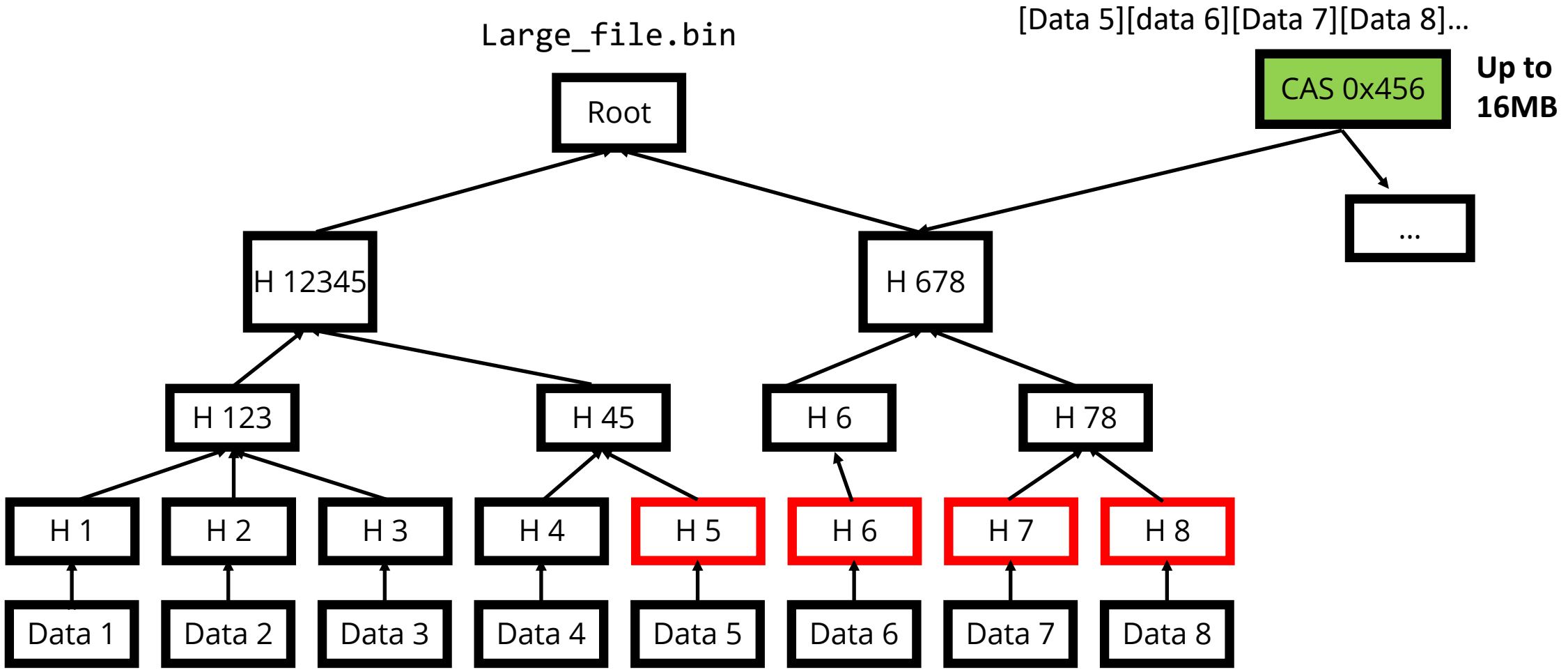
Content Defined Merkle Tree



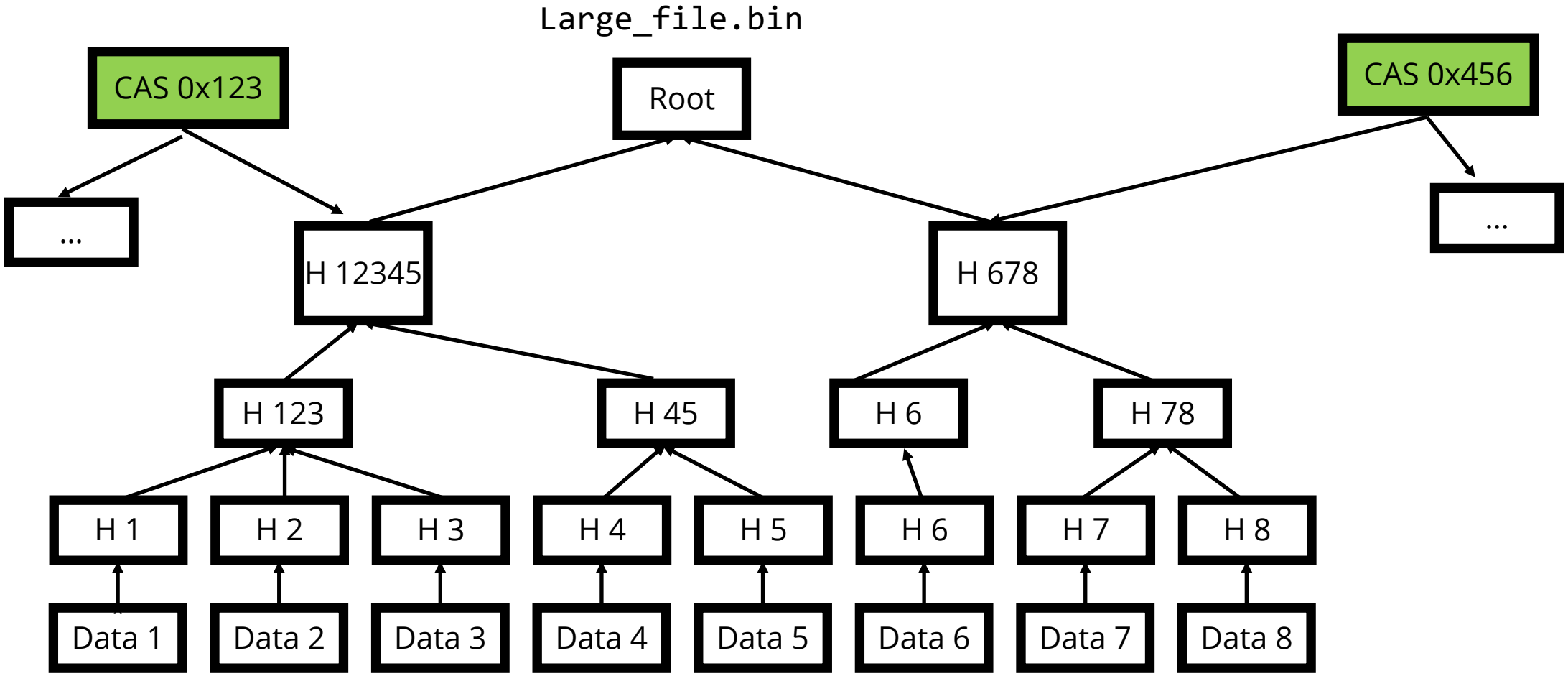
New Chunks


Large_file.bin
Root
H 12345
H 678
H 123
H 45
H 6
H 78
H 1
H 2
H 3
H 4
H 5
H 6
H 7
H 8
Data 1
Data 2
Data 3
Data 4
Data 5
Data 6
Data 7
Data 8

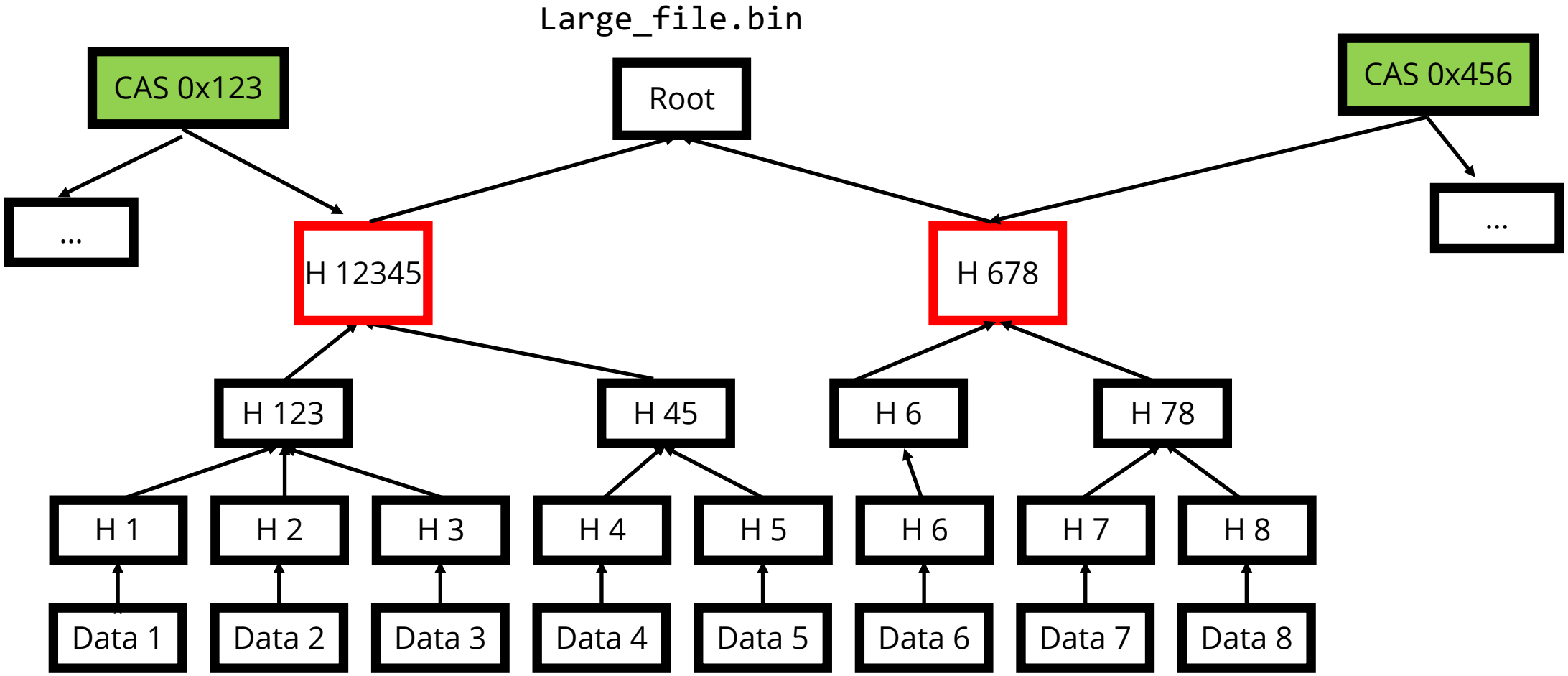
New Chunks


Large_file.bin
[Data 5][data 6][Data 7][Data 8]…
CAS 0x456
Up to 16MB
Root
…
H 12345
H 678
H 123
H 45
H 6
H 78
H 1
H 2
H 3
H 4
H 5
H 6
H 7
H 8
Data 1
Data 2
Data 3
Data 4
Data 5
Data 6
Data 7
Data 8

Smudging (hydration)



Smudging (hydration)



Concatenate range **0x123[...]** with range **0x456[...]**

Merkle Tree Data Dedupe

Data dedupe with small chunks:
supporting insertions and deletions.

Low CAS overhead:
Large block sizes reduce overhead.

High data locality:
If a range in a block is required, it is likely that the rest of the block is also required.

Cord-19 Dataset Benchmark

Time evolving collection of covid-19 papers with full text, authors, abstracts and document embeddings.

2021-02-01 Snapshot

2021-02-08 Snapshot

2021-03-01 Snapshot

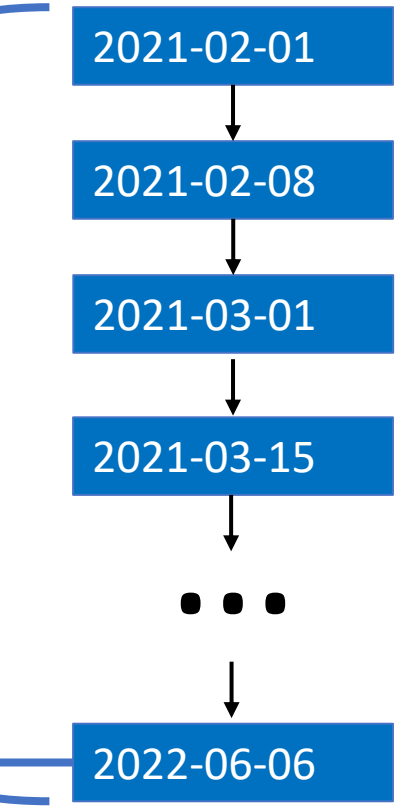
2022-06-06 Snapshot

```
embeddings/
parses/
metadata.csv
…
```

81.5 GB

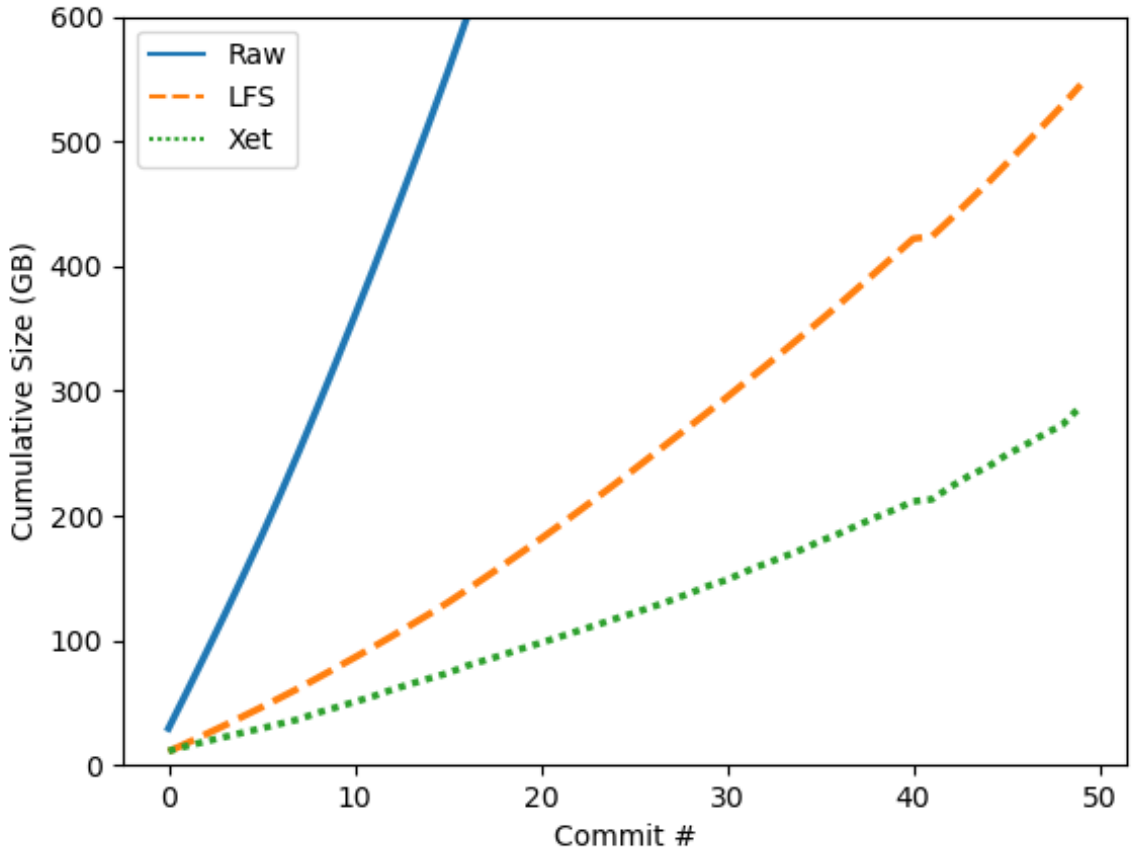
```
git add *
git commit –m “2021-02-01”
git add *
git commit –m “2021-02-08”
git add *
git commit –m “2021-03-01”
git push
```

50 versions



Covid Papers Dataset 50 versions

Naïve Cumulative Size:
2.45TB



LFS (Any File Level Dedupe):
545GB

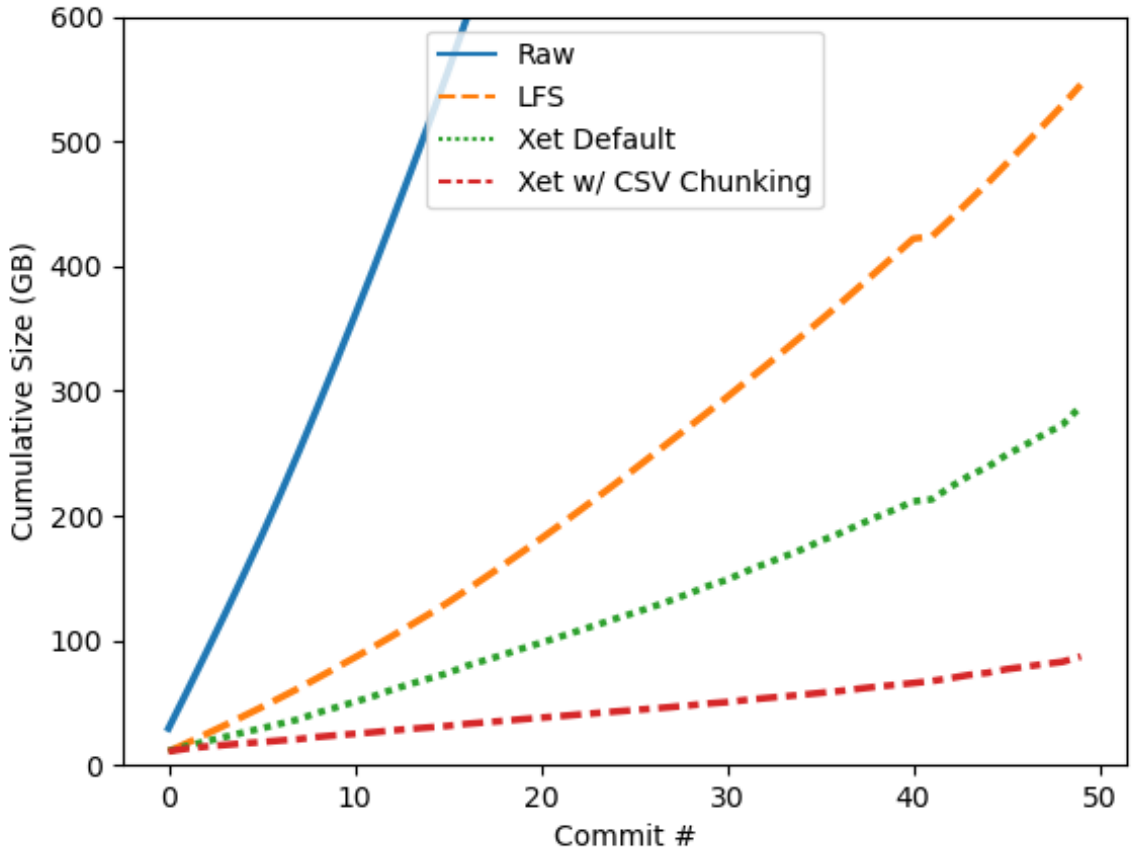
Xet: 287GB

2x smaller!

Very dumb chunker. Can we tune it for different file types?

Covid Papers Dataset 50 versions

Naïve Cumulative Size:
2.45TB



LFS (Any File Level Dedupe):
545GB

Xet: 287GB

Xet + CSV Chunker:
87GB

6.3x smaller!

All 50 dataset versions

Xet + CSV Chunker Total Storage: 87GB

Final 2022-06-06 Snapshot Size: 81.5GB

Only 5.5GB more for all 49 historical versions.

Effective Data Dedupe can substantially improve ML dataset performance.

```
> git clone IncrediblyGiantRepo
```

You probably do not want to do this

Virtual Filesystem

Explore large datasets in seconds:

Laion400M dataset

54GB Parquet files of URLs and other metadata

```
git xet mount https://xethub.com/XetHub/Laion400M

> duckdb.query("select COUNT(*) from 'data/*.parquet’”)
413871335
> duckdb.query("select LICENSE, count() .. group by LICENSE)
> ...
```

~ 1GB downloaded **2% of the dataset**

As fast as local filesystem after first access as local caching is performed

Virtual Filesystem

Bridge the gap between experiment and production

- Same code works for both.
- Stream to GPU machines, no manual data partitioning

Writable Mounts (WIP)

- Virtual Filesystem that acts like a git repo
- “Dropbox with git semantics”

- **Full Git Compatibility** where Data and Code are 1st class
- **High performance dedupe architecture** enables cheap versioning and common ML dataset operations.
- **Virtual Filesystems** to enable scaling to very large repos

Many MLOps concepts are exactly DevOps concepts

Data Quality monitoring → Continuous Integration

Data Pipelines → Build Dependencies

Model Versioning → Build Artifacts

……

MLOps == DevOps + Data Scale

Demonstrate that we can scale the foundations.

Much More Work To Be Done

Scaling further:
Scaling designs to support > 100TB

Writable Mounts:
Virtual Filesystem that acts like a git repo.
“Shared filesystem with git commit semantics”

Collaboration Patterns:
Github has collaboration patterns for code. What are the right patterns for data?

Raised $7.5M Seed Round.

Public Beta: https://xethub.com

We are hiring: careers@xethub.com