MetaSync

File Synchronization Across Multiple Untrusted Storage Services

Seungyeop Han, Haichen Shen, Taesoo Kim*, Arvind Krishnamurthy, Thomas Anderson, and David Wetherall

University of Washington *Georgia Institute of Technology

File sync services are popular

400M of Dropbox users reached in June 2015

Many sync service providers

Dropbox (2GB)

Google Drive (15GB)

MS OneDrive (15GB)

Box.net (10GB)

Baidu(**2TB**)

Can we rely on any single service?

Cloud Storage Often Results in Data Loss

All The Different Ways That 'iCloud' Naked Celebrity Photo Leak Might Have Happened

Red

0

Sha

More

Shutting down Ubuntu One file services

U1, UBUNTU ONE

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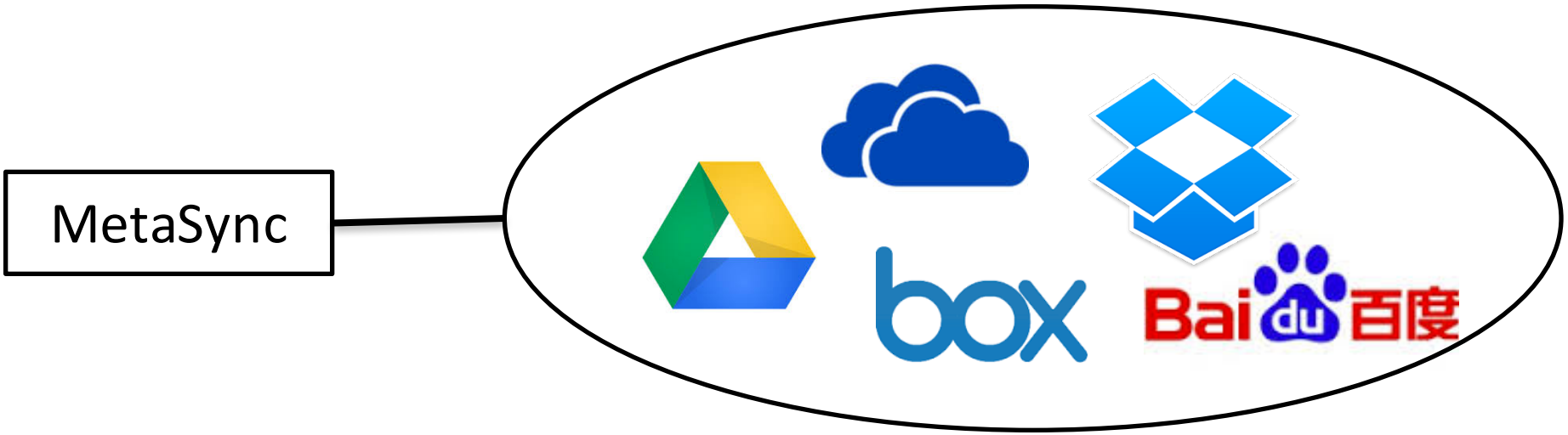
▲ Dropbox confirms that a bug within Selective Sync may have caused data loss (githubusercontent.com)

128 points by ghuntley 6 days ago | comments

Existing Approaches

- Encrypt files to prevent modification
  - Boxcryptor

- Rewrite file sync service to reduce trust
  - SUNDR (Li *et al.*, 04), DEPOT (Mahajan *et al.*, 10)



MetaSync:

Higher availability, greater capacity, higher performance
Stronger confidentiality & integrity

Can we build a better file synchronization system across multiple existing services?

Goals

- Higher availability
- Stronger confidentiality & integrity
- Greater capacity and higher performance

- No service-service, client-client communication
- No additional server
- Open source software

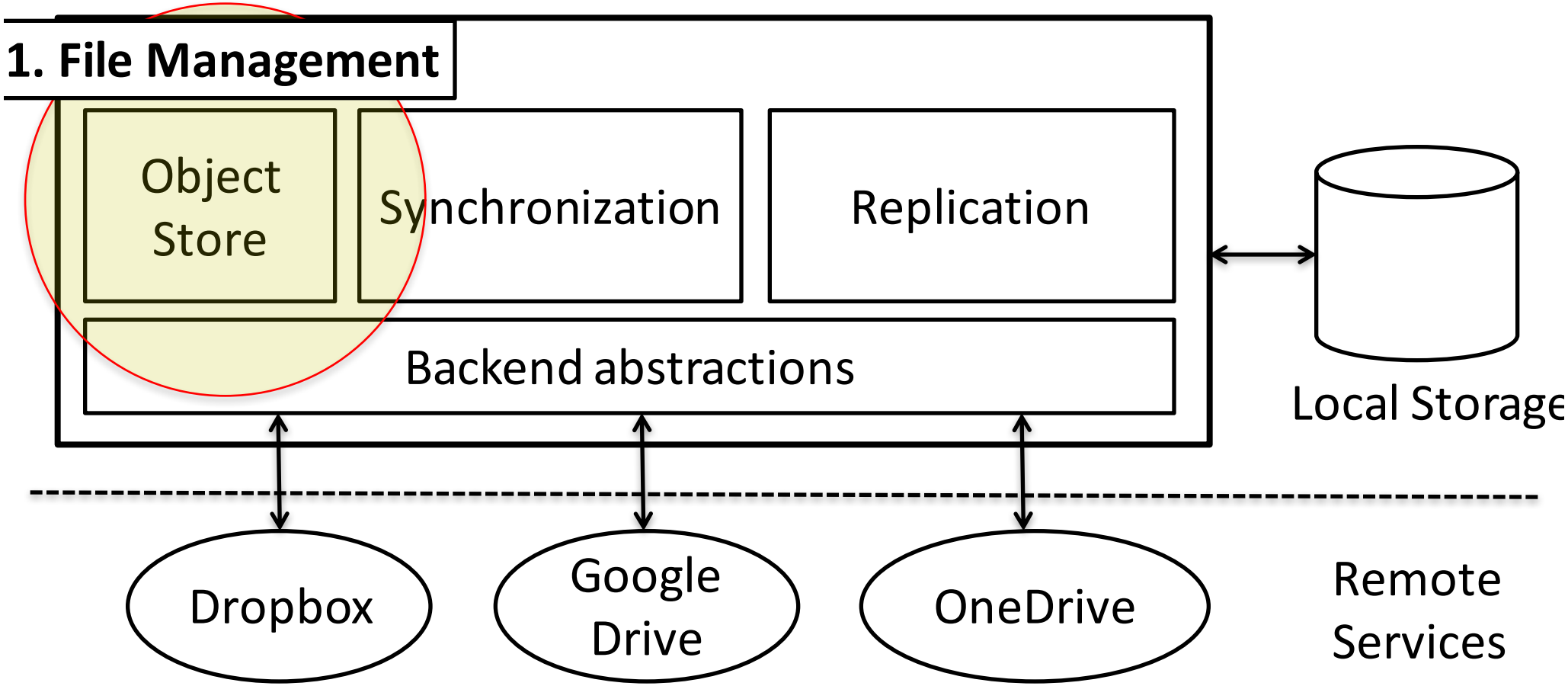
Overview

- Motivation & Goals
- MetaSync Design
- Implementation
- Evaluation
- Conclusion

Key Challenges

- Maintain a *globally consistent view* of the synchronized files across multiple clients
- Using only the service providers' *unmodified APIs without any centralized server*
- Even in the *presence of service failure*

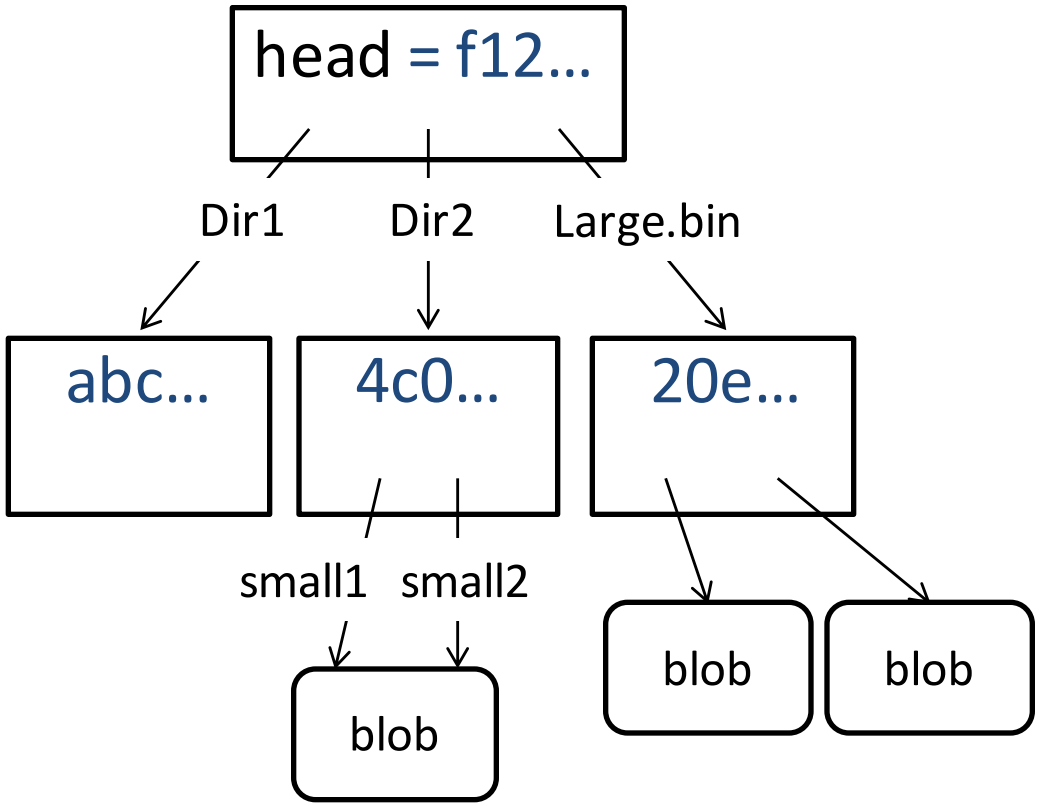
Overview of the Design



Object Store

- Similar data structure with version control systems (e.g., git)
- Content-based addressing
  - File name = hash of the contents
  - De-duplication
  - Simple integrity checks
- Directories form a hash tree
  - Independent & concurrent updates

Object Store



- Files are chunked or grouped into blobs
- The root hash = f12… *uniquely* identifies a snapshot

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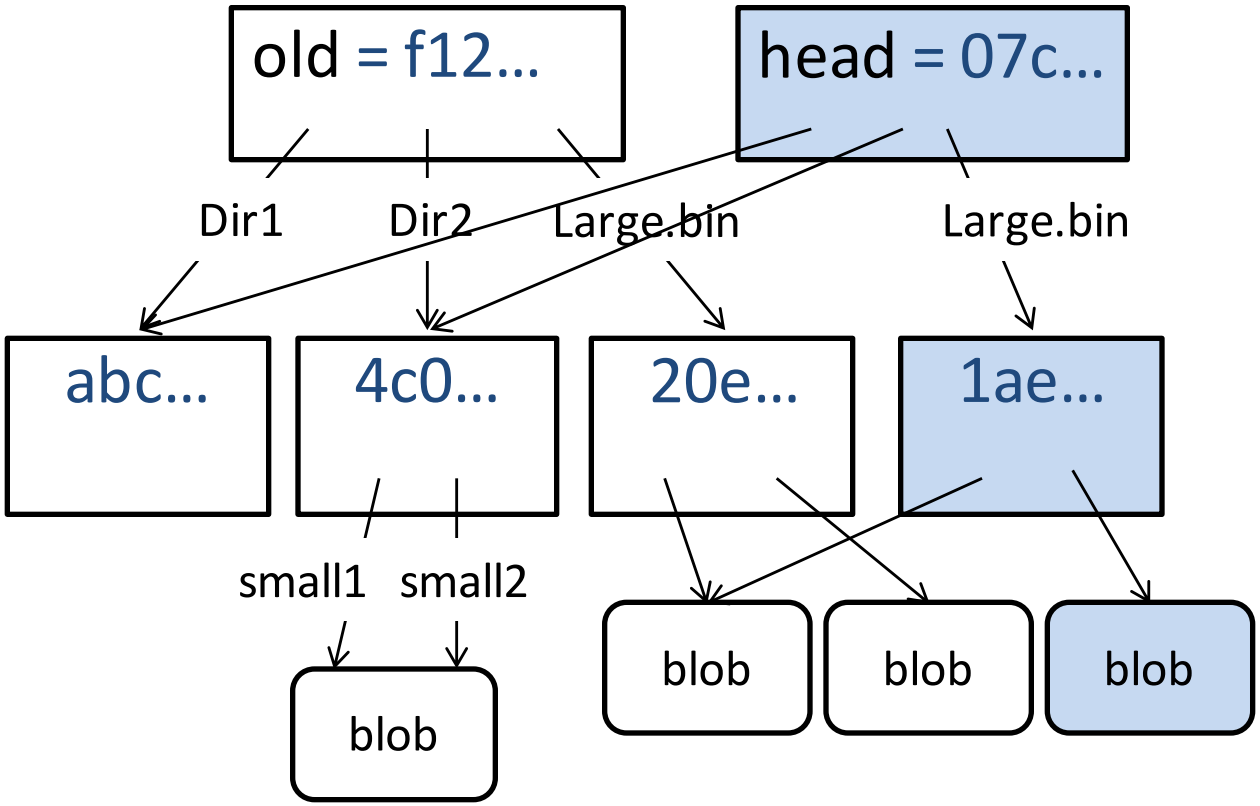

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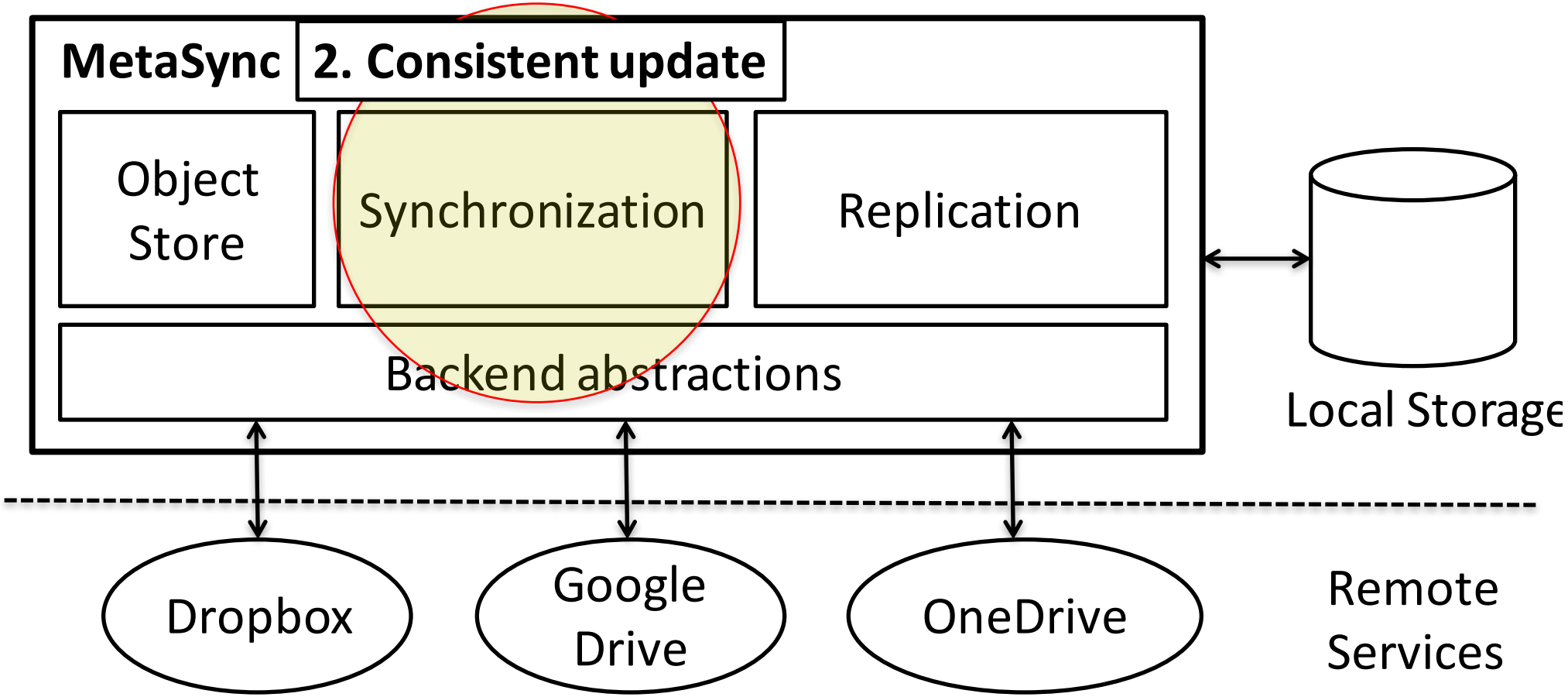
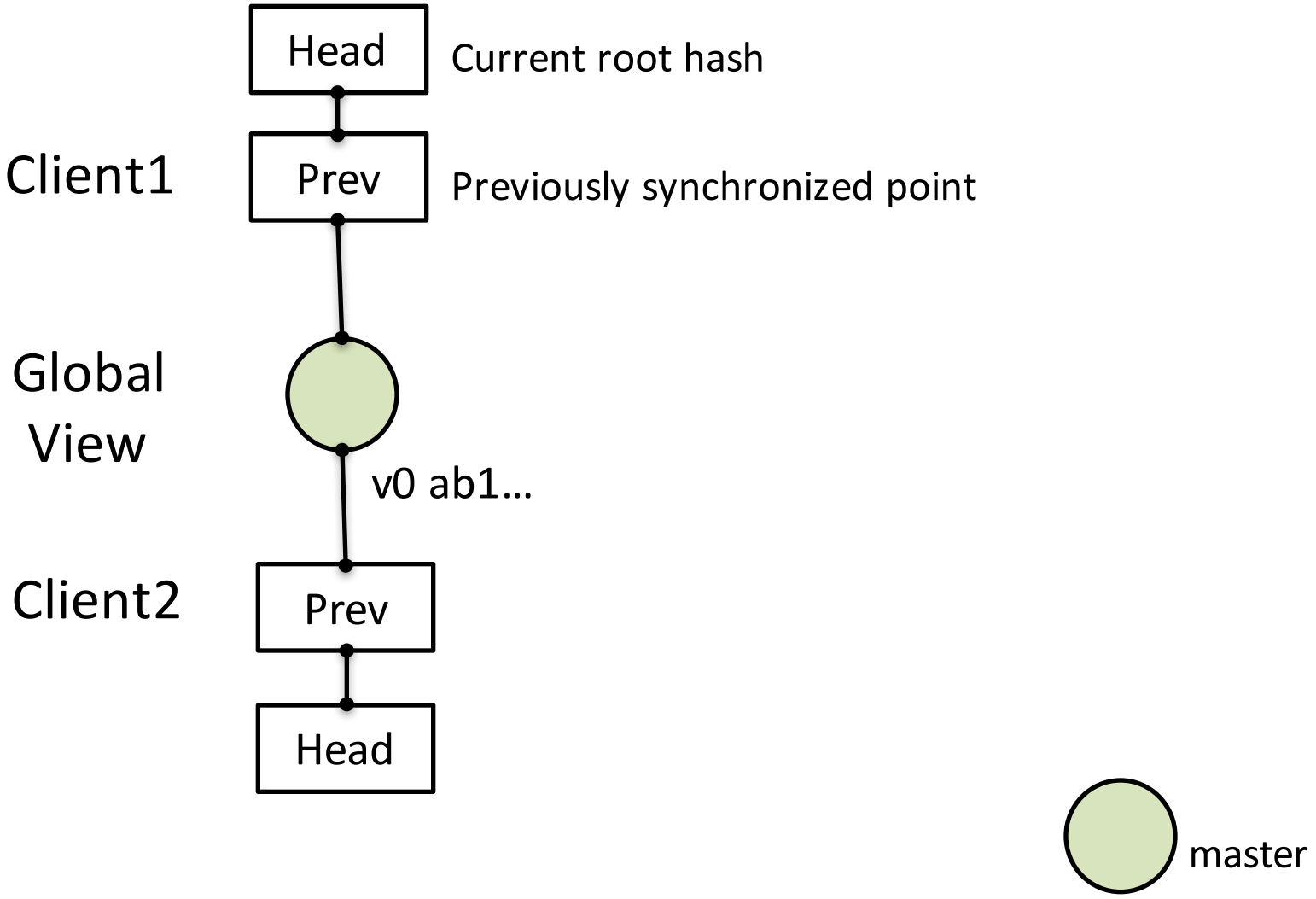


Updating Global View



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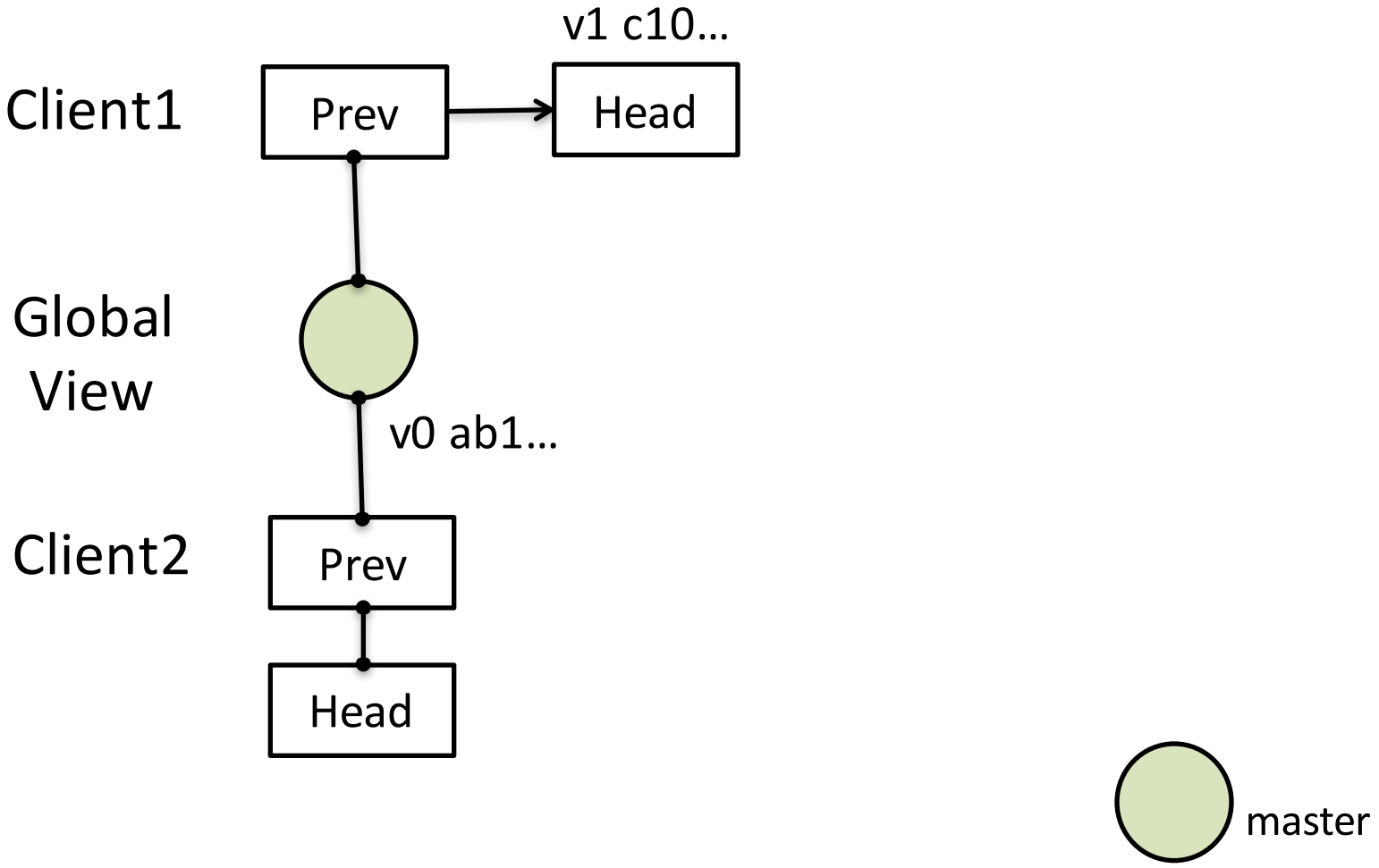

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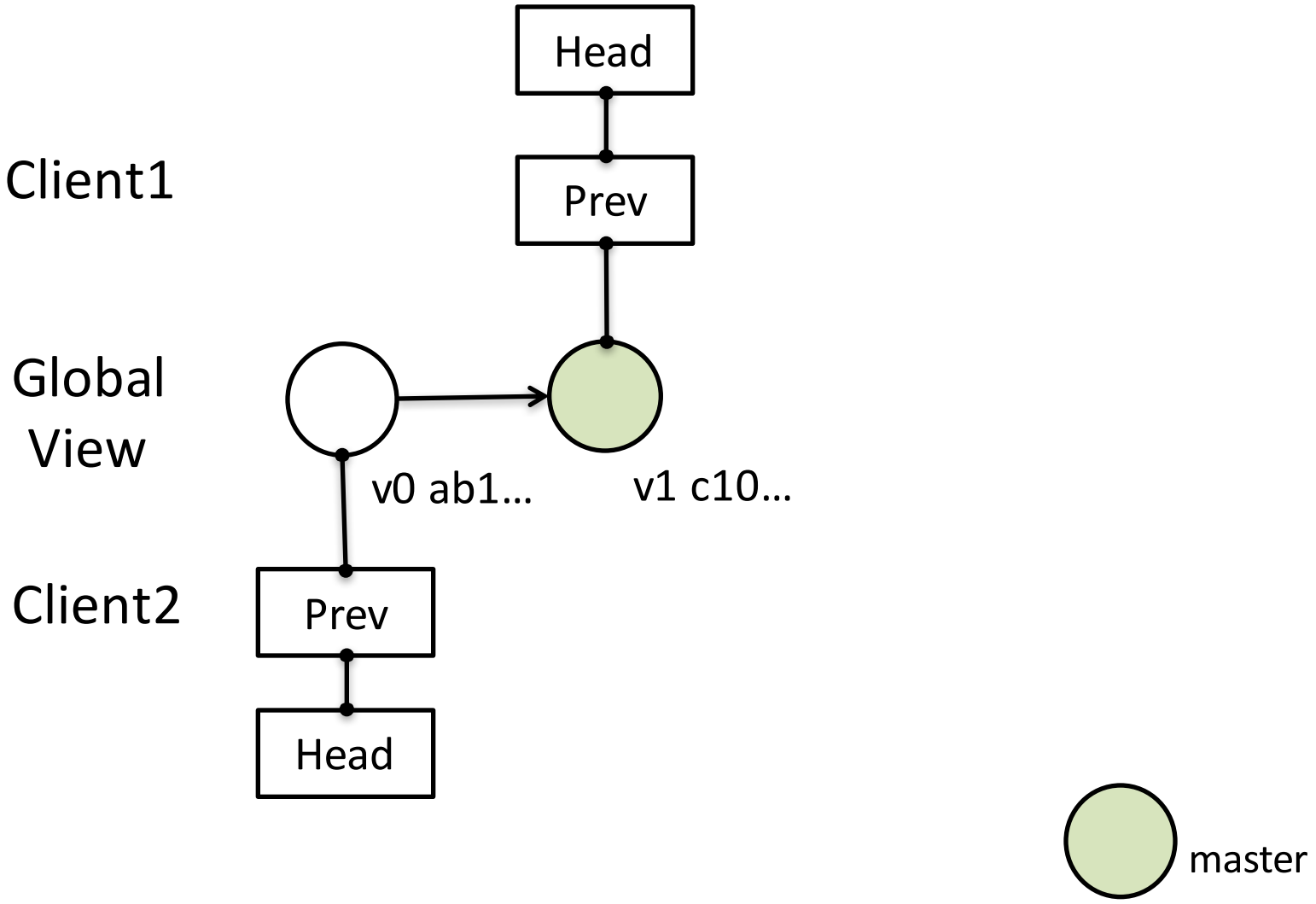

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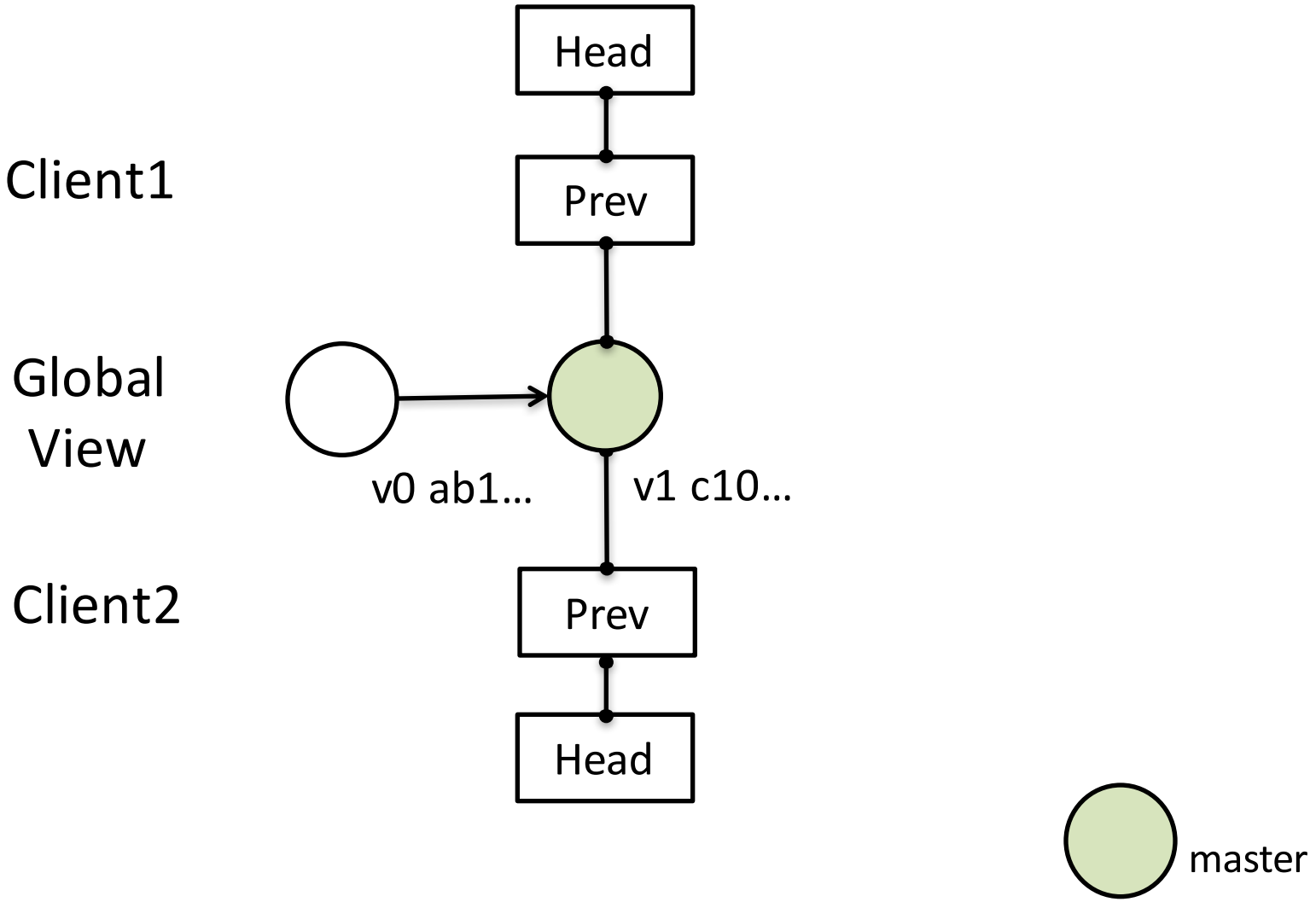

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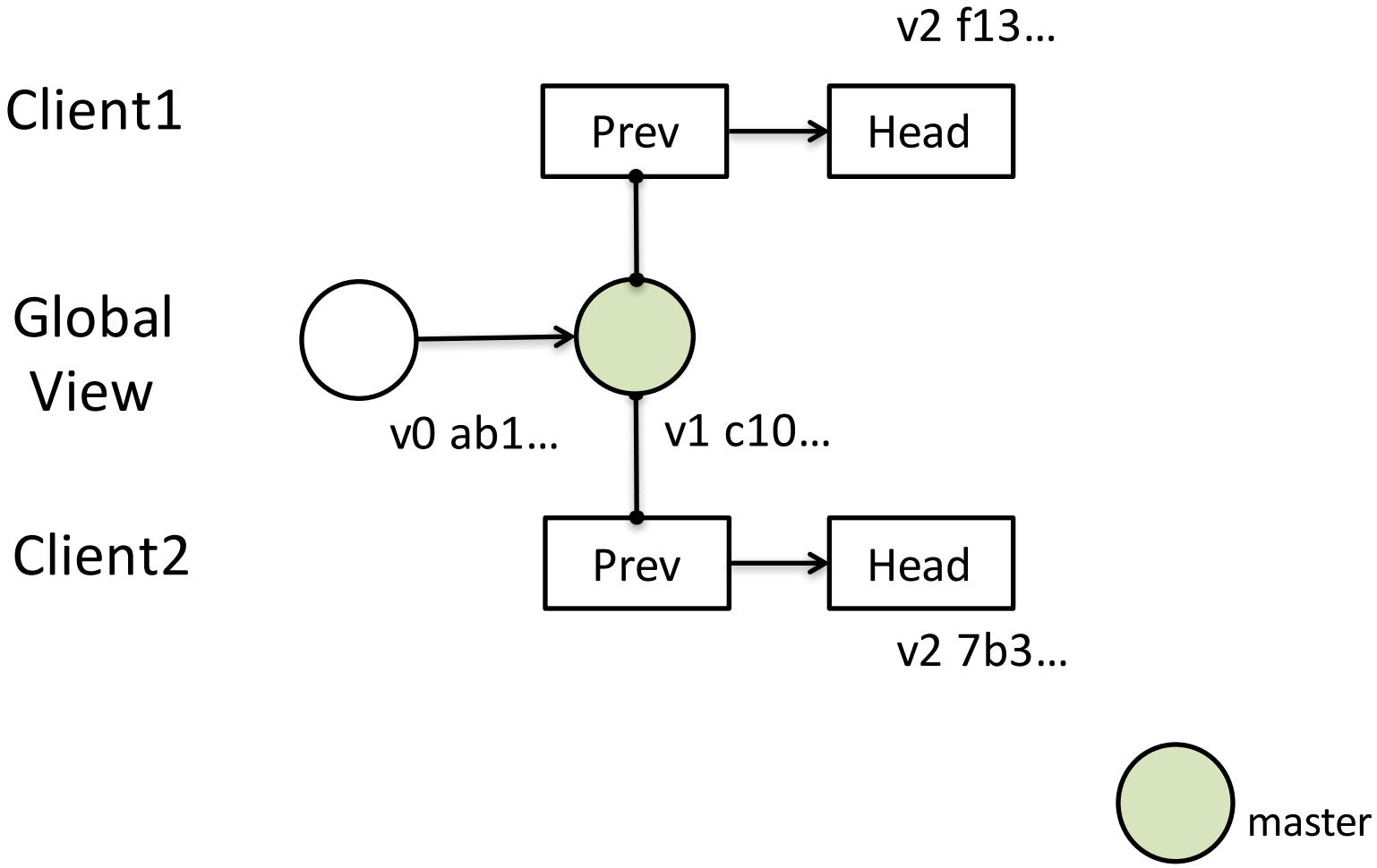

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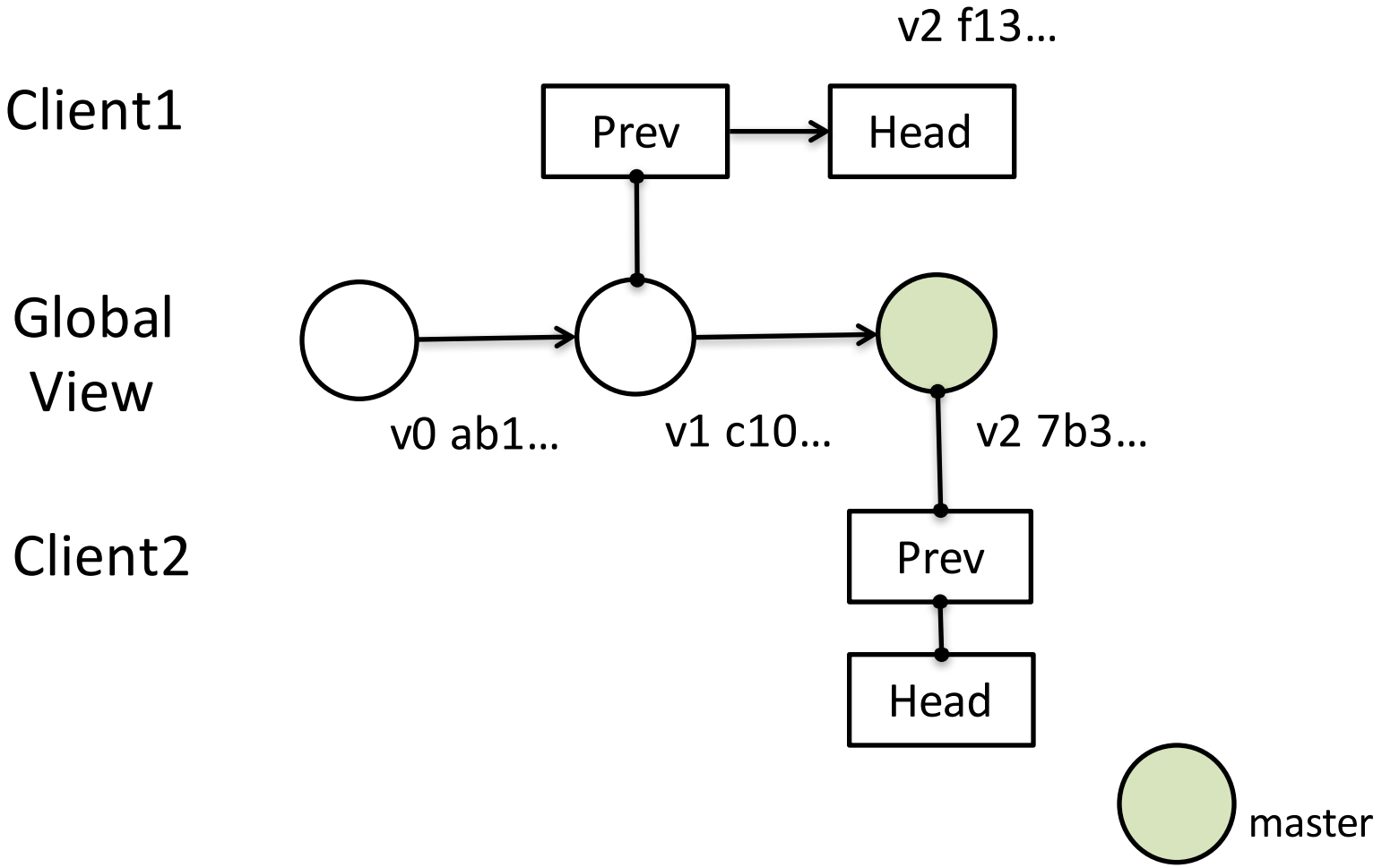

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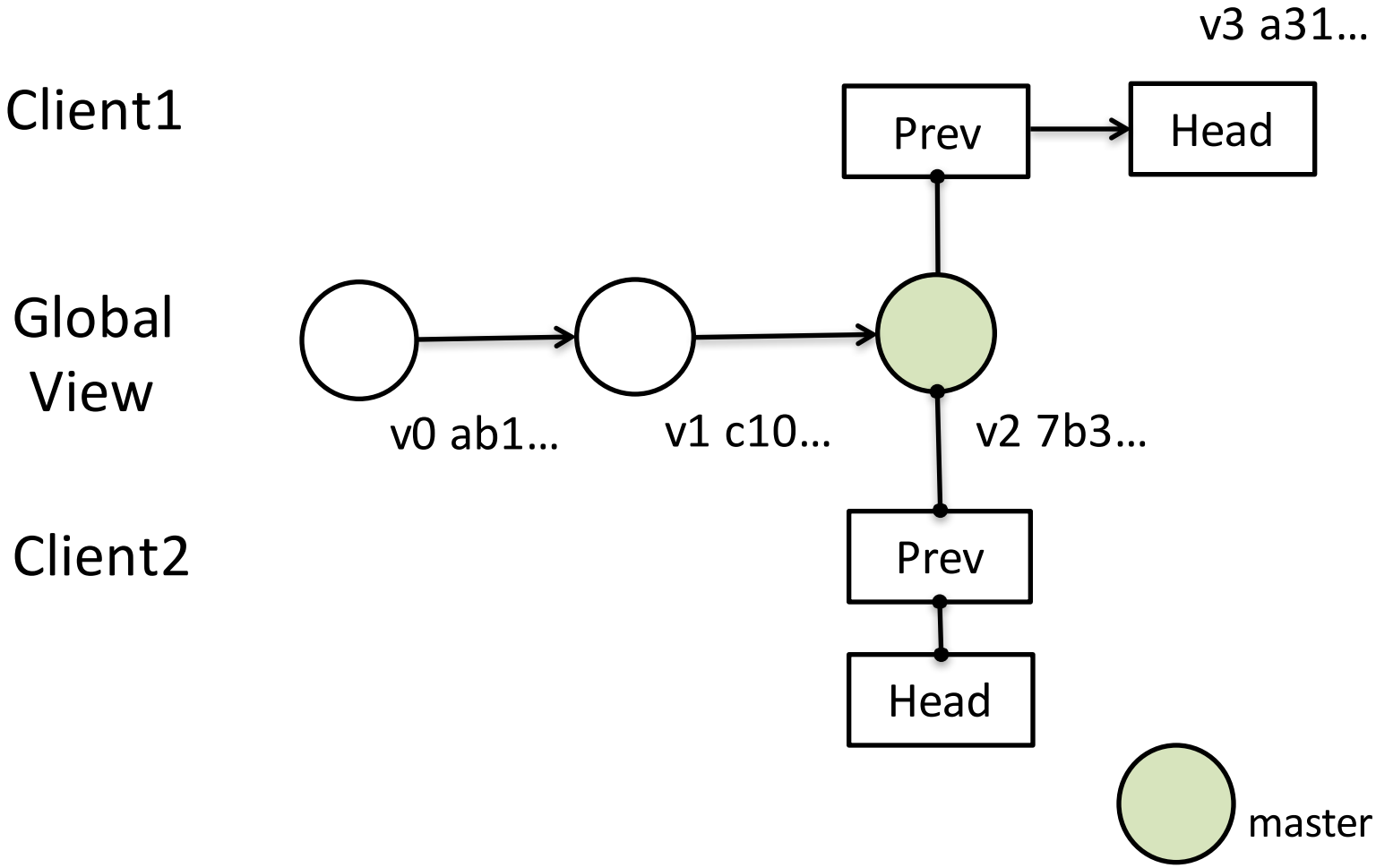
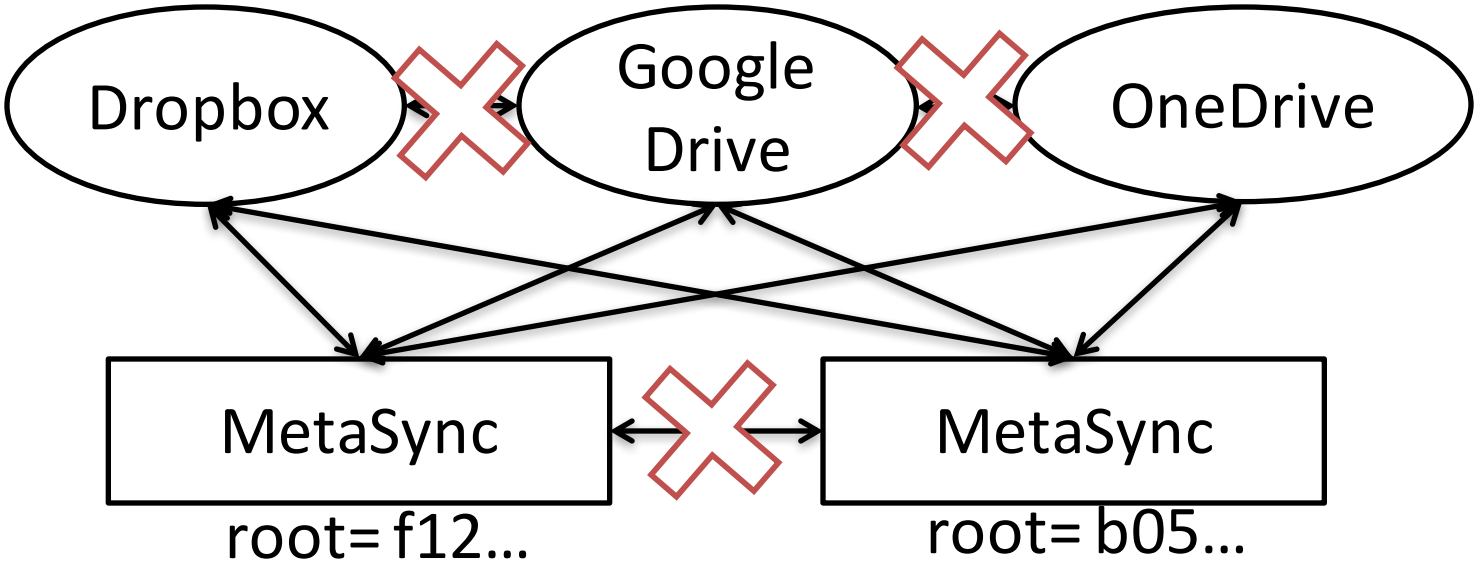


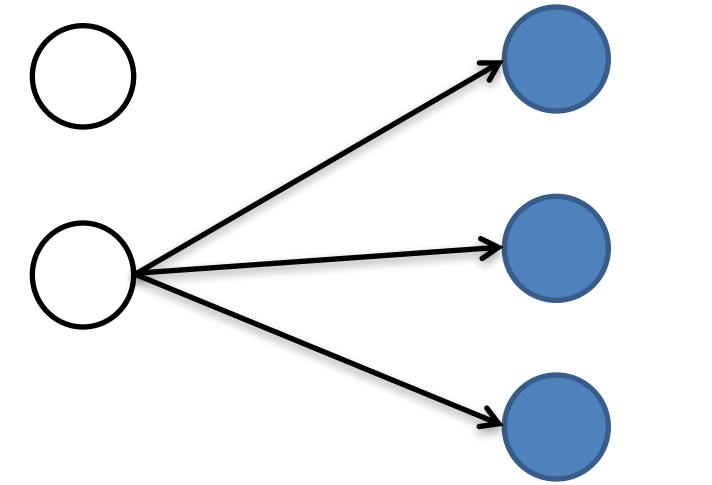
Consistent Update of Global View



- Need to handle concurrent updates, unavailable services based on existing APIs

Paxos

- Multi-round non-blocking consensus algorithm
  - Safe regardless of failures
  - Progress if majority is alive



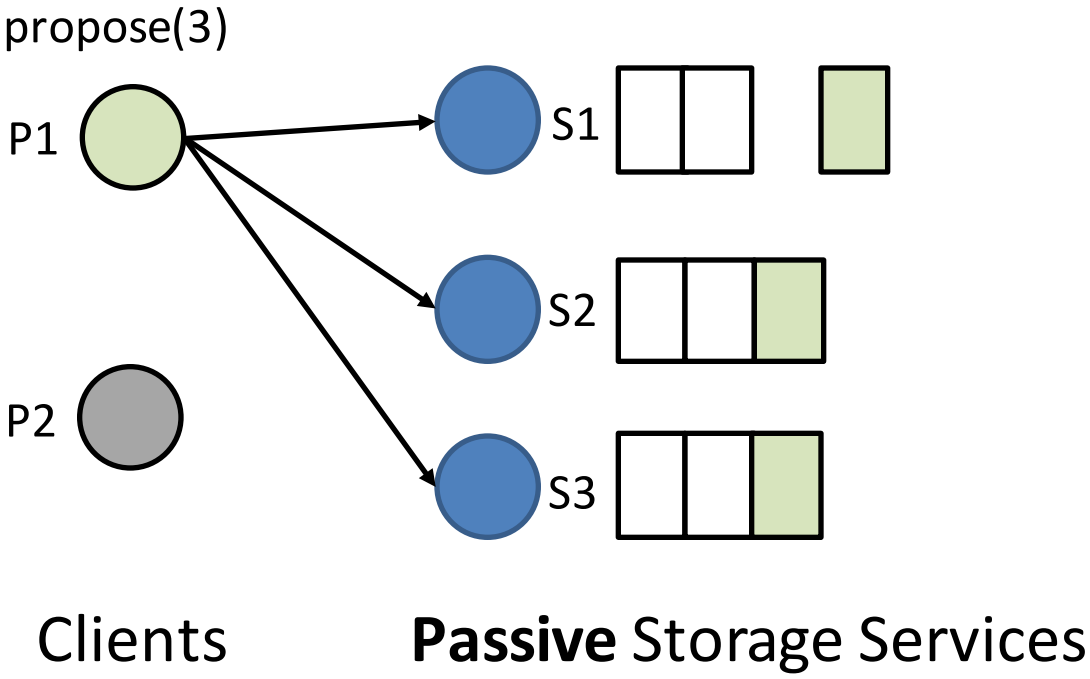
Metasync: Simulate Paxos

- Use an *append-only list* to log **Paxos messages**
  - Client sends normal Paxos messages
  - Upon arrival of message, service appends it into a list
  - Client can fetch a list of the ordered messages

- Each service provider has APIs to build append-only list
  - Google Drive, OneDrive, Box: Comments on a file
  - Dropbox: Revision list of a file
  - Baidu: Files in a directory

Metasync: Passive Paxos (pPaxos)

- Backend services work as passive acceptor
- Acceptor decisions are delegated to clients



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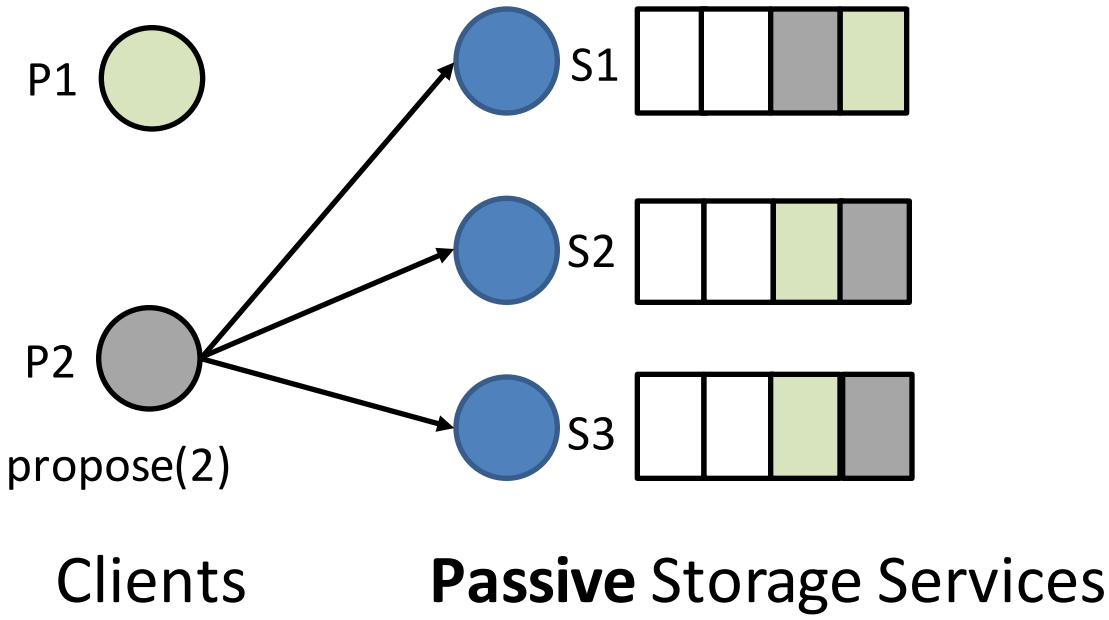

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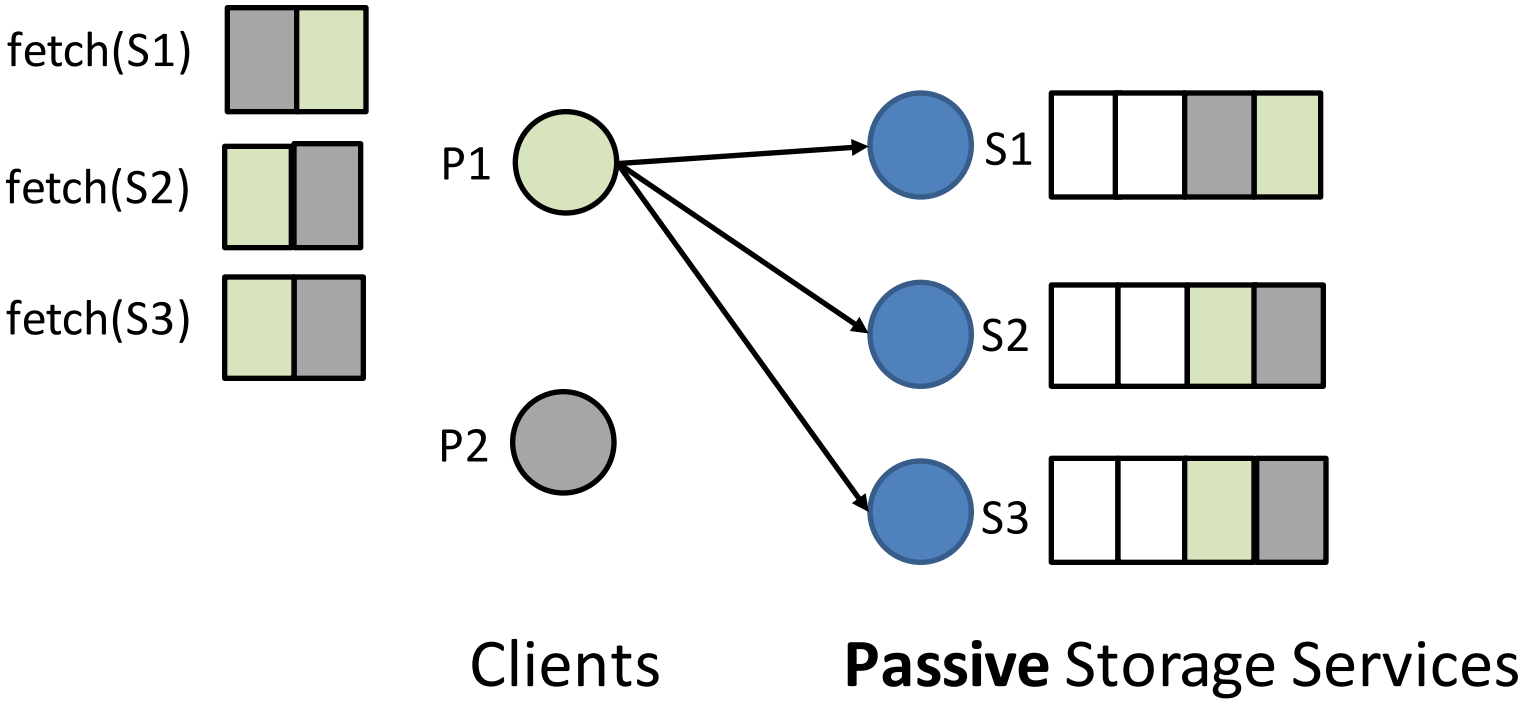

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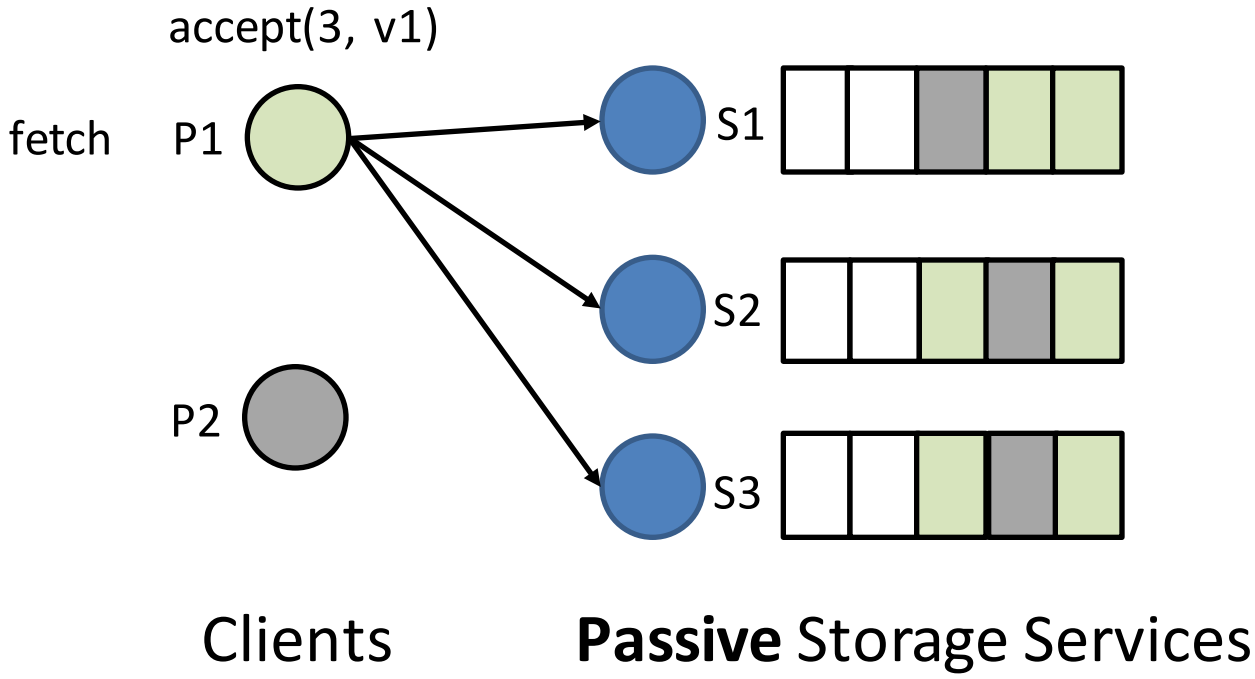
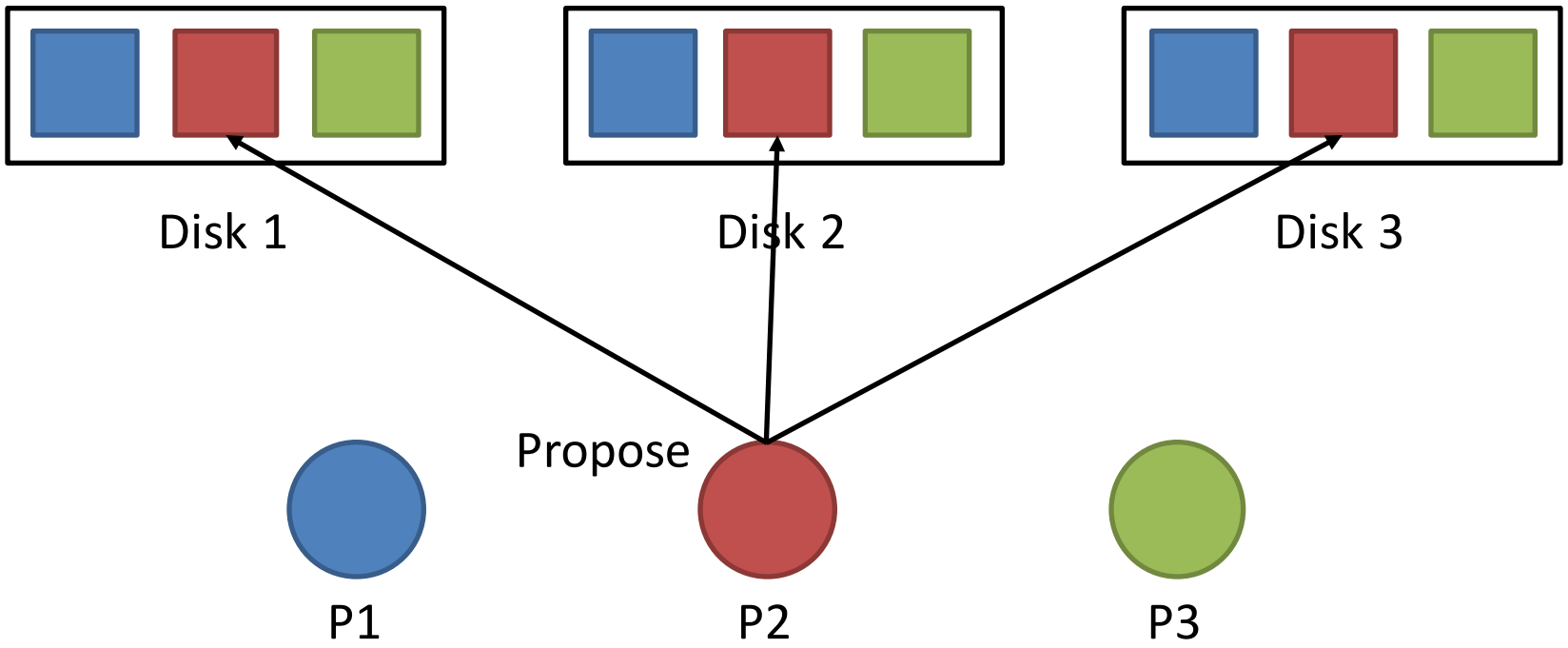


DiskPaxos



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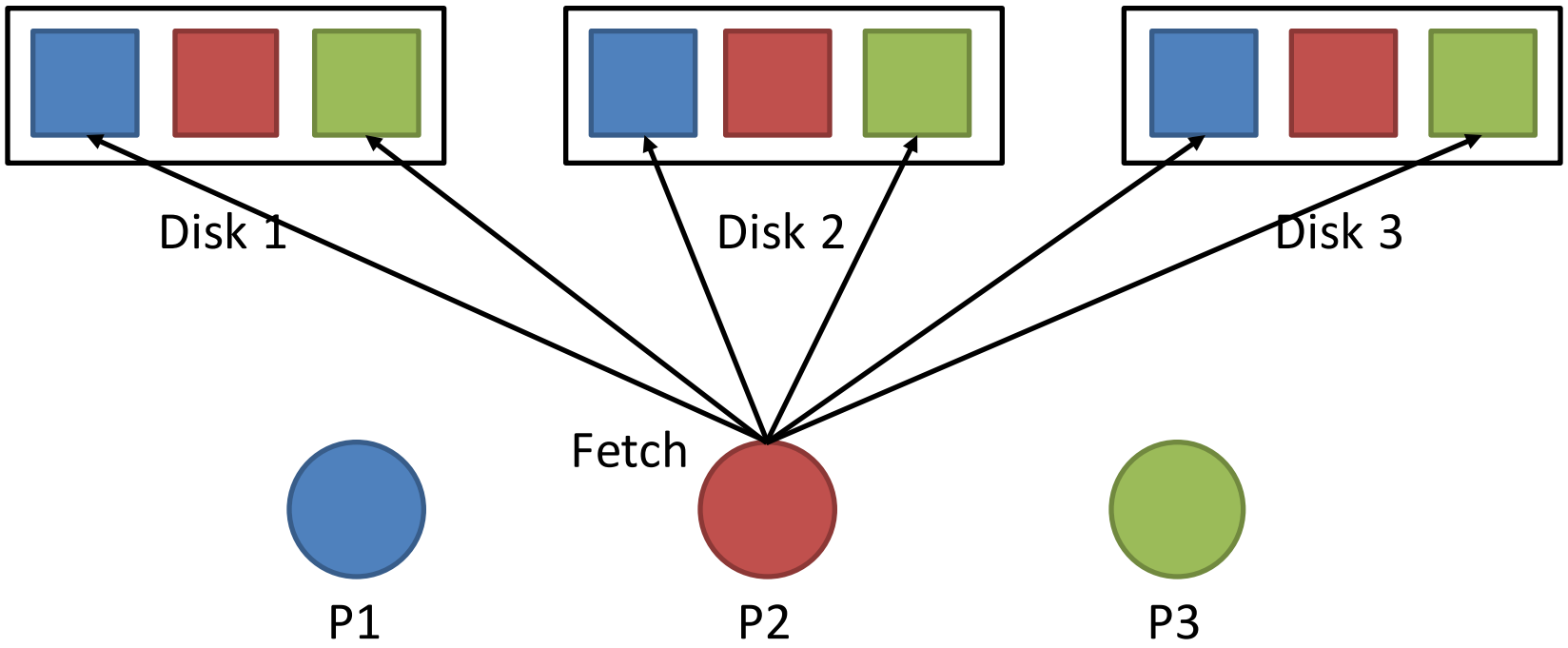
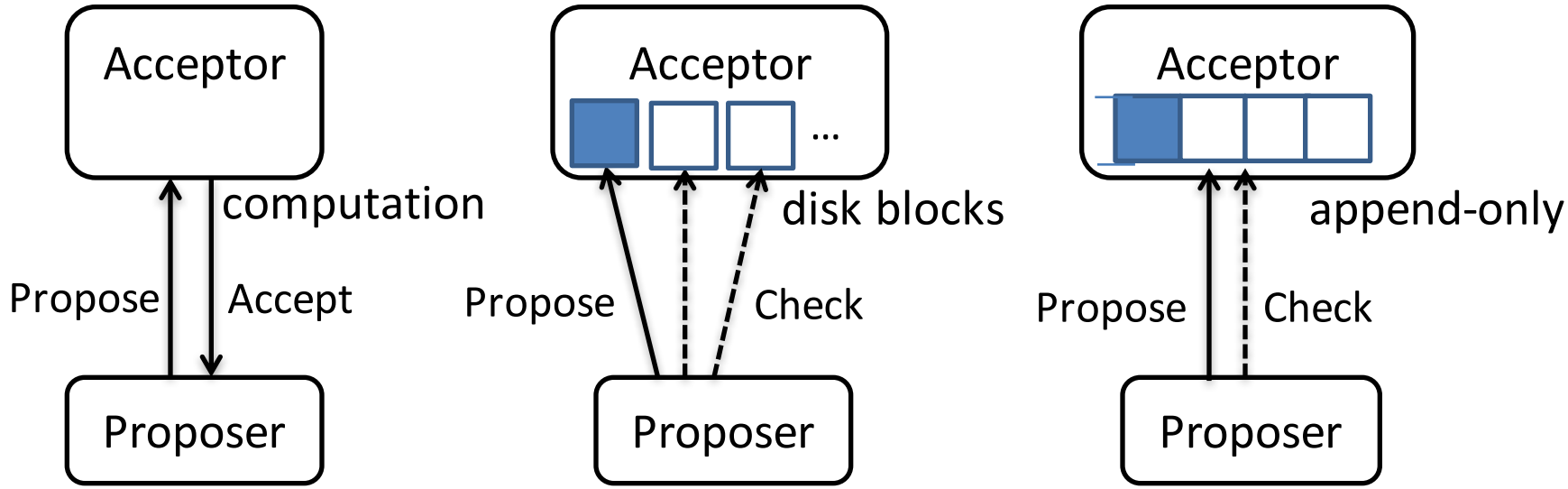


Paxos vs. Disk Paxos vs. pPaxos

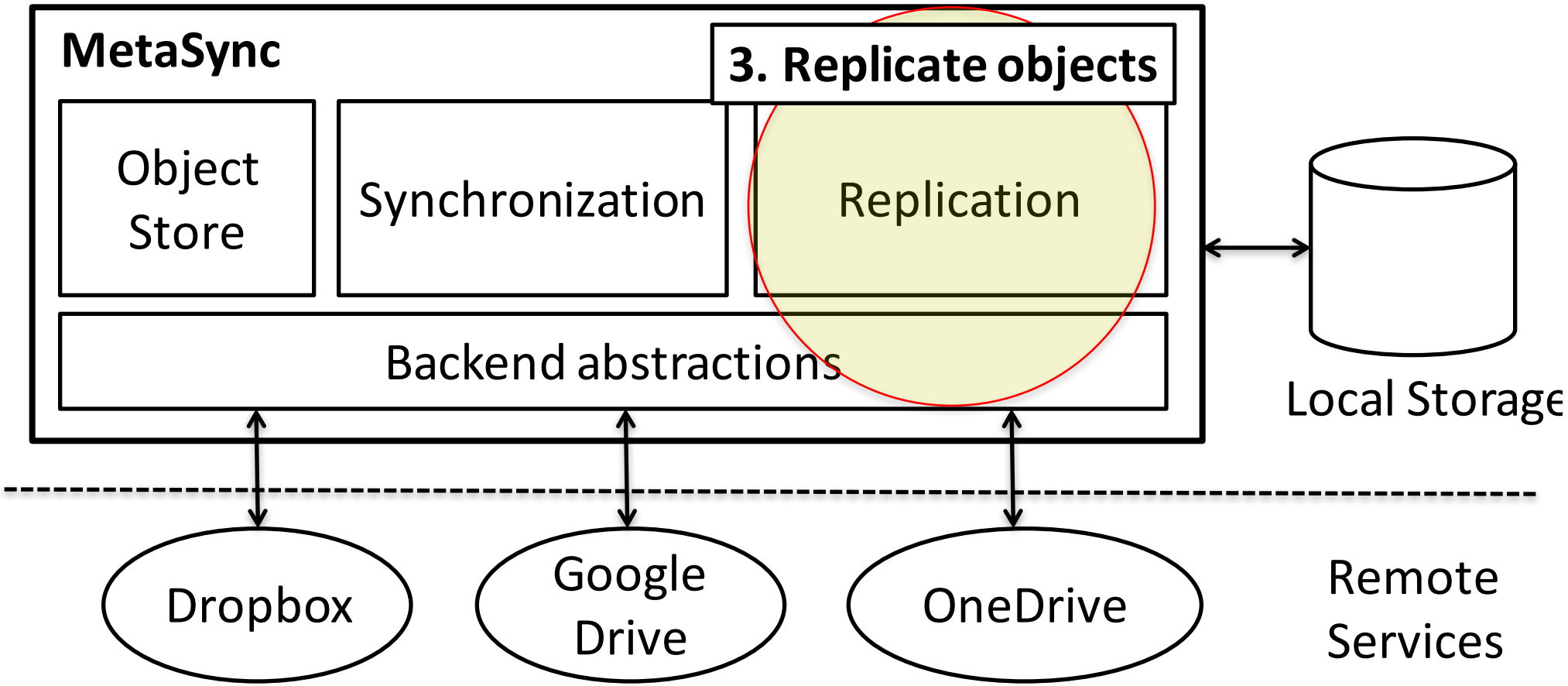
- Disk Paxos: maintains a block per client

  Gafni & Lamport '02



	Paxos	**Disk Paxos**	**pPaxos**
require	Requires acceptor API		
# msgs	O(acceptors)	O(clients x acceptors)	O(acceptors)

Overview of the Design



Stable Deterministic Mapping

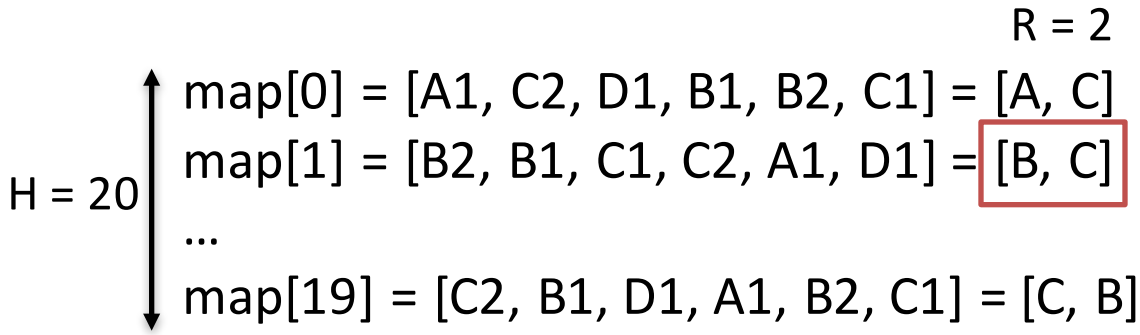
- MetaSync replicates objects R times across S storage providers (R<S)
- Requirements
  - Share minimal information among services/clients
  - Support variation in storage size
  - Minimize realignment upon configuration changes
- Deterministic mapping

$$map : H \rightarrow \{s : |s| = R, s \subset S\}$$

  - E.g., map(7a1…) = Dropbox, Google

Deterministic Mapping Example

- Service = {A(1), B(2), C(2), D(1)}
  Capacity
- N = {A1, B1, B2, C1, C2, D1} (normalized)
- Map(i) = Sorted(N, key= md5(i, serviceID, vID))



bc1… mod 20 = 1 => Replicate onto B and C

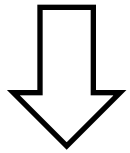
Deterministic Mapping Example

- When C is removed

R = 2

H = 20

map[0] = [A1, C2, D1, B1, B2, C1] = [A, C]
map[1] = [B2, B1, C1, C2, A1, D1] = [B, C]
…
map[19] = [C2, B1, D1, A1, B2, C1] = [C, B]



H = 20

map[0] = [A1, D1, B1, B2] = [A, D]
map[1] = [B2, B1, A1, D1] = [B, A]
…
map[19] = [B1, D1, A1, B2] = [B,D]

The sorted order is maintained
=> Minimize realignments

Implementation

- Prototyped with Python
  - ~8k lines of code
- Currently supports 5 backend services
  - Dropbox, Google Drive, OneDrive, Box.net, Baidu
- Two front-end clients
  - Command line client
  - Sync daemon

Evaluation

- How is the end-to-end performance?
- What's the performance characteristics of pPaxos?
- How quickly does MetaSync reconfigure mappings?

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End-to-End Performance

Synchronize the target between two computers

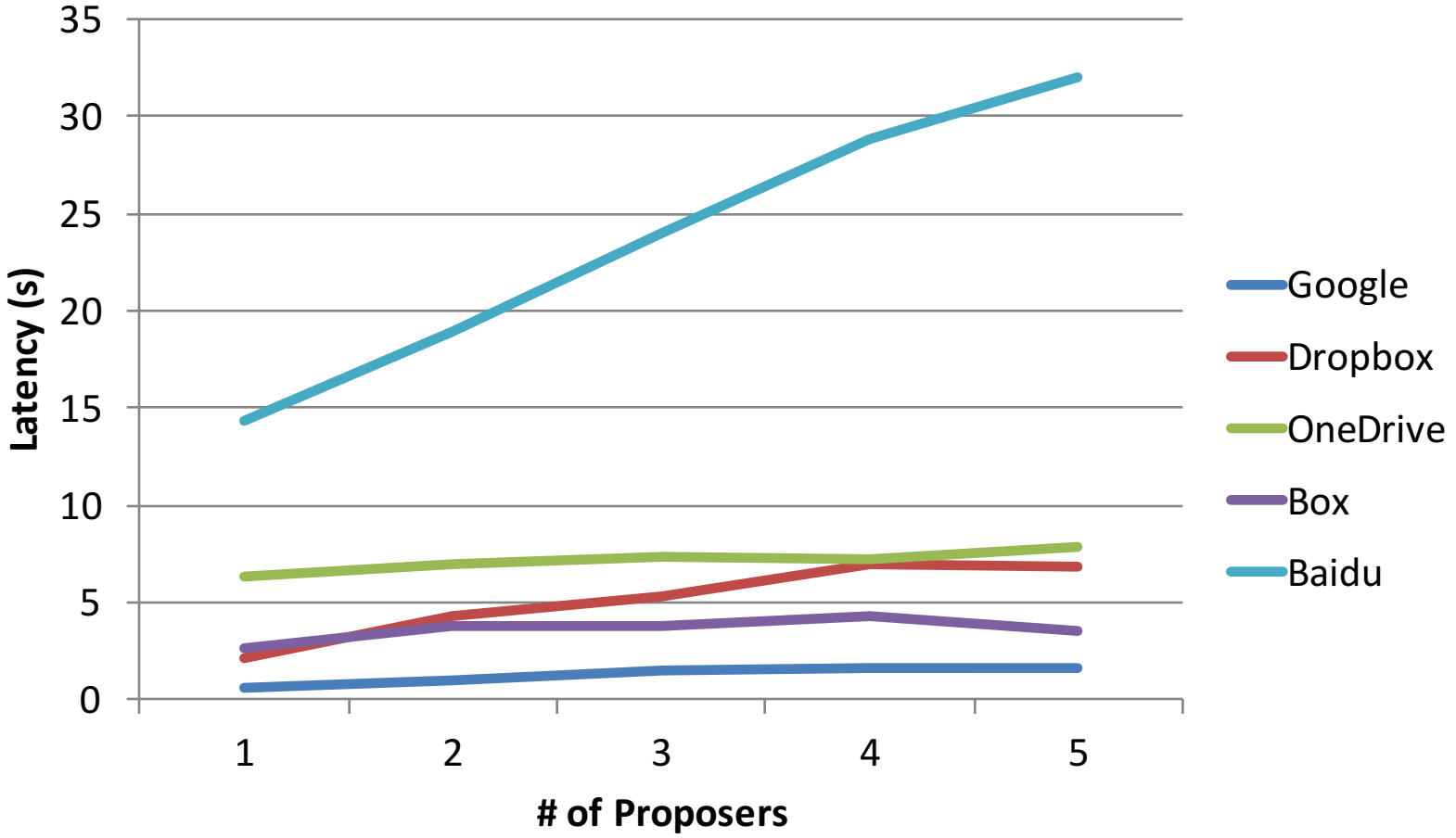
	Dropbox	Google	MetaSync
Linux Kernel 920 directories 15k files, 166MB	2h 45m	> 3hrs	12m 18s
Pictures 50 files, 193MB	415s	143s	112s

(S = 4, R = 2)

Performance gains are from:

- Parallel upload/download with multiple providers
- Combined small files into a blob

Latency of pPaxos



Latency is not degraded with increasing concurrent proposers or adding slow backend storage service

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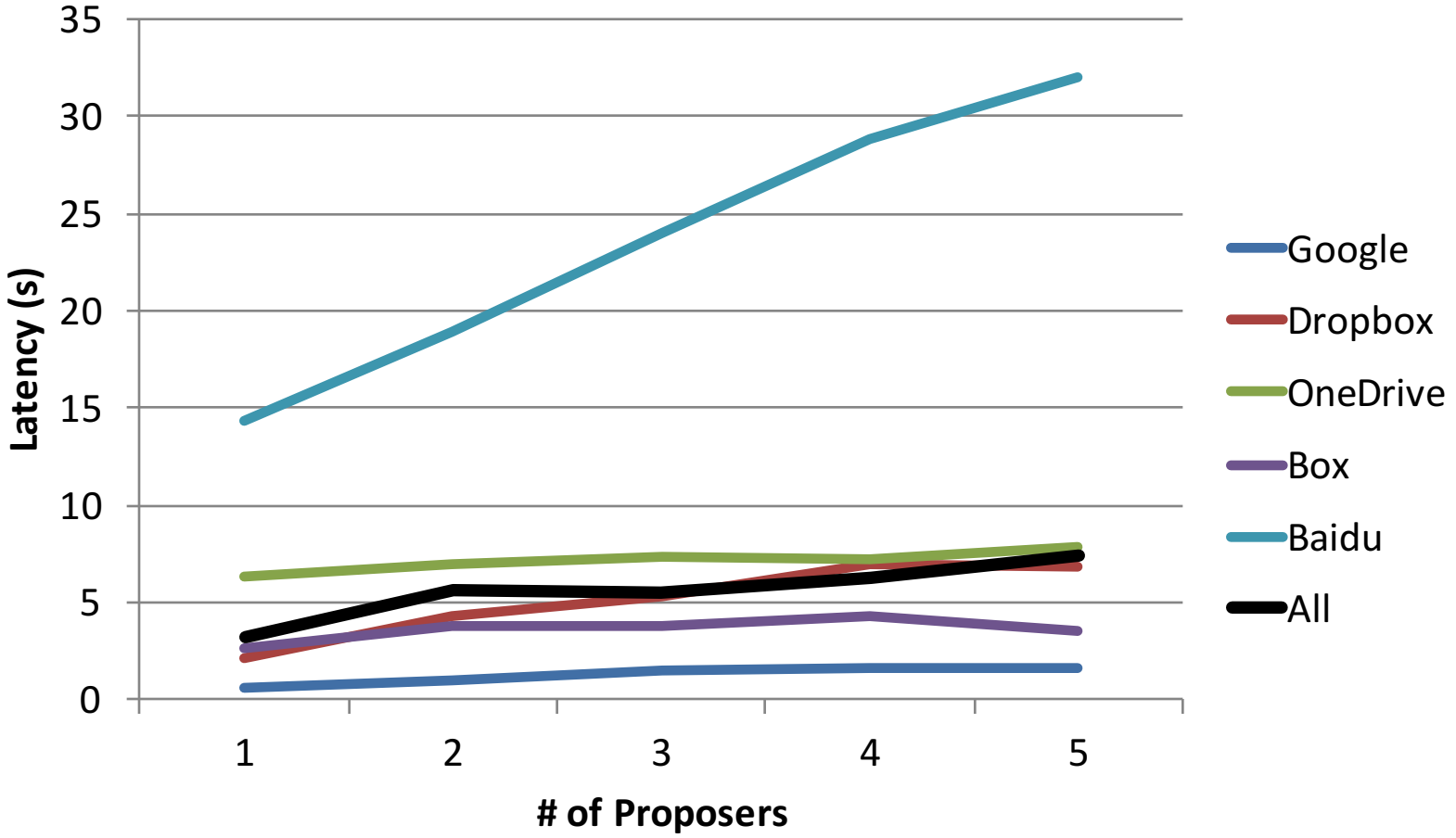

Latency is not degraded with increasing concurrent proposers or adding slow backend storage service

Conclusion

- MetaSync provides a secure, reliable, and performant files sync service on top of popular cloud providers
  - To achieve a consistent update, we devise **a new client-based Paxos**
  - To minimize redistribution, we present **a stable deterministic mapping**
- Source code is available:
  - http://uwnetworkslab.github.io/metasync/