MetaSync

File Synchronization Across Multiple Untrusted Storage Services

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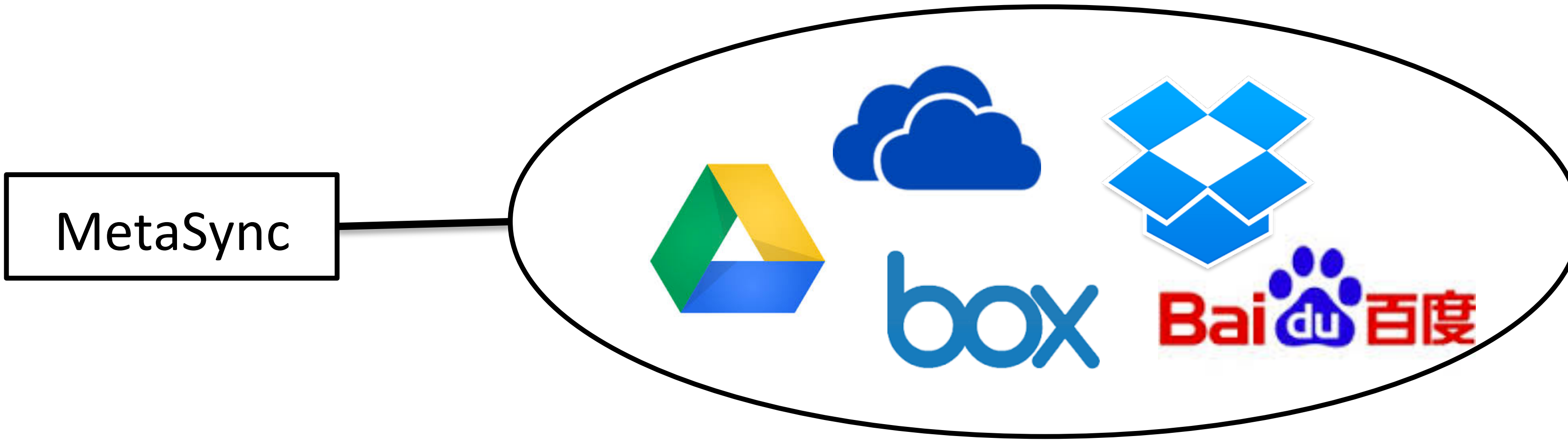
▲ Dropbox confirms that a bug within Selective Sync may have caused data loss (githubusercontent.com)

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 <u>better</u> 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*

Design Choices

- How to manage files?
  - Content-based addressing & hash tree
- How to update consistently with unmodified APIs?
  - Client-based Paxos (pPaxos)
- How to spread files?
  - Stable deterministic mapping
- How to protect files?
  - Encryption from clients
- How to make it extensible?
  - Common abstractions

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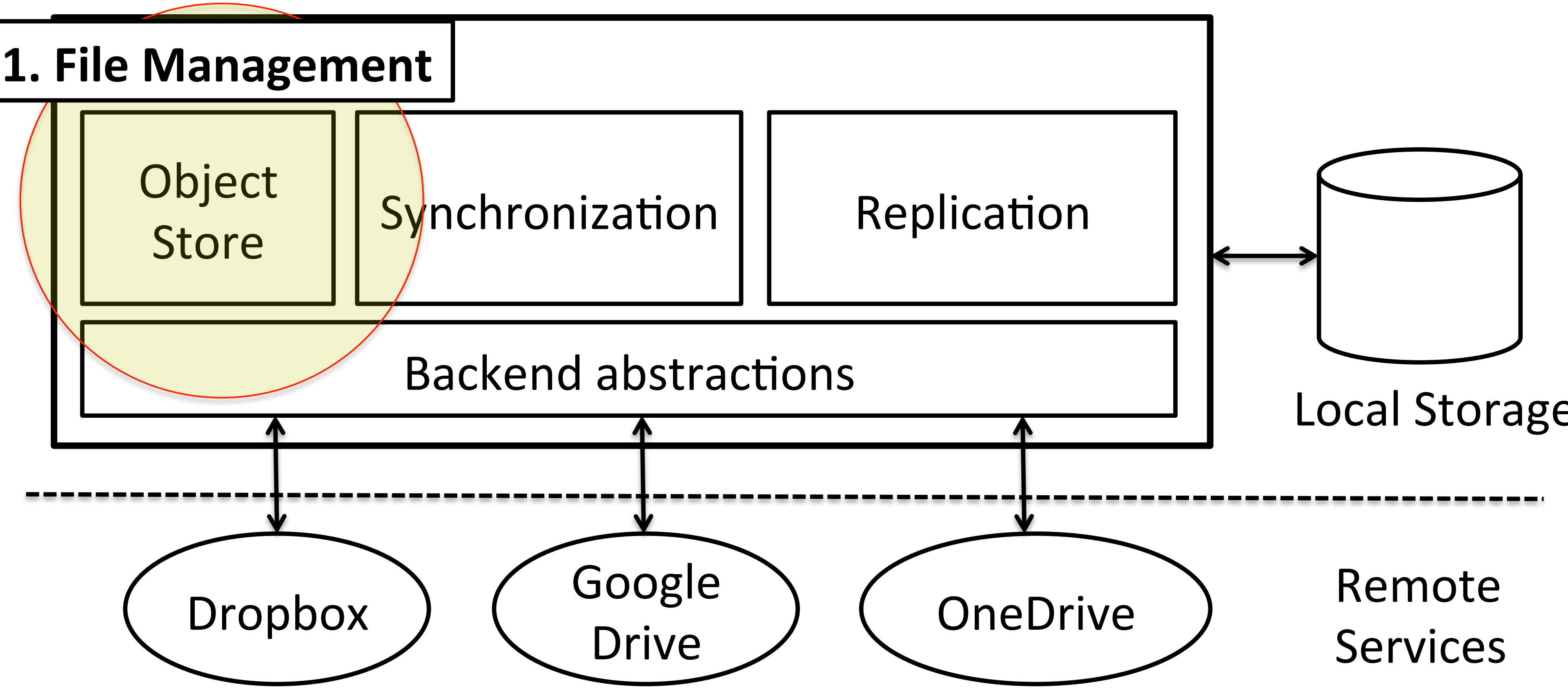
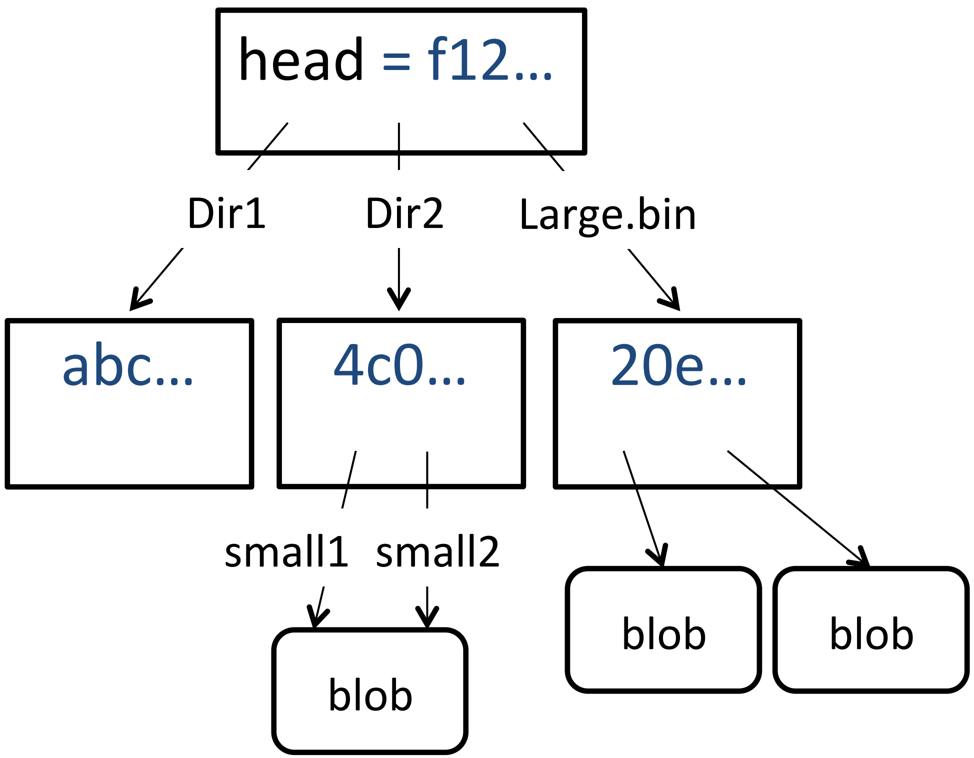
Overview of the Design



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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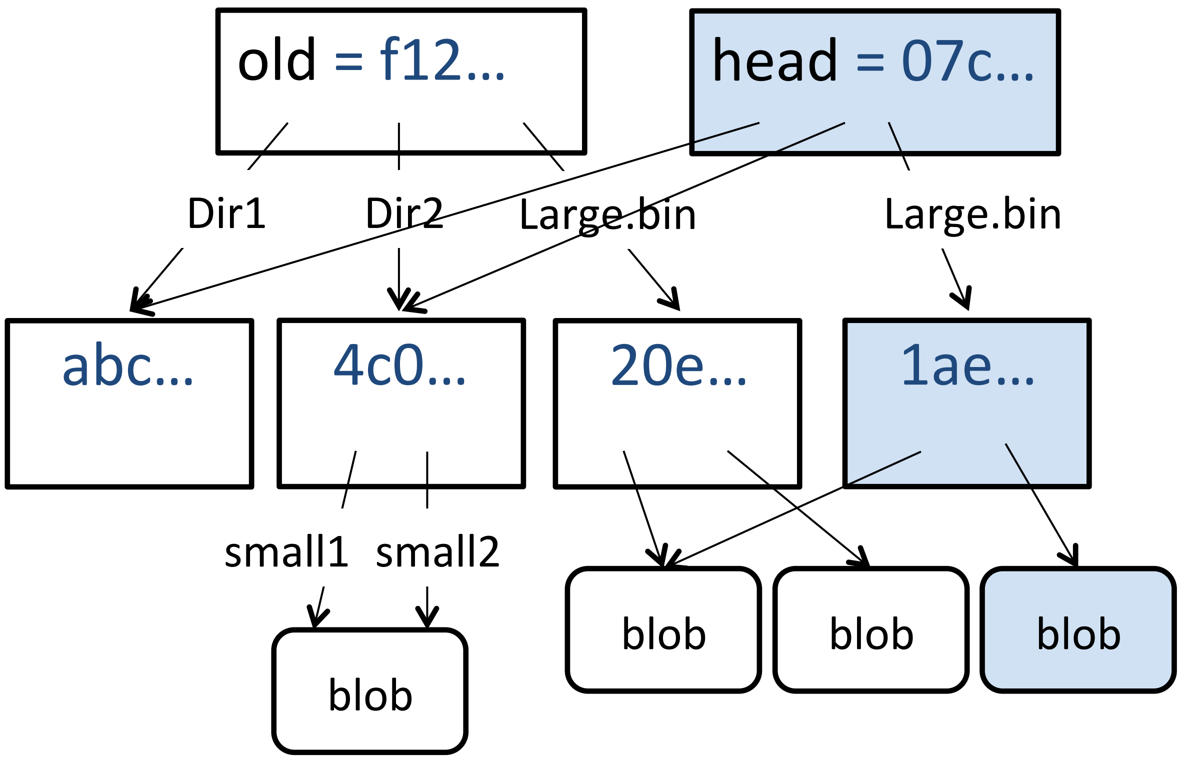

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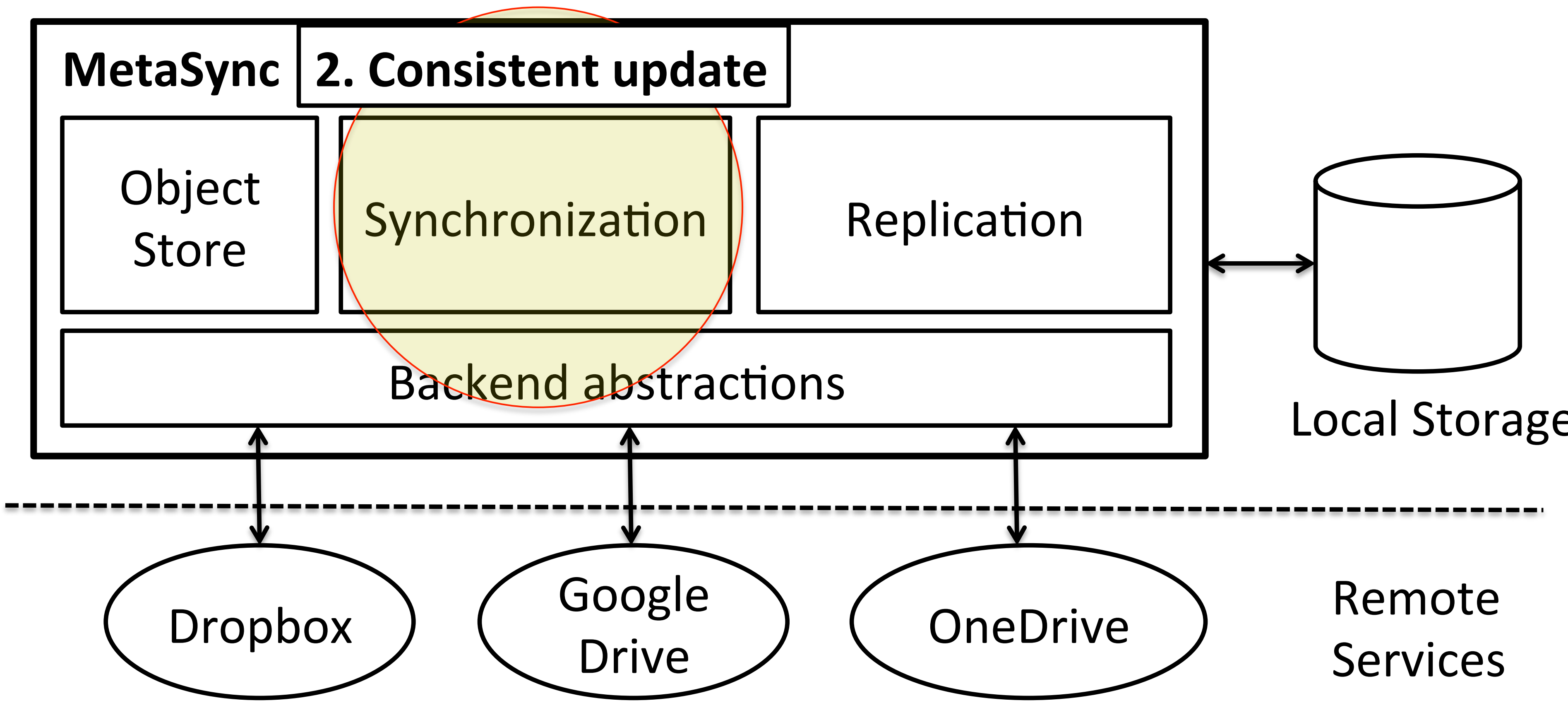
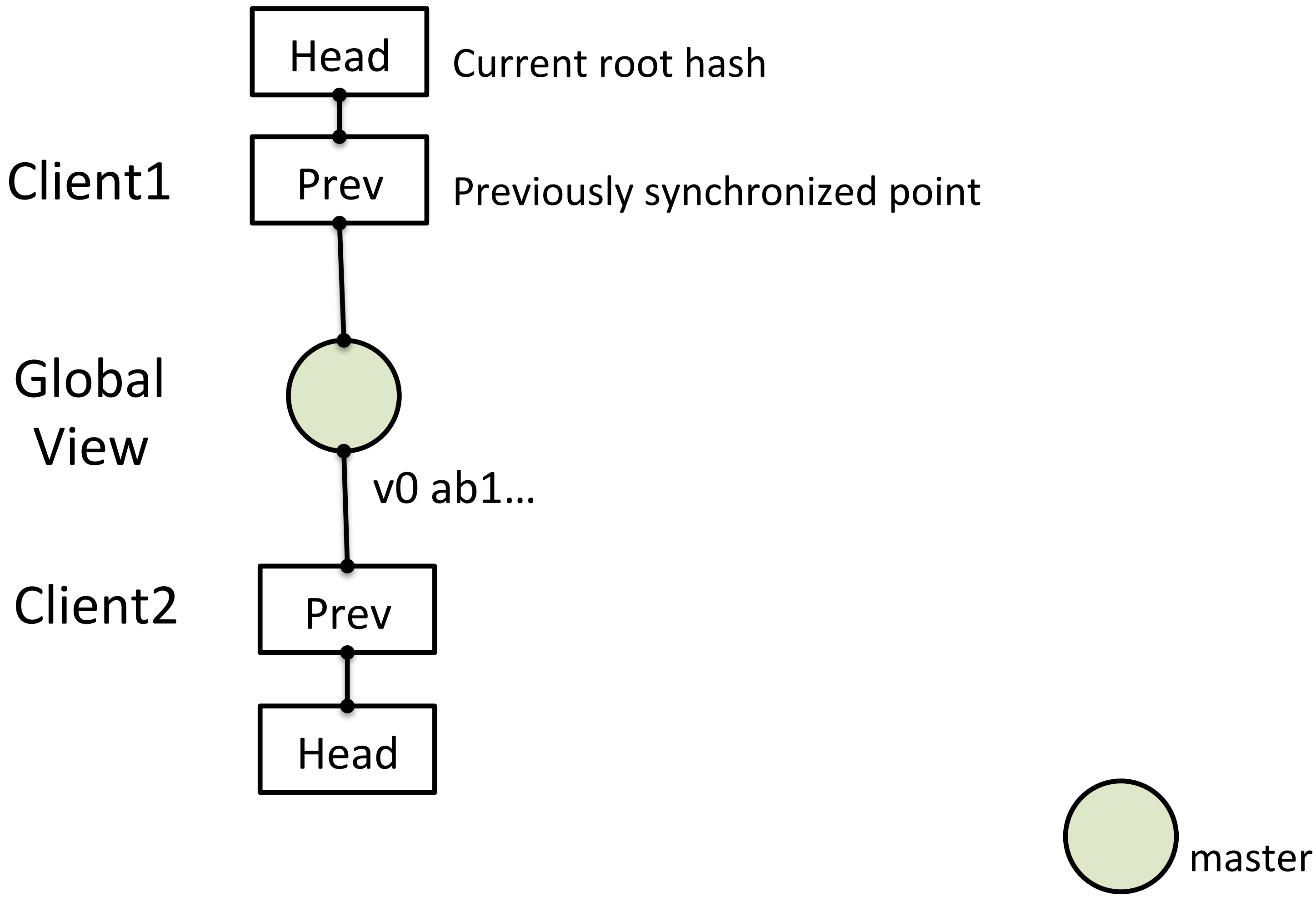


Updating Global View



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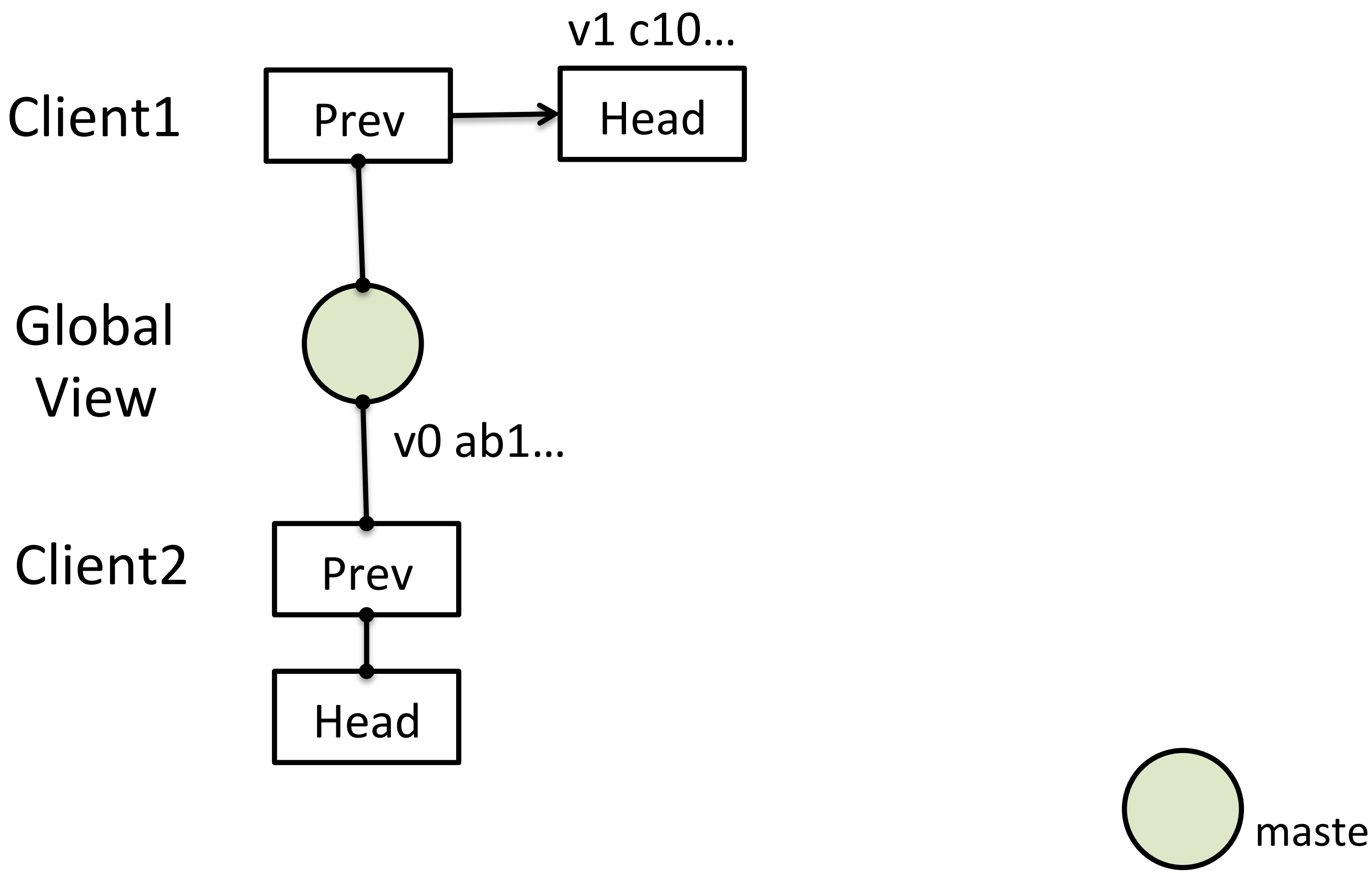

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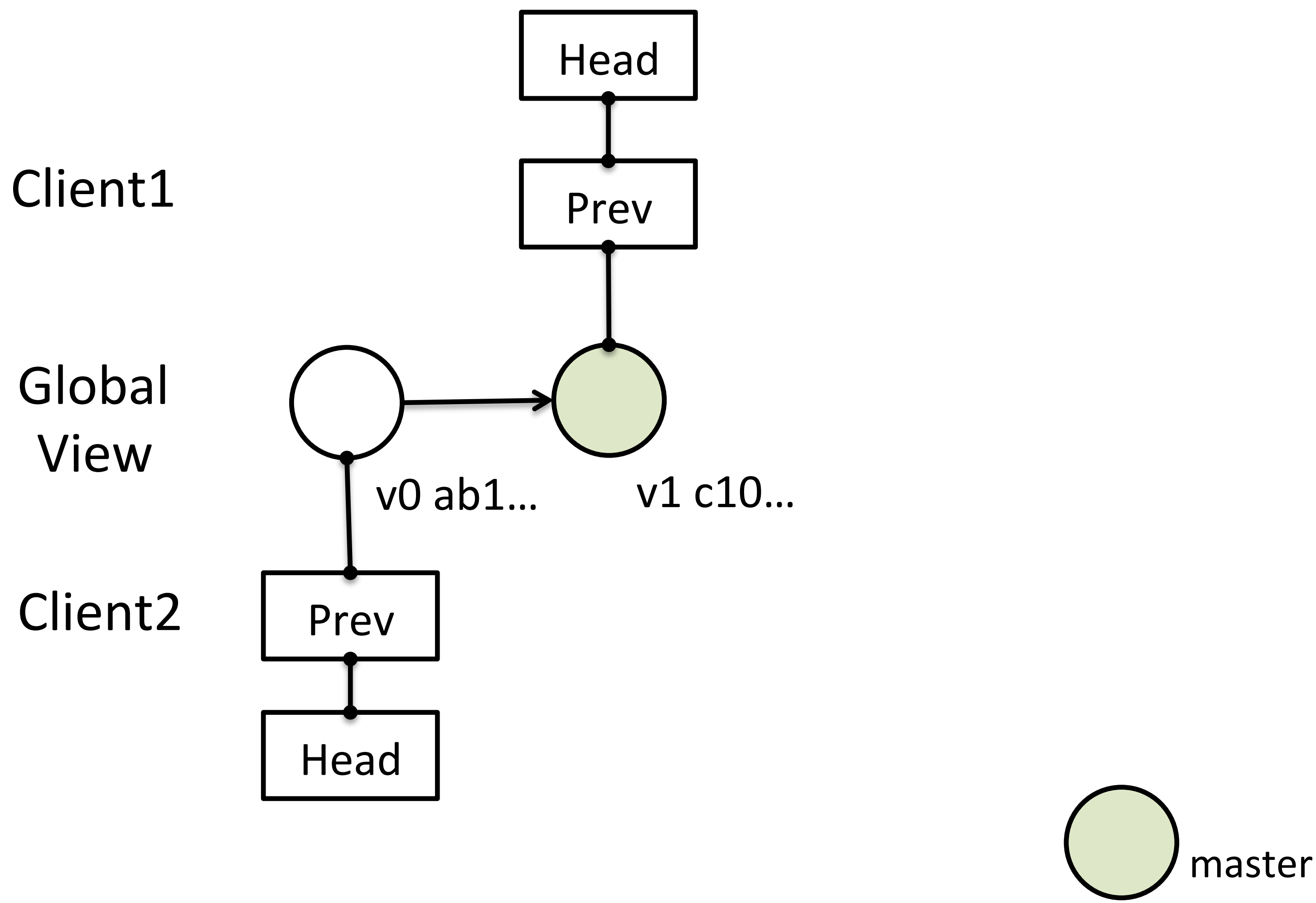

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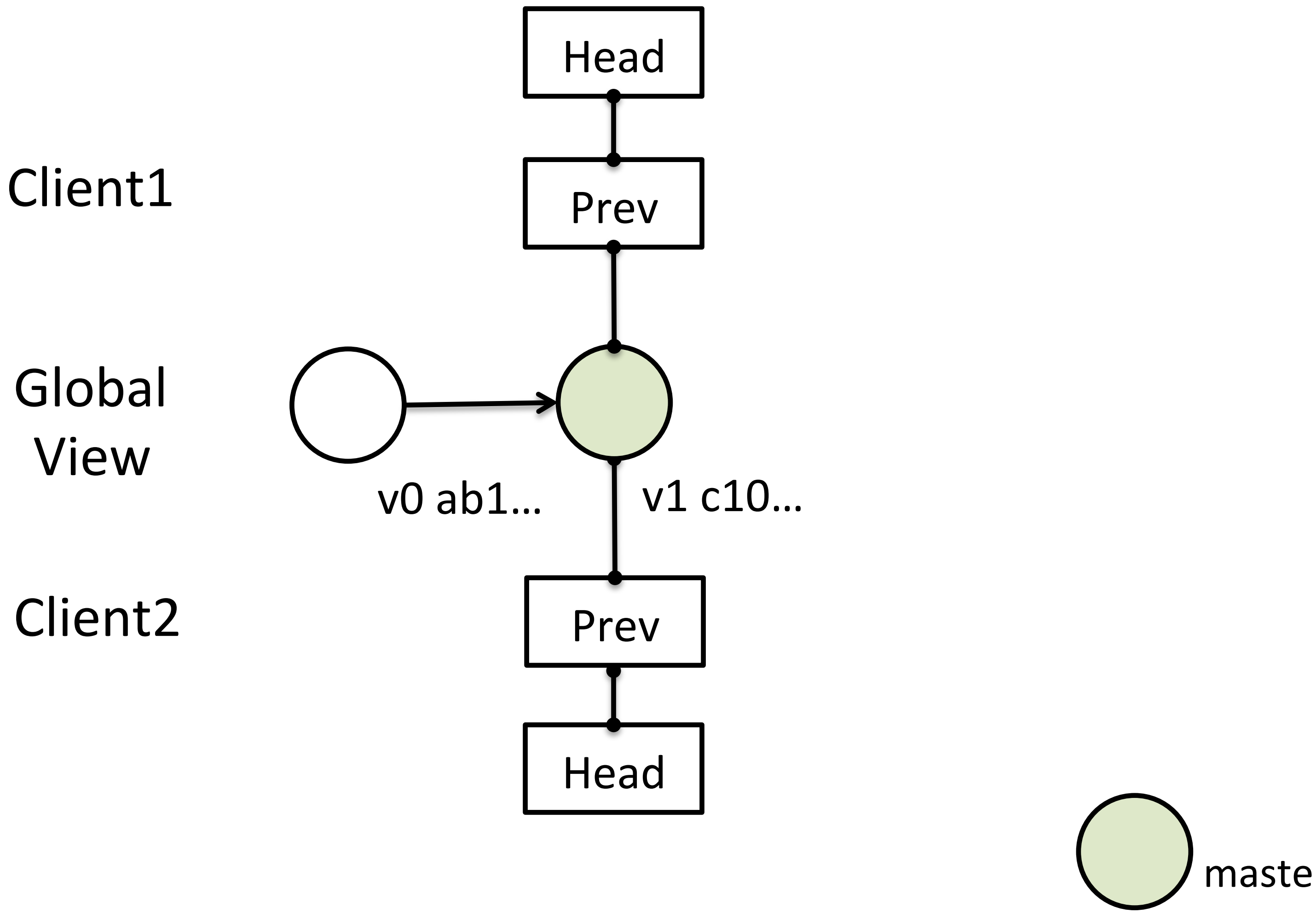

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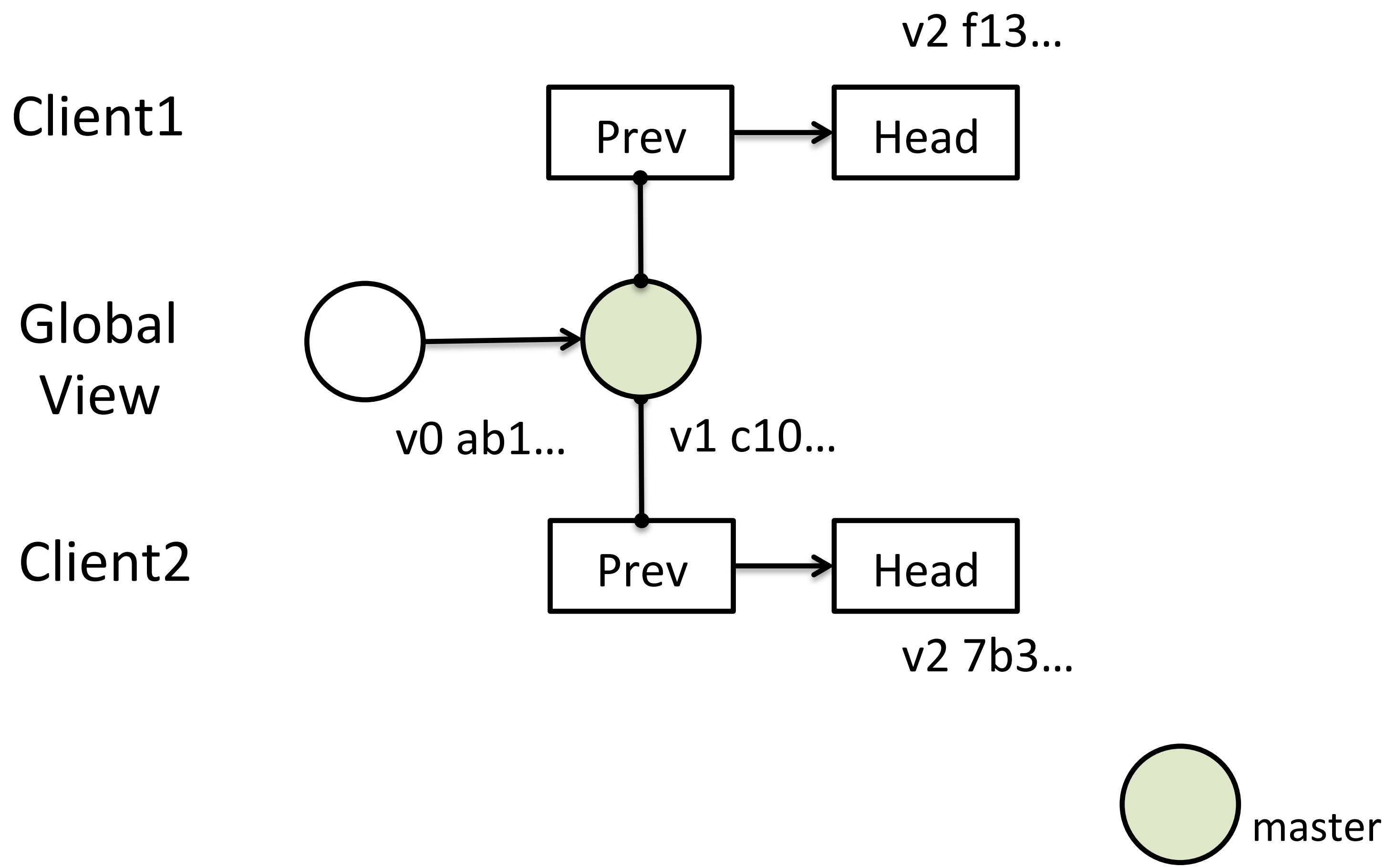

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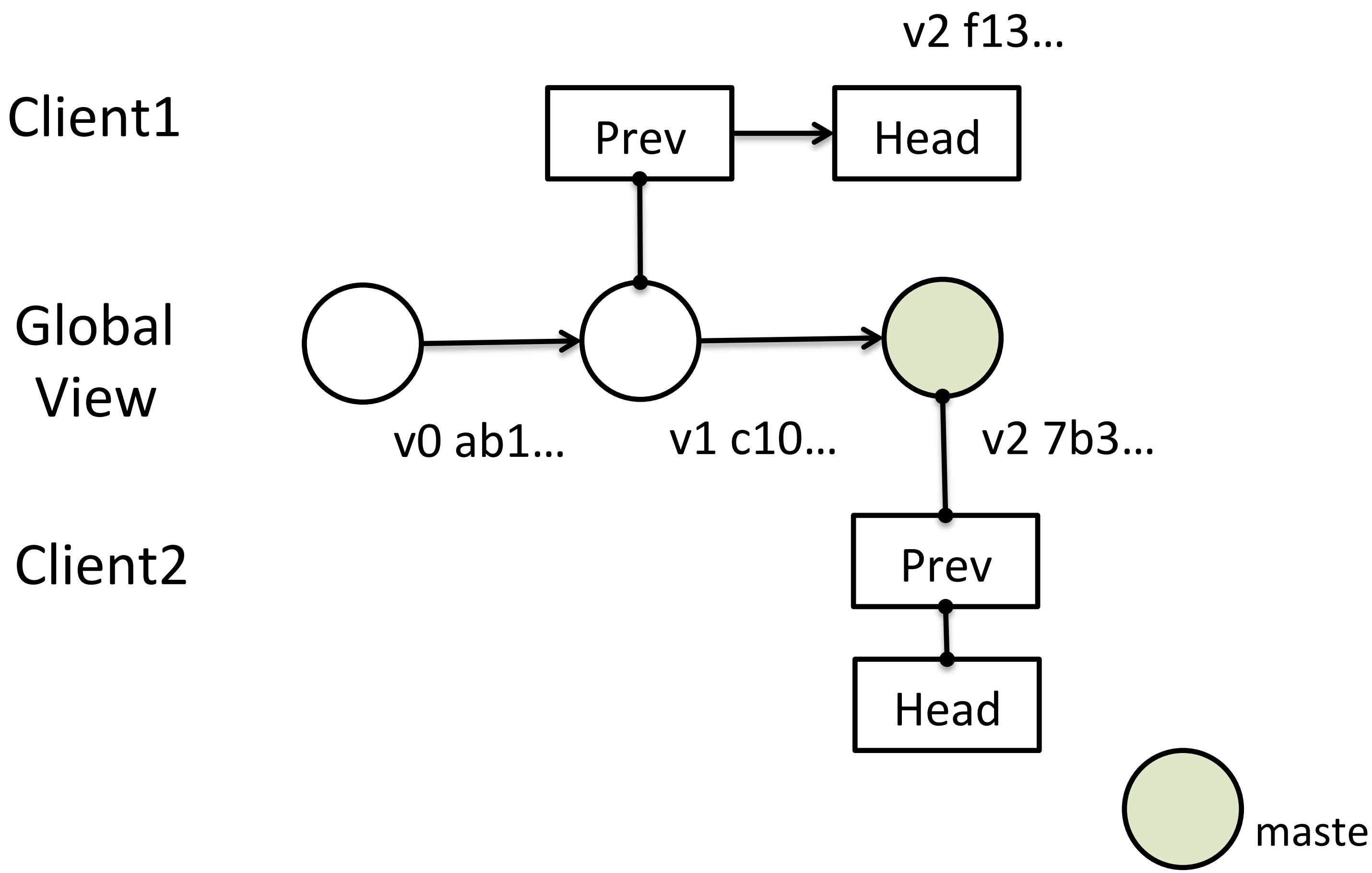

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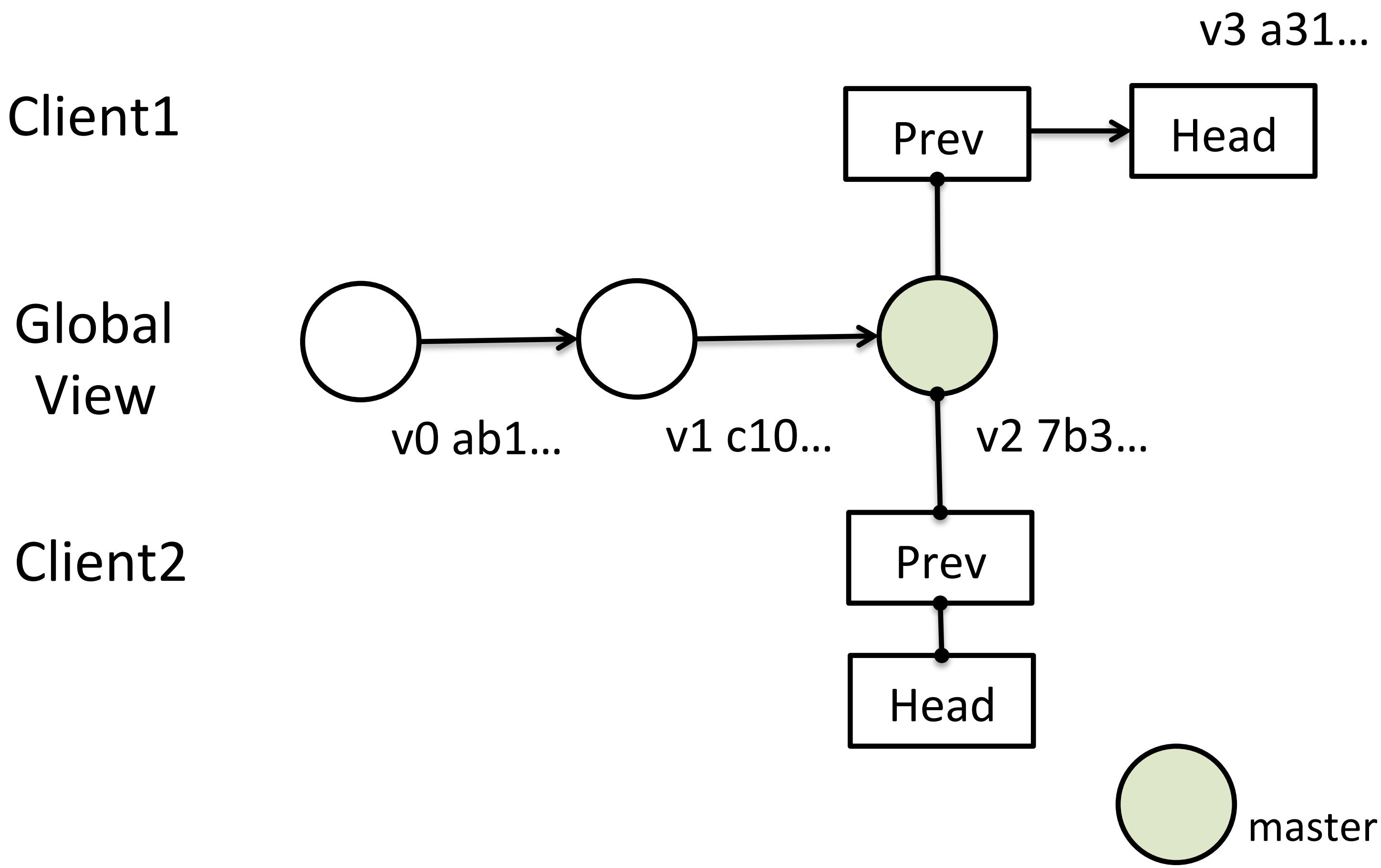
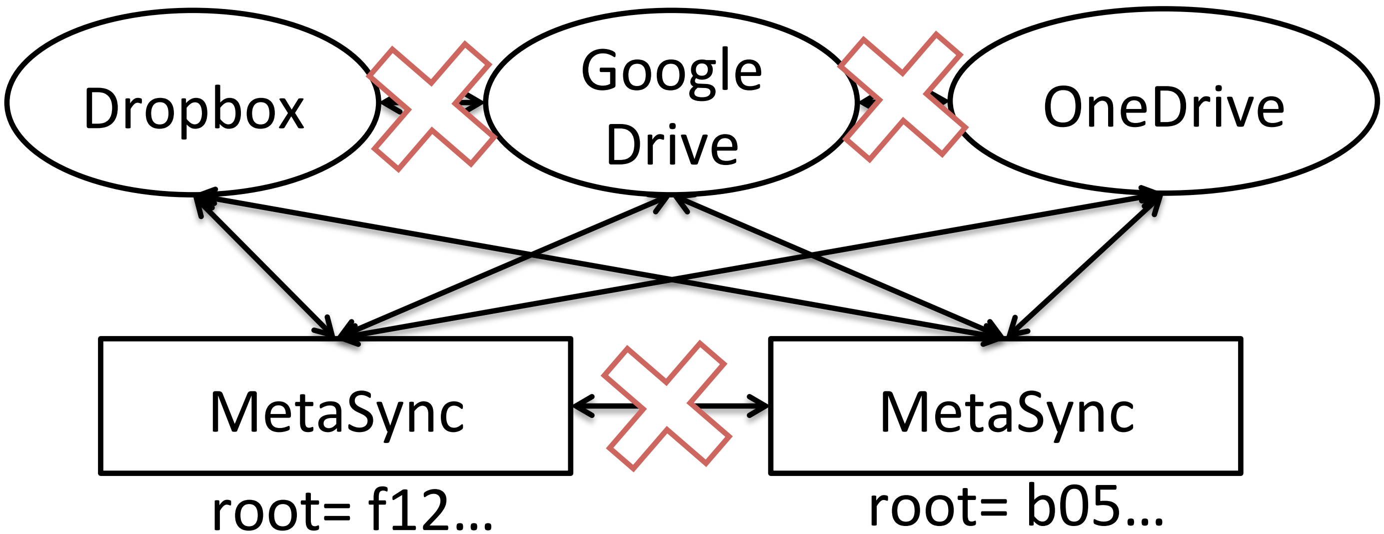


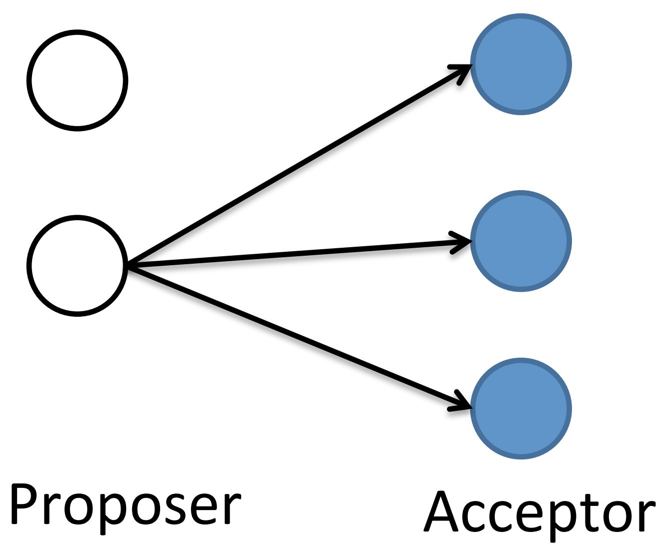
Consistent Update of Global View



- 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



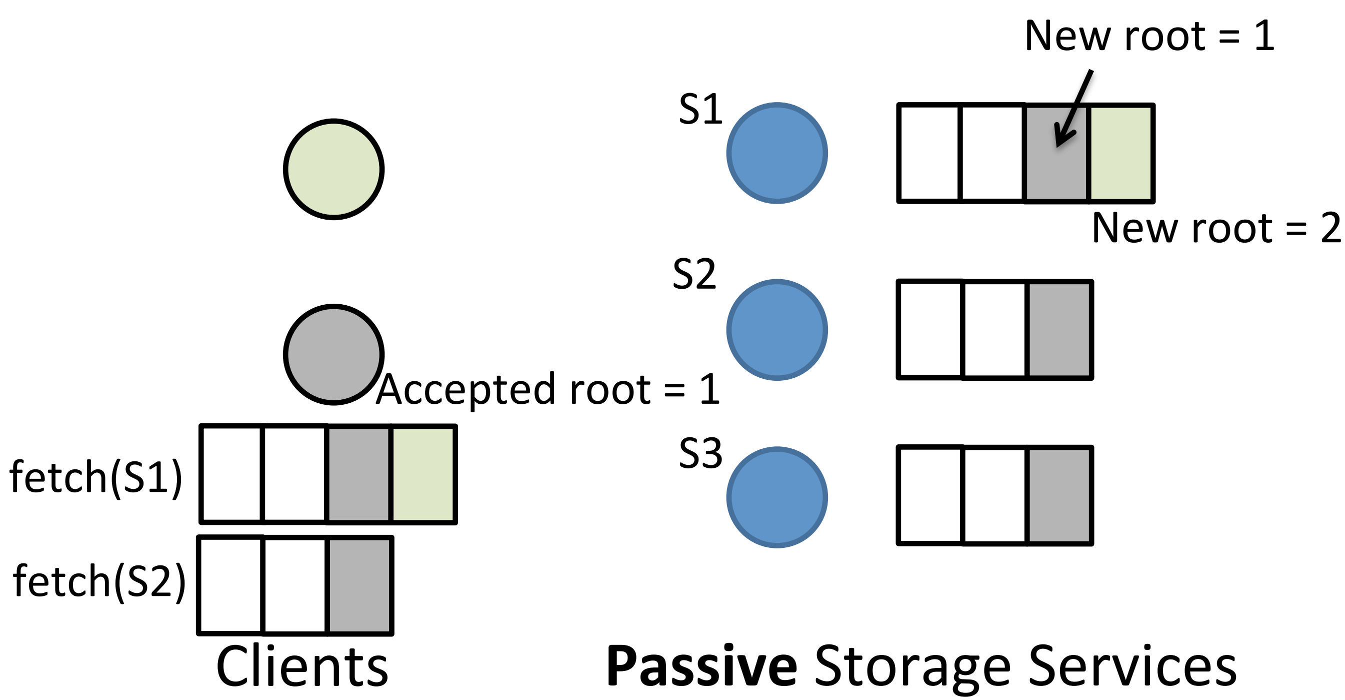
Metasync: Simulate Paxos

- 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)

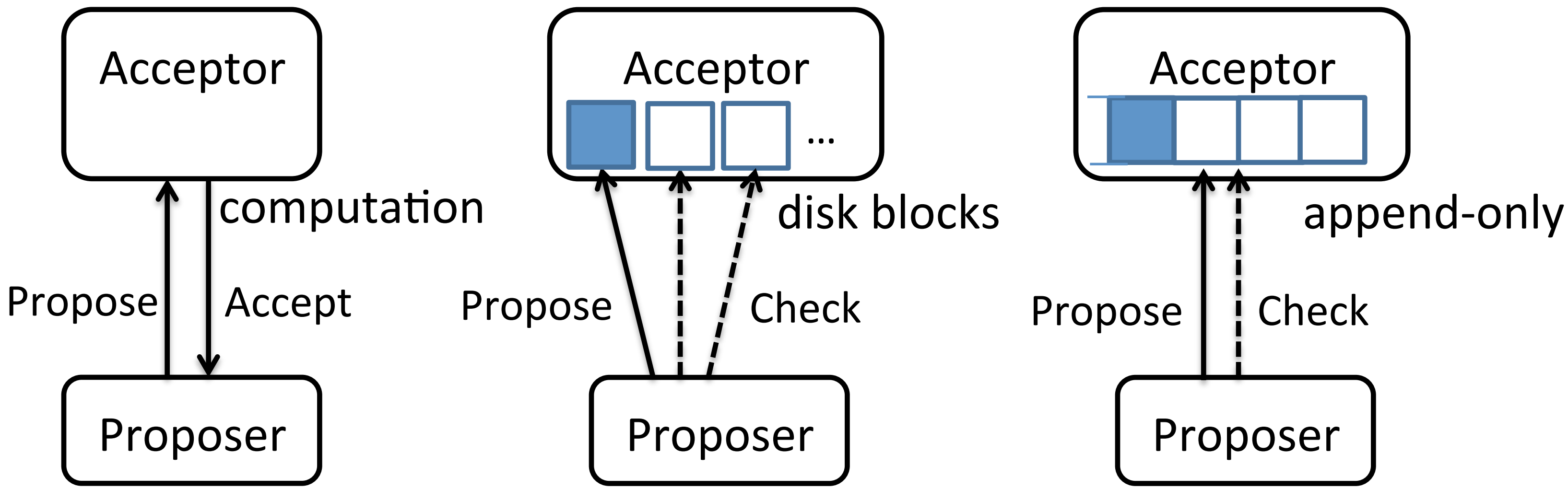
- Backend services work as passive acceptor
- Acceptor decisions are delegated to clients



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)

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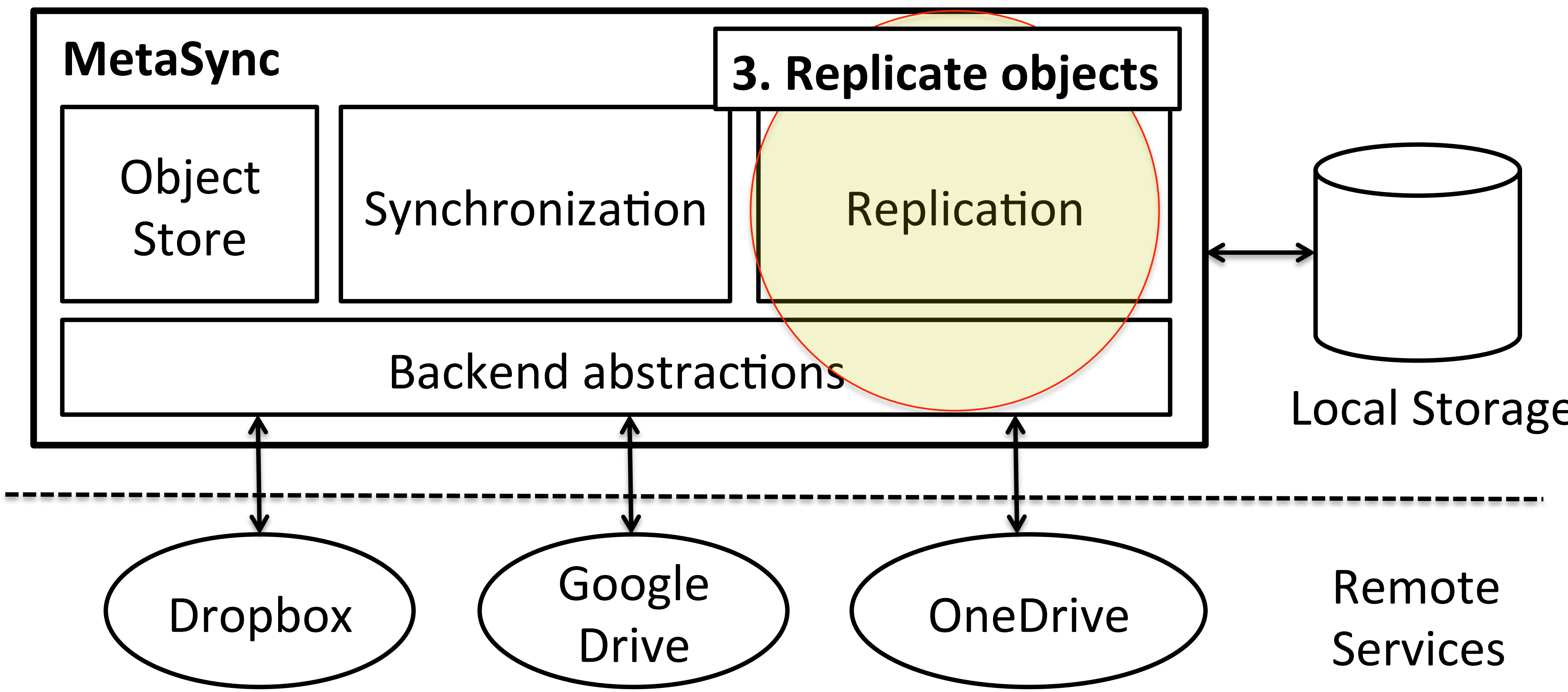

Stable Deterministic Mapping

- 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

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

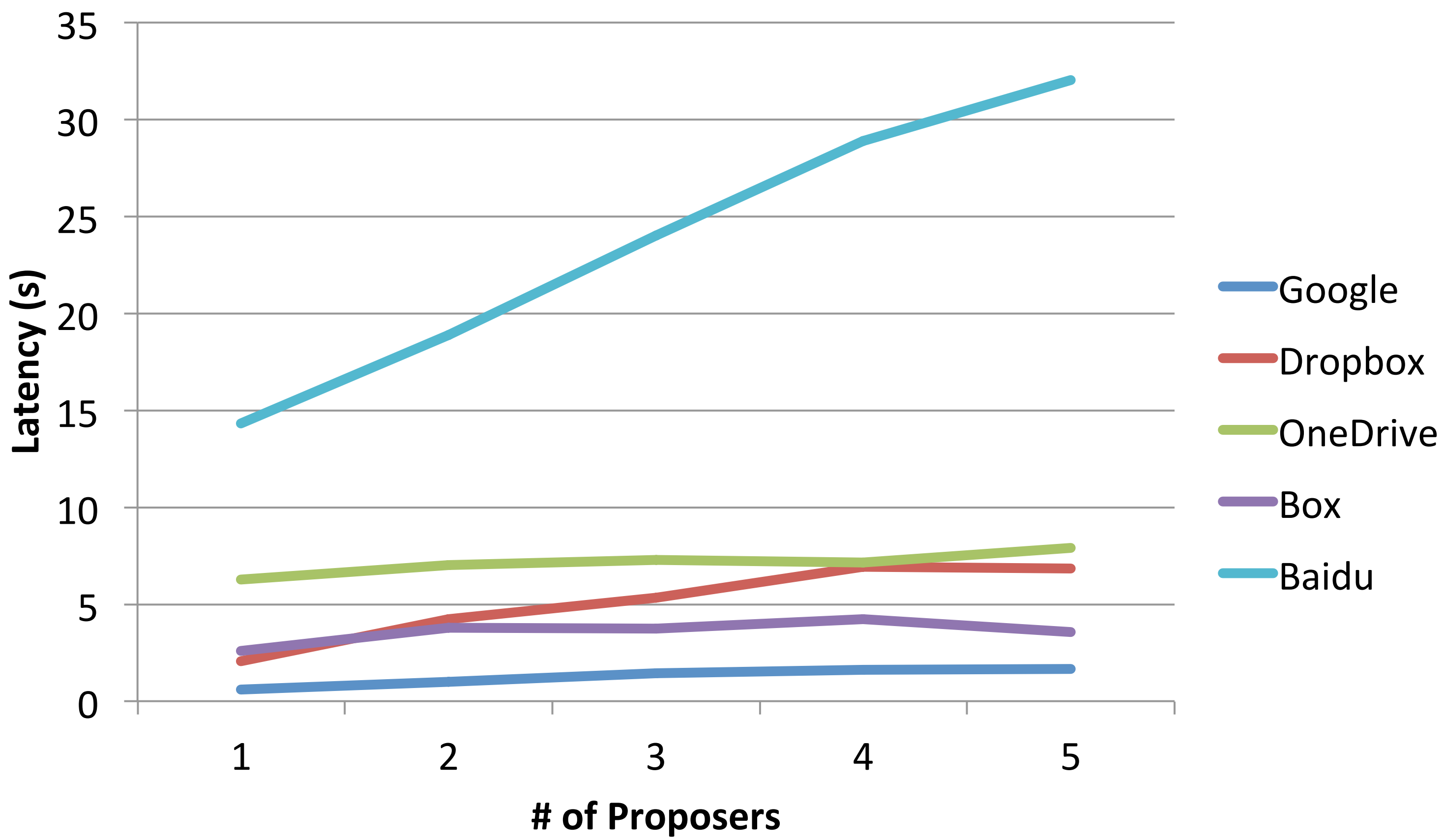
	Dropbox	Google	MetaSync
Linux Kernel 920 directories 15k files, 166MB	2h 45m	> 3hrs	12m 18s
Pictures 50 files, 193MB	415s	143s	112s

(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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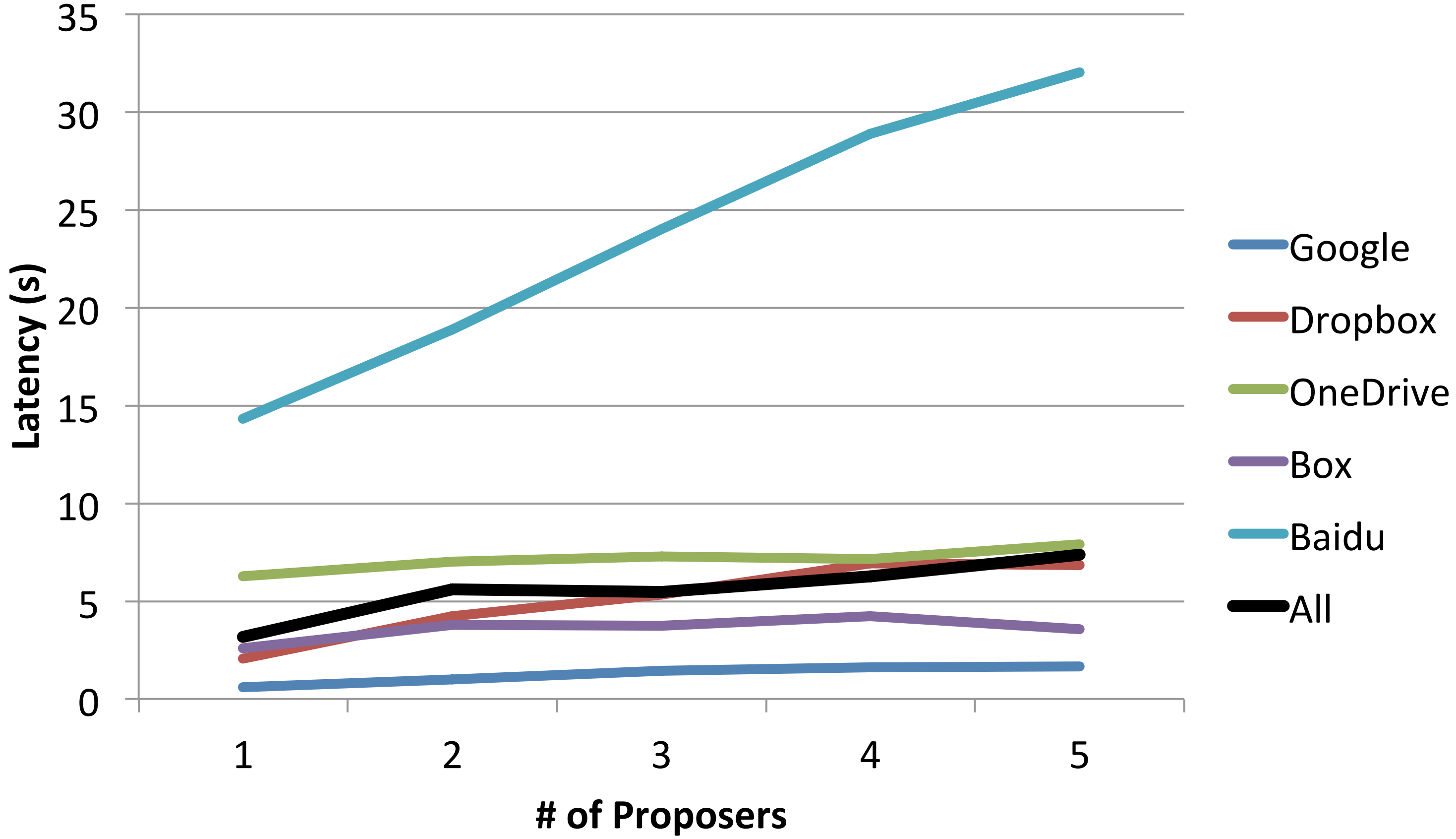

Latency is not degraded with increasing concurrent proposers or adding slow backend storage service

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/