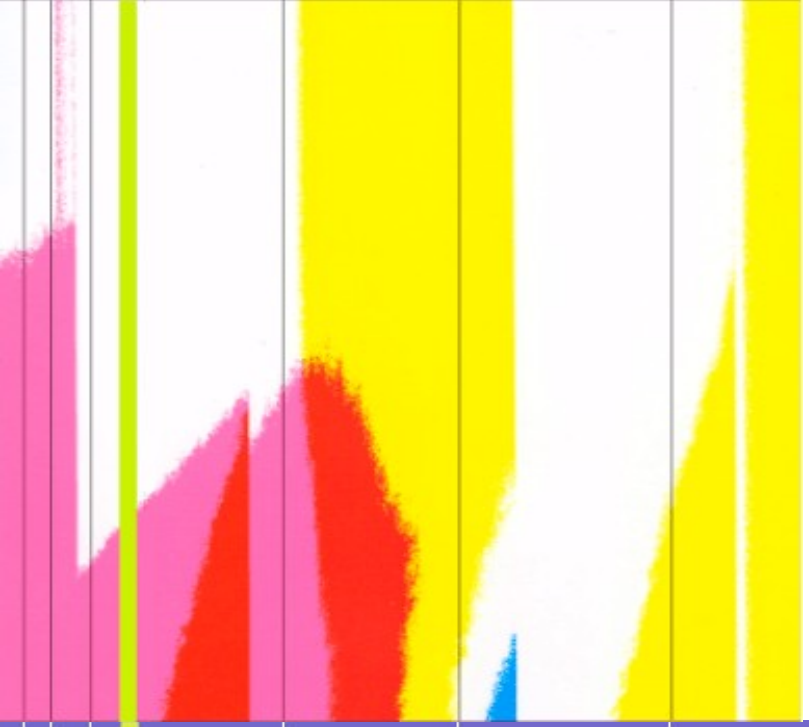

BlobSeer

How to Enable Efficient Versioning for Large Object Storage under Heavy Access Concurrency

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P2P approaches are becoming popular for more and more application classes

- More than 80% of data in circulation is unstructured [Grimes, 2008]
  - Free-form text: web pages, text documents, log files
  - Multimedia files: audio, video, images

- MapReduce [Google, 2004] and Hadoop [Apache, 2008]
  - Designed to deal with unstructured data
  - Transparent high-level data processing frameworks
  - Adaptation attempts for P2P environments [Marozzo, 2008]
  - Data stored in a huge blob (binary large object)

- Scientific applications

Data storage and access faces new challenges

- Mutable data
  - Poor support in traditional storage systems: GFS, HadoopFS
- Huge data size, fast generation rates
  - PB scale storage is necessary to cope with size
  - Order of TB/week not uncommon
- Heavy access concurrency
  - Thousands of clients accessing data simultaneously
- Versioning
  - Support for roll-back
  - Cheap branching

Our approach: BlobSeer

- Blob is fragmented into small equally-sized pages
  - Allows huge data amounts to be distributed all over the peers
  - Avoids contention for simultaneous accesses to disjoint parts of the data block
- Metadata is added to locate pages that make up the blob
  - Fine-grained and distributed as well to avoid contention
- Versioning
  - New pages corresponding to an update / append are generated instead of overwriting old pages
  - Metadata is enriched to incorporate the update
  - Both the old and the new version of the blob are accessible through the associated metadata

Scenario

- Online digital picture enhancing service
  - Users upload, apply filters and download back pictures
  - Pictures include metadata about camera type and settings

- Data mining: avg picture quality for camera type
  - Need to dynamically parse both metadata and image
  - MapReduce approach
    - Store all pictures in a huge blob
    - Use a past blob versions as snapshots for data mining
    - Allow users to update and add new pictures in the background by generating new blob versions

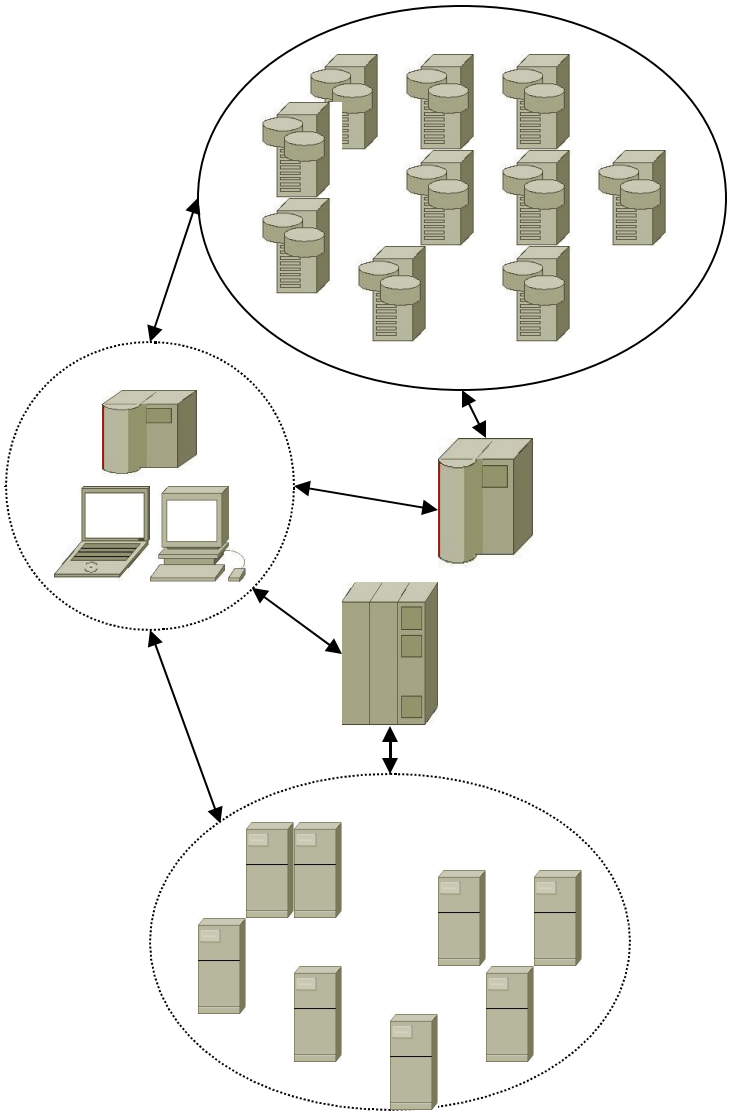
User interface

- Set of primitives:
  - id = CREATE()
  - vw = WRITE(id, buffer, offset, size)
  - va = APPEND(id, buffer, size)
  - READ(id, v, buffer, offset, size)
  - v = GET_RECENT(id)
  - size = GET_SIZE(id, v)
  - SYNC(id, v)
  - bid = BRANCH(id, v)

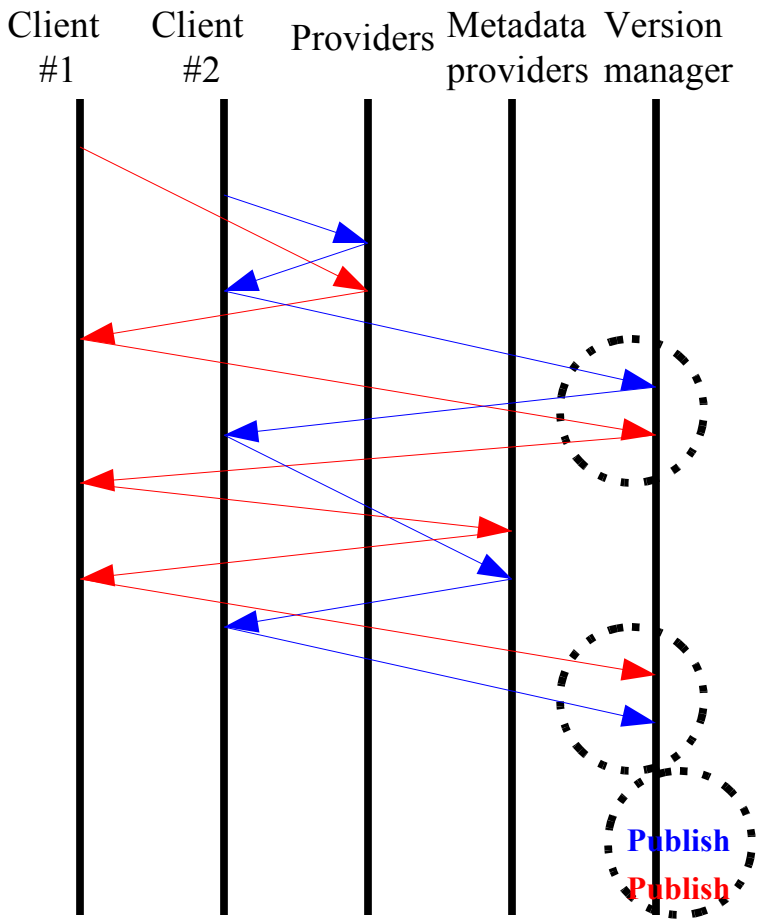
- (offset, size) may cover multiple pages

Architecture

- Clients
  - Perform fine grain blob accesses
- Providers
  - Store the pages of the blob
- Provider manager
  - Monitors the providers
  - Ensures a load balancing strategy of pages among providers
- Metadata providers
  - Store the segment tree associated to the blob
- Version manager
  - Ensures concurrency control



How to enable efficient versioning



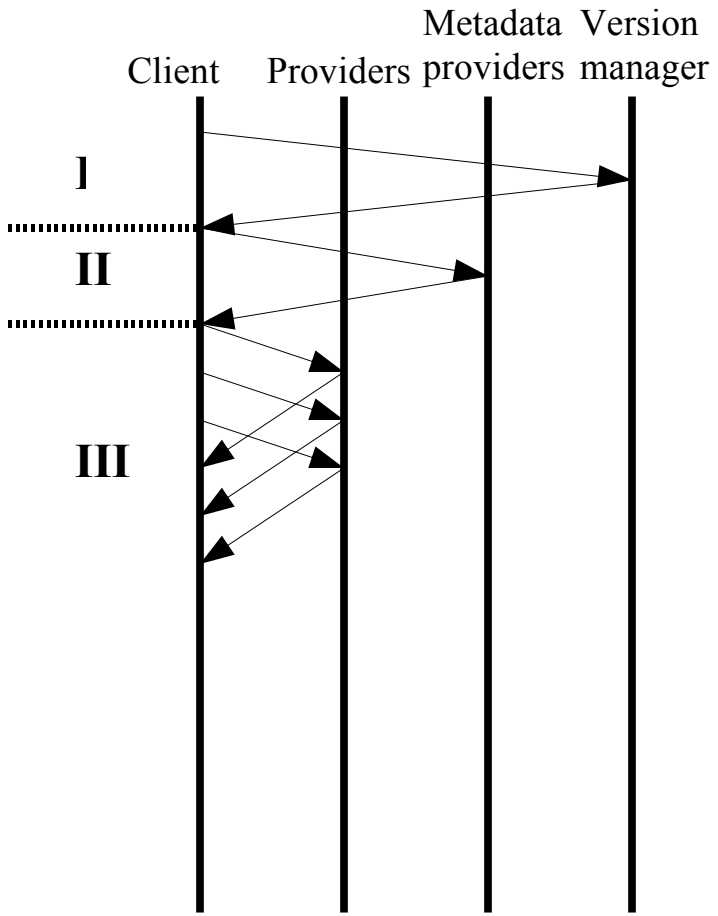
- Pages are written concurrently by the clients
- Versions are assigned in the order the clients finish writing
- Metadata is written concurrently by the clients
- Versions are published in the order they were assigned

How does a read work?

- I: optionally ask the version manager for the latest published version

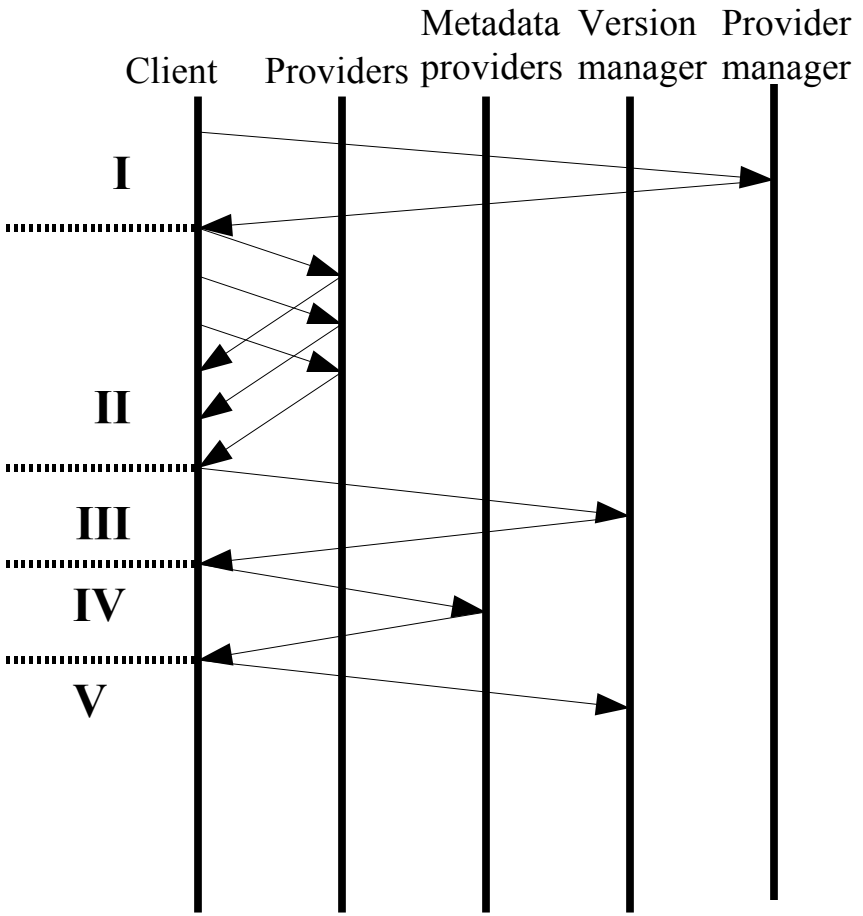
- II: fetch the corresponding metadata from the metadata providers

- III: contact providers in parallel and fetch the pages in the local buffer



How does a write / append work (1) ?

- I: get a list of providers that are able to store the pages, one for each page
- II: contact providers in parallel and write the pages to the corresponding providers
- III: get a version number for the update
- IV: add new metadata to consolidate the new version
- V: report the new version is ready for publication.



How does a write / append work? (2)

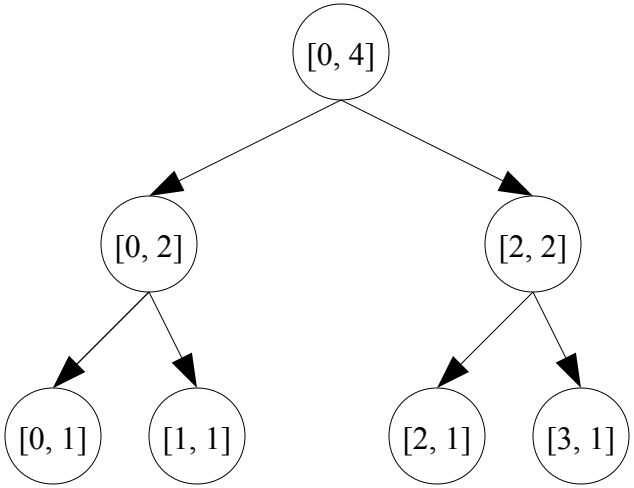
- The version manager holds a queue with all pending writes and ensures versions are published in the order they were assigned

- Priority is given to the least loaded provider when assigning a provider to store a page

- Multiple versions of the same page may be stored on potentially different providers

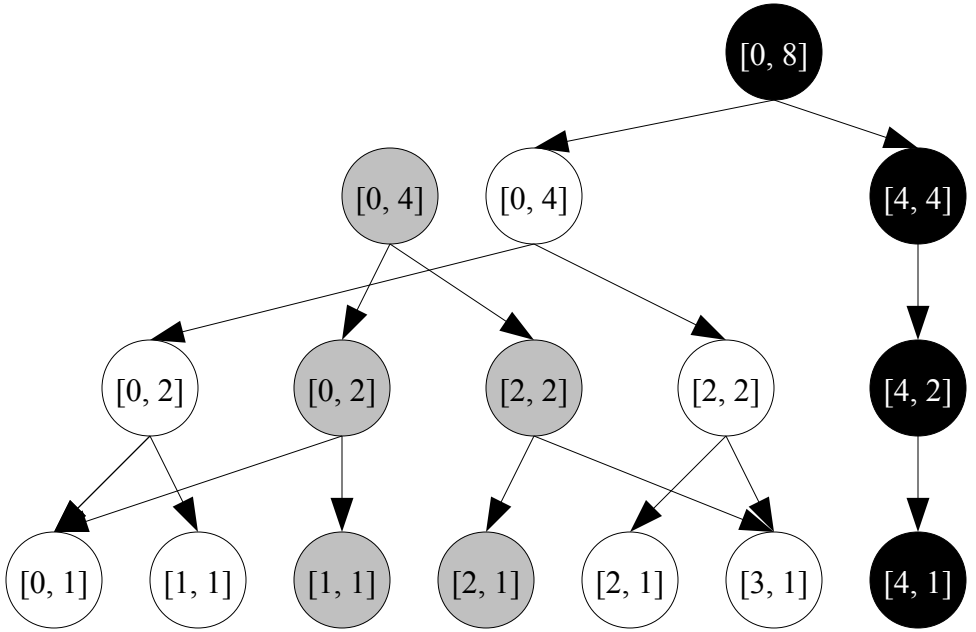
Metadata (1)

- Organized as a segment tree
- Each node covers a range of the blob identified by (offset, size)
- The first/second half of the range is covered by the left/right child
- Each leaf corresponds to a page and holds information about its location



Metadata (2)

- Each node holds versioning information
- Write/Append
  - Add leaves and build subtree up to the root
  - The tree may grow one level
- Read: descend from the root towards the leaves



Metadata (3)

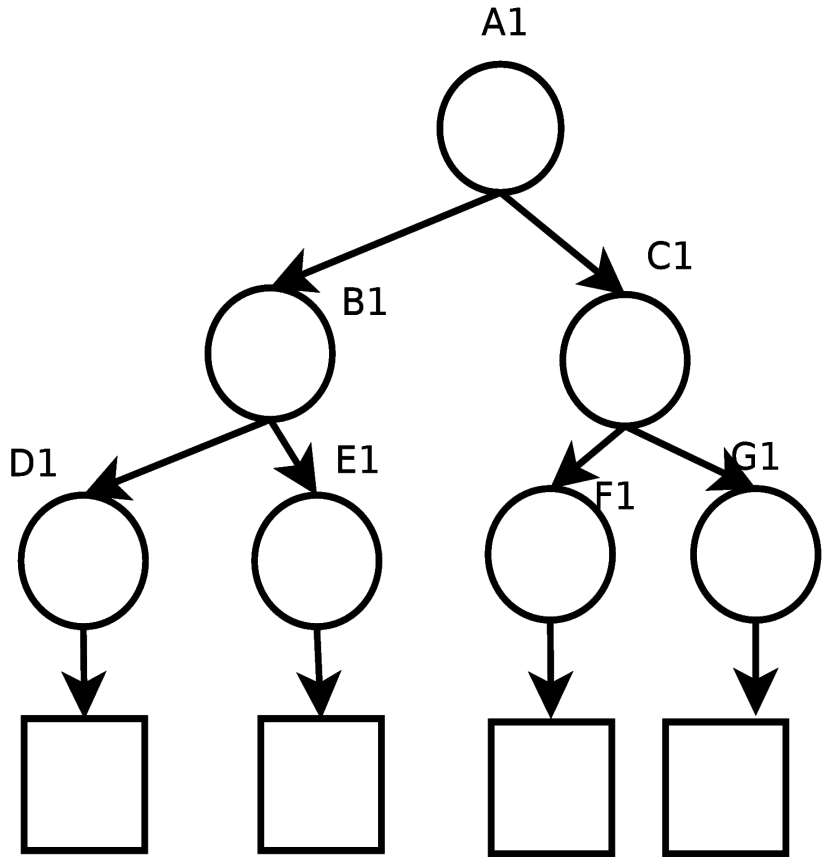
- Fully concurrent metadata consolidation is possible:
  - A node in the metadata tree may have a child labeled with a previous version
  - Such a child may not have been added yet because it belongs to a write (or append) in progress
  - The version manager holds a queue with all pending writes/appends
  - When the client asks the version manager for a new version (after writing the pages), the latter can predict all such children and pass them along

- Tree nodes are distributed among metadata providers

- Clients can fetch multiple nodes in parallel

How concurrent writes work: example

- Initial version: v = 1
- 2 concurrent writers: gray and black
- Both write their pages independently
- Gray is first, it is enqueued on the versioning manager and assigned version v2, black follows and gets v3
- Both write independently the metadata tree nodes: black is faster and links to (the not yet created node) B2
- First to finish is black, it is marked ready
- Next is gray, being the first means its root gets published and it is dequeued
- Finally black gets first in the queue and and will be published



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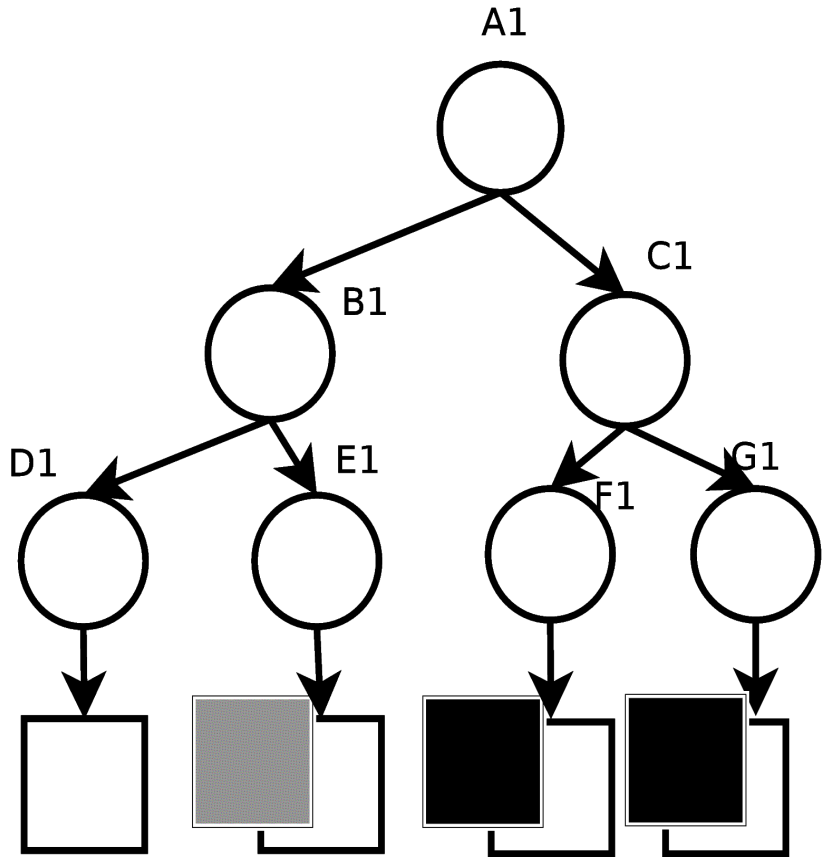

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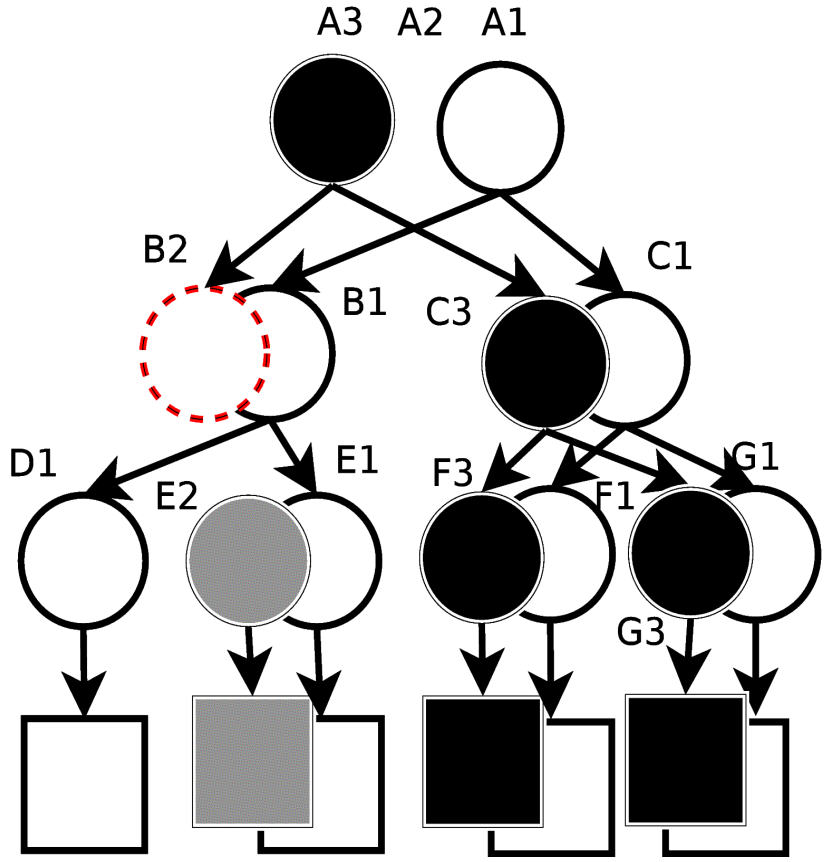

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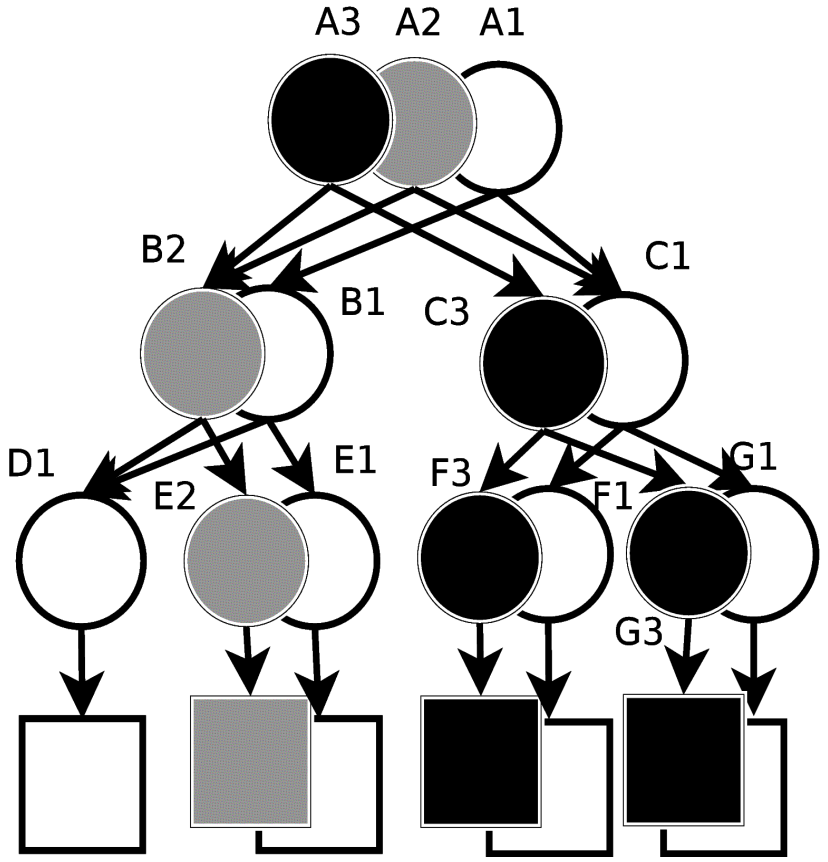


Comparsion with other systems

	Read concurrency	Write concurrency	Append concurrency	Versioning
Traditional FS	-	-	-	-
Lustre, PVFS	X	X	-	-
GFS, HadoopFS	X	-	X	-
DeepStore	-	-	X	X
BlobSeer	X	X	X	X

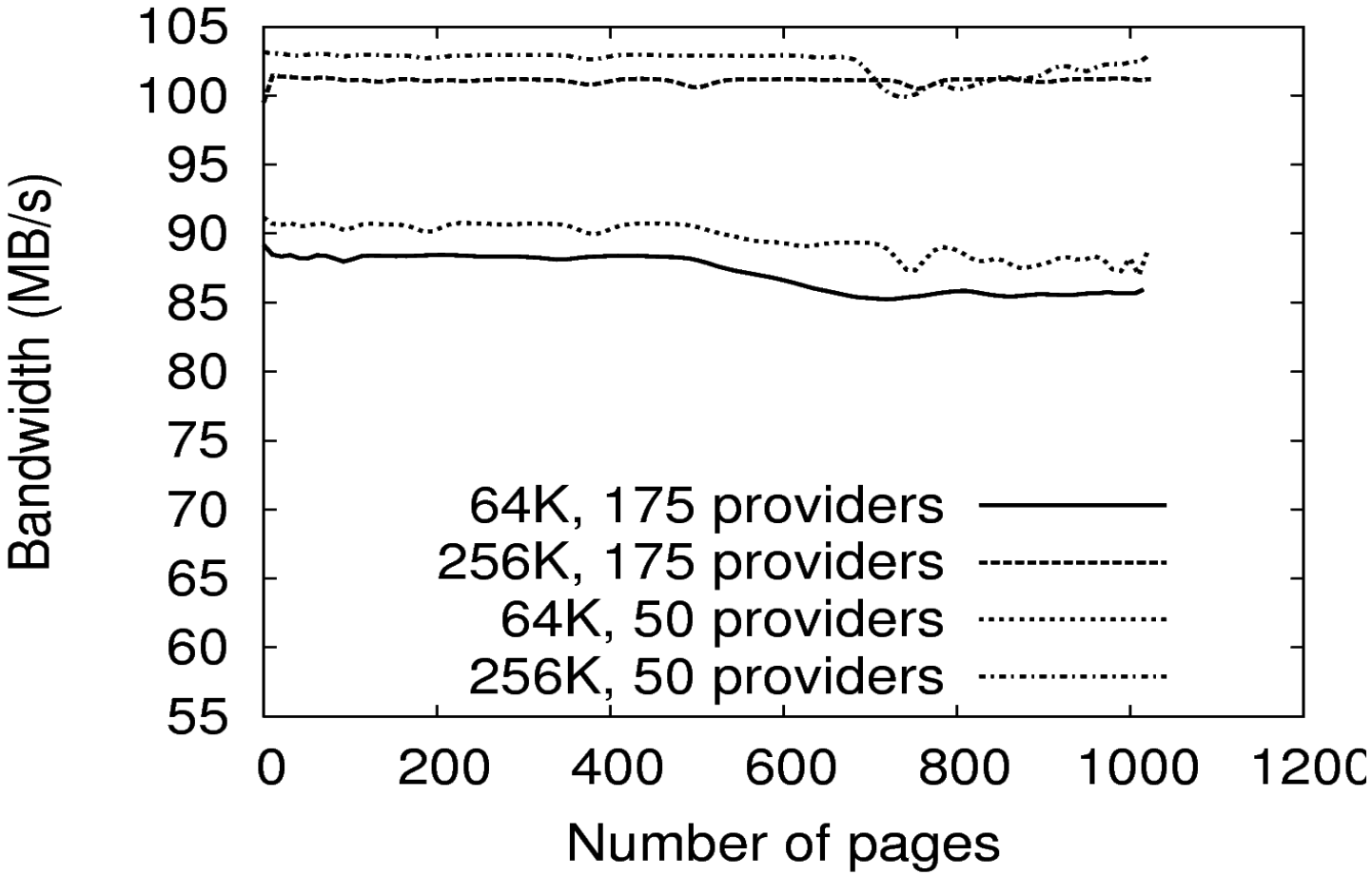
Experimental setup

- Implementation details
  - Custom DHT
  - Boost C++ collection, ASIO

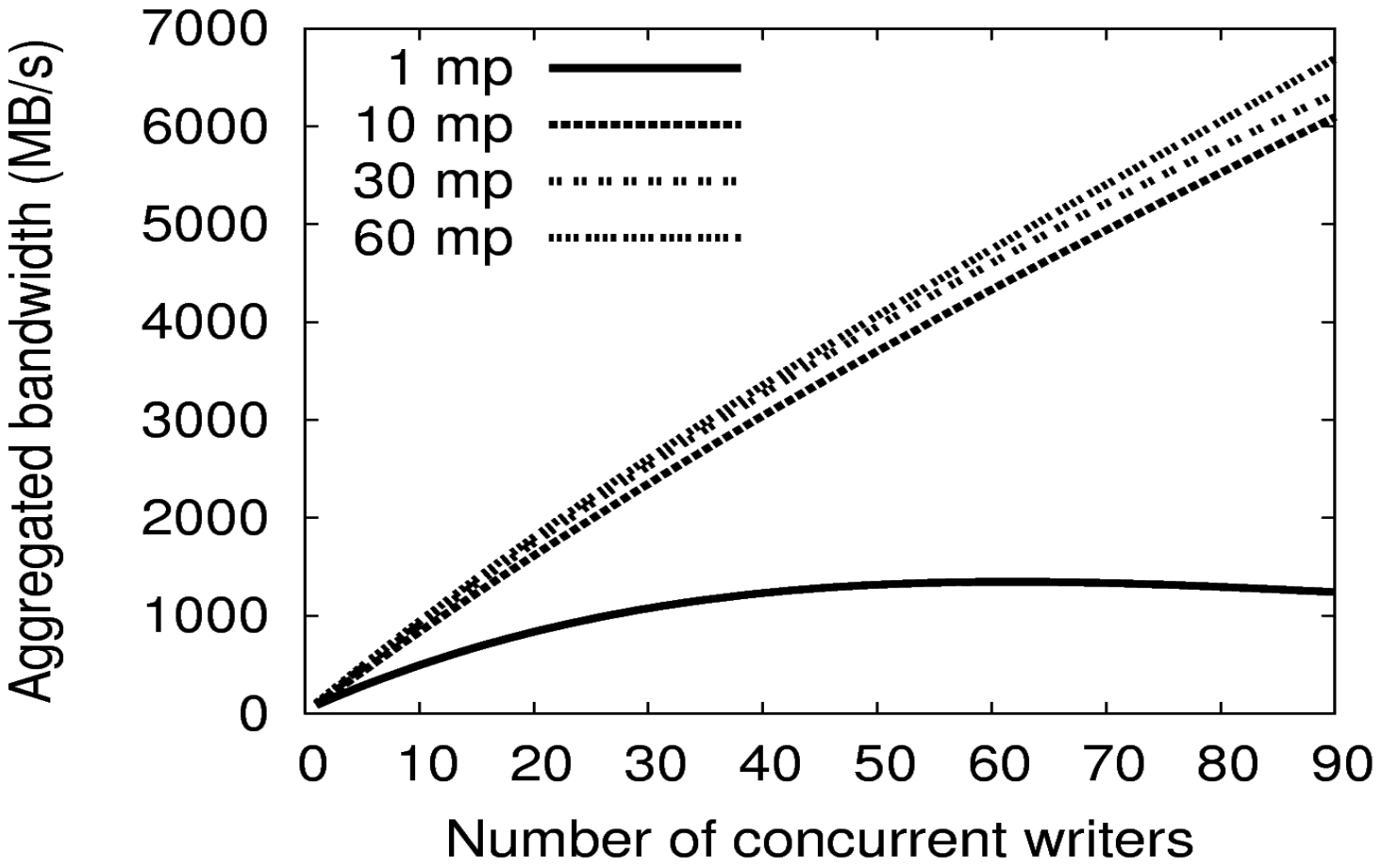
- Our machines: Reservation on Grid'5000 platform
  - 175 nodes
  - Pentium-4 CPU@2.6Ghz, 4GB RAM, Gigabit Ethernet
  - Measured bandwidth: 117.5 MB/s for MTU=1500B

- 3 sets of experiments:
  - Append bandwith for a single client
  - Aggregated write bandwidth under heavy concurrency
  - Sustained read bandwidth under heavy concurrency

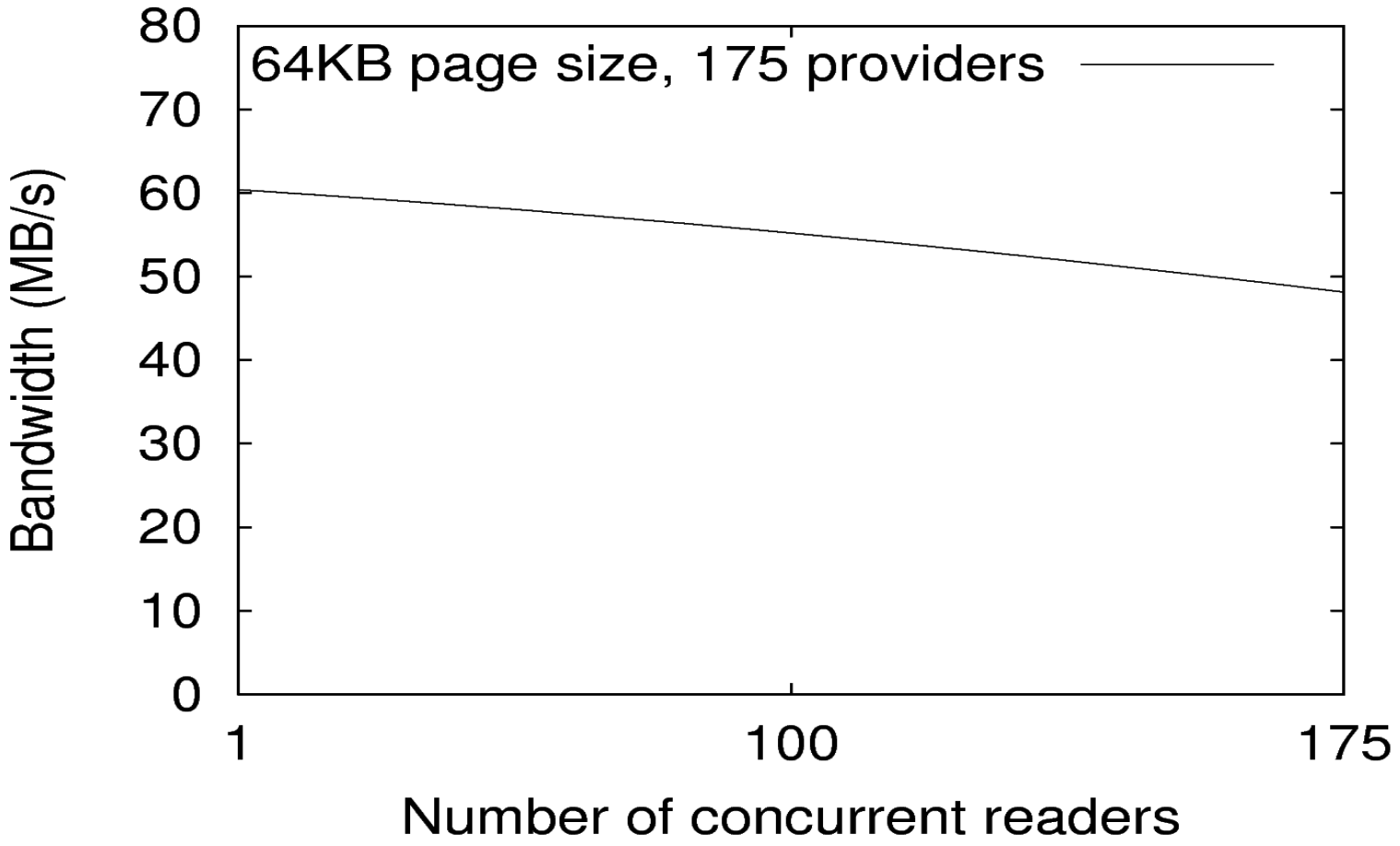
Results (1) – Append performance: single client



Results (2) – Aggregated write bandwidth



Results (3) – Sustained read bandwidth



Conclusion

- Addressed the problem of efficent versioning for blobs under heavy access concurrency in P2P environments

- Proposed a system offering support for:
  - Huge blob size: order of TB
  - Small updates: order of MB
  - Fine granularity, page size: order of KB
  - High degree of concurrency

- Experiments show promising results

Future work

- In progress
  - Fault tolerance
    - Smart replication strategies through global behavioural modeling
  - Advanced monitoring
    - Experimenting with load balancing strategies
  - BlobSeer as a storage layer in Postgres

- Planned:
  - Fault tolerance
    - Decentralized version and provider manager
  - Transactional support:
    - Export a filesystem interface with transaction management
    - Snapshot isolation by making use of multi-versioning support