Building a Better Data Object

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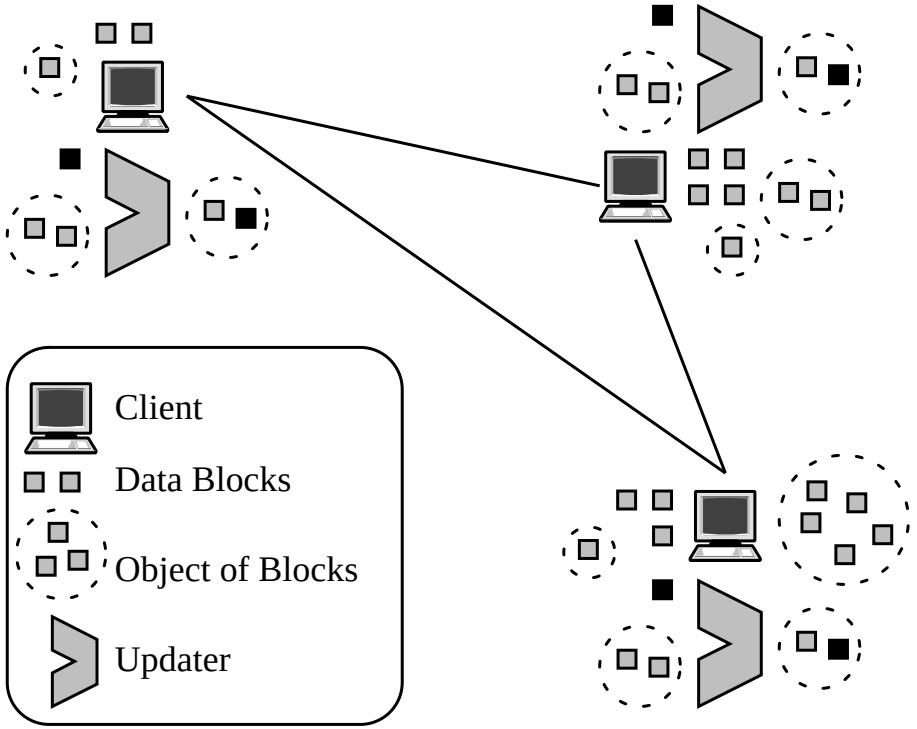
Outline

- Background and Context
- Requirements
- Current Design
- Proposed Improvements
  - New B-tree algorithms
  - Improved verifiability protocols
- Conclusions

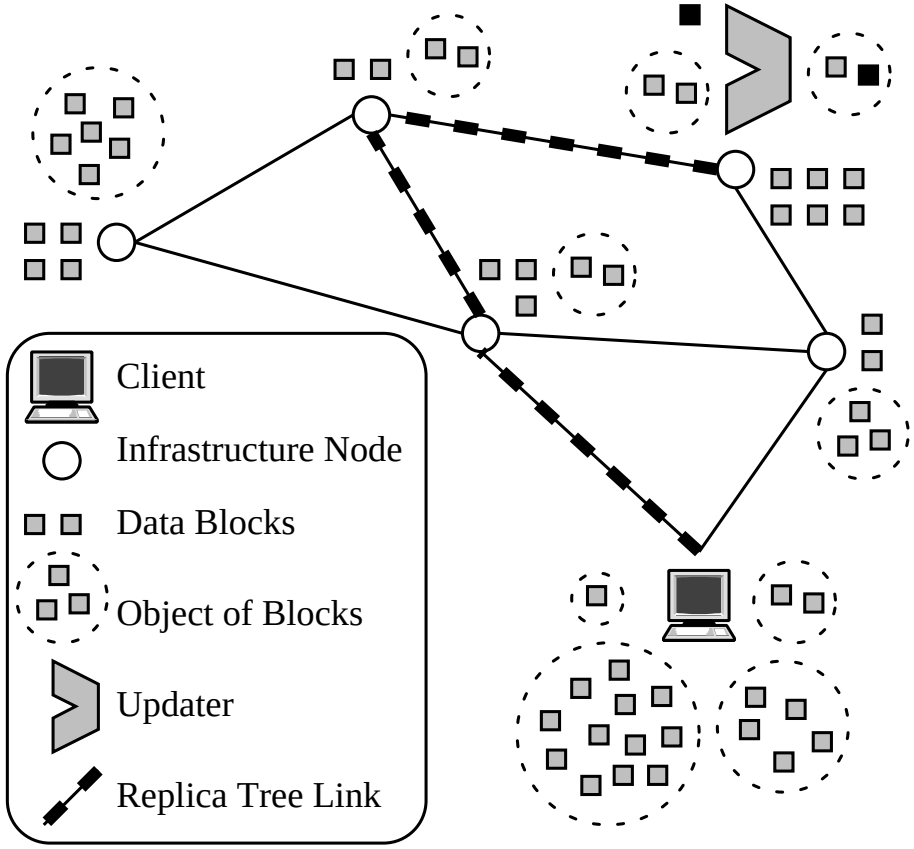
Background: Peer-to-Peer Design Philosophy

- Client-centered architecture
- “Traditional” peer-to-peer system
- Self-organizing networks of machines that communicate symmetrically
- Application functionality at client
- Infrastructure routes messages
- Example: Napster

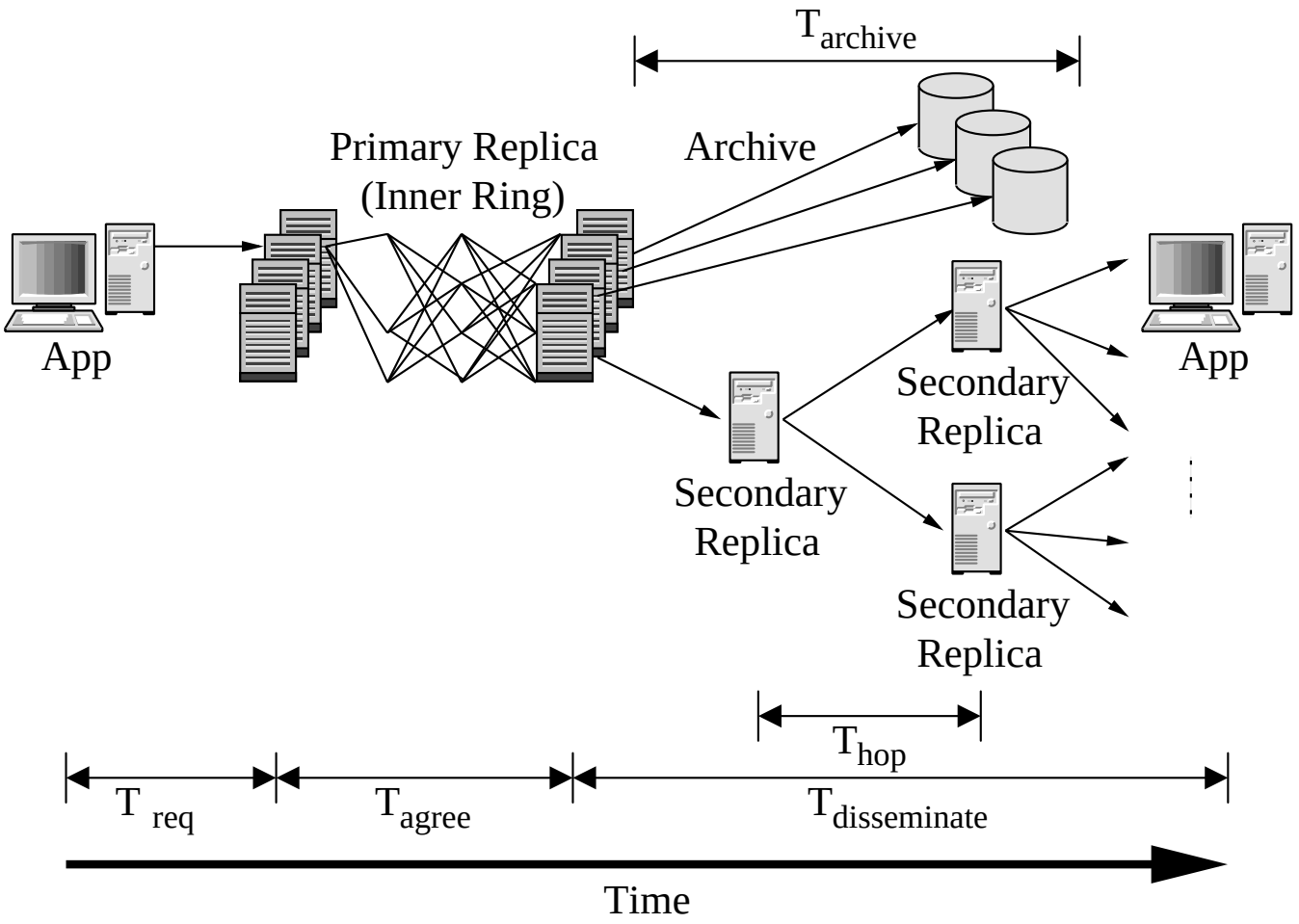


Background: Peer-to-Peer Design Philosophy

- Infrastructure-assisted architecture
- Application functionality distributed throughout infrastructure
- Use powerful, well-connect, well-administered machines in the net-work
- Designers must *export application vocabulary* into infrastructure
- Example: OceanStore



Background: The Path of an Update

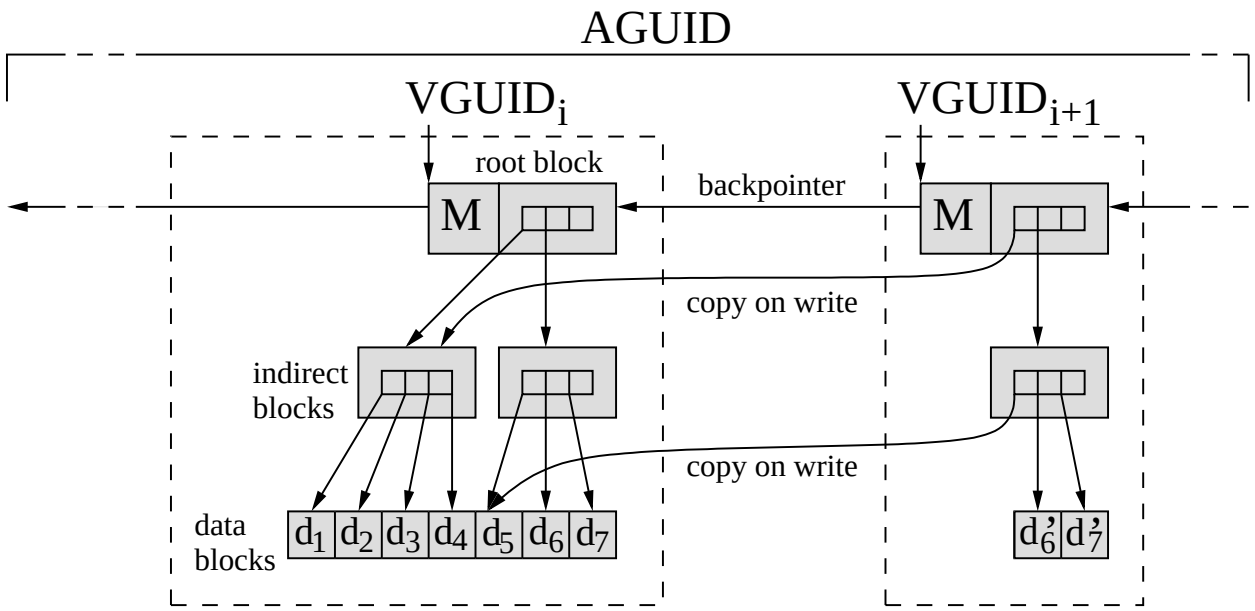


- Inner ring applies updates to data object
- Data object format exported to infrastructure

Requirements

- Self verifying
- Support client-side encryption for privacy
- Support partial file caching
- Provide efficient update dissemination
- Low overhead versioning (copy-on-write)
- Expressive data structure operations
  - random access read, append, replace, insert, truncate, scan

General Data Object Design

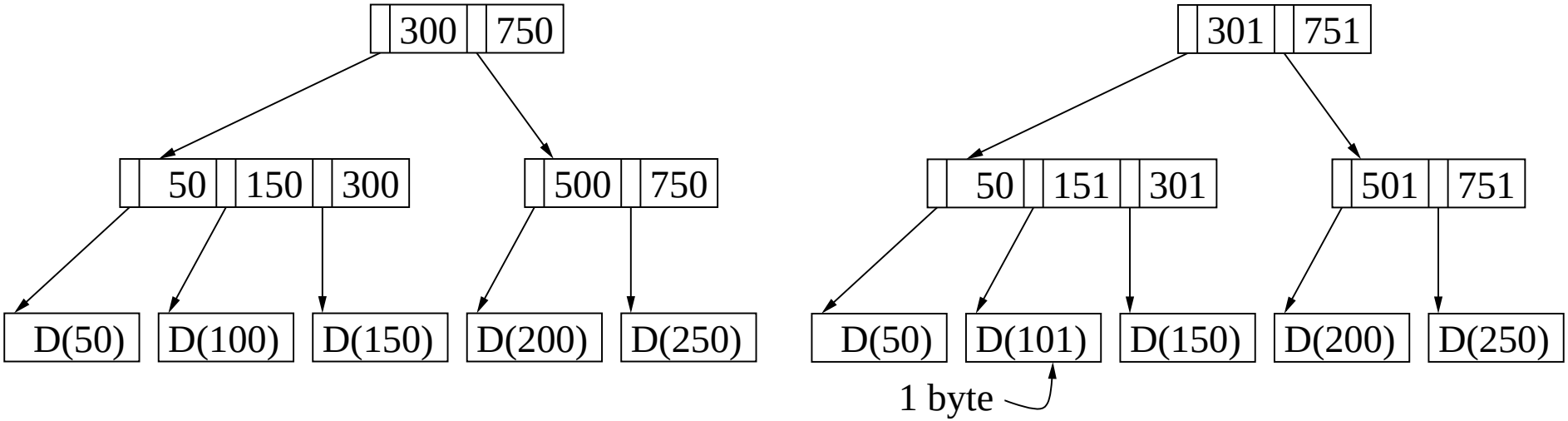


- Data object named by AGUID
- Versions identified by VGUID
- New versions are appended to chain
- Old versions are read-only
- Btree stores object data
- References to children by secure pointer
- Btree can reference blocks from previous versions
- Support copy on write
- Metadata prepended to root of btree

Design Errors

- Btree not sufficiently flexible
  - did not support encrypted data
  - did not support efficient insertions
- Update dissemination overcomplicated
- Inefficient metadata storage
- Poor support for tentative data
- Poor support for version branches

Traditional Btree

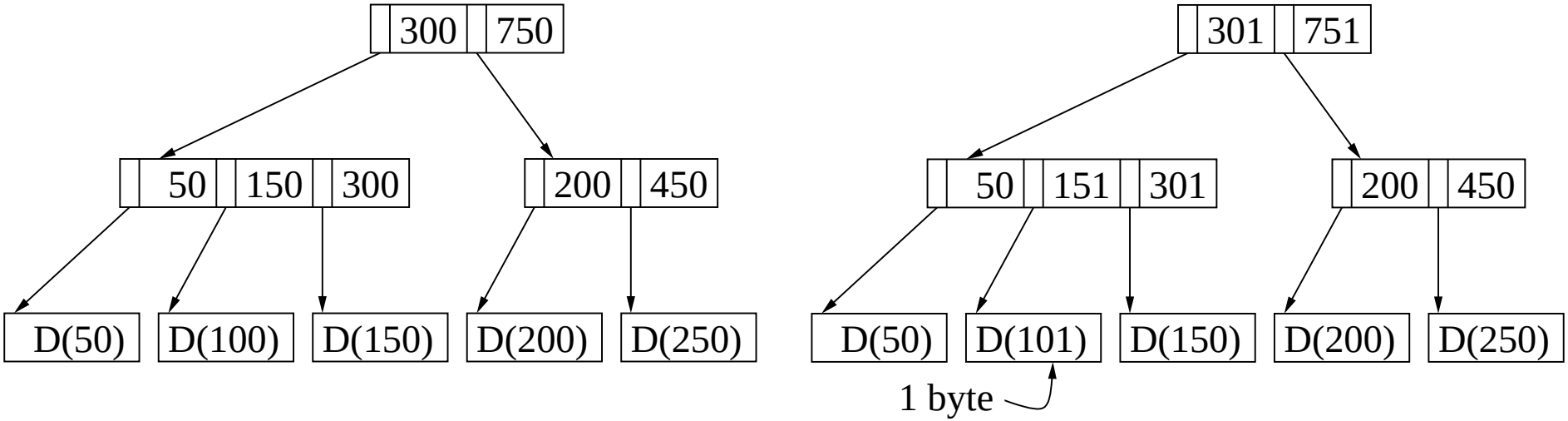


- All offsets are relative to file
- One-byte insert modifies all following interior blocks

Inspiration for New Btree Algorithms

- Exodus Storage Manager
  - Object and File Management in the Exodus Extensible Database System, Carey et. al. (VLDB 1986)
- Supported objects composed of variable-sized blocks that changed over time
- Key feature: index in interior nodes records offsets relative to the block, *not* to the file

Exodus Btree

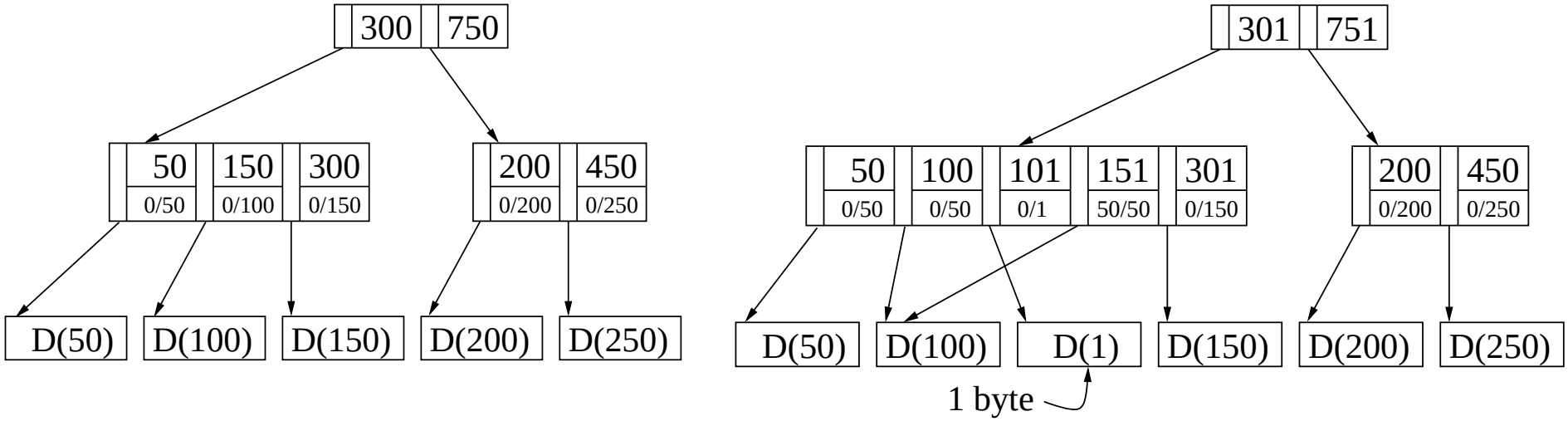


- Offsets are relative to the block
- One-byte insert modifies only blocks between new block and root

OceanStore Extensions

- Problem:
  - Cannot modify encrypted blocks outside of client
  - Limits flexibility of insert
- Solution:
  - Include offset, length fields
  - Allow blocks to be referenced multiple times

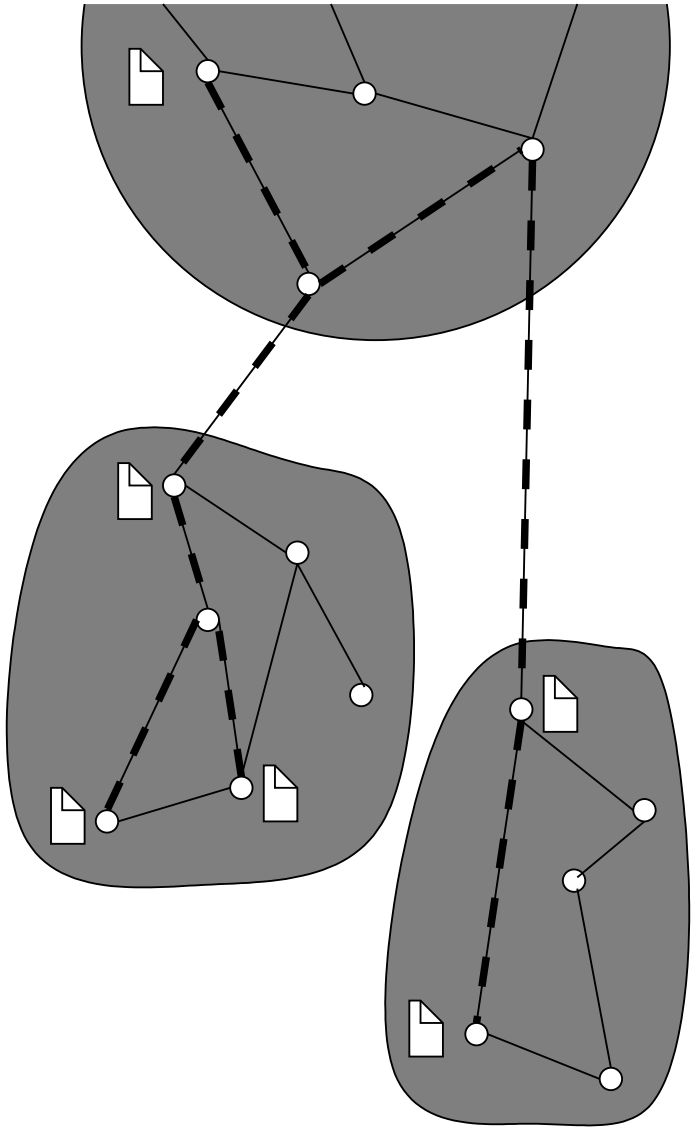
OceanStore Btree



- Offsets are relative to the block
- One-byte insert modifies only blocks between new block and root
- Encrypted blocks are unmodified

Background: Dissemination Tree

- Per-object, self-organizing, application-level multicast tree
- Root at the inner ring
- Distributes update results to replicas



Background: Types of Uncommited Data

- "Tentative" Data
  - updates are propagated epidemically
  - update applied optimistically on secondary replica
  - result checked after receiving result from inner ring
  - version rolled back if necessary

- "Unnamed" Data
  - data created at inner ring before GUID computation
  - archiving is slowest part of applying update
  - roughly 4 times slower than other computation
  - 3% overhead for small updates; 50%+ for large updates

Current Dissemination Approach

- “Tentative” data is not shared
- “Unnamed” data shared via dissemination tree
- GUID - hash of content and archive fragments
  - slow to compute (?)
  - globally verifiable name
  - published in Tapestry
- VHASH - simple secure hash of contents
  - fast to compute
  - verifies only reconstructed blocks
  - communicated via dissemination tree
  - useless for verifying content from archive
- COMPLEXITY PERVADES CODE

Proposed Dissemination Approach

- Simplify, simplify, simplify
- Only external name for data is the GUID
- Data may have other names within a single node
- Validate local computation with inner ring certificates

Proposed Dissemination Approach

- Still possible to share uncommitted data
  - Shared via updates instead of actual data
  - Updates include verifiability measures
  - Nodes apply update locally
  - Verify local computation by inner ring certificate
- Outstanding issues
  - How to populate a new replica?
  - How to recover from missed update?

Other Issues

- Better metadata handling
- Support for version branching
- Support for tentative updates
- Format translation

Conclusions

- Conflicting requirements
- Prototype design met most requirements
- Proposed changes help satisfy remaining requirements
  - Handling of encrypted data
  - Efficient insertions
  - Efficient dissemination