

# Designing a global EMail repository using OceanStore

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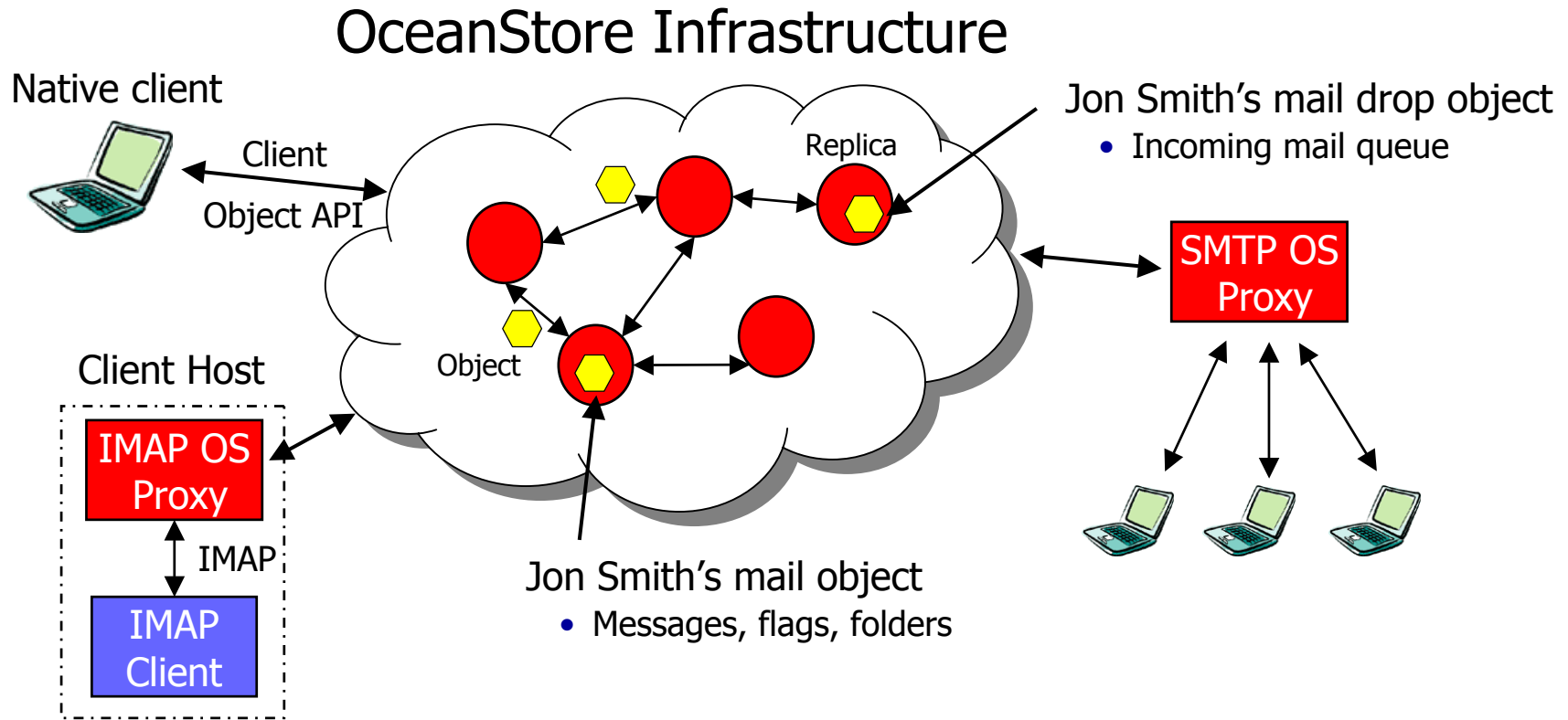
**Summer Retreat**  
**June 11, 2002**  
**UC Berkeley**

# Goal

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- Build an another interesting OceanStore app
  - Further tests OceanStore client APIs
  - Examine conflict resolution strategies
  - Explore data clustering/introspection techniques
- Email infrastructure using OceanStore
  - Fulfills the above criteria
  - Enables mail delivery, retrieval, and organization
  - Legacy access methods (IMAP, SMTP, POP)

# System architecture

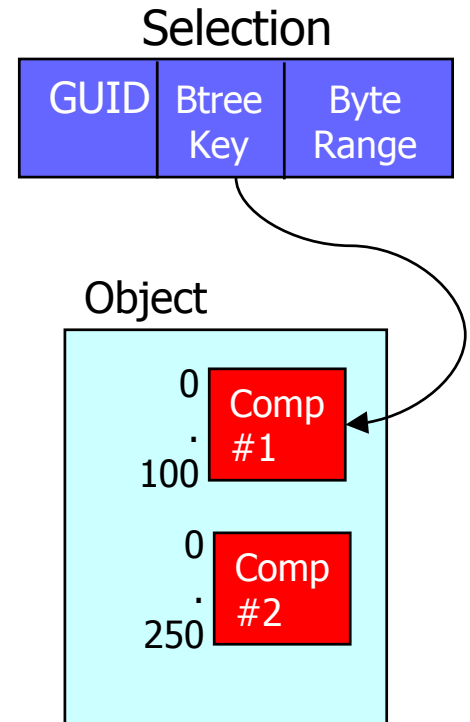


- Benefits of using OceanStore
  - High availability of data
  - Automatic archiving
  - Objects migrate towards client

# OceanStore API

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- Stores objects
  - Composed of encrypted blocks
- Objects addressed through...
  - GUID (which object)
  - Key (which component of an object)
  - Byte range (which bytes of the component)
- Changing an object
  - Update, expand, truncate
- Predicates on changes
  - What must hold true for a change to succeed
  - Example: object version must equal 1.2
- Updates within an object are atomic
- Notified when predicate fails (conflicts)



# Designing OceanStore applications

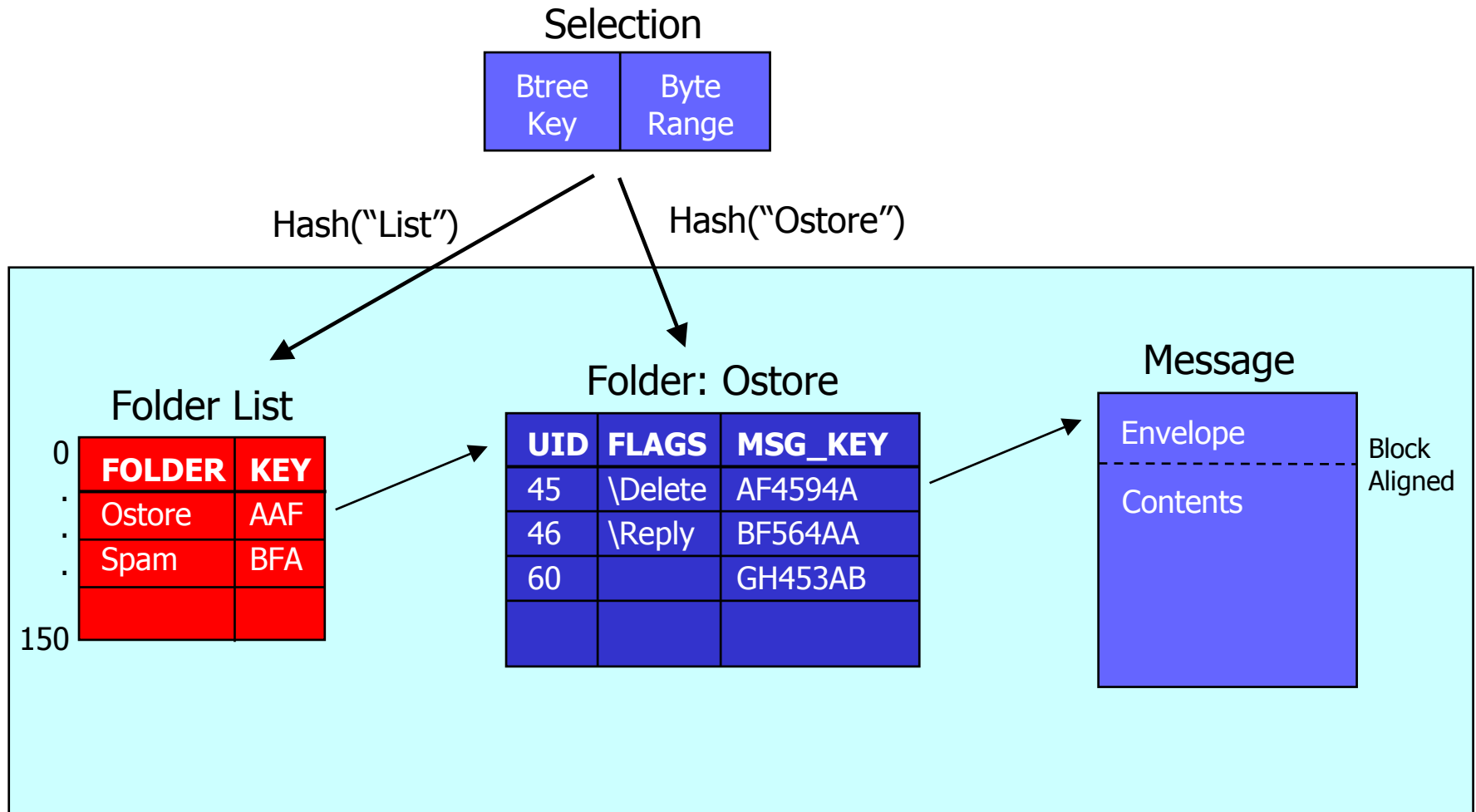
- Three important areas to consider
- Object layout
  - Defines OceanStore usage
  - Affects conflicts and migration
- Conflict detection and resolution
  - Minimize false conflicts
  - Roll back and retry to resolve
- Migration strategy
  - Enable clustering for pre-fetching

# Object design

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- Information to store
  - Messages, folder listings, flags, envelopes
- Object granularity choices
  - Per message
  - Per folder
  - Per user
- Per user granularity
  - Atomic actions only involve one object
  - Minimizes number of objects
- Separate object for user mail drop
  - Requires different security/permissions

# Object layout



OS Mail Account Object

# Conflict detection and resolution

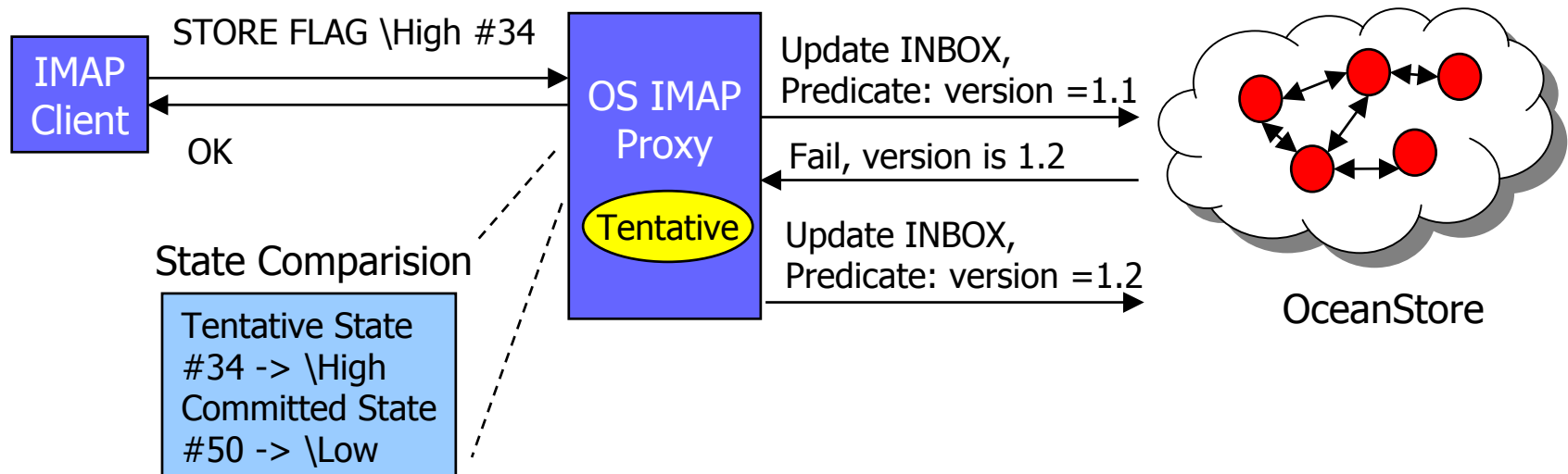
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- Sources of conflicts
  - Mail arrival while user browsing (more likely)
  - Tentative updates delayed too long
  - Clients updating same account (less likely)
- Possible conflicts
  - Updates on same message
    - Changing different flags, moving to different folders
  - Updates to same folder
    - Appending new messages, deleting a folder
  - Updates on folder list
    - Create new folders with same name



# Conflict resolution design

- General strategy
  - Upon detection, application reads offending state
  - Compares state w/ tentative to classify conflict
  - For false conflicts, simply retry
  - For true conflicts, take most conservative action
  - Works for most, but there are special cases

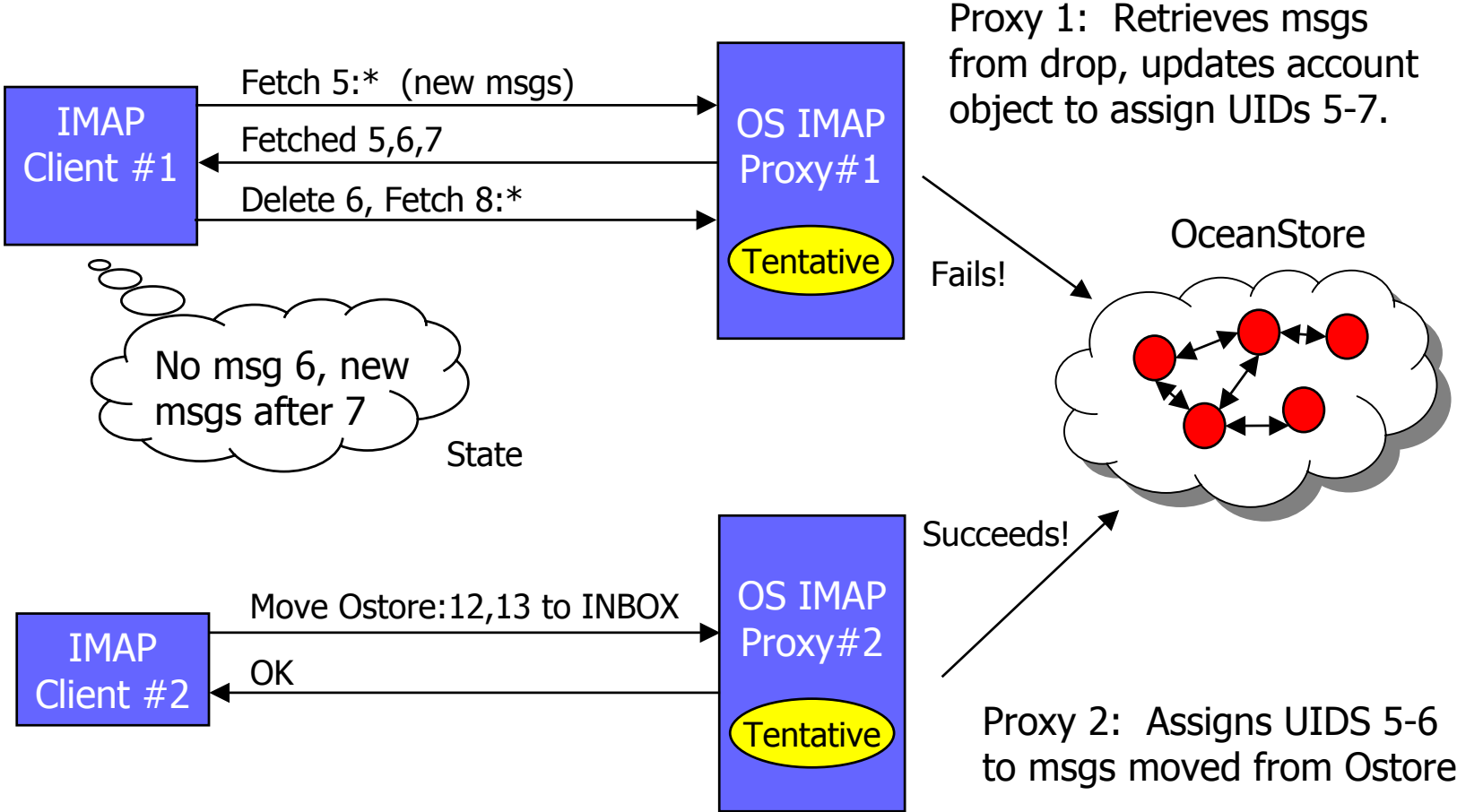


# Special case: Assigning UIDs

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- Unique Identifiers (UIDs) in IMAP
  - Each UID maps to a message
  - Mappings are permanent
  - UID namespace is per folder
  - Invariant: UID numbers are strictly increasing, ordered by addition time
- Possible conflicts:
  - Same UID used for two different messages
  - Msg added with UID smaller than largest in folder
  - Both cause clients to miss messages

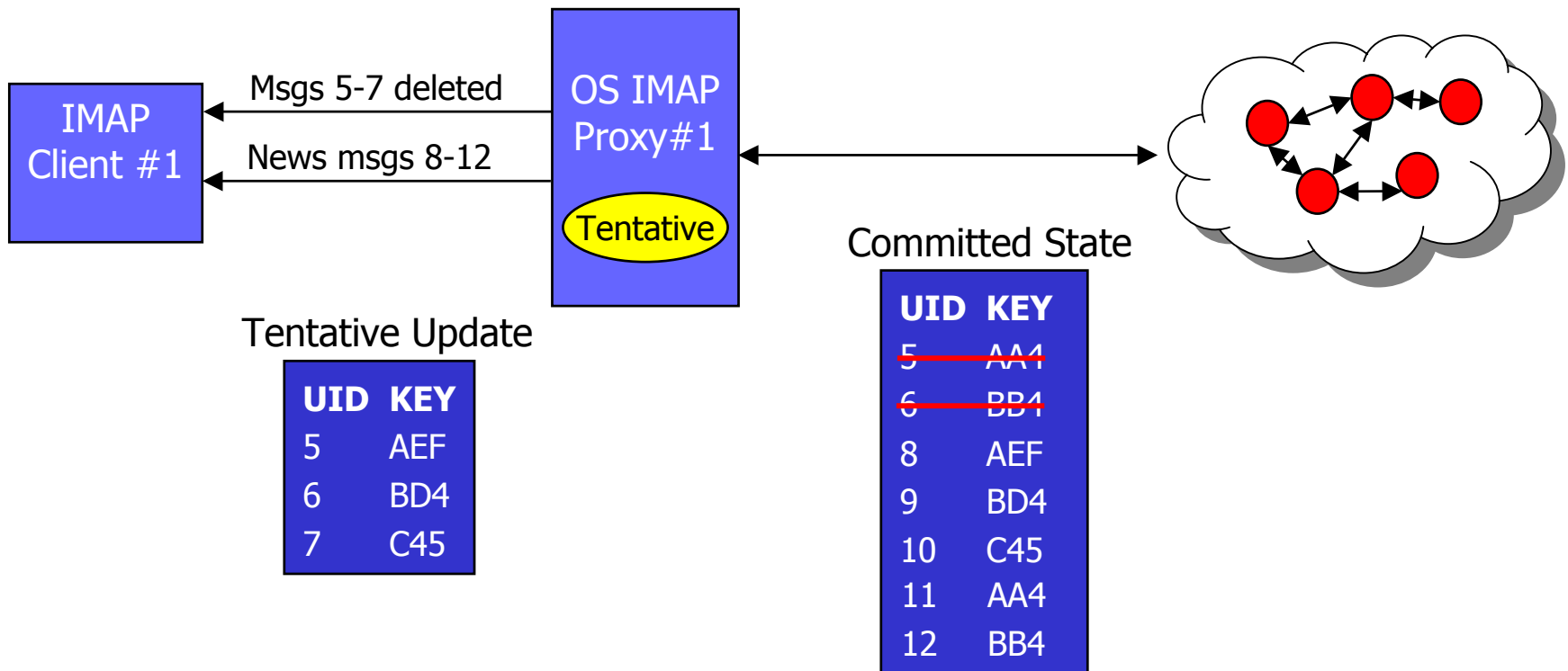
# Conflict example: Assigning UID



Client #1's state is incorrect: No msg 6, wrong msg 5

# UID assignment algorithm

- Algorithm replicated at all clients
  - Defer assigning UIDs
  - Rollback back conflict by “deleting” messages
  - Re-add messages with higher, non-conflicting UIDs

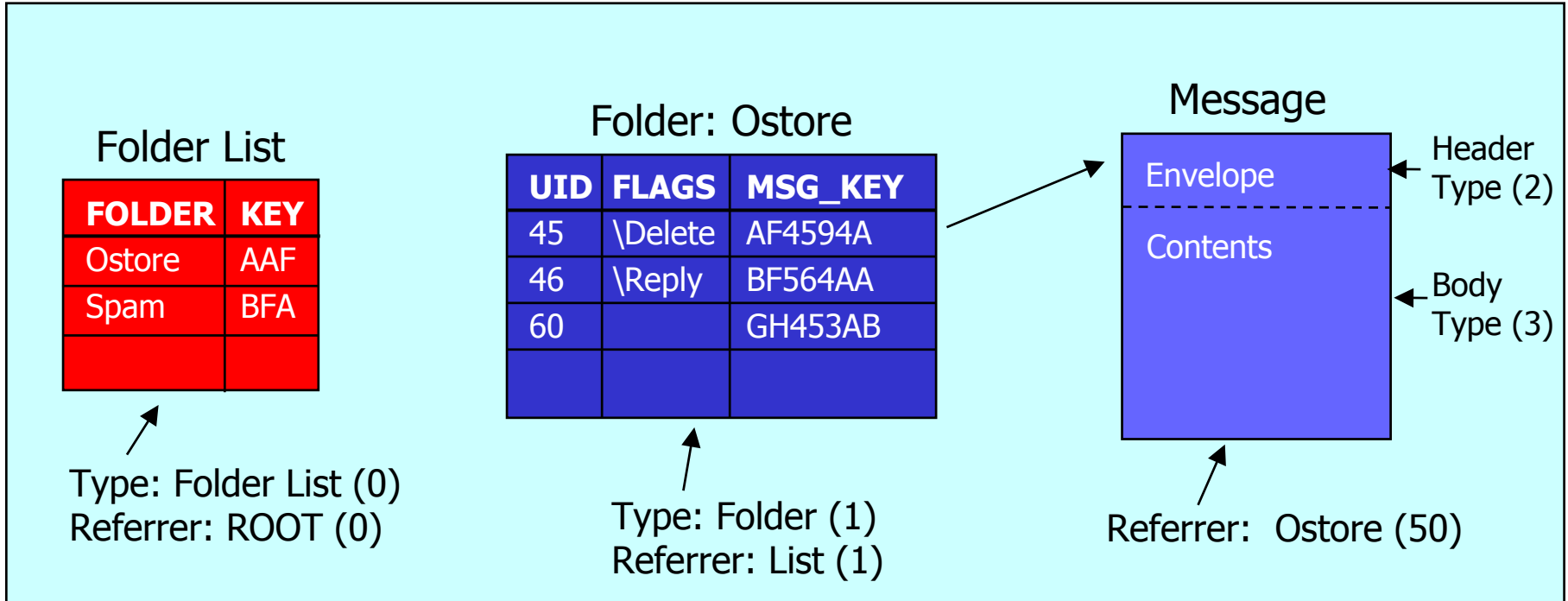


# Block clustering

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- Designed pre-fetching behavior
  - Pre-fetch message envelopes
  - Priority to envelopes in INBOX
- But, OceanStore cannot see these attributes
- Initial strategy
  - Provide hints through object's metadata
  - Assign type ids to blocks (envelope, msg body, ...)
  - Assign referrer ids to blocks (INBOX, Ostore, ...)
- Should improve pre-fetching ability

# Example block hints



OS Mail Account Object

# Future work

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- Implementation this summer
- Re-design with new client API features
  - Finer grain conflict detection
  - Support for data clustering hints
- Experiments
  - System scalability
  - Bandwidth usage measurements
  - Clustering effectiveness

# Some thought questions

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- Should we have objects per message?
  - Implement sharing of messages (mailing lists)
- Should we only have one SMTP server?
  - Without active checks, open to spam
- How feasible is disconnected operation?
- Can we generalize our introspective solution?