The SCADS Toolkit

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(it’s catching…)

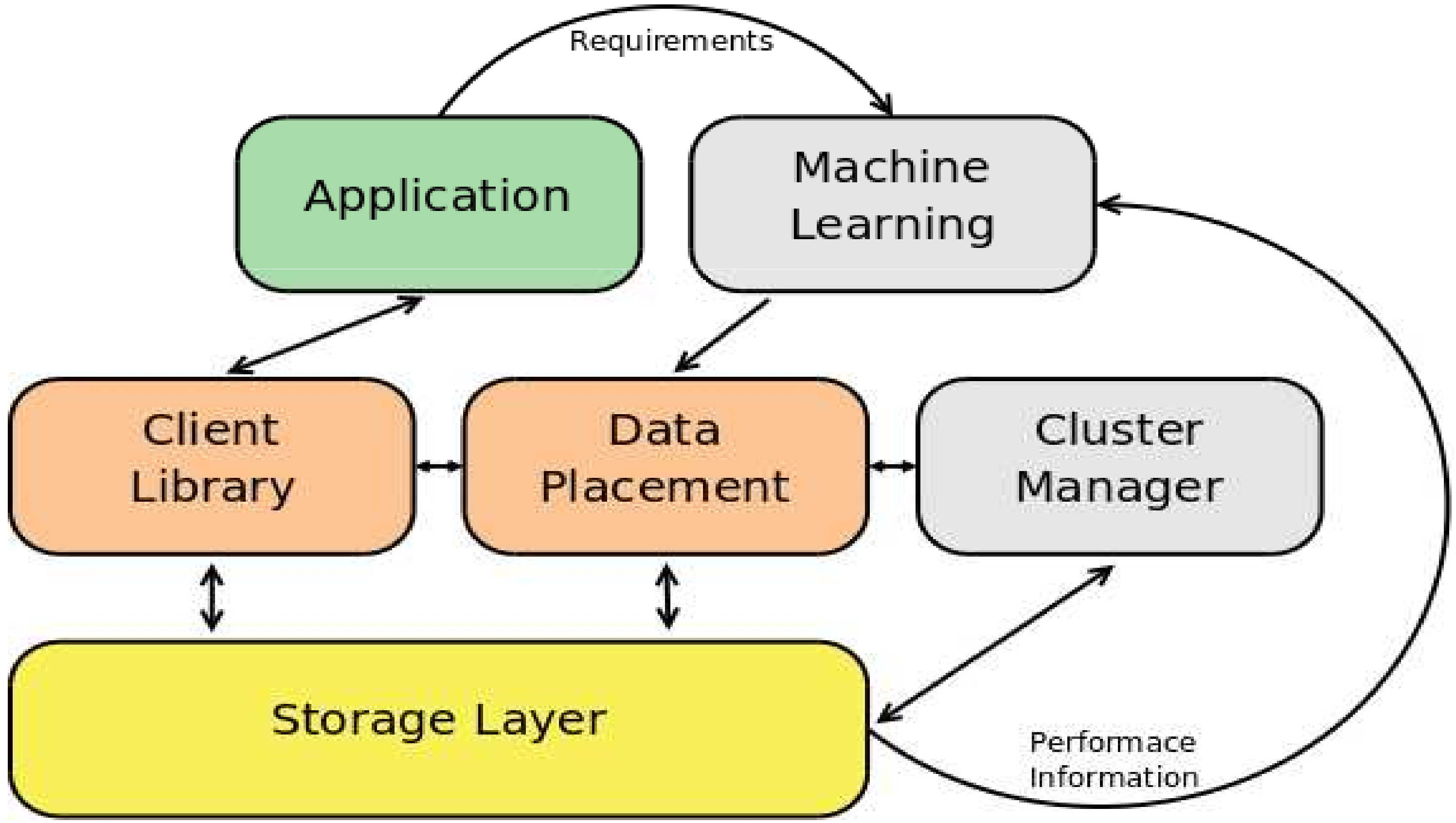
SCADS Overview

- SCADS is a scalable, non-relational datastore for highly concurrent, interactive workloads.
- Scale Independence - as new users join
  - No changes to application
  - Cost per user doesn't increase
  - Request latency doesn't change
- Key Innovations
  1. Performance safe query language
  2. Declarative performance/consistency tradeoffs
  3. Automatic scale up and down using machine learning

Toolkit Motivation

- Investigated other open-source distributed key-value stores
  - Cassandra, Hypertable, CouchDB
  - Monolithic, opaque point solutions
  - Make many decisions about how to architect the system a-prori
- Want set of components to rapidly explore the space of systems' design
  - Extensible components communicate over established APIs
  - Understand the implications and performance bottlenecks of different designs

SCADS Components



Component Responsibilities

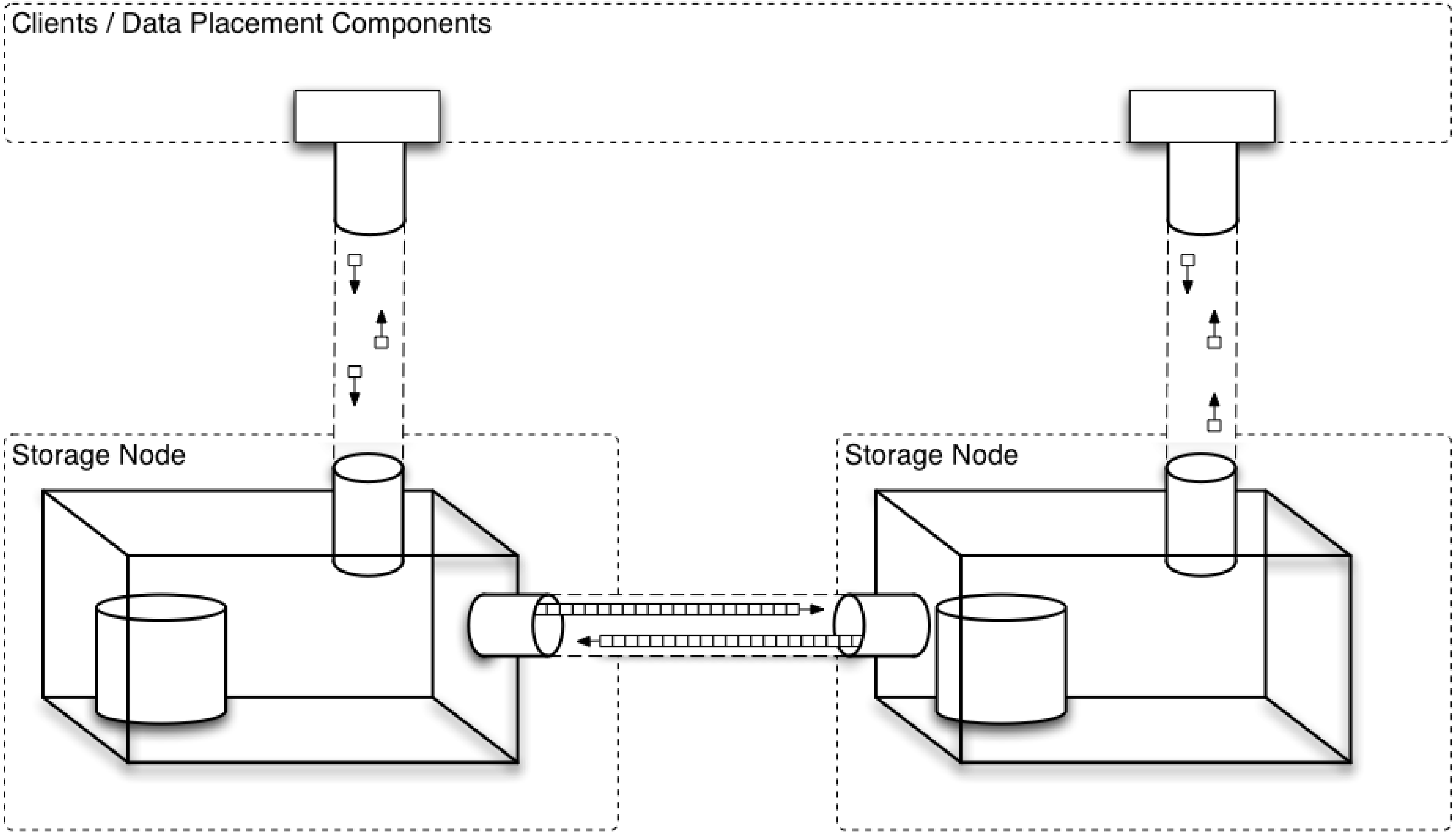
- Storage Layer
  - Persist and serve data for a specified key responsibility
  - Copy and sync data between storage nodes
- Data Placement Layer
  - Assign node key responsibilities
  - Manage replication and partition factors
  - Provide clients with key to node mapping
  - Provides mechanism for machine learning policies
- Client Library
  - Hides client interaction with distributed storage system
  - Provides higher-level constructs like indexes and query language

Storage Layer

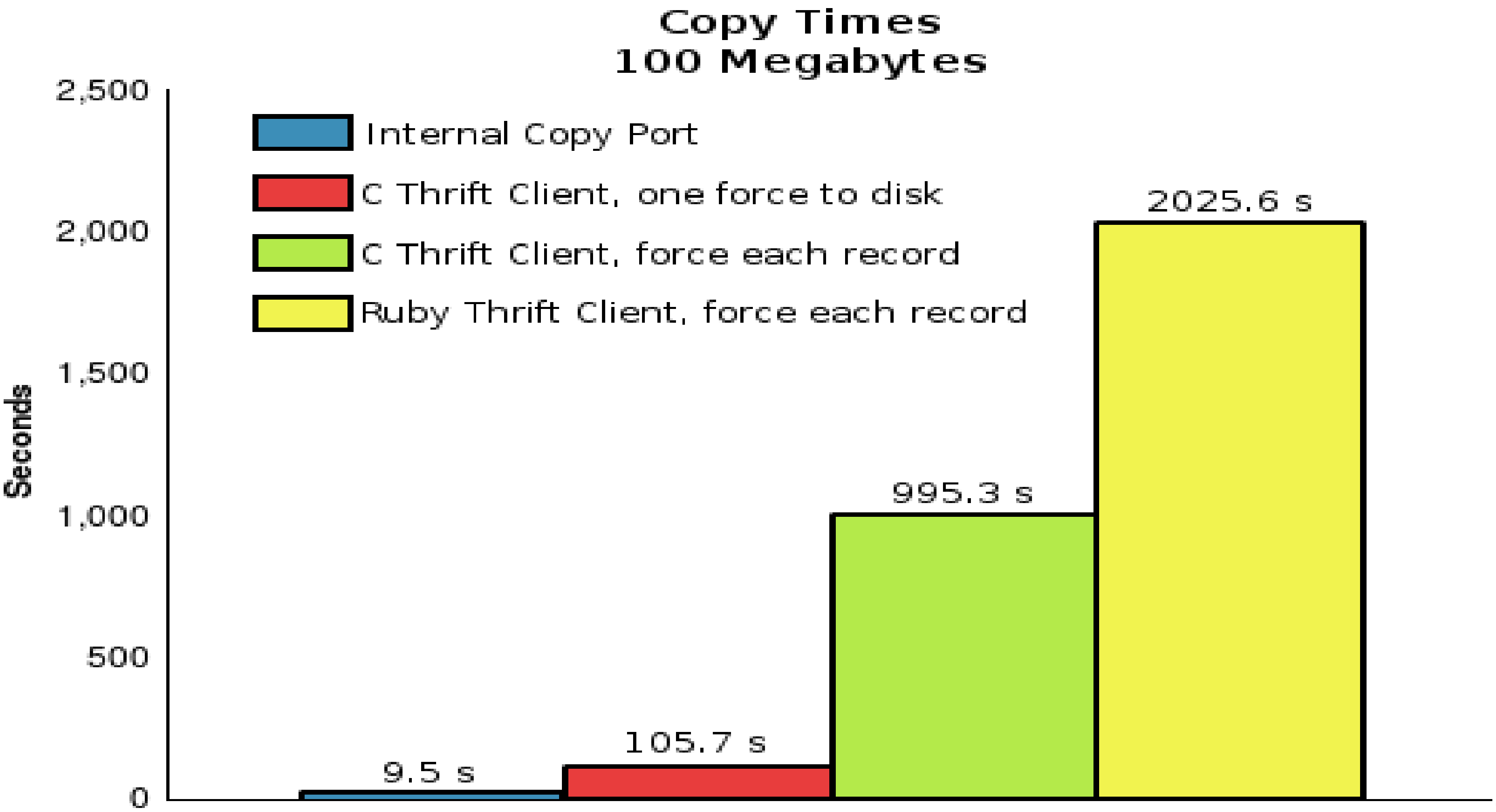
- Key-value store that supports range queries built on BDB
- API

```
Record get(NameSpace ns, RecordKey key)
list<Record> get_set(NameSpace ns, RecordSet rs)
bool put(NameSpace ns, Record rec)
i32 count_set(NameSpace ns, RecordSet rs)
bool set_responsibility_policy(NameSpace ns,RecordSet policy)
RecordSet get_responsibility_policy(NameSpace ns)
bool sync_set(NameSpace ns, RecordSet rs, Host h, ConflictPolicy
    policy)
bool copy_set(NameSpace ns, RecordSet rs, Host h)
bool remove_set(NameSpace ns, RecordSet rs)
```

Storage Layer



Storage Layer

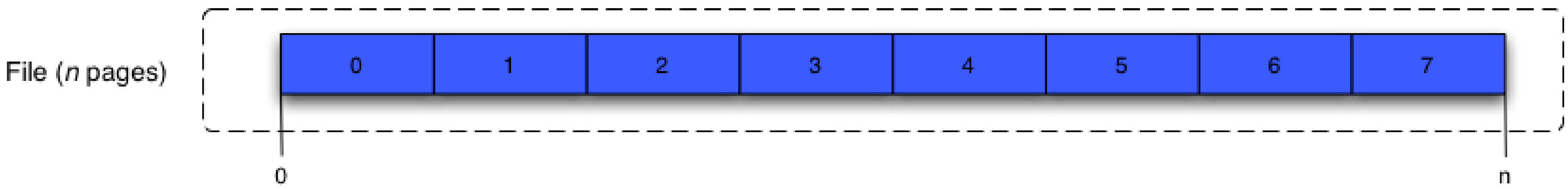


Storage Layer: Synchronize

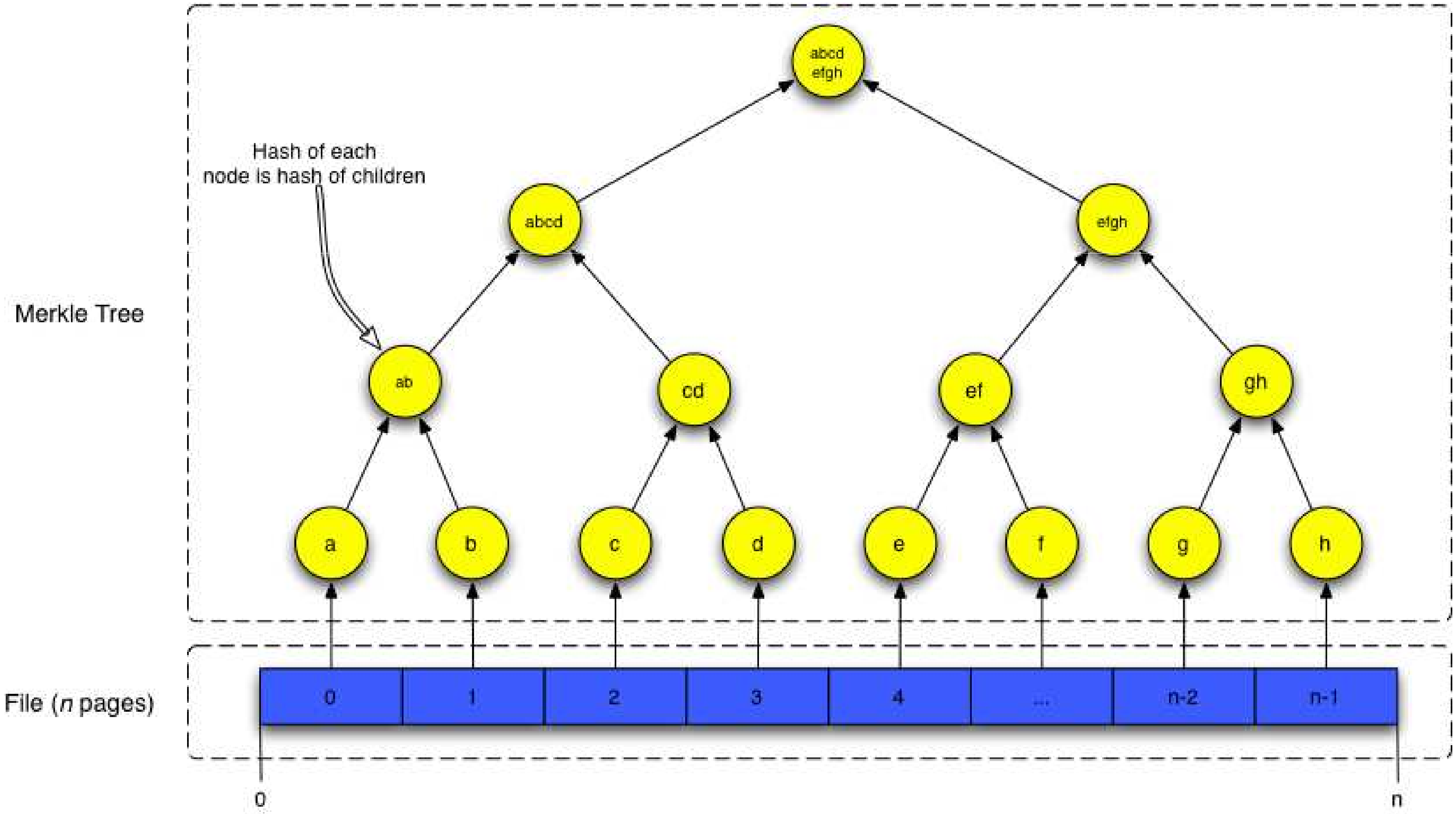
- Replicas may diverge during network partitions (in order to preserve availability).
- Need way to resolve divergence when connectivity is restored.
- But, nodes may store arbitrarily large quantities of data
- So...
- Need efficient way to determine set difference between nodes (key-value pairs with differing values or the presence of new pairs)
- Sounds like a job for: Merkle Trees!

Merkle Tree

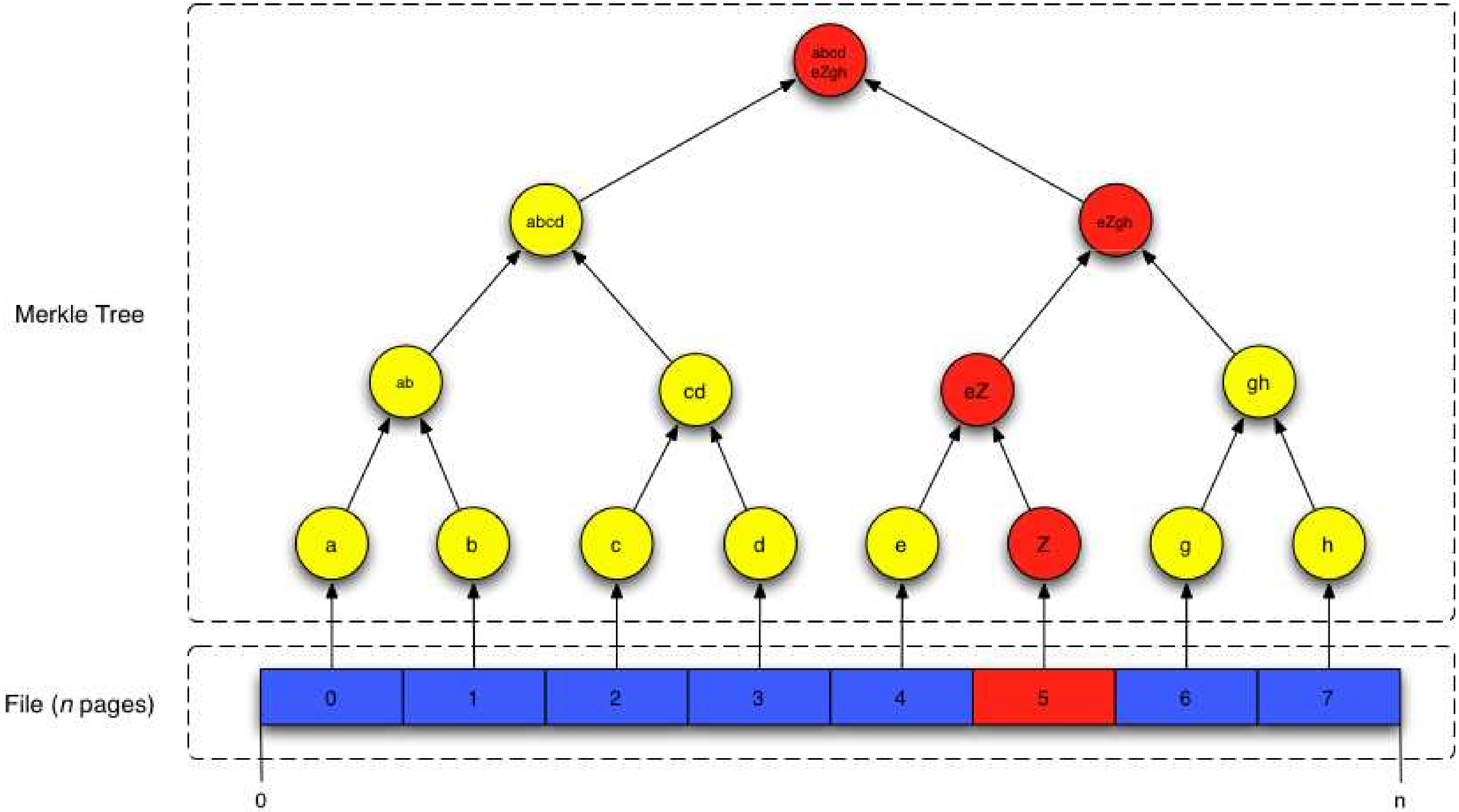
- Merkle Tree (a.k.a Hash Tree)
  - Tree that computes a signature for a file by recursively hashing the nodes of the tree.
  - Can quickly determine which portions of a file are different
- Quick How-to:
  - Take a file of length *n*



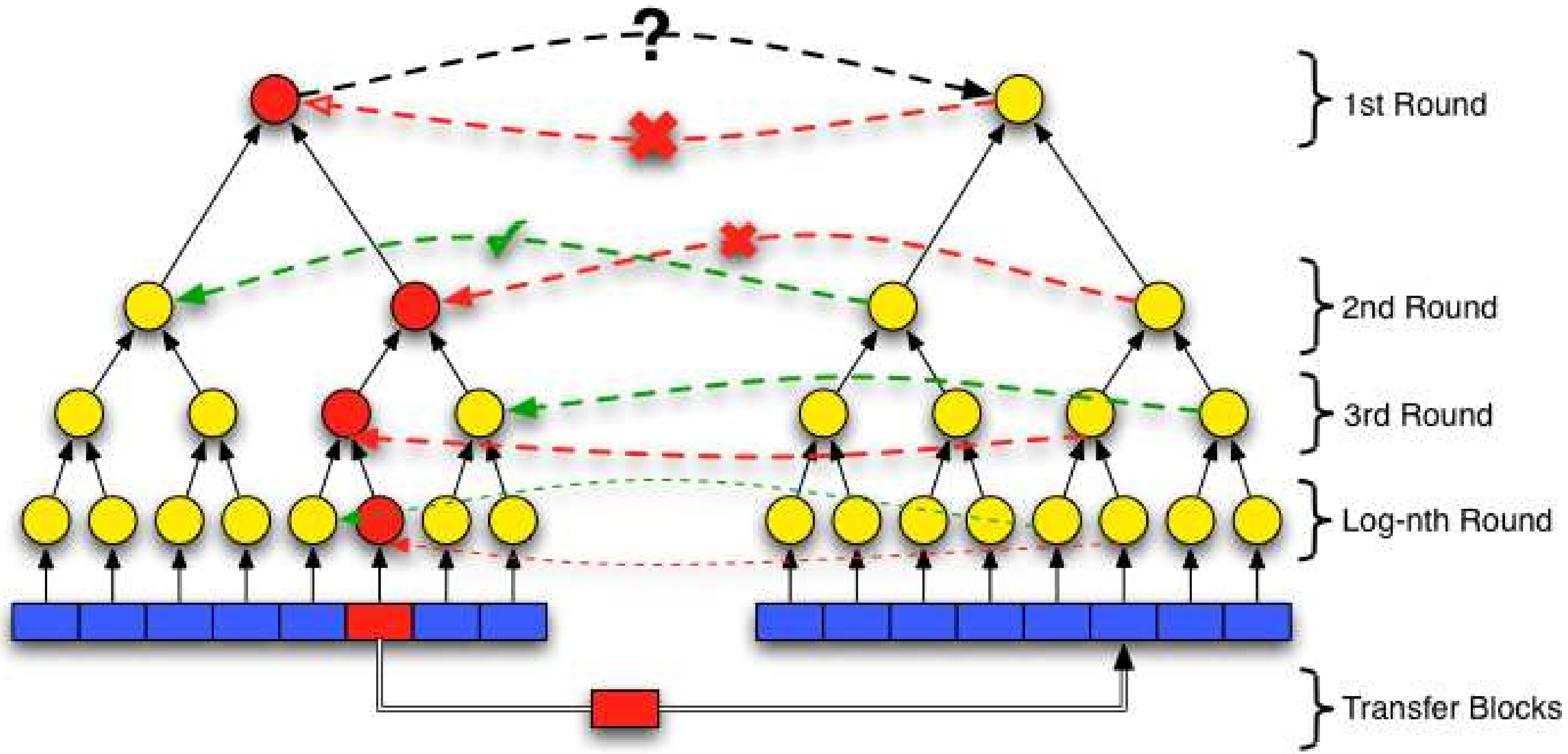
Merkle Tree: Construction



Merkle Tree: Inserts



Merkle Tree: Sync

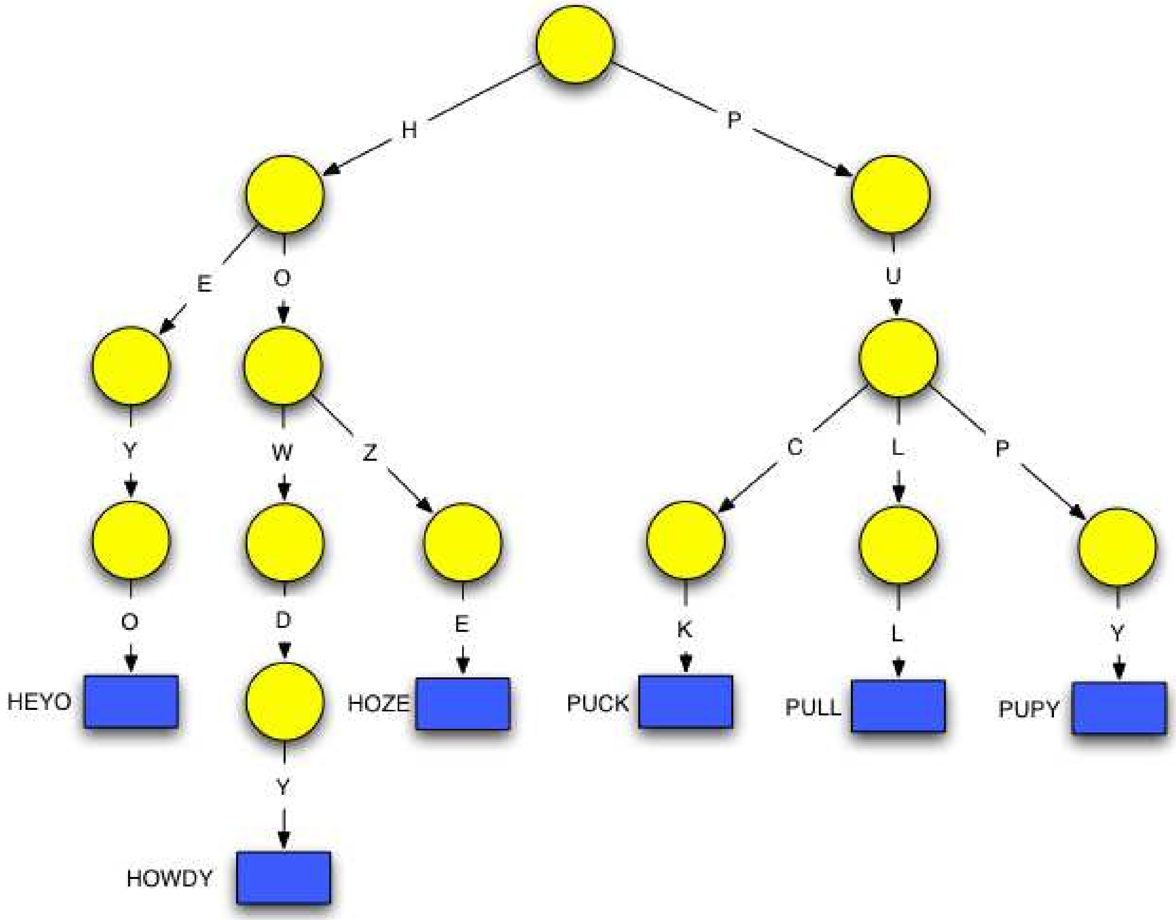


Storage Engine

- Alas, Merkle Tree relies on known quantity of data. :(
- We have a key-value store, may have inserts or deletions on one side and not the other... Need a dynamic data structure.
- Furthermore, we can't use a regular B-Tree.
  - Insertions may occur in different orders
  - Re-balancing the root would result in entirely different hash for the tree.
- We need a tree that has a deterministic structure, given a set of key-value pairs
  - Trie!

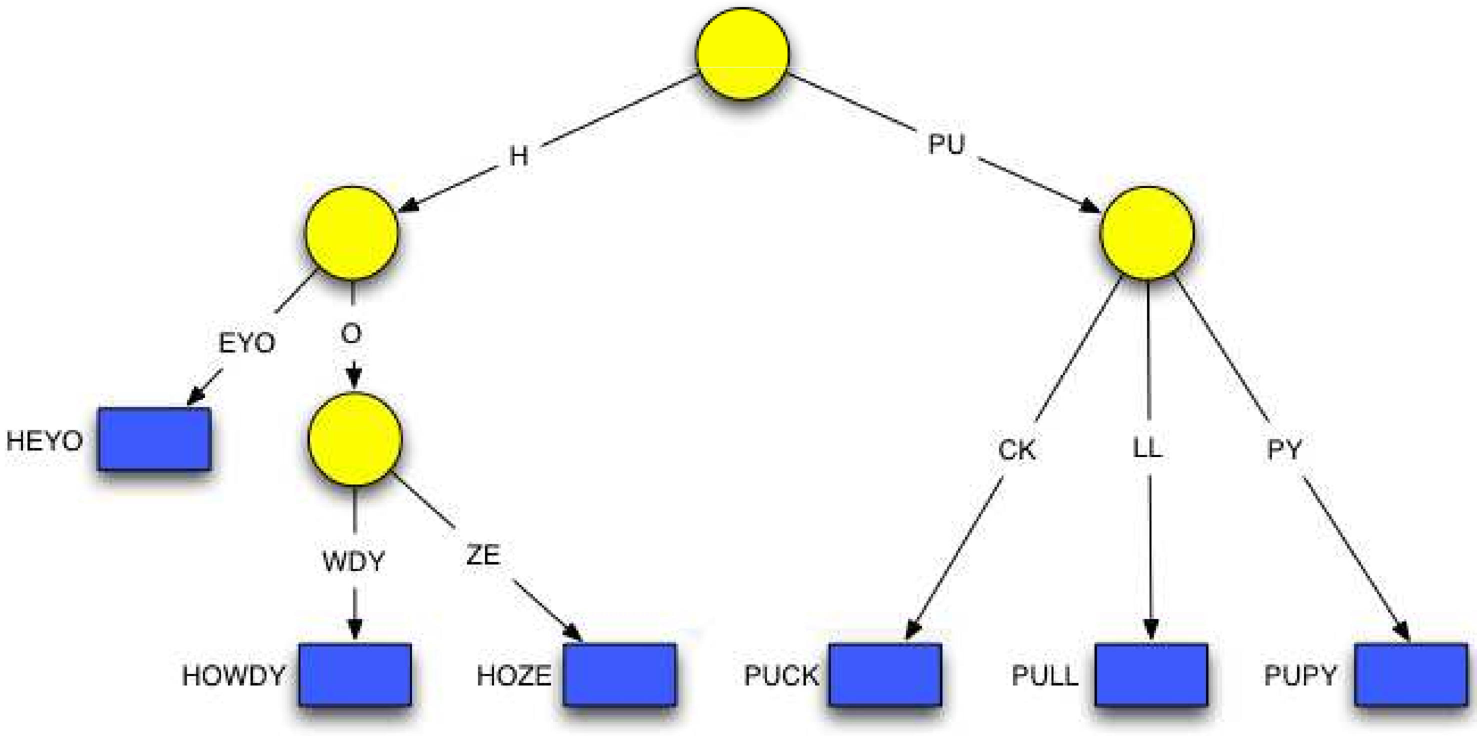
Trie (a.k.a Prefix Tree)

- Edges labeled with characters
- Key is path to leaf
- Compute hashes up this tree

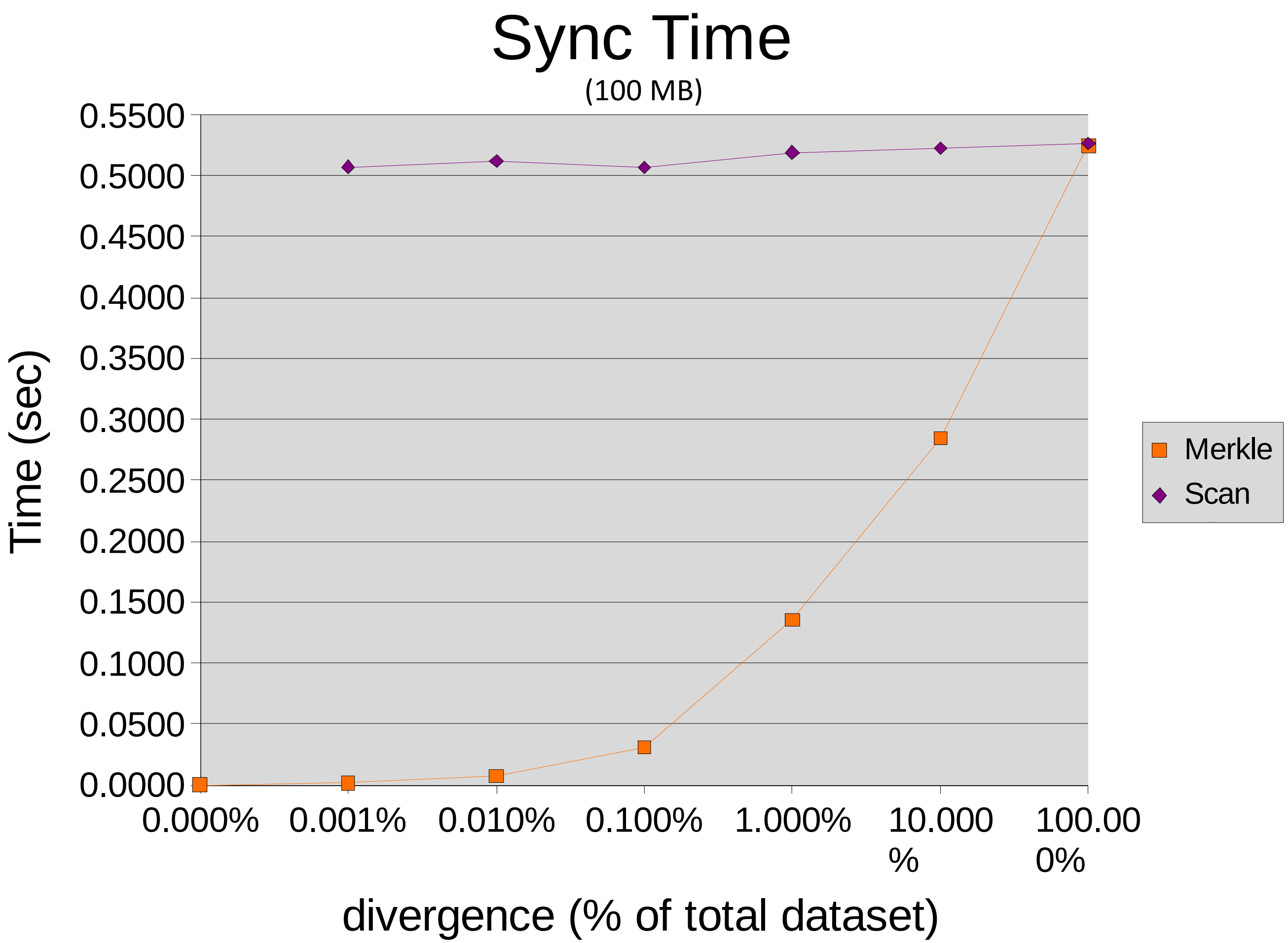


Patricia Trie

- Optimization:
  - Collapse any node that has only one child



Sync: performance



Sync Conclusion

- Merkle Trees areTiger Hash are often called Tiger Trees.
- We are using the Tiger Hash Algorithm
- Thus, we are using a “Patricia Merkle Tiger Trie”
  - Awesome.

Data Placement & Client Library

- Data Placement Layer
  - Maintains global view of data placement in cluster via node to key range mappings
  - Orchestrates transfer of data and changes in node responsibility polices without interruption in data availability
- Client Library
  - Receives requests from client applications
  - Caches key to node mappings received from DP layer
  - Current implementation: ROWA
  - Coordinates get_set() requests to nodes to satisfy client

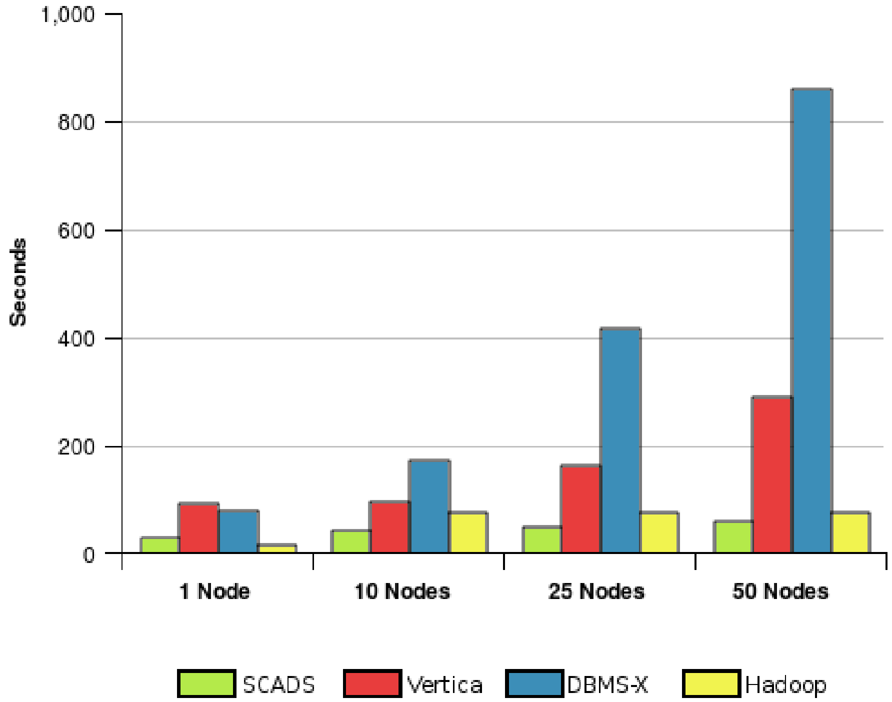
Mechanics of Data Movement

- Machine learning: “move data from node A to node B”
- Copy data from A to B
- Map data assignments to A and B
- Assign B’s responsibility policy
- Update A’s responsibility policy
- Sync A and B
- Remove old data from A

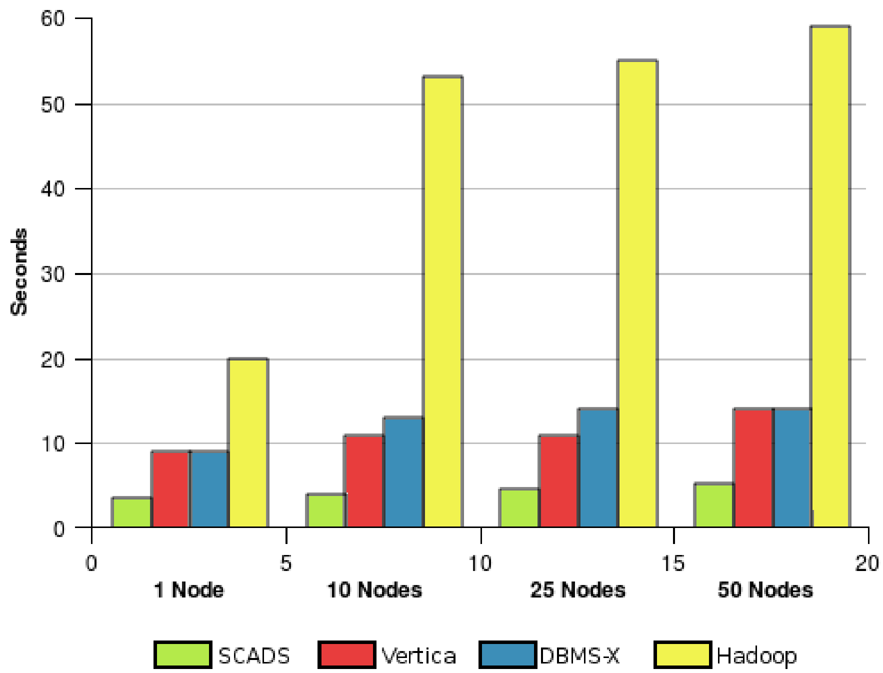
SCADr

- Goal
  - Gain experience with how application developers use SCADS
  - See what performance problems arise
- Twitter clone written in RoR by undergraduates
  - Use SCADS instead of ActiveRecord
- DEMO!
  - http://scadr.radlab.net
    - Use it!

Performance Tests: GREP

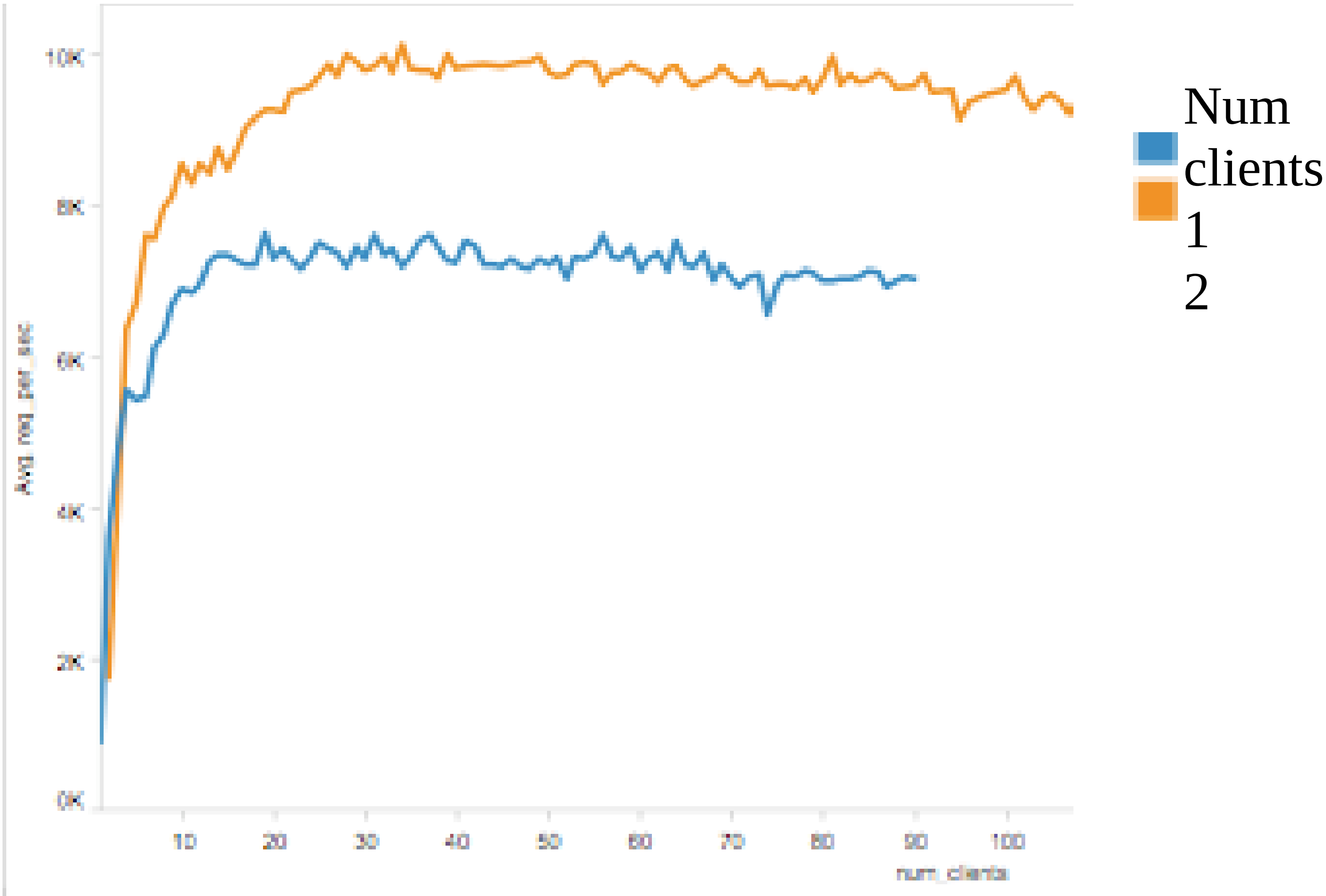


Load times

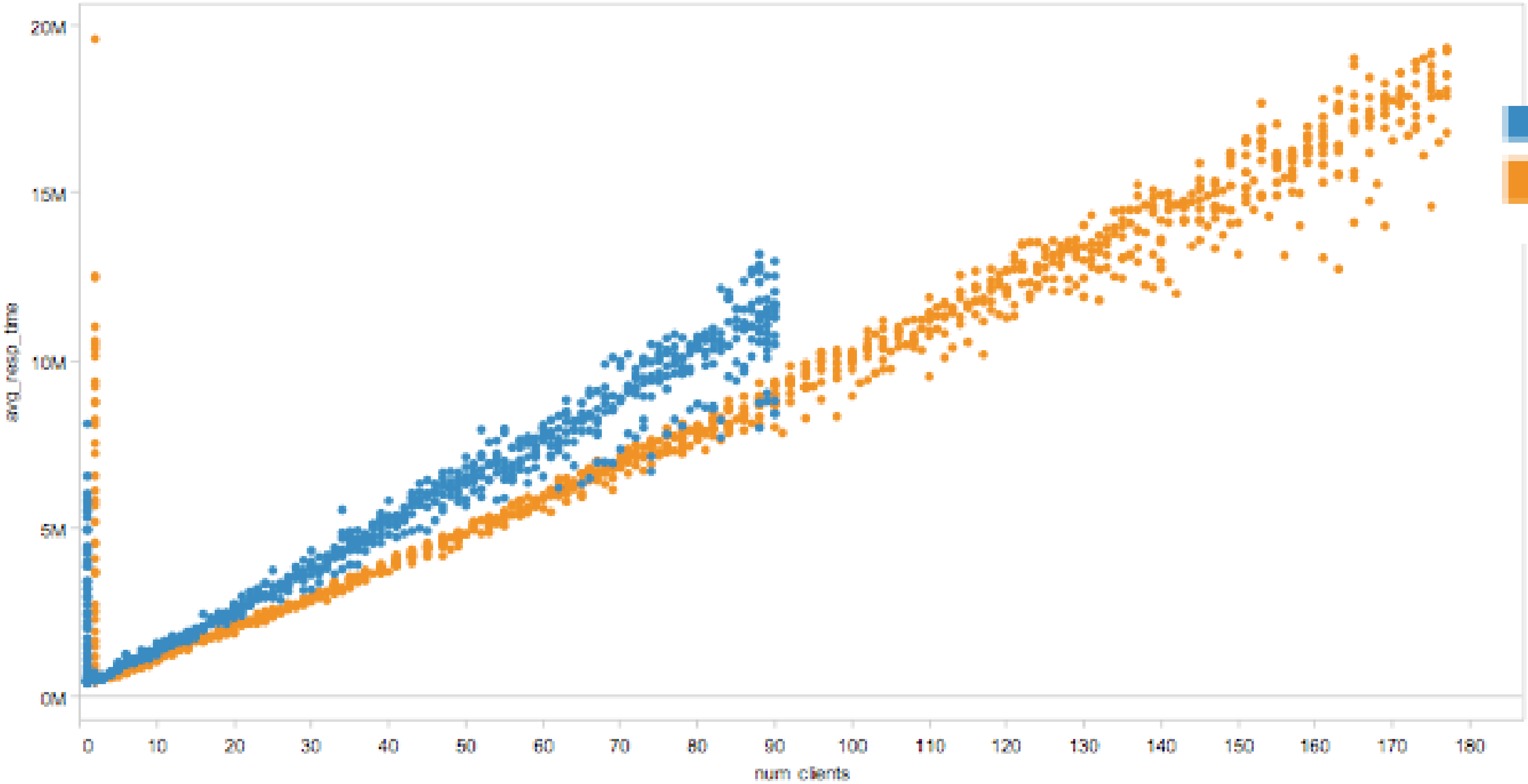


Task times

Performance Tests: Storage Layer

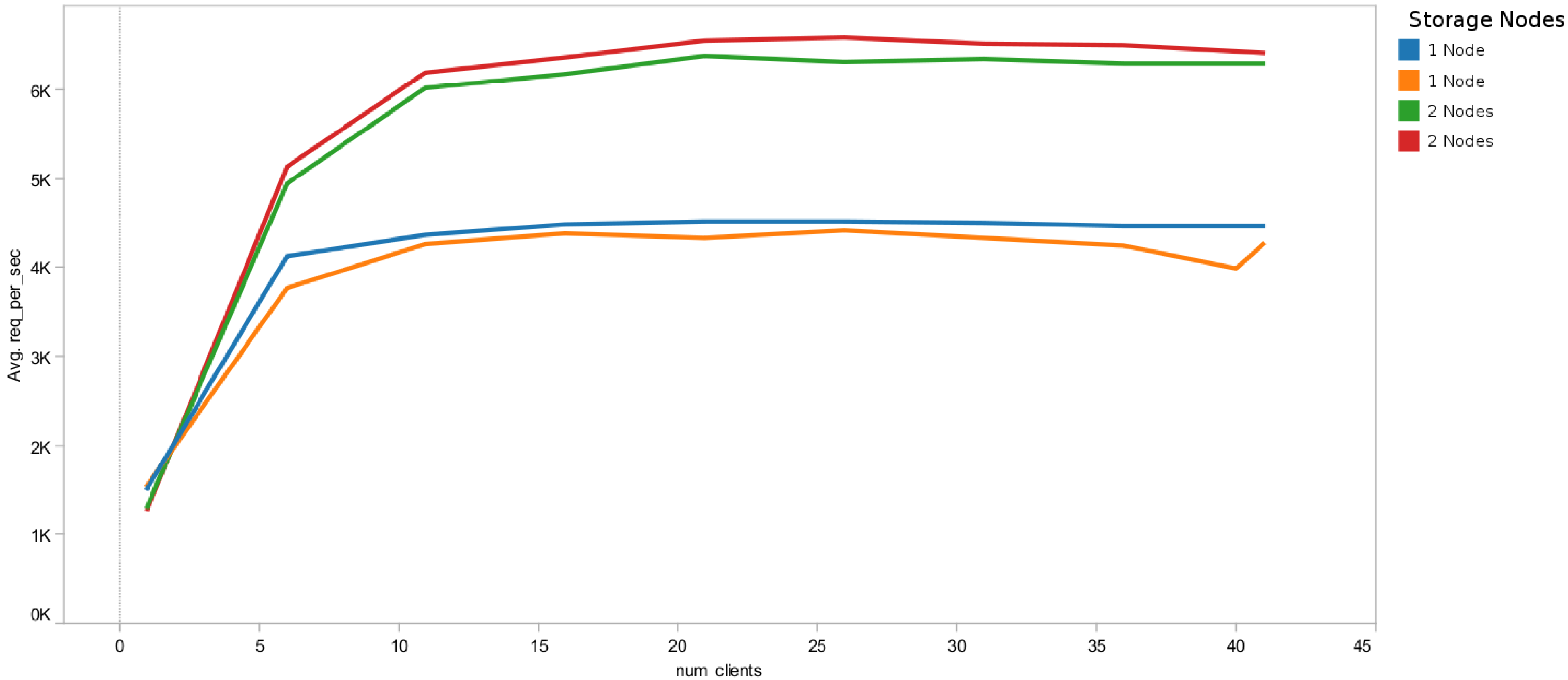


Performance Tests: Storage Layer

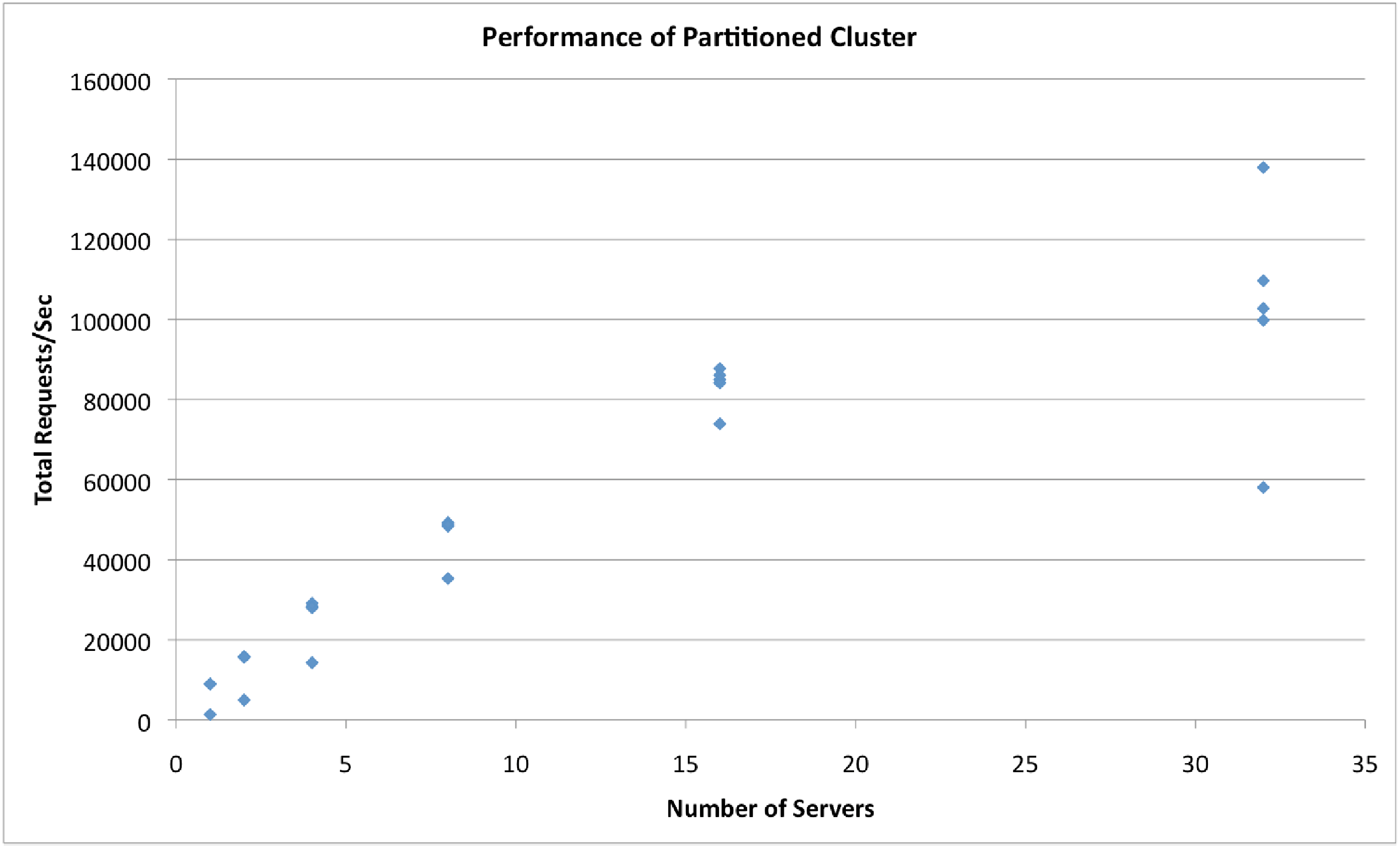


Num clients
1
2

Performance Tests: Data Placement



Performance Tests: More Nodes



Future Work

- Predicting system performance
  - X-Trace track requests through system components
  - Built into Thrift protocol layer