Performance Debugging Scalable Table Stores using YCSB++

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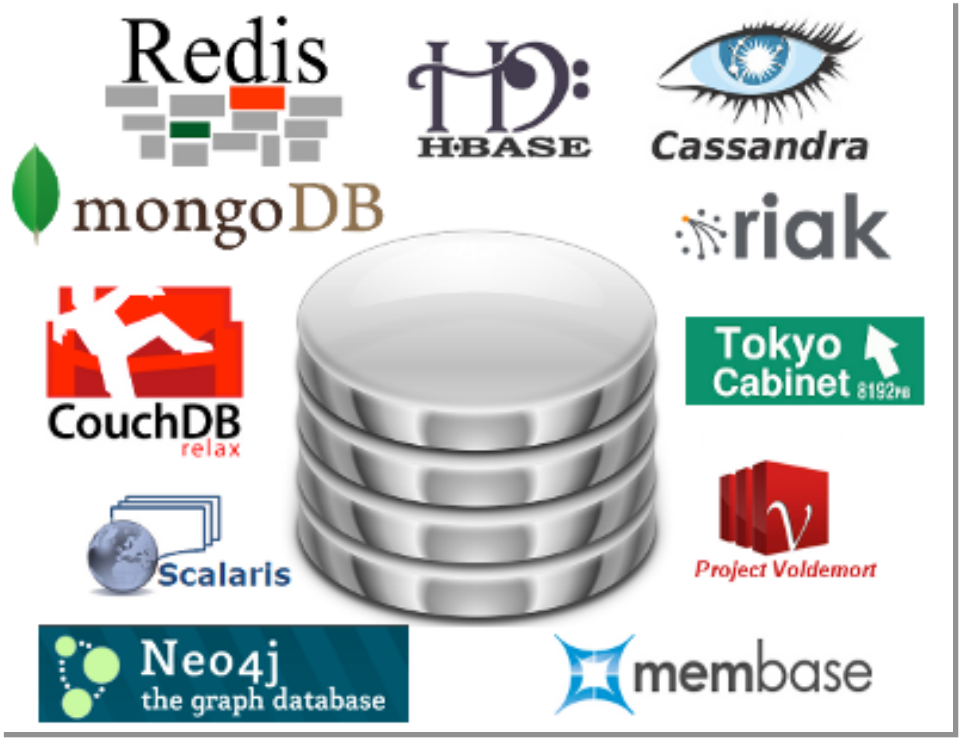
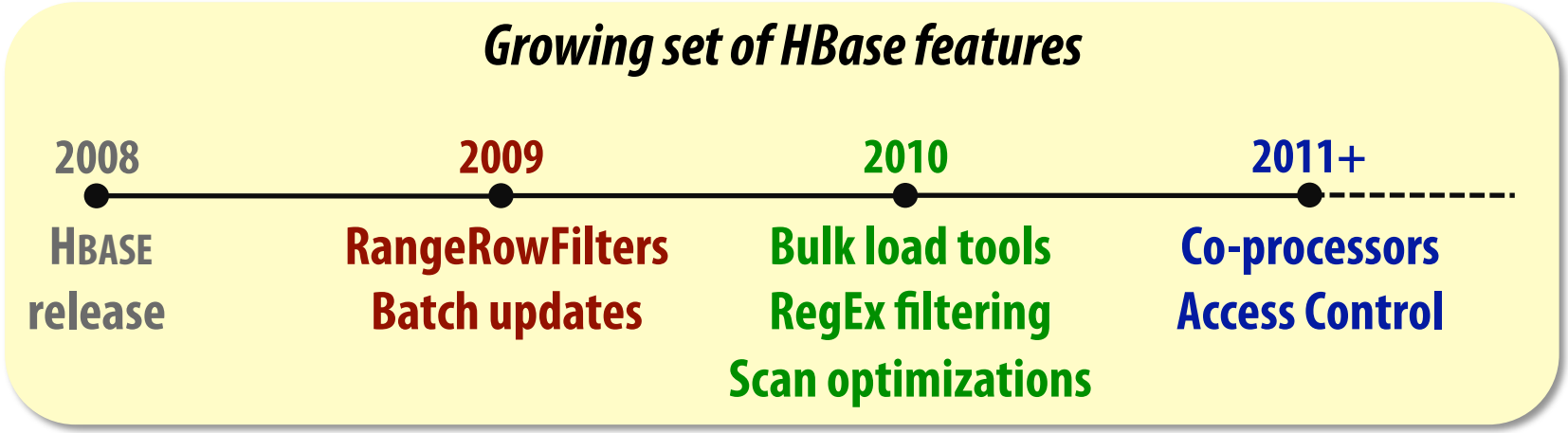
Importance of scalable table stores



- For data processing and analysis
- For systems services (e.g., metadata in Colossus)

Growing complexity of table stores



Simple, lightweight → complex, feature-rich stores

- Supports a broader range of applications
- Hard to debug performance issue and complex component interactions

State of table store benchmarking

YCSB: Yahoo Cloud Serving Benchmark *[Cooper2010]*

- Modular design to test different table stores
- Great for CRUD (create-read-update-delete) benchmarking, but not for sophisticated features

Need richer tools for understanding advanced features in table stores …

This talk: YCSB++ tool

Mechanisms to ease performance debugging

- Abstractions to write parallel tests with multiple clients and heterogeneous phases
- Integrated monitoring that correlates performance with system behavior

Used to test advanced features

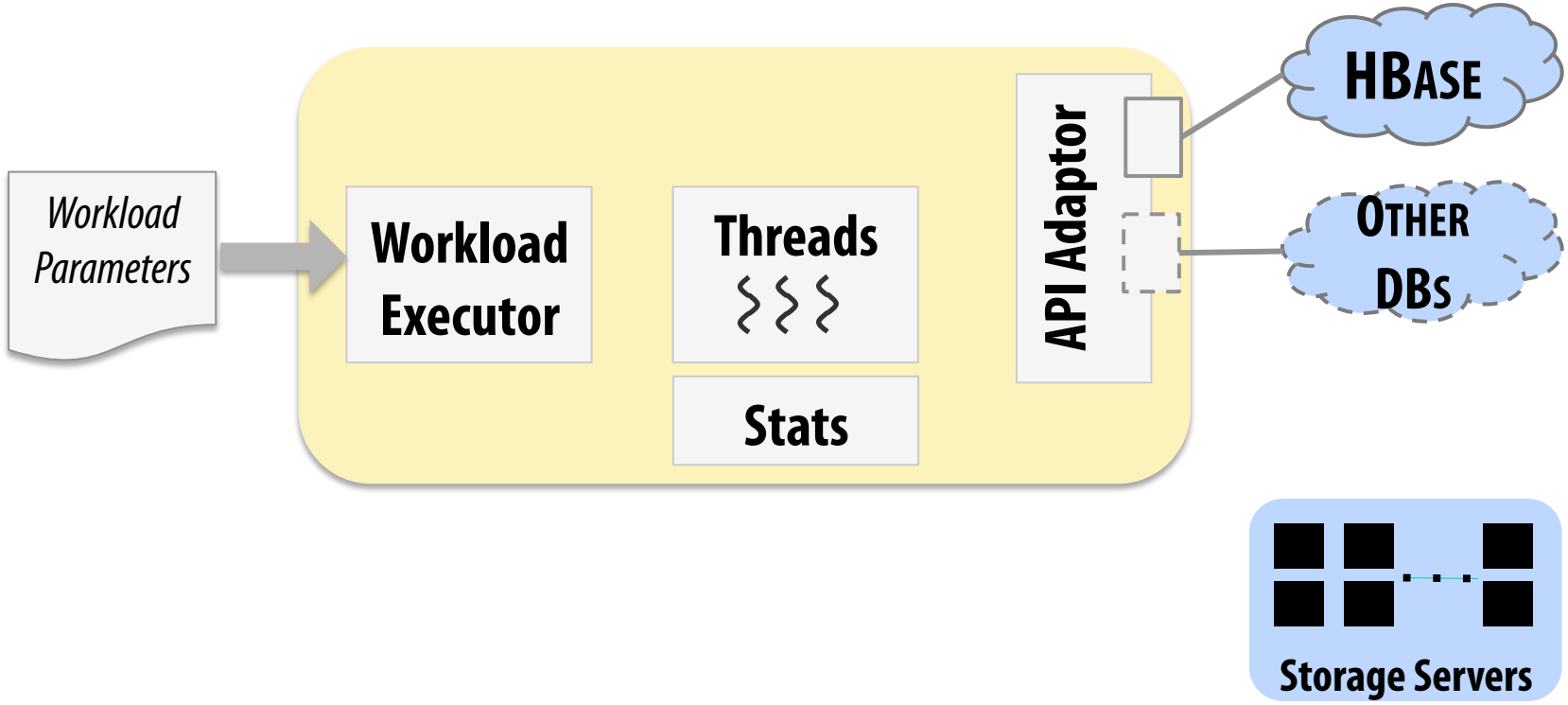
- Bulk loading, table pre-spitting, batch writing
- Weak consistency, server-side filtering, security

Tool released at http://www.pdl.cmu.edu/ycsb++

Talk Outline

- Motivation
- YCSB++ architecture
- Illustrative examples of using YCSB++
- Summary and ongoing work

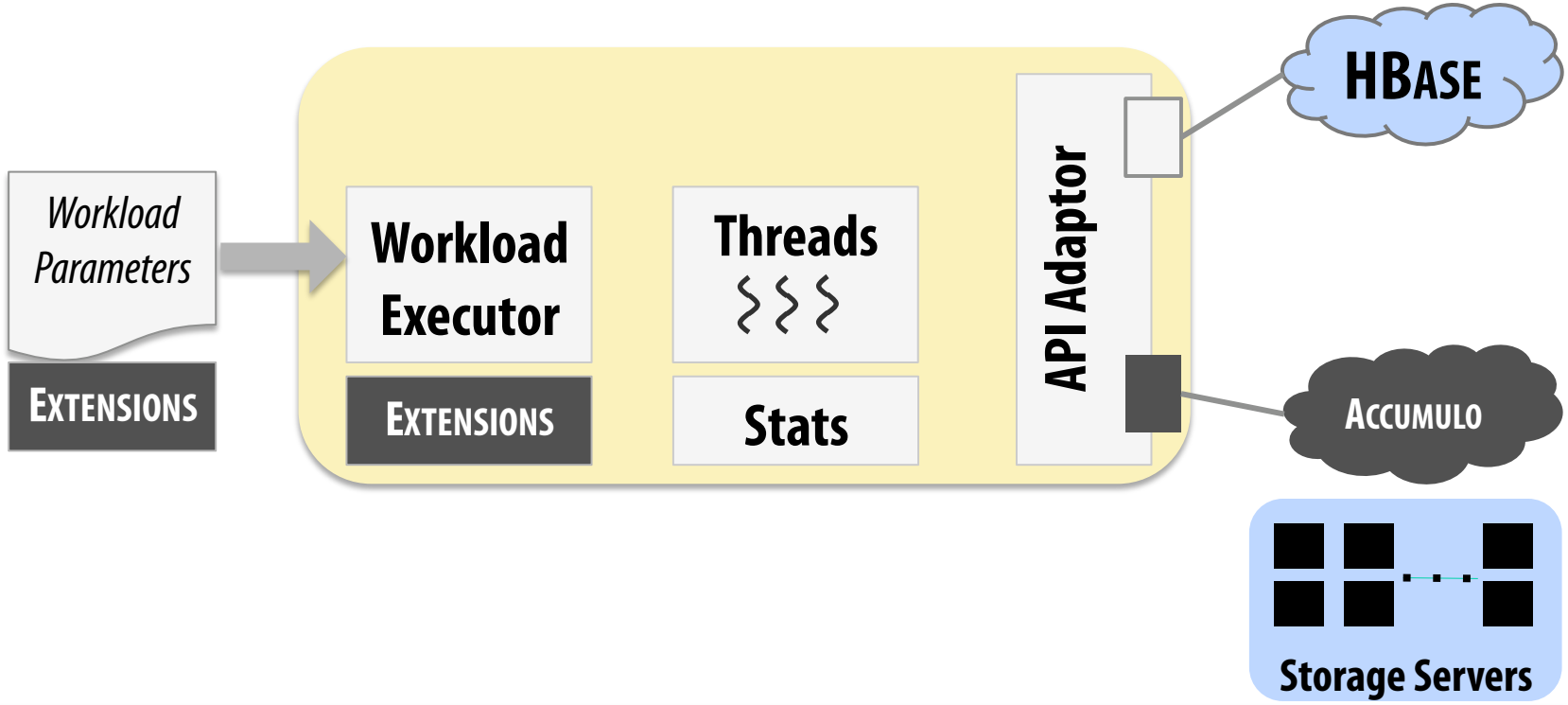
Original YCSB framework



Configurable workload generation to test stores

- API adaptor converts **`read(K)`** to **`hbase_get(K)`**

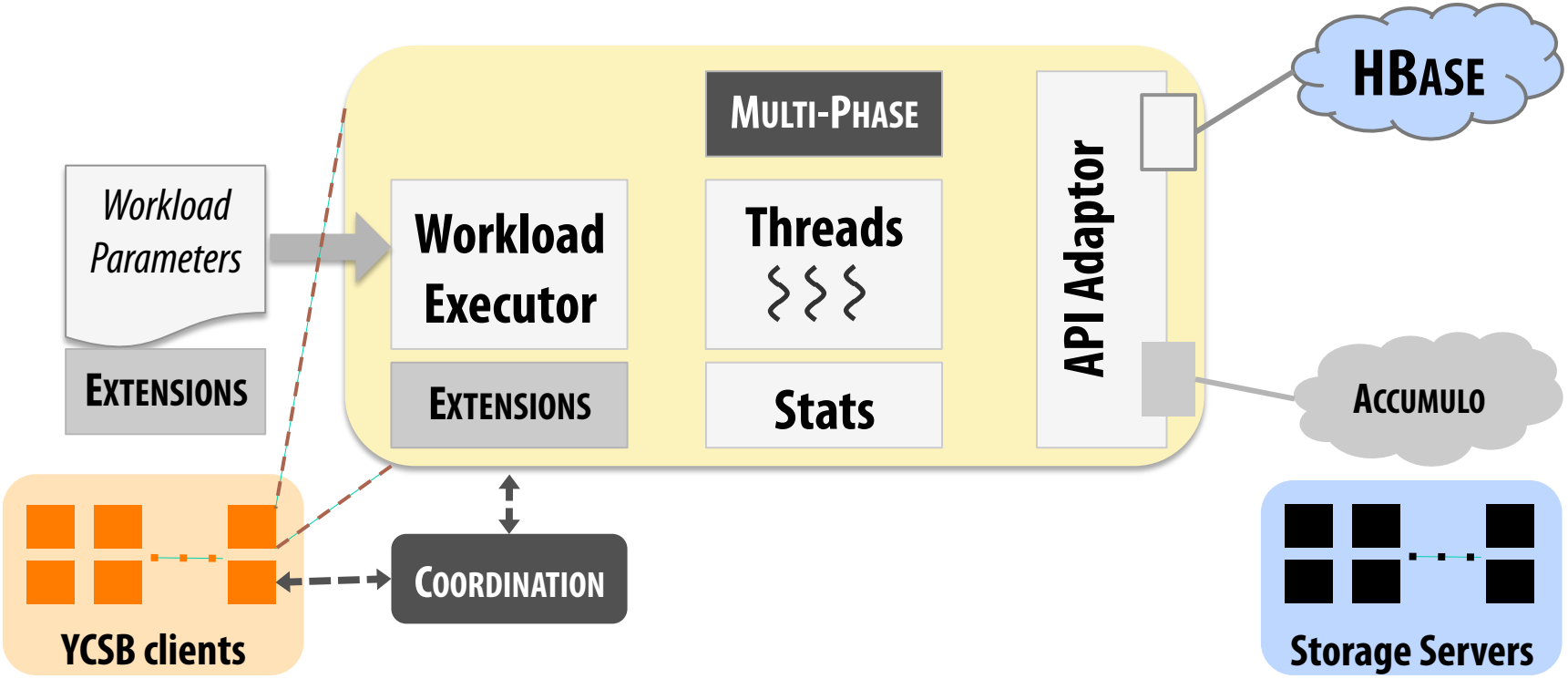
YCSB++ supports new table store



New DB adaptor for Apache Accumulo table store

- New parameters and workload executor extensions

Coordinated & multi-phase tests



ZooKeeper-based coordination & synchronization

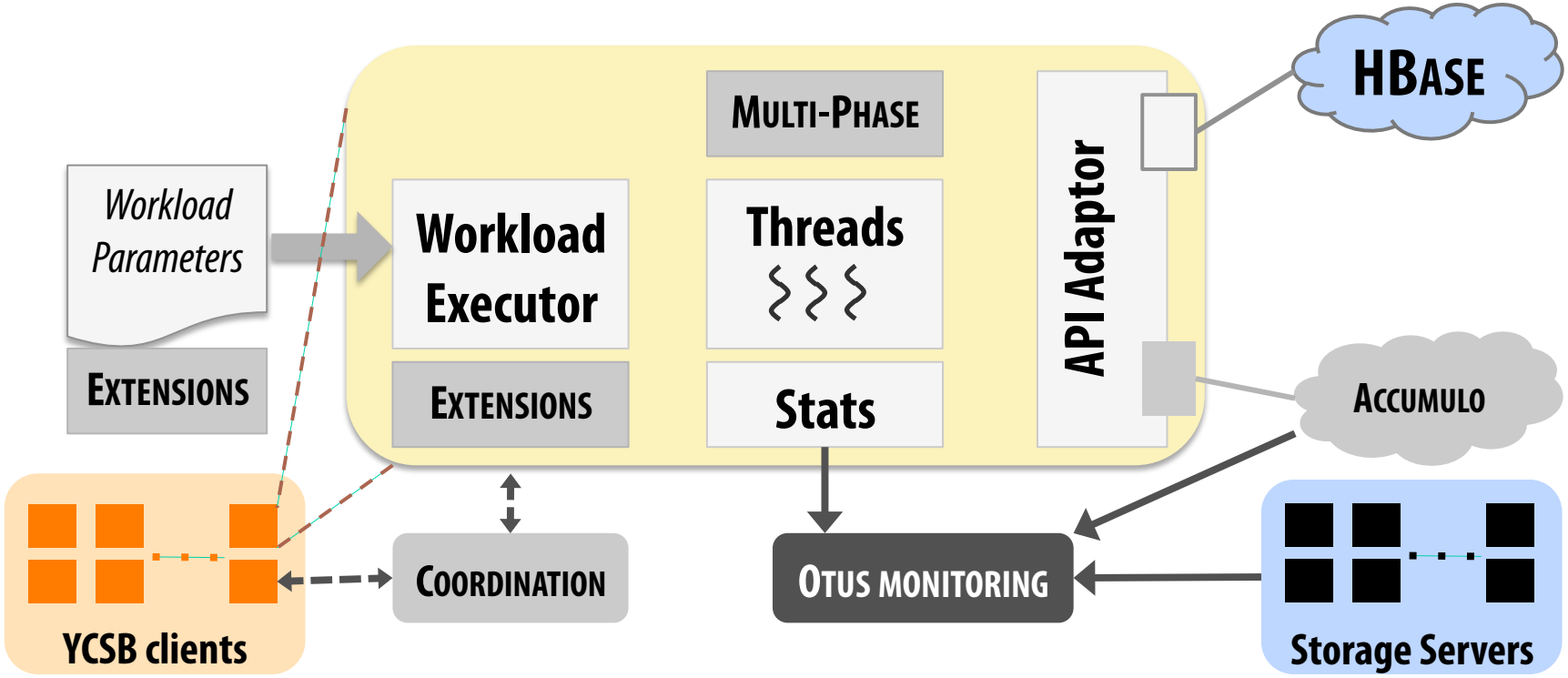
- Enables heavy workloads and asymmetric testing

Coordinated & multi-phase YCSB++

- Distributed, multi-client tests
  - Allows clients to co-ordinate their test actions
  - Rely on shared data structures in ZooKeeper
  - Used to study weak consistency models

- Multi-phase tests
  - Can construct tests comprising of different phases
  - Built on ZooKeeper-based barrier-synchronization
  - Used for analyze high-speed ingest features

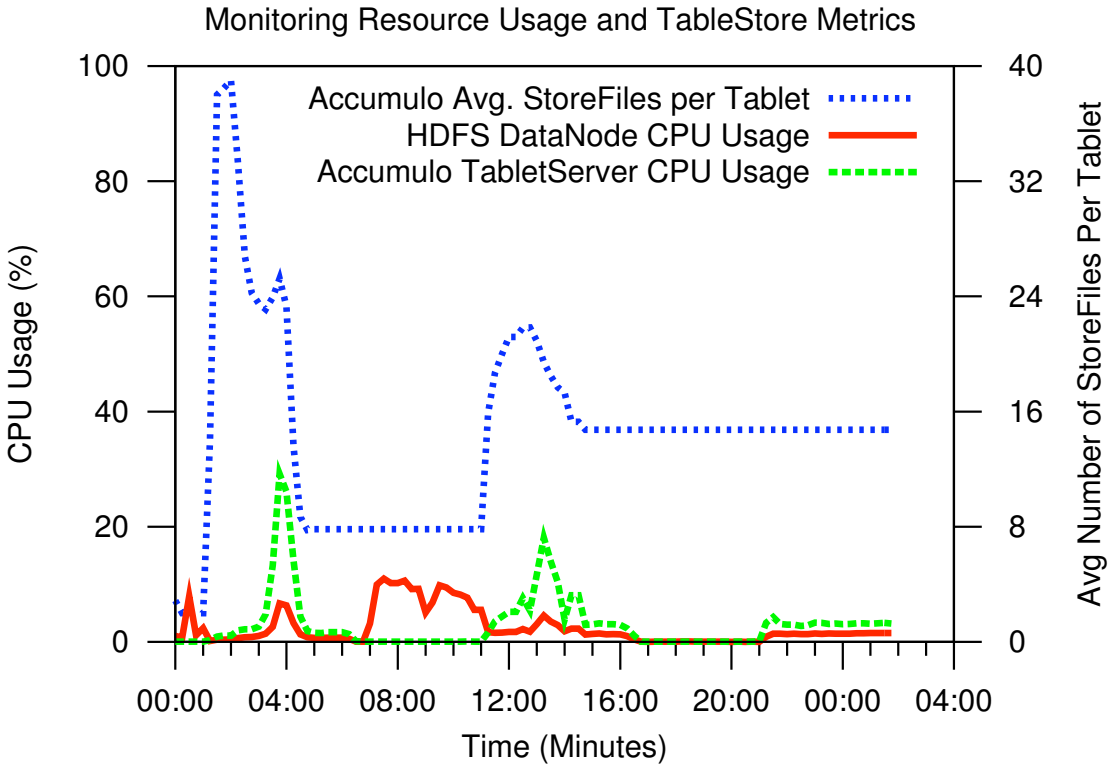
Collective monitoring in YCSB++



Fine-grained resource monitoring using Otus[Ren2011]

- Collects from YCSB, table stores, HDFS and `/proc`

Example of OTUS monitoring



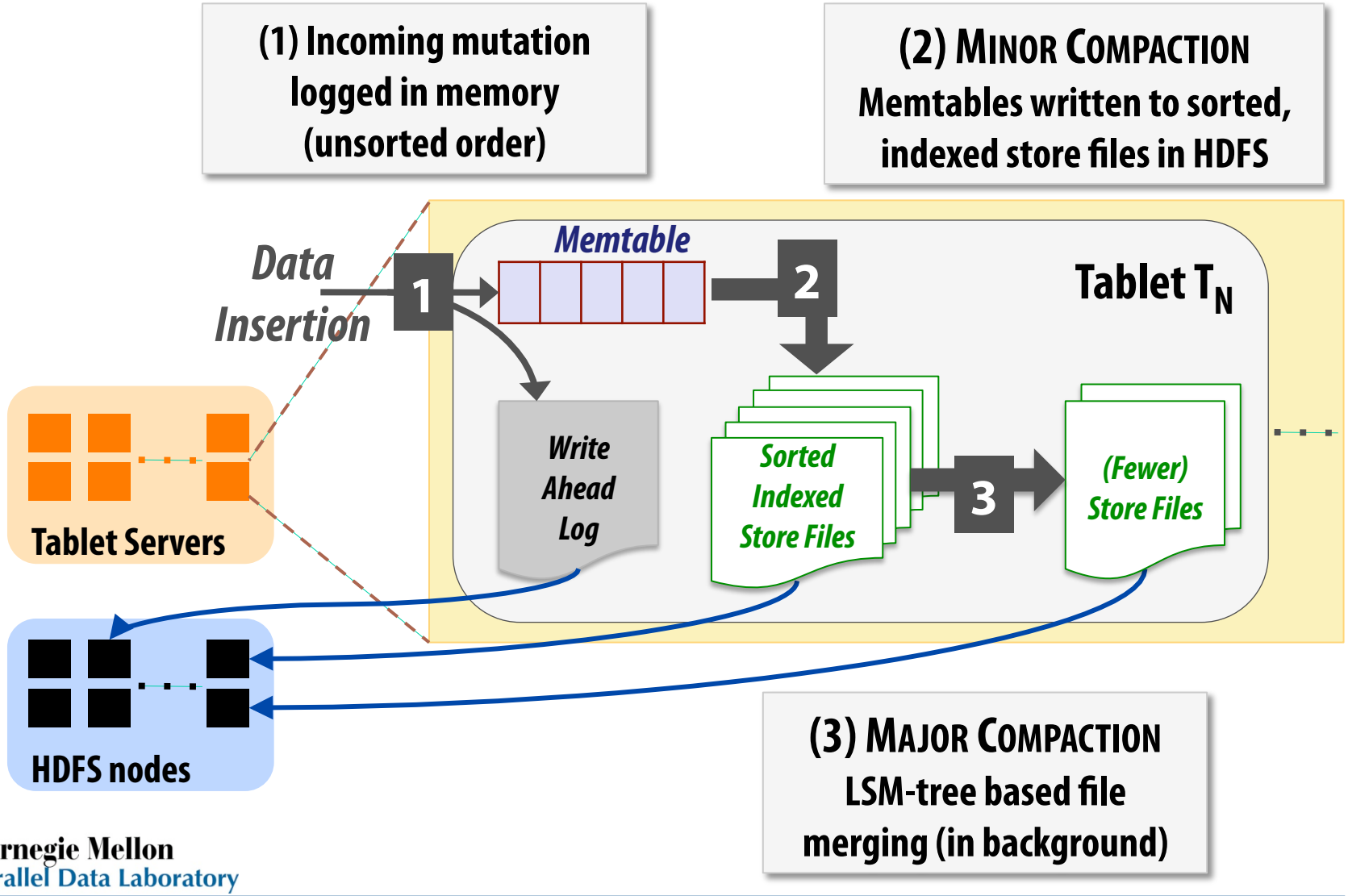
Accounts resources used by different services

- Useful when each machine has multiple services

Talk Outline

- Motivation
- YCSB++ architecture
- Illustrative examples of using YCSB++
  - Case study: HBase and Accumulo
  - Both are Bigtable-like table stores
- Summary and ongoing work

Primer on Bigtable-like stores



Accumulo table store

- Started at NSA; now an Apache project
  - Built for high-speed ingest and scan workloads
  - http://incubator.apache.org/projects/accumulo.html
- New features in Accumulo
  - Iterator framework for user-specified programs placed in different stages of DB pipeline
    - E.g., Supports joins and stream processing
  - Also provides fine-grained cell-level access control
  - Fault tolerant cross-server operations

FEATURES TESTED BY YCSB++

- Table bulk loading
- Batch writing
- Weak consistency
- Table pre-splitting
- Server-side filtering
- Access control

ILLUSTRATIVE EXAMPLE

Table bulk loading

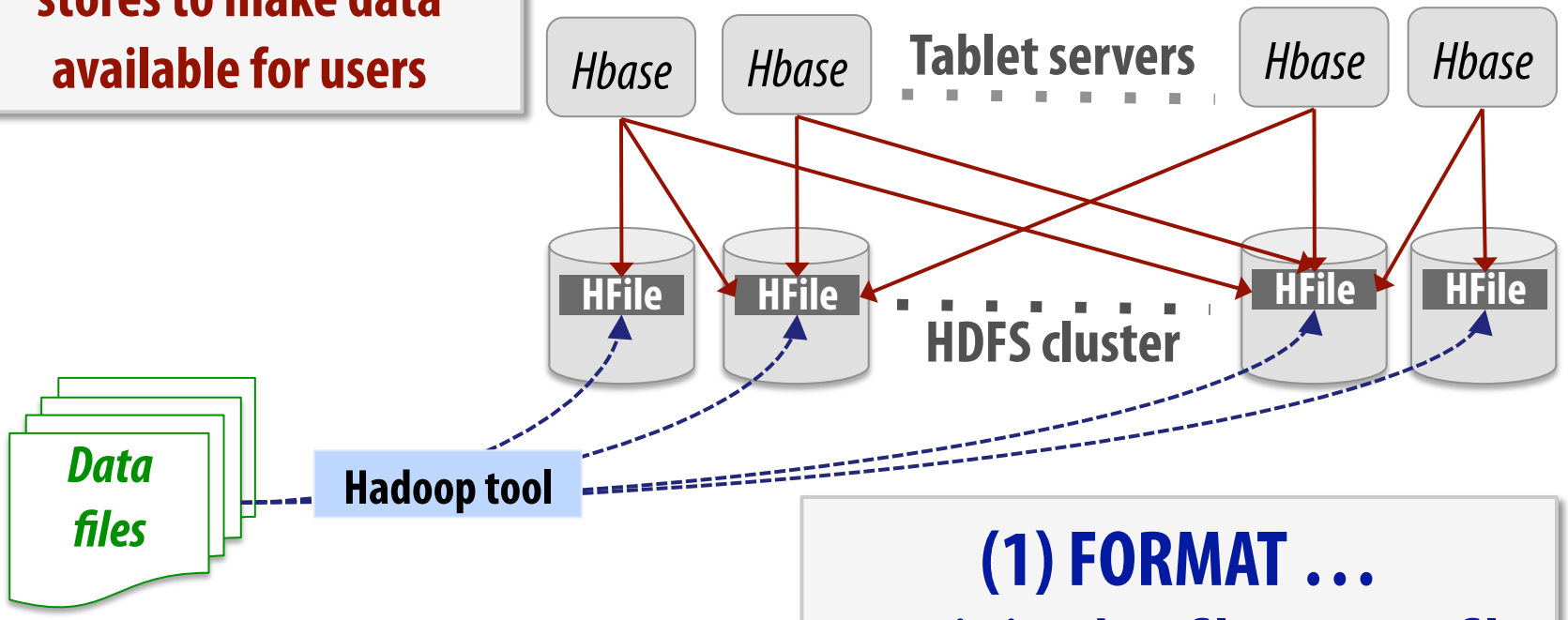
High-speed ingestion through minimal data migration

Need careful tuning and configuration [Sasha2002]

Table bulk loading in action

(2) IMPORT …

… store files into table stores to make data available for users



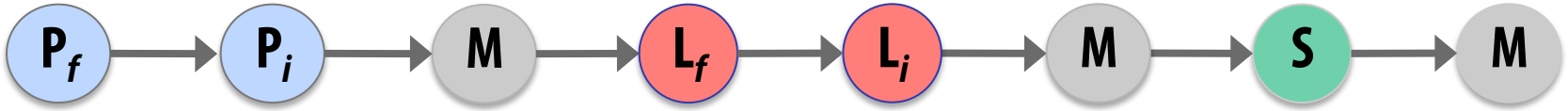
(1) FORMAT …

… existing data files to store-file specific format using Hadoop

8-phase bulk load test in YCSB++

Measurement phase

- Light mix of Read/Update operations
- Interleaved to study performance over time



Pre-load data

- Insert 6M rows in empty table

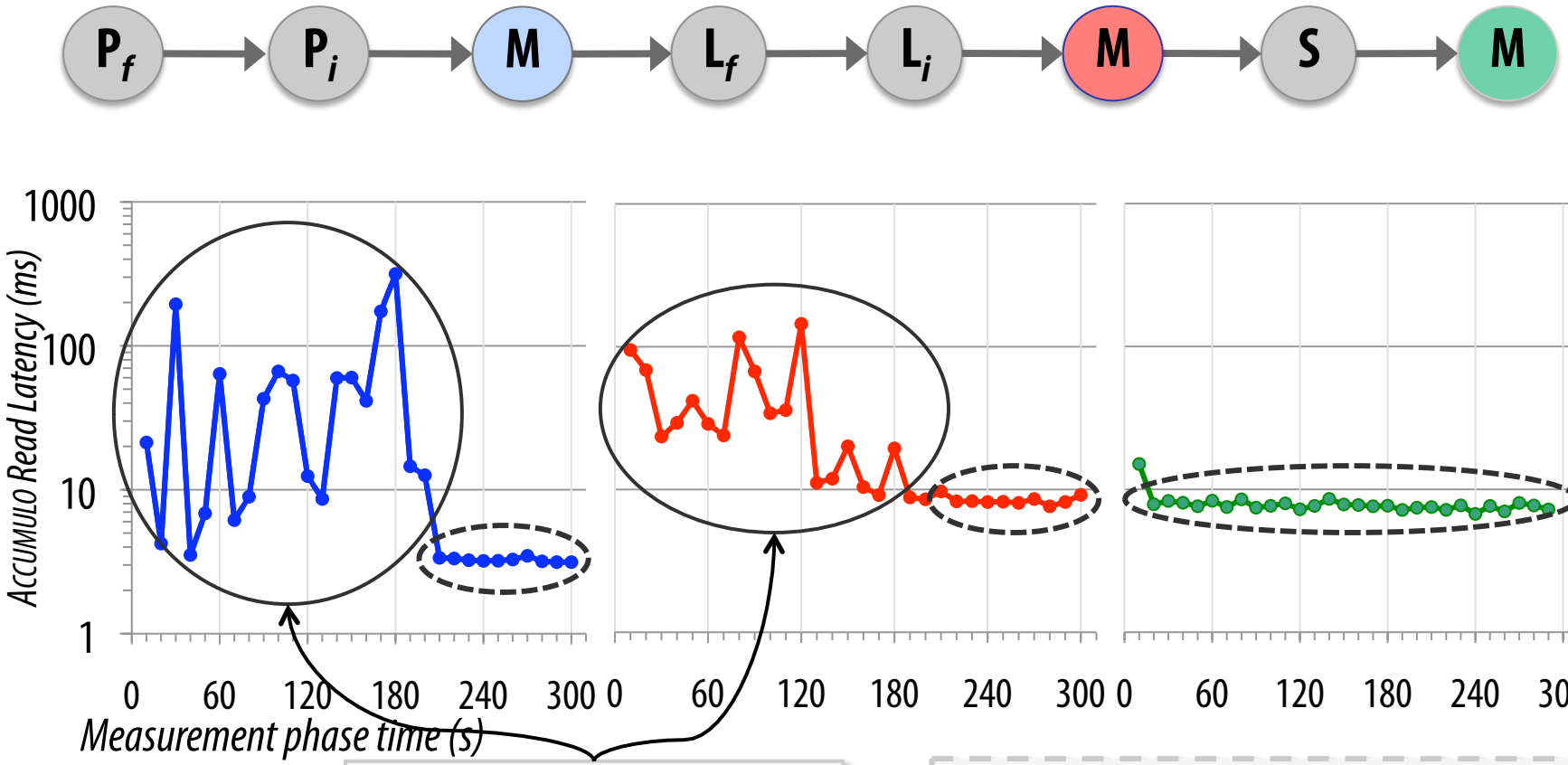
Load data

- Load 48M rows in existing table

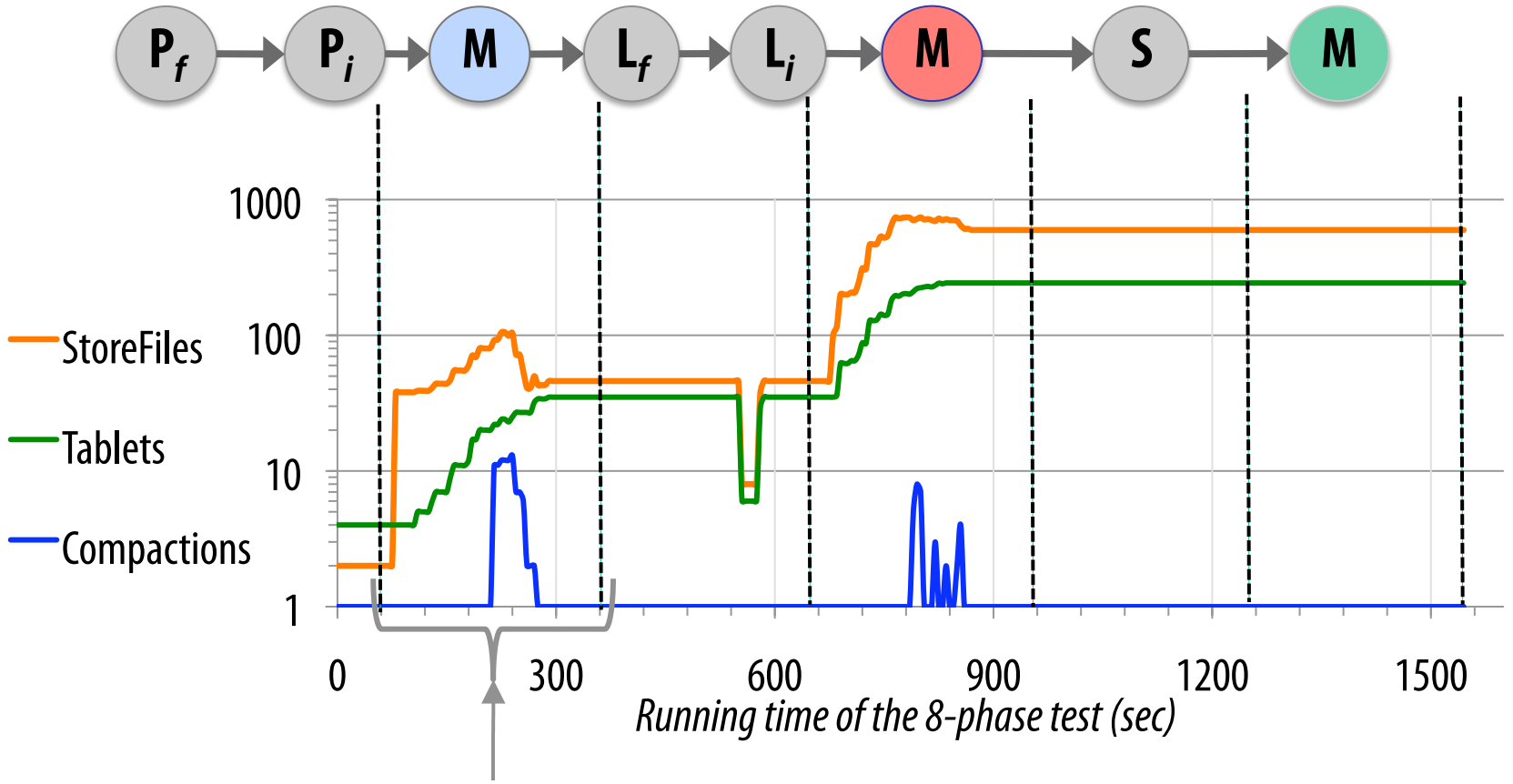
Sleep

- Let servers finish balancing work

Multi-phase tests show variation

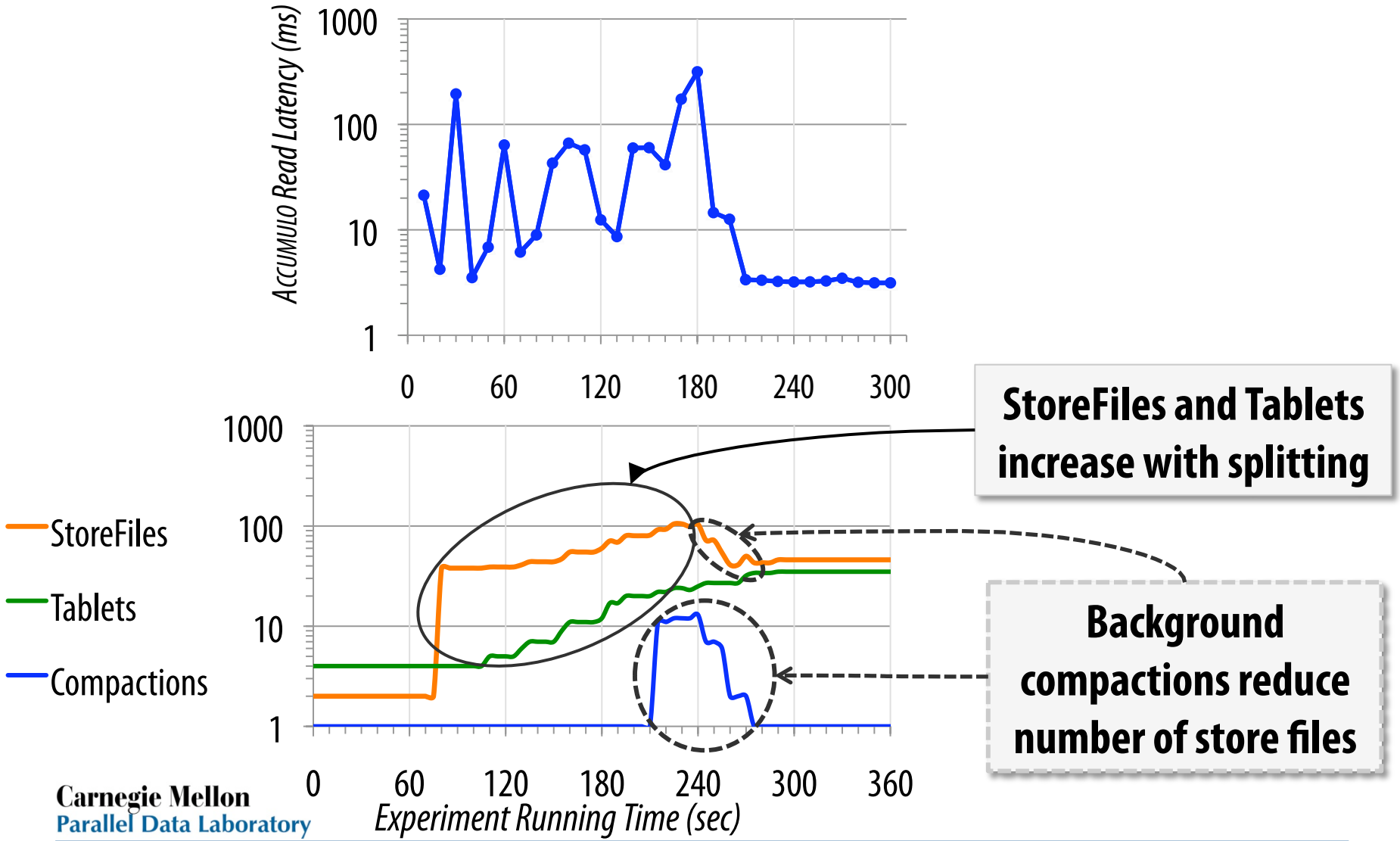


Monitoring rebalancing at servers



Let's take a closer look at correlating performance with server-side state

Correlate latency with server-side work



FEATURES TESTED BY YCSB++

Batch writing

Weak consistency

Table bulk loading

Table pre-splitting

Server-side filtering

Access control

Details in ACM SOCC 2011 paper

FAQ: Are workloads realistic?

YCSB++ uses synthetic workloads

- Uses YCSB's synthetic workload generator based on record size, distribution and operation types

Goal: How can we create real workloads?

- Trace real applications running on table stores
  - E.g., Twitter, photo stores, RSS, data mining
- YCSB++ can replay these (anonymized) traces

Need real application traces

Example workload: Monitoring application

- All OpenCloud cluster monitoring information is stored in HBase
- OTUS tool queries HBase to create graphs
- Trace these calls to create a “monitoring” workload

ISTC-CC: How and what can we trace?

- Looking for ways to collect traces from table store deployment with real applications

Summary: YCSB++ tool

- For benchmarking & debugging performance of **advanced features** using **extensions to YCSB**

Weak consistency semantics	**Distributed clients using ZooKeeper**
Fast insertion (pre-splits, bulk loads)	**Multi-phase testing (with Hadoop)**
Server-side filtering	**New workload generators and database client API extensions**
Fine-grained access control	

- Two case-studies: HBase & Accumulo
- Download at http://www.pdl.cmu.edu/ycsb++