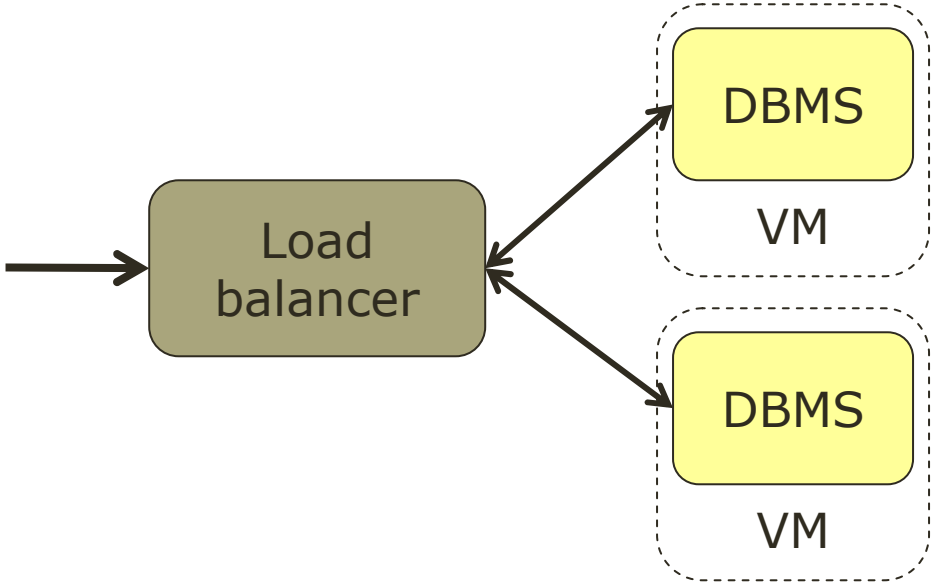
FlurryDB
A Dynamically Scalable Relational Database with Virtual Machine Cloning

Michael Mior and Eyal de Lara

University of Toronto

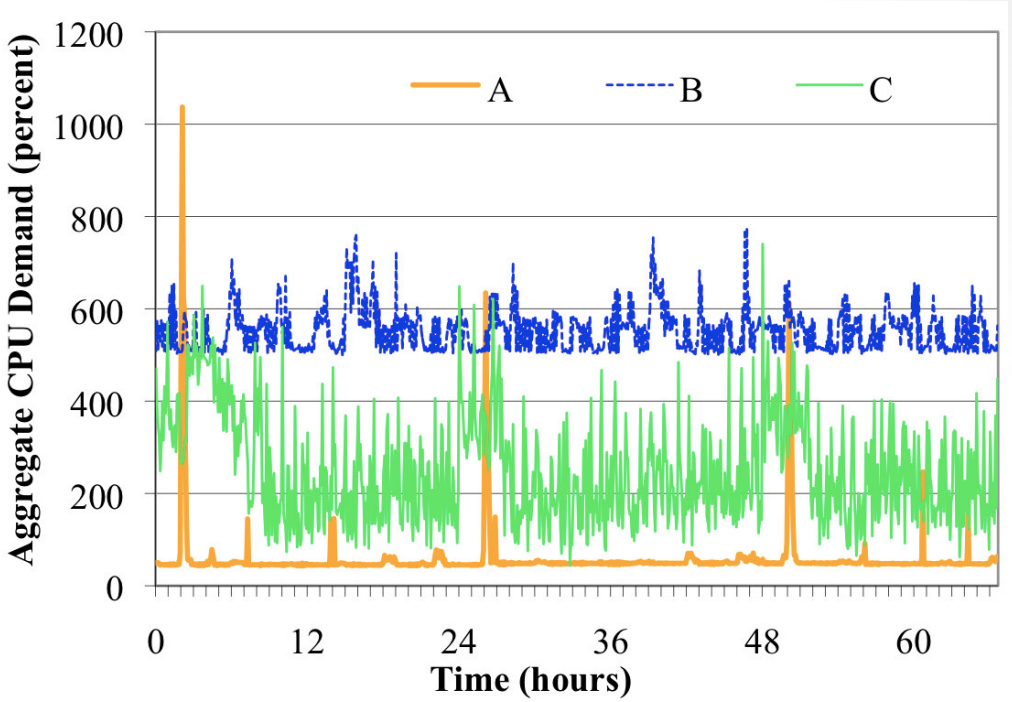
Computer Science
UNIVERSITY OF TORONTO

Cluster Databases



- We use read-one write all (ROWA) replication
  - Send reads to any server instance
  - Send writes to all server instances
- Two-phase commit is required for writes

Problem



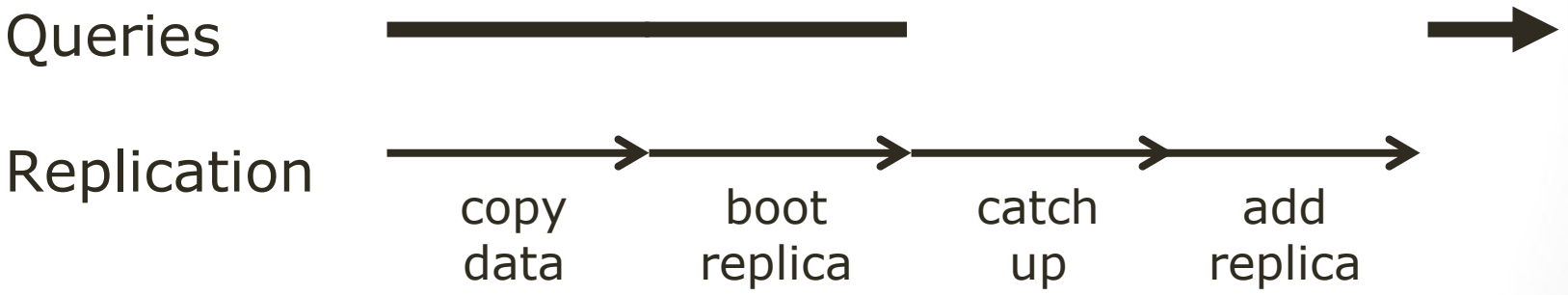
- Loads may fluctuate drastically over time
- Pay-as-you-go IaaS clouds should be ideal

However

We want to adapt the size of the cluster to match the load

Problem

- Databases have large state and are hard to scale
- A complete copy may be required for new instances
- Copying large databases may take hours



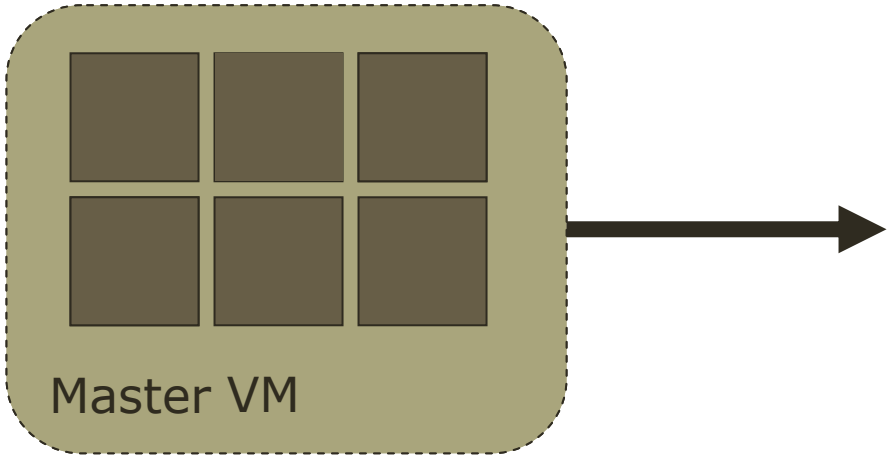
- Overprovisioning is necessary to maintain service

Solution – Virtual Machine Fork

- Analogous to fork() for OS processes
- Clones start immediately
- State fetched on-demand
  - Page faults fetch the memory or disk page

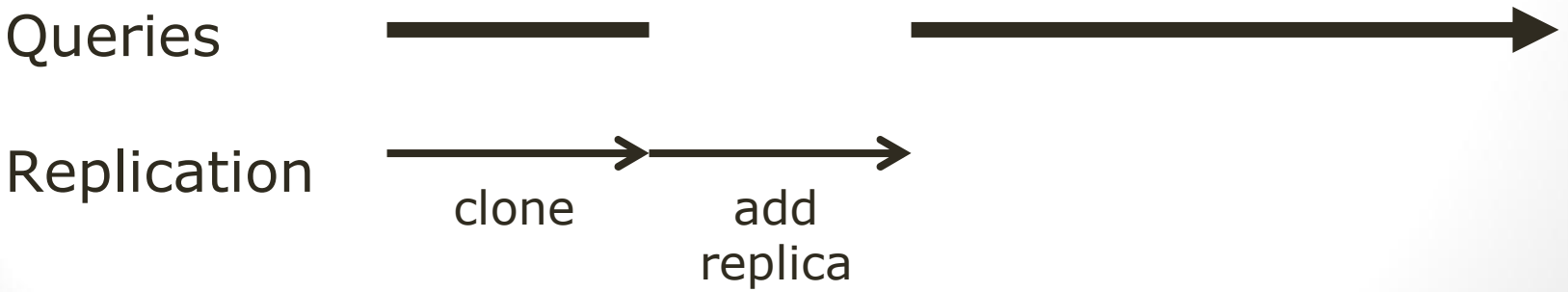
This can reduce instantiation time from minutes or hours to seconds

VM Fork



FlurryDB

- Use VM fork to provision new instances and add elasticity to unmodified MySQL
- Making distributed commit cloning-aware to handle in-flight transactions



FlurryDB Challenges

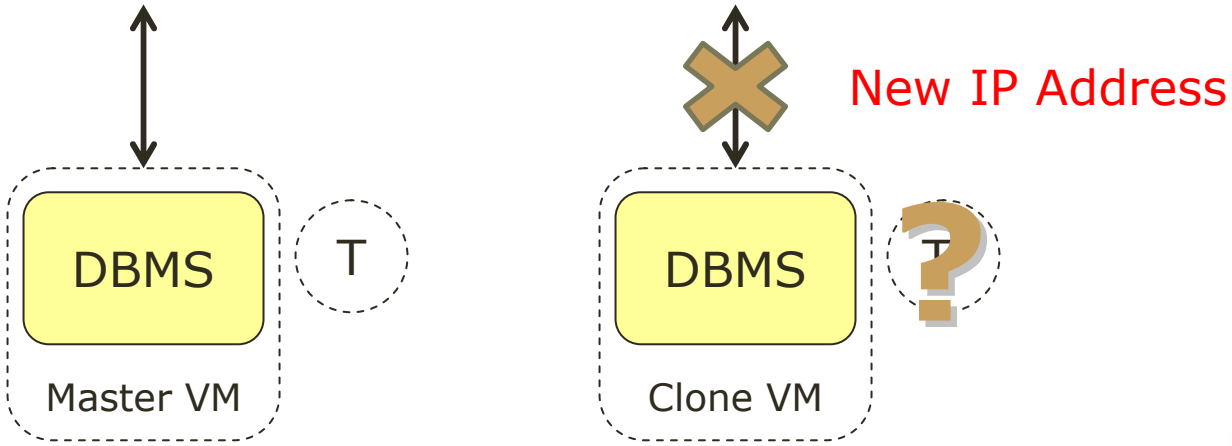
1. Incorporate new worker into cluster
2. Preserve application semantics

Incorporate new worker

- Clone must connect to the load balancer
- Load balancer must begin sending transactions to the clone

Preserve application semantics

- Transactions may be in-progress at the time of cloning
- Clone gets new IP address
- Doing nothing drops connections and transaction status is unknown

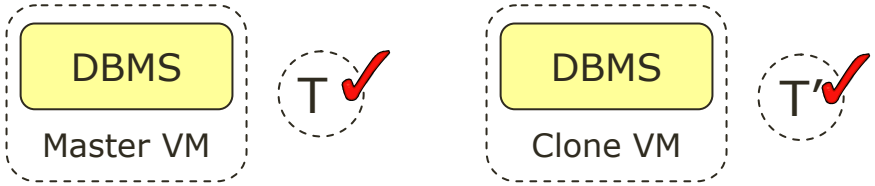


Solutions to consistency

1. Employ a write barrier

2. Roll back all transactions in progress

3. Allow all transactions to complete

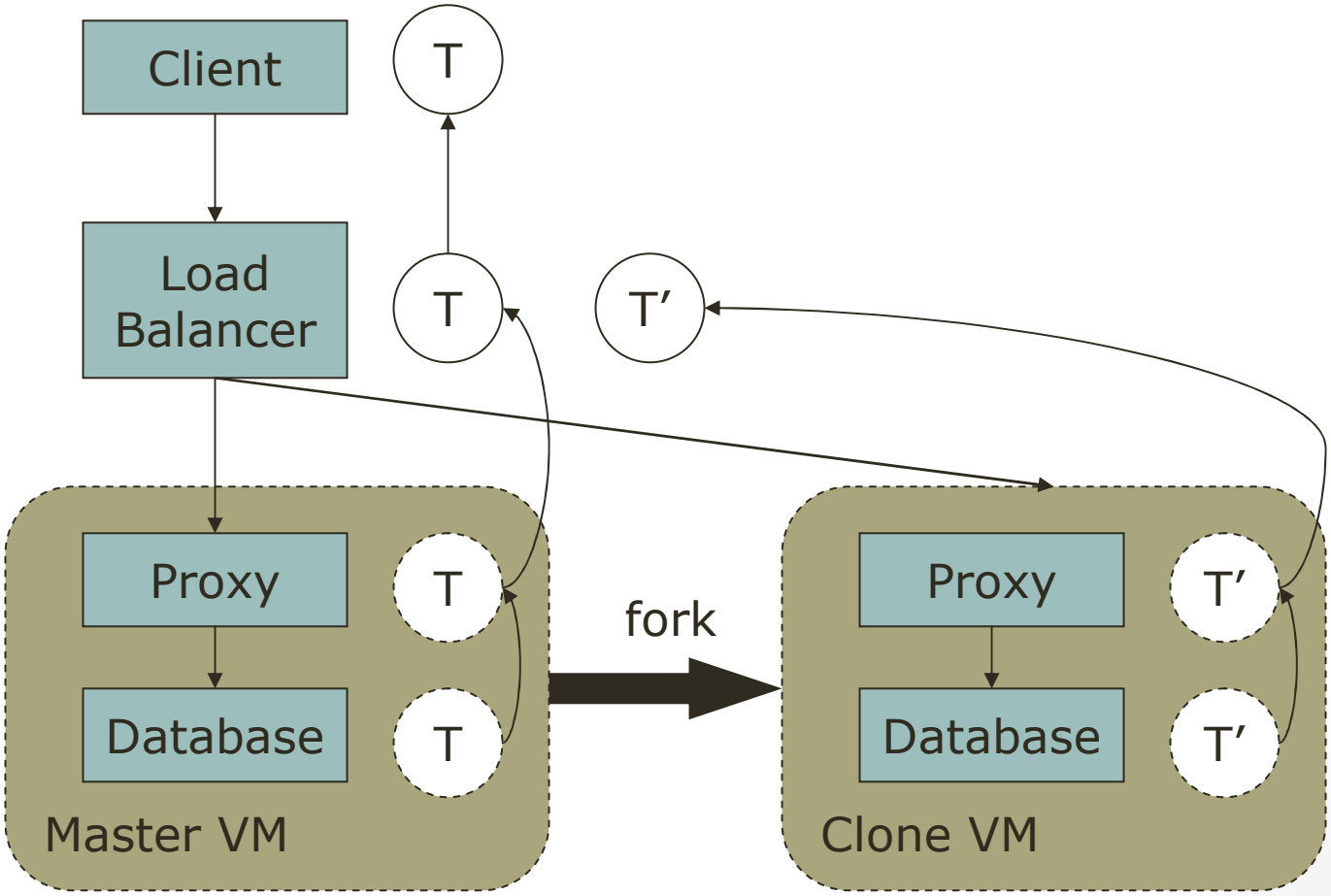


FlurryDB: Consistency beyond VM fork

Solution

Use a proxy which is aware of VM fork inside the virtual machine to maintain the database connection

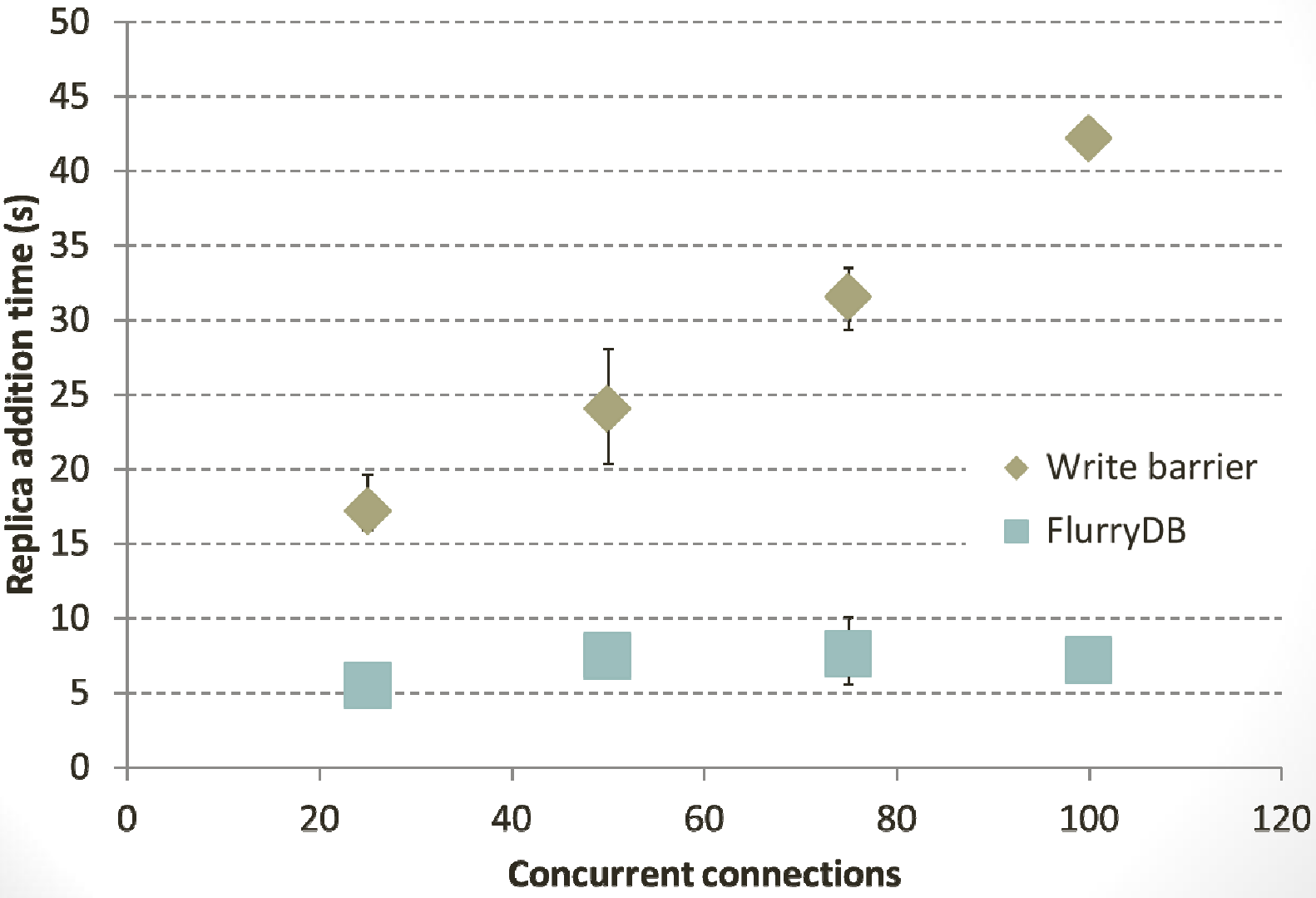
Two-phase commit during cloning



Replica addition delay

- Update 10,000 rows concurrently
- Clone and measure replica addition delay in two cases
  - **Write barrier** - wait for outstanding writes to complete before cloning
  - **FlurryDB** - use double-proxying to allow completion on the clone

Replica addition delay



Proxy overhead

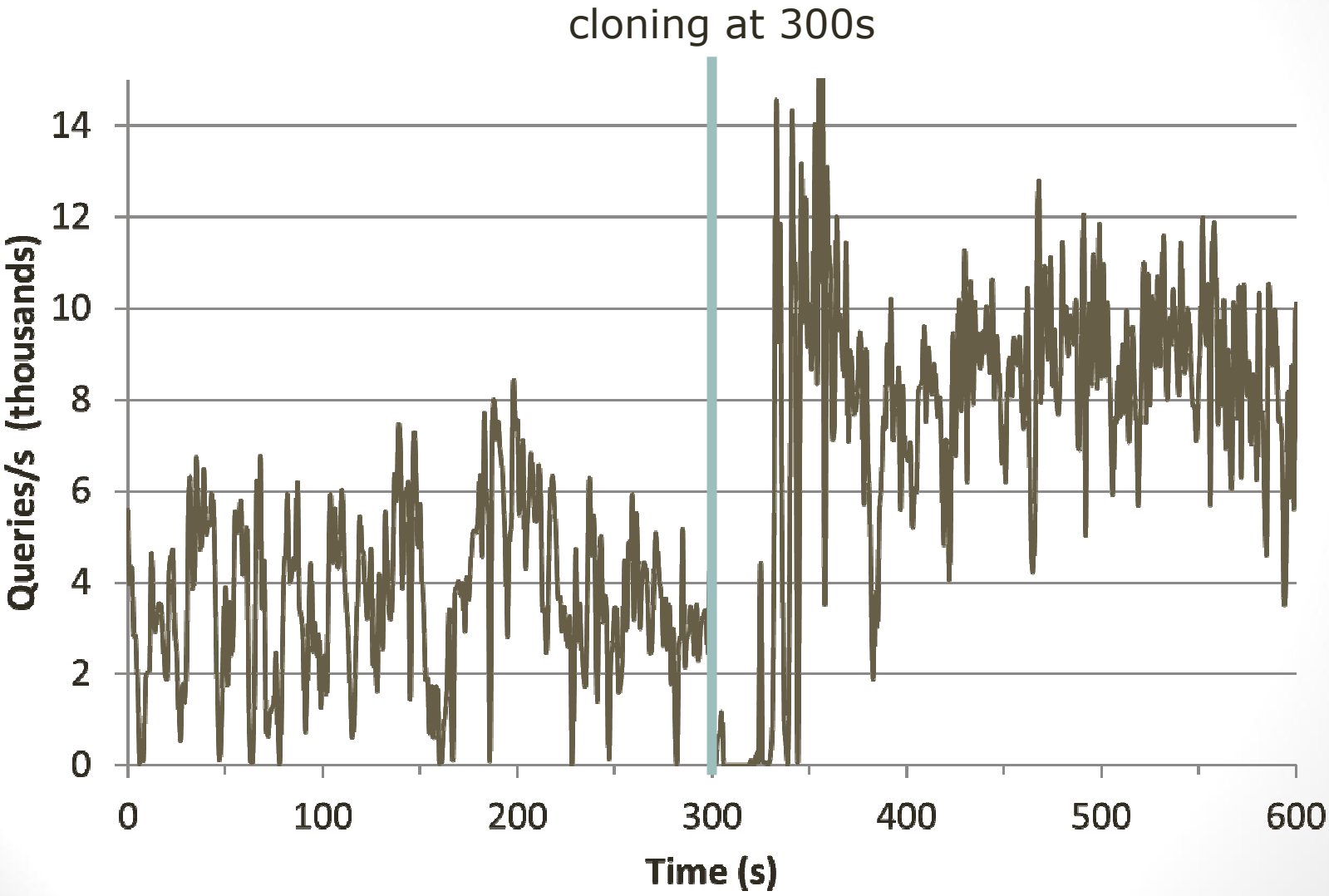
- Measurement of large SELECT transfer times shows ~5% drop in bandwidth
- Reconnection to new servers ~10x faster with no authentication

RUBBoS

- Simulates a news website such as Slashdot
- Users read, post, and comment on stories

- We run server at full capacity (25 clients)
- After 5 minutes, we clone to two servers and double the number of clients
- Throughput in queries per second is measured at the load balancer

RUBBOS Results



Summary

- FlurryDB adds elasticity to unmodified MySQL by interposing a cloning-aware proxy
- VM fork handles most of the issues with replica addition
- A proxy handles in-flight requests
- New replicas can be made available in seconds while maintaining consistency

Future Work

- Experiment with varying consistency protocols (e.g. master-slave, eventual consistency)
- Test scalability with larger numbers of clones
- Optimize virtual disk performance
- Provide support for transactional workloads

Questions?

Related Work

- “NoSQL” (perhaps more accurately, NoACID) systems using eventual consistency or key-value data models such as Cassandra or Dynamo
- Relational Cloud uses dynamic partitioning across a cluster of MySQL/PostgreS instances
- Urgaonkar et al. use rapid changes in resource allocate to provision a multi-tier Internet application
- Soundararajan et al. present dynamic replication policies for scaling database servers
- HyPer uses process fork and memory snapshots to enable a hybrid OLAP/OLTP workload