Karlsruhe Institute of Technology

Position Paper: Cloud System Deployment and Performance Evaluation Tools for Distributed DBs

Markus Klems – HotTopiCS Workshop 2013, April 20–21, 2013

Agenda

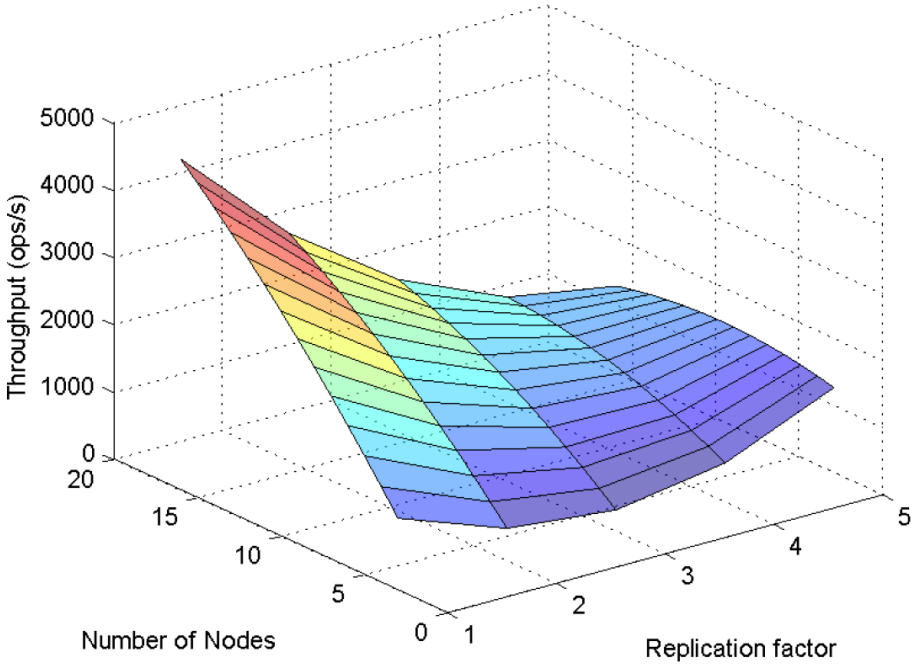
- Introduction
- Background on Cassandra and Cloud Benchmarking
- Our Experiment Framework & Tools
- Lessons Learned
- Related Work
- Conclusion & Outlook

Introduction

- **NoSQL/Cloud Databases**
  - Examples: Dynamo, BigTable, Sherpa, Cassandra, HBase, …
  - Distributed database systems which are designed in favor of high performance, elastic scalability, and high availability
  - Application-specific database solutions in lieu of one-size-fits-all
- **Guiding Questions**
  - Which database should I use for my application?
  - How well does the database really perform?
  - How can I optimize the database?
  - What are the trade-offs?
- **Problems**
  - The systems are too complex to be captured in analytical models
  - Performance evaluation experiments with distributed systems require substantial effort and use of hardware resources

Introduction – our experimentation experience

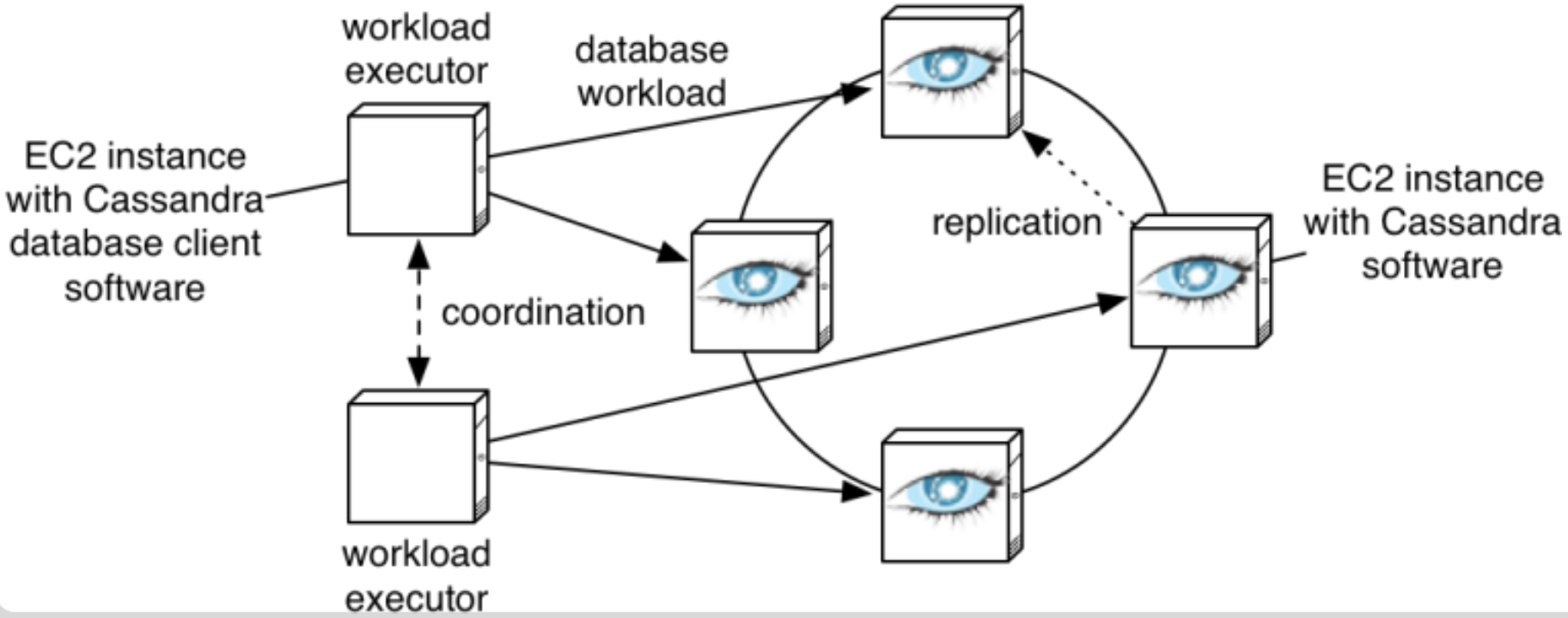
- Semi-automated performance experiments deliver initial insights.
- Conducting these experiments requires a lot of manual effort.
- It is difficult to reproduce the experiments without mistakes.
- The system under test is a “moving target” – every new software release brings along a lot of changes.



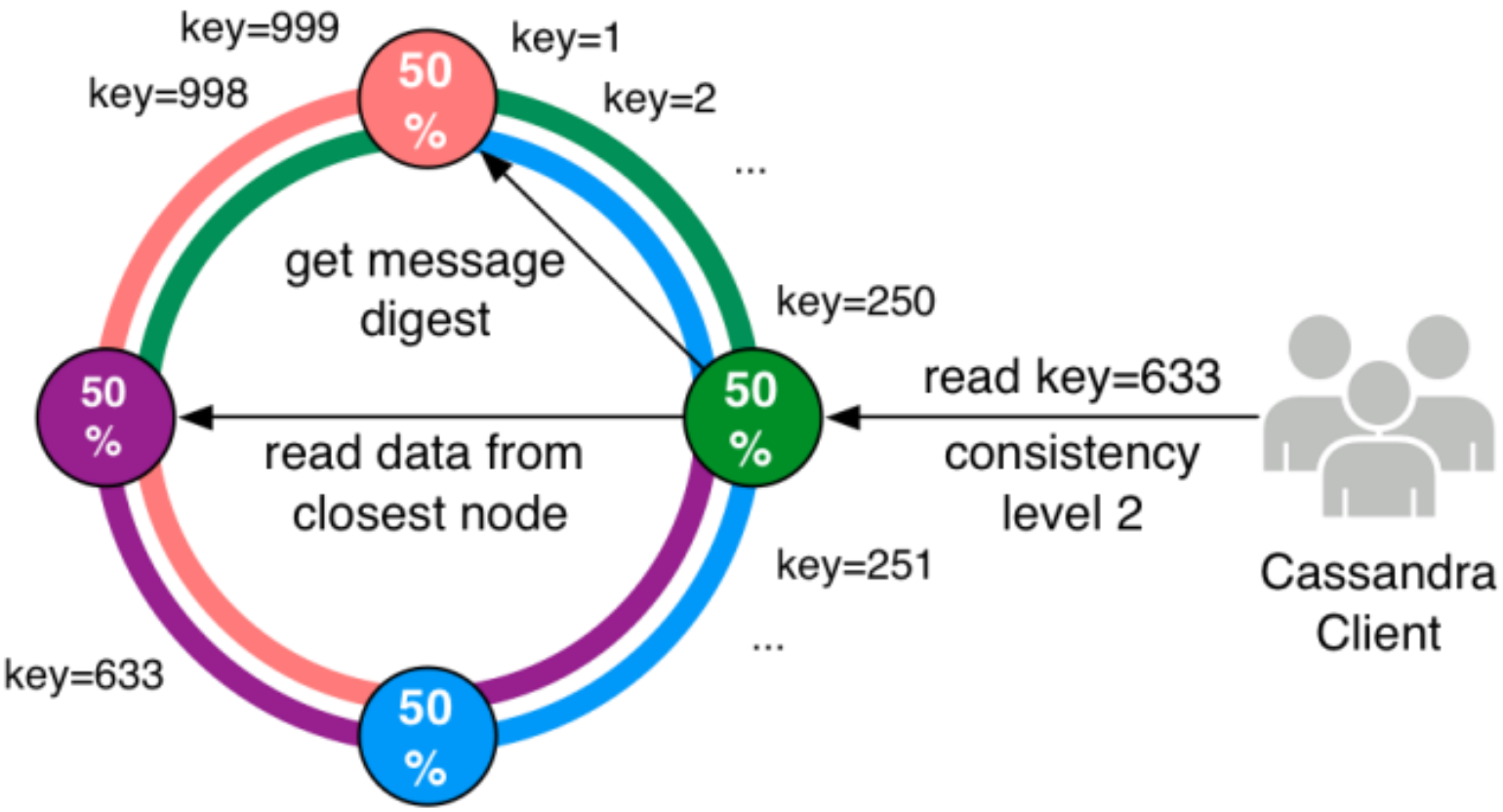
Cassandra average throughput, depending on the number of small EC2 instances and replication factor N [Klems, et. al. 2012].

Introduction

- **Objectives of this talk**
  - Suggest concepts for experiment automation in the cloud
  - Discuss challenges and lessons learned
- **Example: Apache Cassandra on Amazon EC2**

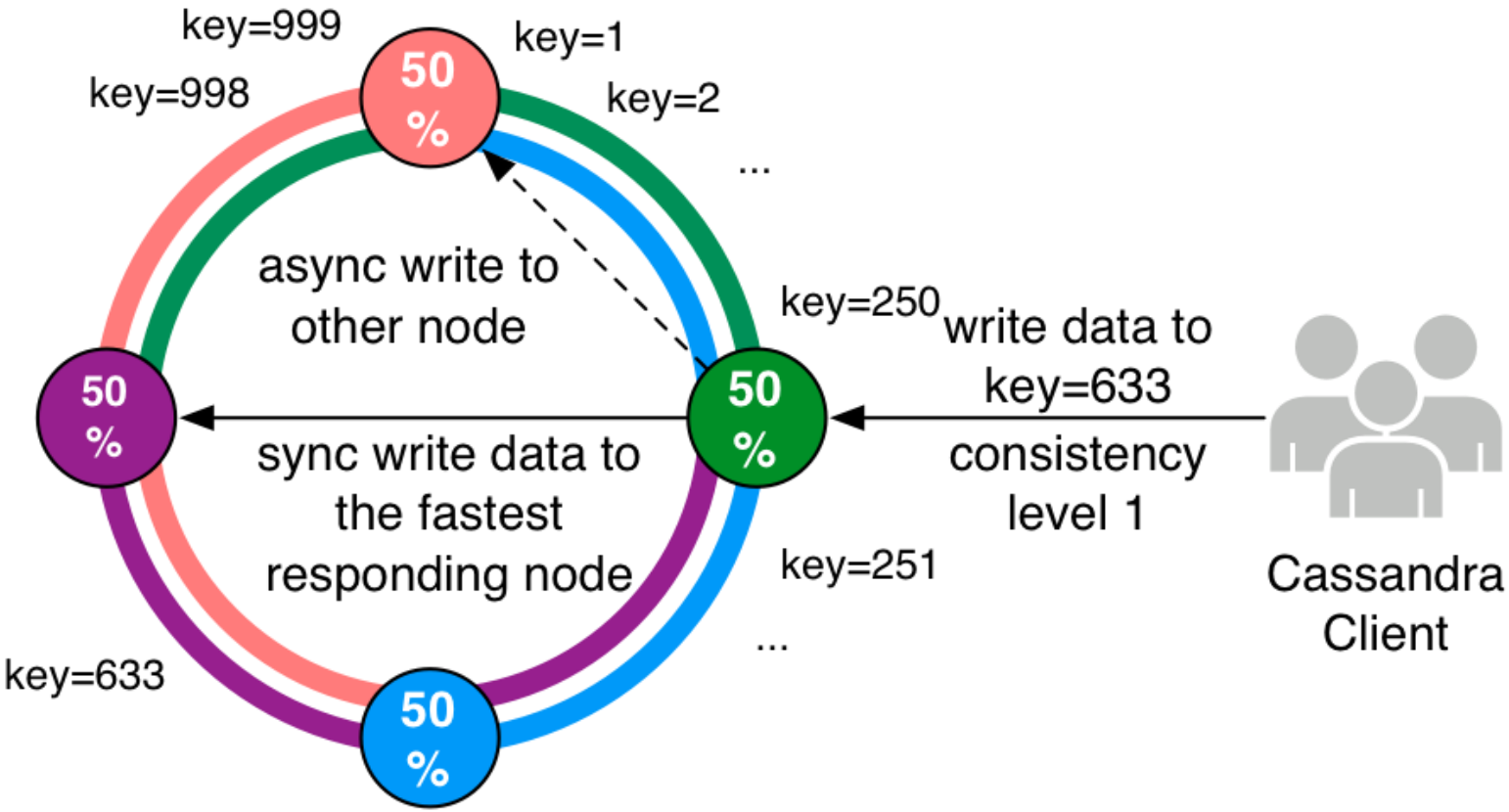


Background: Apache Cassandra
Dynamo-style Replication Architecture



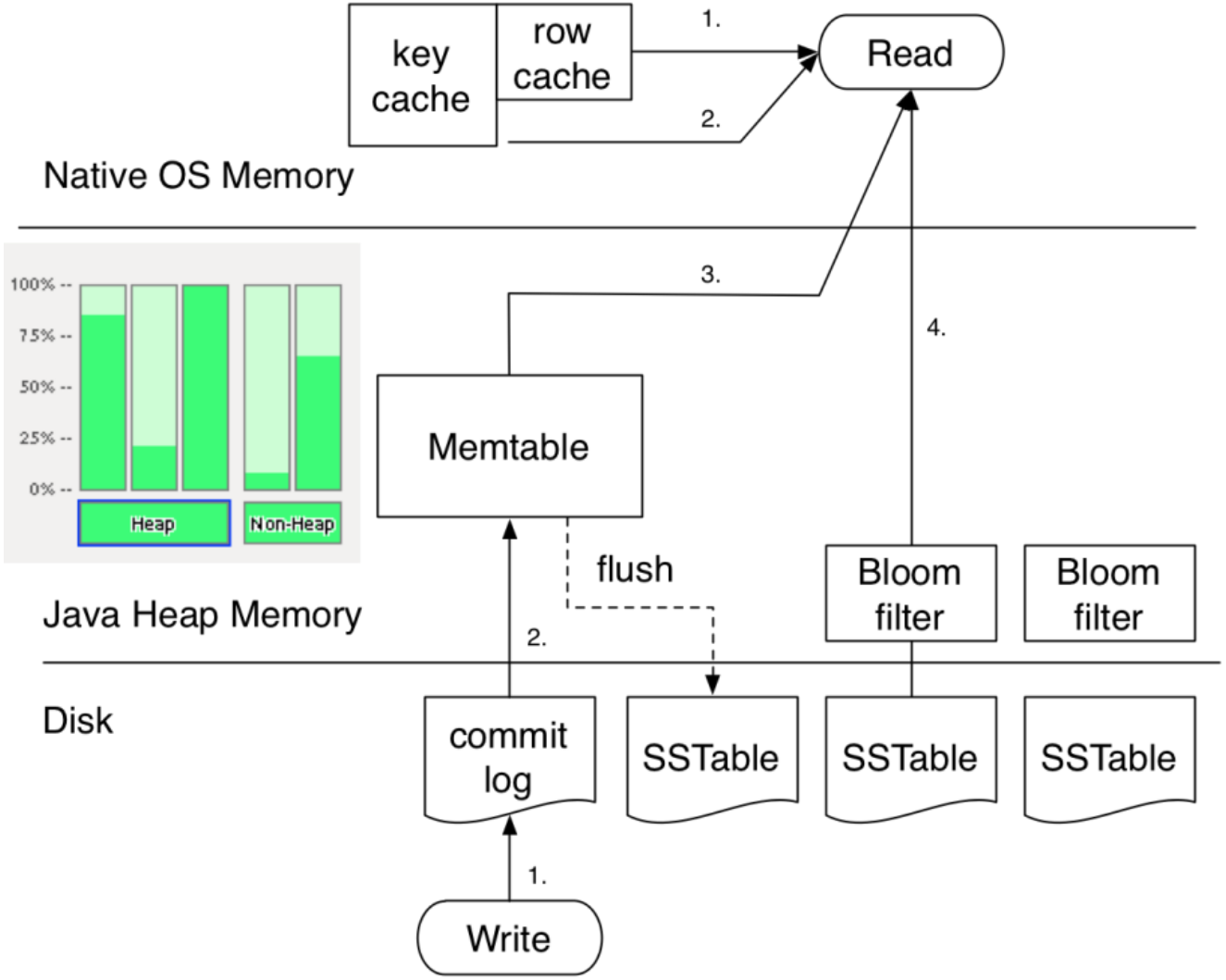
Cassandra Cluster with 4 nodes
and Replication Factor = 2

Background: Apache Cassandra
Dynamo-style Replication Architecture

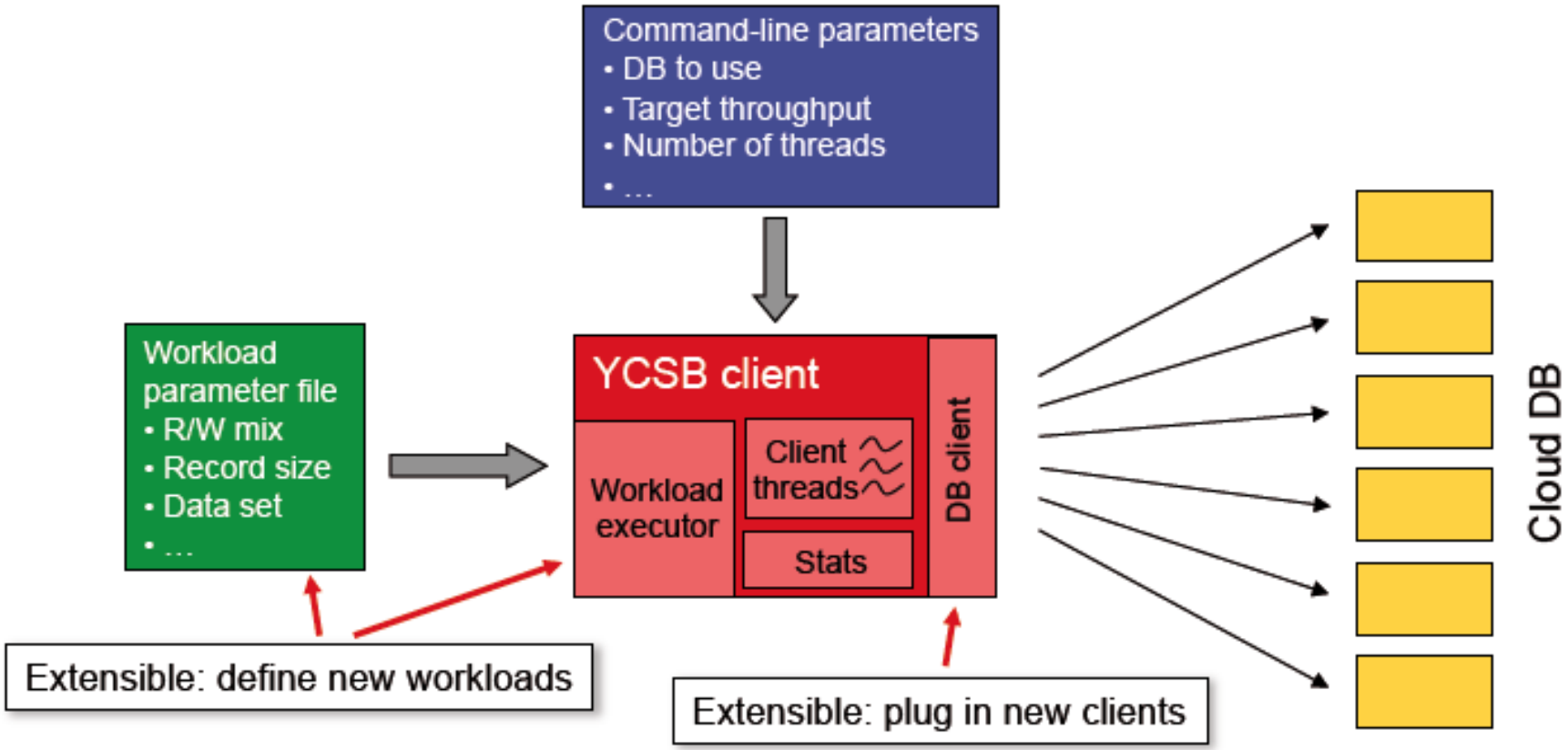


Cassandra Cluster with 4 nodes
and Replication Factor = 2

Background: Apache Cassandra BigTable-style Storage Engine

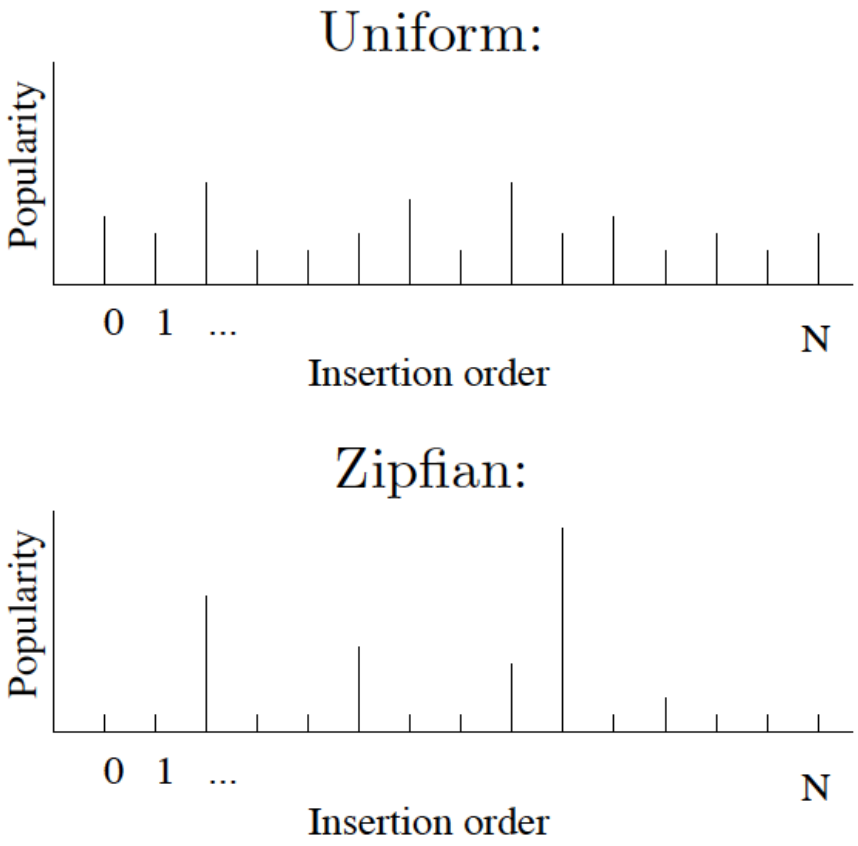


Background: Cloud Benchmarking with the Yahoo! Cloud Serving Benchmark Tool (YCSB)



Source: [Cooper et al. 2010]

Background: Workload Model



Probability distributions: Horizontal axes represents items in order of insertion, and vertical axes represent probability of being chosen.

Source: [Cooper et al. 2010]

Experiment Framework

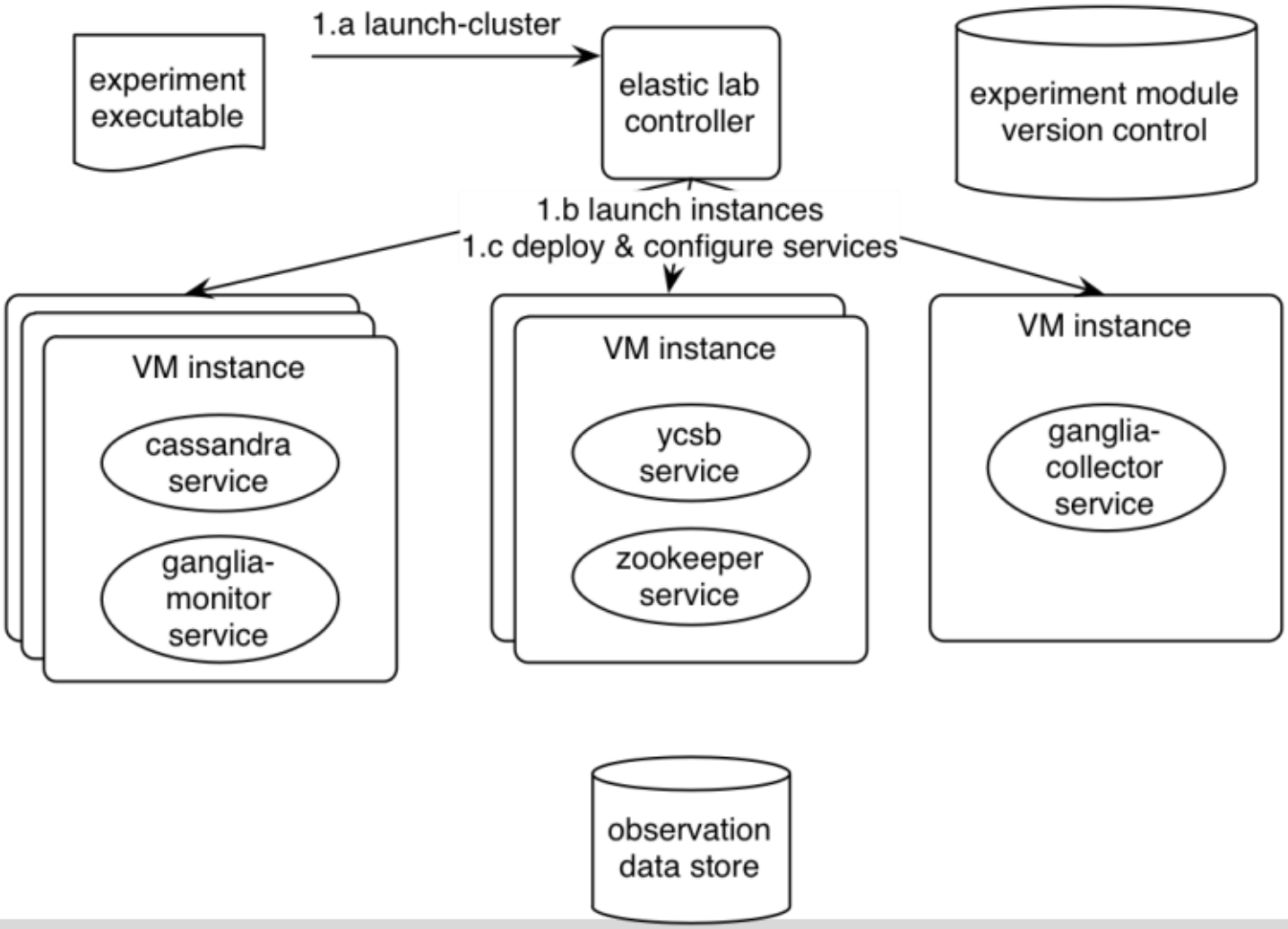
- **Experiment Module**
  - Capture the experiment plan in a “software module”
- **Elastic Lab**
  - `launch` - Provision a cluster or individual machine in the compute cloud in a given configuration.
  - `destroy` - Destroy the cluster or individual machine by terminating the virtual machine(s).
  - `apply-treatment` - Apply the experiment treatment to one of {cloud, cluster, machine}.
  - `prepare-experiment` - Configure the observer servers and the experimental unit servers.
  - `run-experiment` - Run an experiment and collect observation data.
- **Collaboration Features**
  - Collaborate on experiment modules
  - Share observation measurements

An Experiment Module's Experiment Profile

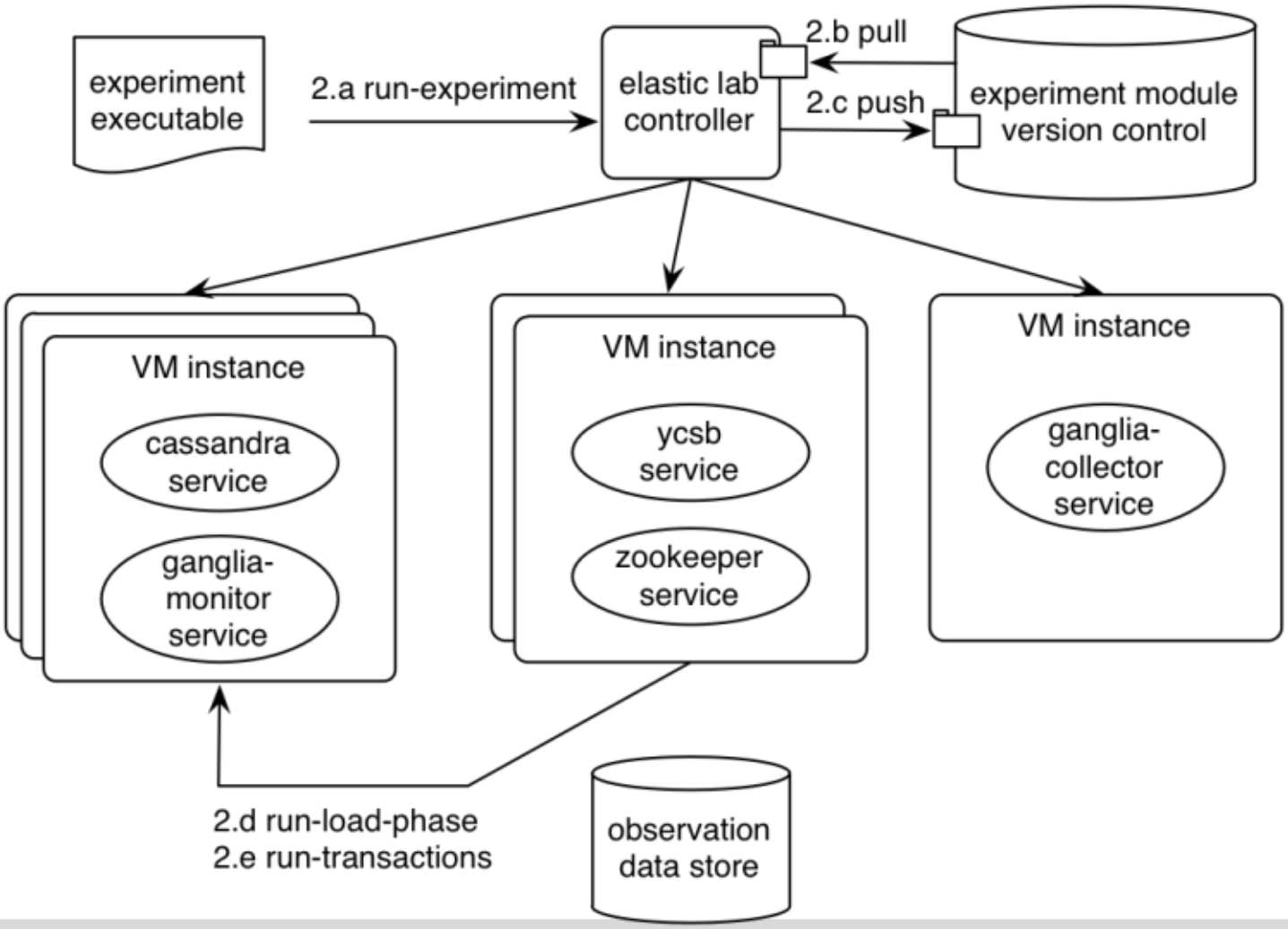
```
service1:
        name: cassandra
        attributes:
                backup: ec2
                replication_factor: 1
                partitioner: RandomPartitioner
                key_cache_size_in_mb: 93
                row_cache_size_in_mb: 93
service2:
        name: ycsb
        attributes:
                load: 'no'
                recordcount: 3000000
                operationcount: 3000000
                readproportion: 0.99
                updateproportion: 0.01
                requestdistribution: veryhotspot
                hotspots: 300
                variance: 0.0001
                alpha: 0.5
```

```
profile1:
        provider: aws
        snapshot: false
        regions:
                region1:
                        name: us-east-1
                        machine_type: xlarge
                        template: 3 cassandra, 1 ycsb
                region2:
                        name: us-west-1
                        machine_type: xlarge
                        template: 2 cassandra, 1 ycsb
```

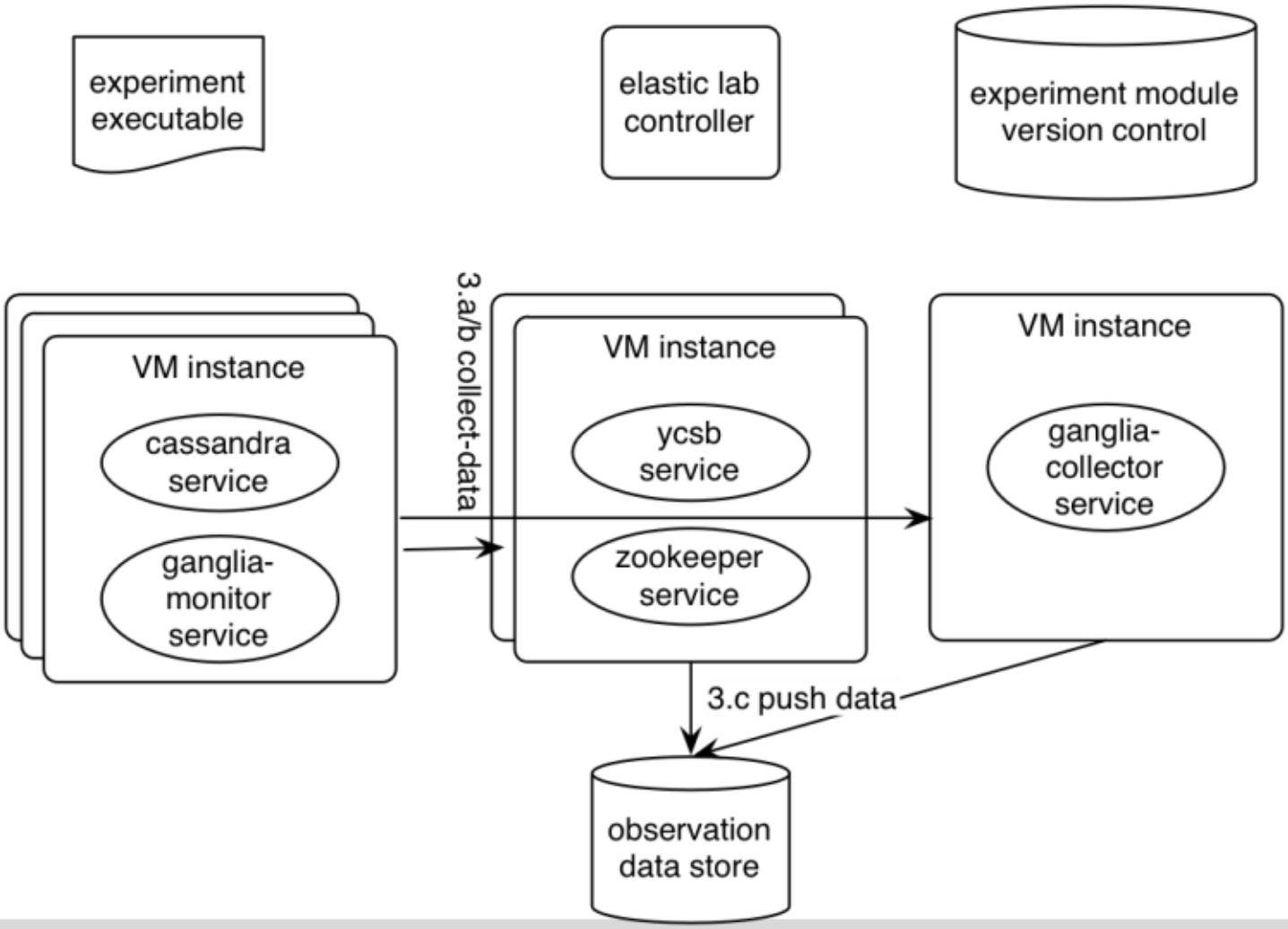
Elastic Lab – Launch (1)



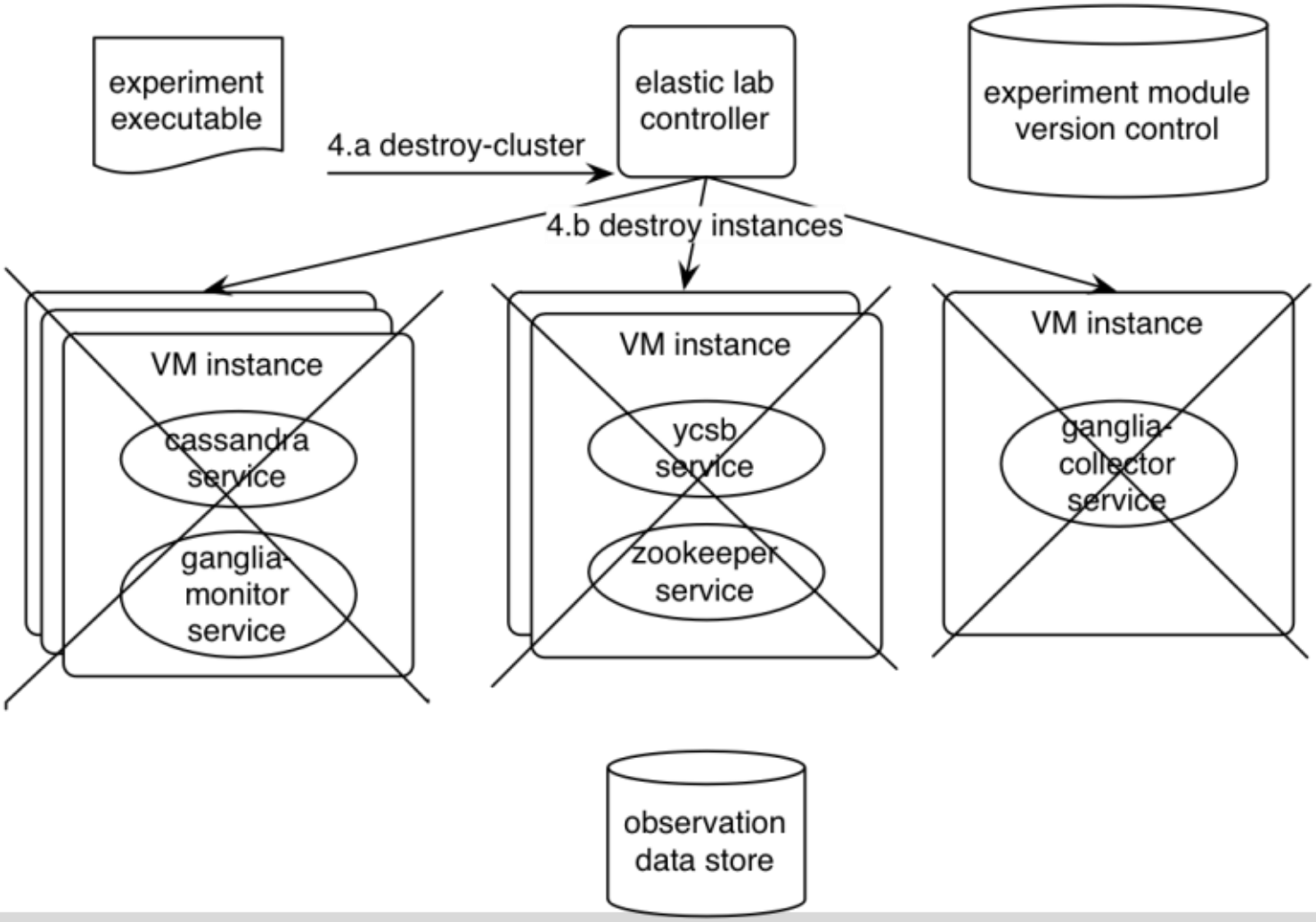
Elastic Lab – Run Experiment (2)



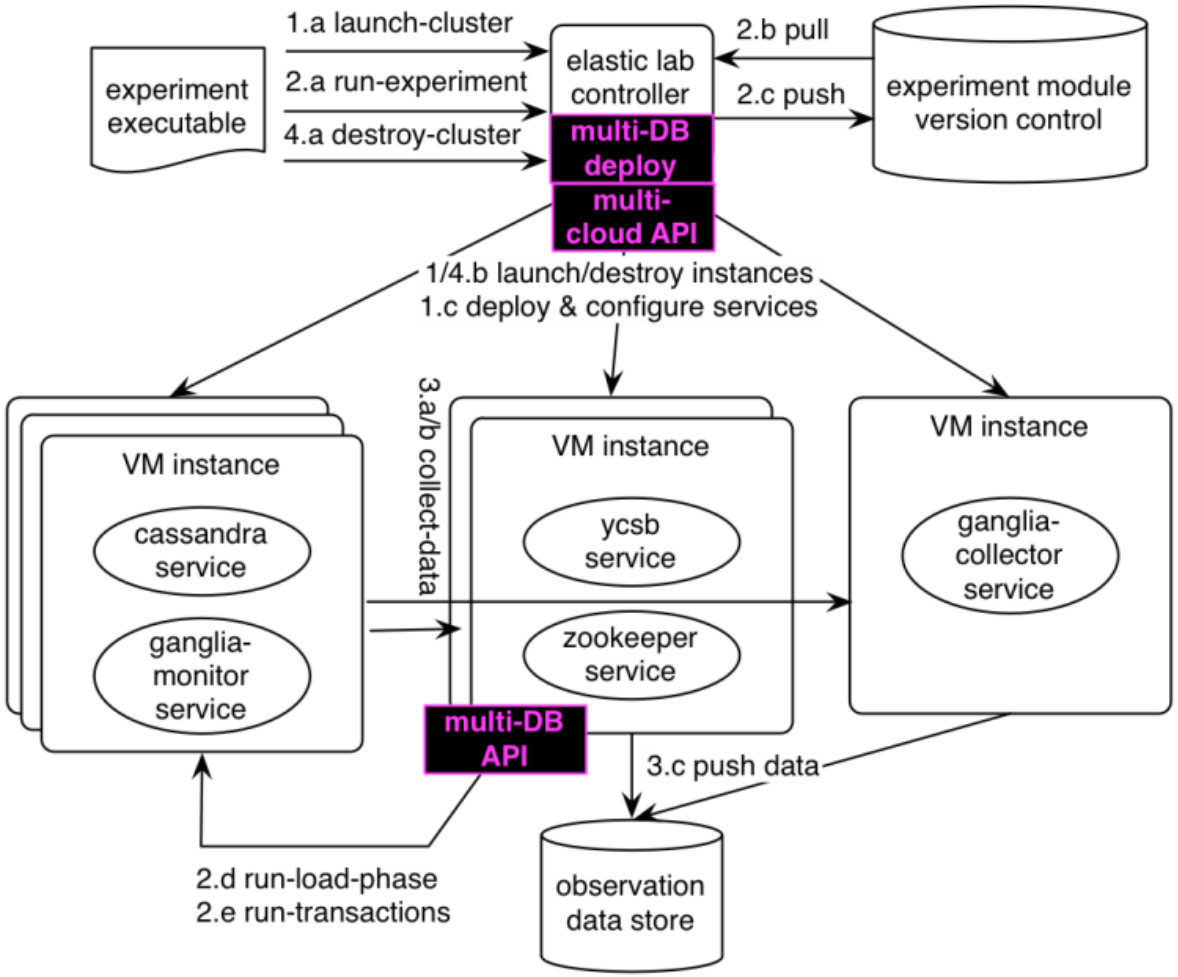
Elastic Lab – Collect Data (3)



Elastic Lab – Destroy (4)



Multi-Cloud & Multi-DB Experiment Tool Design



Open Challenges & Lessons Learned

- Extensible design for multiple OSs and DBs
  - Hard-coding experiment plans into VMs is too static.
  - Java plus shell scripts: hard to extend and debug.
  - Better but not perfect: Ruby-based tool using Chef or Puppet
- Collaboration
  - Source code management system for experiment module collaboration, e.g. git and github.
  - Cloud storage with version control for data collection, e.g. S3.
- Shared virtualized infrastructure causes side-effects
  - Amazon EC2 network is a shared resource
  - Use large or extra-large instance types for somewhat predictable i/o
  - API unreliability and long provisioning times of some cloud providers other than AWS can prohibit efficient experimentation.

Related Work

- **Experiment Automation in Grid Computing**
  - The NMI Test & Build Laboratory for continuous integration of heterogeneous distributed computing systems [Pavlo 2006].
  - DiPerF is an automated performance evaluation framework for experiments with client-server systems, such as the metadata and directory service of the Globus Toolkit [Dumitrescu et al. 2004].
  - The Weevil framework combines a simulation-based workload generator with a model-based configuration management and system automation approach for experiments with distributed systems on PlanetLab [Wang 2005].
- **Experiment Automation in Cloud Computing**
  - A recent publication by IBM Research: CloudBench [Silva et al. 2013]

Conclusion & Outlook

- **Conclusion**
  - A basic approach and initial tooling for conducting experiments with distributed database systems in the cloud:
  - Capture experiment plans as Experiment Modules.
  - Run experiments using a multi-cloud and multi-system Elastic Lab.
  - Collaborate using source code management services and cloud storage services.
- **Outlook**
  - Develop a set of basic experiments that can be used out-of-the-box.
  - Use Response Surface Methodology for more efficient experimentation.

Thank you!

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https://github.com/myownthemepark/csde

Research group: eorganization.de