CS 744: PYWREN

Shivaram Venkataraman

Spring 2024

ADMINISTRIVIA

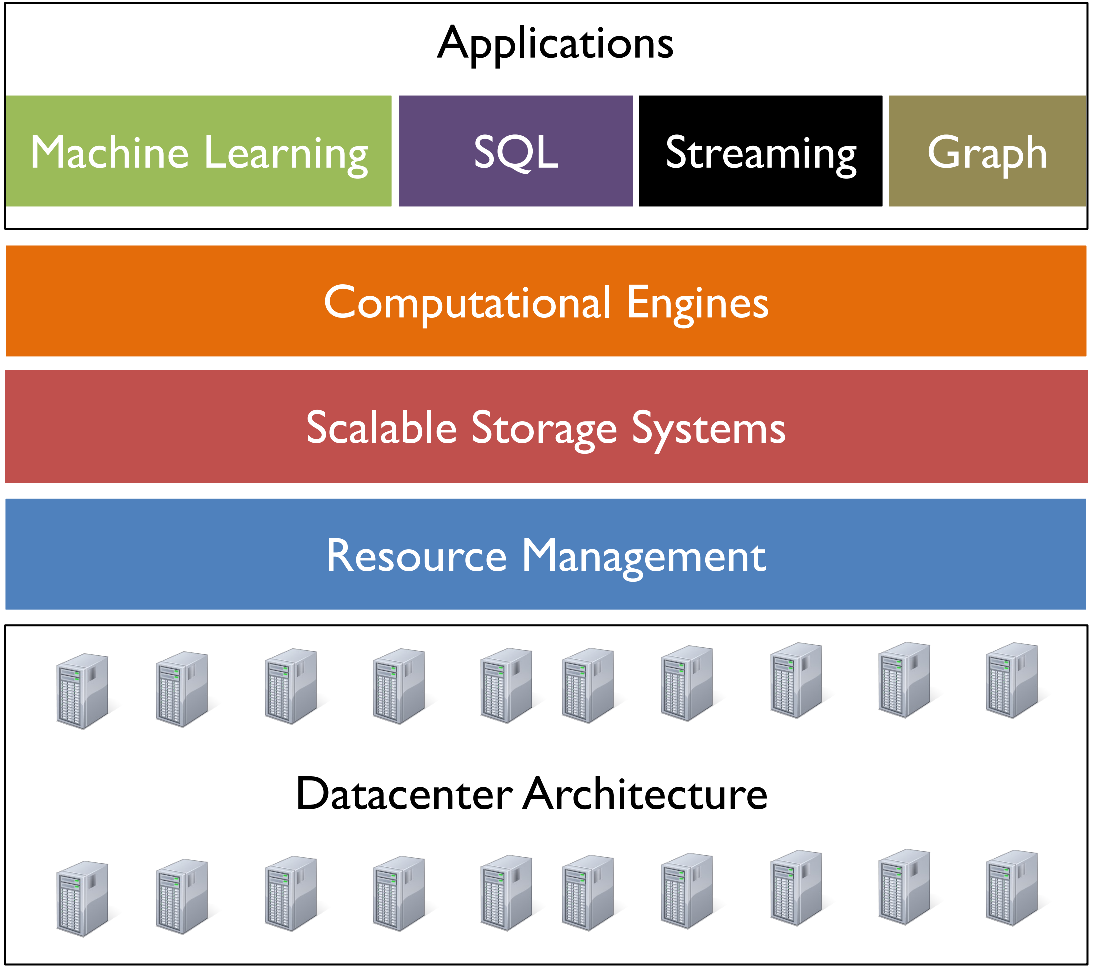
Project checkins due today!

Poster presentation: May 2

Final report: May 7

Project grade breakdown

- Intro: 5%
- Mid-semester checkin: 5%
- Poster: 10%
- Final Report: 10%


Applications
Machine Learning
SQL
Streaming
Graph
Computational Engines
Scalable Storage Systems
Resource Management
Datacenter Architecture

NEW DATA, HARDWARE MODELS

Serverless Computing

Compute Accelerators

Infiniband Networks

Non-Volatile Memory

SERVERLESS COMPUTING

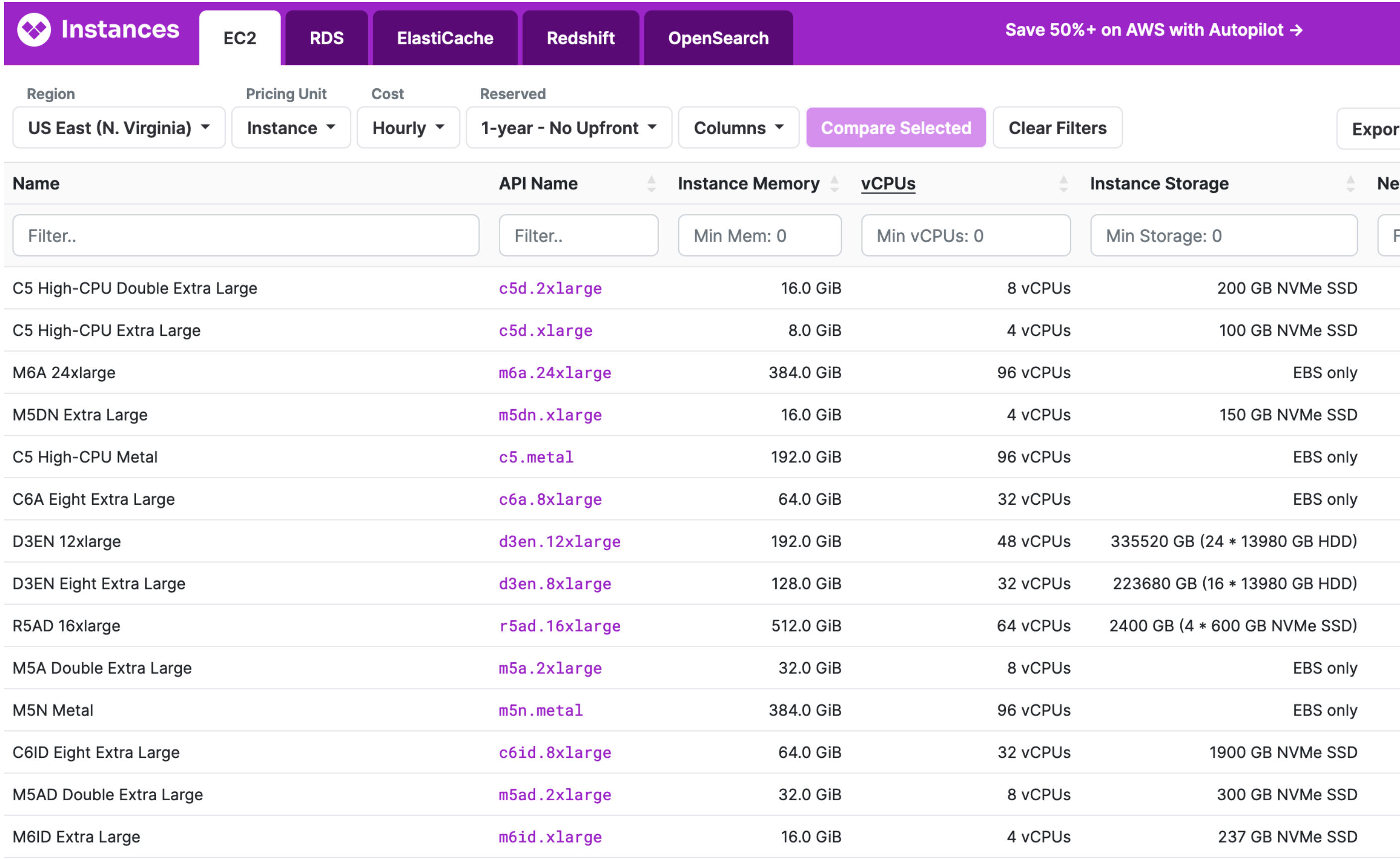
MOTIVATION: USABILITY

What instance type?

What base image?

How many to spin up?

What price? Spot?

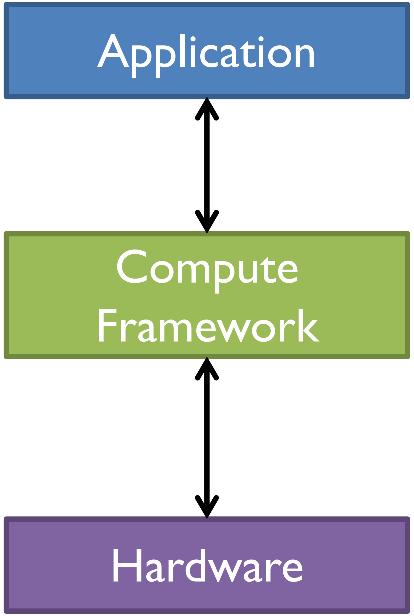

Instances | EC2 | RDS | ElastiCache | Redshift | OpenSearch | Save 50%+ on AWS with Autopilot →

Region: US East (N. Virginia) | Pricing Unit: Instance | Cost: Hourly | Reserved: 1-year - No Upfront | Columns | Compare Selected | Clear Filters | Expor

Name	API Name	Instance Memory	vCPUs	Instance Storage	Ne
Filter..	Filter..	Min Mem: 0	Min vCPUs: 0	Min Storage: 0	F
C5 High-CPU Double Extra Large	c5d.2xlarge	16.0 GiB	8 vCPUs	200 GB NVMe SSD	
C5 High-CPU Extra Large	c5d.xlarge	8.0 GiB	4 vCPUs	100 GB NVMe SSD	
M6A 24xlarge	m6a.24xlarge	384.0 GiB	96 vCPUs	EBS only	
M5DN Extra Large	m5dn.xlarge	16.0 GiB	4 vCPUs	150 GB NVMe SSD	
C5 High-CPU Metal	c5.metal	192.0 GiB	96 vCPUs	EBS only	
C6A Eight Extra Large	c6a.8xlarge	64.0 GiB	32 vCPUs	EBS only	
D3EN 12xlarge	d3en.12xlarge	192.0 GiB	48 vCPUs	335520 GB (24 * 13980 GB HDD)	
D3EN Eight Extra Large	d3en.8xlarge	128.0 GiB	32 vCPUs	223680 GB (16 * 13980 GB HDD)	
R5AD 16xlarge	r5ad.16xlarge	512.0 GiB	64 vCPUs	2400 GB (4 * 600 GB NVMe SSD)	
M5A Double Extra Large	m5a.2xlarge	32.0 GiB	8 vCPUs	EBS only	
M5N Metal	m5n.metal	384.0 GiB	96 vCPUs	EBS only	
C6ID Eight Extra Large	c6id.8xlarge	64.0 GiB	32 vCPUs	1900 GB NVMe SSD	
M5AD Double Extra Large	m5ad.2xlarge	32.0 GiB	8 vCPUs	300 GB NVMe SSD	
M6ID Extra Large	m6id.xlarge	16.0 GiB	4 vCPUs	237 GB NVMe SSD	


When to use the Cloud ?
Data
- Large amounts of data. Can't store locally
- Shared data across users
- Long term storage
Compute
- Need lots of CPUs for
- Varying
- No admin
Why is there no "cloud button"?

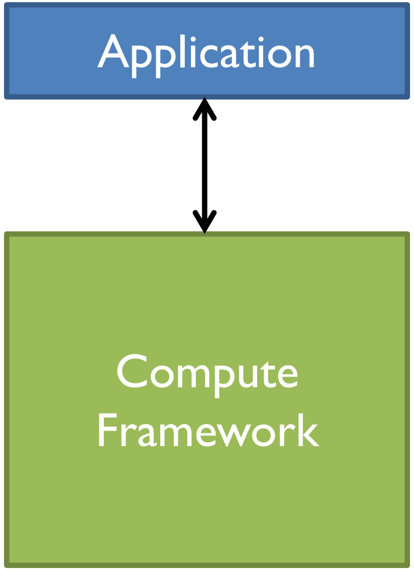
ABSTRACTION LEVEL ?



Logistic Regression

Spark

Amazon EC2
CloudLab
Private Cluster
…



"SERVERLESS" COMPUTING

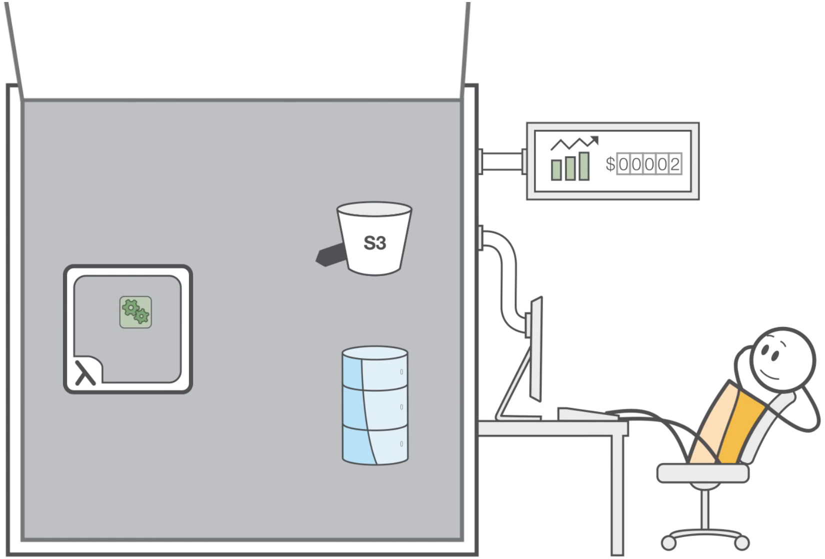
~~300~~ 900 seconds single-core

~~512~~ 512-10240 MB in /tmp

~~3~~ 10GB RAM

Python, Java, node.js, Ruby, Go etc.

Support for containers



Google Cloud Platform

CLOUD FUNCTIONS ALPHA

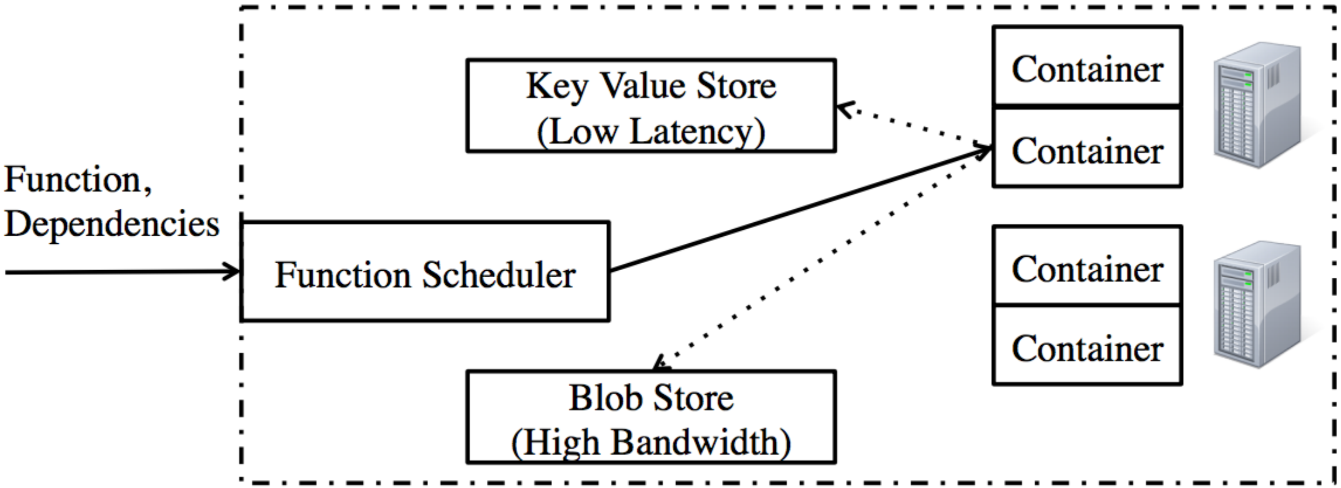
A serverless platform for building event-based microservices

Microsoft Azure

Azure Functions

Process events with a serverless code architecture

STATELESS DATA PROCESSING



PYWREN API

```
import pywren
import numpy as np

def addone(x):
    return x + 1

wrenexec = pywren.default_executor()
xlist = np.arange(10)
futures = wrenexec.map(addone, xlist)

print [f.result() for f in futures]
```

The output is as expected:

```
[1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
```

PYWREN: HOW IT WORKS

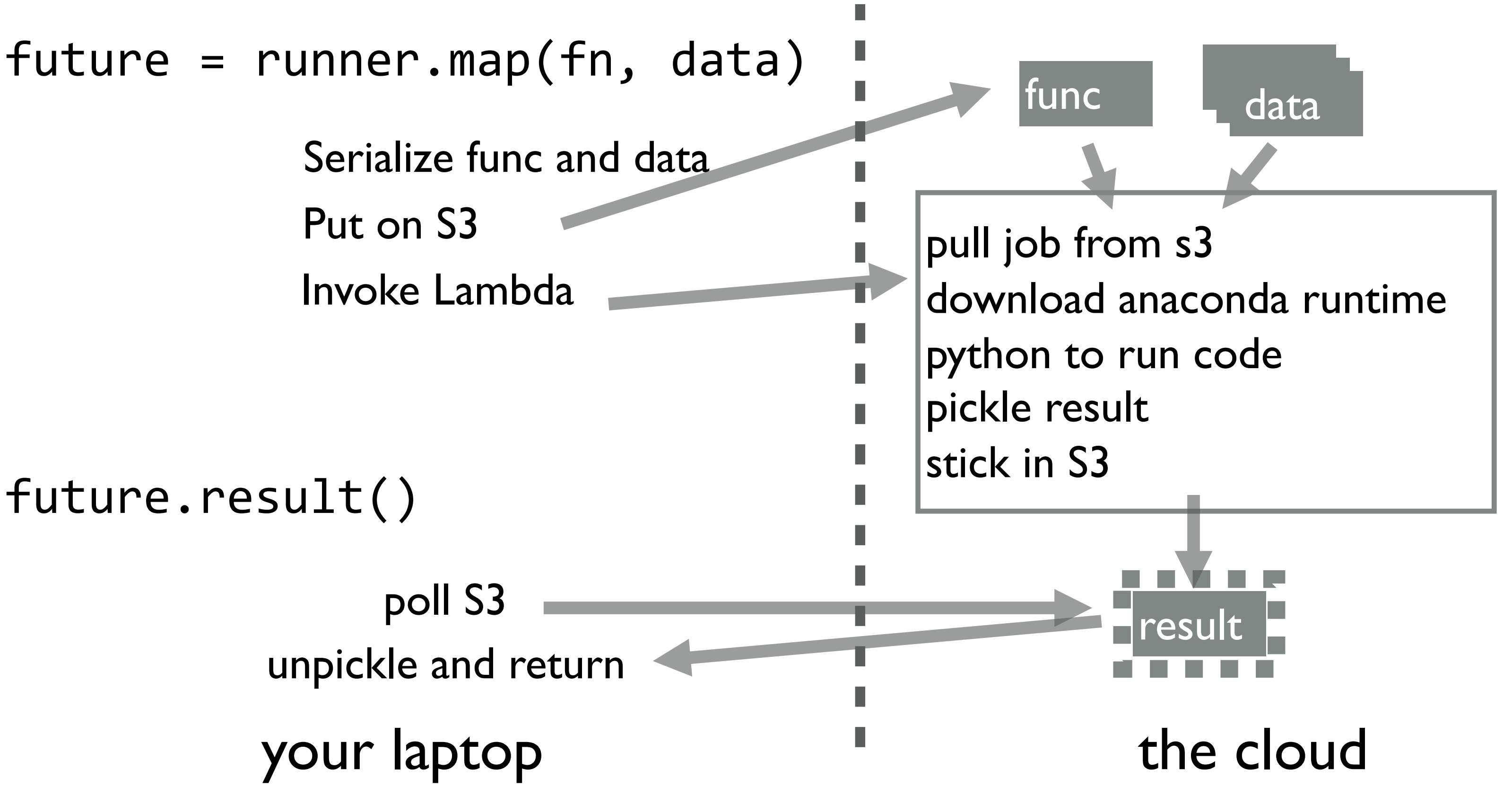
```
future = runner.map(fn, data)
```

```
future.result()
```

your laptop

the cloud

HOW IT WORKS

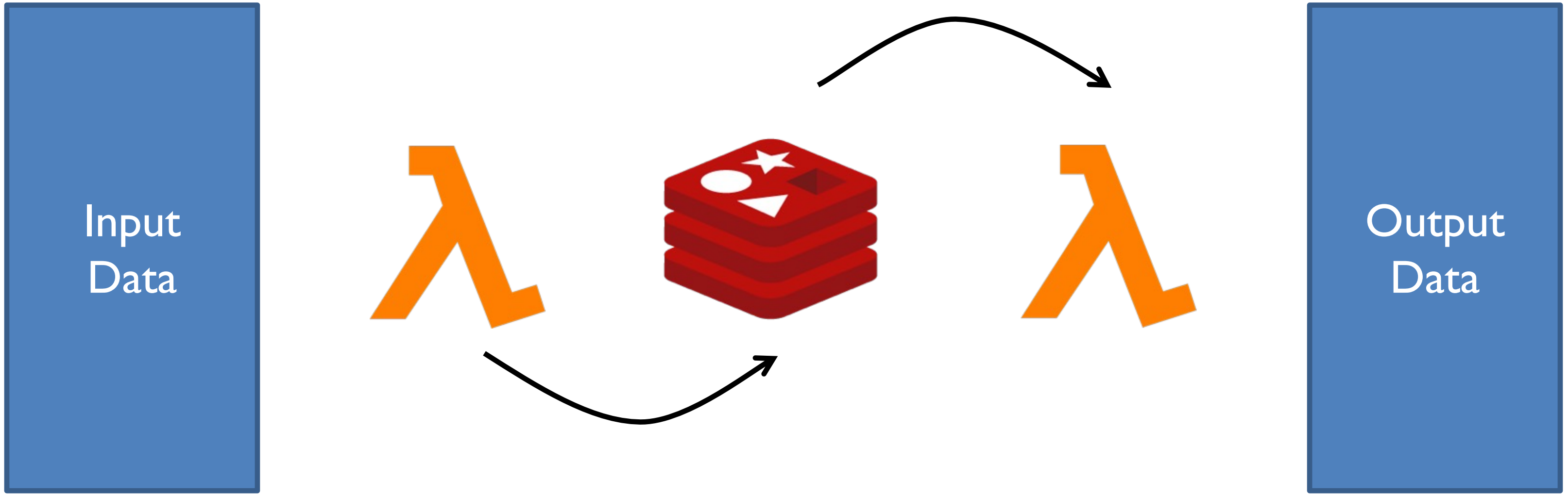

future = runner.map(fn, data)
Serialize func and data
Put on S3
Invoke Lambda
func
data
pull job from s3
download anaconda runtime
python to run code
pickle result
stick in S3
future.result()
poll S3
unpickle and return
result
your laptop
the cloud

STATELESS FUNCTIONS: WHY NOW ?

What are the trade-offs ?

Storage Medium	Write Speed (MB/s)
SSD on `c3.8xlarge`	208.73
SSD on `i2.8xlarge`	460.36
4 SSDs on `i2.8xlarge`	1768.04
S3	501.13

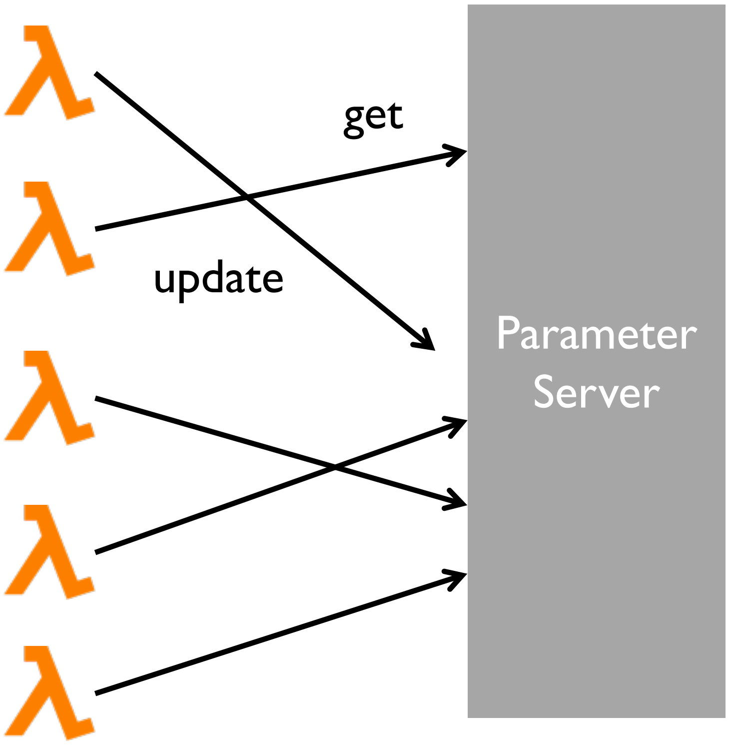
MAP AND REDUCE ?



PARAMETER SERVERS

Use lambdas to run “workers”

Parameter server as a service ?



WHEN SHOULD WE USE SERVERLESS ?

Yes!	Maybe not ?

SUMMARY

Motivation: Usability of big data analytics

Approach: Language-integrated cloud computing

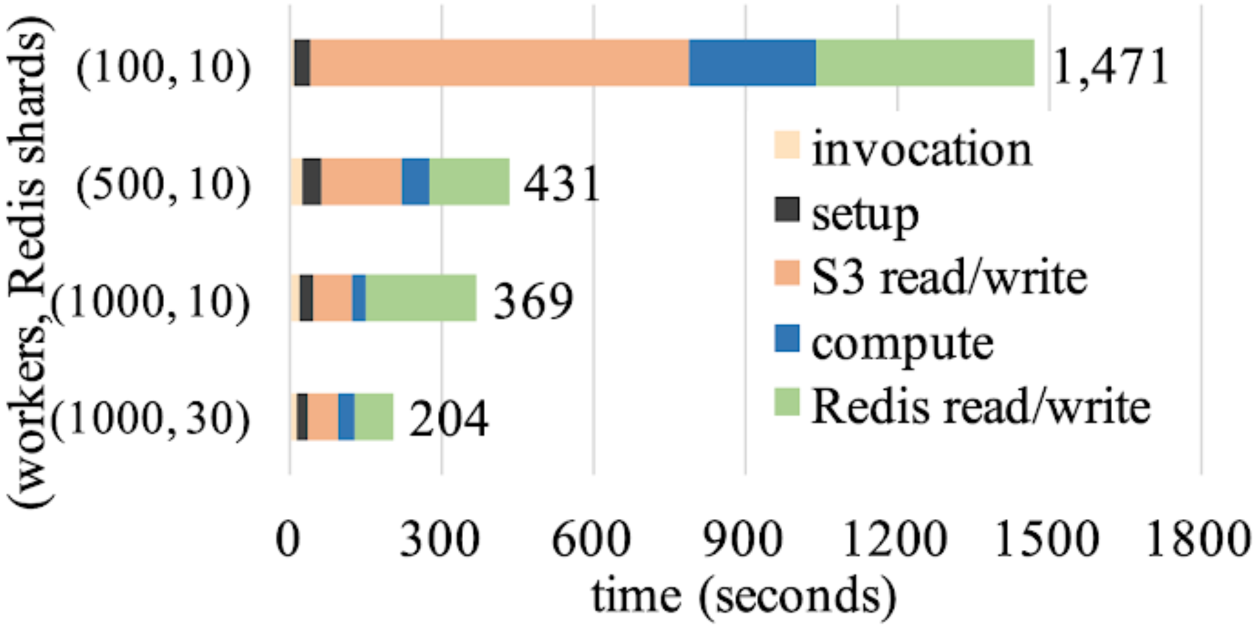
Features

- Breakdown computation into stateless functions
- Schedule on serverless containers
- Use external storage for state management

Open question on scheduling, overheads

DISCUSSION

https://forms.gle/cEvaUK4JR65Ykp7p9


(workers, Redis shards)
(100, 10)
(500, 10)
(1000, 10)
(1000, 30)
1,471
431
369
204
invocation
setup
S3 read/write
compute
Redis read/write
0
300
600
900
1200
1500
1800
time (seconds)

Consider you are a cloud provider (e.g., AWS) implementing support for serverless. What could be some of the new challenges in scheduling these workloads compared to schedulers we have studied in this class ? How would you go about addressing them?

NEXT UP

Next steps:

- Mid-semester project check-in
- TPU next