CS 4530 Software Engineering

Lesson 8.2: Deployment Infrastructure

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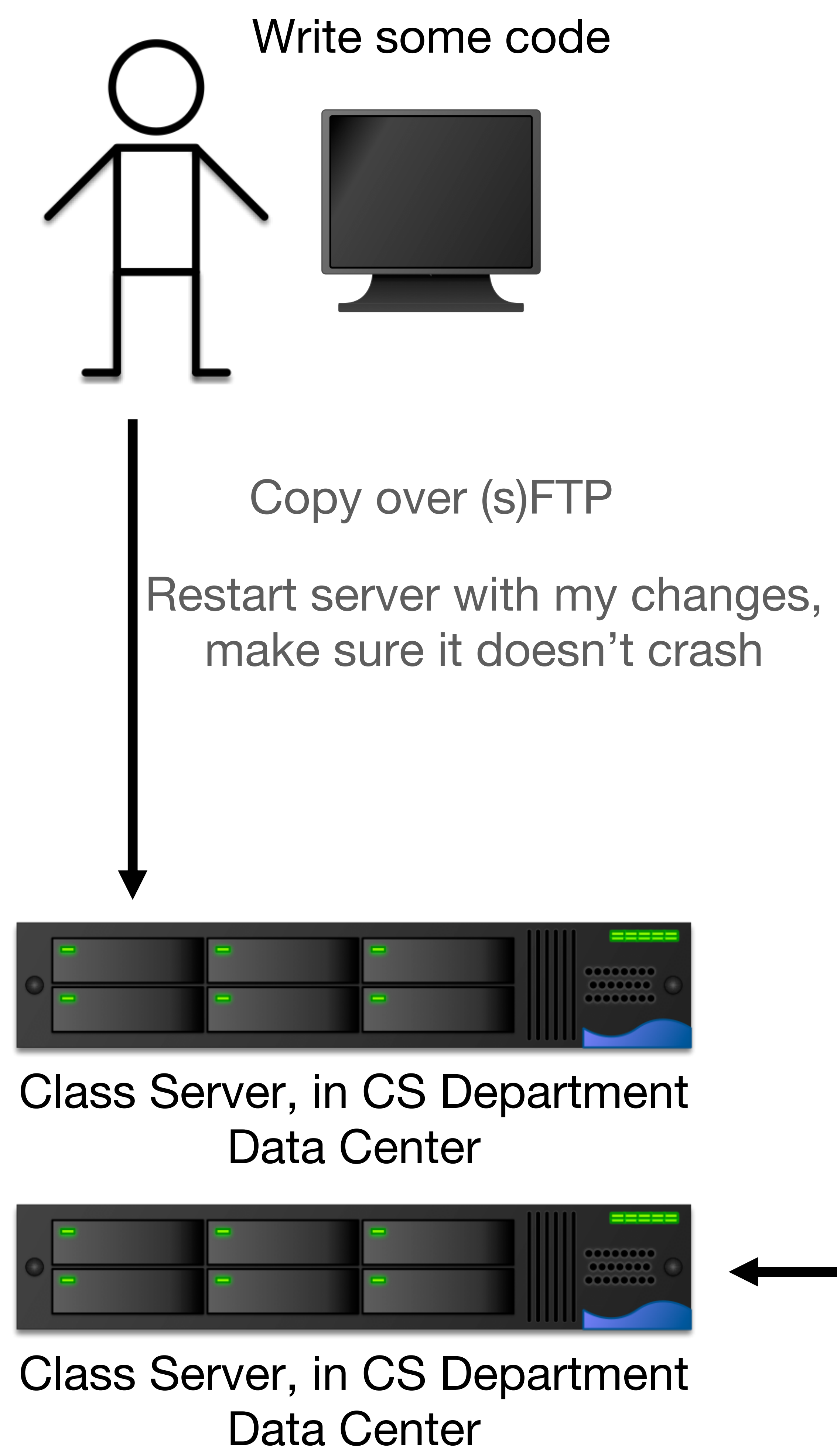
Learning Objectives for this Lesson

By the end of this lesson, you should be able to…

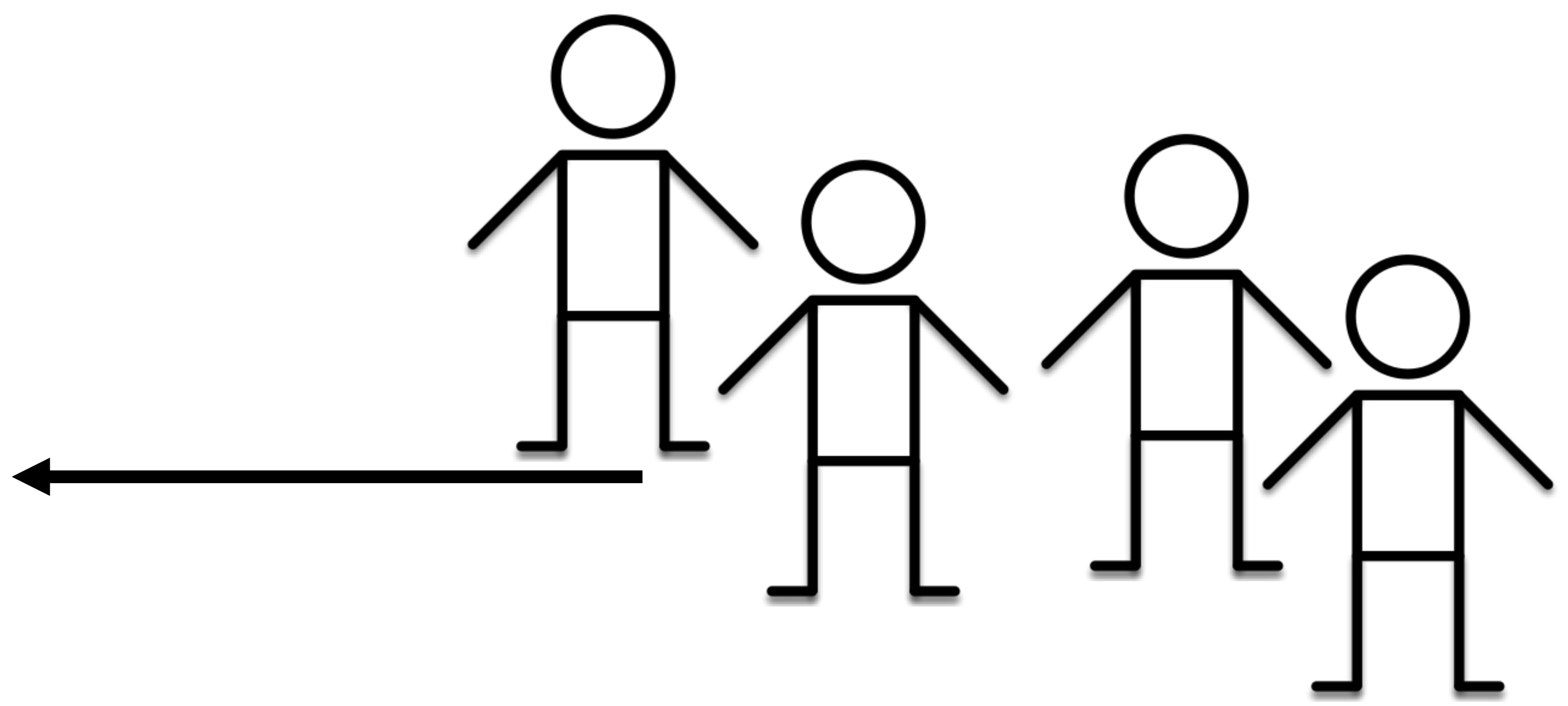
- Describe the difference between key deployment container abstractions and their role in modern software
- Compare the performance and cost of different deployment infrastructures, including platform-as-a-service

Deploying a Web App

Circa 2008: Manual deployments to private or shared machines


Write some code
Copy over (s)FTP
Restart server with my changes, make sure it doesn't crash
Class Server, in CS Department Data Center
Class Server, in CS Department Data Center

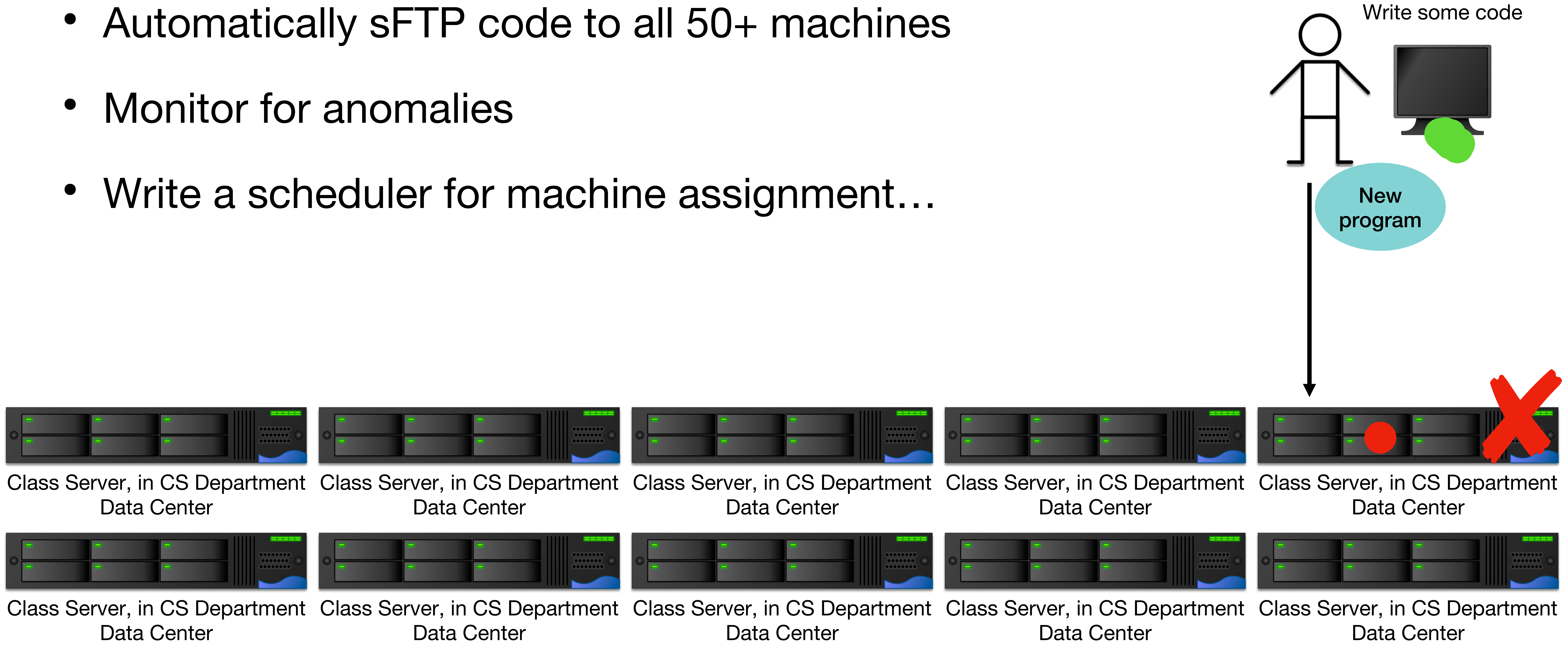
- A simple approach that works, but does not scale in:
  - Number of machines
  - Number of programs
  - Size of programs
  - Frequency of deployments



Deploying a Web App

Making it better: automation

- Automatically sFTP code to all 50+ machines
- Monitor for anomalies
- Write a scheduler for machine assignment…


Write some code
New program
Class Server, in CS Department Data Center
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Class Server, in CS Department Data Center
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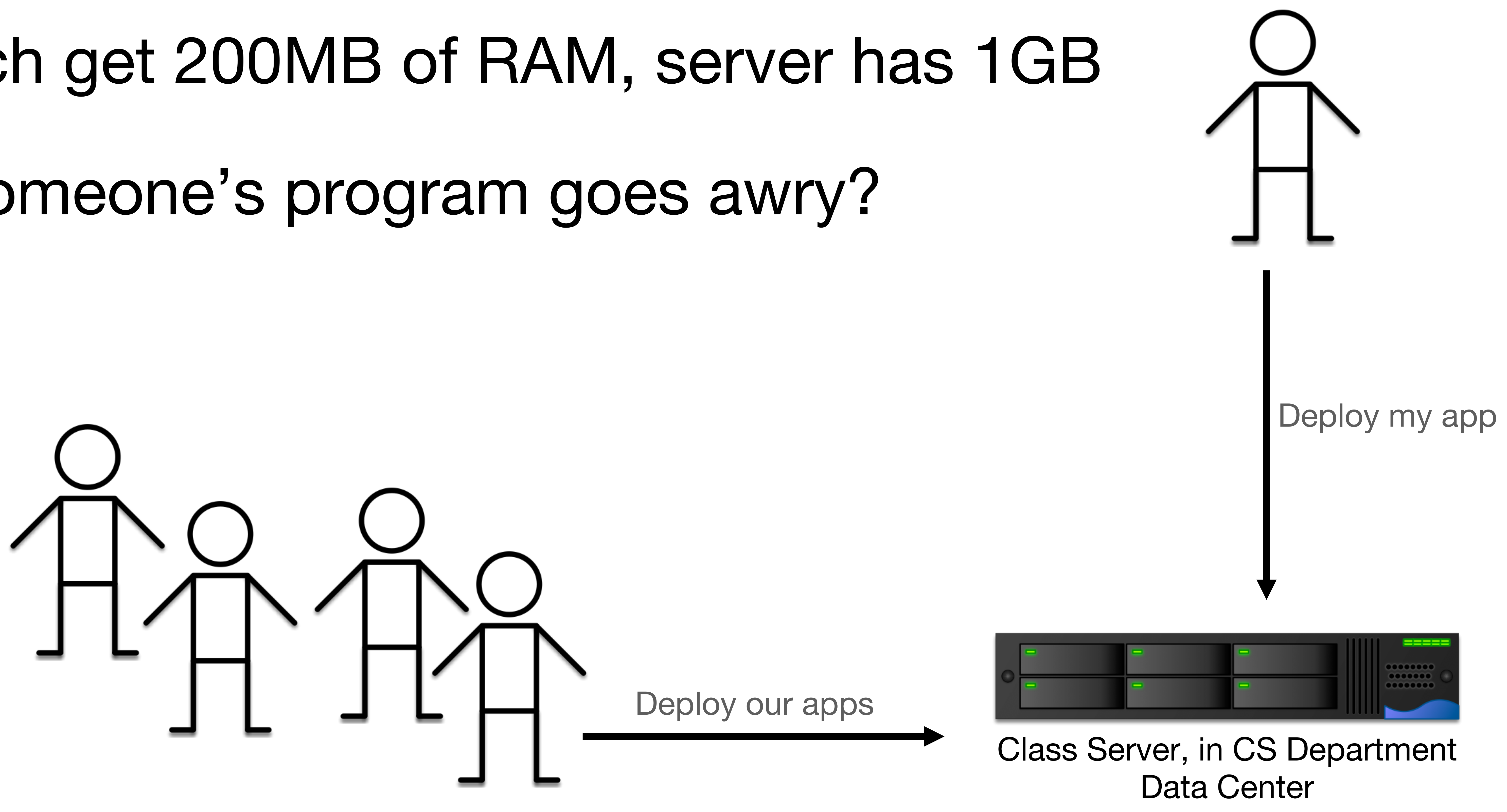
Class Server, in CS Department Data Center

Deploying a Web App

Making it better: Multitenancy

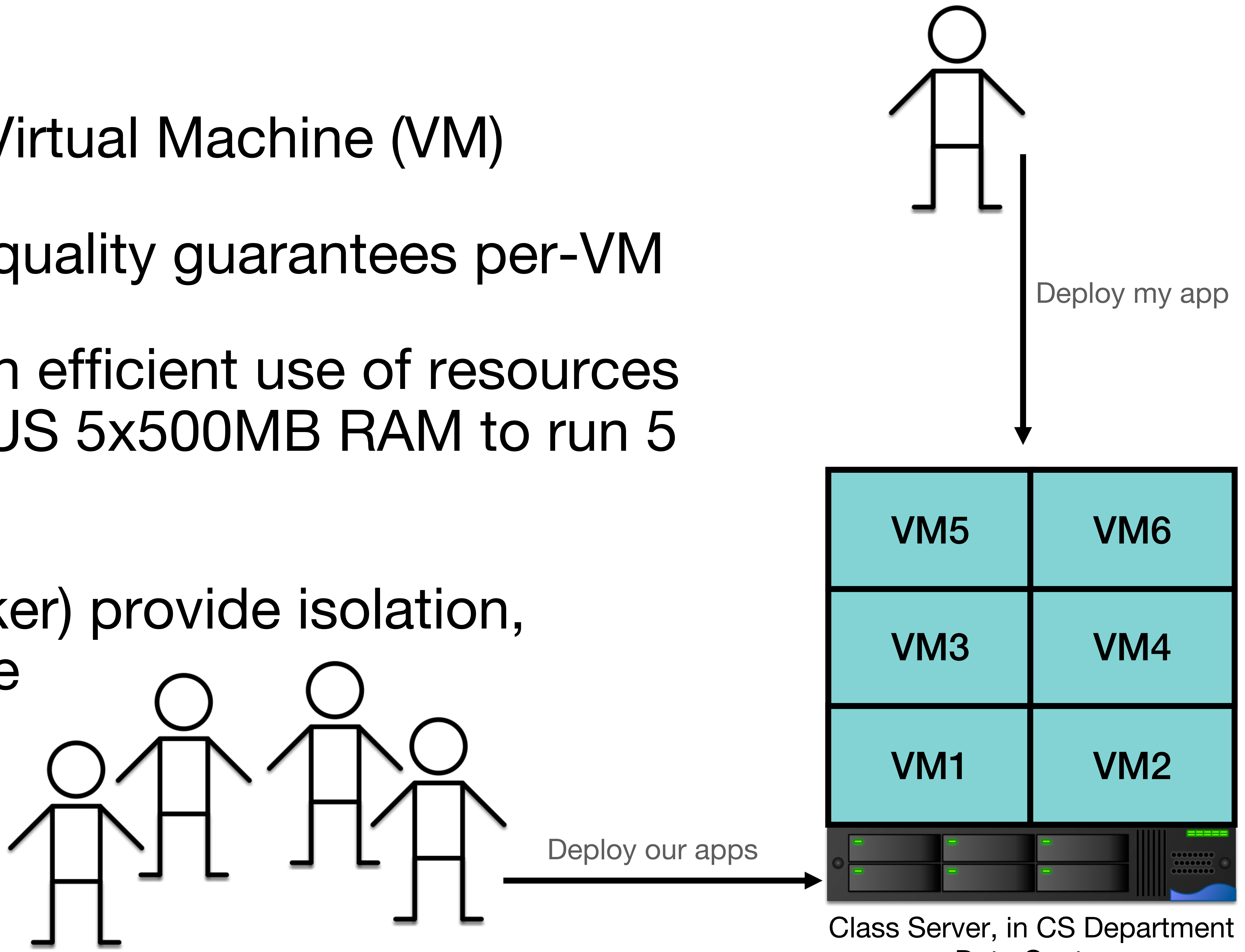
- What if the mapping of programs/users to machines is not 1:1?
- Example: 5 applications, each get 200MB of RAM, server has 1GB
- Problem: What happens if someone's program goes awry?



Multi-Tenancy

Virtualization to the rescue

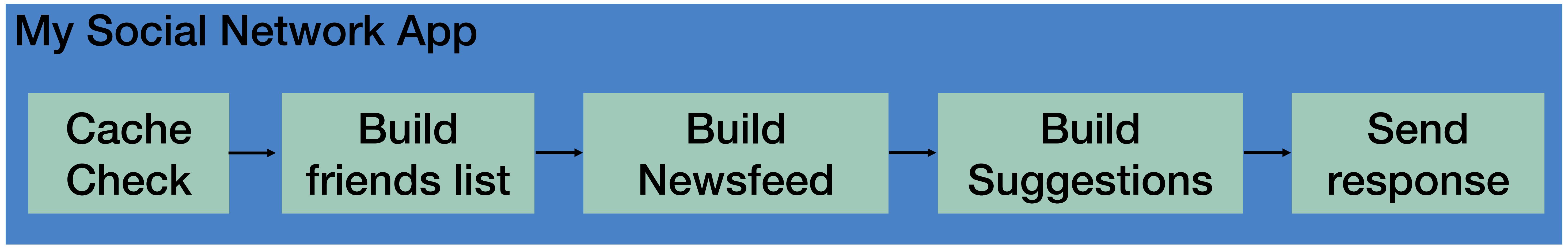
- Solution: Each app gets its own Virtual Machine (VM)
- OS provides resource limits and quality guarantees per-VM
- Each VM runs its own OS - not an efficient use of resources (5x200MB RAM for each app PLUS 5x500MB RAM to run 5 OS's)
- Lightweight containers (e.g. Docker) provide isolation, but run in same OS, less resource utilization



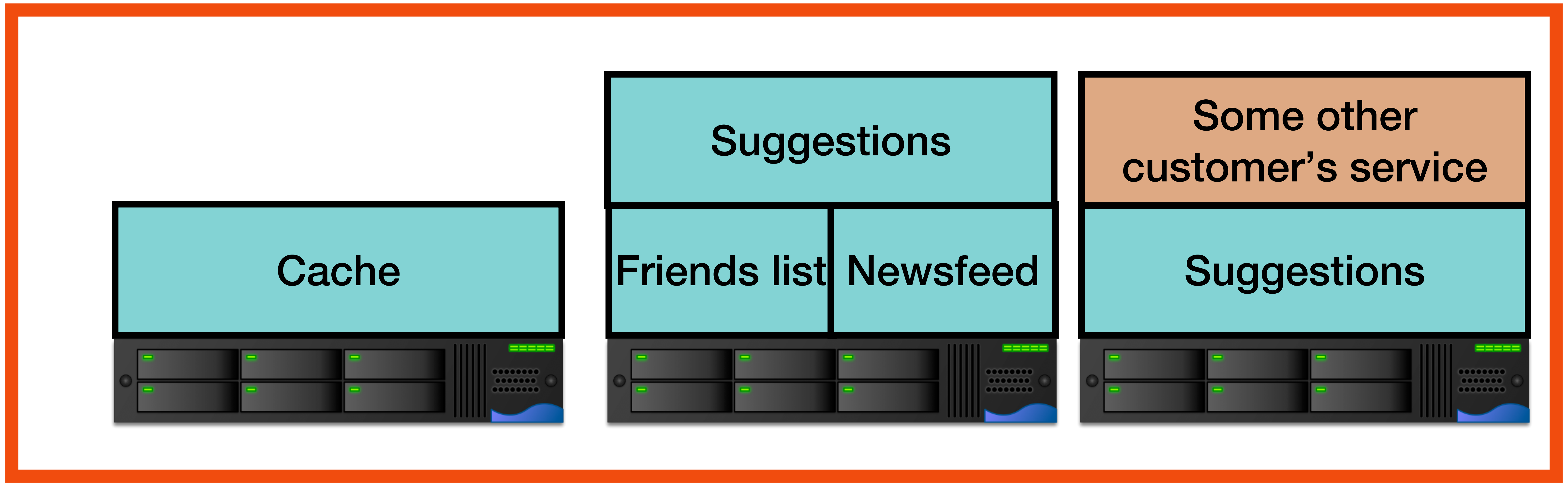
Class Server, in CS Department Data Center

Automating Deployment of Complex Infrastructure

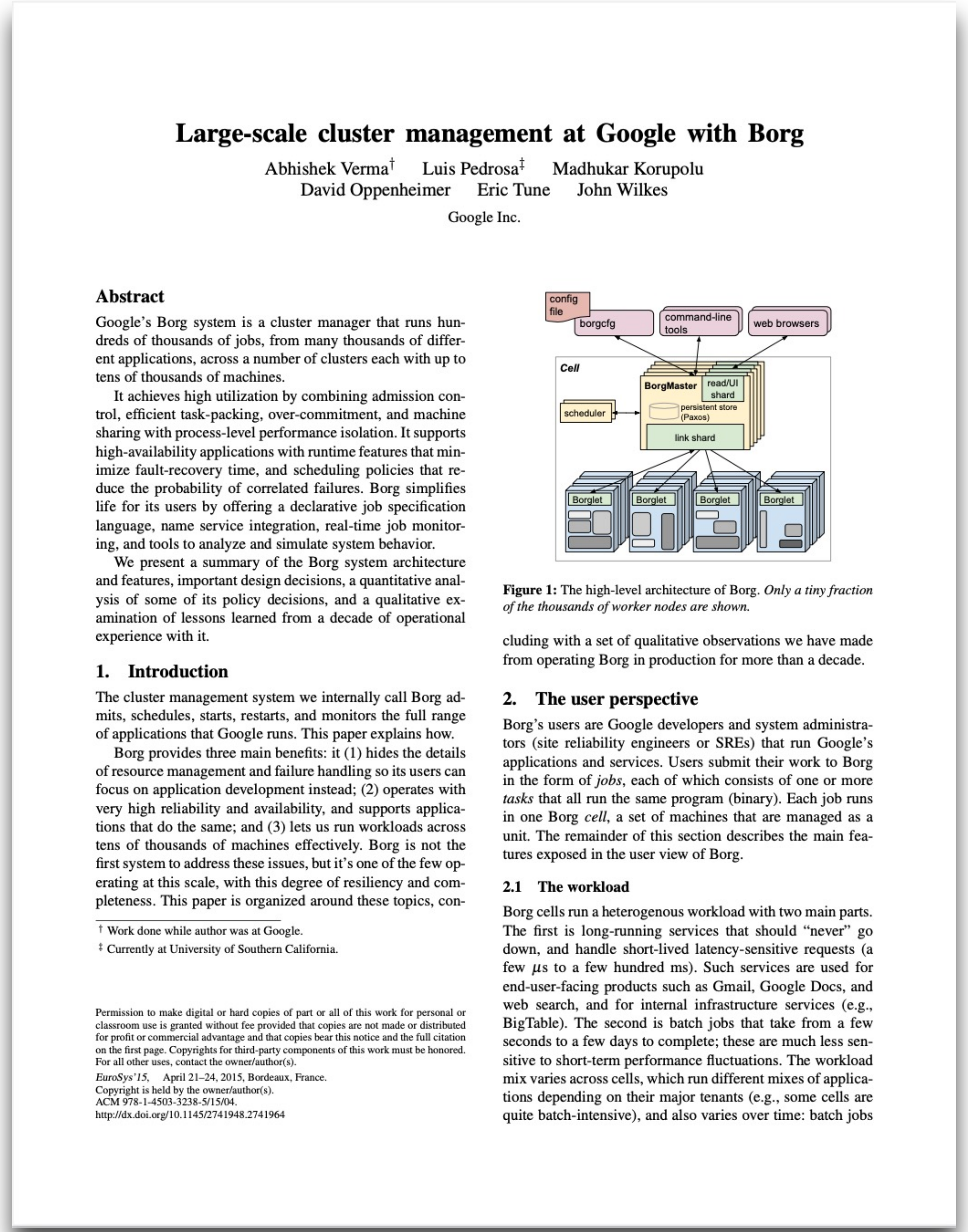
Automation + Multi-tenancy: Kubernetes



“Give me at least 1 of each of these app services in their own docker containers, and if the load gets above a threshold, spin up more of them”



Managed by Kubernetes



Large-scale cluster management at Google with Borg

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David Oppenheimer Eric Tune John Wilkes
Google Inc.

Abstract

Google’s Borg system is a cluster manager that runs hundreds of thousands of jobs, from many thousands of different applications, across a number of clusters each with up to tens of thousands of machines.

It achieves high utilization by combining admission control, efficient task-packing, over-commitment, and machine sharing with process-level performance isolation. It supports high-availability applications with runtime features that minimize fault-recovery time, and scheduling policies that reduce the probability of correlated failures. Borg simplifies life for its users by offering a declarative job specification language, name service integration, real-time job monitoring, and tools to analyze and simulate system behavior.

We present a summary of the Borg system architecture and features, important design decisions, a quantitative analysis of some of its policy decisions, and a qualitative examination of lessons learned from a decade of operational experience with it.

1. Introduction

The cluster management system we internally call Borg admits, schedules, starts, restarts, and monitors the full range of applications that Google runs. This paper explains how.

Borg provides three main benefits: it (1) hides the details of resource management and failure handling so its users can focus on application development instead; (2) operates with very high reliability and availability, and supports applications that do the same; and (3) lets us run workloads across tens of thousands of machines effectively. Borg is not the first system to address these issues, but it’s one of the few operating at this scale, with this degree of resiliency and completeness. This paper is organized around these topics, concluding with a set of qualitative observations we have made from operating Borg in production for more than a decade.

[†] Work done while author was at Google.

[‡] Currently at University of Southern California.

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http://dx.doi.org/10.1145/2741948.2741964

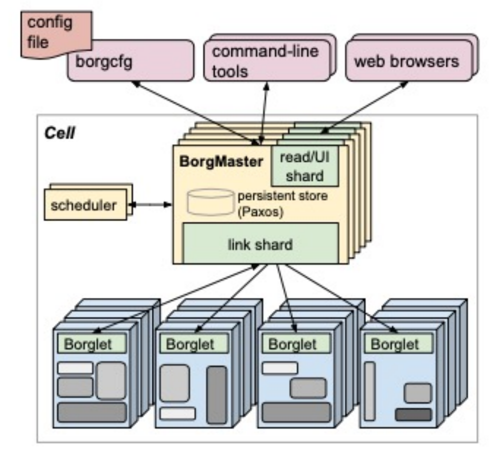


Figure 1: The high-level architecture of Borg. *Only a tiny fraction of the thousands of worker nodes are shown.*

2. The user perspective

Borg’s users are Google developers and system administrators (site reliability engineers or SREs) that run Google’s applications and services. Users submit their work to Borg in the form of *jobs*, each of which consists of one or more *tasks* that all run the same program (binary). Each job runs in one Borg *cell*, a set of machines that are managed as a unit. The remainder of this section describes the main features exposed in the user view of Borg.

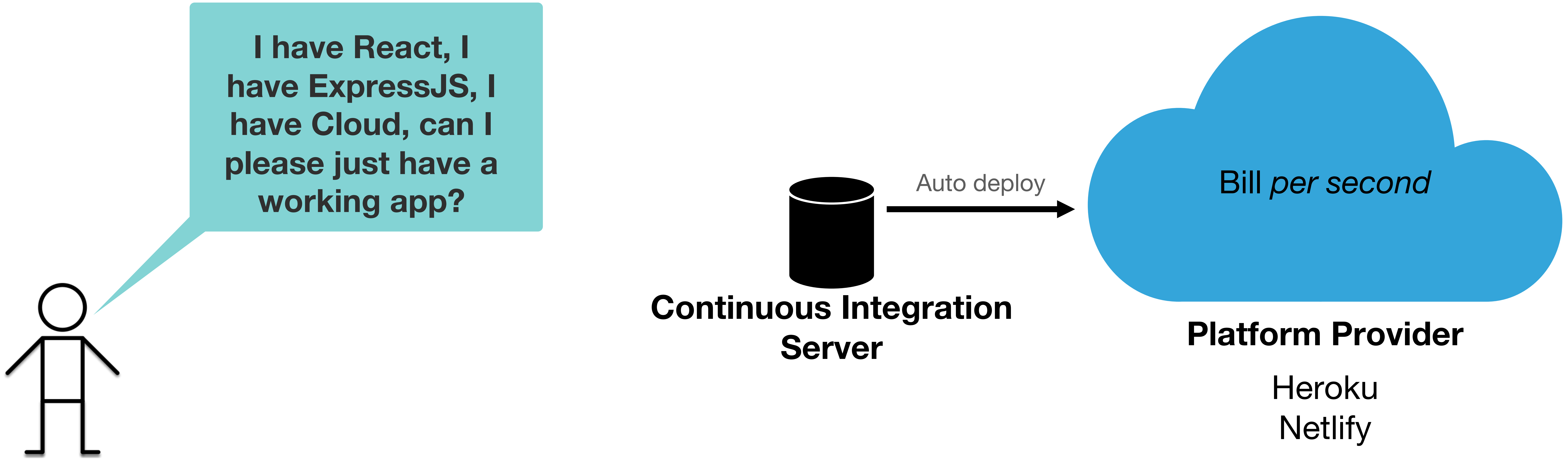
2.1 The workload

Borg cells run a heterogenous workload with two main parts. The first is long-running services that should “never” go down, and handle short-lived latency-sensitive requests (a few μs to a few hundred ms). Such services are used for end-user-facing products such as Gmail, Google Docs, and web search, and for internal infrastructure services (e.g., BigTable). The second is batch jobs that take from a few seconds to a few days to complete; these are much less sensitive to short-term performance fluctuations. The workload mix varies across cells, which run different mixes of applications depending on their major tenants (e.g., some cells are quite batch-intensive), and also varies over time: batch jobs

https://research.google/pubs/pub43438/

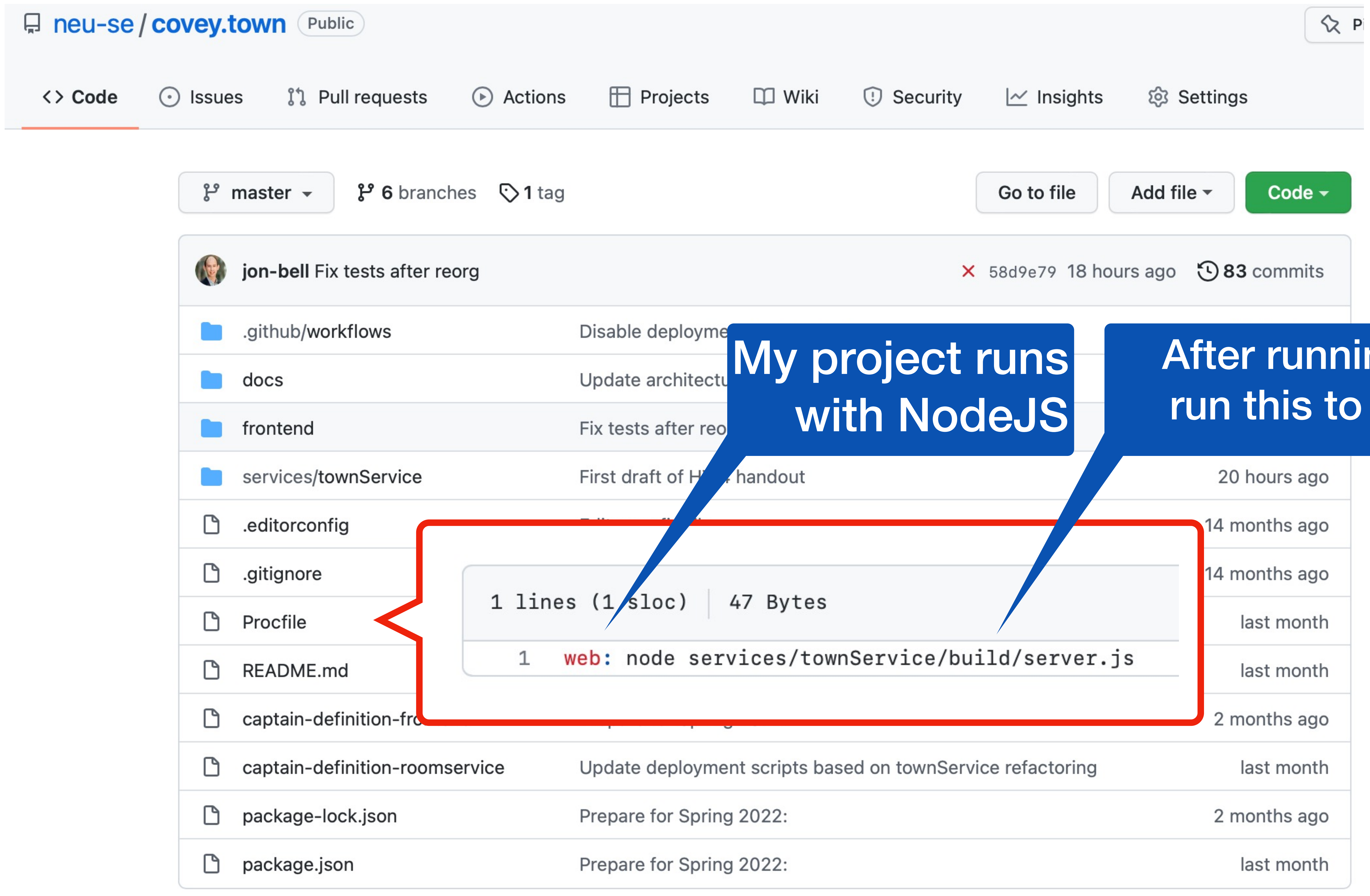
Multi-Tenancy

Platform-as-a-service: What if we *don't care* about the infrastructure?


I have React, I have ExpressJS, I have Cloud, can I please just have a working app?
Continuous Integration Server
Auto deploy
Bill *per second*
Platform Provider
Heroku
Netlify

Platform-as-a-Service: Covey.Town Deployment

Heroku


neu-se / covey.town Public
Code Issues Pull requests Actions Projects Wiki Security Insights Settings
master 6 branches 1 tag Go to file Add file Code

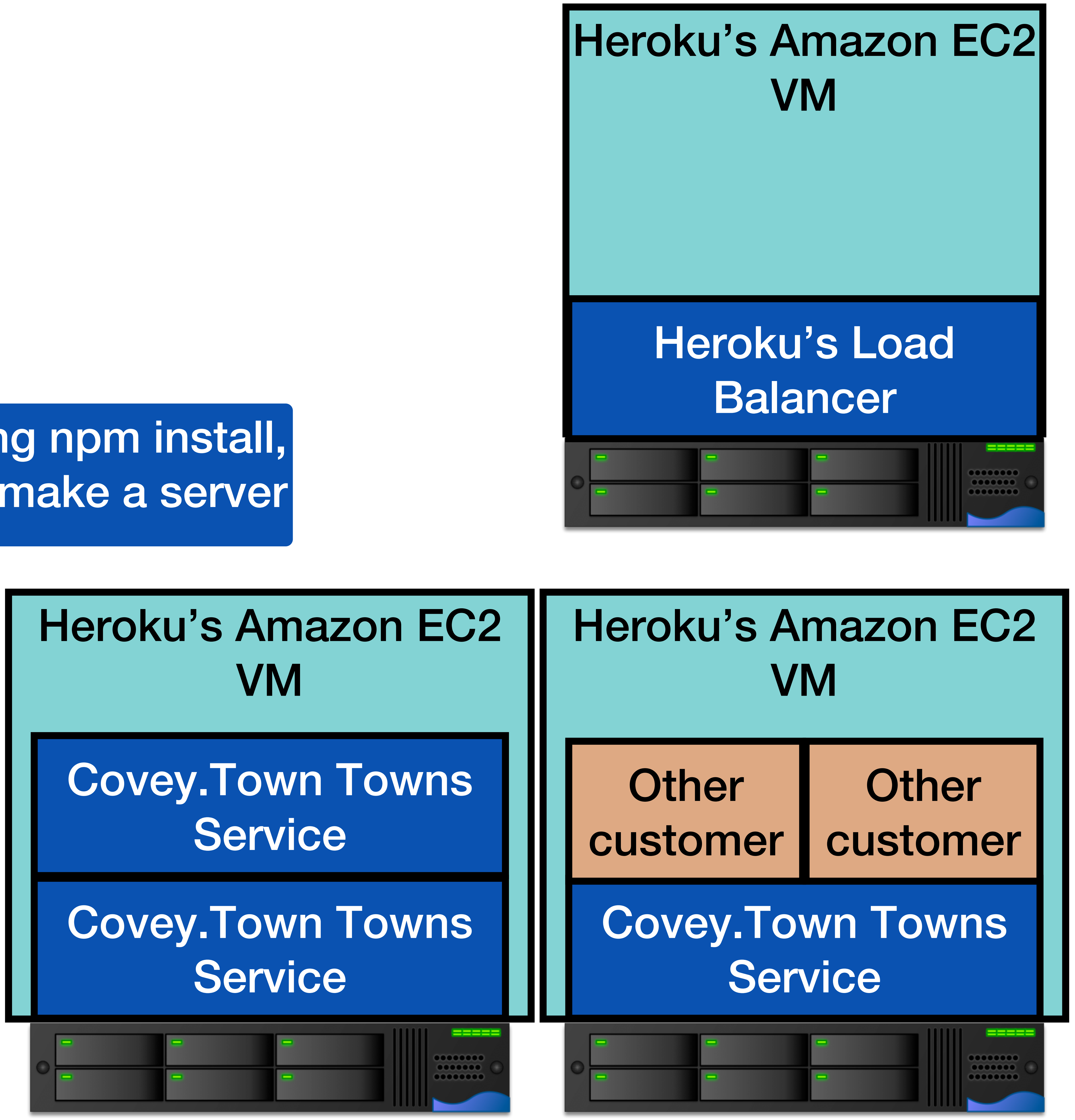
jon-bell Fix tests after reorg × 58d9e79 18 hours ago 83 commits

.github/workflows	Disable deployme	
docs	Update architectu	
frontend	Fix tests after reo	
services/townService	First draft of H handout	20 hours ago
.editorconfig		14 months ago
.gitignore		14 months ago
Procfile		last month
README.md		last month
captain-definition-fro		2 months ago
captain-definition-roomservice	Update deployment scripts based on townService refactoring	last month
package-lock.json	Prepare for Spring 2022:	2 months ago
package.json	Prepare for Spring 2022:	last month

```
1 lines (1 sloc) | 47 Bytes
web: node services/townService/build/server.js
```

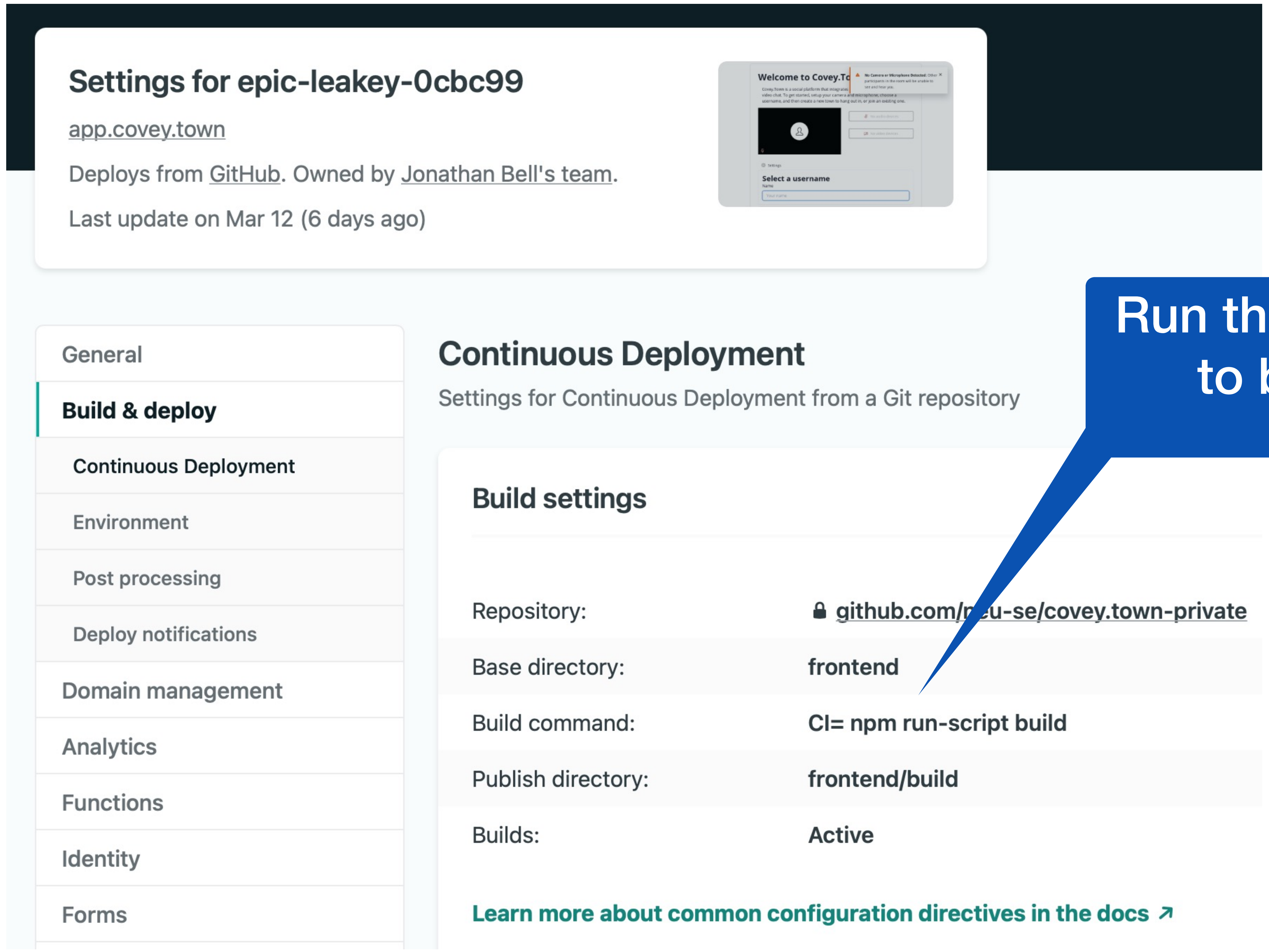
My project runs with NodeJS

After running npm install, run this to make a server



Platform-as-a-Service: Covey.Town Deployment

Netlify



Settings for epic-leakey-0cbc99

app.covey.town

Deploys from GitHub. Owned by Jonathan Bell's team.

Last update on Mar 12 (6 days ago)

Continuous Deployment

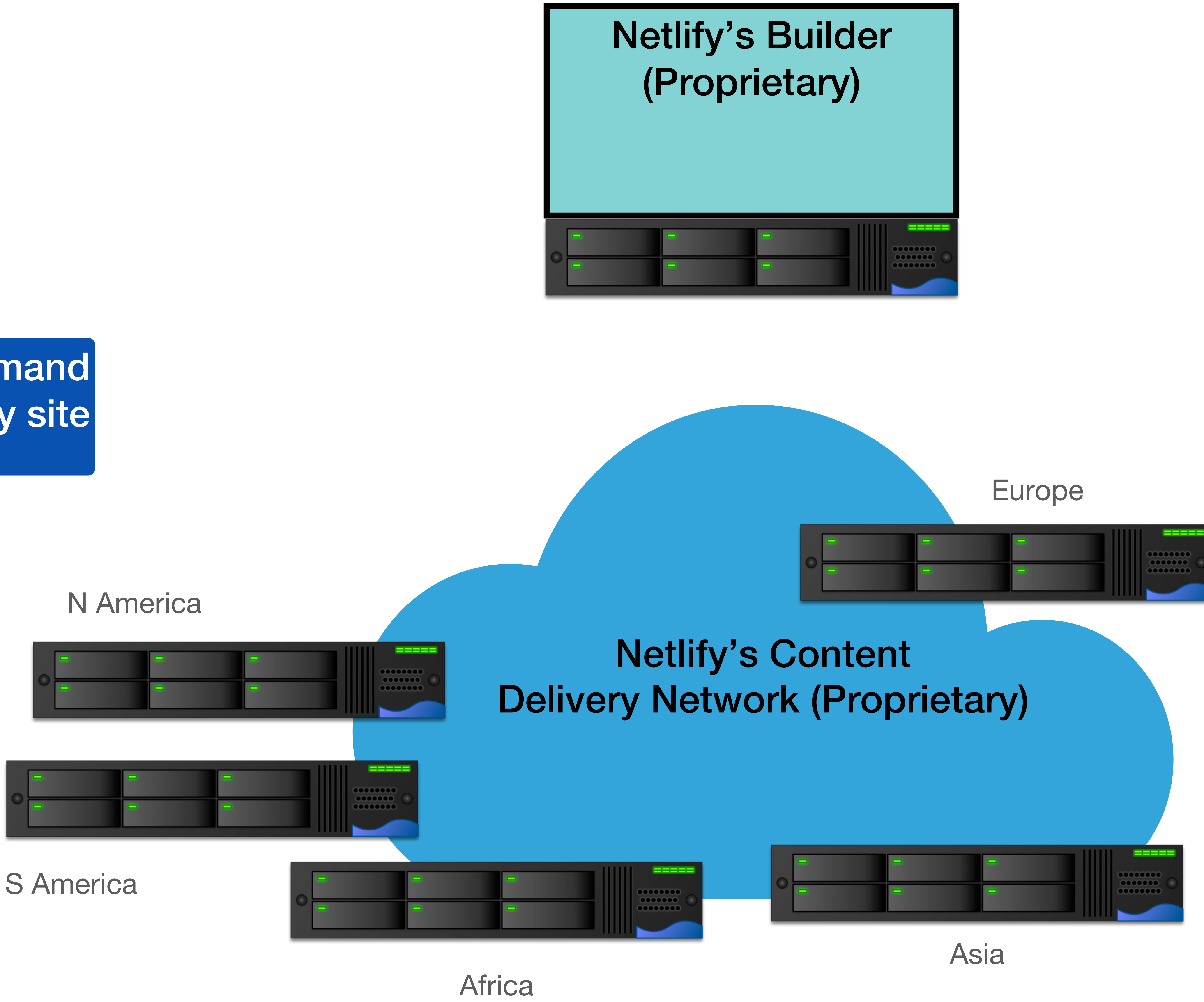
Settings for Continuous Deployment from a Git repository

Build settings

Repository:	github.com/neu-se/covey.town-private
Base directory:	frontend
Build command:	CI= npm run-script build
Publish directory:	frontend/build
Builds:	Active

Learn more about common configuration directives in the docs ↗

Run this command to build my site


Netlify's Builder (Proprietary)
Netlify's Content Delivery Network (Proprietary)
Europe
N America
S America
Africa
Asia

Computing Infrastructure

Choosing an abstraction for your application

- Centralization vs customization: “machines as cattle vs machines as pets”
- How do we manage state?
- What is our expected scale?
- How much management overhead do we want to take on?

Computing Infrastructure

Summary of the options

- Deploy VMs: Greatest degree of control, greatest cost, greatest latency
- Deploy containers: Better resource utilization
- Platform-as-a-service: Minimal degree of control, YMMV with cost