# 15-319 / 15-619
# Cloud Computing

Recitation 5

September 26th, 2017

# Overview

- **Administrative issues**
- Office Hours, Piazza guidelines
- **Last week's reflection**
- Project 2.1, OLI Unit 2 modules 5 and 6
- **This week's schedule**
  - Quiz 4 - September 29, 2017 (Modules 7, 8, 9)
  - Project 2.2 - October 1, 2017
  - Start exploring teams for the Team Project

# Announcements

- Monitor your expenses regularly
  - Check your bill frequently on TheProject.Zone
  - Check on AWS, use Cost Explorer & filter by tags
  - Check on the Azure portal since only $100/sem

- **Terminate** your resources when you are done
  - Stopping a VM still costs EBS money ($0.1/GB/month)
  - Amazon EC2 and Amazon Cloudwatch fees for monitoring, ELB
  - AutoScaling Group - no additional fees

# Announcements

- Use spot instances as much as possible
- Protect your credentials
  - Crawlers are looking for AWS credentials on public repos!
- Primer for 3.1 is out
  - Storage I/O Benchmarking

# Last Week's Reflection

- OLI: Conceptual Content
  - Unit 2 - Modules 5 and 6:
    - Cloud Management & Software Deployment Considerations
  - Quiz 3 completed
- P2.1: Azure, GCP, and AWS EC2 APIs
  - CLI, Java, Python
- P2.1: Load Balancing and AutoScaling
  - Experience horizontal scaling
  - Programmatically manage cloud resources and deal with failure
  - Initial experience with load balancing

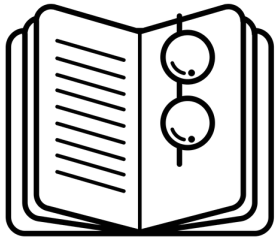
# Project 2.1

- To evaluate how well other people can read your code, we will be manually grading your submitted code
  - Azure
  - GCP
  - AWS (Horizontal and Autoscaling)
  - To enhance readability
    - Use the Google Code Style guidelines
  - Always add comments especially for complex parts

# Project 2.1

- You gained experience working with Cloud Service Provider's APIs
  - Documentation may be unclear or may omit certain details.
  - Have to ensure you’re referencing the correct documentation version.
- Considerations of cost vs performance

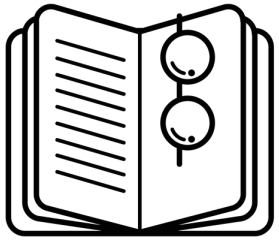
# This Week: Content



CollabU Course on OLI:

- Complete Units 1 and 2 by Sunday October 8 at 11:59PM ET.
- 15-619 Only
  - To help you prepare for the team project
- Detailed instructions on Piazza
  - https://piazza.com/class/j6qnpbww91r7hl?cid=654

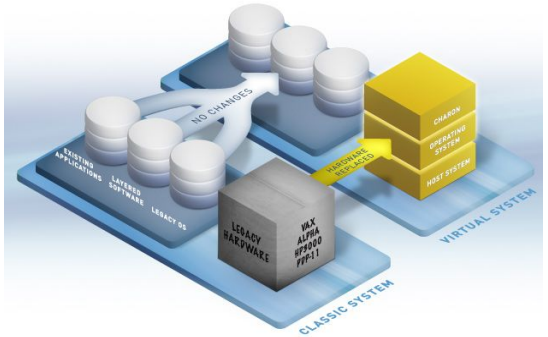
# This Week: Content



- UNIT 3: Virtualizing Resources for the Cloud
  - Module 7: Introduction and Motivation
  - Module 8: Virtualization
  - Module 9: Resource Virtualization - CPU
  - Module 10: Resource Virtualization - Memory
  - Module 11: Resource Virtualization – I/O
  - Module 12: Case Study
  - Module 13: Network and Storage Virtualization

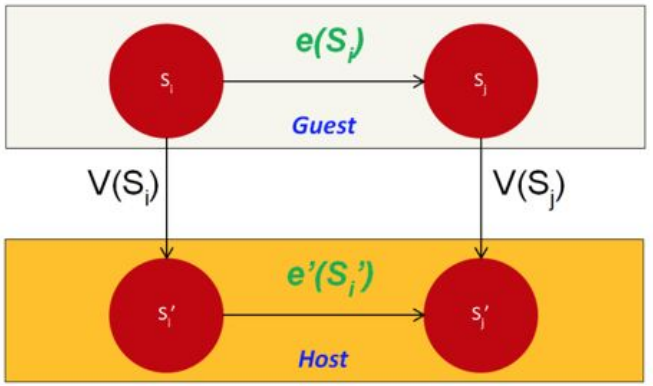
# OLI Module 7 - Virtualization Introduction and Motivation

- Why virtualization
  - Enabling the cloud computing system model
  - Elasticity
  - Resource sandboxing
  - Limitation of General-Purpose OS
  - Mixed OS environment
  - Resource sharing
    - Time
    - Space
  - Improved system utilization and reduce costs from a cloud provider perspective



# OLI Module 8 - Virtualization

- What is Virtualization
  - Involves the construction of an isomorphism that maps a virtual guest system to a real (or physical) host system
  - Sequence of operations *e* modify guest state
  - Mapping function *V(Si)*

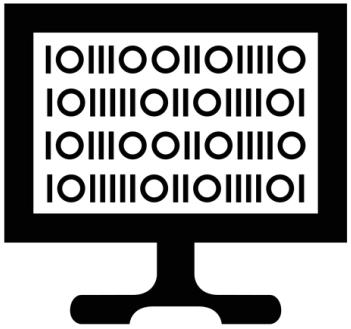



- Virtual Machine Types
  - Process Virtual Machines
  - System Virtual Machines

# OLI Module 9
# Resource Virtualization - CPU

- Steps of CPU Virtualization
  - Multiplexing a physical CPU among virtual CPUs
  - Virtualizing the ISA (Instruction Set Architecture) of a CPU
- Code Patch, Full Virtualization and Paravirtualization
- Emulation (Interpretation & Binary Translation)
- Virtual CPU

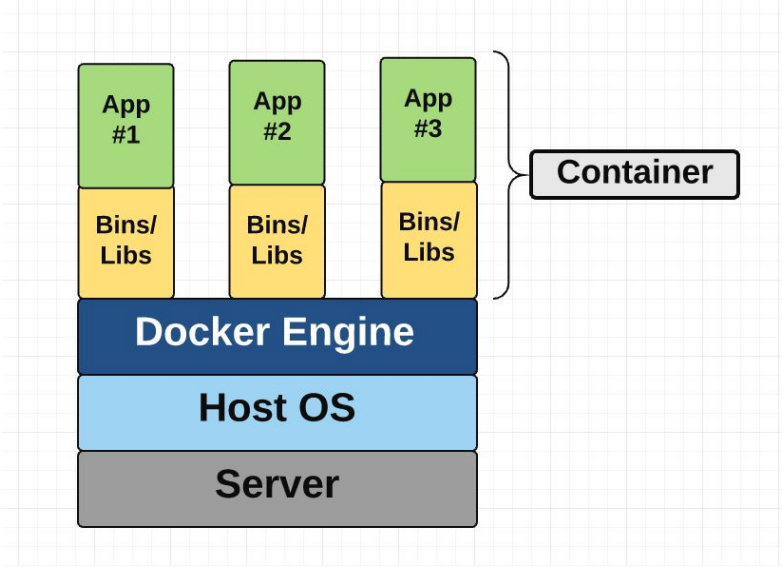
# This Week: Project



- P2.1: Horizontal Scaling and Autoscaling
  - MSB Interview
- P2.2: Containers and Kubernetes
  - Building a Coding Interview Playground
  - Working with Docker and Kubernetes

# Containers

- Provides OS-level virtualization.
- Provides private namespace, network interface and IP address, etc.
- Big difference with VMs is that containers share the host system's kernel with other containers.



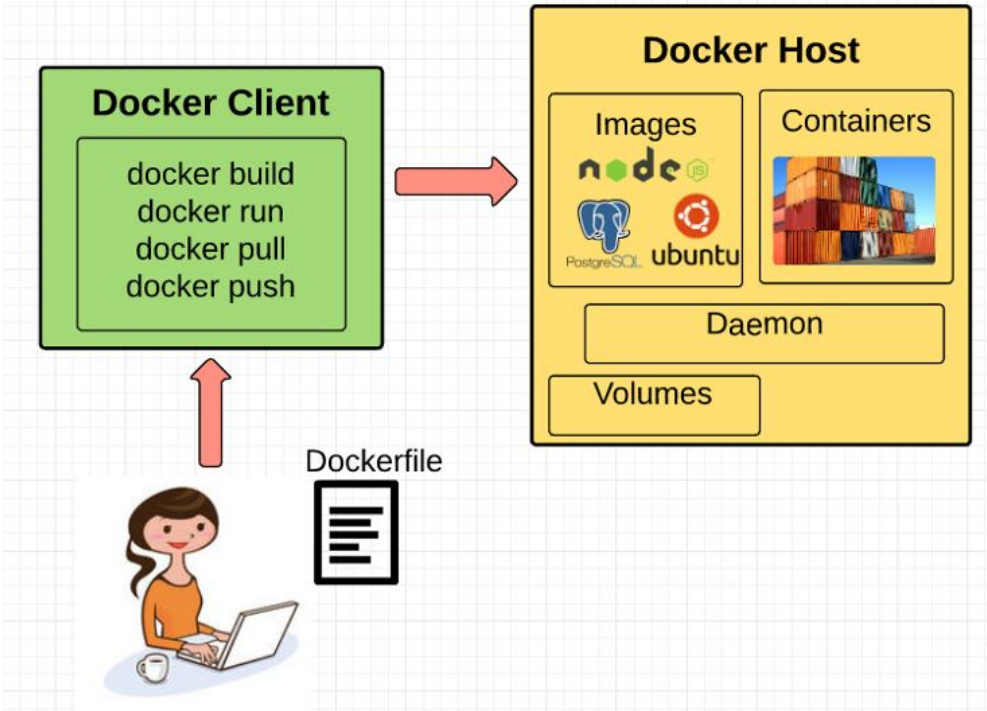
# Why Containers?

- Faster deployment
- Portability across machines
- Version control
- Simplified dependency management

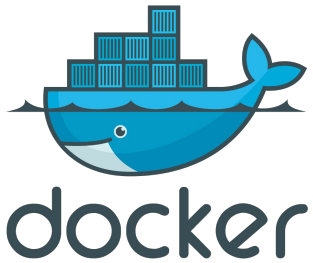
Build once, run anywhere

# Docker Engine

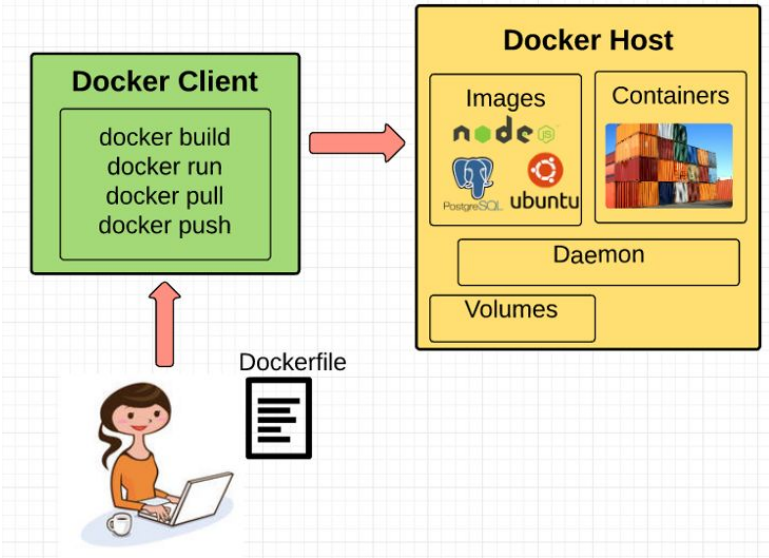
- An orchestrator that comprises:
  - Docker Daemon
  - Docker Client
  - REST API



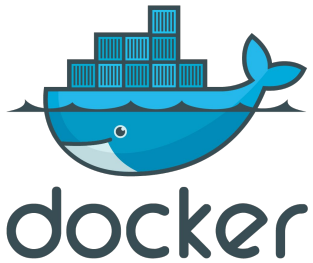
# Docker Daemon




- Main brains behind Docker Engine
- The Docker Client is used to communicate with the Docker Daemon
- The Daemon does not have  to be on the same machine as the Client



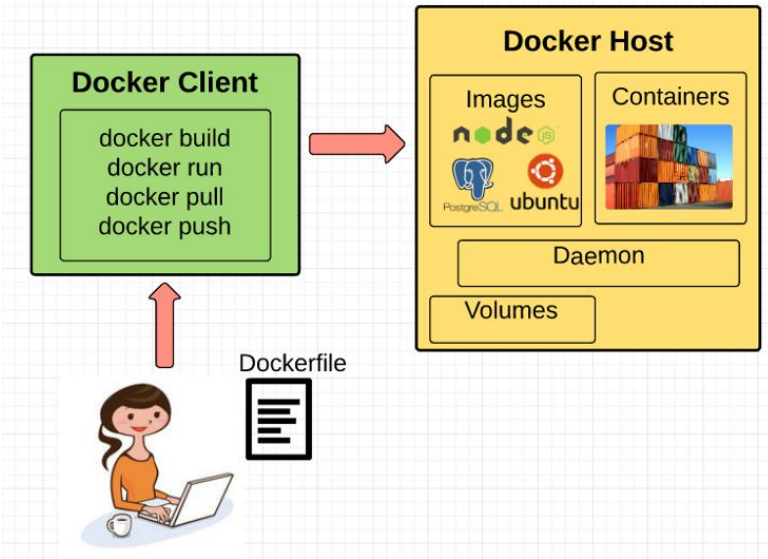
# Docker Client



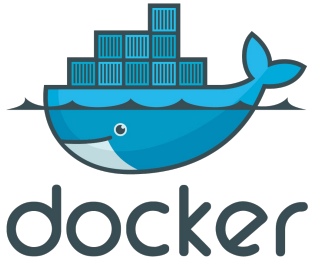

- Also known as Docker CLI
- When you type:

```
docker build nginx
```

You are telling the Docker client to forward the `build nginx` instruction to the Daemon



# Dockerfile




- We can use a Dockerfile to build container **images**
- Dockerfile tells Docker:
  - What base image to work from
  - What commands to run on base image
  - What files to copy to the base image
  - What ports should the container listen on?
  - What binaries to execute when the container launches?
- In short, Dockerfile is a recipe for Docker images

Let's go through a sample Dockerfile!

# Example Dockerfile

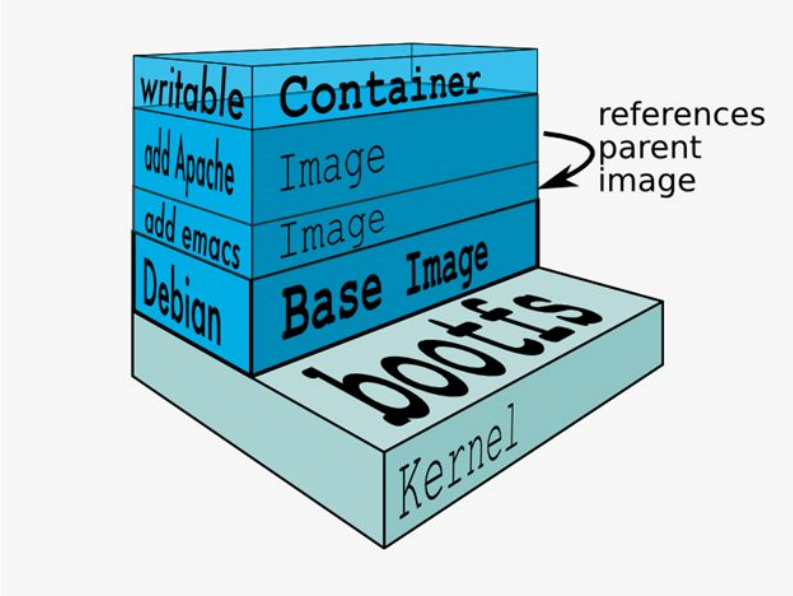
```
# Debian as the base image
FROM debian:latest

# Install additional packages
RUN apk add --update emacs
RUN apk add --update apache

# index.html must be in the current directory
ADD index.html /home/demo/

# Define the command which runs when the container starts
CMD ["cat /home/demo/index.html"]

# Use bash as the container's entry point. CMD is the argument to this entry point
ENTRYPOINT ["/bin/bash", "-c"]
```



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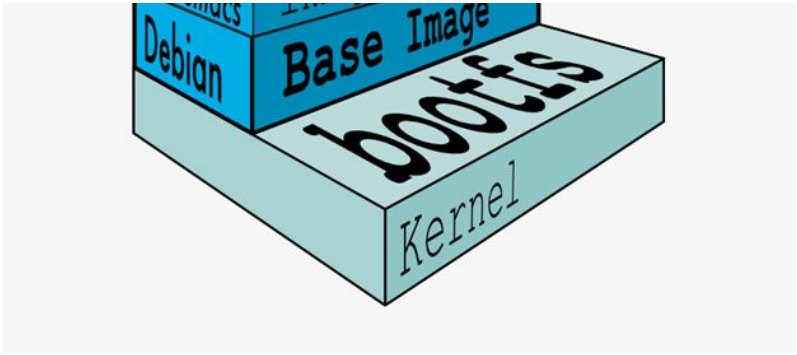

# Example Dockerfile

```
# Alpine Linux as the base image
FROM debian:latest

# Install additional packages
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ADD index.html /home/demo/

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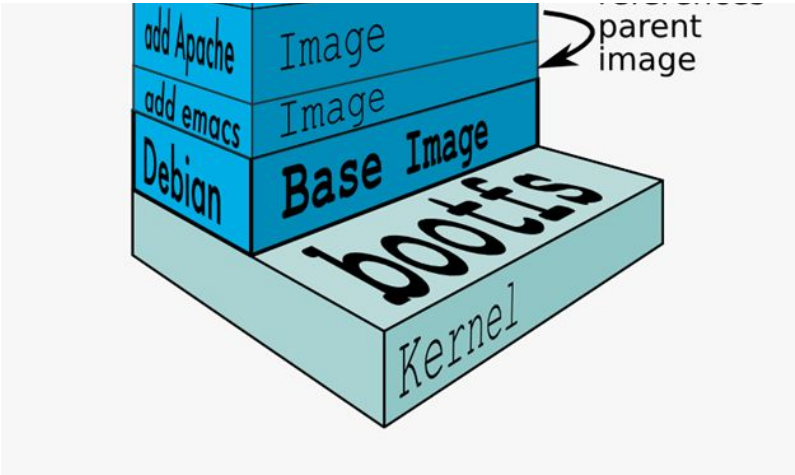

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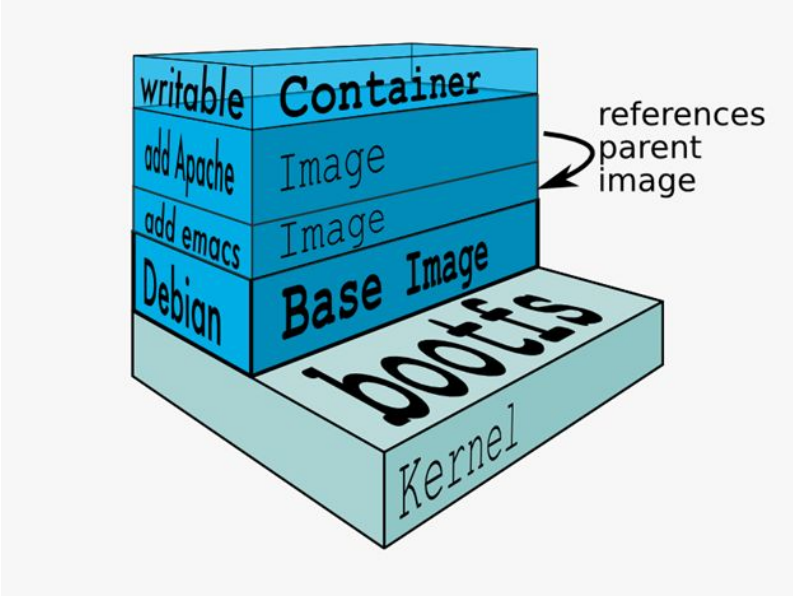

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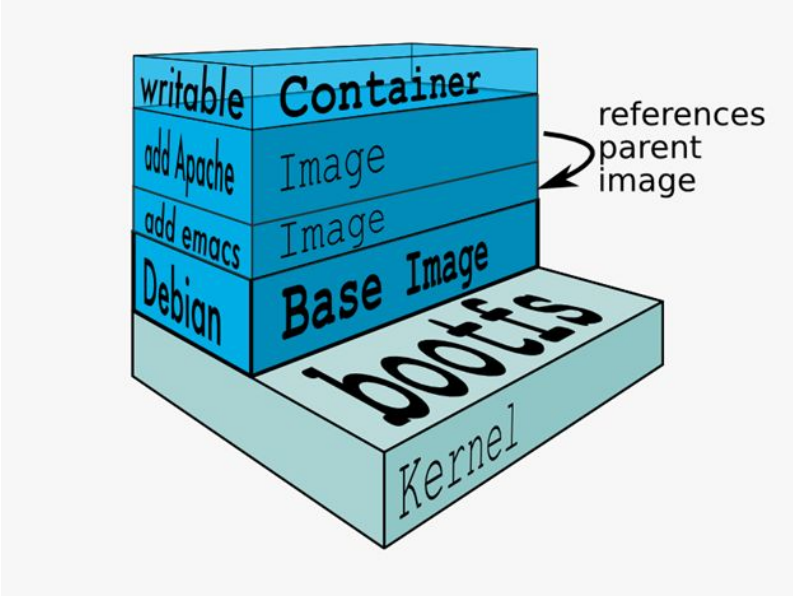


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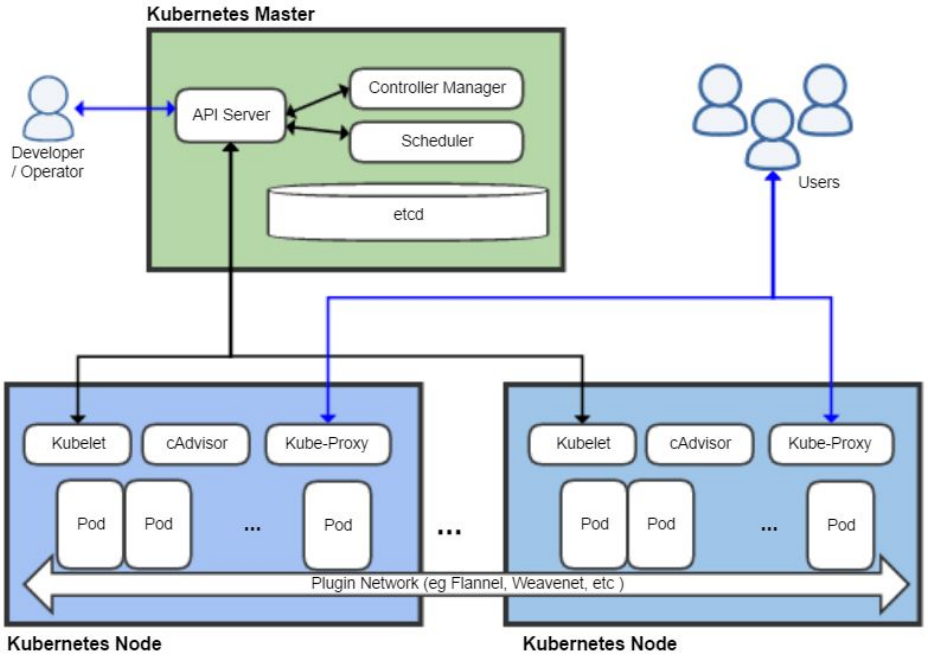
# Images & Containers

- An image: is a static file; never changes
- A container: a live instance of an image
- Think of it this way – you have a DVD that installs Windows OS (image). After you install it, you can write files to it (container).
- `docker build`
  - builds an image
- `docker run`
  - runs a container based off of an image

# Kubernetes

- Kubernetes is an open-source platform for automating deployment, scaling, and operations of application containers.
  - Containers built using Docker
  - Images stored in a private registry
  - Application defined using a YAML (or JSON) template

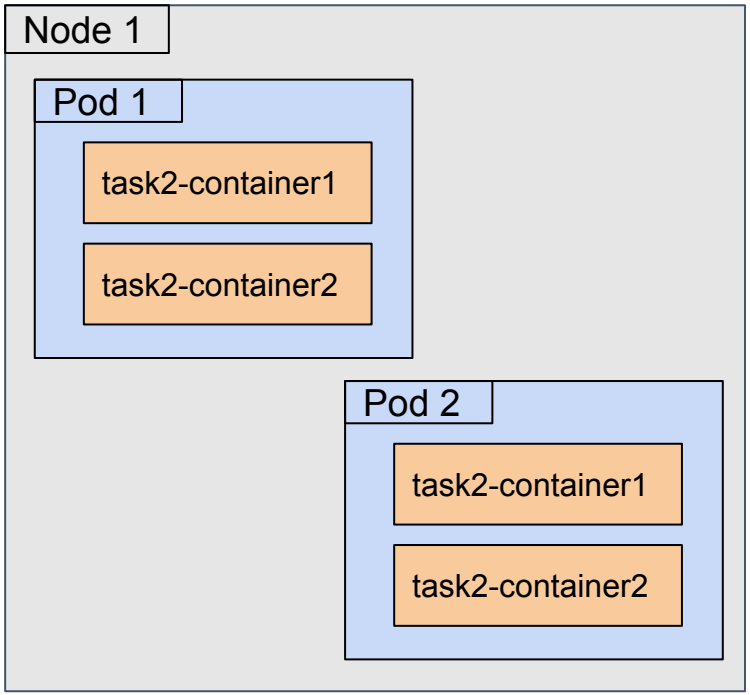



https://upload.wikimedia.org/wikipedia/commons/b/be/Kubernetes.png

# Deploying with Kubernetes

- kubectl is the command that interacts with the Kubernetes Master (API Server)
- Pod Configuration Reference
  - `kubectl create -f demo_pod.yaml`

```
apiVersion: v1
kind: Pod
metadata:
  name: test
  labels:
    app: test
spec:
  containers:
    - name: backend1
      image: us.gcr.io/cc-p22/task2-container1:v0
      ports:
       - name: http
         containerPort: 8080
  ...
```



# Project 2.2 - Containers

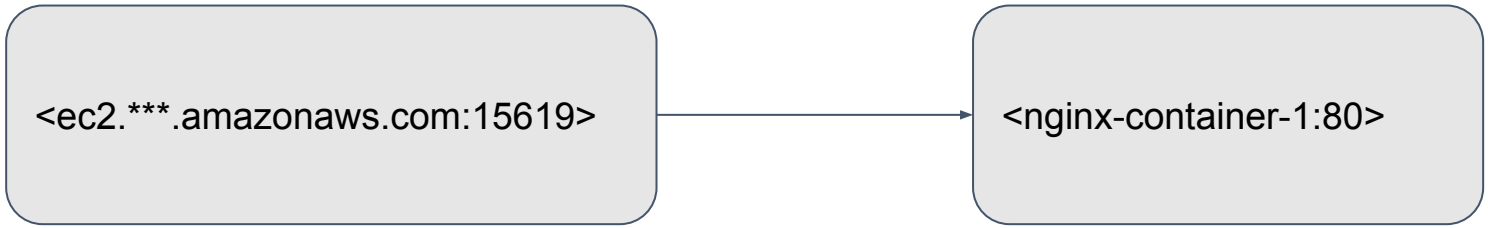
- Build a service to compile and run user code submitted through a front end.
- Four tasks:
  - Task 1: Containerize an Nginx server and run container locally.
  - Task 2: Build a Python web service to evaluate Python code submitted from the UI and return the result.
  - Task 3: Multi-cloud deployment. The Python code evaluation service will be replicated across clouds.
  - Task 4: Implementing fault tolerance and autoscaling rules.

# Task 1 Objectives

- Work with Dockerfiles
- Master the Docker CLI, including useful commands like:
  - `docker build`
  - `docker images`
  - `docker run`
  - `docker ps`
- Think about integration between the host and the container

# Task 1 Overview

- Configure a Docker container with an Nginx web server
- Nginx server listening on port 15619
- Port 15619 of host VM mapped to the container port

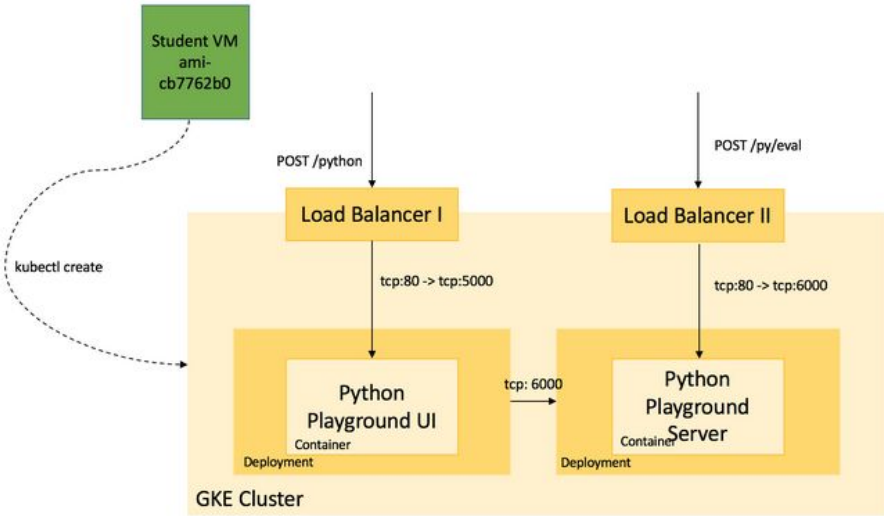


# Task 2 Objectives

- Developing a code execution service
  - Accepts Python code from the UI (over HTTP)
  - Use the provided API specification to develop your application.
    - Service that consumes and produces JSON.
- Develop Kubernetes YAML definition
  - Application for UI, exposed as Service via LB
  - Backend service also exposed to the Internet

# Task 2 Overview

- Python code evaluation service architecture.
- The UI is exposed on the internet, accepts POST requests.




Python

Python Code

```
1  # Welcome to the Python Explorer
2  import random;
3
4  firstRandom = random.randint(1, 100);
5  secondRandom = random.randint(1, 100);
6
7  sum = firstRandom + secondRandom;
8
9  print ("The first random number is: " + str(firstRandom));
10 print ("The second random number is: " + str(secondRandom));
11
12 print ("The sum of the random numbers is: " + str(sum));
13
```

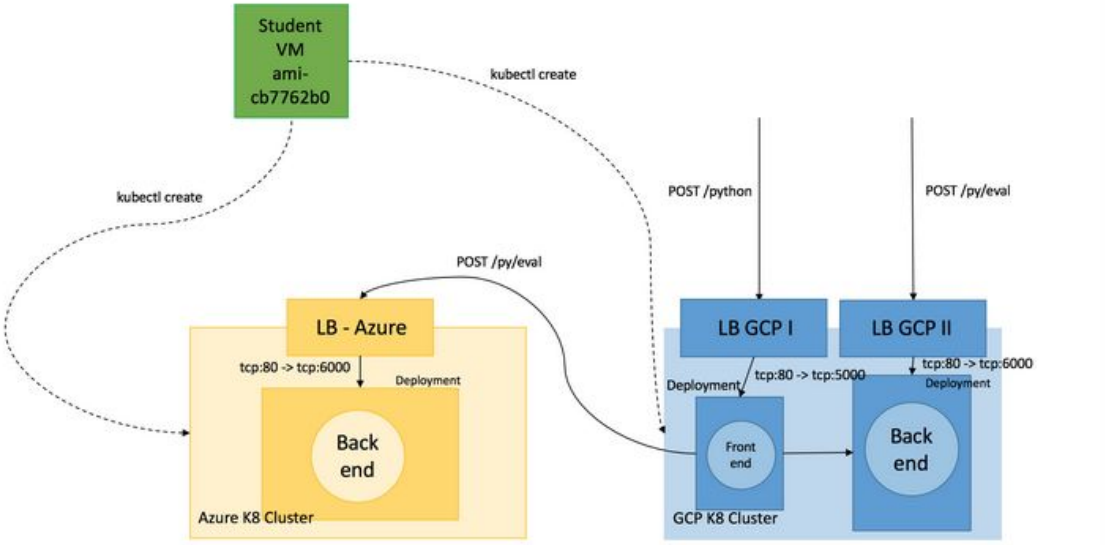
Output

```
1 The first random number is: 34
2 The second random number is: 74
3 The sum of the random numbers is: 108
4
```

Submit

# Task 3 Objectives & Overview

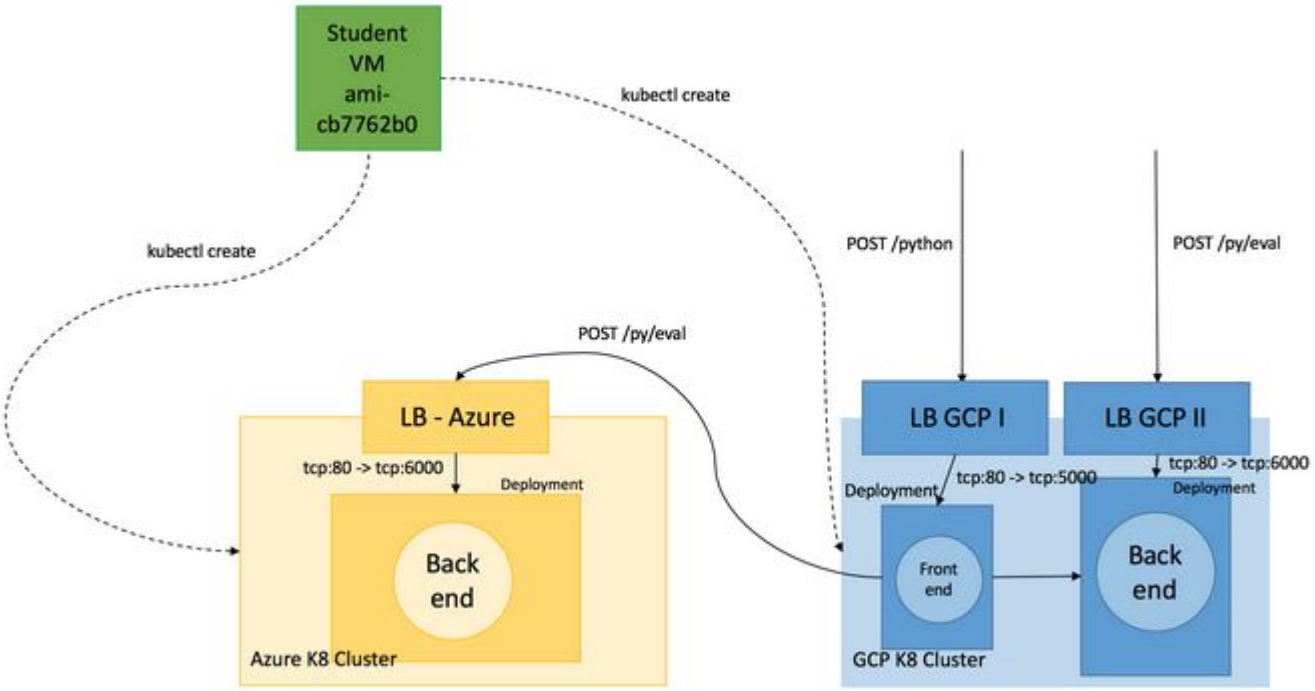
- Builds on task 2. Introduces Kubernetes clusters in Azure.
- Replicate backend deployment to Azure cluster. Update frontend to route traffic.



# Task 4 Objectives

- Task 4 will build on task 3
  - Same architecture, but have to consider downstream service failures.
- Achieve high availability!
  - Multi cloud deployment!
  - Autoscaling Kubernetes deployments to accommodated increased traffic due to failures.
  - HorizontalPodAutoscaler

# Task 4 Architecture



# Tips, Trips, and Tricks

- Debug, debug, debug
  - This project has many moving pieces!
  - Where is the issue occurring?
  - What is the expected behaviour of the system?

- Pods and Logs
  - Did my pod start? `(kubectl get pods , kubectl describe pods)`
  - Is my pod generating any logs? `(kubectl logs …)`

# Project 2.2 Penalties

Danger

## Project Grading Penalties

| Violation | Penalty of the project grade |
| --- | --- |
| Spending more than $1 for this project on AWS | -10% |
| Spending more than $2 for this project on AWS | -100% |
| Failing to tag all your resources in any task (EC2 instances) for this project; `Key: Project` and `Value: 2.2` | -10% |
| Incomplete submission of required files | -10% |
| Provisioning resources in regions other than `us-east-1` in AWS | -10% |
| Using instances other than t2.micro in AWS as the submitter instance | -100% |
| Submitting your AWS, GCP, or Azure credentials, other secrets, or Andrew ID in your code for grading | -100% |
| Submitting executables ( `.jar` , `.pyc` , etc.) instead of human-readable code ( `.py` , `.java` , `.sh` , etc.) | -100% |
| Attempting to hack/tamper the autograder in any way | -100% |
| Cheating, plagiarism or unauthorized assistance (please refer to the university policy on academic integrity and our syllabus) | -200% & potential dismissal |

# Upcoming Deadlines

- Quiz 4: Modules 7, 8 and 9:

  Due: Friday September 29, 2017 11:59PM Pittsburgh

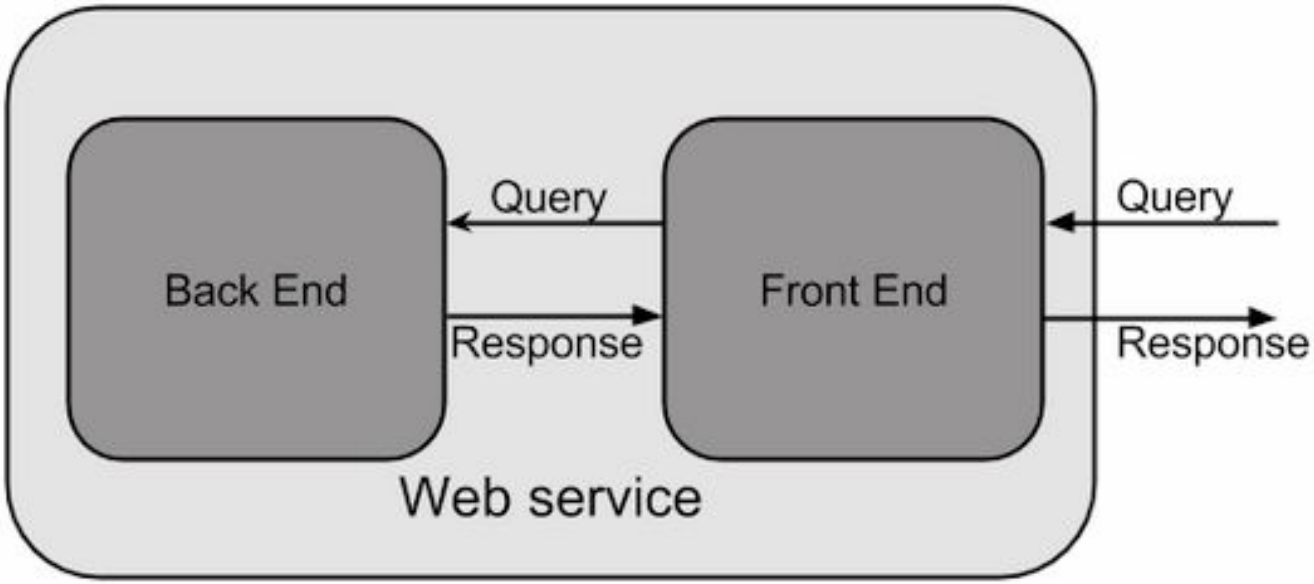
- Project 2.2: Docker and Kubernetes

  Due: Sunday October, 1 2017 11:59PM Pittsburgh

- Team Project: Team Formation

  Due: October, 2 2017 11:59PM Pittsburgh

# Team Project Architecture




- Writeup and Queries will be released on Monday, **October 9th, 2017**
- We can have more discussions in subsequent recitations
- For now, ensure 3-person teams you decide have experience with web frameworks and database, storage principles and infra setup/hacking

# Questions?