Lecture 3: Kubernetes

AC295

Advanced Practical Data Science

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Outline

Communications

Exercise week 1 due today

Exercise week 2 will be released today

Outline

Recap

Virtual Environment

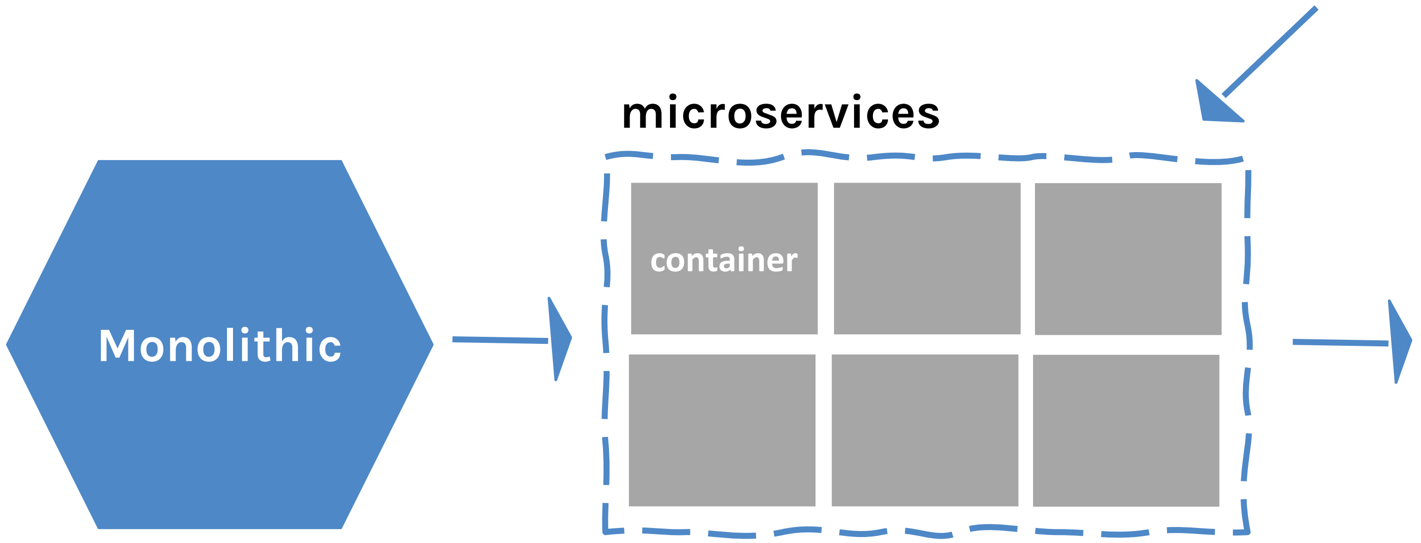
Pros: remove complexity
Cons: does not isolate from OS

Virtual Machines

Pros: isolate OS guest from host
Cons: intensive use hardware

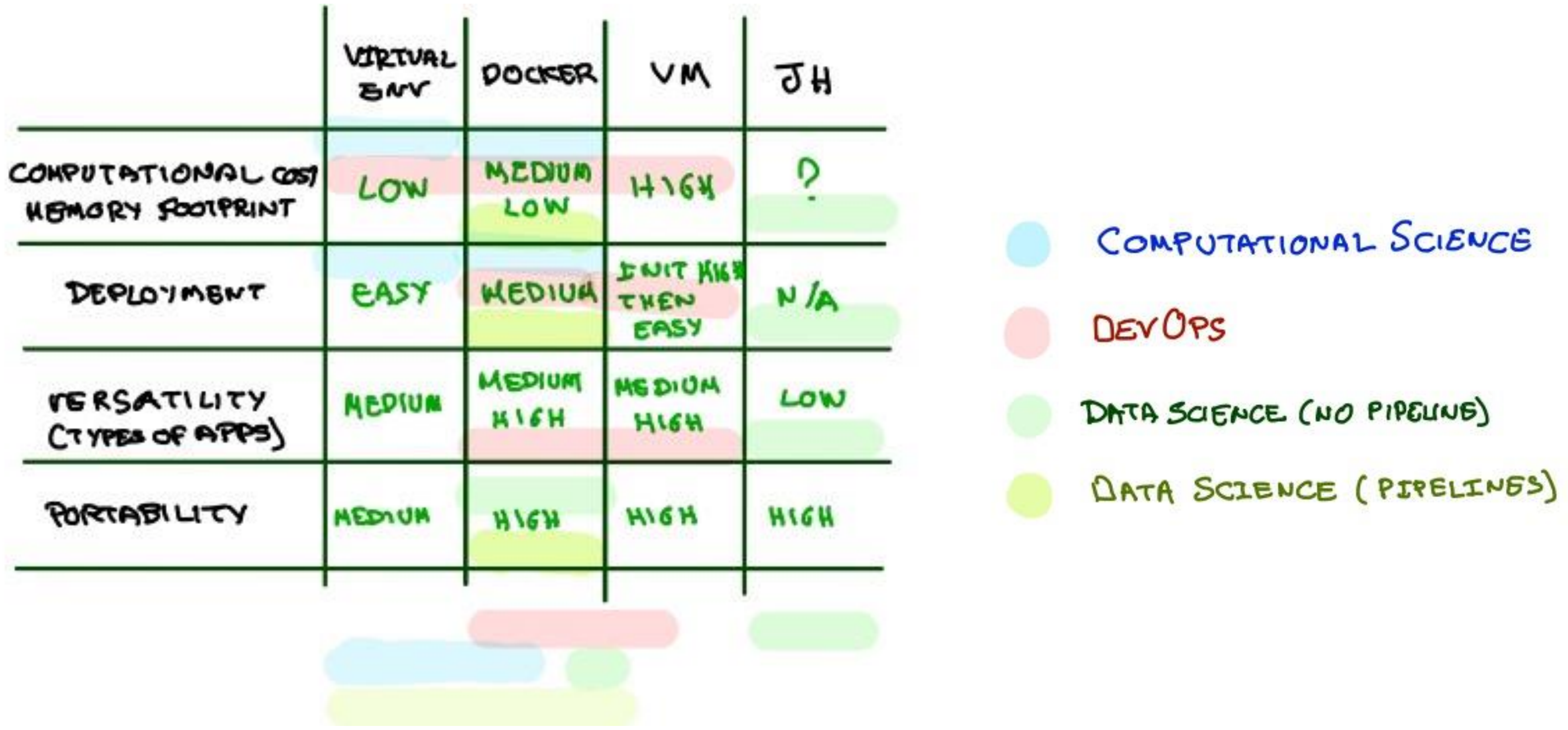
Containers

Pros: lightweight
Cons: issues with security, scalability, and control



How to manage microservices?

Recap



	VIRTUAL ENV	DOCKER	VM	JH
COMPUTATIONAL COST MEMORY FOOTPRINT	LOW	MEDIUM LOW	HIGH	?
DEPLOYMENT	EASY	MEDIUM	INIT HIGH THEN EASY	N/A
VERSATILITY (TYPES OF APPS)	MEDIUM	MEDIUM HIGH	MEDIUM HIGH	LOW
PORTABILITY	MEDIUM	HIGH	HIGH	HIGH

● COMPUTATIONAL SCIENCE

● DEVOPS

● DATA SCIENCE (NO PIPELINE)

● DATA SCIENCE (PIPELINES)

Recap

We talked about pros/cons of **environments** (removed complexity/does not isolate from OS), **virtual machines** (isolate OS guest from host/intensive use of the hardware), and **containers** (lightweight/issue with security, scalability, and control)

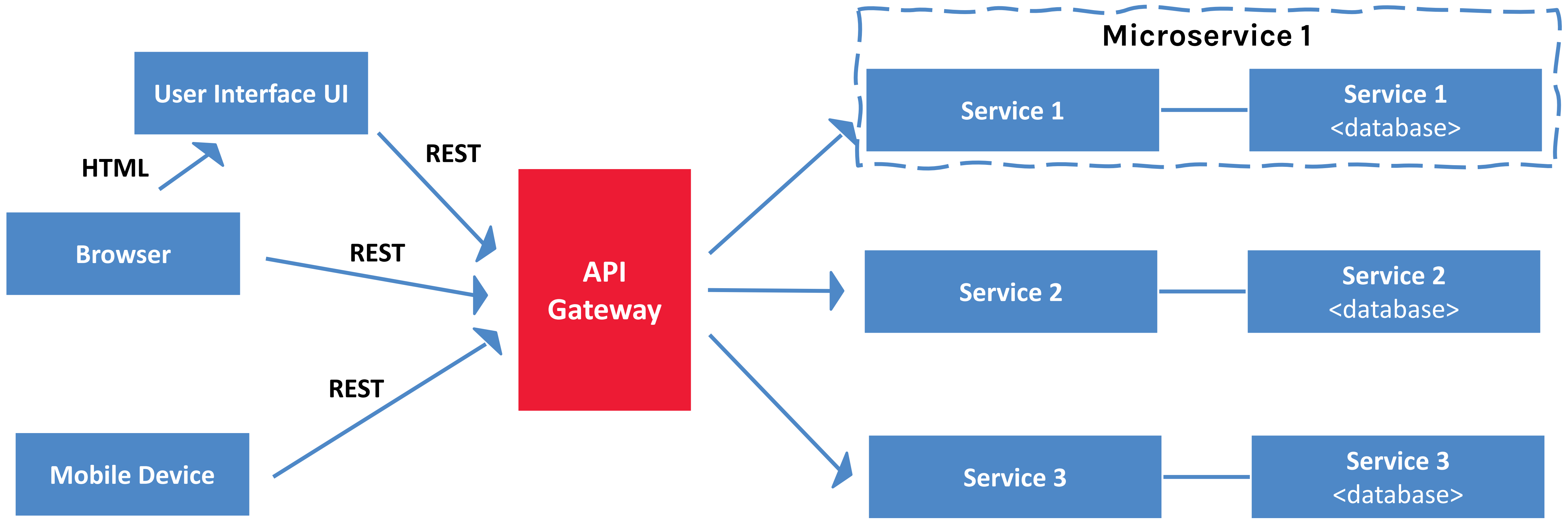
Goal: **find effective ways to deploy our apps** (more difficult than we might initially imagine) and to **break down a complex application** into smaller ones (*i.e. microservices*)

Issues we have fixed so far:

- conflicting/different operating system
- different dependencies
- "inexplicable" strange behavior

Outline

Use Microservice Architecture to build App

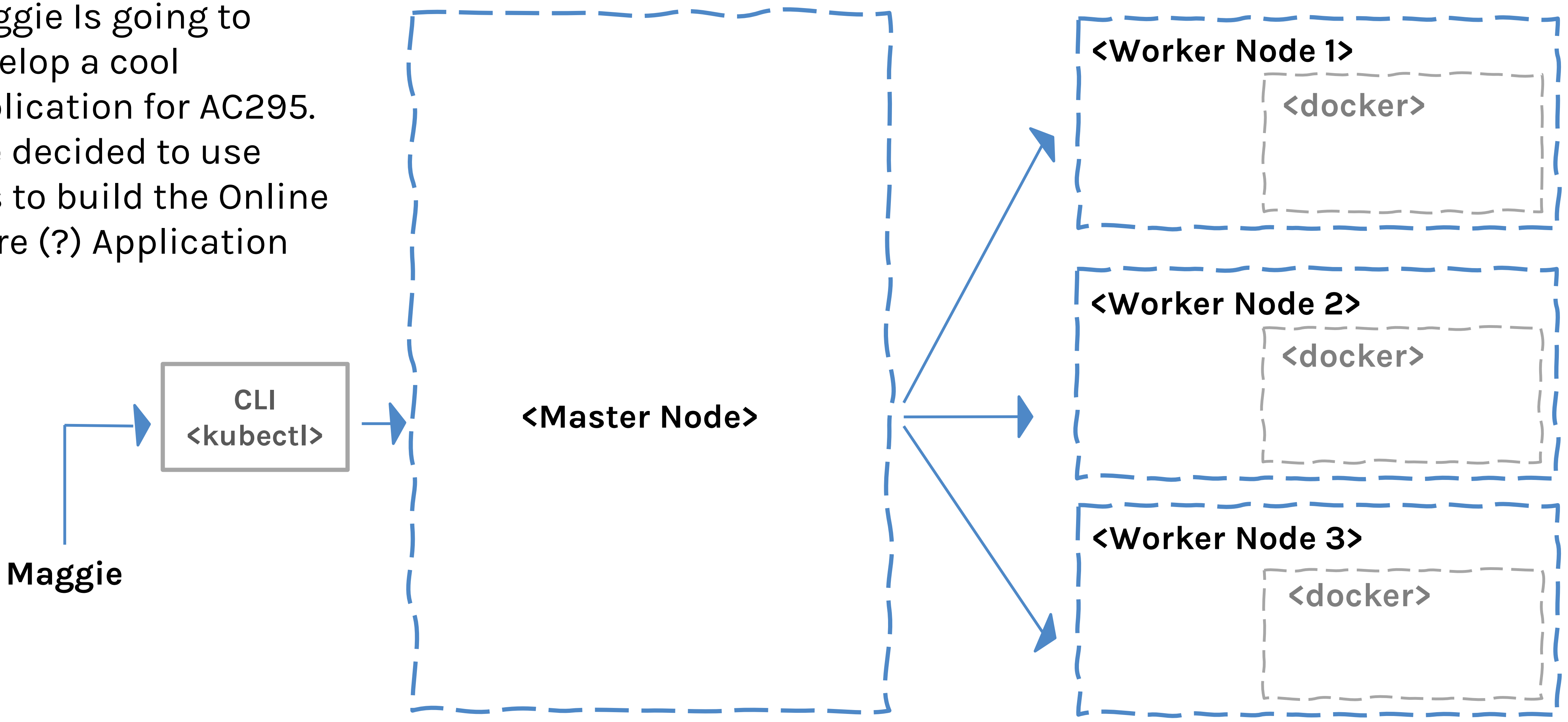


Kubernetes to the Rescue <K8s>

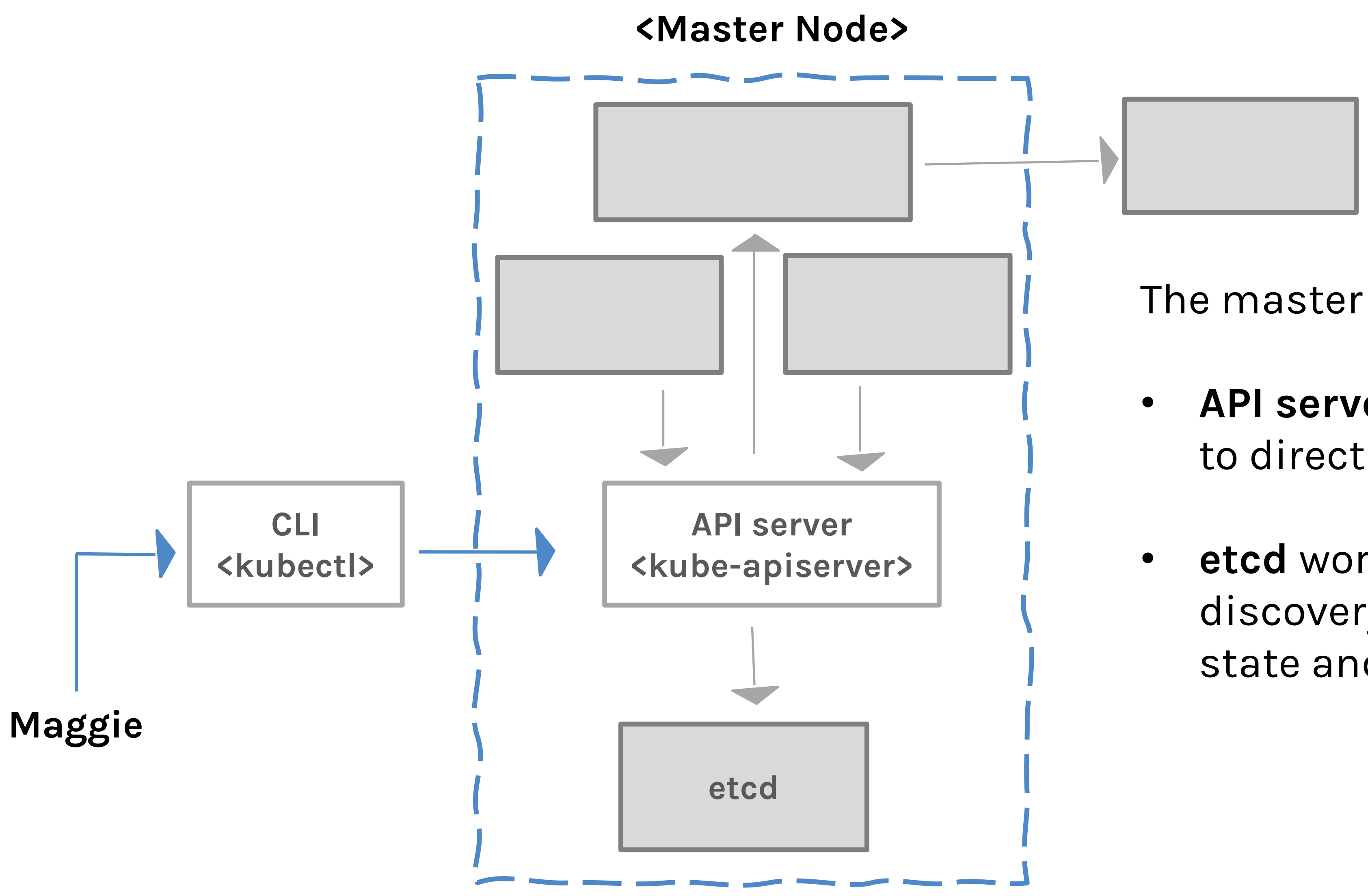
- K8s is an orchestration tool for **managing distributed services** or containerized applications across a distributed cluster of nodes.
- K8s itself follows a **client-server architecture with a master and worker nodes**. Core concepts in Kubernetes include pods, services (logical pods with a stable IP address) and deployments (a definition of the desired state for a pod or replica set).
- K8s **users define rules** for how container management should occur, and then K8s handles the rest!

How do we build it with K8s? Components & Architecture

Maggie Is going to develop a cool application for AC295. She decided to use K8s to build the Online Store (?) Application



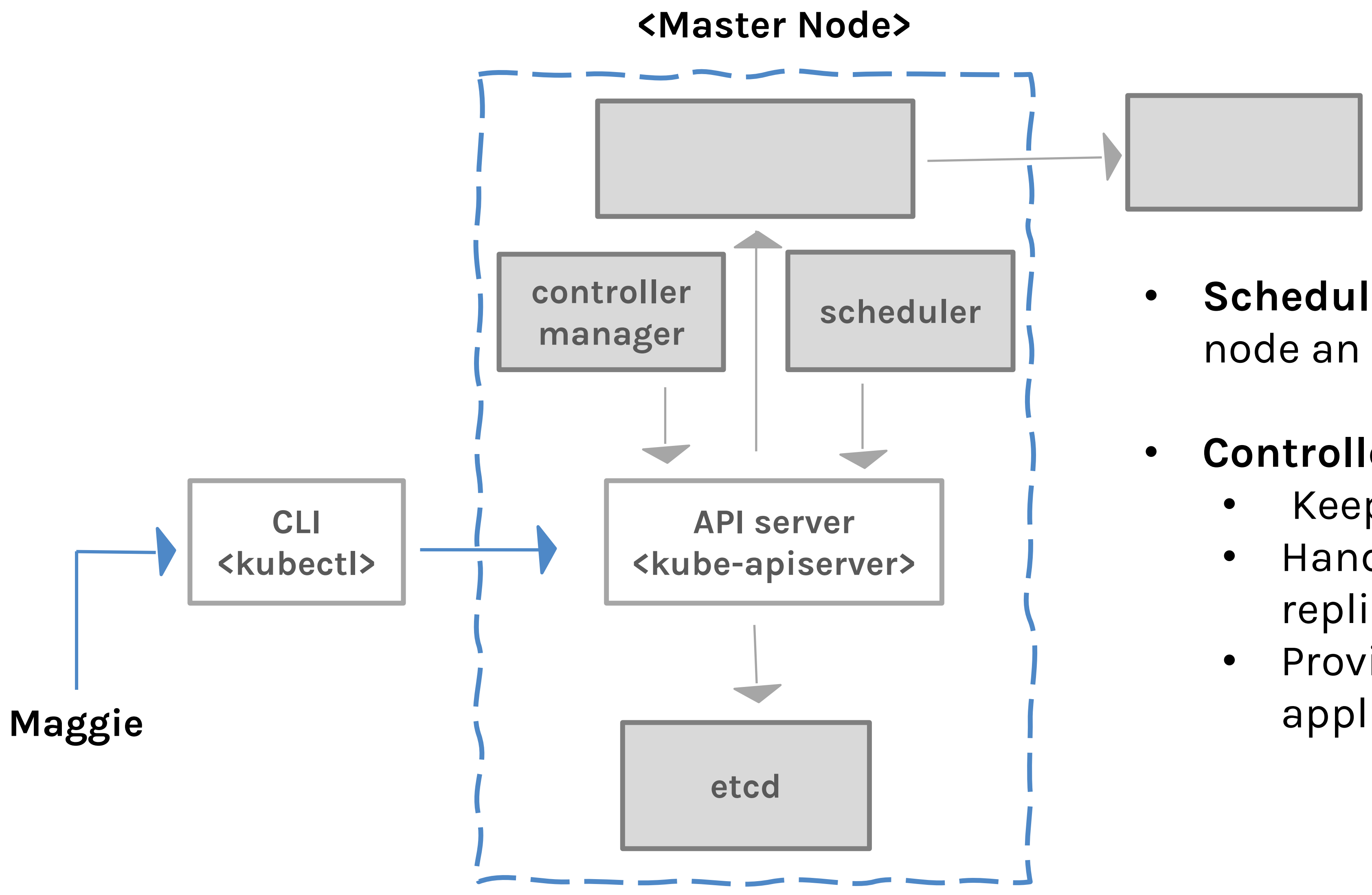
K8s Components & Architecture <cont>



The master node has:

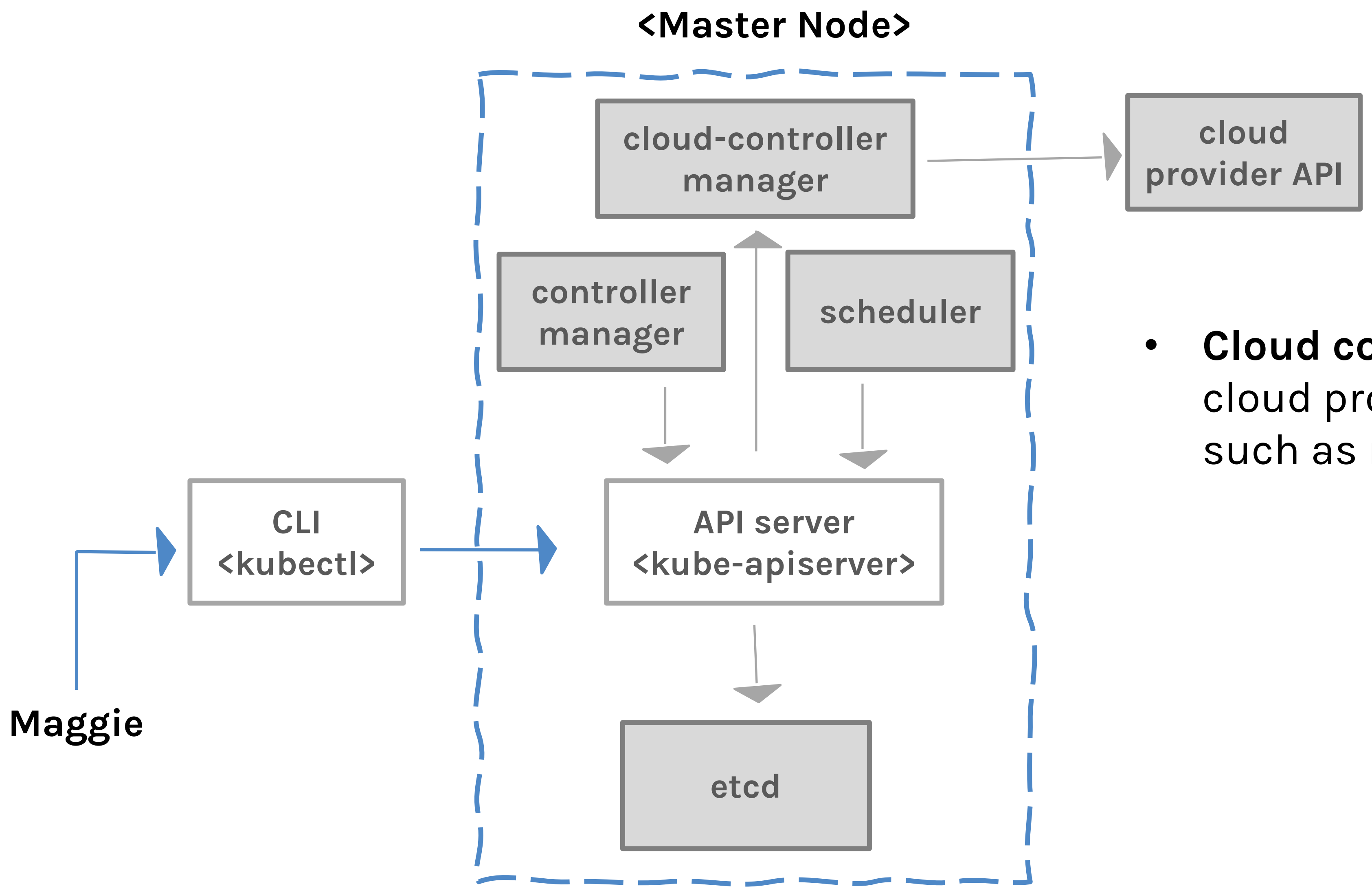
- **API server** contains various methods to directly access the Kubernetes
- **etcd** works as backend for service discovery that stores the cluster's state and its configuration

K8s Components & Architecture <cont>



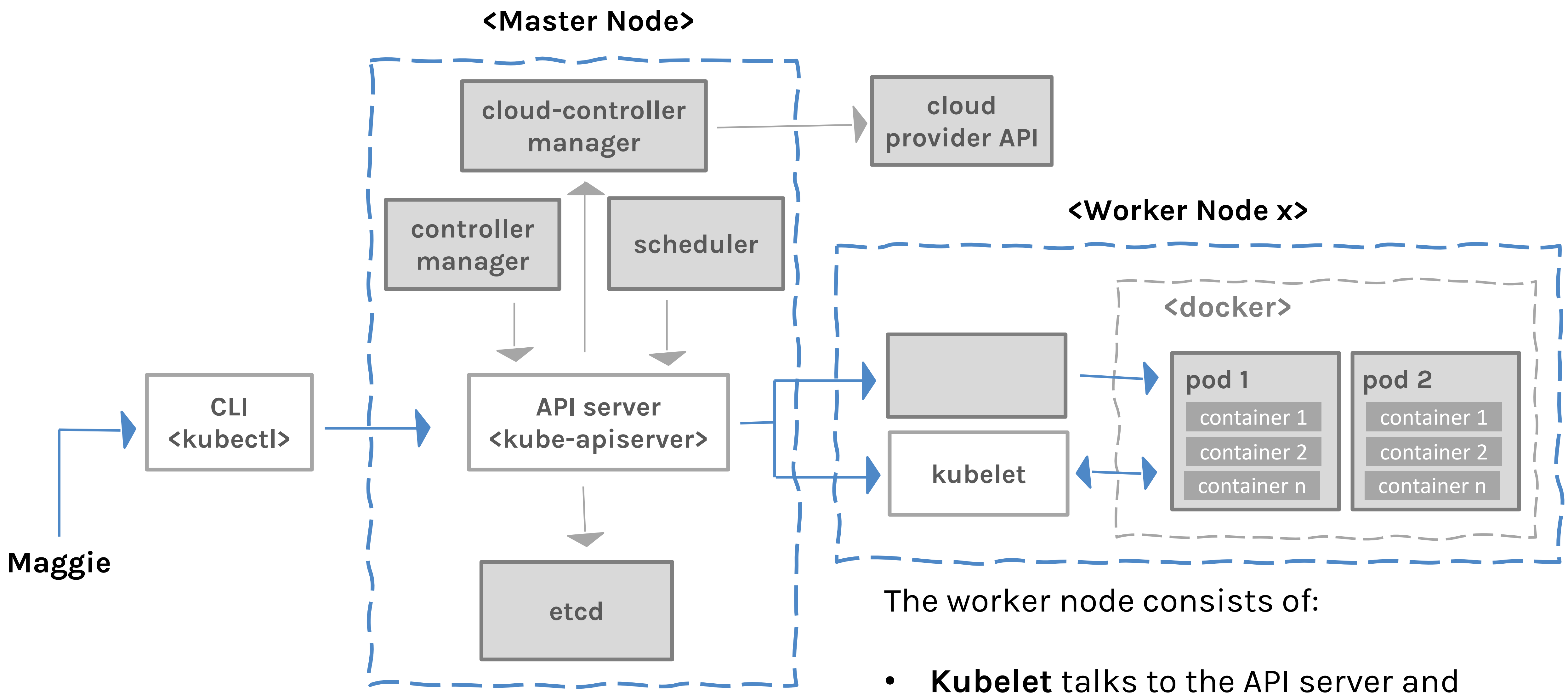
- **Scheduler** assigns to each worker node an application
- **Controller manager:**
  - Keeps track of worker nodes
  - Handles node failures and replicates if needed
  - Provide endpoints to access the application from the outside world

K8s Components & Architecture <cont>



- **Cloud controller** communicates with cloud provide regarding resources such as nodes and IP addresses

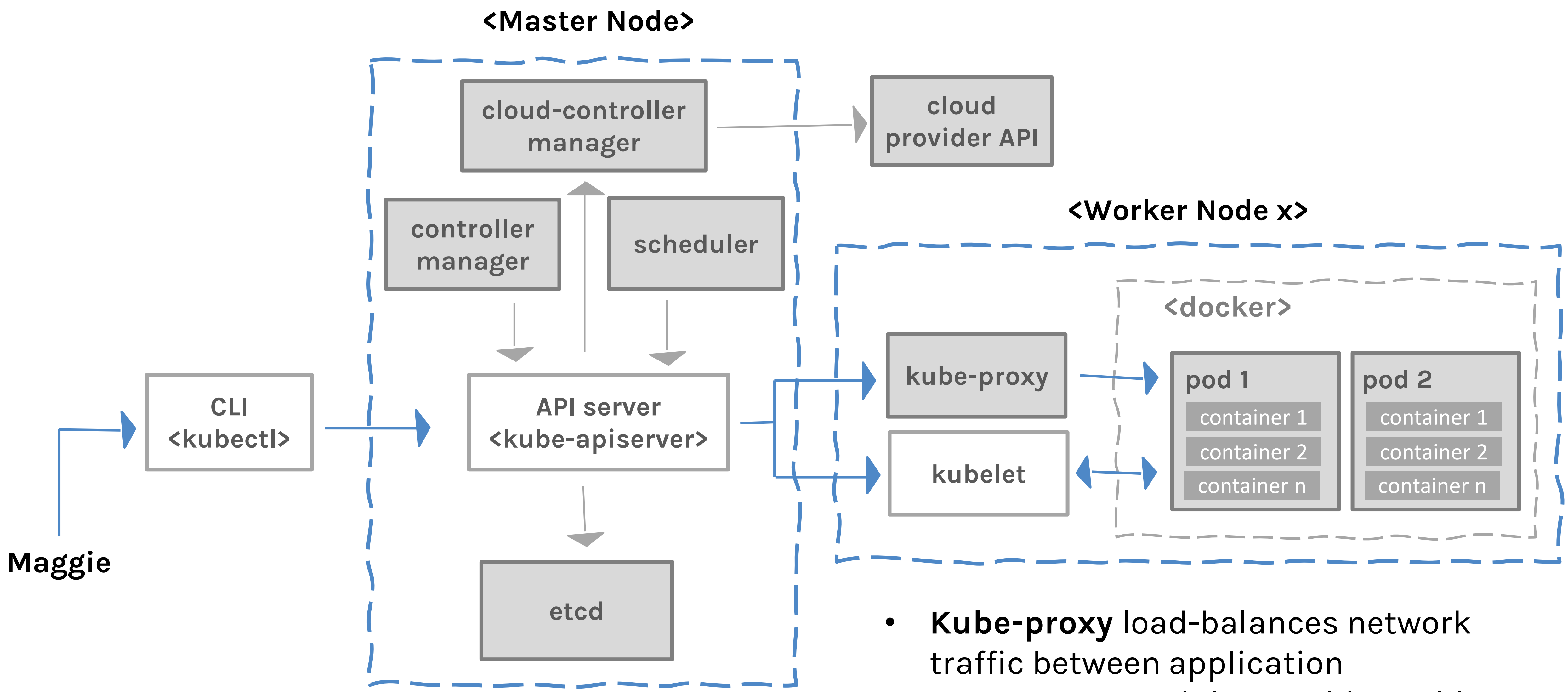
K8s Components & Architecture <cont>



The worker node consists of:

- **Kubelet** talks to the API server and manages containers on its node

K8s Components & Architecture <cont>



- **Kube-proxy** load-balances network traffic between application components and the outside world

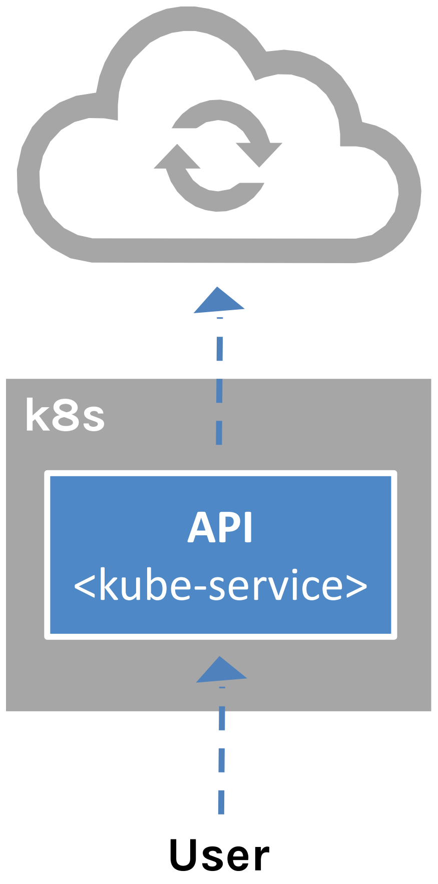
Outline

Advantages of using Kubernetes

There are many reasons why people come to use containers and container APIs like Kubernetes:

1. **Velocity**
2. **Scaling** (of both software and teams)
3. **Abstracting the infrastructure**
4. **Efficiency**

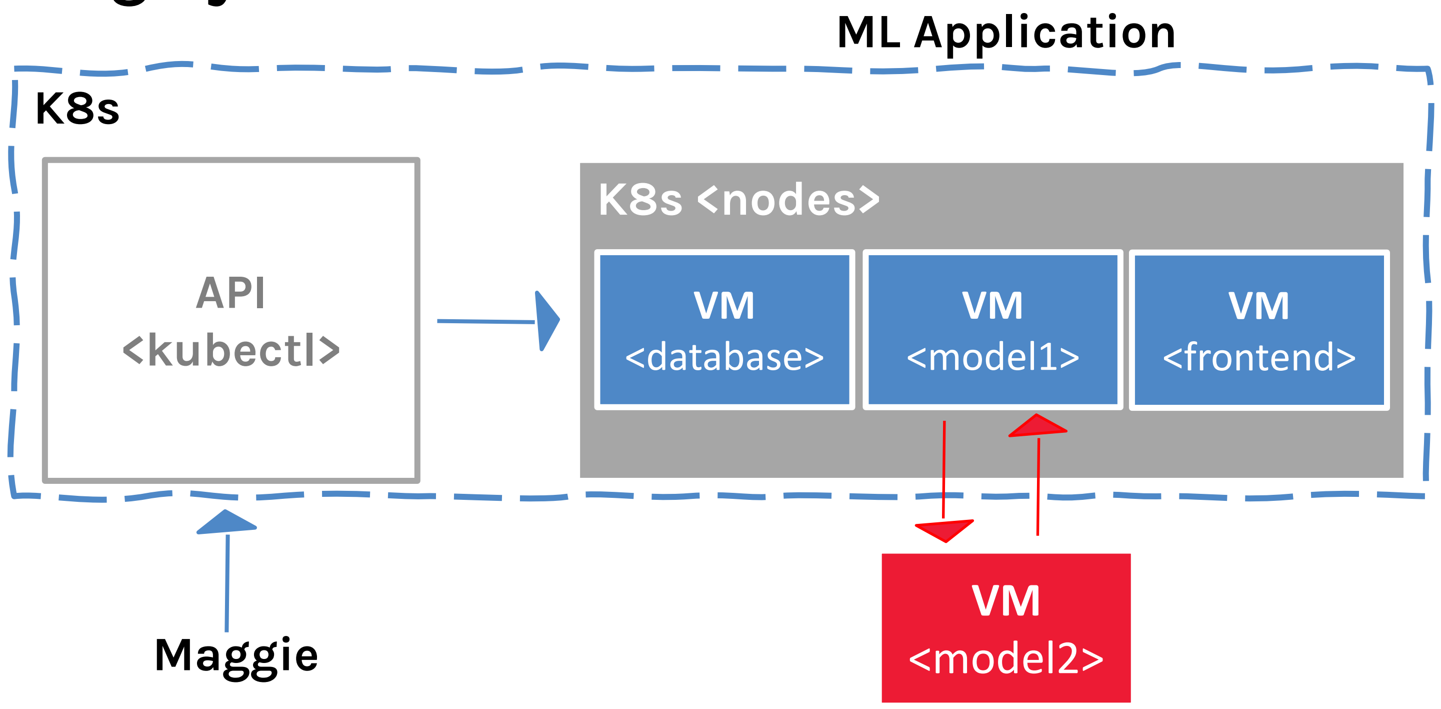
All these aspects relate to each other to speed up process that can reliably deploy software.



Advantages of using Kubernetes: Velocity

It is the speed with which you can respond to innovations developed by others (e.g. change in software industry from shipping CDs to delivering over the network)

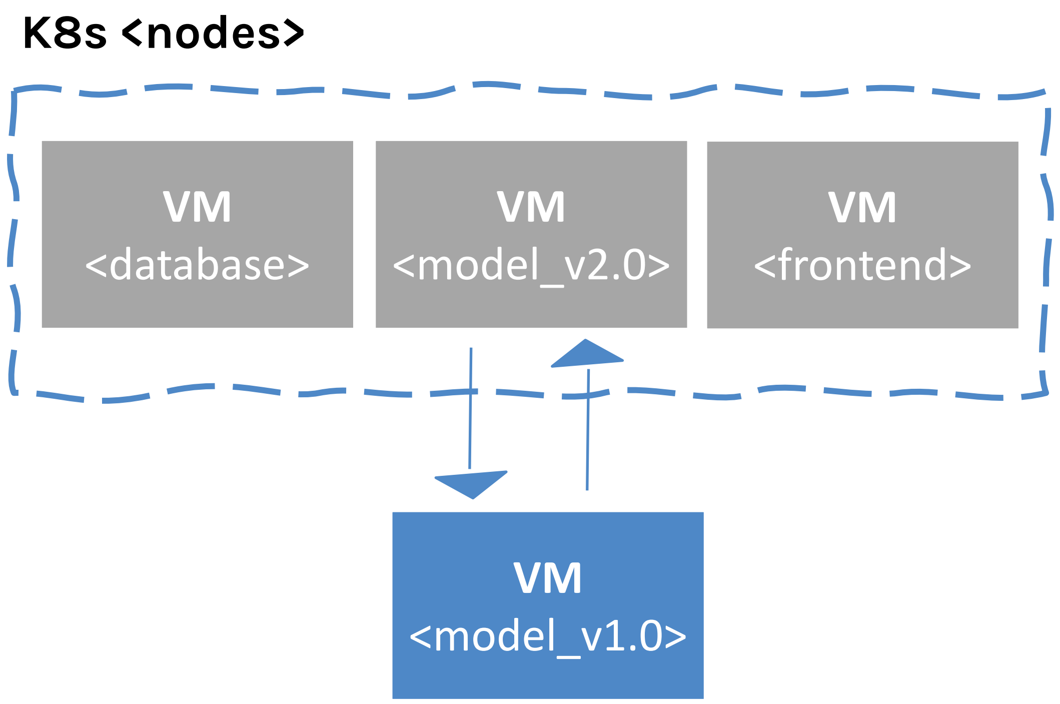
Velocity is measured not in terms of the number of things you can ship while **maintaining a highly available service**



Velocity <cont>

Velocity is enabled by:

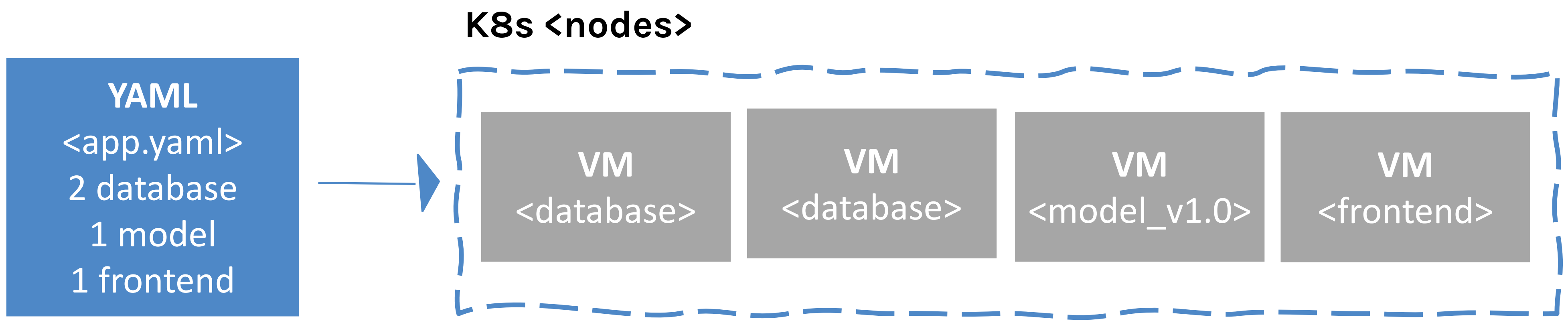
- **Immutable system:** you can't change running container, but you create a new one and replace it in case of failure (allows for keeping track of the history and load older images)



Velocity <cont>

Velocity is enabled by:

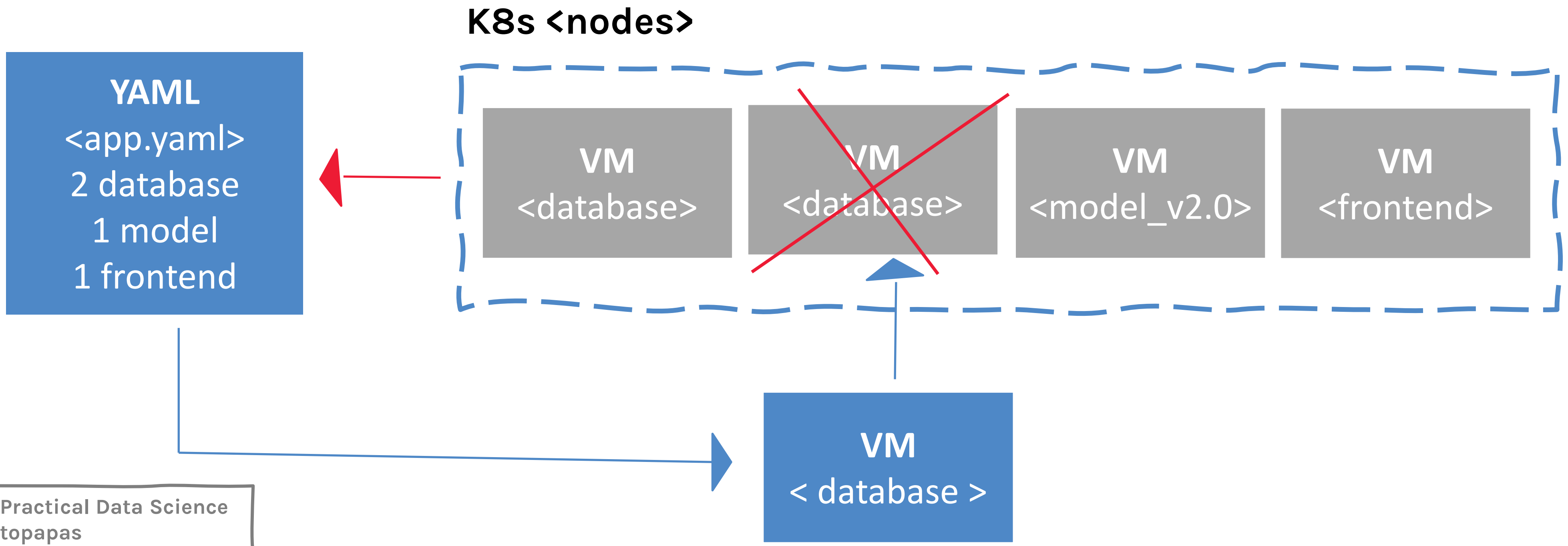
- **Declarative configuration:** you can define the desired state of the system restating the previous declarative state to go back. ***Imperative*** configuration are defined by the execution of a series of instructions, but not the other way around.



Velocity <cont>

Velocity is enabled by:

- **Online self-healing systems:** k8s takes actions to ensure that the current state matches the desired state (as opposed to an operator enacting the repair)



Advantages of using Kubernetes: Scaling

As your product grows, it’s inevitable that you will need to scale:

- Software
- Team/s that develop it

Scaling

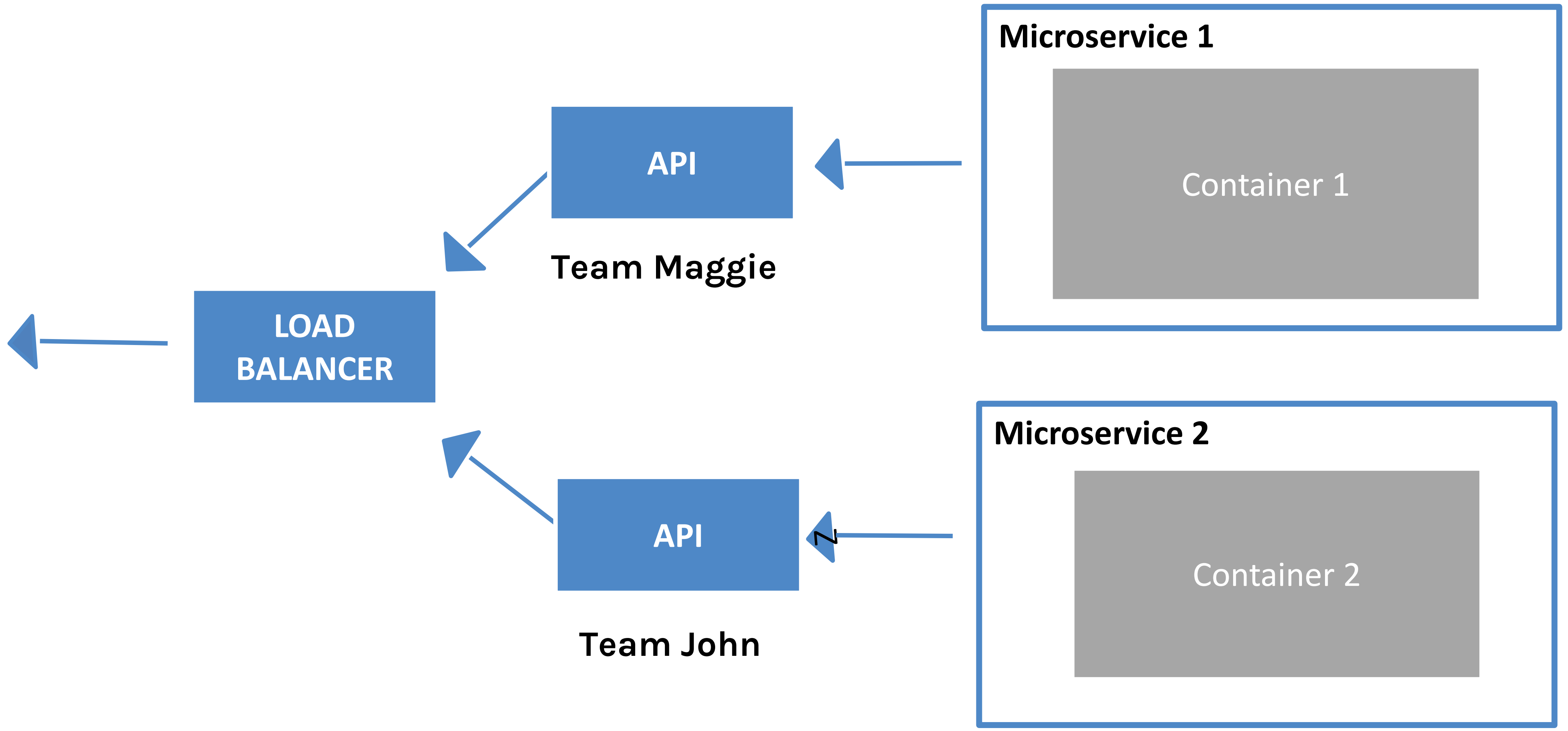
Kubernetes provides numerous advantages to address scaling:

- **Decoupled architectures**: each component is separated from other components by defined APIs and *service load balancers*.

- **Easy scaling for applications and clusters**: simply changing a number in a configuration file, k8s takes care of the rest (part of declarative).

- **Scaling development teams with microservices**: small team is responsible for the design and delivery of a service that is consumed by other small teams (optimal group size: 2 pizzas team).

Scaling <cont>


Microservice 1
Container 1
API
Team Maggie
LOAD BALANCER
Microservice 2
Container 2
API
Team John

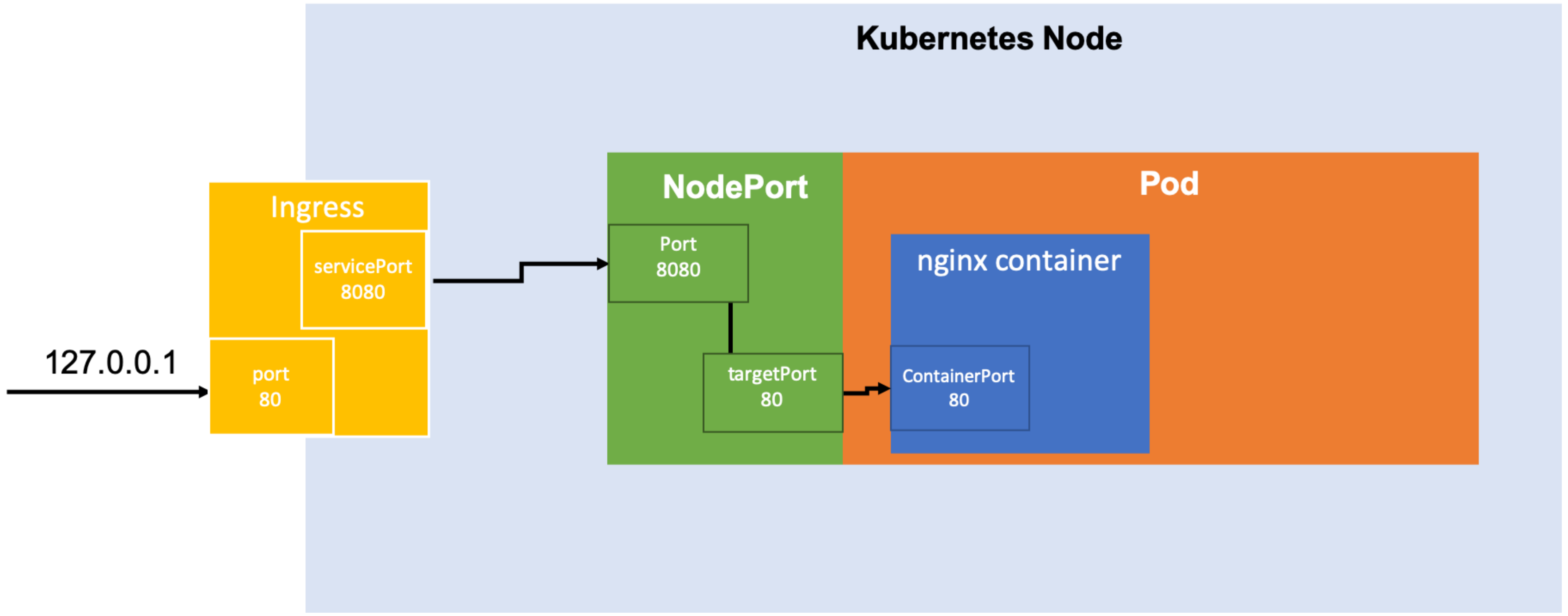
Scaling <cont>

Kubernetes provides numerous **abstractions** and APIs that help building these decoupled microservice architectures:

- **Pods** can group together container images developed by different teams into a single deployable unit (similar to docker-compose)
- **Other services to isolate** one microservice from another such (e.g. load balancing, naming, and discovery)
- **Namespaces** control the interaction among services
- **Ingress** combine multiple microservices into a single externalized API (easy-to-use frontend)

K8s provides full spectrum of solutions between doing it “the hard way” and a fully managed service

Scaling <cont>


Kubernetes Node
Ingress
servicePort 8080
port 80
127.0.0.1
NodePort
Port 8080
targetPort 80
Pod
nginx container
ContainerPort 80

Advantages of using K8s: Abstracting your infrastructure

Kubernetes allows to build, deploy, and manage your application in a way that is portable across a wide variety of environments. The move to application-oriented container APIs like Kubernetes has two concrete benefits:

- **separation**: developers from specific machines
- **portability**: simply a matter of sending the declarative config to a new cluster

Advantages of using K8s: Efficiency

There are concrete economic benefit to the abstraction because tasks from multiple users can be packed tightly onto fewer machines:

- **Consume less energy** (ratio of the useful to the total amount)
- **Limit costs of running a server** (power usage, cooling requirements, datacenter space, and raw compute power)
- **Create quickly a developer's test environment** as a set of containers
- **Reduce cost of development instances in your stack**, liberating resources to develop others that were cost-prohibitive

Outline

Deploying a Kubernetes Cluster

To deploy your cluster you must install Kubernetes. In the exercise you are going to use minikube to deploy a cluster in local mode.

- After installing minikube, use *start* to begin your session creating a virtual machine, *stop* to interupt it, and *delete* to remove the VM. Below are the commands to execute these tasks:

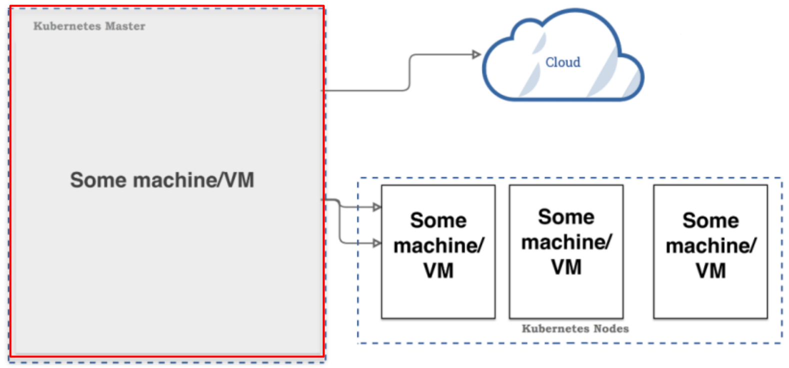
```
$ minikube start
$ minikube stop
$ minikube delete
```

Deploying a Kubernetes Cluster

You can easily access the Kubernetes Client using the following command:

- to check your cluster status use:

```
$ kubectl get componentstatuses
```



- and should see output below:

```
NAME                 STATUS    MESSAGE              ERROR
scheduler            Healthy   ok
controller-manager   Healthy   ok
etcd-0               Healthy   {"health": "true"}
```

Deploying a Kubernetes Cluster

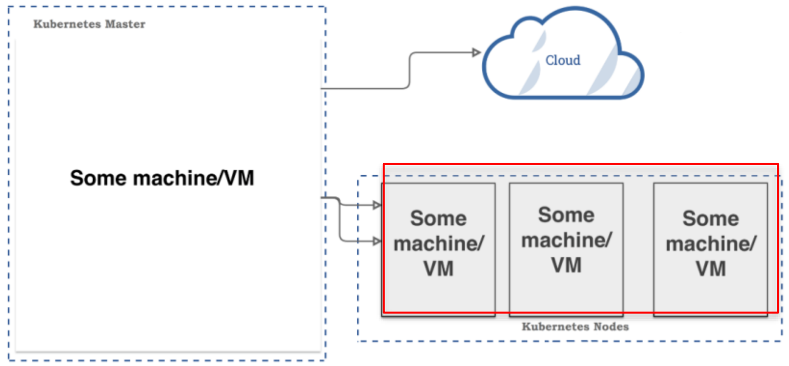
You can easily access the Kubernetes Client using the following command:

- to list the nodes in your cluster use:

```
$ kubectl get nodes
```

- and should see output below:

```
NAME          STATUS          AGE        VERSION
kubernetes    Ready,master    45d        v1.12.1
node-1        Ready           45d        v1.12.1
node-2        Ready           45d        v1.12.1
node-3        Ready           45d        v1.12.1
```



Outline

Common kubectl Commands

- **Let’s practice Kubernetes!** Useful commands to complete the exercise:

```
$ kubectl create -f app-db-deploymnet.yaml
$ kubectl get deployment
$ kubectl get pods
$ kubectl get pods /
  -o=custom-columns=NAME:.metadata.name,IP:.status.podIP
$ kubectl create -f app-server-deploymnet.yaml
$ kubectl expose deployment /
app-deployment --type=LoadBalancer --port=8080
$ kubectl get services
$ kubectl delete service app-deployment
$ kubectl delete deployment app-server-deployment
$ kubectl delete deployment app-db-deployment
```

THANK YOU