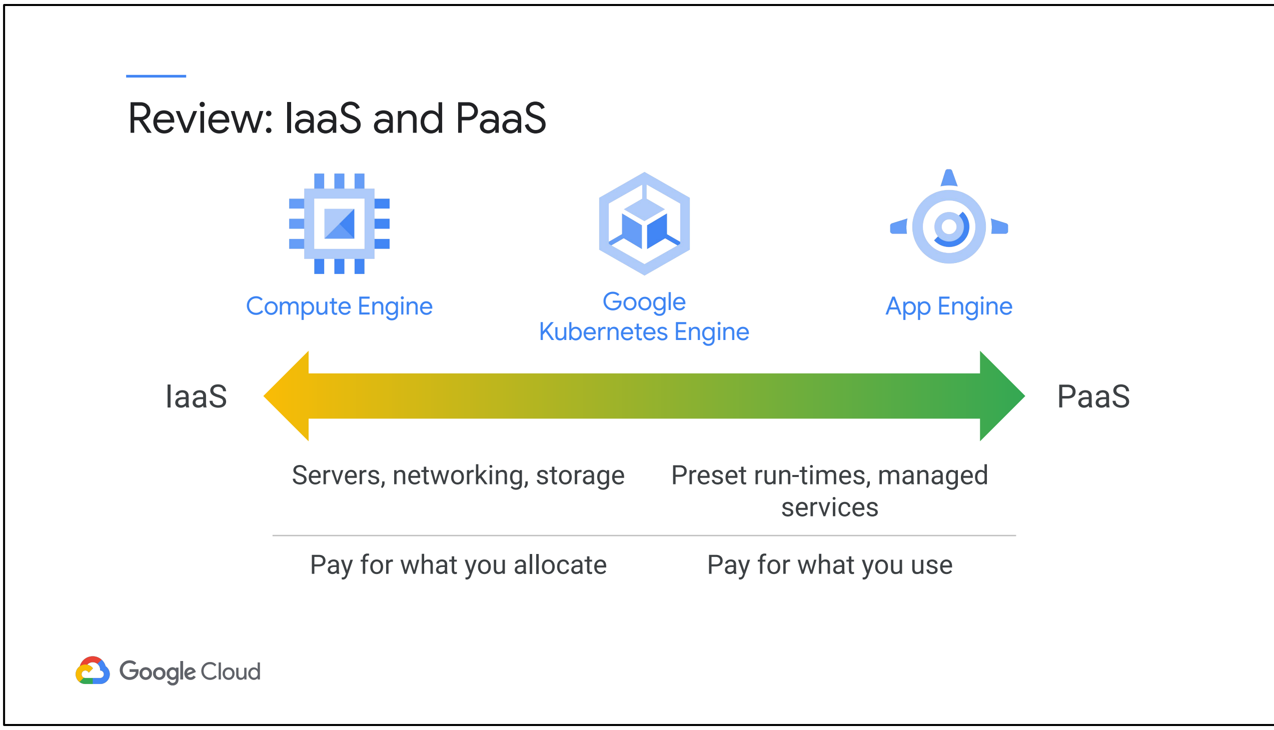
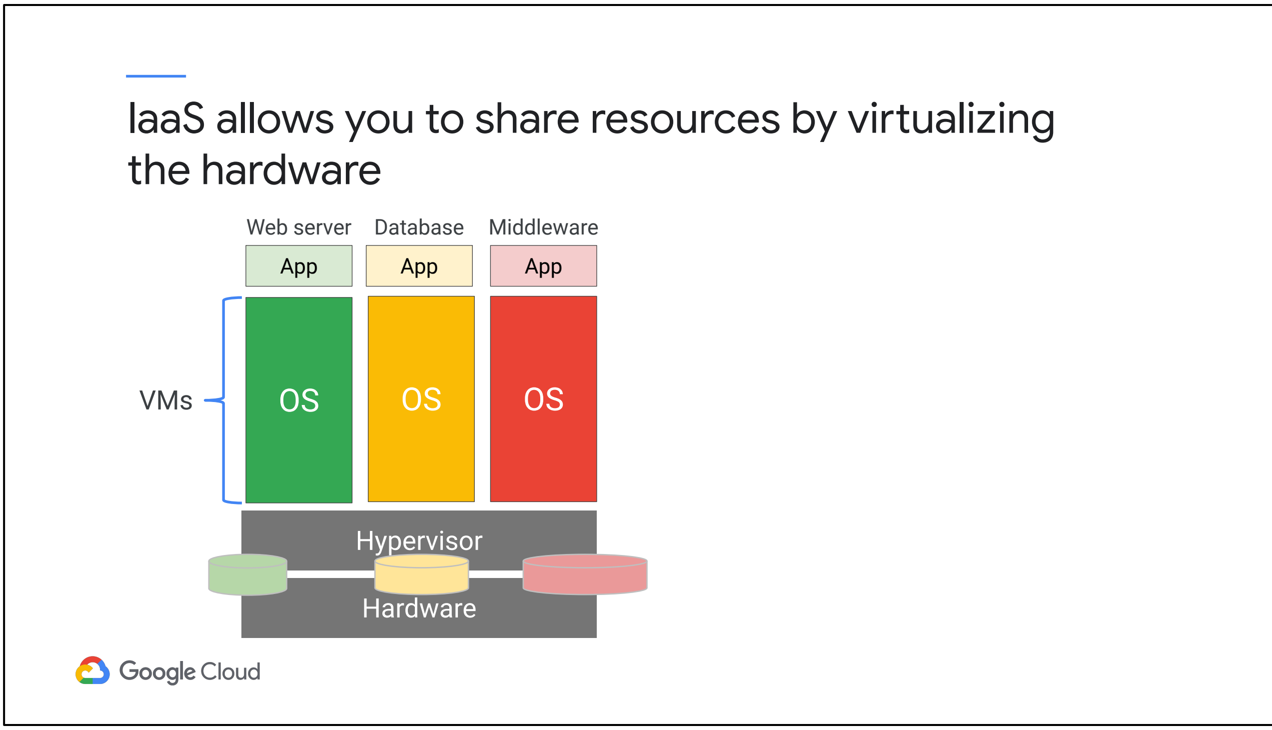


We've already discussed **Compute Engine**, which is Google Cloud's **Infrastructure as a Service** offering, with access to servers, file systems, and networking.

And **App Engine** which is Google Cloud's **PaaS** offering.

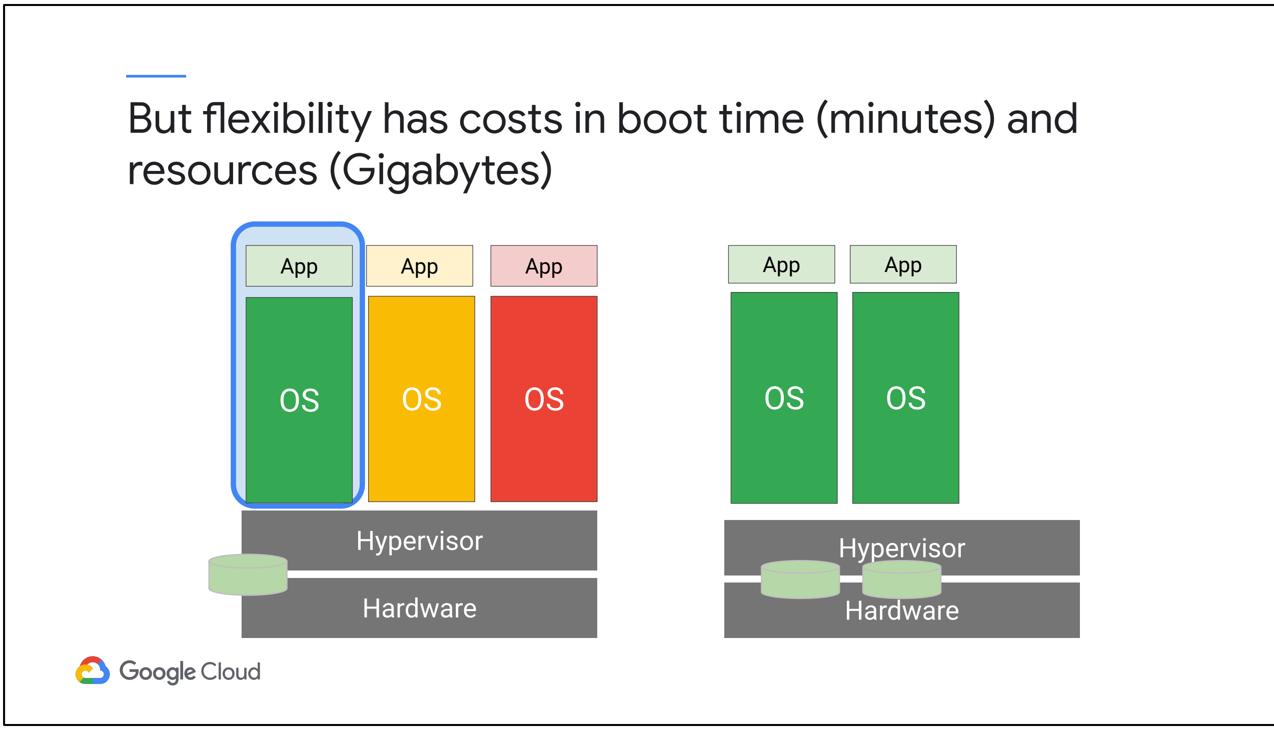
Now I'm going to introduce you to containers and Google Kubernetes Engine, which is a hybrid which conceptually sits between the two and benefits from both.



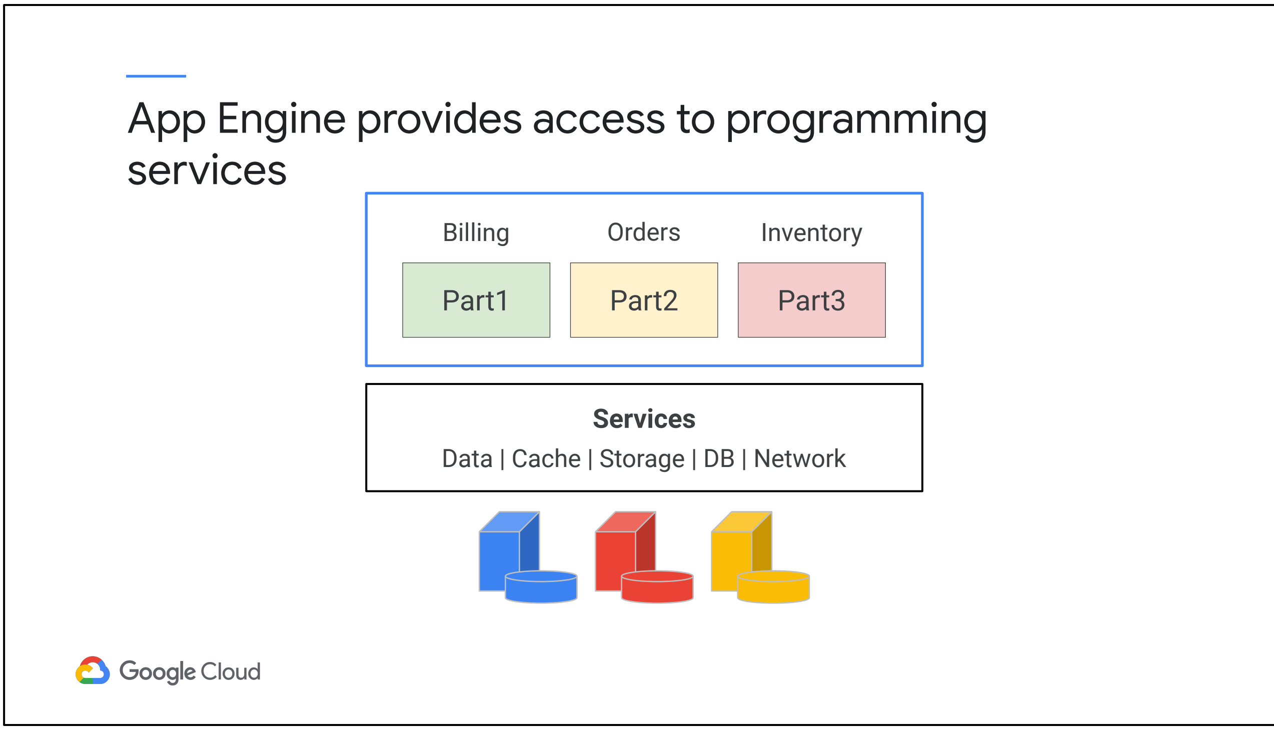
Let's begin, by remembering that **Infrastructure as a Service** allows you to share compute resources with other developers by **virtualizing the hardware** using **virtual machines**. Each developer can deploy their own operating system, access the hardware, and build their applications in a self-contained environment with access to RAM, file systems, networking interfaces, and so on.

But flexibility comes with a cost. The smallest unit of compute is an app with its **VM**. The guest OS may be large, even gigabytes in size, and takes minutes to boot.

But you have your tools of choice on a configurable system. So you can install your favorite runtime, web server, database, or middleware, configure the underlying system resources, such as disk space, disk I/O, or networking and build as you like.



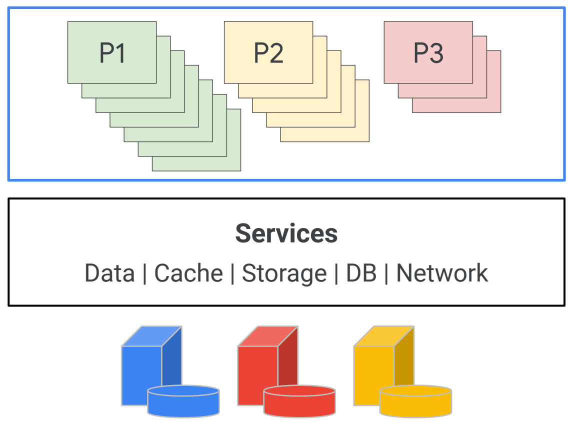
However, as demand for your application increases, you have to copy an entire VM and boot the guest OS for each instance of your app, which can be slow and costly.



With App engine, you get access to programming services.

So all you do is write your code in self-contained **workloads** that use these services and include any dependent libraries.

The platform scales to meet demand



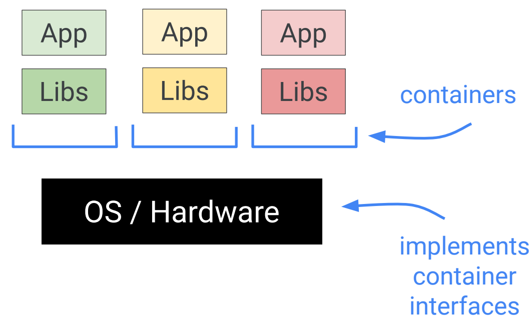
As demand for your app increases, the platform scales your app seamlessly and independently by workload and infrastructure.

This scales rapidly but you won't be able to fine-tune the underlying architecture to save cost.

Containers offer IaaS flexibility and PaaS scalability

Containers provide:

- An abstraction layer of the hardware and OS.
- An invisible box with configurable access to isolated partitions of file system, RAM, and networking.
- Fast startup (only a few system calls).



Google Cloud

That's where containers come in.

The idea of a container is to give you the independent scalability of workloads in PaaS and an abstraction layer of the OS and hardware in IaaS.

What you get is an invisible box around your code and its dependencies, with limited access to its own partition of the file system and hardware.

It only requires a few system calls to create and it starts as quickly as a process.

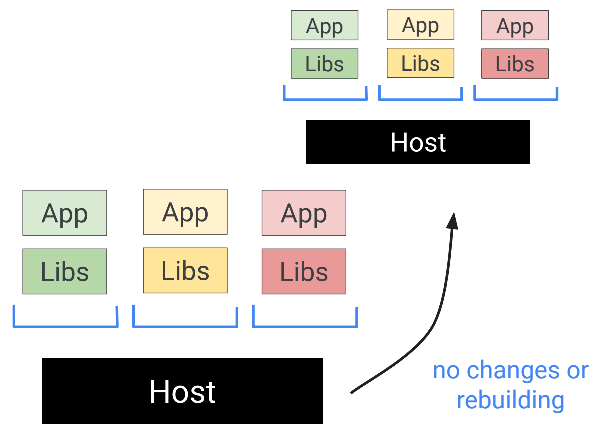
All you need on each host is an OS kernel that supports containers and a container runtime.

In essence, you are virtualizing the OS. It scales like PaaS, but gives you nearly the same flexibility as IaaS.

Containers are configurable, self-contained, and ultra-portable

With containers, you can:

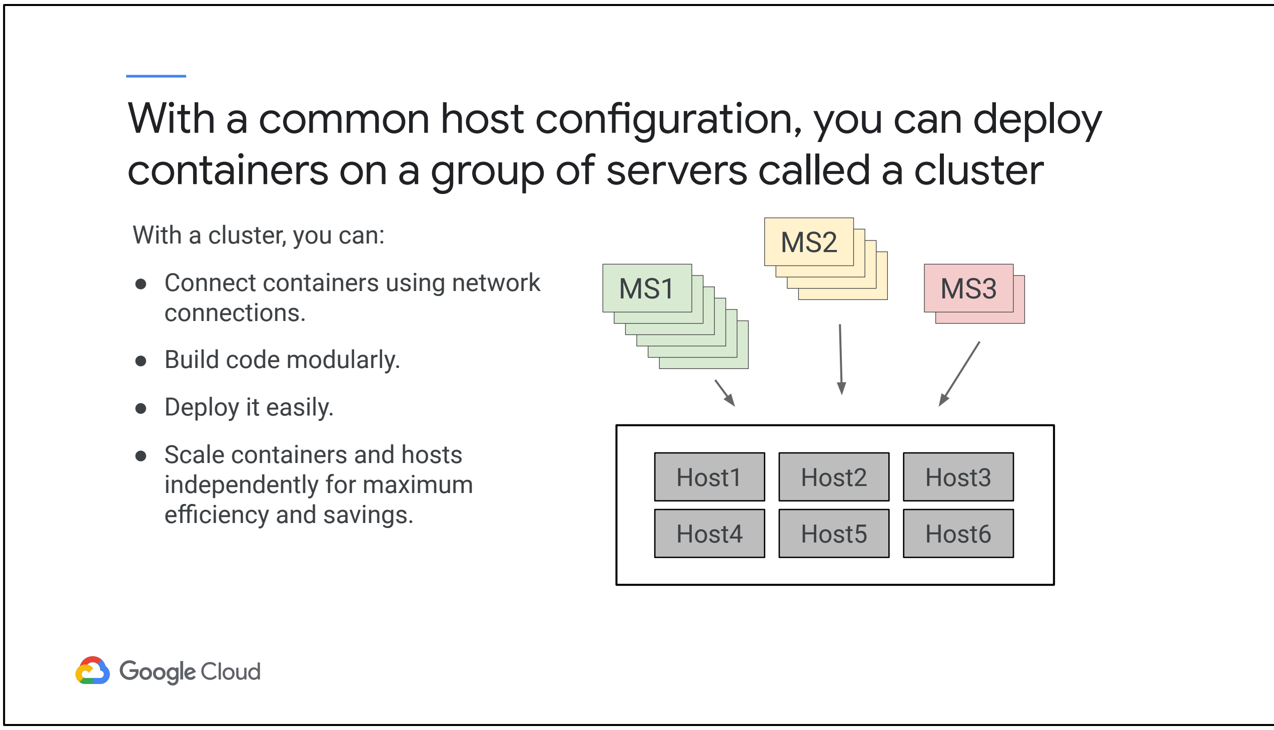
- Define your own hardware, OS, and software stack configurations.
- Treat the OS and hardware as a black box and go from dev, to staging, to production, or your laptop to the cloud, without changing or rebuilding anything.



Google Cloud

With this abstraction, your code is ultra portable and you can treat the OS and hardware as a black box.

So you can go from development, to staging, to production, or from your laptop to the cloud, without changing or rebuilding anything.



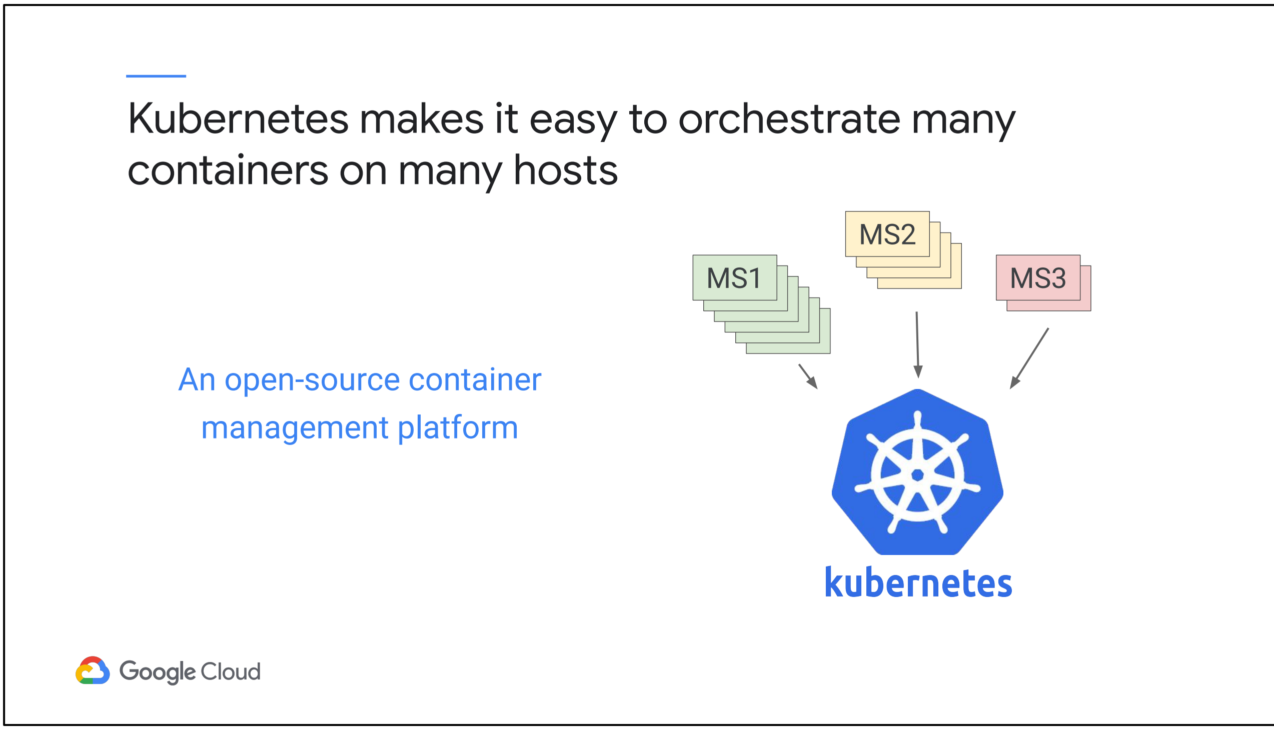
If you want to scale, for example, a web server, you can do so in seconds and deploy dozens or hundreds of them (depending on the size or your workload) on a single host.

Now that's a simple example of scaling one container running the whole application on a single host.

You'll likely want to build your applications using lots of containers, each performing their own function like **microservices**.

If you build them this way, and connect them with network connections, you can make them modular, deploy easily, and scale independently across a group of **hosts**.

And the hosts can scale up and down and start and stop containers as demand for your app changes or as hosts fail.



A tool that helps you do this well is **Kubernetes**.

Kubernetes makes it easy to orchestrate many containers on many hosts, scale them as microservices, and deploy rollouts and rollbacks.

First, I'll show you how you build and run containers.

Let's begin by building and running an app as a container

- We'll use an open-source tool called **Docker** that bundles your app, its dependencies, and system settings. (You could use another tool like **Cloud Build**.)
- Here is an example of some code you may have written:
  - It's a Python app that says 'hello world'.
  - Or if you reach the second endpoint, it gives you the version.

app.py

```
from flask import Flask
app = Flask(__name__)

@app.route("/")
def hello():
  return "Hello World!\n"

@app.route("/version")
def version():
  return "Helloworld 1.0\n"

if __name__ == "__main__":
  app.run(host='0.0.0.0')
```

Google Cloud

I'll use an open-source tool called **Docker** that defines a format for bundling your application, its dependencies, and machine-specific settings into a container; you could use a different tool like **Cloud Build**. It's up to you.

Here is an example of some code you may have written.

It's a Python app.

It says "Hello World"

Or if you reach the second endpoint '/version', it gives you the version.

How do you get this app into Kubernetes?

requirements.txt

```
Flask==0.12
uwsgi==2.0.15
```

Dockerfile

```
FROM ubuntu:18.10
RUN apt-get update -y && \
    apt-get install -y python3-pip python3-dev
COPY requirements.txt /app/requirements.txt
WORKDIR /app
RUN pip3 install -r requirements.txt
COPY . /app
ENTRYPOINT ["python3", "app.py"]
```

You use a Dockerfile to specify such things as:

- A requirements.txt file for Flask dependencies.
- Your OS image and version of Python.
- How to install Python.
- How to run your app.

Google Cloud

So how do you get this app into Kubernetes?

You have to think about your version of Python, what dependency you have on Flask, how to use the requirements.txt file, how to install Python, and so on.

So you use a **Dockerfile** to specify how your code gets packaged into a container.

For example, if you're a developer, and you're used to using Ubuntu with all your tools, you start there.

You can install Python the same way you would on your dev environment.

You can take that requirements file from Python that you know.

And you can use tools inside **Docker** or **Cloud Build** to install your dependencies the way you want.

Eventually, it produces an app, and you run it with the ENDPOINT command.

Then you build and run the container as an image

```
$> docker build -t py-server .
$> docker run -d py-server
```

- **`docker build`** builds a container and stores it locally as a runnable image.
- You can upload images to a registry service (like **Container Registry**) for sharing.
- **`docker run`** starts the container image.

Google Cloud

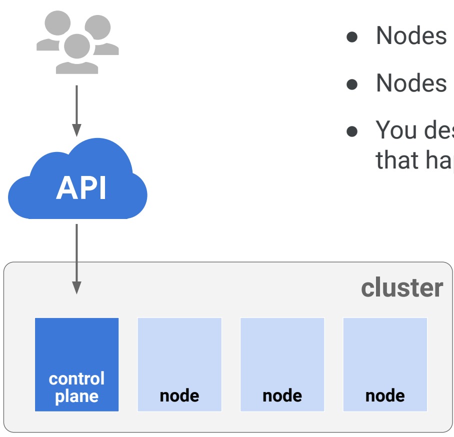
Then you use the "**docker build**" command to build the container.

This builds the container and stores it locally as a runnable **image**. You can save and upload the image to a container registry service and share or download it from there.

Then you use the "**docker run**" command to run the image.

As it turns out, packaging applications is only about 5% of the issue. The rest has to do with: application configuration, service discovery, managing updates, and monitoring. These are the components of a reliable, scalable, distributed system.

You use Kubernetes APIs to deploy containers on a set of nodes called a cluster



- Nodes run containers.
- Nodes are VMs (in GKE they're Compute Engine instances).
- You describe the apps, Kubernetes figures out how to make that happen.

Google Cloud

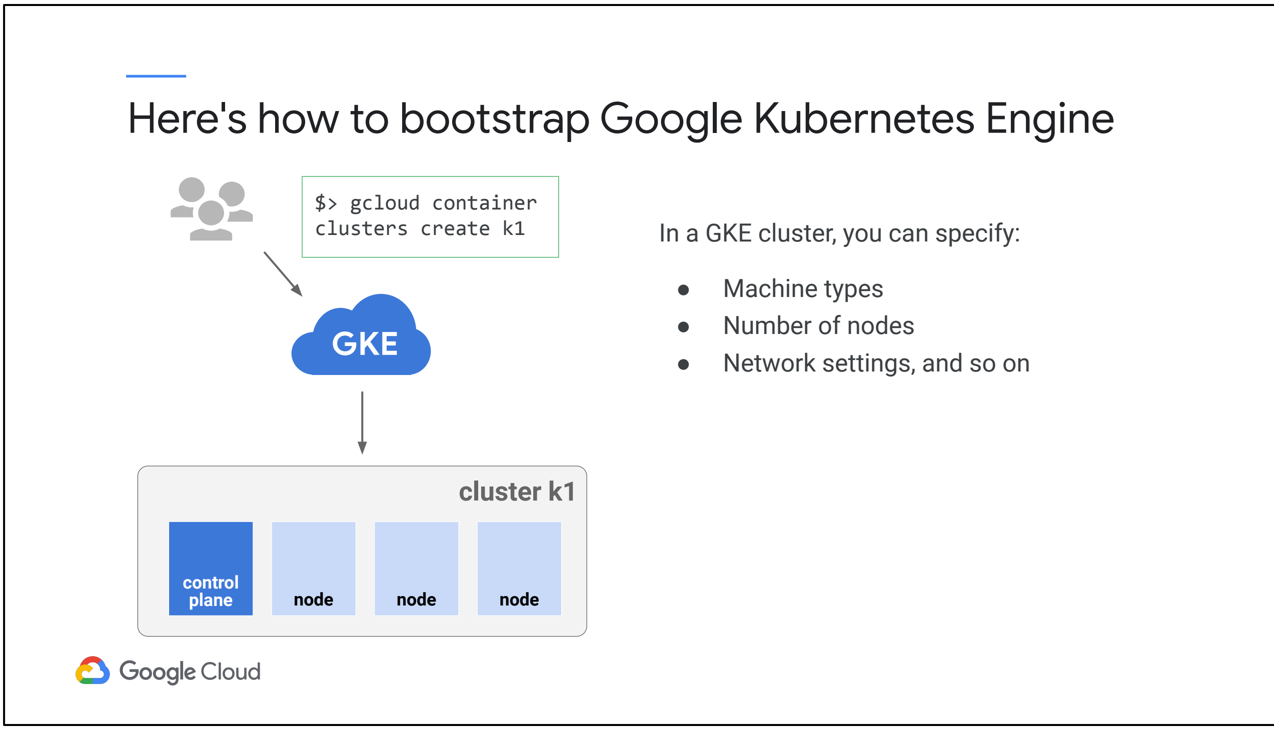
Now, I'll show you where **Kubernetes** comes in.

Kubernetes is an open-source **orchestrator** that abstracts containers at a higher level so you can better manage and scale your applications.

At the highest level, Kubernetes is a set of APIs that you can use to deploy containers on a set of **nodes** called a **cluster**.

The system is divided into a set of primary components that run as the **control plane** and a set of **nodes** that run containers. In Kubernetes, a node represents a computing instance, like a machine. In Google Cloud, nodes are virtual machines running in Compute Engine.

You can describe a set of applications and how they should interact with each other and Kubernetes figures how to make that happen



Now that you've built a container, you'll want to deploy one into a **cluster**.

Kubernetes can be configured with many options and add-ons, but can be time consuming to bootstrap from the ground up. Instead, you can bootstrap Kubernetes using **Google Kubernetes Engine** or (GKE).

GKE is a hosted Kubernetes by Google. GKE clusters can be customized and they support different machine types, number of nodes, and network settings.

To start up Kubernetes on a **cluster** in GKE, all you do is run this command: **`$> gcloud container clusters create k1`**

At this point, you should have a cluster called 'k1' configured and ready to go.

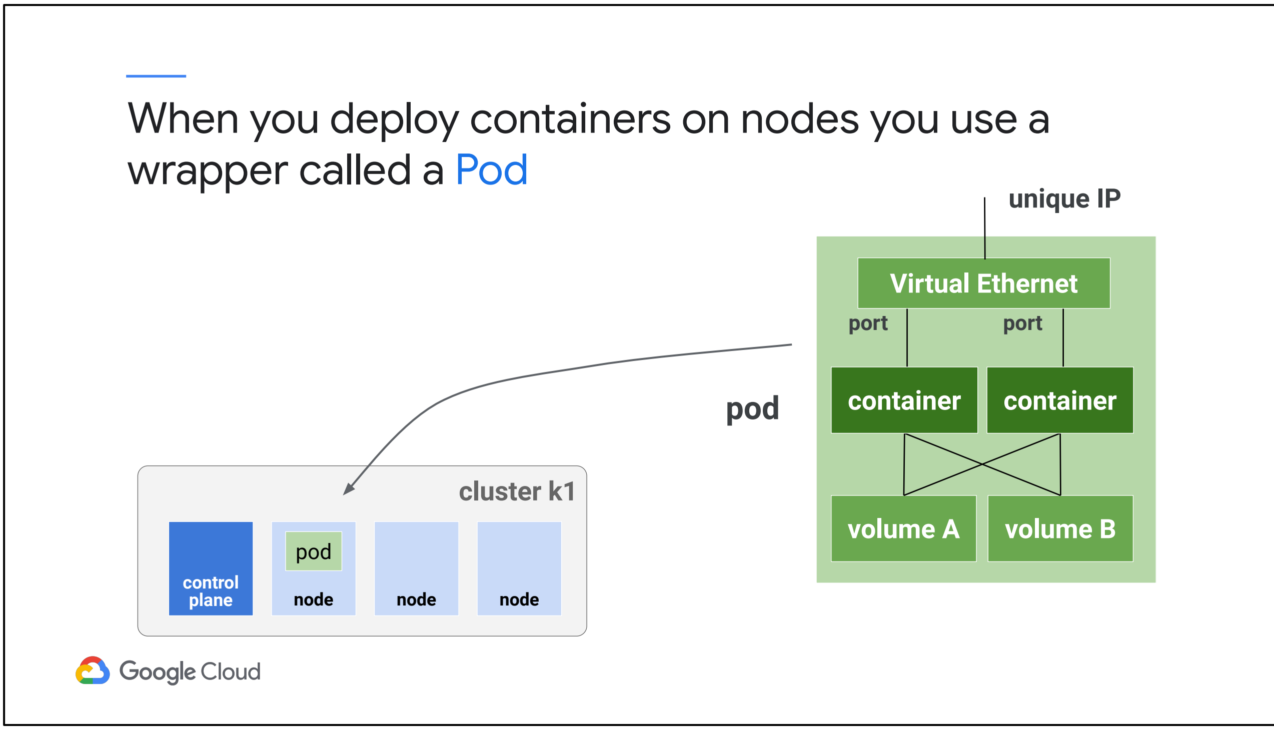
You can check its status in admin console.

Notes about commands 1

```
gcloud container clusters create k1
```

We need to specify a zone, region, etc

```
gcloud container clusters create k1 --zone us-central1-a
```

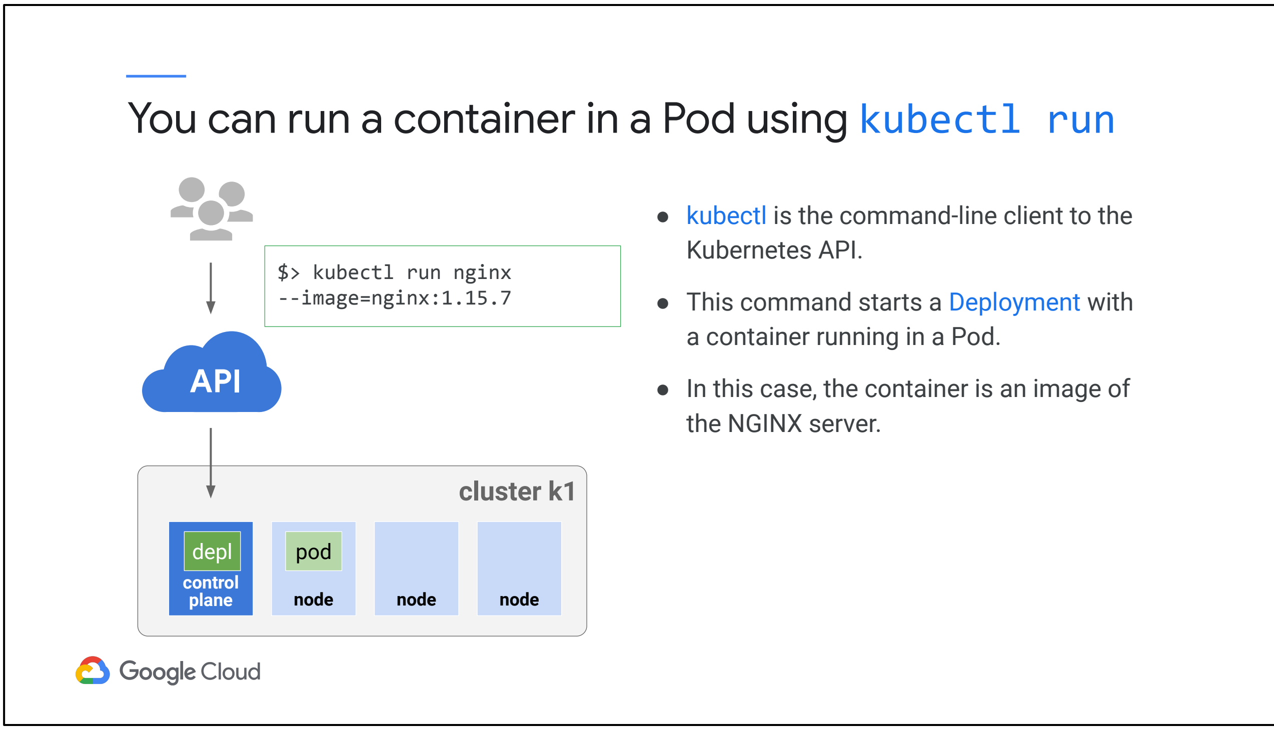


Then you deploy **containers** on nodes using a wrapper around one or more containers called a Pod.

A **Pod** is the smallest unit in Kubernetes that you create or deploy. A Pod represents a running process on your cluster as either a component of your application or an entire app.

Generally, you only have one container per pod, but if you have multiple containers with a hard dependency, you can package them into a single pod and share networking and storage. The Pod provides a unique network IP and set of ports for your containers, and options that govern how containers should run.

Containers inside a Pod can communicate with one another using localhost and ports that remain fixed as they're started and stopped on different nodes.



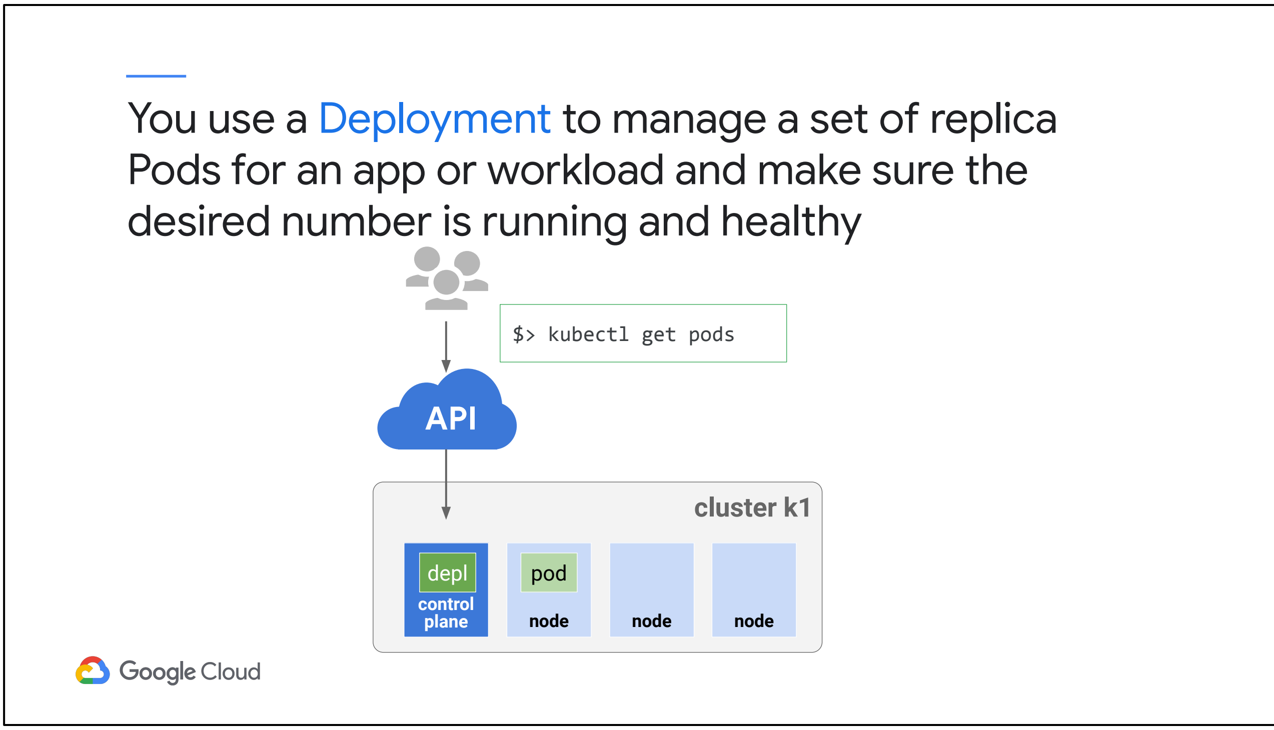
One way to run a container in a Pod in Kubernetes is to use the **kubectl run** command. We'll learn a better way later in this module, but this gets you started quickly.

This starts a **Deployment** with a container running in a **Pod** and in this case, the container inside the Pod is an image of the nginx server.

Notes about commands 2

```
kubectl run nginx --image=nginx:1.15.7
```

Now, this command will not create a Deployment



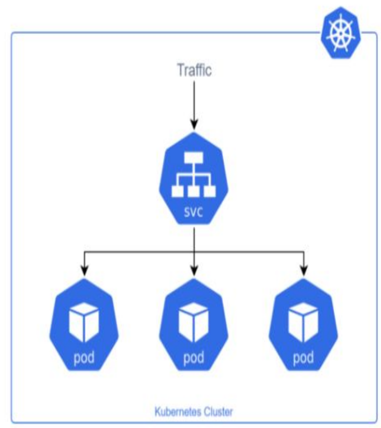
A **Deployment** represents a group of replicas of the same Pod and keeps your Pods running even when nodes they run on fail. It could represent a component of an application or an entire app. In this case, it's the nginx web server.

To see the running nginx Pods, run the command: $ kubectl **get pods**

K8s Service Types

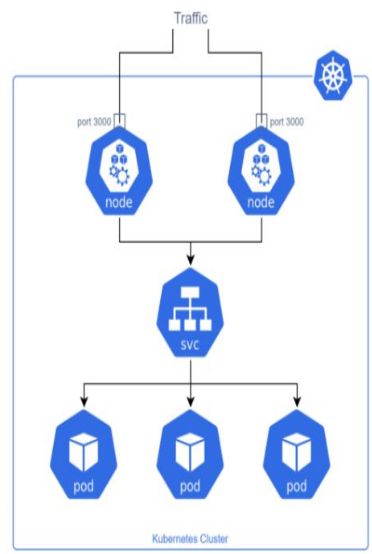
Service Types - 1) ClusterIP

- Inter service communication
- Ex: FE and BE communication



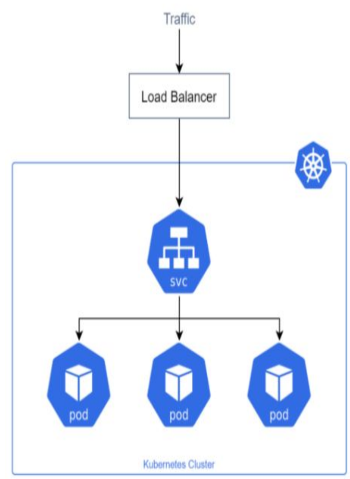
Service Types - 2) NodePort

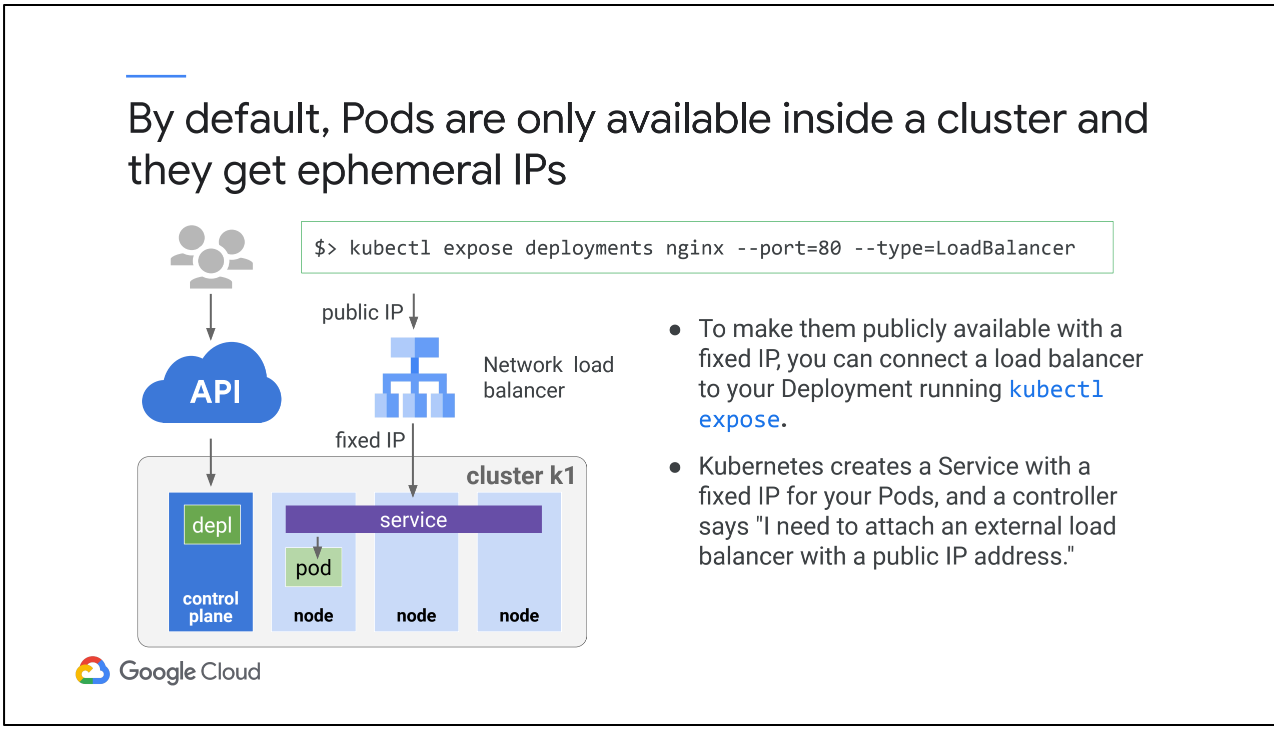
- Enable external connectivity
- Freedom to set up your own LB



Service Types - 3) LoadBalancer

- Host K8s via cloud provider
- Use cloud provider LB





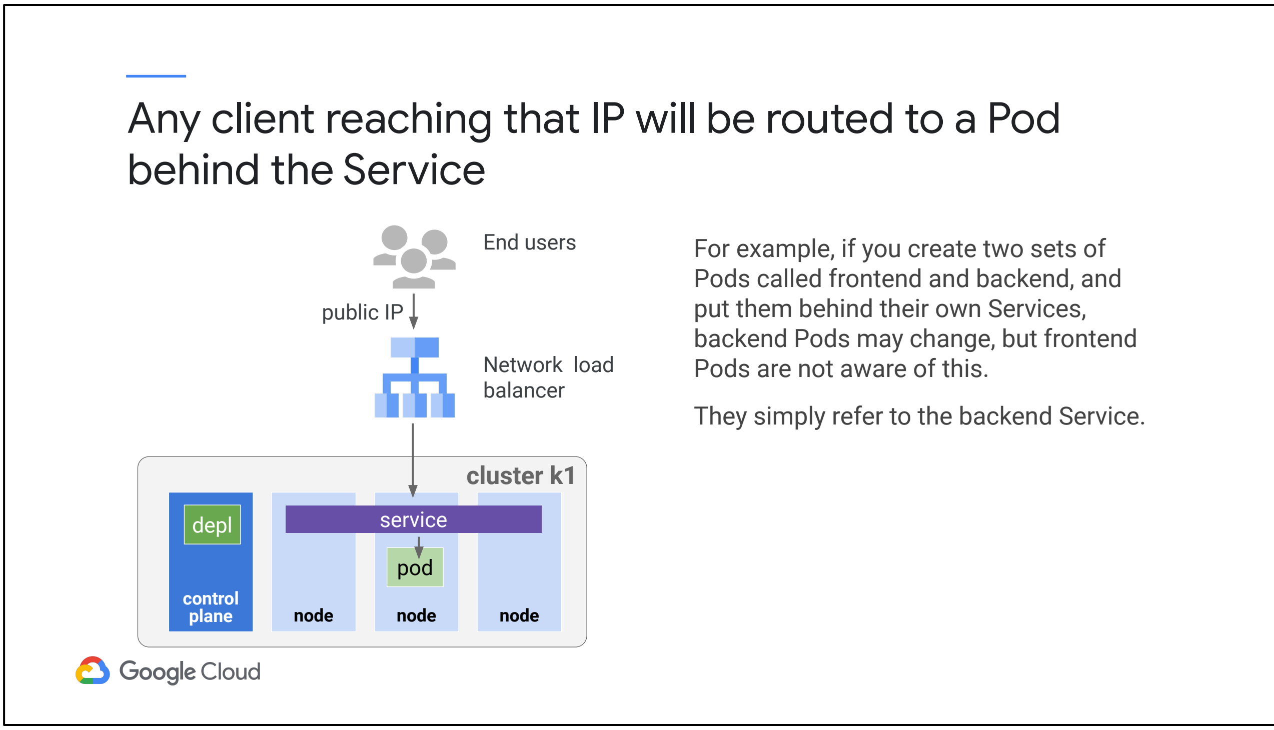
By default, Pods in a Deployment are only accessible inside your GKE cluster.

To make them publicly available, you can connect a load balancer to your Deployment by running the **kubectl expose** command:

Kubernetes creates a **Service** with a fixed IP for your Pods,

and a controller says "I need to attach an external **load balancer** with a public IP address to that **Service** so others outside the cluster can access it".

In **GKE**, the load balancer is created as a **Network Load Balancer**.



Any client that reaches that IP address will be routed to a Pod behind the Service, in this case there is only one--your simple nginx Pod.

A **Service** is an abstraction which defines a logical set of Pods and a policy by which to access them.

As Deployments create and destroy Pods, Pods get their own IP address. But those addresses don't remain stable over time.

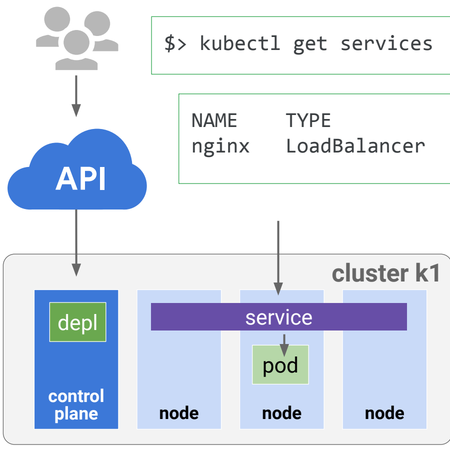
A Service groups a set of Pods and provides a stable endpoint (or fixed IP) for them.

For example, if you create two sets of Pods called frontend and backend, and put them behind their own Services, backend Pods may change, but frontend Pods are not aware of this. They simply refer to the backend Service.

Run `kubectl get services` to get the Service's public IP

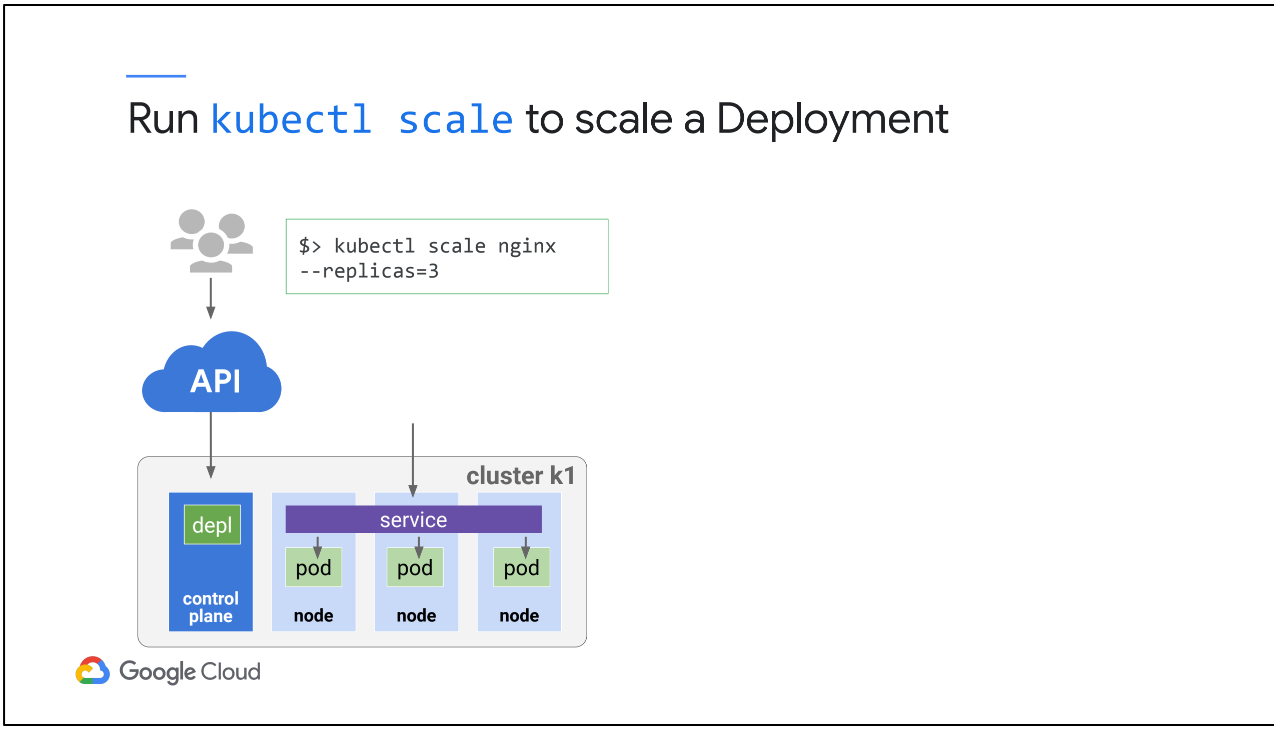
```
$> kubectl get services
```

```
NAME    TYPE          CLUSTER-IP    EXTERNAL-IP      PORT(S)  AGE
nginx   LoadBalancer  10.0.65.118   104.198.149.140  80/TCP   5m
```



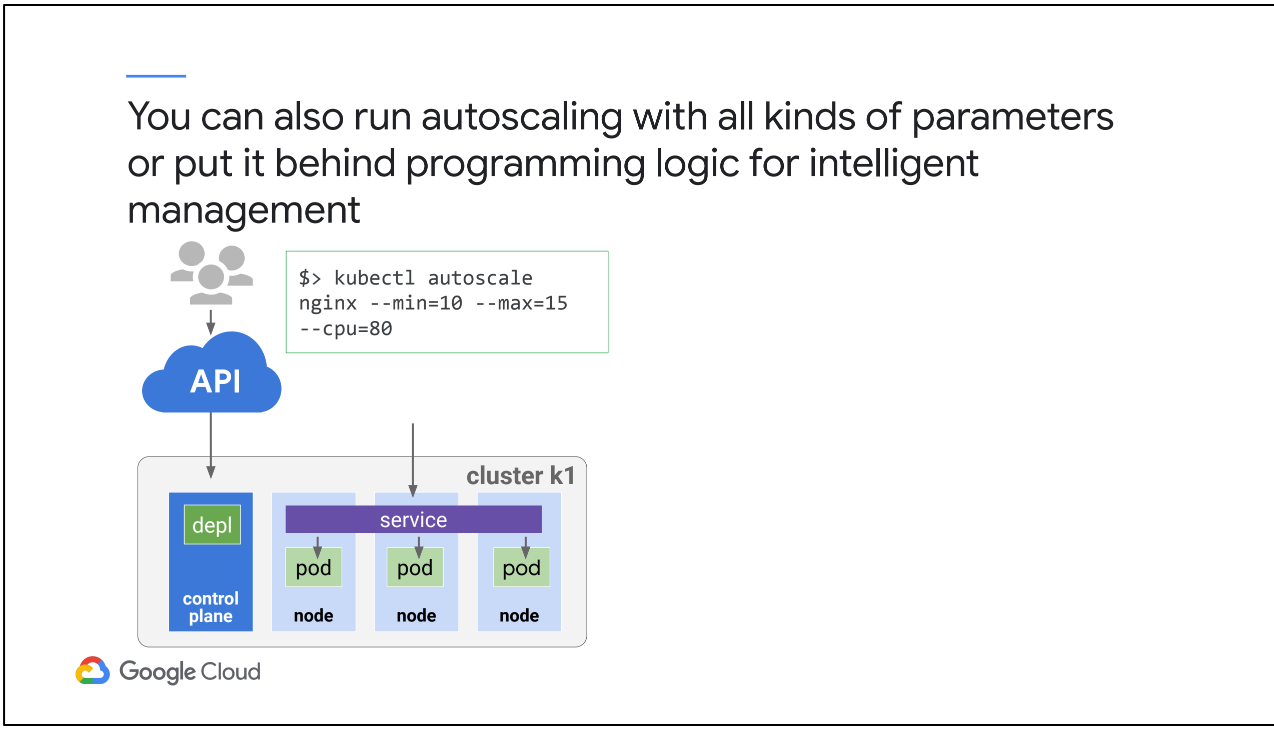
Google Cloud

You can run the **kubectl get services** command to get the public IP to reach the nginx container remotely.



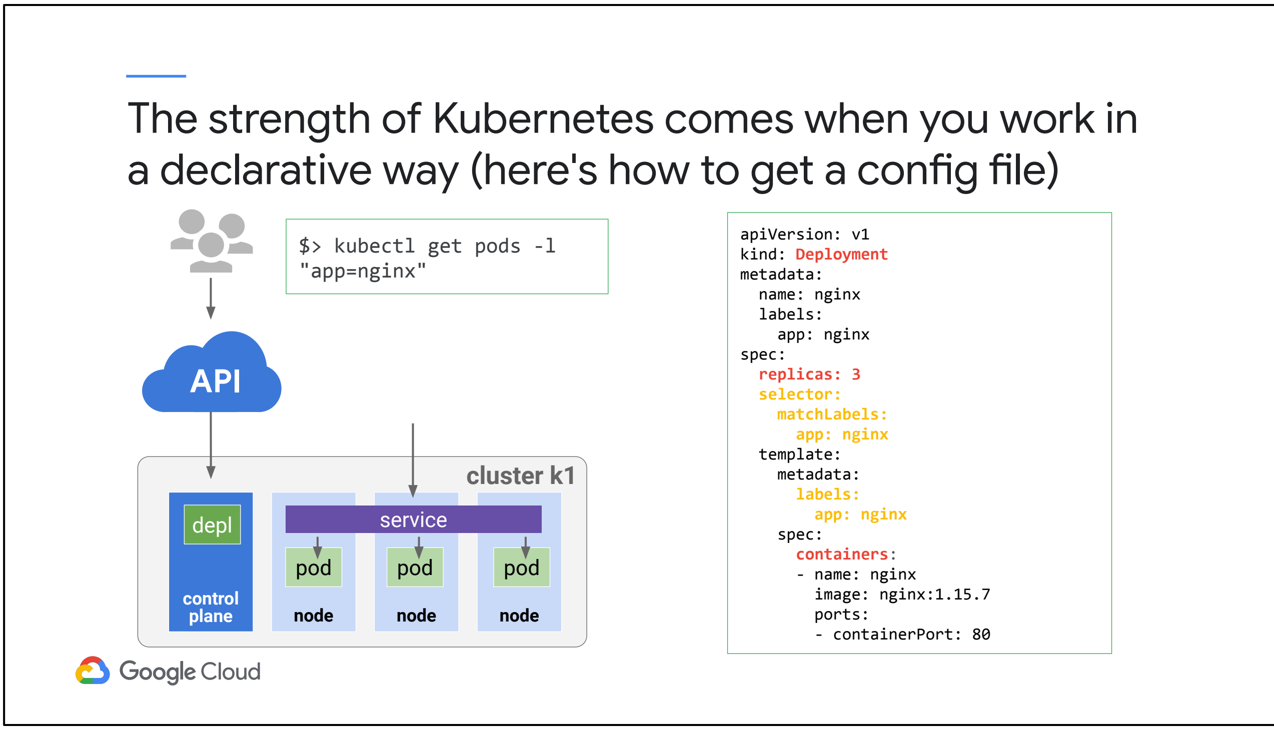
To scale a Deployment, run the **kubectl scale** command.

In this case, three Pods are created in your Deployment and they're placed behind the Service and share one fixed IP.



You could also use **autoscaling** with all kinds of parameters.

Here's an example of how to autoscale the Deployment to between 10 and 15 Pods when CPU utilization reaches 80 percent.



So far, I've shown you how to run **imperative** commands like **expose** and **scale**. This works well to learn and test Kubernetes step-by-step.

But the real strength of Kubernetes comes when you work in a **declarative** way.

Instead of issuing commands, you provide a configuration file that tells Kubernetes what you want your desired state to look like, and Kubernetes figures out how to do it.

Let me show you how to scale your Deployment using an existing Deployment config file.

To get the file, you can run a kubectl get pods command like the following, and you'll get a Deployment configuration file like the following.

In this case, it declares you want three replicas of your nginx Pod.

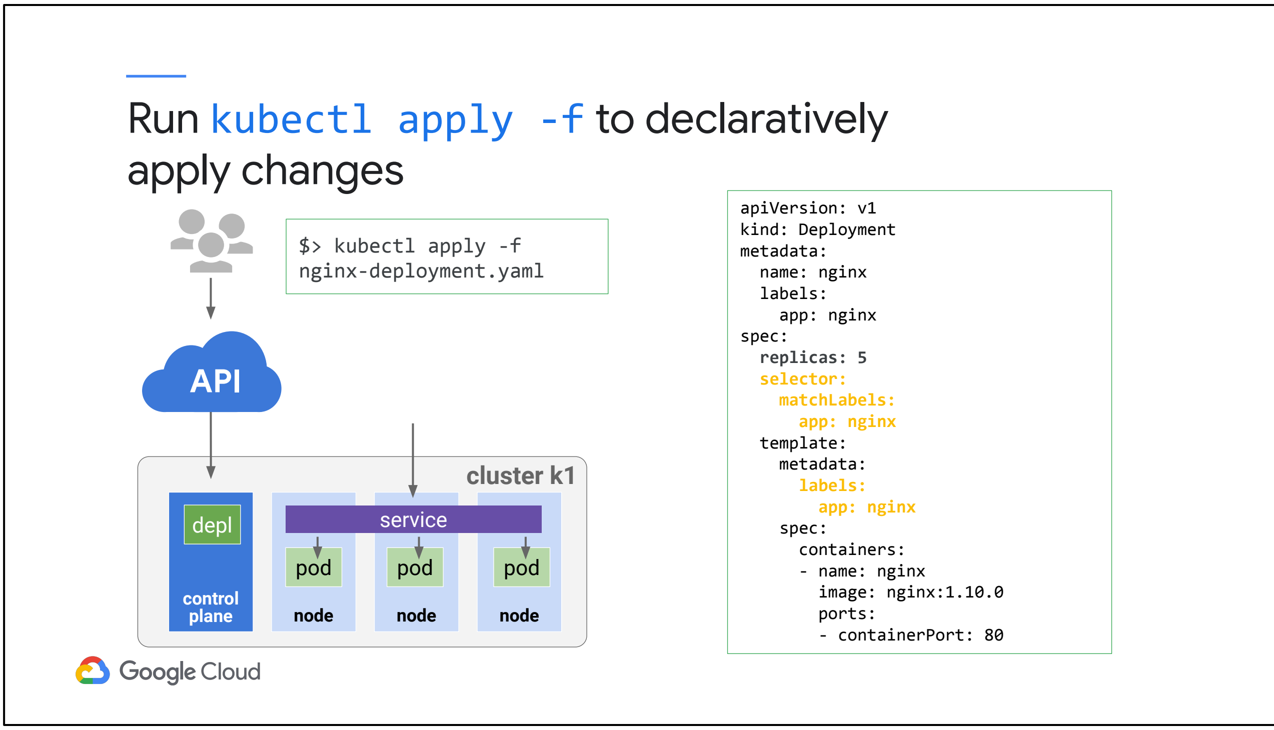
It defines a **selector** field so your Deployment knows how to group specific Pods as replicas, and you add a **label** to the Pod template so they get selected.

Notes about commands 3

```
kubectl get pods -l "app=nginx
```

To get the YAML file, use the command

```
kubectl get pod pod0 -o yaml
```



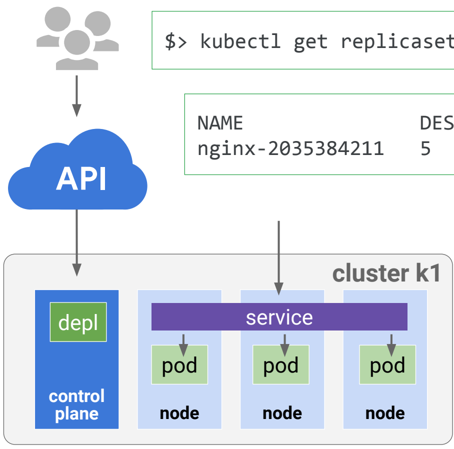
To run five replicas instead of three, all you do is update the Deployment config file.

And run the **kubectl apply** command to use the config file.

Run `kubectl get replicasets` to see the updated state

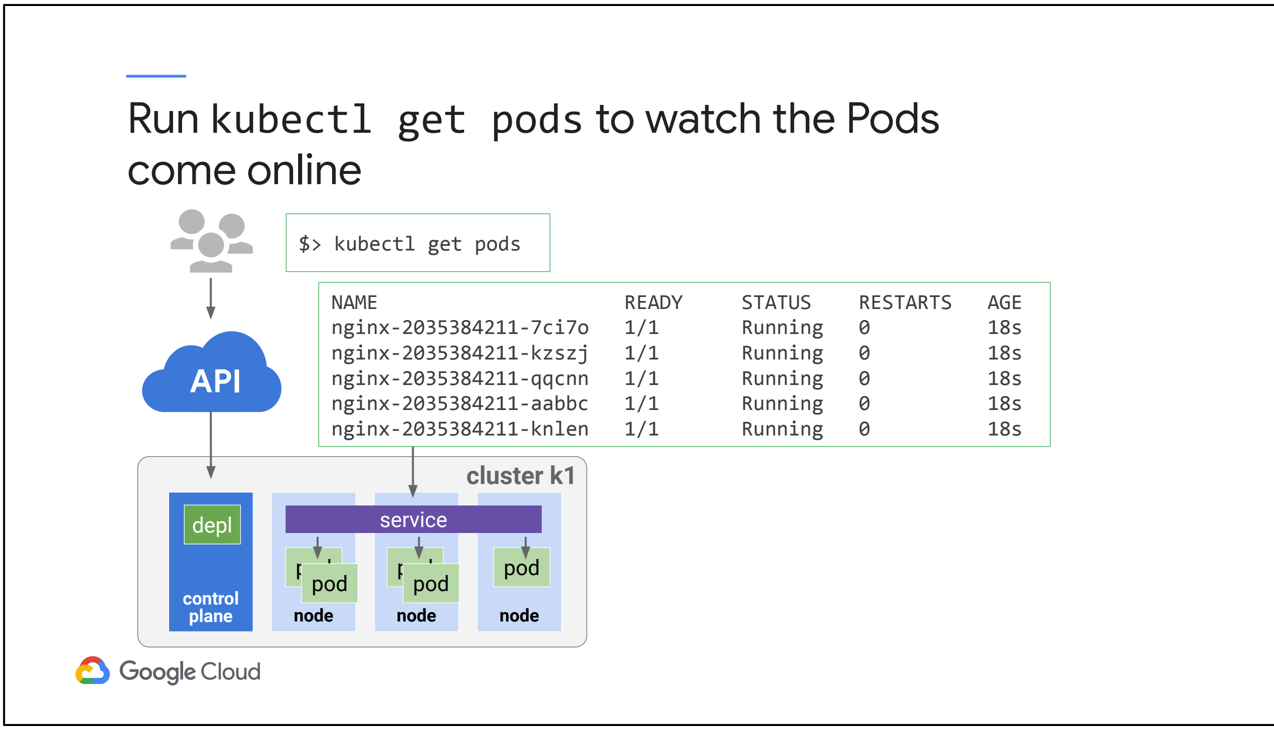
```
$> kubectl get replicasets
```

```
NAME              DESIRED   CURRENT   READY   AGE
nginx-2035384211  5         3         3       2s
```



Google Cloud

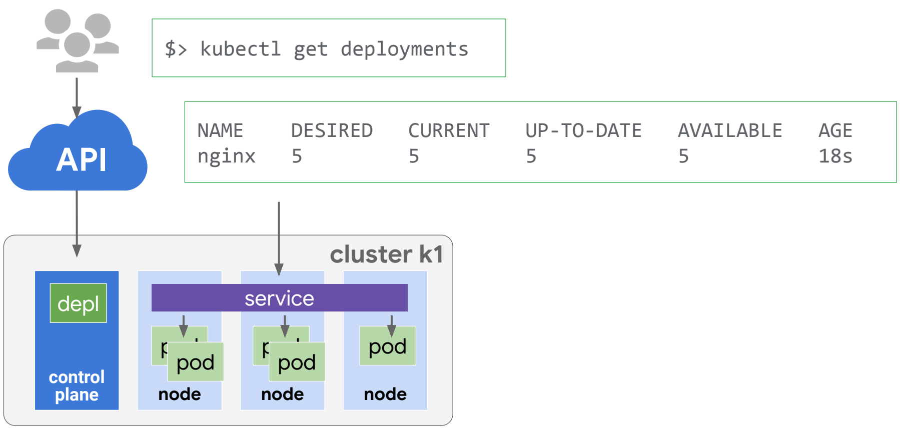
Now look at your replicas to see their updated state.



Then use the **kubectl get pods** command to watch the pods come online.

In this case, all five are **READY** and **RUNNING**.

Run `kubectl get deployments` or describe deployments to ensure the proper number of replicas are running



Google Cloud

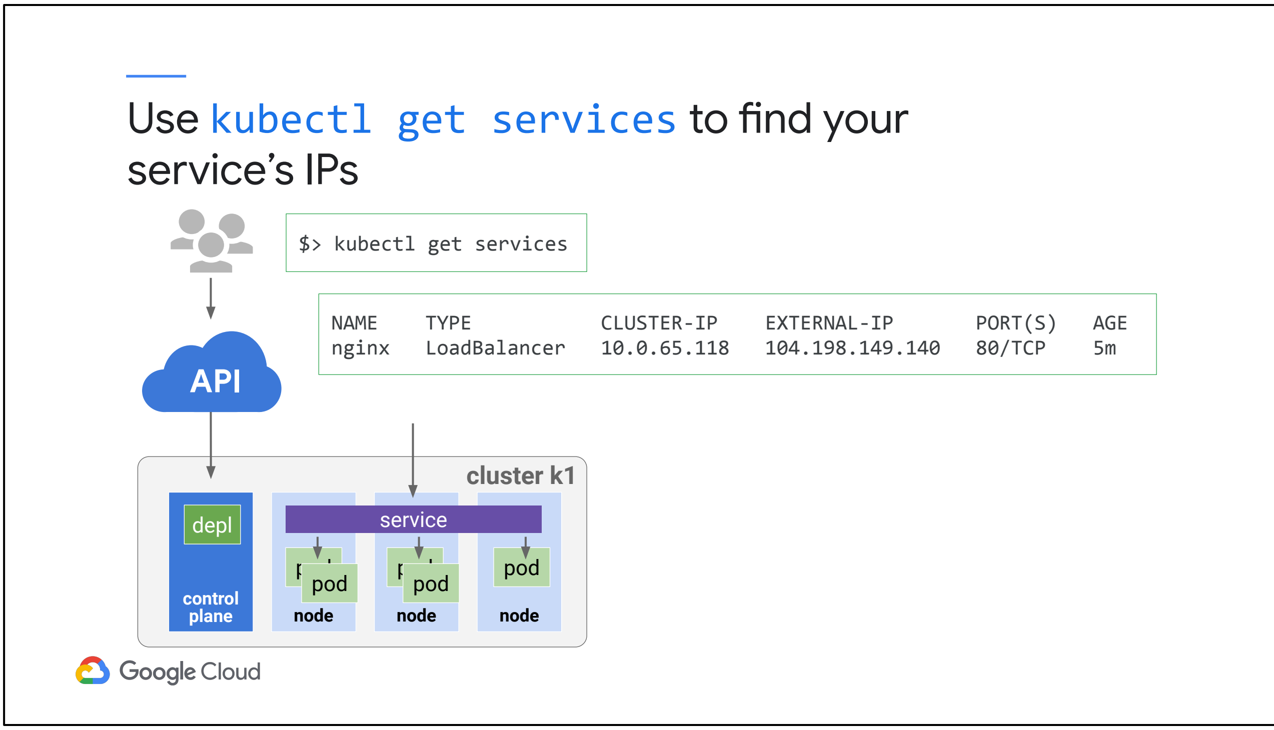
And check the Deployment to make sure the proper number of replicas are running using either $ kubectl **get deployments** or $ kubectl **describe deployments**. In this case, all five Pod replicas are **AVAILABLE**.

Notes about commands 4

```
kubectl describe deployments
```

When to use the above command and
When to use the following command

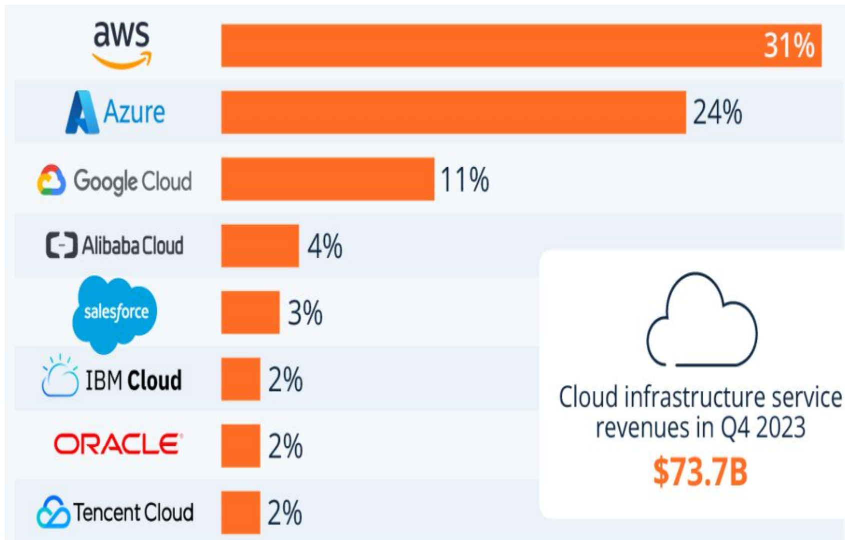
```
kubectl get deployments
```



And you can still reach your endpoint like before using $ kubectl **get services** to get the external IP of the Service, and reach the public IP from a client.

At this point, you have five copies of your nginx Pod running in GKE, and you have a single Service that's proxying the traffic to all five Pods. This allows you to share the load and scale your Service in Kubernetes.

Cloud Provider Global Market Share



https://www.statista.com/chart/18819/worldwide-market-share-of-leading-cloud-infrastructure-service-providers/