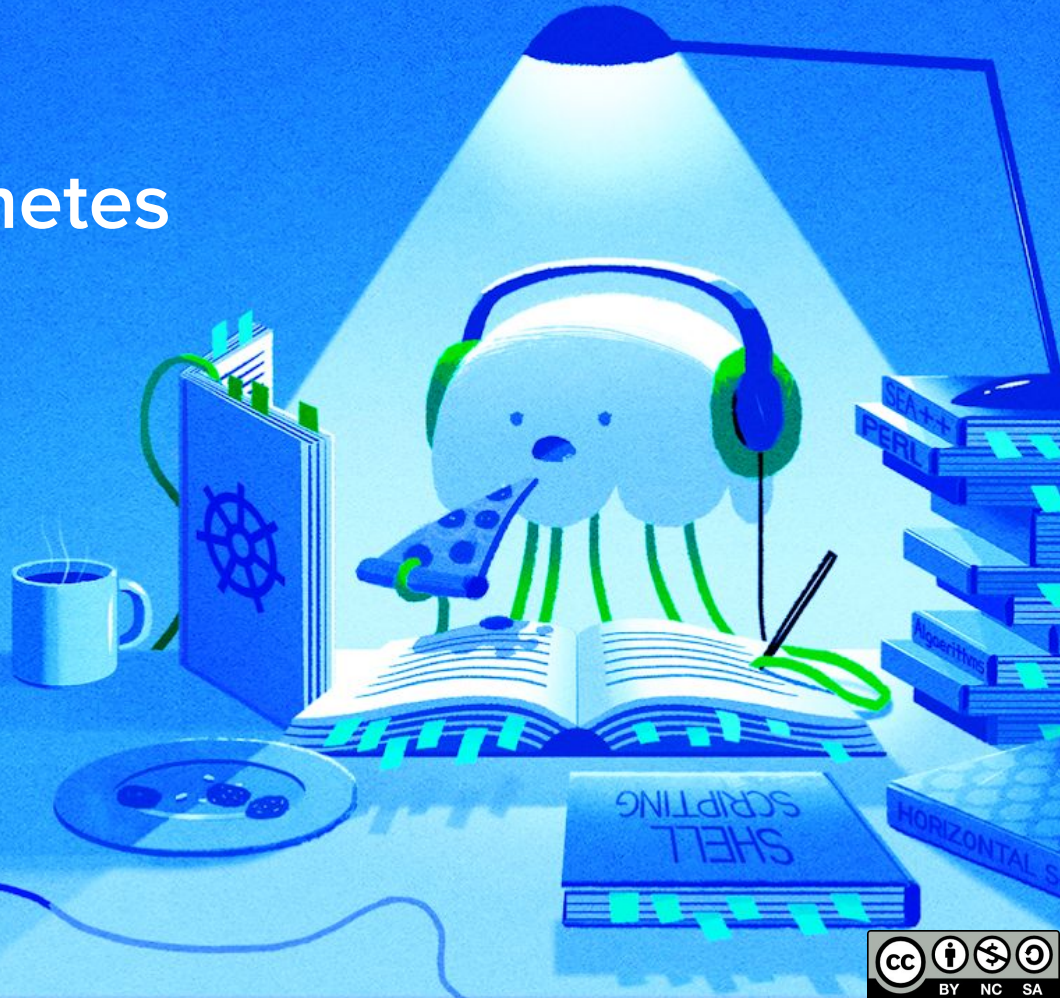
Getting Started with Containers and Kubernetes



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Hi! I’m...

- Wayne Warren
  - I am a Software Engineer
  - Based out of Chicago
  - Working on DigitalOcean Kubernetes (DOKS)

Webinar Goals

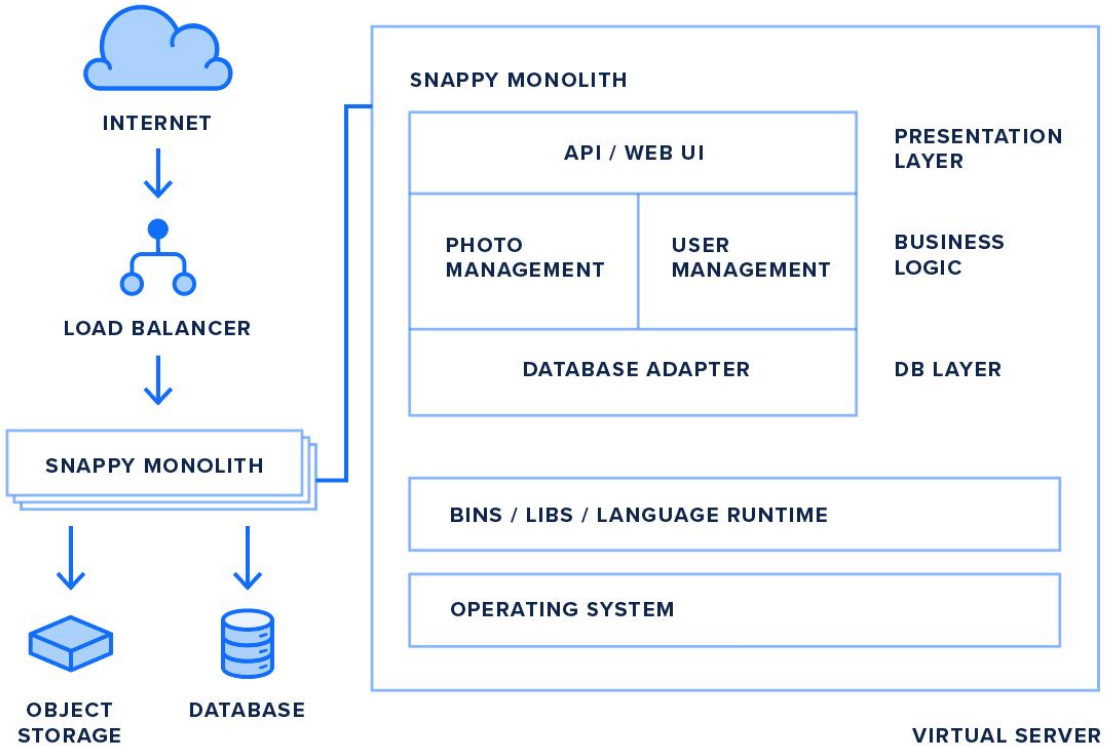
- Discuss trends in app design and deployment
- High-level overview of and motivation for containers
- Learn about Kubernetes architecture and objects
- Demo
  - Build a continer image for a demo Flask app
  - Deploy Flask app to Kubernetes cluster
  - Create a public load-balancer to access that app

Prerequisites

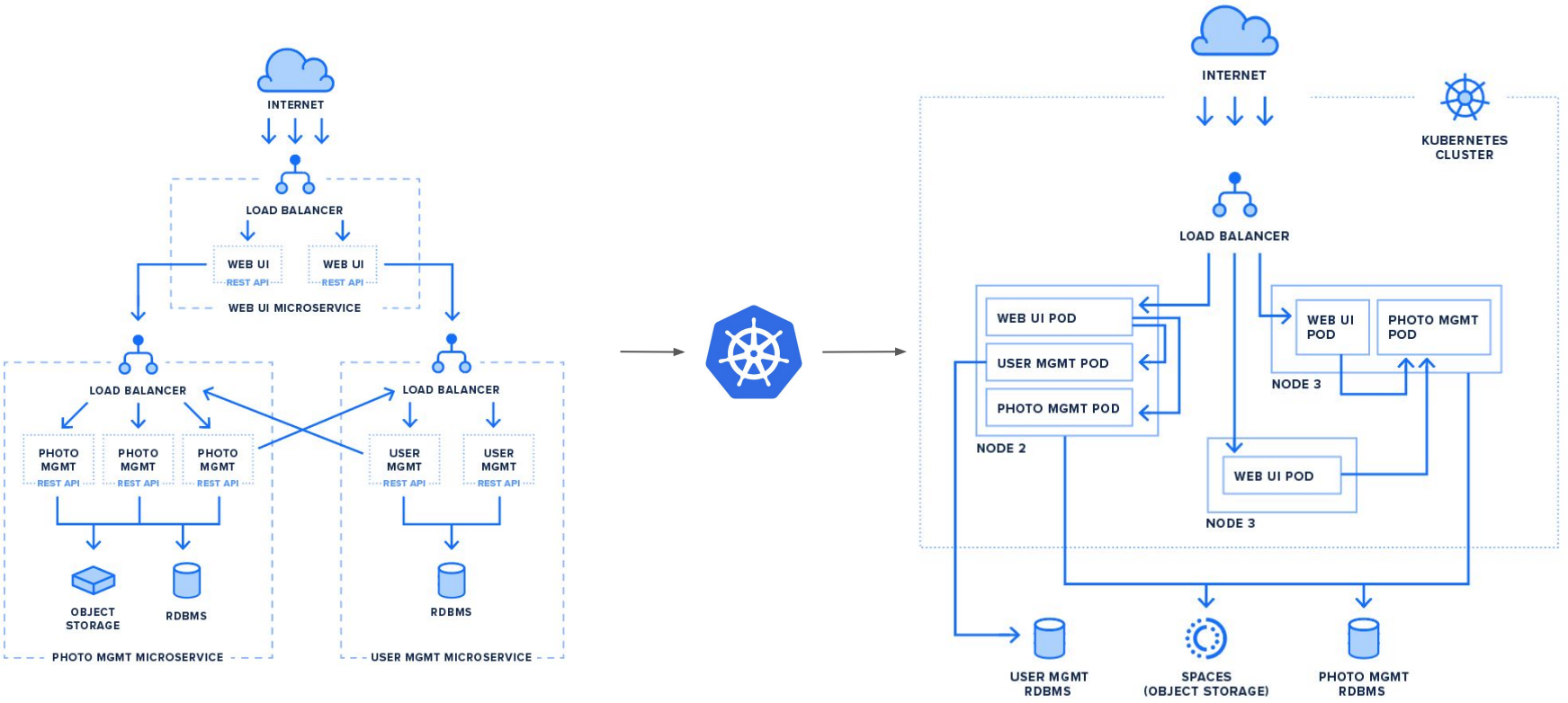
- Kubernetes cluster you have access to (we'll use DigitalOcean Kubernetes throughout this talk)
- On your machine:
  - Kubectl configured to access your cluster
  - Git
  - Docker
- Clone the Flask demo code
  - `git clone https://github.com/do-community/k8s-intro-meetup-kit.git`
  - `cd k8s-intro-meetup-kit`

App Modernization: Monoliths vs Microservices

The Monolith



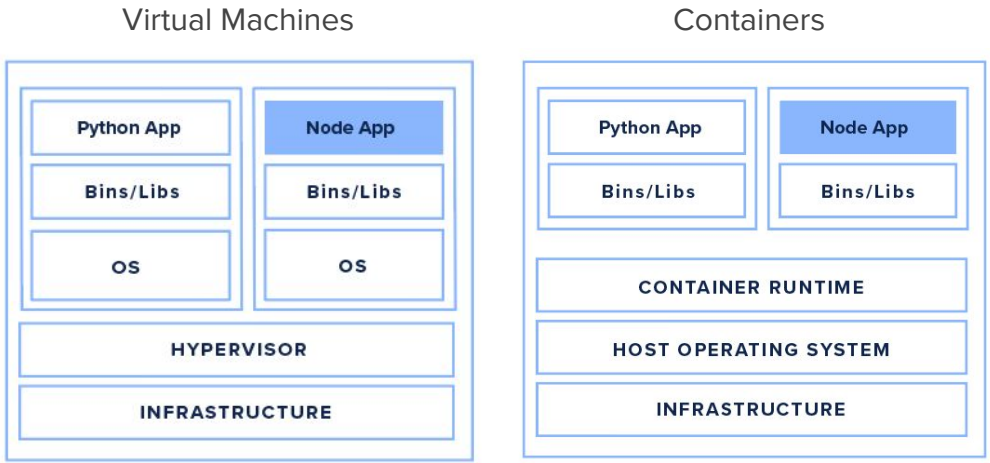
Breaking the Monolith



Revisiting Containers

What is a Container?

- VMs vs. Containers
- Container features
  - Lightweight
  - Portable
  - Isolated



But what are they, really?

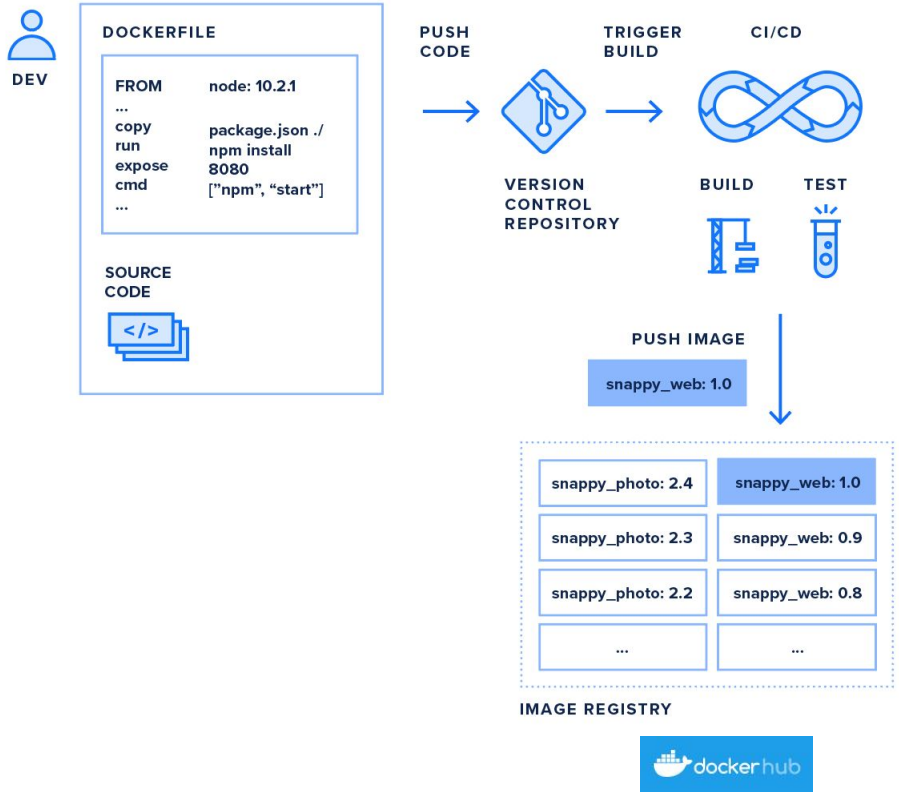
- A package of application code and all of its dependencies
  - Includes everything needed to run the application
- Built around two Linux kernel features
  - Namespaces: Process isolation
  - Cgroups: Resource limits

Let’s try it out!

- Create a PID namespace from scratch
  - `ps aux`
  - `sudo unshare --fork --pid --mount-proc /bin/bash`
  - `ps aux`
- In a **new shell**, find process id of PID namespace we created:
  - `pgrep -af /bin/bash`
  - `pid=<pid of /bin/bash process under unshare parent>`
- Enter into the PID namespace
  - `ps aux`
  - `sudo nsenter -a -t $pid`
  - `ps aux`

Container Ecosystem

- Container
- Container Images
- Container Runtime
- Container Registries



docker

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containerd

Example: Containerized Flask App

App Code (`cat app/app.py`**)**

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

@app.route('/')
def hello_world():
    return 'Hello, World!'

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

Example: Containerized Flask App

Dockerfile (`cat app/Dockerfile`)

```
FROM python:3-alpine

WORKDIR /app

COPY requirements.txt .
RUN pip install -r requirements.txt

COPY . .

EXPOSE 5000

CMD ["python", "app.py"]
```

- Build & tag image
  - `docker build -t flask:v0 .`
  - `docker images`
- Run container / test
  - `docker run -p 5000:5000 flask:v0`
  - `docker ps`
  - `curl http://localhost:5000`
- Push to Docker Hub repo (optional)
- What would this look like in VM world?

Container Clusters

Container Clusters

- What if we have 10s, 100s, 1000s of running containers on multiple VMs?
- How to deploy, scale, restart, manage all of these containers?
- What problems do they solve?
  - Management
    - Metrics
    - Health checks
    - Security
  - Abstraction of hardware
  - Networking
  - Scheduling
  - Scaling
  - Deployment
    - Rollbacks
    - Zero-downtime / blue-green
  - Service discovery

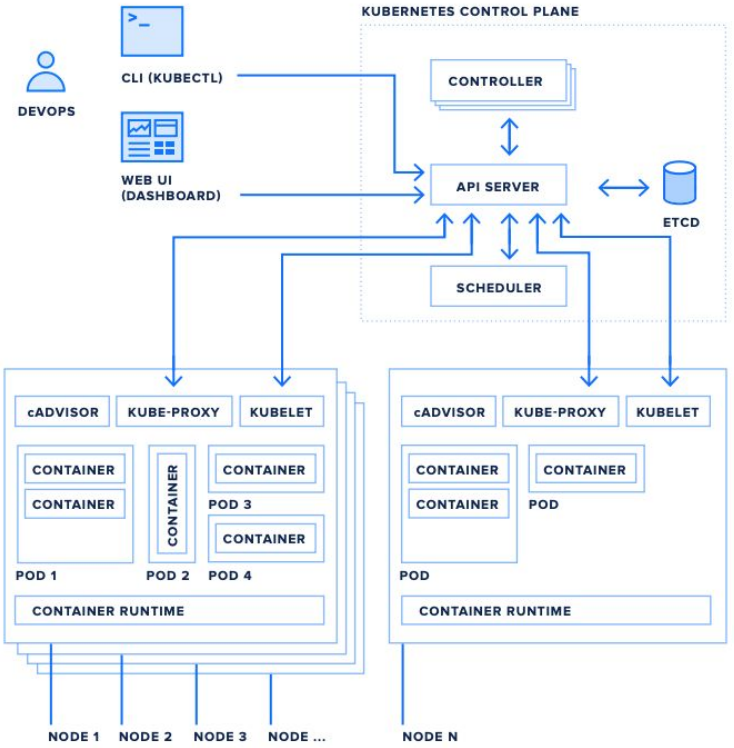
A Brief Kubernetes History

- “K8s”
- Evolved out of Borg (Google’s internal container cluster)
- Open sourced ~2014
- Grew in popularity, open source velocity increased
- Now the most popular container cluster (most cloud platforms have some sort of managed K8s offering)
- Features added regularly and frequently
- Cloud Native / CNCF - Kubernetes, Prometheus, Fluentd

CLOUD NATIVE
COMPUTING FOUNDATION

Kubernetes Architecture

- Client-Server architecture
  - Server: Control Plane
  - Clients: Nodes



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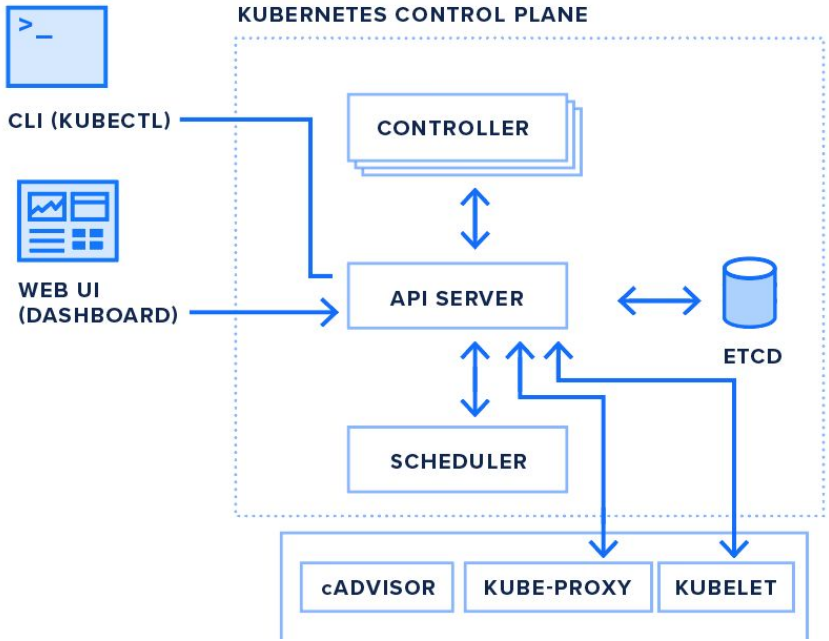
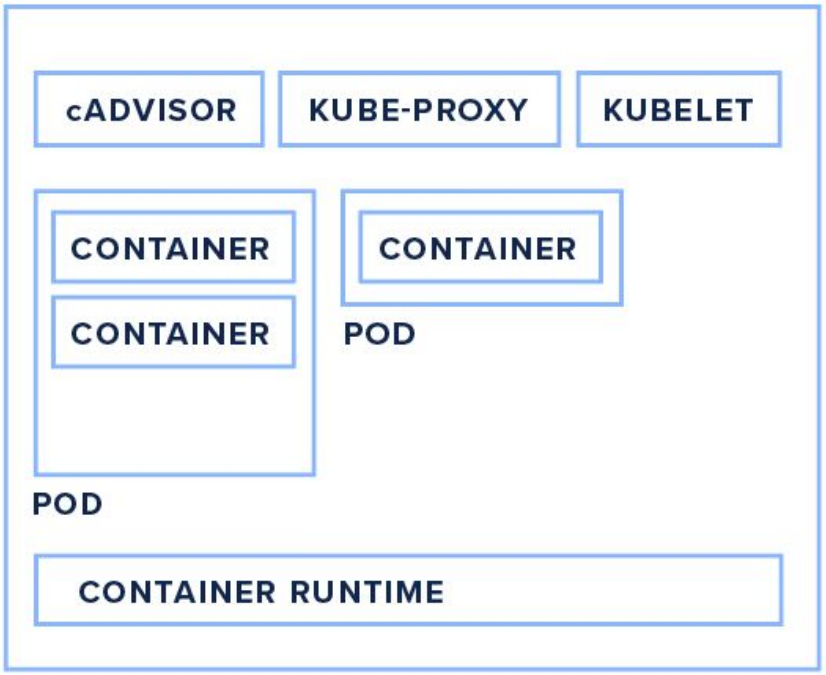
Kubernetes Architecture

- Control Plane
  - API server
  - Scheduler
  - Controllers
    - Kubernetes
    - Cloud
  - Etcd



Kubernetes Architecture

- Nodes
  - Kubelet
  - Kube-proxy
  - cAdvisor
  - Container runtime



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How do I interact with a Kubernetes cluster?

- Hit REST API directly
  - Can use curl, client libraries, etc.
- Kubectl
  - Command-line tool to interact with control plane
  - Abstracts away multiple REST API calls
  - Provides “get” “create” “delete” “describe”, etc. functionality
  - Filtering results
- Set up kubectl
  - `cp k8s_config_file ~/.kube/config`
  - May need to create this directory, depending on your OS
  - `kubectl cluster-info`

Some Kubectl Commands...

- kubectl get
- kubectl apply
- kubectl rollout status
- kubectl rollout undo

- kubectl create
- kubectl delete
- kubectl expose
- kubectl edit
- kubectl patch

Kubernetes Objects: Pods and Workloads

Namespaces

- An abstraction that allows you to divide a cluster into multiple scoped “virtual clusters”
  - E.g. Each team gets its own Namespace with associated resource quota
- Primary mechanism for scoping and limiting access
- Kubernetes usually starts with 3 Namespaces by default
  - default
  - kube-system
  - kube-public

Creating a Namespace

- List namespaces with kubectl:
  - `kubectl get namespaces`
  - `kubectl get ns`
- Create your own:
  - `kubectl create ns flask`
- Specify a namespace with kubectl:
  - `kubectl -n flask get all`
- If you don't want to use the `-n` flag with every command: **contexts**
  - `kubectl config current-context`
  - `kubectl config set-context --current --namespace=flask`
  - `kubectl config get-contexts`
  - `kubectl get all`

Pods

- Fundamental Kubernetes work unit
- Can run one or more containers
  - Why more than one?
- Pod containers share resources
  - Storage
  - Network (localhost)
  - Always run on the same Node

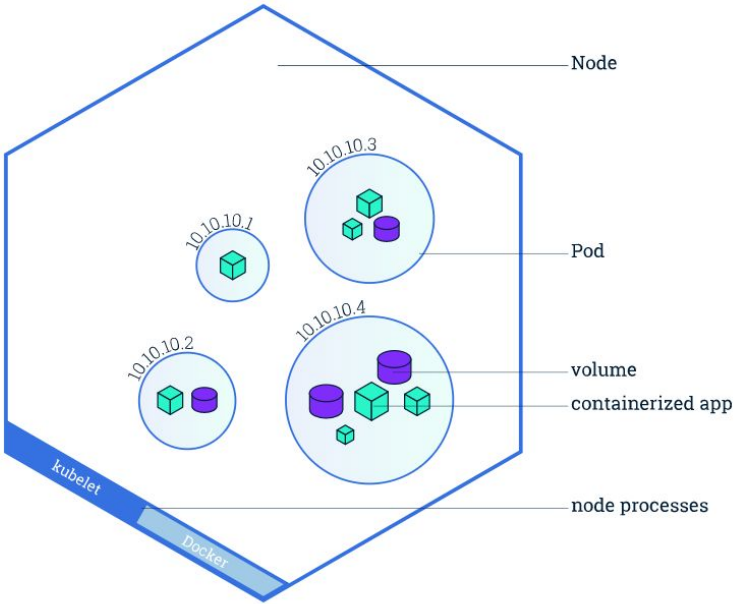


Image Attribution: [K8s Official Docs]

Pod Manifest Example

Pod Manifest (`cat k8s/flask-pod.yaml`)

```
apiVersion: v1
kind: Pod
metadata:
  name: flask-pod
  labels:
    app: flask-helloworld
spec:
  containers:
  - name: flask
    image: digitalocean/flask-helloworld:latest
    ports:
    - containerPort: 5000
```

- Deploy the Flask Pod
  - `kubectl apply -f flask_pod.yaml -n flask`
- Check that it's up
  - `kubectl get pod -n flask`
- Forward a local port into the cluster so that we can access it
  - `kubectl port-forward -n flask pods/flask-pod 5000:5000`
  - `curl http://localhost:5000`
- Delete the Pod
  - `kubectl delete pod flask-pod -n flask`

Labels

- Key/value pairs: think of them as object “tags”
- Almost everything can be labeled
  - Even Nodes
- *Not* Unique
- Used to select objects with *selectors*
- Examples:
  - env: prod
  - env: staging
  - release: stable
  - release: canary

Kubernetes Workloads

- Deployments (stateless apps)
  - ReplicaSets
    - Pods
      - Containers
        - Namespaces & cgroups
- StatefulSets (stateful apps - e.g. databases)
- DaemonSets (think of these as “agents” / daemons)
- Jobs & CronJobs

Deployments

- How to manage multiple Pods?
- Higher-level object that “contains” the Pod object
- Pod management
  - Deployment
  - Scaling
  - Updates

Deployment example

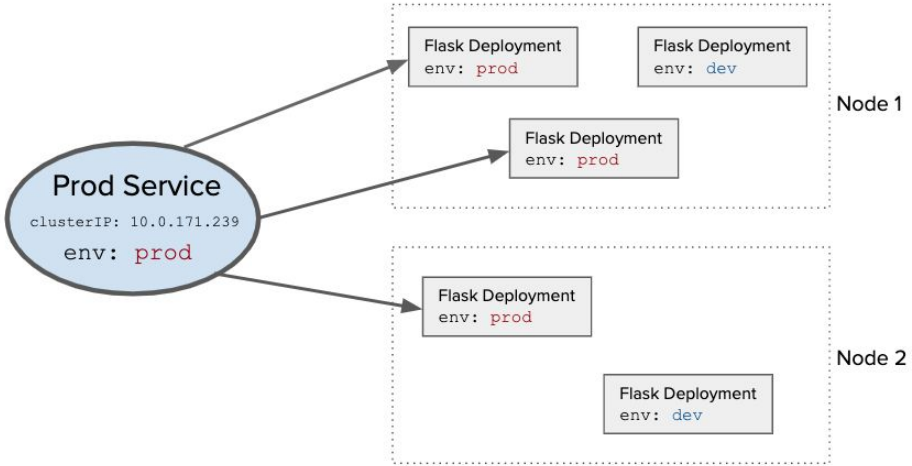
Deployment Manifest (`cat k8s/flask-deployment.yaml` **)**

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: flask-dep
  labels:
    app: flask-helloworld
spec:
  replicas: 2
  selector:
    matchLabels:
      app: flask-helloworld
  template:
    metadata:
      labels:
        app: flask-helloworld
    spec:
      containers:
      - name: flask
        image: digitalocean/flask-helloworld
        ports:
        - containerPort: 5000
```

- Roll out the Flask Deployment
  - `kubectl apply -f flask_deployment.yaml -n flask`
- Check that it's up
  - `kubectl get deploy -n flask`
  - `kubectl get pods -n flask`
- Forward a local port into the cluster so that we can access it
  - `kubectl port-forward -n flask deployment/flask-dep 5000:5000`
  - `curl http://localhost:5000`

Services: Exposing your apps to the outside world

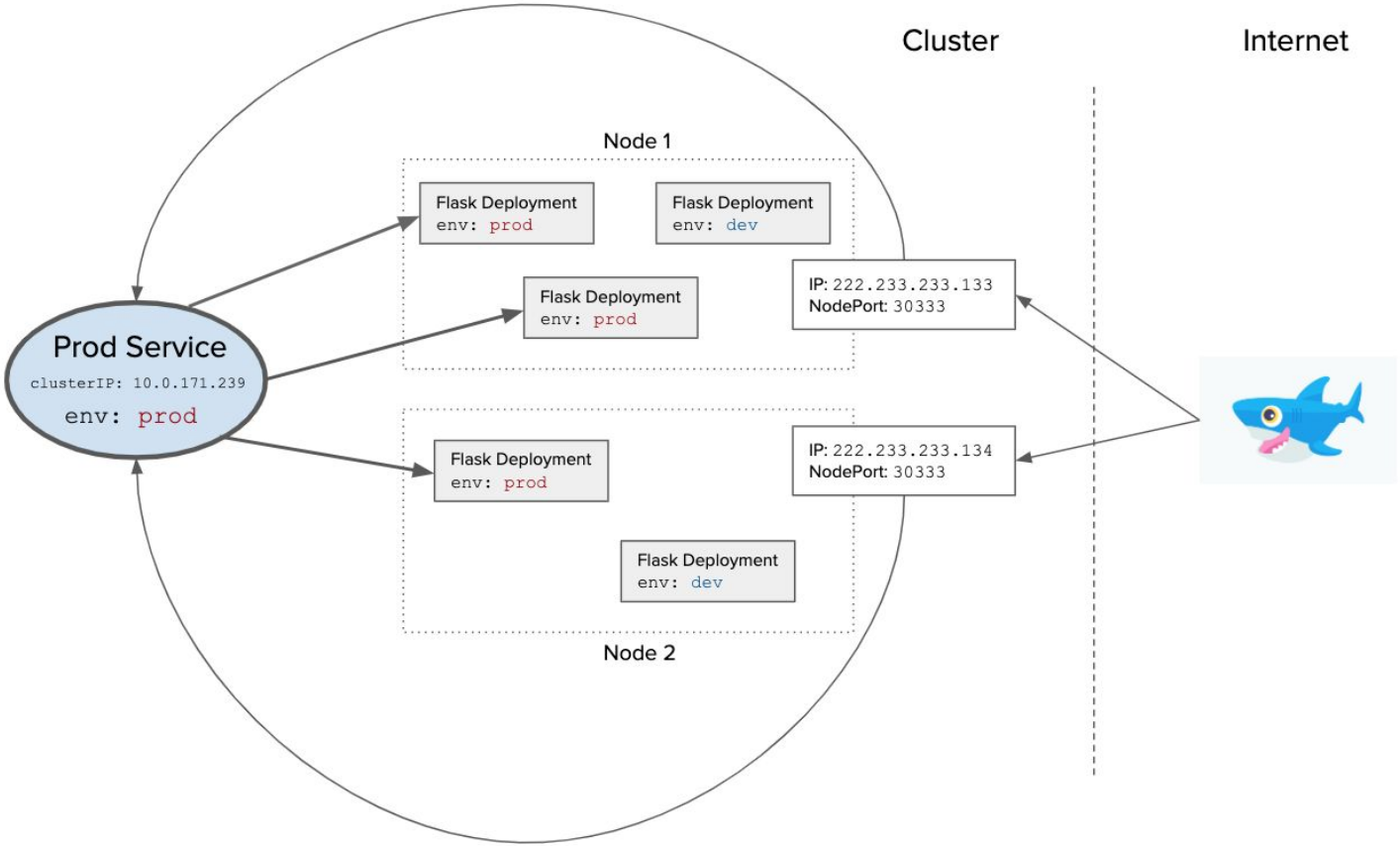
- By default, every Pod will be assigned an ephemeral cluster-internal IP address
- If you have a set of Pod replicas (Deployment), how to create a stable endpoint?
- Services: Abstraction to expose an app as a *service* (think microservices)
- Load balancing traffic
  - Routing to “healthy” / “available” Pods
- Again uses Labels + Selectors
- Example: “Prod Service”
  - ClusterIP
  - Stable network endpoint
  - Load-balances traffic to prod Deployment Pods



Service Types

- ClusterIP
  - Expose the service on a Cluster-internal IP
- NodePort
  - Expose the service on each Node's IP at a static port ("NodePort")
- LoadBalancer
  - Create an external LoadBalancer which routes requests to Nodeport & ClusterIP services
- Aside: Ingress Controllers

NodePort Service



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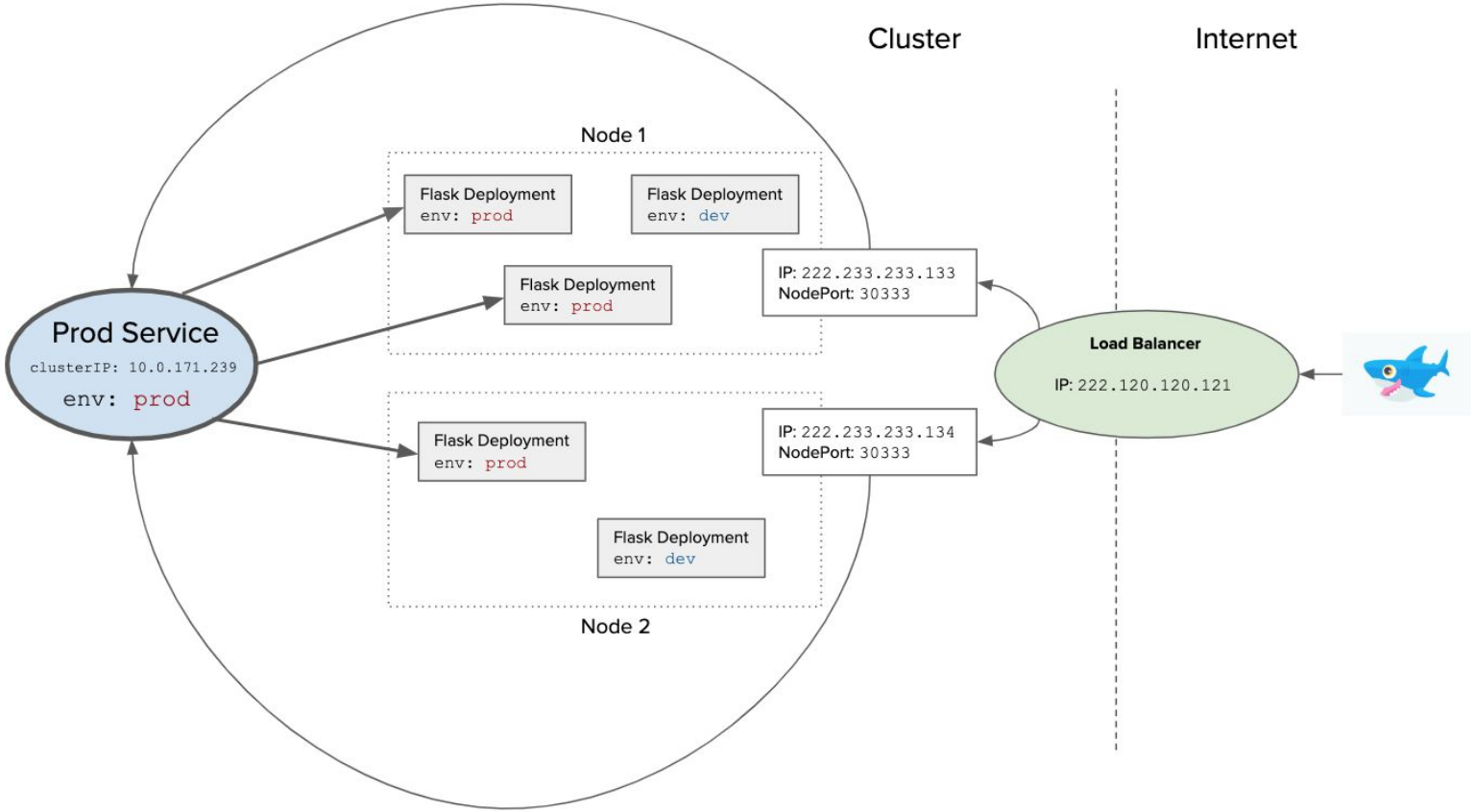
LoadBalancer Service



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Example: Flask App LoadBalancer Service

Service Manifest (`cat k8s/flask-service.yaml` **)**

```
apiVersion: v1
kind: Service
metadata:
  name: flask-svc
  labels:
    app: flask-helloworld
spec:
  type: LoadBalancer
  ports:
  - port: 80
    targetPort: 5000
    protocol: TCP
  selector:
    app: flask-helloworld
```

- Deploy the Flask LoadBalancer Service
  - `kubectl apply -f flask-service.yaml -n flask`
- Check that it's up (may have to wait for external IP)
  - `kubectl get svc -n flask`
  - `curl loadbalancer_external_ip`
- Get external IPs of Nodes (for NodePort services)
  - `kubectl get node -o wide`

Other Kubernetes Resources

Configuration: ConfigMaps & Secrets

- Kubernetes provides various features for externalizing and versioning config parameters
  - Stored in etcd
- ConfigMaps
  - Hostnames, runtime parameters for commands, config files
- Secrets
  - Base64-encoded, encrypted
  - Passwords, credentials, etc.
- Versatile, can be created and used in a number of ways
  - Env vars
  - Mounted as Volumes attached to Pods

Storage & Volumes (briefly)

- Volumes
  - Tied to the lifecycle of the Pod that requests it
  - Can be used to share data between containers in a Pod
- Persistent Volumes & PVCs
  - Abstraction that allows operators to separate storage provisioning from consumption
  - For example:
    - A PV could be a 10Gi DO block storage disk made available to the cluster
    - The PVC (defined in the workload manifest) states that this particular app needs a 10Gi disk. A controller matches the PVC with the PV
- Storage Classes

More K8S Features...

- Resource requests & limits
- Autoscaling
- Node affinity, taints, tolerations
- Dashboard
- Metrics-server

Helm: a K8S “Package Manager”

- Tool for managing Kubernetes applications
  - Think “apt-get” for Ubuntu / package managers
- Architecture
  - Helm (client)
  - Tiller (server, runs in the cluster)
- How it works
  - Charts
  - `helm install stable/wordpress`
- Sample apps: Wordpress, Prometheus, MySQL, Drupal, ...

Where to go from here?

- Kubernetes For Fullstack Developers Curriculum
- Kubernetes White Paper
- DigitalOcean Kubernetes Community Tutorials
- Kubernetes Official Documentation
- Kubernetes GitHub Project
- The History of Kubernetes and the Community Behind It
- K9s

Any questions?

Thank you!