From Monolith to Micro-services with Kubernetes

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Slides & source code at https://mjbright.github.io/Talks

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Outline

- [Why?] Monoliths to Micro-services
- Orchestration: Kubernetes
- Deployment Strategies
- Architecture Design patterns
- Summary

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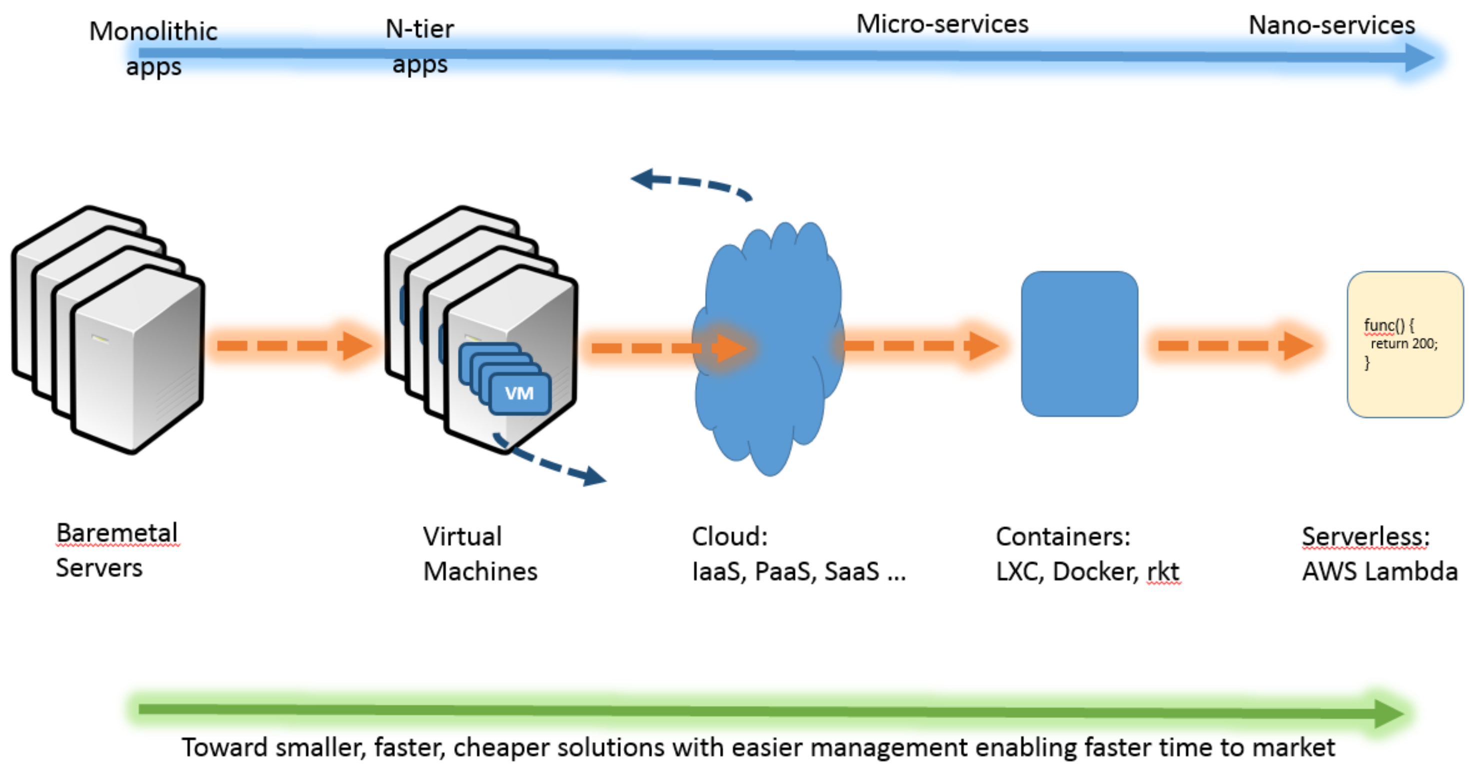

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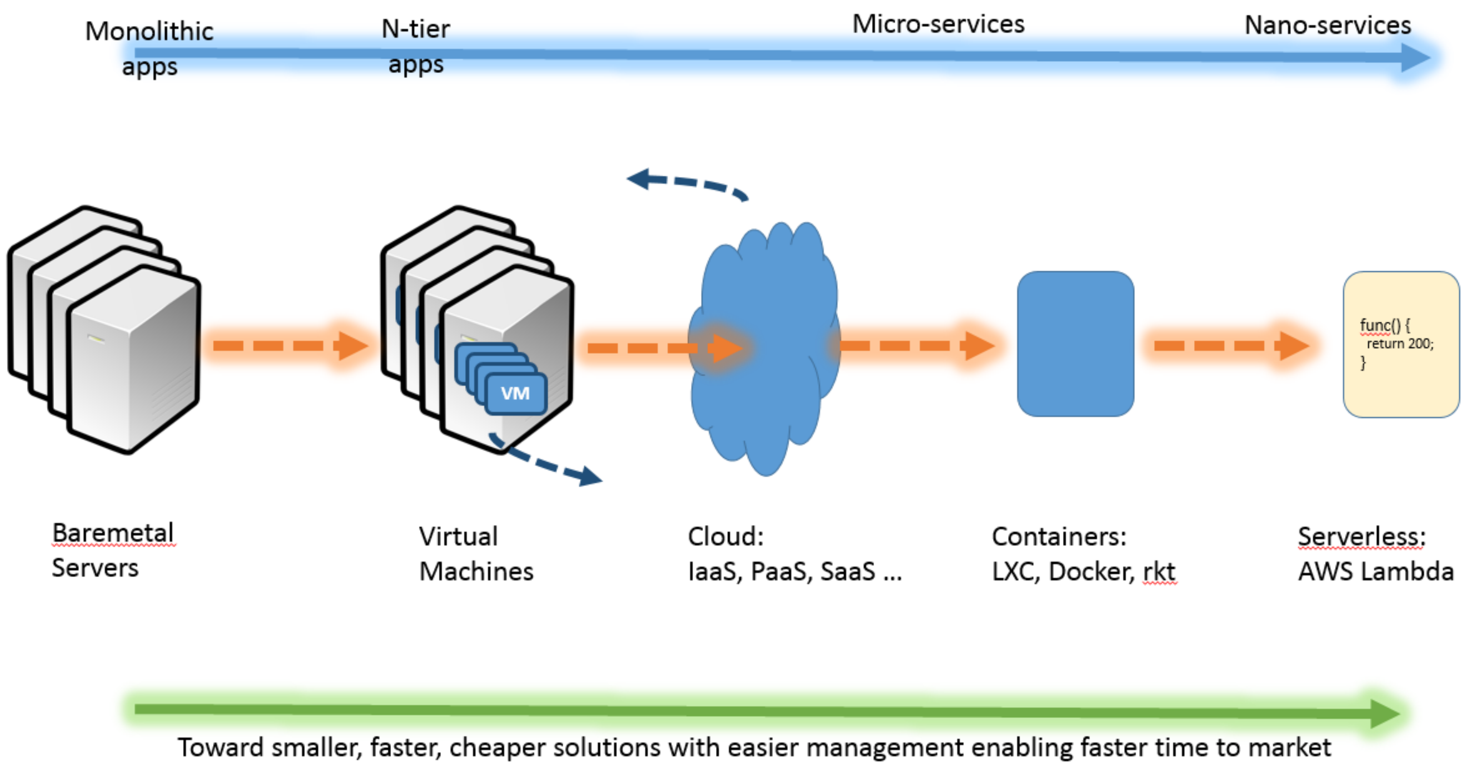
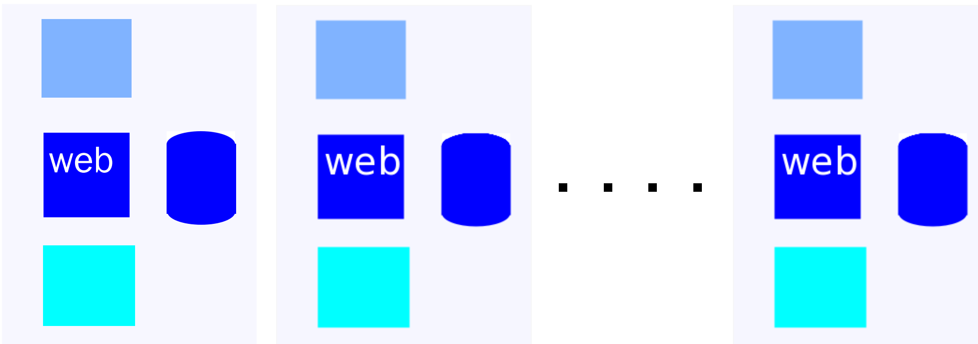


Note: The future will be hybrid ... (technologies, providers, on-prem/cloud ...)

[Why?] Monoliths to Micro-services

Traditionally software has been delivered as large packages which can only be ***deployed, scaled, upgraded, reimplemented*** as a whole.



Problem: A paradigm ill-adapted to enterprise or *web-scale*

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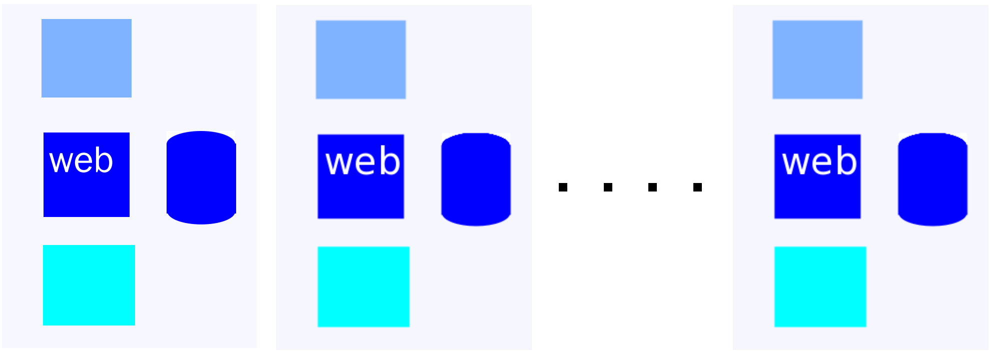


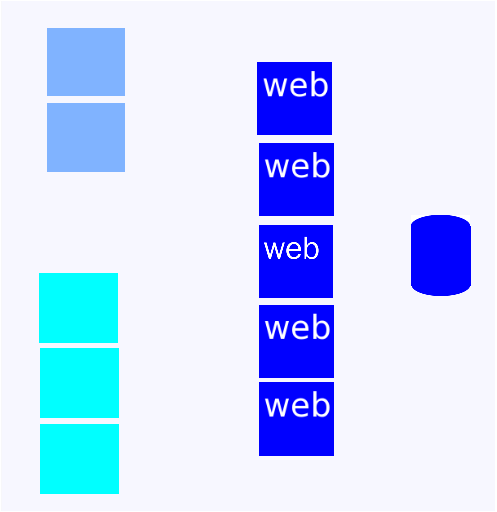
Problem: A paradigm ill-adapted to enterprise or *web-scale*

- Tightly-coupled components exist as a unit, are difficult to reuse
- Waterfall release cycles make software difficult to patch
- Difficult to innovate due to slow release cycles

Monoliths to Micro-services

Micro-services use small loosely-coupled software components

Individual components can be ***deployed, scaled, upgraded, replaced*** …



Micro-service architecture components are lightly-coupled

- interconnected by network
- can be scaled independently
- can be deployed/upgraded independently

Advantages of Micro-services

Separation of Concerns: "do one thing well"

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So are they a panacea?

Disadvantages

Greater complexity

- Require orchestration, and rigorous component version management
- Need to *evolve* to greater organizational complexity
- Monitoring, debugging, end-2-end test are more difficult

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Useless without adopting best practices

- Behaviour and Test-Driven Development, CI/CD
- Require rigorous documentation of interfaces/APIs
- Stable APIs and backward-compatibility support

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Problem: As our systems scale it becomes impossible to manage 1000's of diverse containers running across a data center of 100's of nodes.

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  - to ensure availability
  - to satisfy affinity, non-affinity constraints
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- which containers are malfunctioning?
- which are started and ready to go?
- how to easily upgrade applications?
- how to auto-scale applications?

We need Orchestration

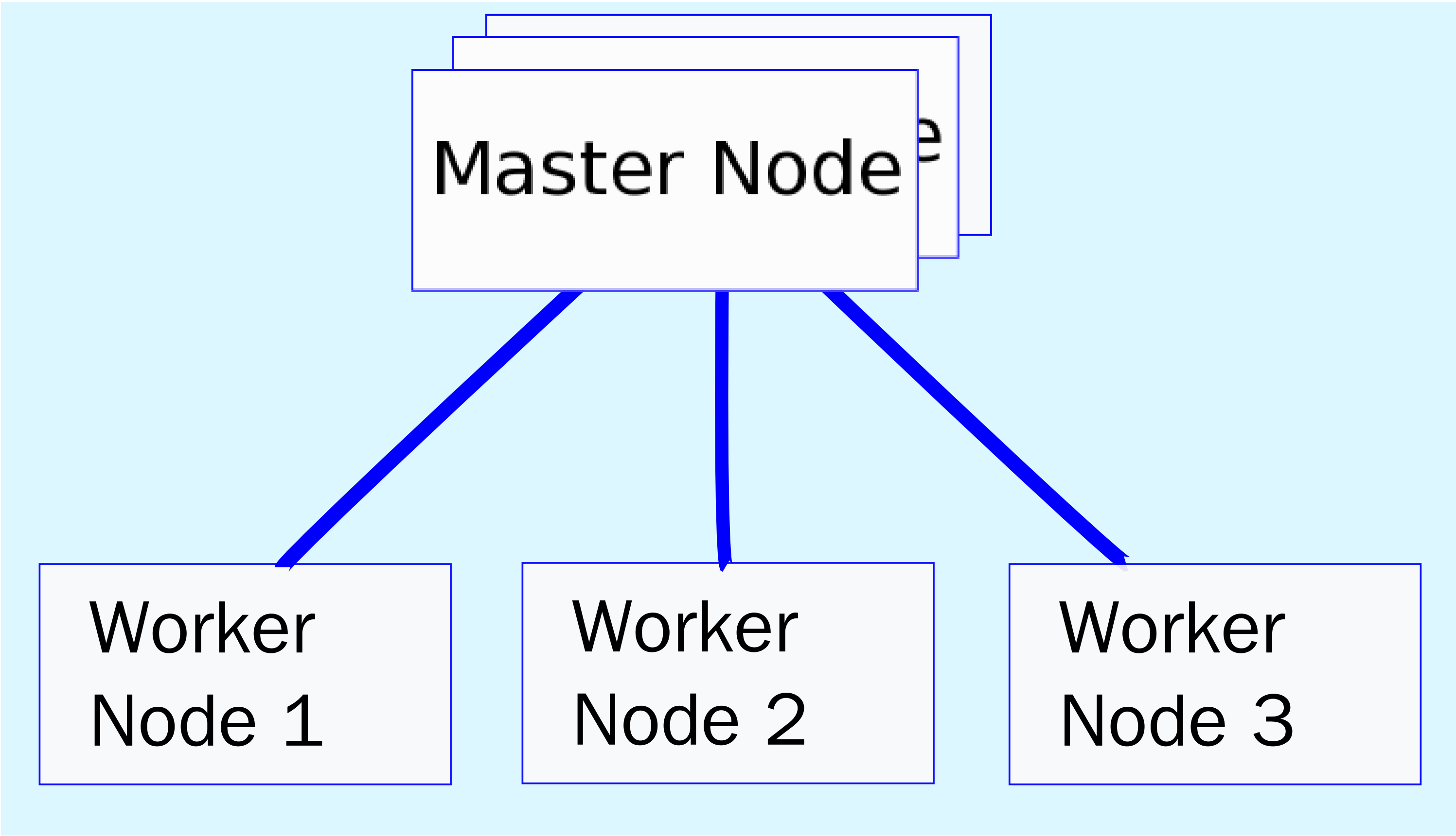
Orchestration Feature Wish-list

- **Health checks** - to Verify when a task is ready to accept traffic
- **Dynamic port-mapping** - Ports are assigned dynamically when a new container is spun up
- **Zero-downtime deployments** - Deployments do not disrupt end users
- **Service discovery** - Automatic detection of new containers and services
- **Auto scaling** - Automatically scale resources up or down based on the load

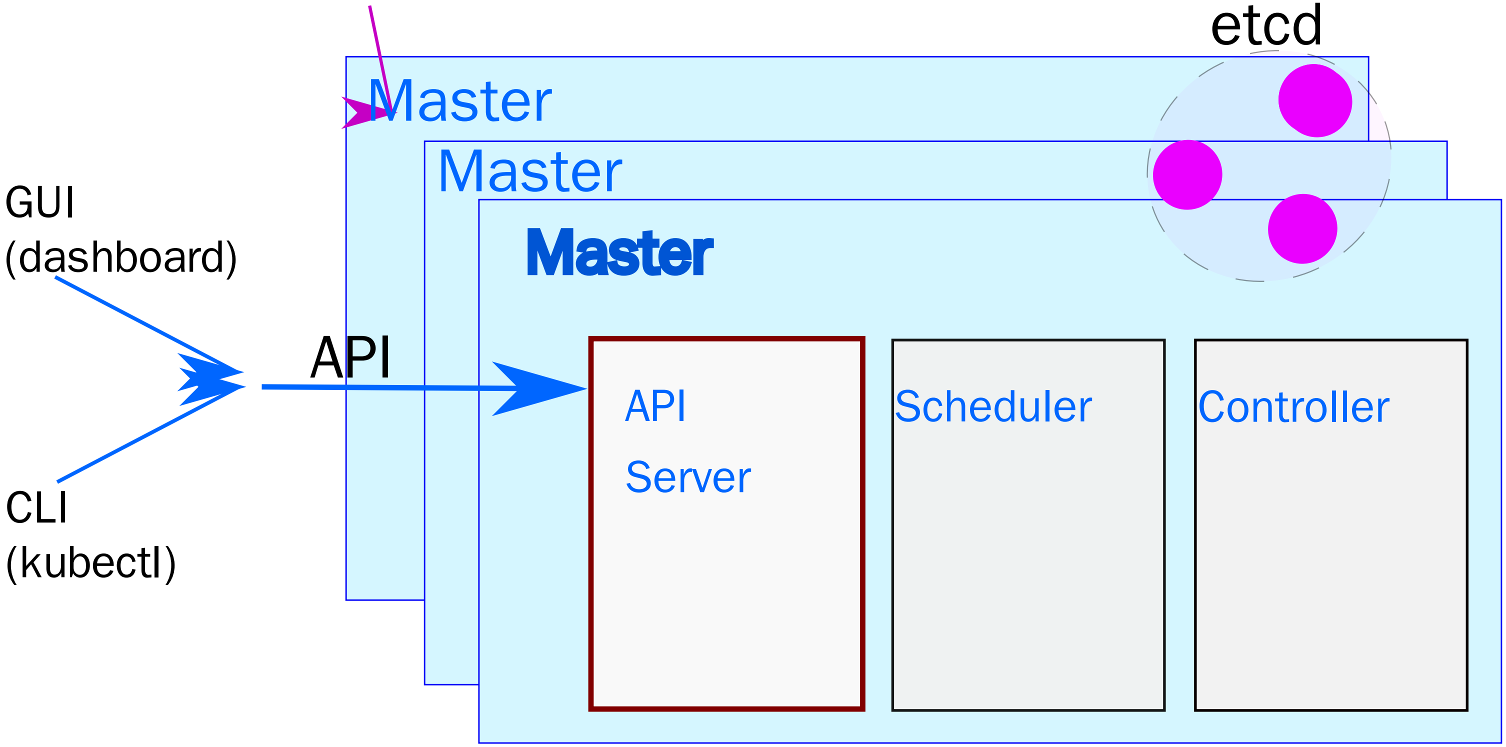
- **Provisioning** - New containers should select hosts based on resources and configuration

- **Other** - Load balancing, logging, monitoring, authentication and authorization, security… predictability, scalability, and high availability…

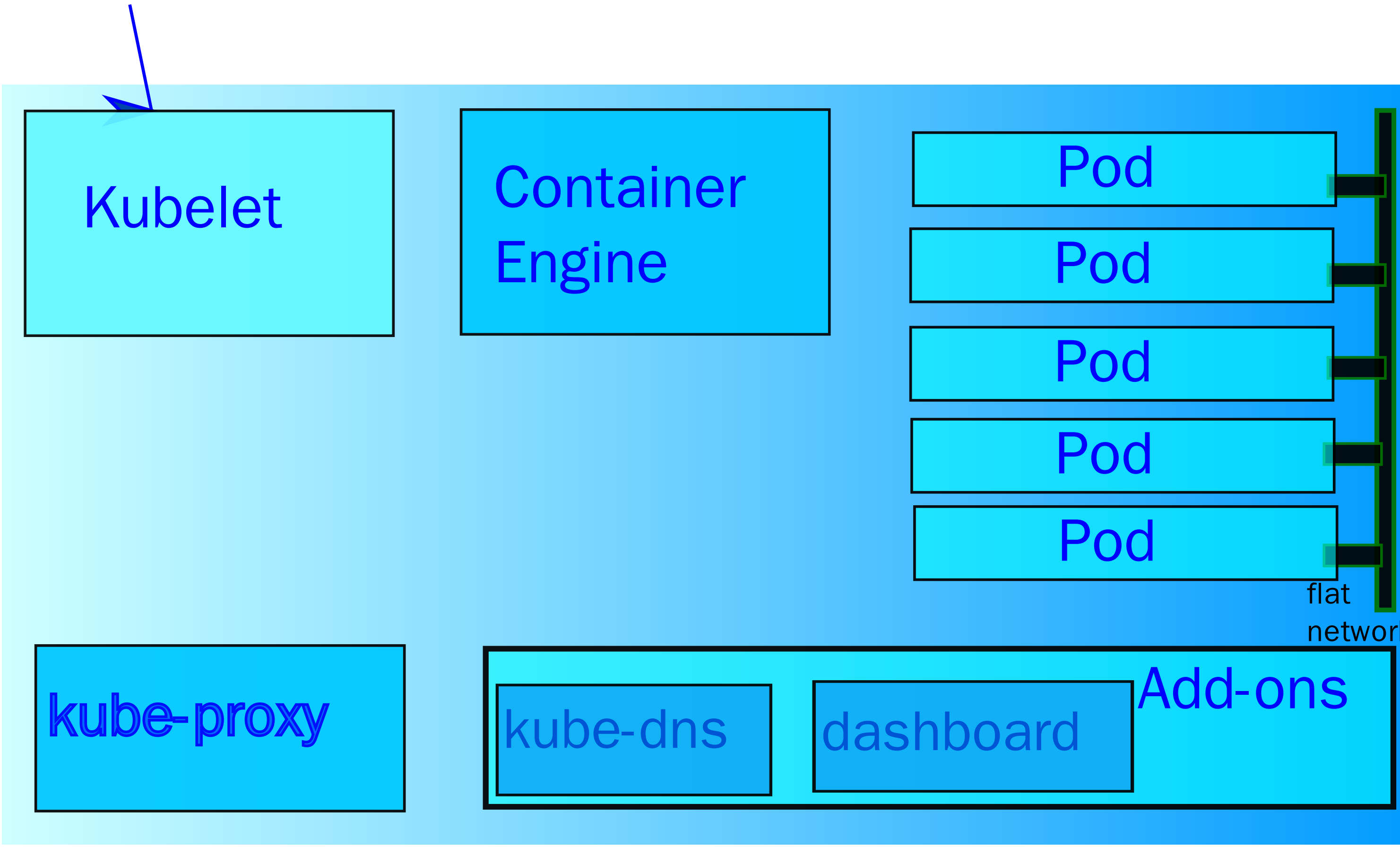
Kubernetes - Architecture



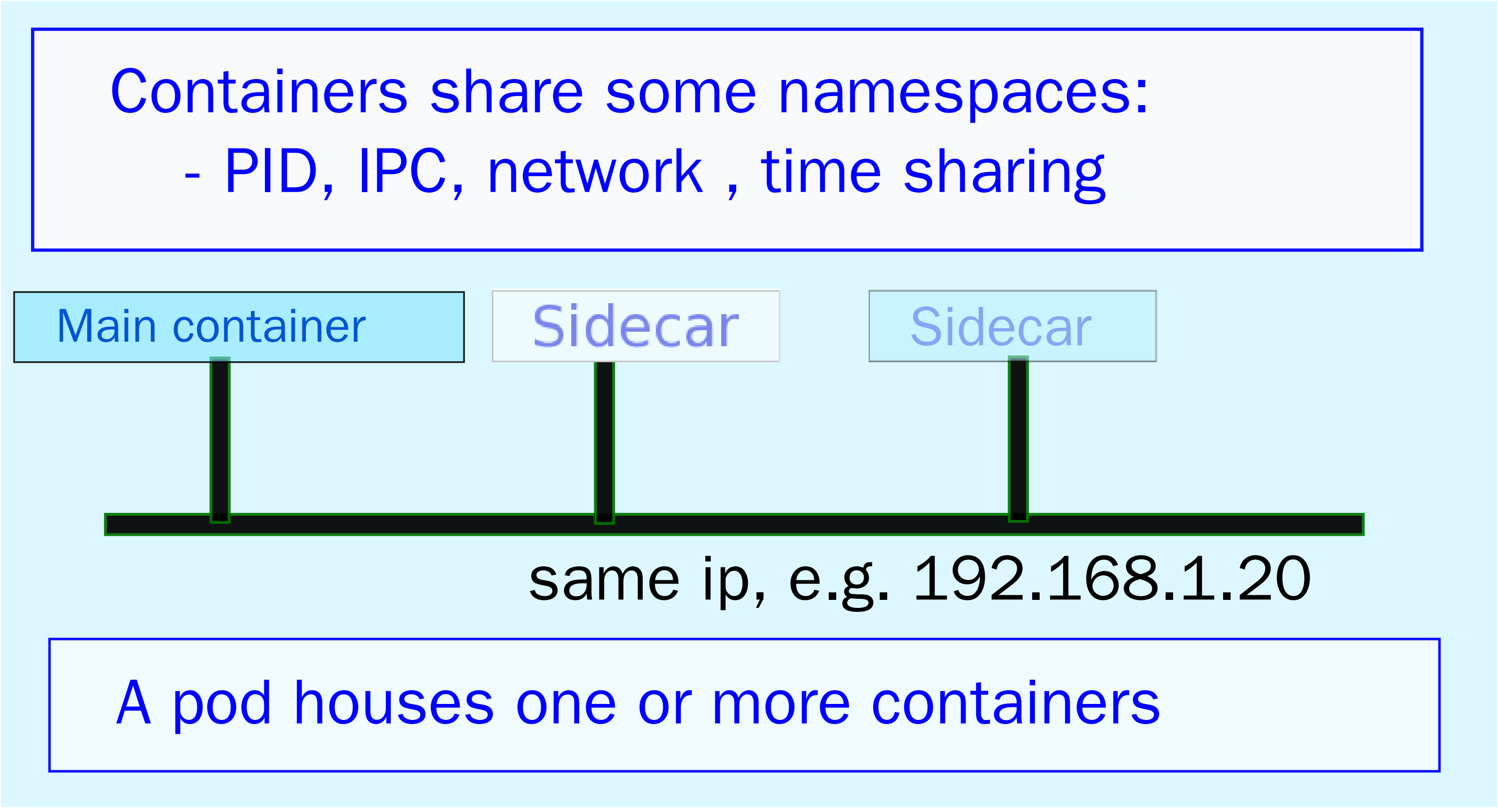
Kubernetes - Master Nodes



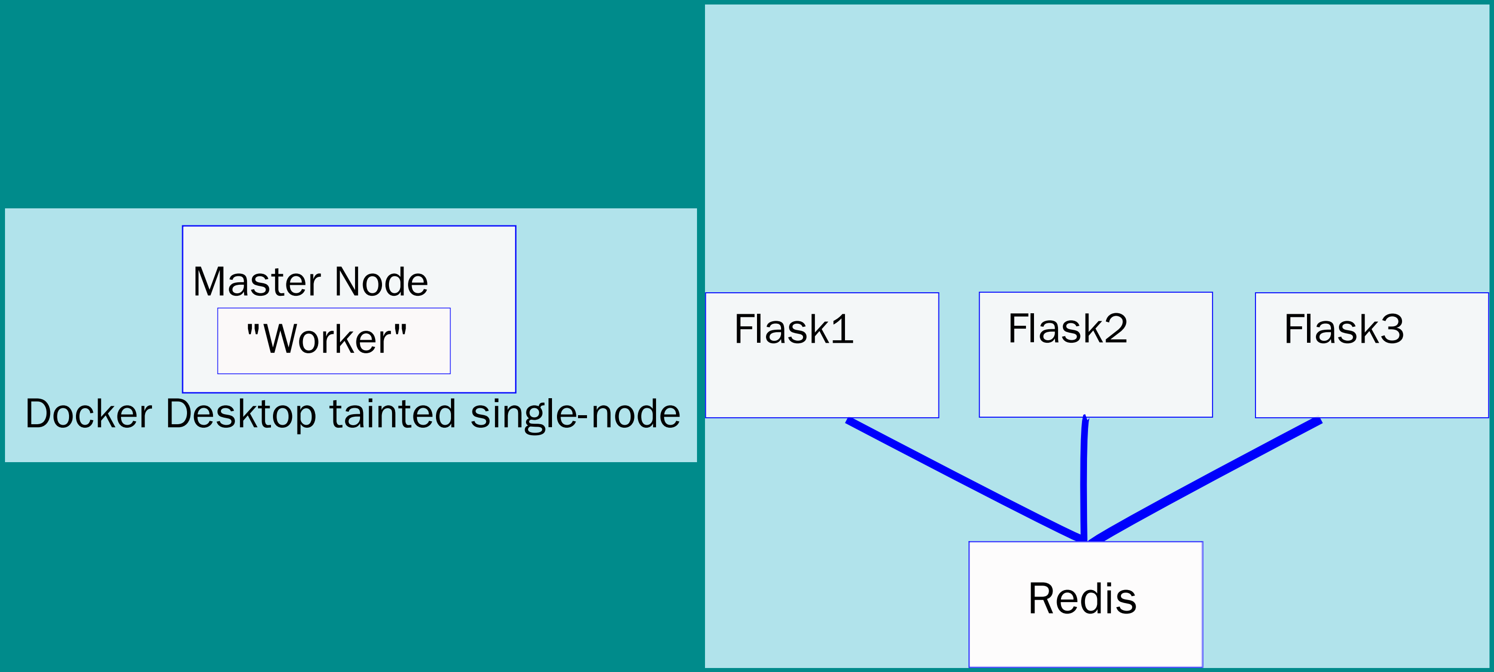
Kubernetes - Worker Nodes



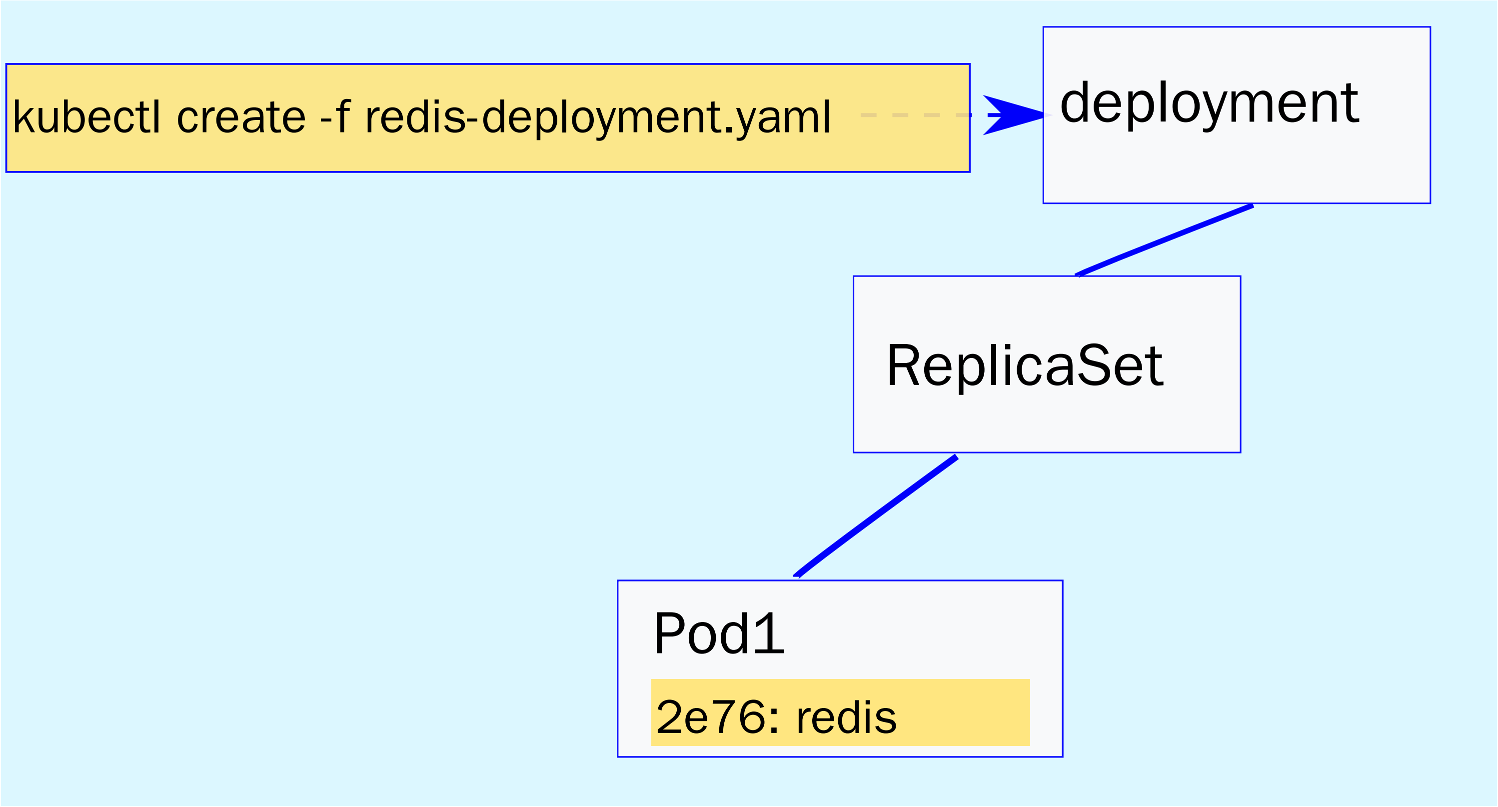
Kubernetes - Pods



Kubernetes Demo



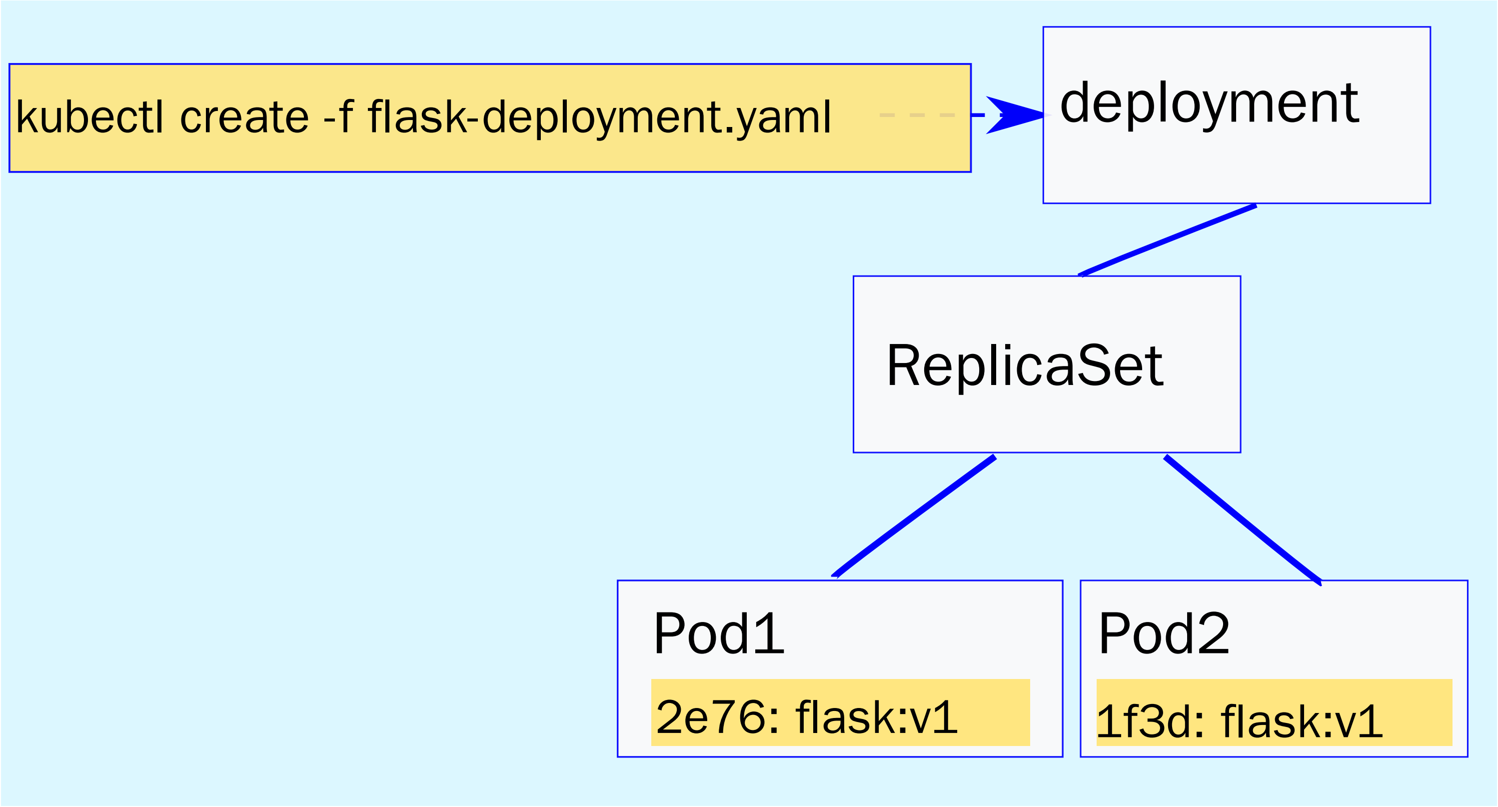
Kubernetes - Deploying Redis



Kubernetes - Deploying Redis

Kubernetes - Deploying Redis (yaml)

Kubernetes - Deploying Flask



Kubernetes - Deploying Flask

```
# kubectl run flask-app --image=$IMAGE --port=5000

$ kubectl apply -f flask-deployment.yaml
deployment.extensions "flask-app" created

$ kubectl get pods
NAME                         READY     STATUS              RESTARTS   AGE
flask-app-8577b44db-96cht    0/1       Pending             0          1s
redis-68595c4d95-rr4pr       0/1       ContainerCreating   0          1s
```

Kubernetes - Deploying Flask (yaml)

```yaml
apiVersion: extensions/v1beta1
kind: Deployment
metadata:
  labels:
    run: flask-app
  name: flask-app
spec:
  replicas: 1
  selector:
    matchLabels:
      run: flask-app
  template:
    metadata:
      labels:
        run: flask-app
    spec:
      containers:
      - image: mjbright/flask-web:v1
        name: flask-app
        ports:
        - containerPort: 5000
```

Operations - Scaling

```
# kubectl scale deploy flask-app --replicas=4

$ kubectl edit -f flask-deploy.yaml
```

```
...
spec:
  replicas: 4
```

Kubernetes - Scaling Flask (yaml)

```yaml
apiVersion: extensions/v1beta1
kind: Deployment
metadata:
  labels:
    run: flask-app
  name: flask-app
spec:
  replicas: 4
  selector:
    matchLabels:
      run: flask-app
  template:
    metadata:
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        name: flask-app
        ports:
        - containerPort: 5000
```

Kubernetes - Scaling Flask

```
$ kubectl apply -f flask-deployment-r4-v1.yaml
deployment.extensions "flask-app" created

$ kubectl get pods
NAME                          READY     STATUS              RESTARTS   AGE
flask-app-8577b44db-96cht     1/4       Pending             0          1h
redis-68595c4d95-rr4pr        1/1       Running             0          1h
```

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Deployment Strategies

Problem: How can we simply/automatically upgrade micro-services ?

- across a data center
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Solution: Several deployment strategies exist

- Some strategies can be implemented by Kubernetes alone
- Some strategies must be handled by external routing

Micro-service Deployment Strategies

- Service Upgrade Strategies
- Health Checks
- Strangler Pattern - migration pattern

Operations - Service Upgrade Strategies

Several strategies exist

Ref: *Kubernetes deployment strategies, Container Solutions*, github

`recreate` - terminate old version before releasing new one

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`blue/green` - release new version alongside old version then switch

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`blue/green` - release new version alongside old version then switch

`canary` - release new version to subset of users, proceed to full rollout

`a/b testing` - release new version to subset of users in a precise way (HTTP headers, cookie, weight, etc.).

Operations - Service Upgrade Strategies

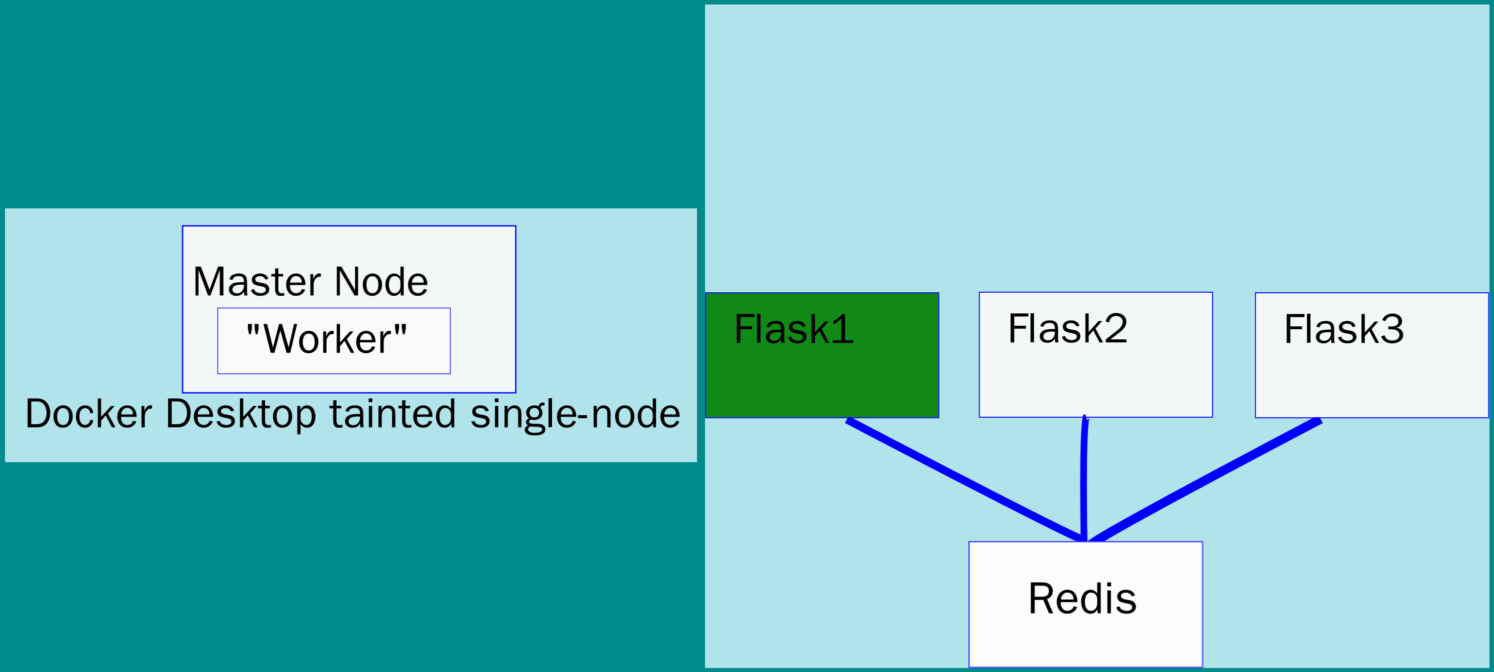
Ramped

```
# kubectl set image deploy flask-app flask-app=mjbright/flask-web:v2

$ kubectl edit -f flask-deploy.yaml
$ kubectl rollout status deployment/flask-app
```

```
...
    spec:
      containers:
      - image: mjbright/flask-web:v2
```

Demo


Master Node
"Worker"
Docker Desktop tainted single-node
Flask1
Flask2
Flask3
Redis

Containers - Are you healthy, ready ?

Problem: But how can the system determine if a Service is healthy and available

We'd like the system to not route traffic to unhealthy service instances.

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Kubernetes Healthchecks (Liveness and Readiness probes) provide a solution.

Ref: Kubernetes Liveness, Readiness Probes Documentation

- Liveness probe can be used to force re-creation of blocked image
- Readiness probe can be used to await startup

Operations - Healthchecks

Liveness probes

- This probe is used to establish if the container is healthy

  (or blocked, unable to progress).

- The probe can specify

  - A command to execute
  - An http request to try
  - A TCP request to try

Operations - Healthchecks

Liveness probes

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  (or blocked, unable to progress).

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Readiness probes

- Once started the container still needs time before being able to accept traffic

- This probe tests the readiness to receive and process requests

- Probe types are as for Liveness probes

Operations - Liveness probes

```
apiVersion: v1
kind: Pod
metadata:
  labels:
    test: liveness
  name: liveness-exec
spec:
  containers:
  - name: liveness
    image: k8s.gcr.io/busybox
    args:
    - /bin/sh
    - -c
    - touch /tmp/healthy; sleep 30; rm -rf /tmp/healthy; sleep 600
    livenessProbe:
      exec:
        command:
        - cat
        - /tmp/healthy
      initialDelaySeconds: 5
      periodSeconds: 5
```

Operations - Readiness probes

It is sufficient to replace 'livenessProbe:' by 'readinessProbe:' in the yaml

```
readinessProbe:
  exec:
    command:
    - cat
    - /tmp/healthy
  initialDelaySeconds: 5
  periodSeconds: 5
```

How to Migrate to Micro-services ?

Problem: We may not have the luxury of a *Greenfield* deployment !!

So how can we migrate an existing Monolith to Micro-services ?

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Do we wait 6 months before having a new implementation

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So how can we migrate an existing Monolith to Micro-services ?

It's a monolith after all !

Do we wait 6 months before having a new implementation

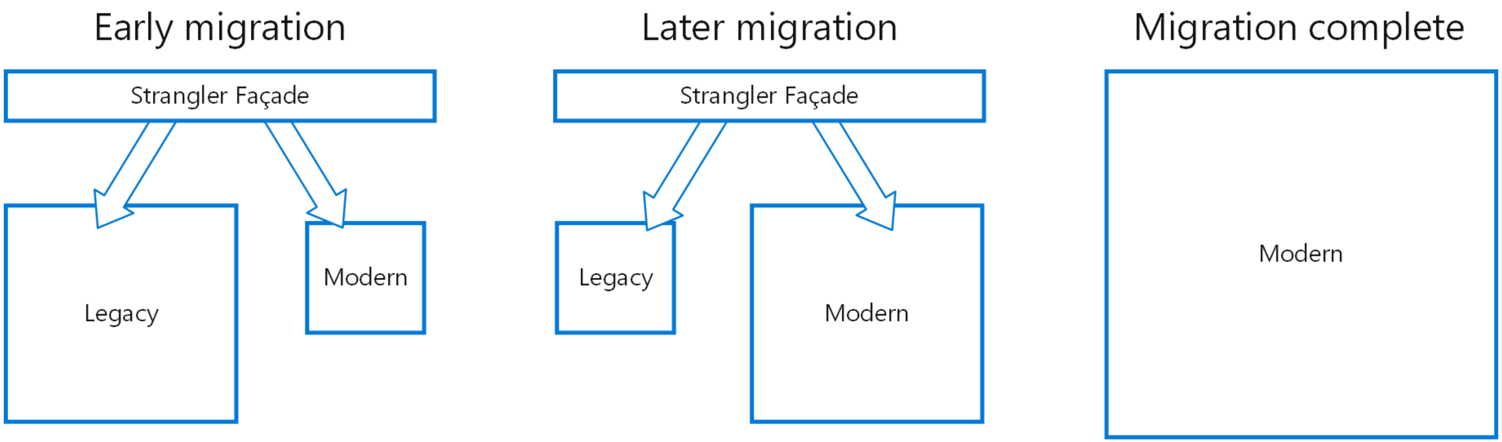
`(*with no extra features!*) ?`

The **Strangler** Pattern provides a possible solution.

Migration - Strangler Pattern

The Strangler is a pattern used in the initial migration from a Monolithic architecture to a Micro-services architecture

Ref: Azure Docs - "*Strangler pattern*"



Micro-service - Architecture Design Patterns

Here, we are not concerned with:

- Standard Component *Design Patterns*
- Micro-services themselves (!) - Fine-grained SOA
- Sidecar

Micro-service - Architecture Design Patterns

We are concerned with:

Exposing Services

Ingress

providing access to the Kubernetes cluster …

Micro-service - Architecture Design Patterns

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providing access to the Kubernetes cluster …

and ways of providing offload-functionality

API Gateway

Service Mesh

Hybrid Apps - "API Gateway Pattern"

Micro-service - Architecture Design Patterns

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Exposing Services

Ingress

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API Gateway

Service Mesh

Hybrid Apps - "API Gateway Pattern"

Note: This is the new war-zone as API Gateways battle it out, Service Meshes battle it out and both battle it out!

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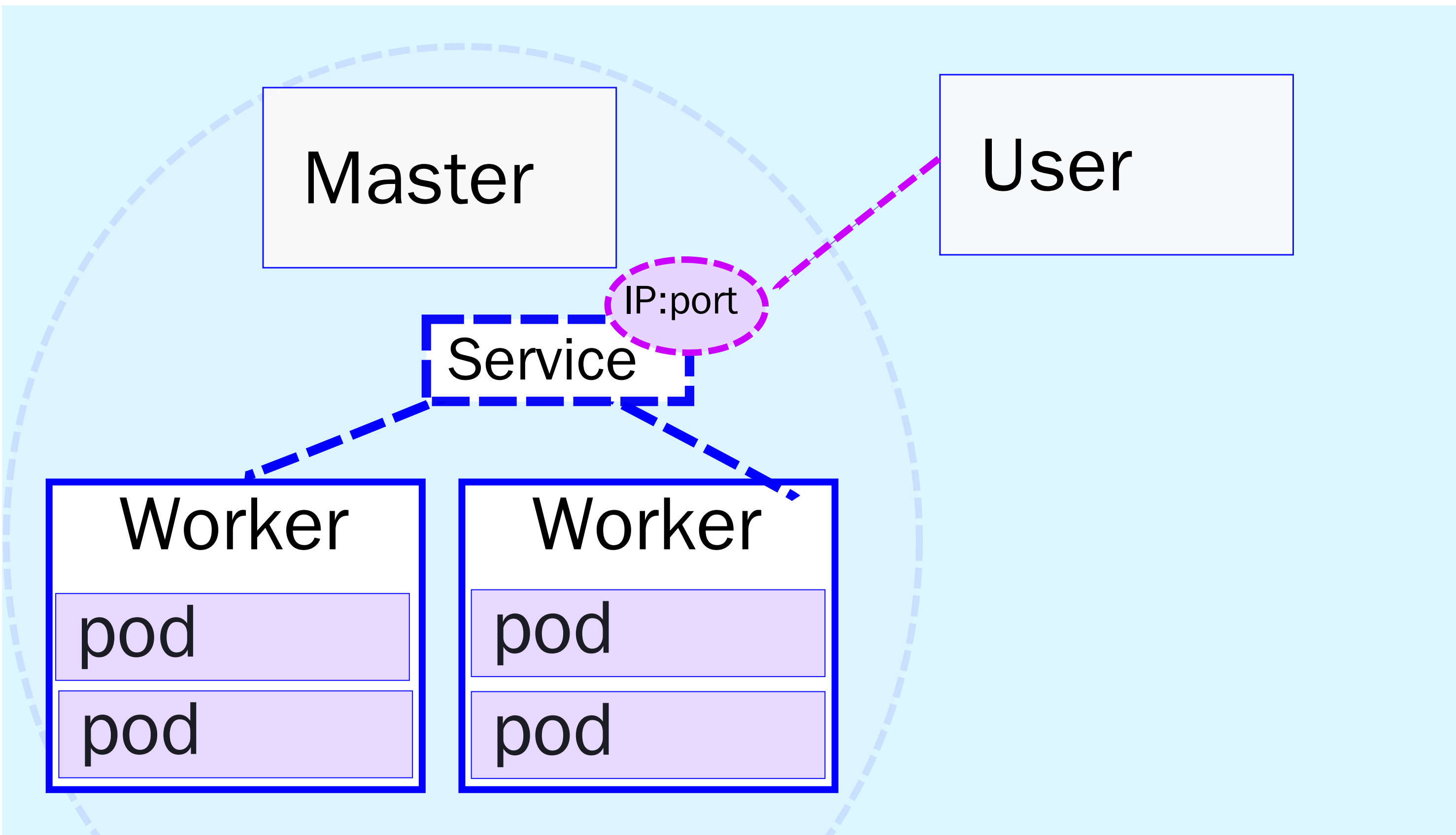
So we provide *well-known endpoints* to reliably/safely **expose services**

Kubernetes - Exposing Services

The general pattern is to provide a *cluster-wide, well-known endpoint* which remains available as Pods come and go

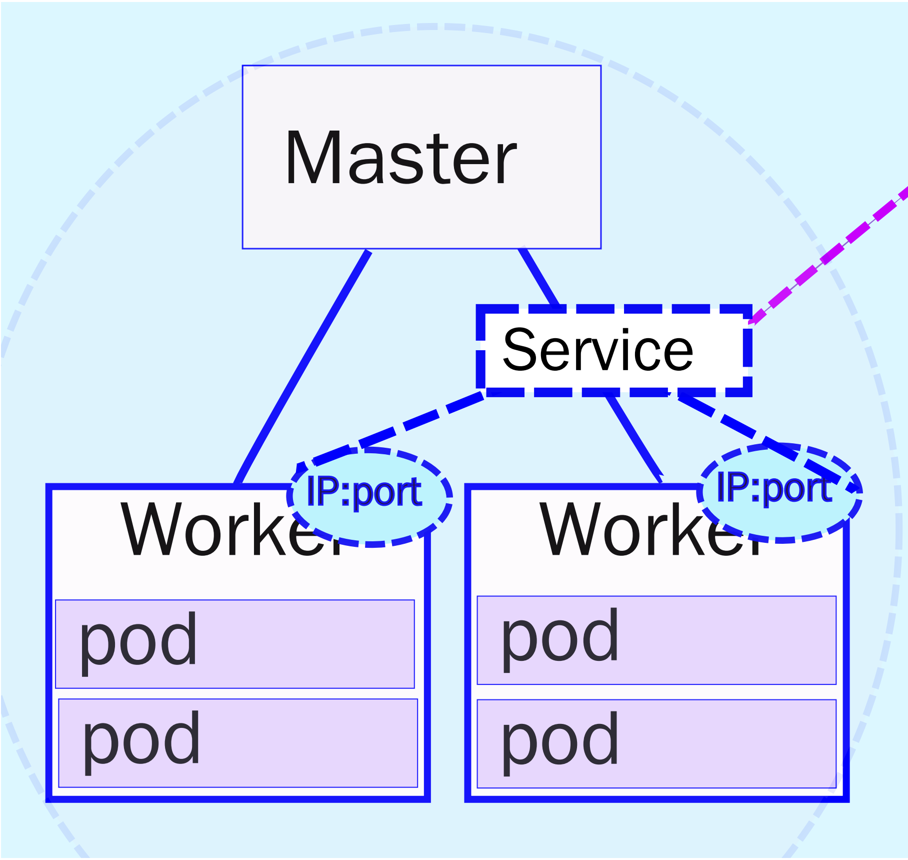


Design Pattern - Services

Services can be exposed via

- NodePort
- HostPort
- ClusterIP
- LoadBalancer

Exposing Services (NodePort)

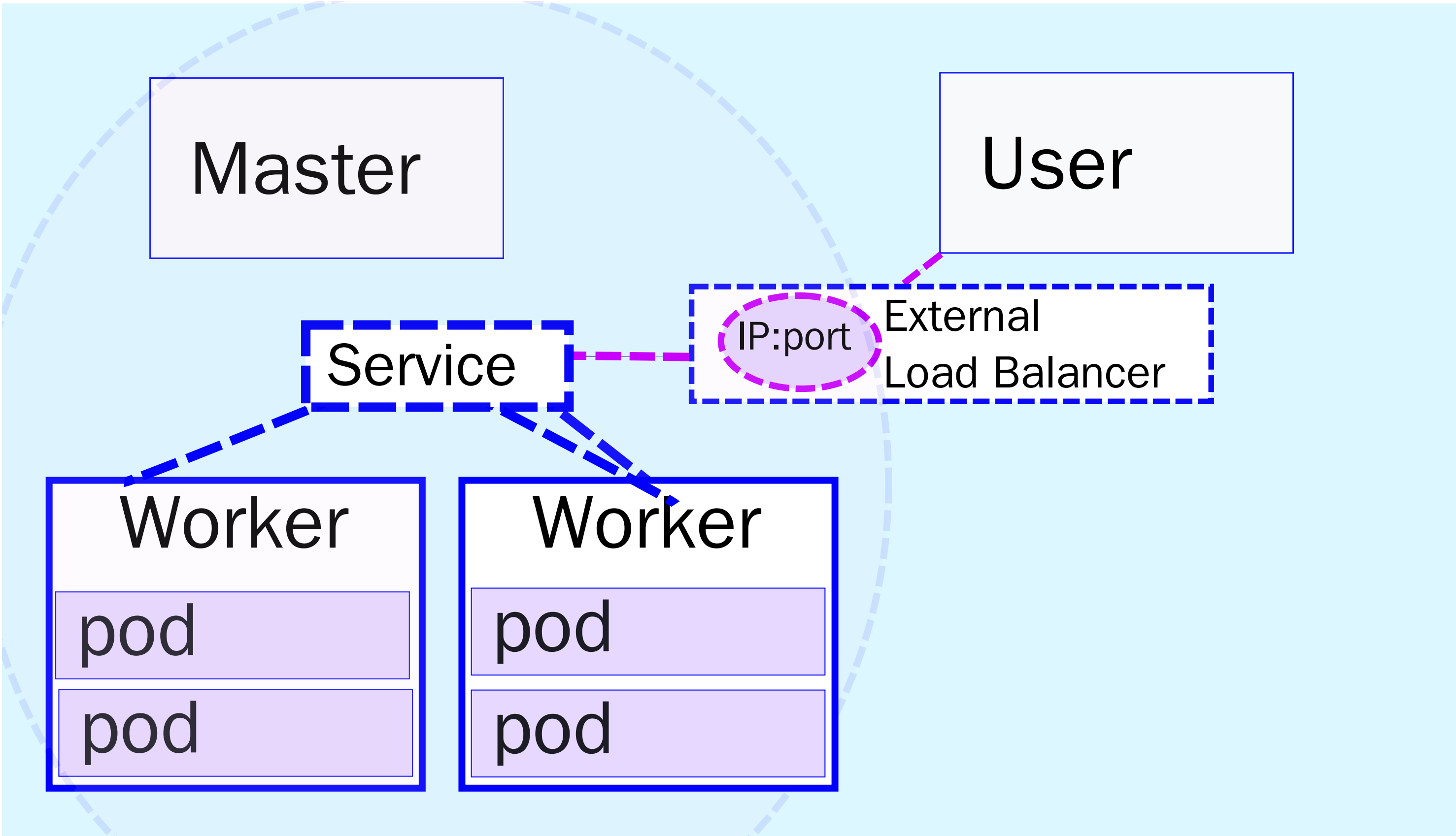


User connects

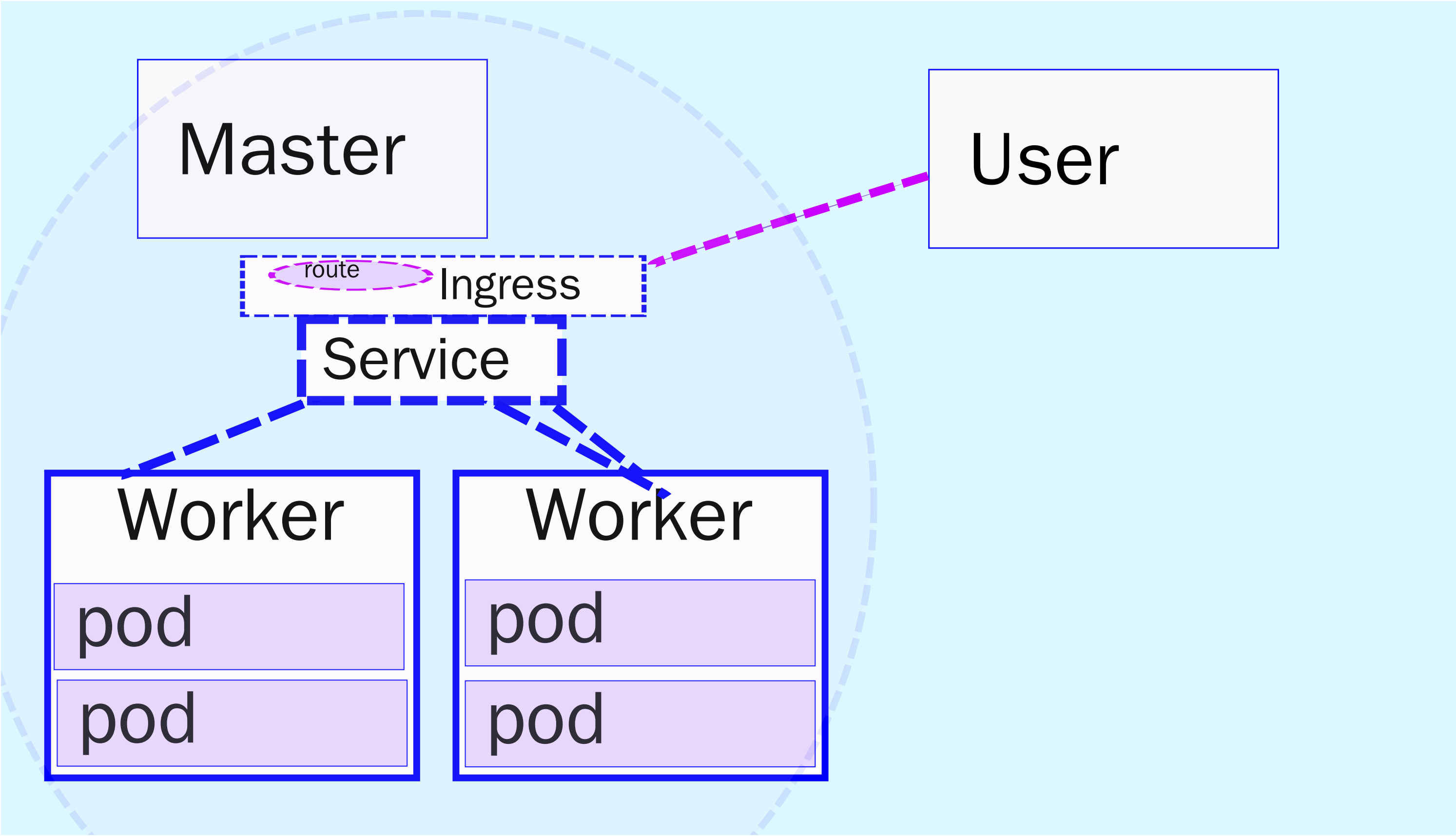
to IP/port of one

of the Nodes

Exposing Services (LoadBalancer)



Exposing Services (IngressController)



Exposing Redis Service (LoadBalancer)

```
# kubectl expose deployment redis --type=LoadBalancer

$ kubectl apply -f redis-service.yaml
service "redis" created

$ kubectl get svc
NAME         TYPE           CLUSTER-IP       EXTERNAL-IP   PORT(S)          AGE
kubernetes   ClusterIP      10.96.0.1        <none>        443/TCP          5h
redis        LoadBalancer   10.101.158.201   <pending>     6379:31218/TCP   1s
```

Exposing Redis Service (LoadBalancer)

```yaml
apiVersion: v1
kind: Service
metadata:
  labels:
    run: redis
  name: redis
spec:
  ports:
  - port: 6379
    protocol: TCP
    targetPort: 6379
  selector:
    run: redis
  type: LoadBalancer
```

Exposing Flask Service (LoadBalancer)

```
# kubectl expose deployment flask-app --type=LoadBalancer

$ kubectl apply -f flask-service.yaml
service "flask-app" created

$ kubectl get svc
NAME         TYPE           CLUSTER-IP       EXTERNAL-IP   PORT(S)          AGE
flask-app    LoadBalancer   10.103.154.19    <pending>     5000:32201/TCP   1s
kubernetes   ClusterIP      10.96.0.1        <none>        443/TCP          5h
redis        LoadBalancer   10.101.158.201   <pending>     6379:31218/TCP   2s
```

Exposing Flask Service (LoadBalancer)

```
apiVersion: v1
kind: Service
metadata:
  labels:
    run: flask-app
  name: flask-app
spec:
  ports:
  - port: 5000
    protocol: TCP
    targetPort: 5000
  selector:
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Design Pattern - Ingress

Ingress is the general term for controlling *incoming* traffic

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In the context of Kubernetes it refers to the ability (limited feature set) to control incoming traffic. See Kubernetes Docs - Ingress

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In the context of Kubernetes it refers to the ability (limited feature set) to control incoming traffic. See Kubernetes Docs - Ingress

A set of **Ingress Rules** is specified to be implemented by a **Kubernetes Controller** which typically implements Load Balancer, Gateway features.

There are many projects providing such controller functionality such as *Nginx*, *HAproxy*, *Ambassador*, *Gloo*, *Traefik*

Exposing Services (Ingress)

```
$ minikube addons enable ingress
ingress was successfully enabled

$ kubectl apply -f misc/ingress-definition.yaml
ingress.extensions "ingress-definitions" created

$ sudo vi /etc/hosts
...
192.168.99.100  minikube.test flaskapp.test
```

Exposing Services (Ingress)

```yaml
apiVersion: extensions/v1beta1
kind: Ingress
metadata:
  name: ingress-definitions
  annotations:
    nginx.ingress.kubernetes.io/rewrite-target: /
spec:
  backend:
    serviceName: default-http-backend
    servicePort: 80
  rules:
  - host: minikube.test
    http:
      paths:
      - path: /
        backend:
          serviceName: k8sdemo
          servicePort: 8080
  - host: flaskapp.test
    http:
      paths:
      - path: /flask
        backend:
          serviceName: flask-app
          servicePort: 5000
```

Exposing Services (Ingress)

```
$ minikube service list
|-------------|----------------------|-----------------------------|
|  NAMESPACE  |         NAME         |             URL             |
|-------------|----------------------|-----------------------------|
| default     | flask-app            | http://192.168.99.100:32201 |
| default     | k8sdemo              | http://192.168.99.100:31280 |
| default     | redis                | http://192.168.99.100:31218 |
| kube-system | kubernetes-dashboard | http://192.168.99.100:30000 |
|-------------|----------------------|-----------------------------|

$ curl http://192.168.99.100:31280

$ curl http://minikube.test/k8sdemo
```

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|-------------|----------------------|-----------------------------|

$ curl http://192.168.99.100:32201
[flask-app-8577b44db-kbwpn] Redis counter value=214

$ curl http://flaskapp.test/flask
[flask-app-8577b44db-kbwpn] Redis counter value=215
```

Design Pattern - API Gateway

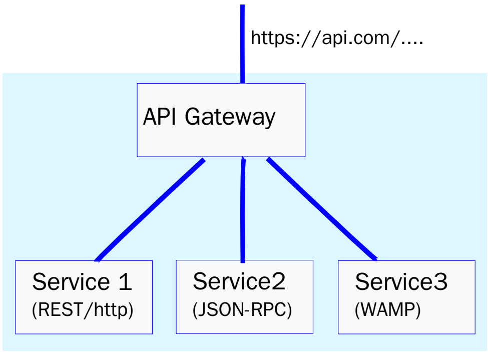
Ref: "*What is an API Gateway?*"

Classic API Gateways date back to Web Service (SOAP APIs) which offloaded Ingress functions into a single system.

API Gateways are API proxies between the client (API consumer) and server (API Provider).

- API Security
- API Control and governance
- API Monitoring
- API Administration
- API Transformation: See "*API Gateway Pattern*"

Design Pattern - API Gateway



External entrypoint exposes APIs

- Offloads common Ingress functions => reduces μ-service complexity
  - rate limiting, security, authorisation, DDOS protection
  - Protocol version translation, e.g. REST to SOAP, *-RPC ...
  - TLS decryption/encryption
- Hides internal infrastructure detail => controls access
  - service routing, load-balancing
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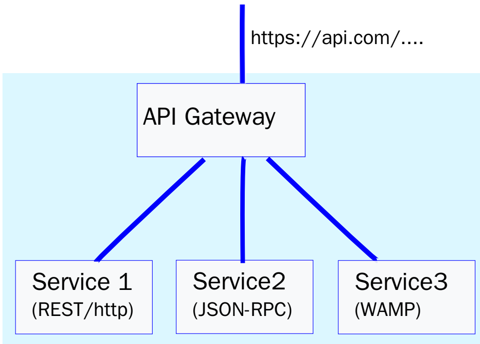

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Needs to scale, be H.A.

Design Pattern - API Gateway

There are many API Gateways including

- NGInx, HA-Proxy,
- Newer generation: Envoy-based such as Ambassador, Gloo

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- NGInx, HA-Proxy,
- Newer generation: Envoy-based such as Ambassador, Gloo

But can API Gateways resist the pressure coming from the next contender …

Design Pattern - Service Mesh

Problem: Micro-services are fine, but we see the need for common functions

- Logging and tracing
- Reliable network communication
- Encryption betweem components

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Service Mesh helps to address this issue by offloading such functionality

This keeps our micro-services small and simple.

Offload-functionality is provided through **Sidecar** containers - *not libraries*.

Design Pattern - Service Mesh

Abstraction above TCP/IP, secure reliable inter-service connectivity.

Platforms such as Linkerd (v2) and Istio (v1) provide offload for μ--services

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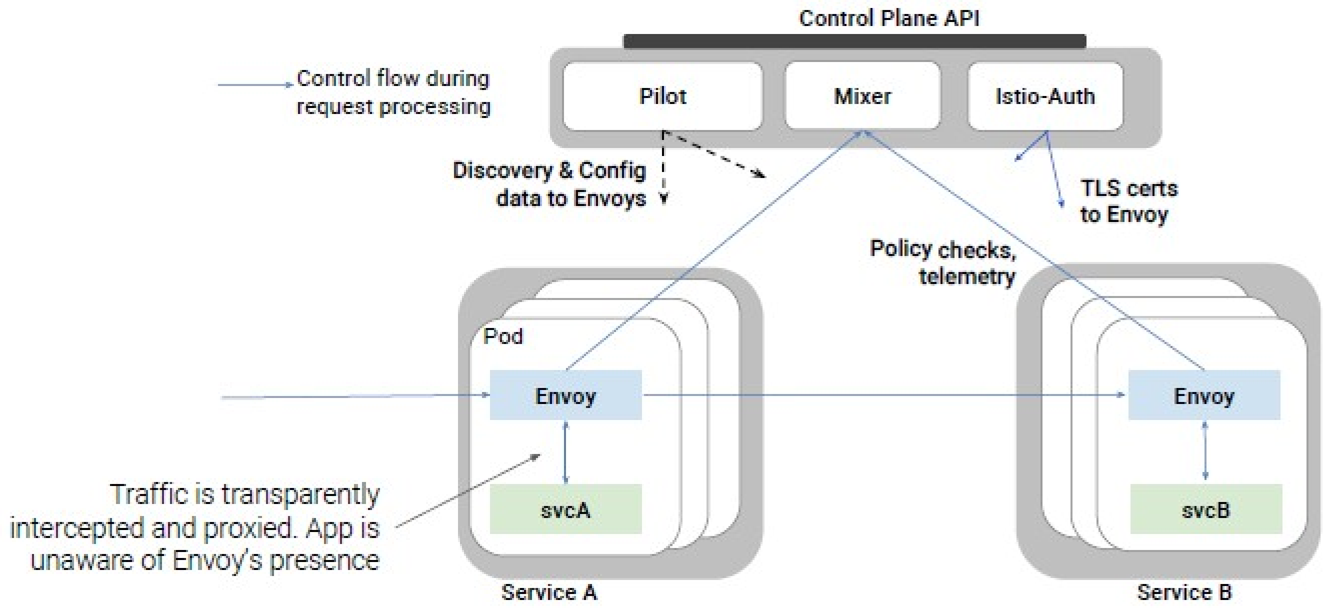

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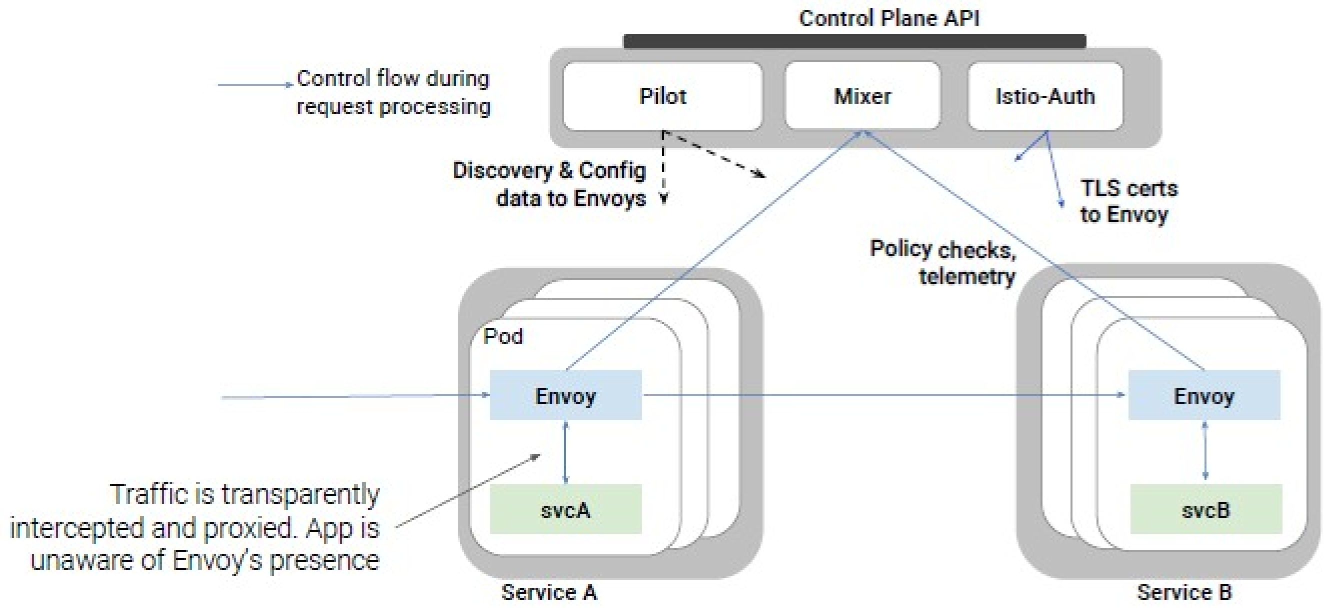

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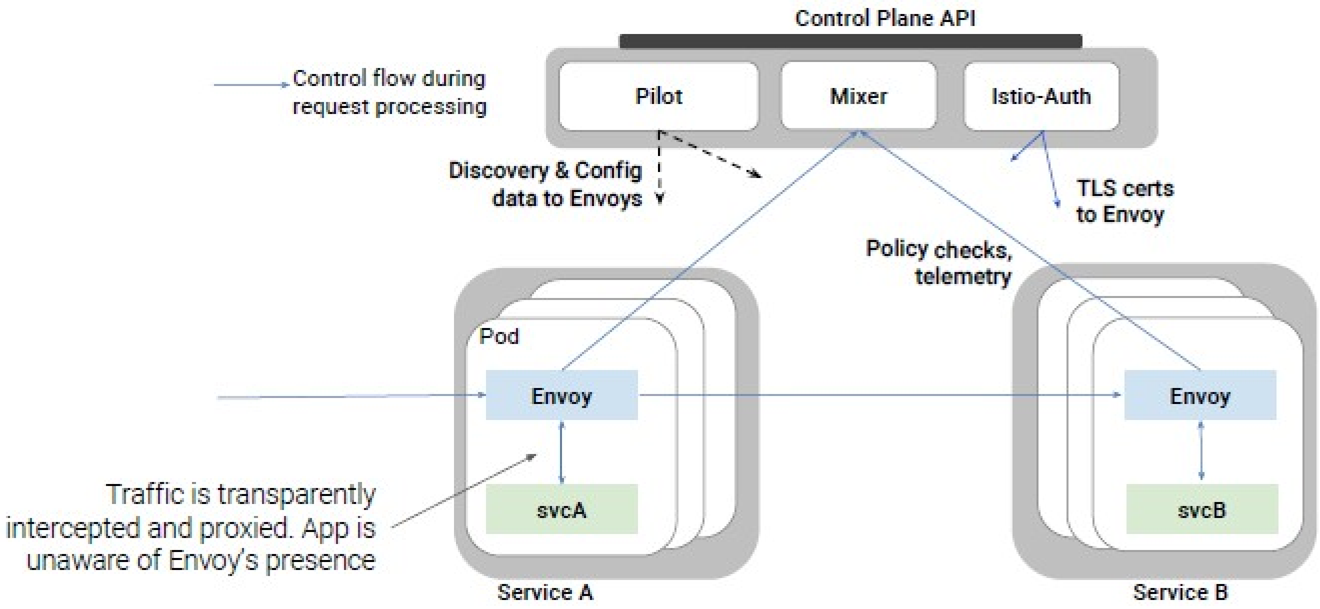
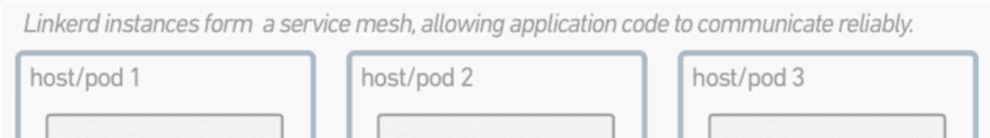




Hybrid Apps - *API Gateway Pattern*

Problem: But wouldn't it be better if we could mix legacy and new paradigms

The Strangler pattern is an option but requires being able to rebuild the original monolith to extract functionality.

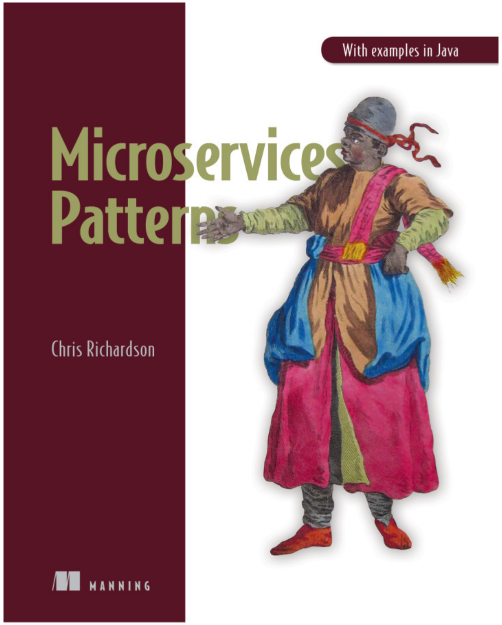
It would be useful to be able to add new functionality in a less invasive way.

Hybrid Apps - *API Gateway Pattern*

There is a "*API Gateway*" pattern whereby the gateway has the ability to understand the API protocols.

It may also understand the underlying Infrastructure and Platform APIs.

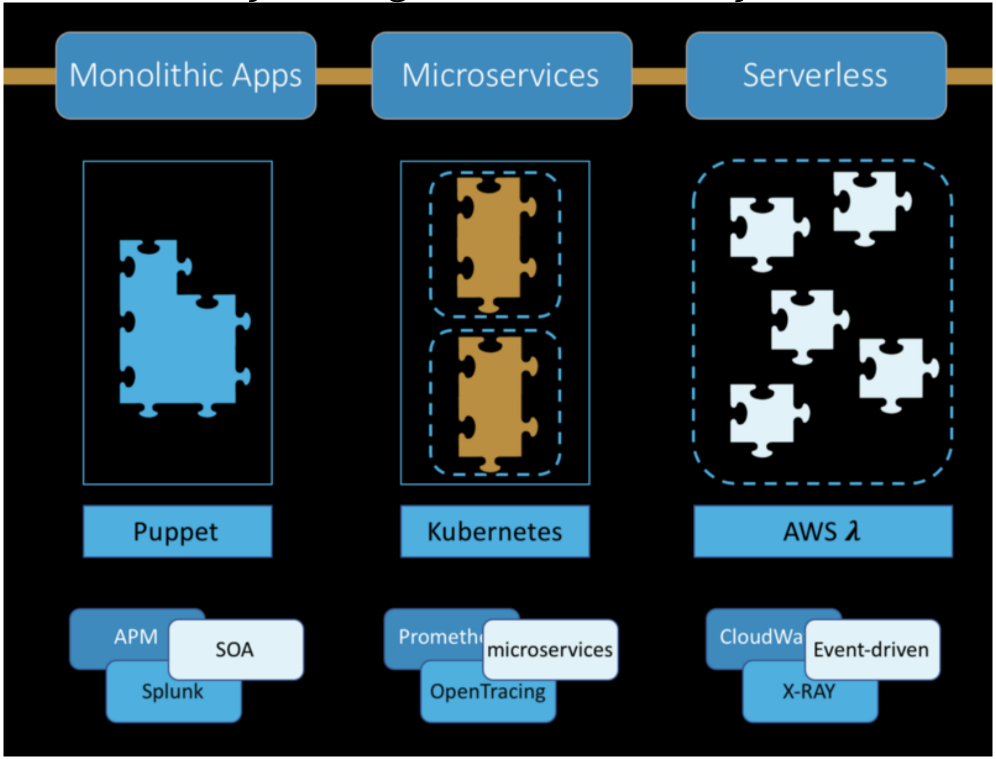
This allows to perform API translation and routing and really take advantage of the orchestration platforms.



"*Microservices Patterns* Book

Hybrid Apps - *API Gateway Pattern*

Gloo allows to route between legacy apps, micro-services and serverless incrementally adding new functionality.



https://medium.com/solo-io/building-hybrid-apps-with-gloo-1eb96579b070

Hybrid Apps - *API Gateway Pattern*

Gloo understands the infrastructure on which it is running and the APIs being used.

Gloo is one of several open source projects from Solo.io to facilitate the adoption of modern paradigms such as Micro-services

- Gloo: API Gateway
- Sqoop: Tool for modelling API interactions
- Squash: Micro-service debugging tool

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So API Gateways or Service Mesh ?

Service Mesh and API Gateways provide similar functionality

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- May be overkill for some use cases
- Istio now includes basic Gateway (N-S) functionality
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Going forward we can expect to see Service Mesh incorporating more and more Gateway functionality

Outline

- [Why?] Monoliths to Micro-services
- Orchestration: Kubernetes
- Deployment Strategies
- Architecture Design patterns
- Summary

Summary

Micro-services offer new deployment possibilities

- with ease of deployment, scaling, upgrading

- facilitate "Best in Class" technology choices/replacements

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Micro-services offer new deployment possibilities

- with ease of deployment, scaling, upgrading
- facilitate "Best in Class" technology choices/replacements

BUT moving to μ-services requires

- organizational changes and best practices !
- incremental rollout - small steps / Strangler
- hybrid approaches - old/new, cloud/on-premise, VM/container/μ-service
- offload via API Gateway and/or Service Mesh

Thank you !

From Monologue to Discussions ... ?

Questions ?

Michael Bright, @mjbright

Cloud Native Training (Docker, Kubernetes, Serverless)

linkedin.com/in/mjbright github.com/mjbright

Slides & source code at https://mjbright.github.io/Talks

Summary

Getting started with Kubernetes

- Start by learning Docker principles
- Experiment by Dockerizing some applications
- Learn about Container Orchestration
- Hands-on with Kubernetes online or Minikube(*)
- Kubernetes Visualization with KubeView
- https://github.com/mjbright/kubeview

Resources

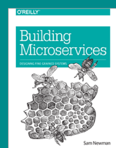
minikube

Download	https://github.com/kubernetes/minikube/releases
Documentation	https://kubernetes.io/docs/getting-started-guides/minikube/
Hello Minikube	https://kubernetes.io/docs/tutorials/stateless-application/hello-minikube/

Resources - Articles

Martin Fowler	https://martinfowler.com/articles/microservices.html
MuleSoft, "The top 6 Microservices Patterns"	https://www.mulesoft.com/lp/whitepaper/api/top-microservices-patterns
FullStack Python	https://www.fullstackpython.com/microservices.html
Idit Levine	https://medium.com/solo-io/building-hybrid-apps-with-gloo-1eb96579b070
SSola	https://medium.com/@ssola/building-microservices-with-python-part-i-5240a8dcc2fb
Deployment	http://container-solutions.com/kubernetes-deployment-strategies/

Resources - Books

Publisher		**Title, Author**
O'Reilly		"Building Microservices", Sam Newman, July 2015
PacktPub		"Python Microservices Development", Tarek Ziade, July 2017

kNative - O'Reilly

Istio - Manning

Istio - O'Reilly

Testdriven.io