WSO2Con 2015 USA San Francisco

Kubernetes: a platform for automating deployment, scaling, and operations

Brian Grant

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What is Kubernetes?

Old way: install applications on host

Application and OS share filesystem

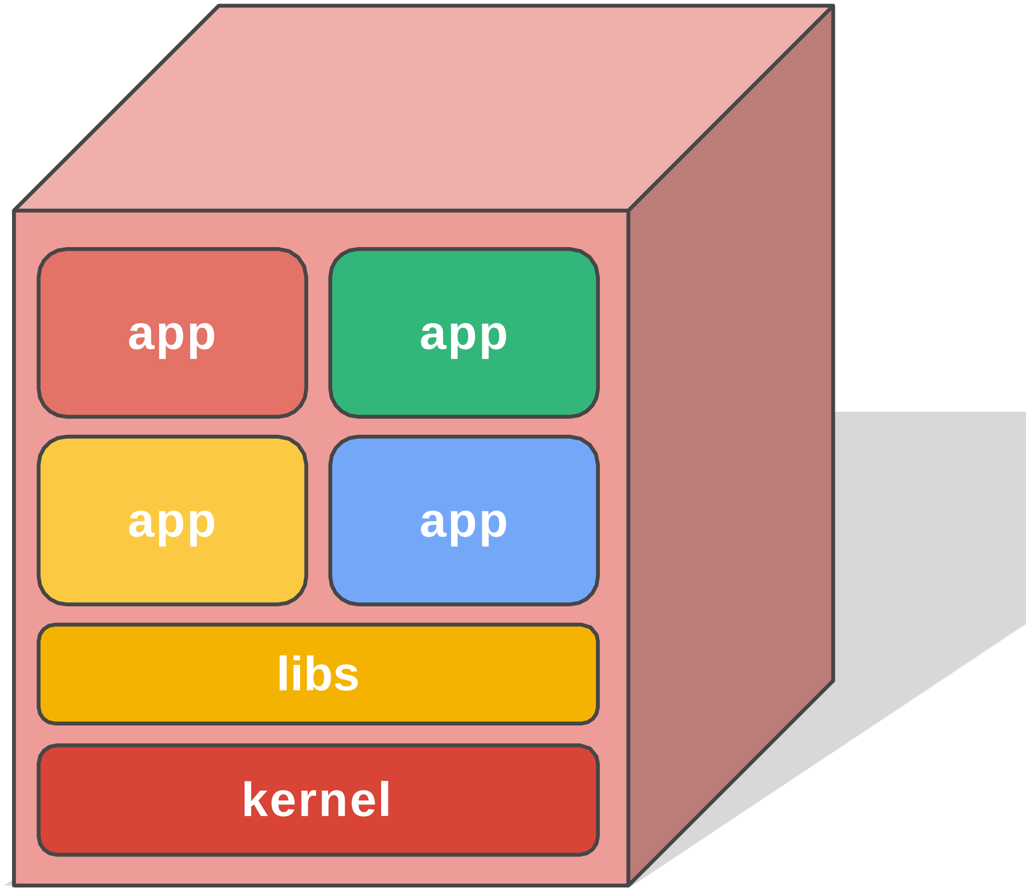
Use OS distribution package manager

Entangled with each other and with host

- Executables
- Configuration
- Shared libraries
- Process and lifecycle management

Immutable VM images provide predictable rollouts and rollbacks

- but are not portable and heavyweight



New way: deploy containers

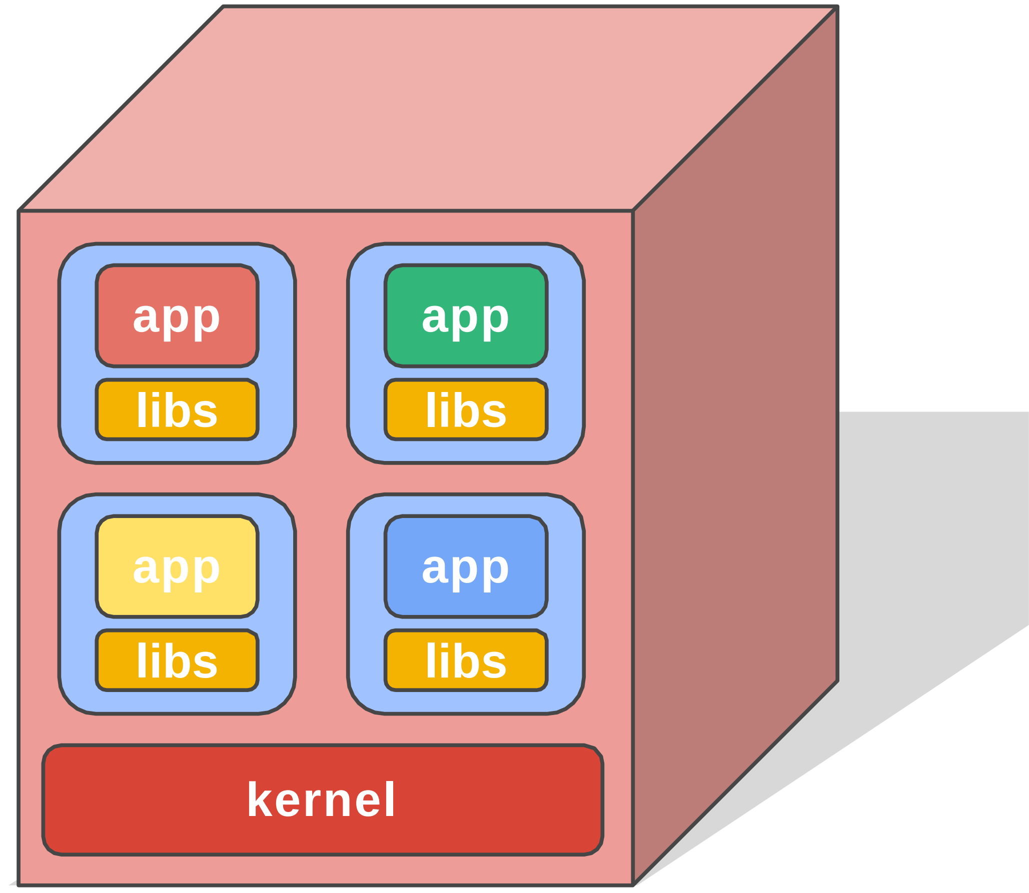
OS-level virtualization

Isolated, from each other and from the host

- filesystems
- processes
- resources

Small and fast ⇒ enables 1:1 app to image

- Unlocks benefits of microservices
- Decouple build (Dev) from deployment (Ops)
- Consistency from development to production
- Portable across OS distros and clouds
- Application-centric management



Need container-centric infrastructure

Scheduling: Decide where my containers should run

Lifecycle and health: Keep my containers running despite failures

Scaling: Make sets of containers bigger or smaller

Naming and discovery: Find where my containers are now

Load balancing: Distribute traffic across a set of containers

Storage volumes: Provide data to containers

Logging and monitoring: Track what’s happening with my containers

Debugging and introspection: Enter or attach to containers

Identity and authorization: Control who can do things to my containers

Want to automate orchestration for velocity & scale

Diverse workloads and use cases demand still more functionality

- Rolling updates and blue/green deployments
- Application secret and configuration distribution
- Continuous integration and deployment
- Workflows
- Batch processing
- Scheduled execution
- Application-specific orchestration

...

A composable, extensible **Platform** is needed

Kubernetes

Greek for *"Helmsman"*; also the root of the words *"governor"* and *"cybernetic"*

- Infrastructure for containers
- Schedules, runs, and manages containers on virtual and physical machines
- Platform for automating deployment, scaling, and operations
- Inspired and informed by Google's experiences and internal systems
- **100% Open source**, written in Go

Deployment

```
$ kubectl run my-nginx--image=nginx
replicationcontroller "my-nginx" created

$ kubectl get po
NAME              READY     STATUS     RESTARTS     AGE
my-nginx-         1/1       Running    0            1m
wepbv
```

Scaling

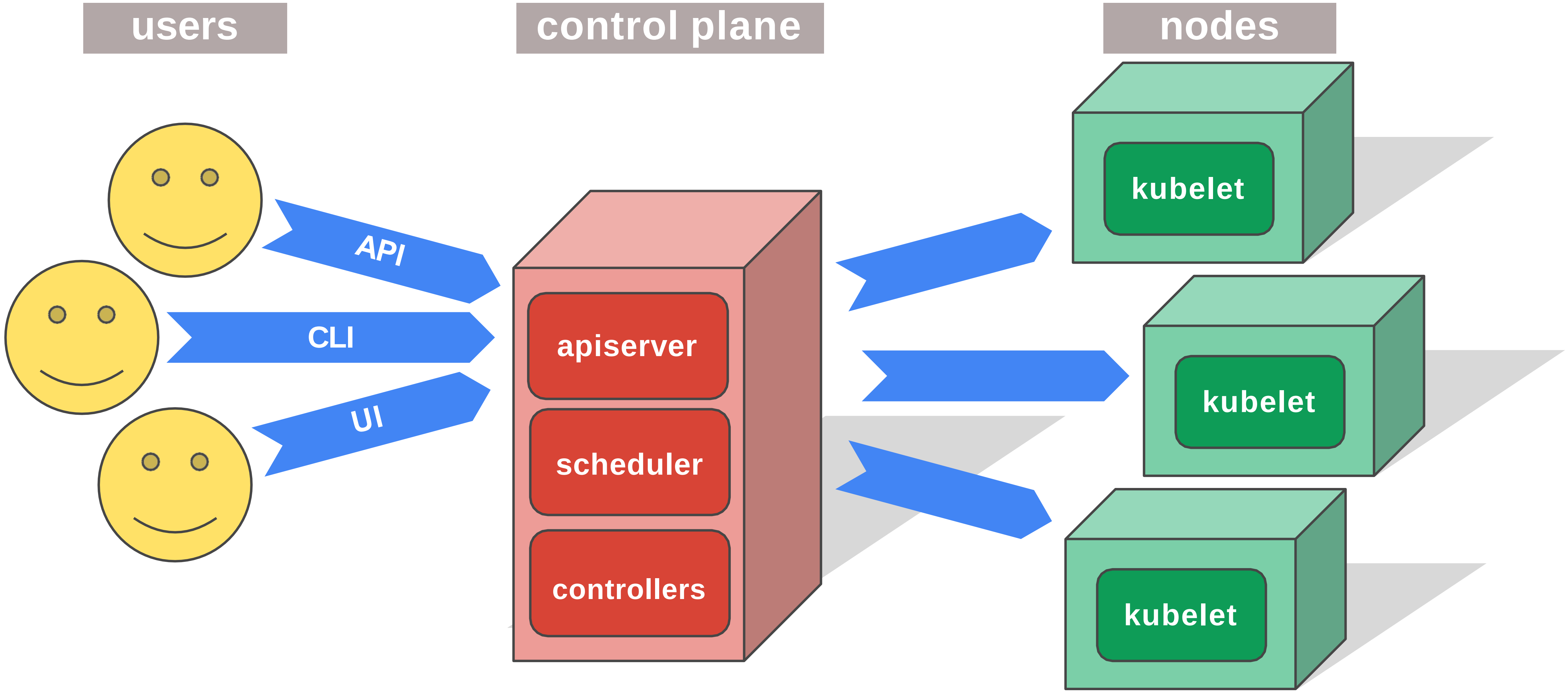
```
$ kubectl scale rc my-nginx --replicas=2
replicationcontroller "my-nginx" scaled

$ kubectl get po
NAME              READY     STATUS     RESTARTS    AGE
my-nginx-         1/1       Running    0           1m
wepbv
my-nginx-yrf3u    1/1       Running    0           20s
```

Shutdown

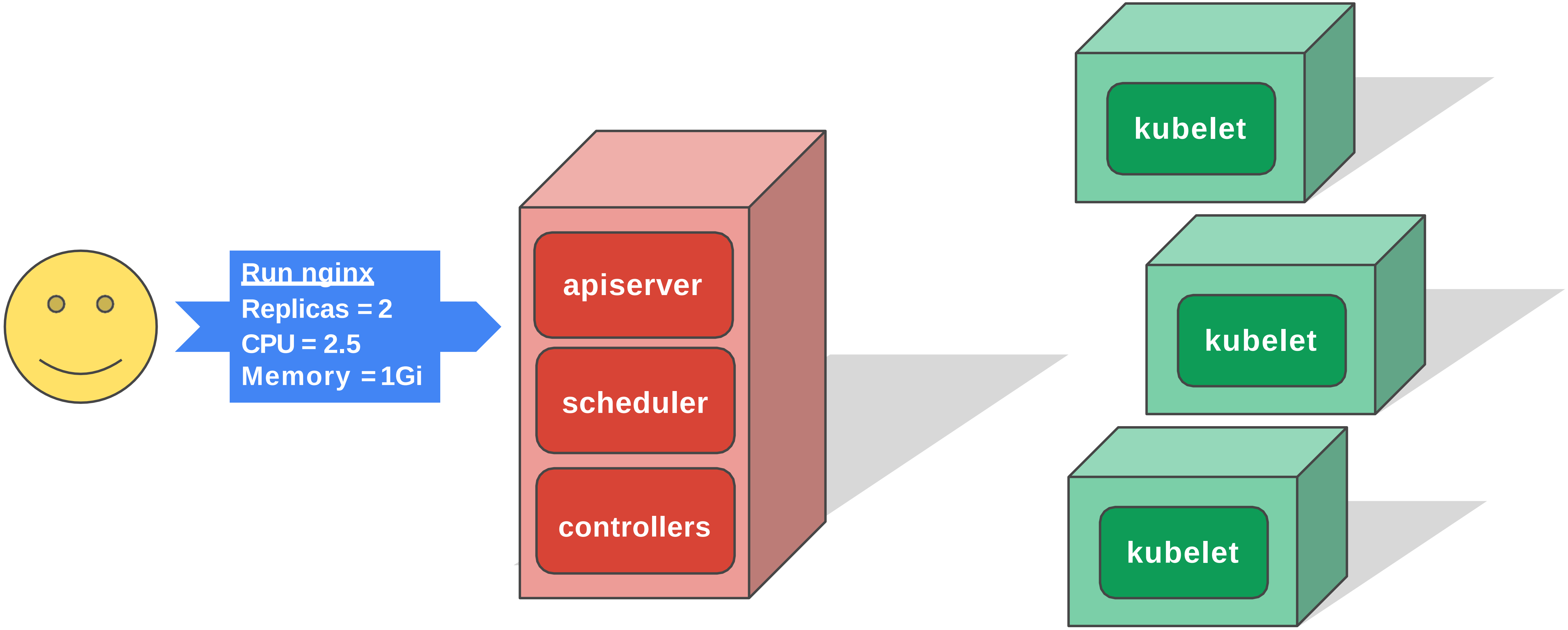
```
$ kubectl delete rc my-nginx
replicationcontroller "my-nginx" deleted

$ kubectl get po
NAME              READY   STATUS        RESTARTS   AGE
my-nginx-         0/1     Terminating   0          4m
wepbv
my-nginx-yrf3u    0/1     Terminating   0          3m

$ kubectl get po


$
```

Kubernetes architecture

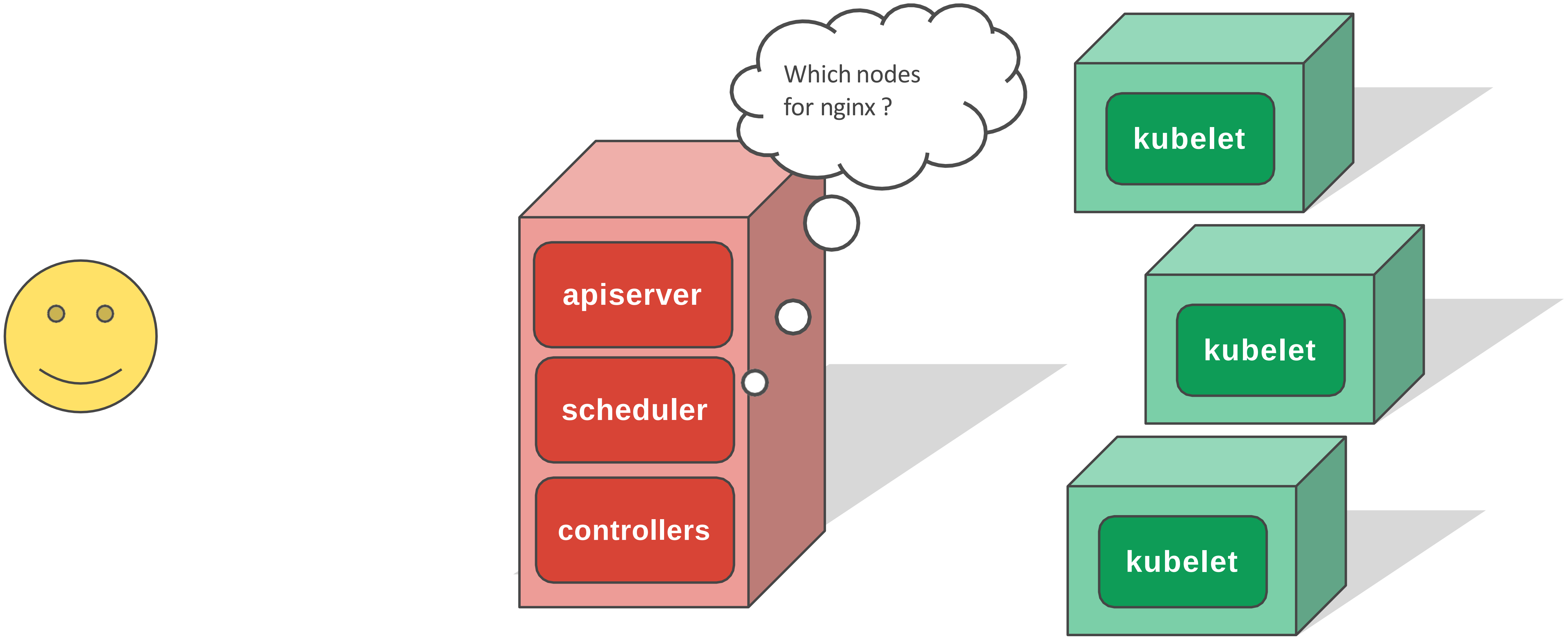
Kubernetes architecture



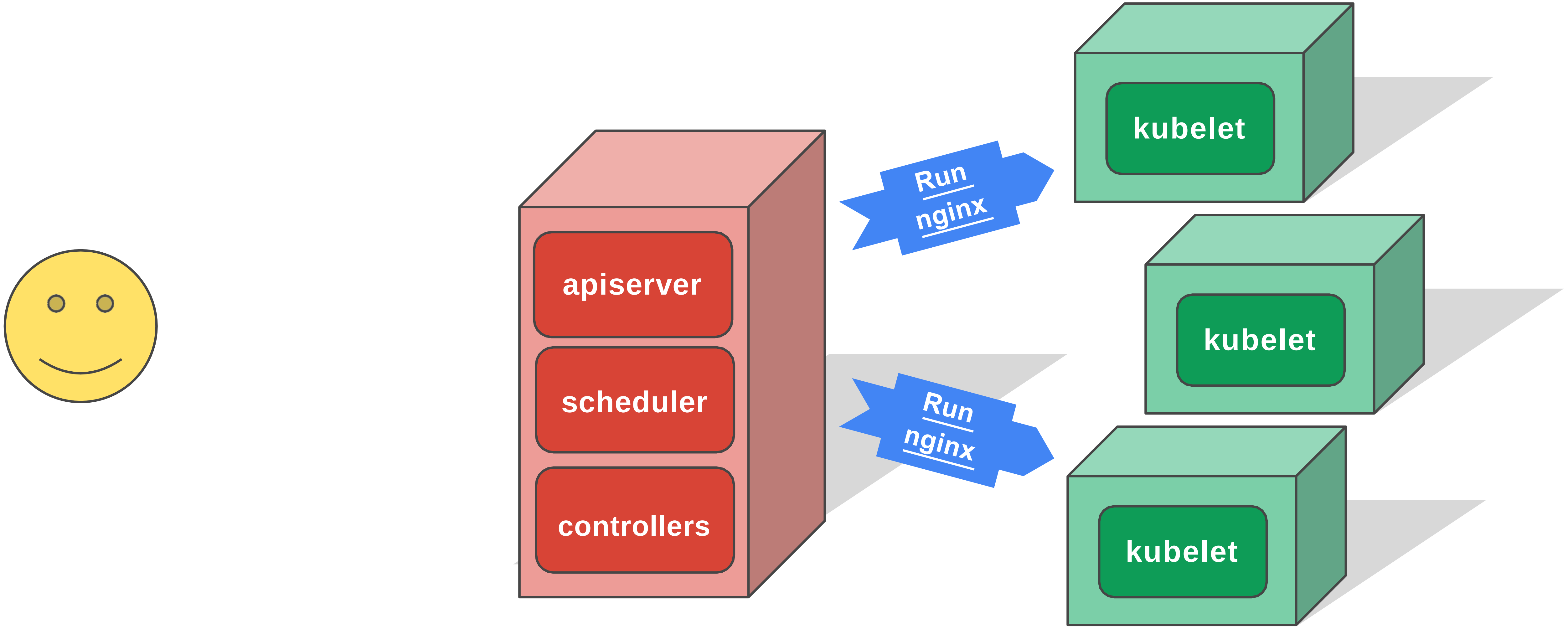
Post desired state (aka spec) via API



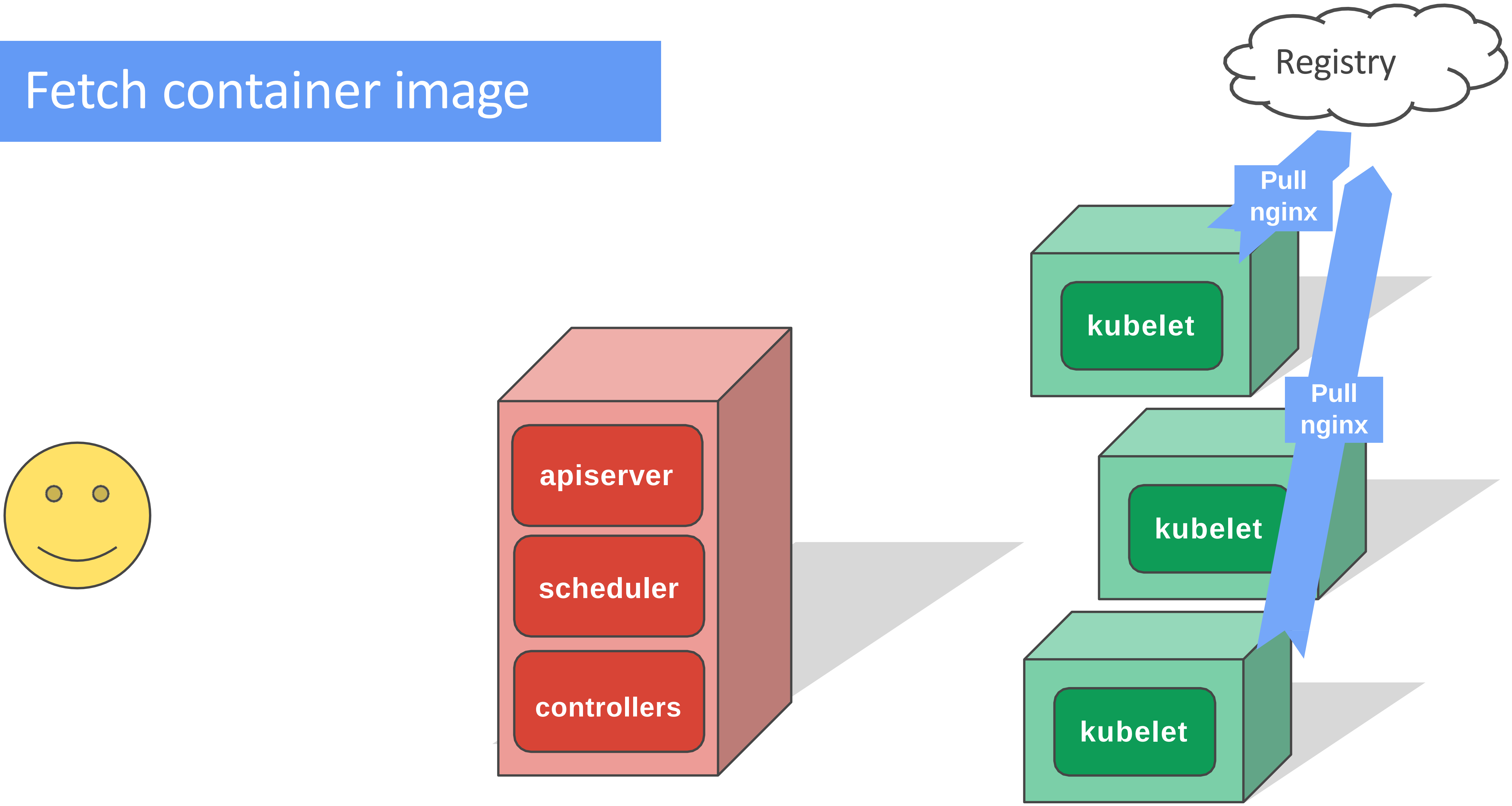
Placement (aka scheduling)



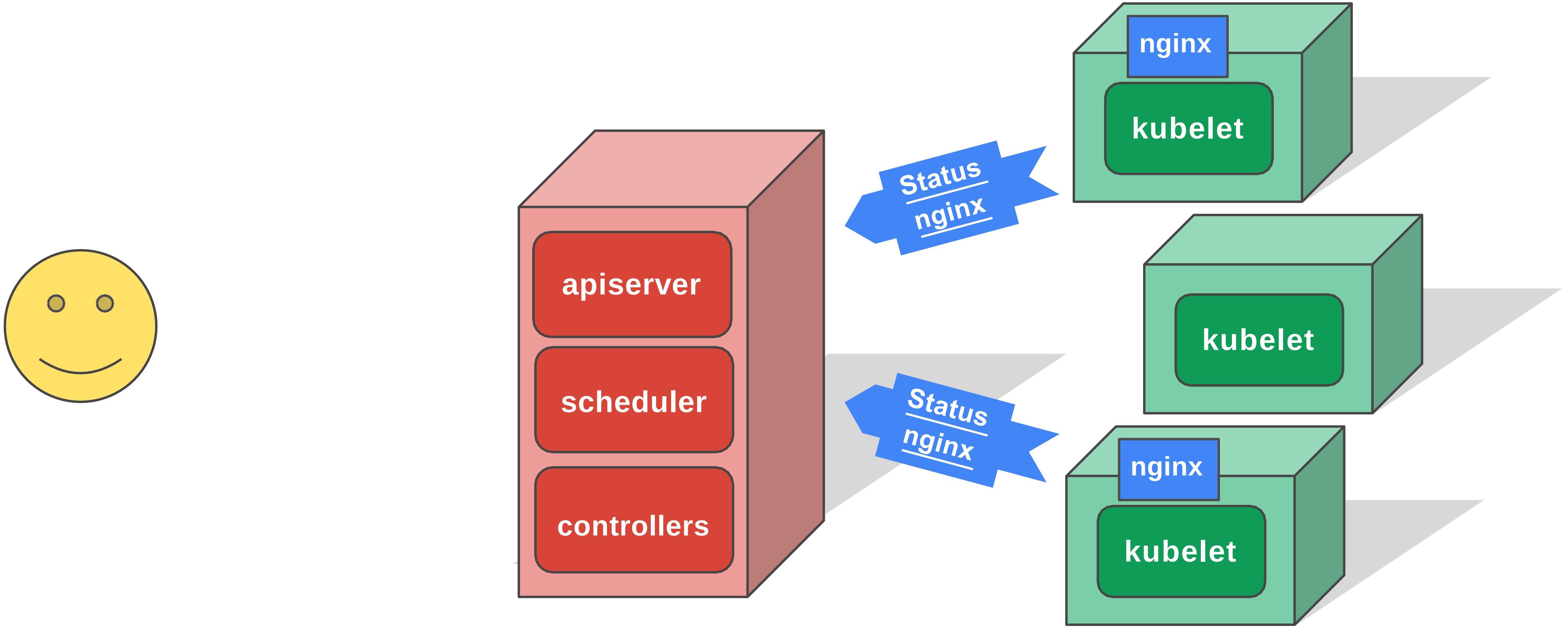
Assignment (aka binding)



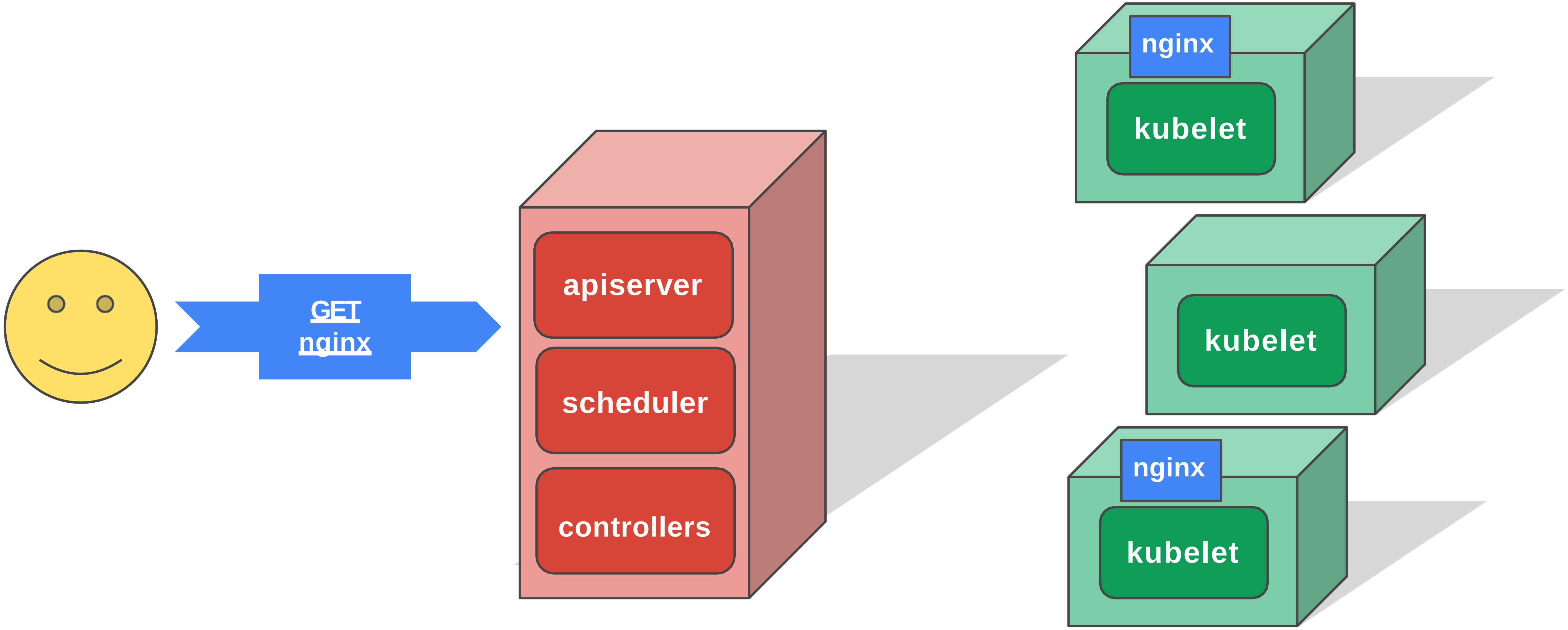
Fetch container image



Execution and lifecycle management



Get current status via API



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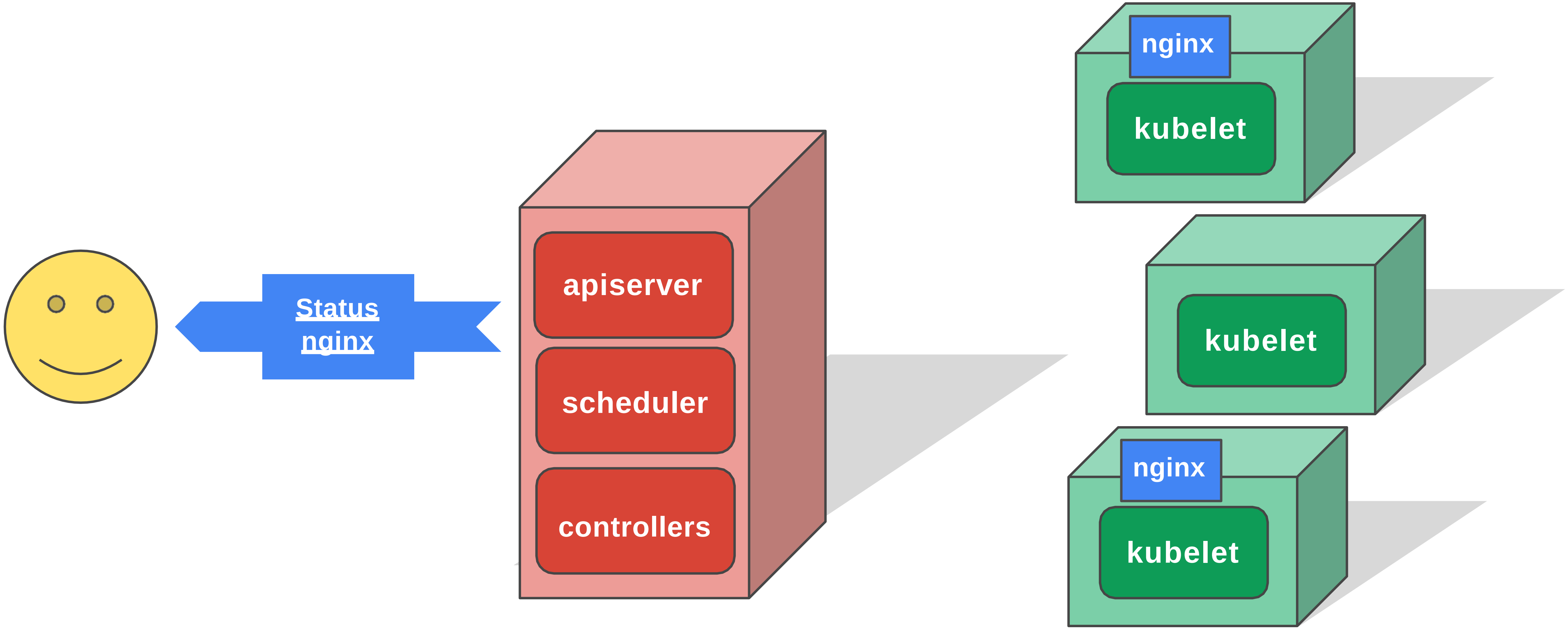
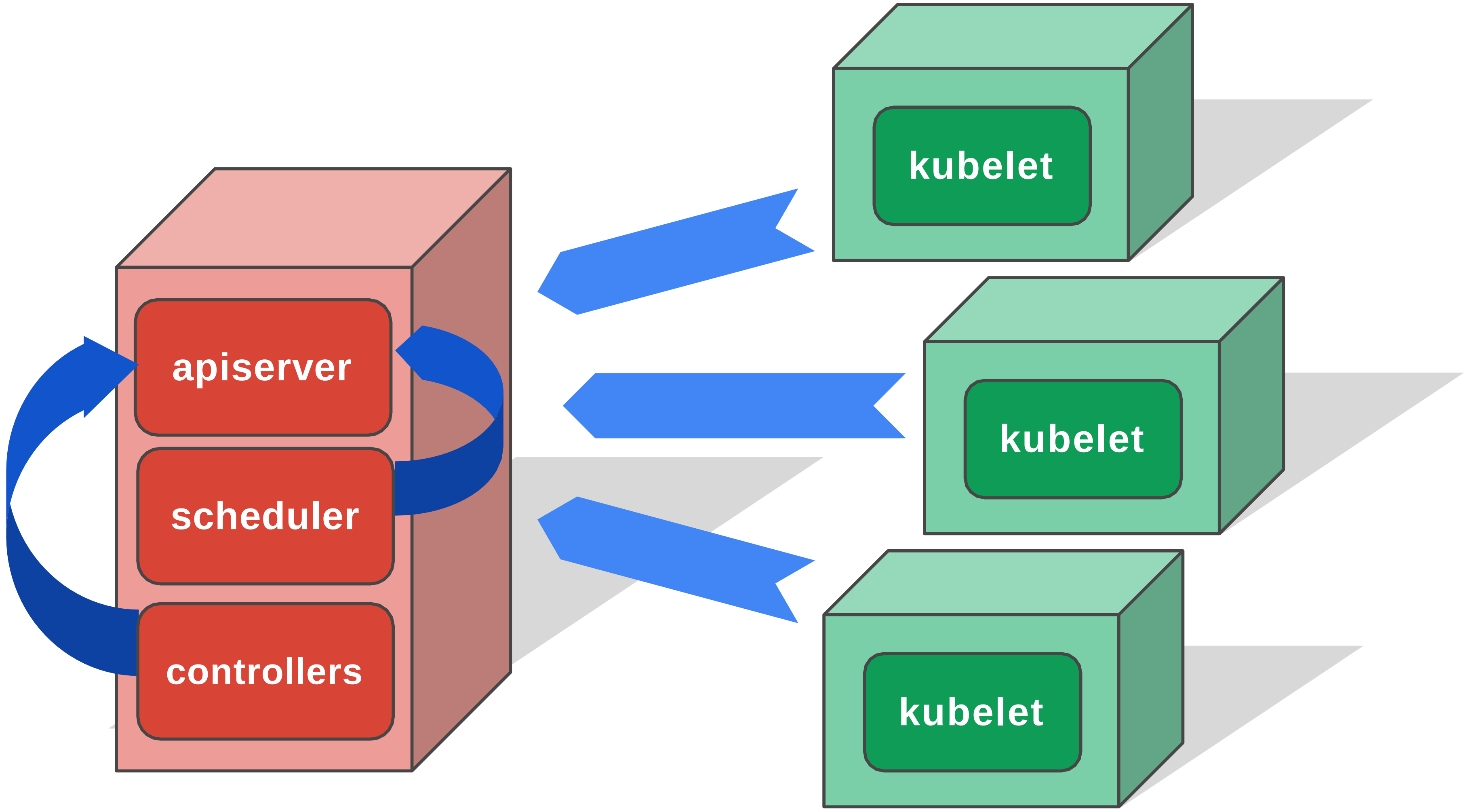


Kubernetes uses the same APIs as users



Modularity

Modularity facilitates

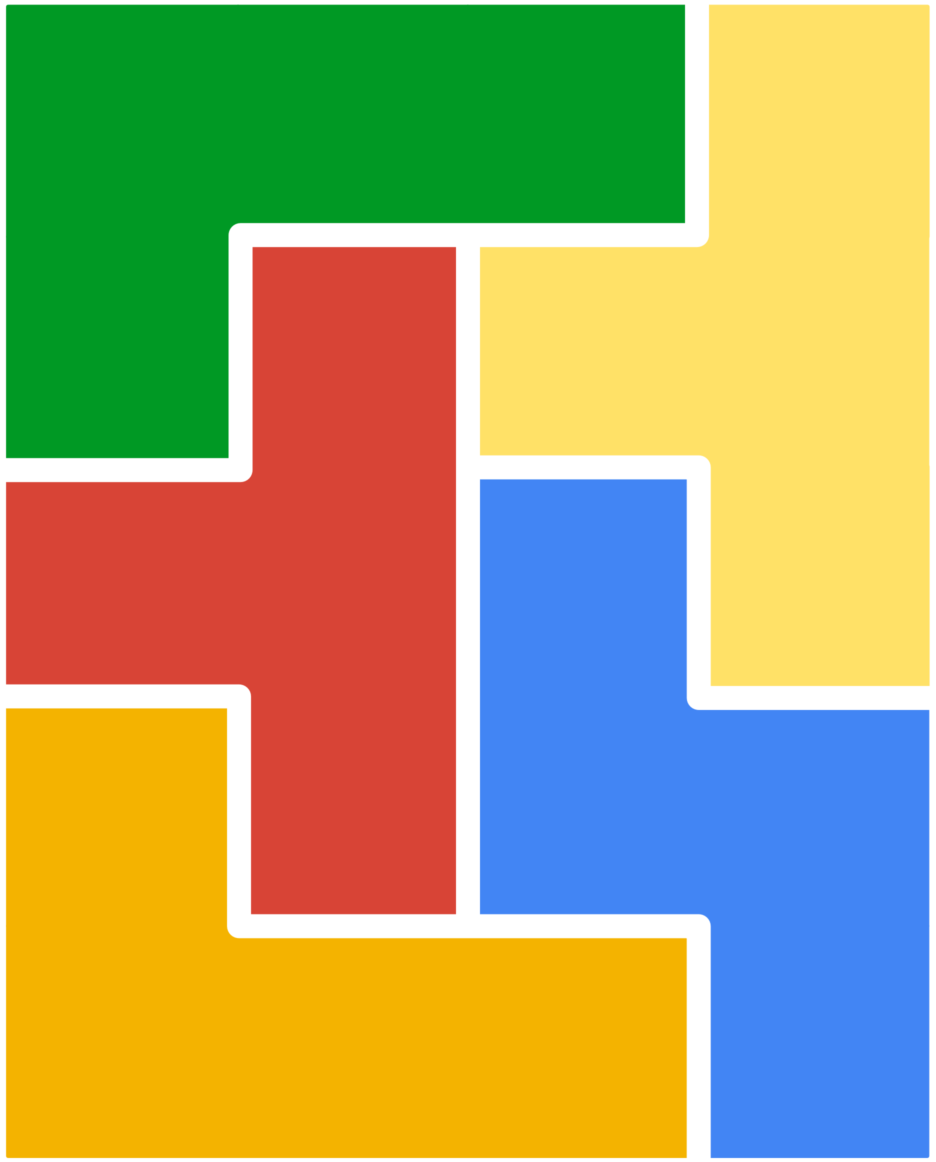
- composability
- extensibility

APIs - **no shortcuts** or back doors

- ensures extensions are on equal footing

Example: Scheduler

Example: Controllers



Control loops

Drive **current state → desired state**

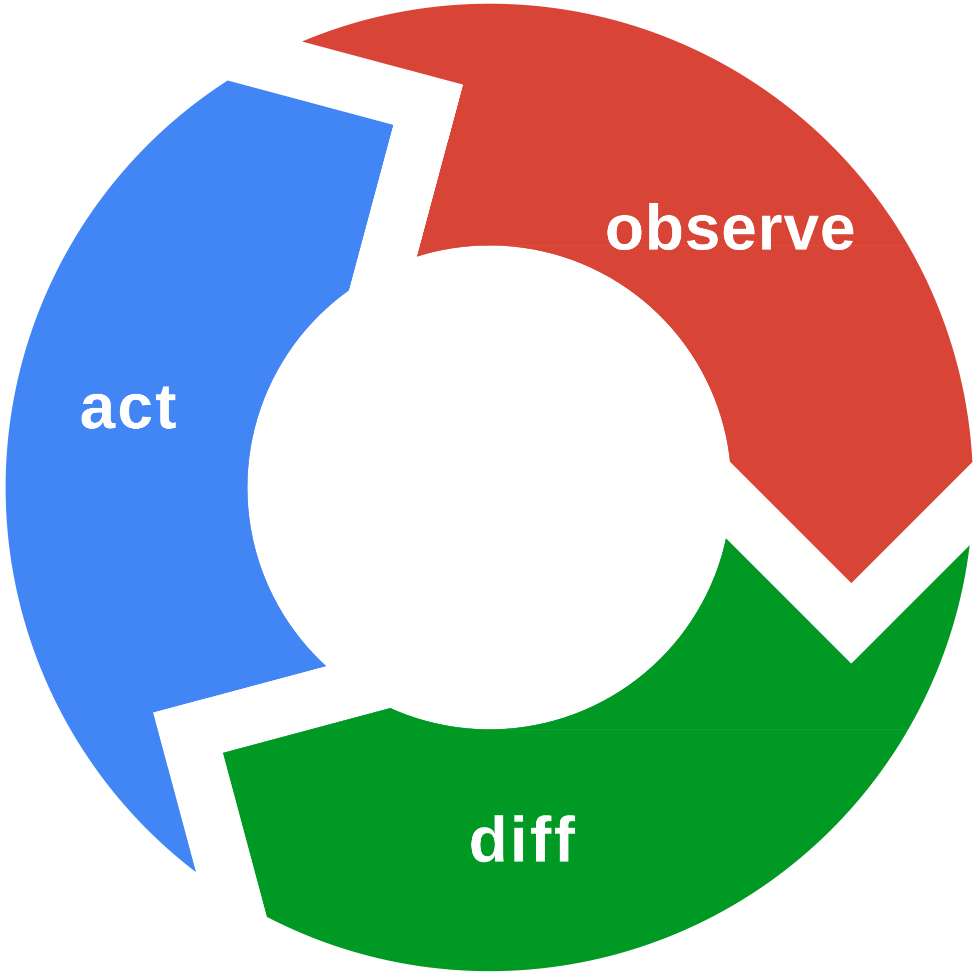
Observed state is truth

Act independently

- *choreography* rather than *orchestration*

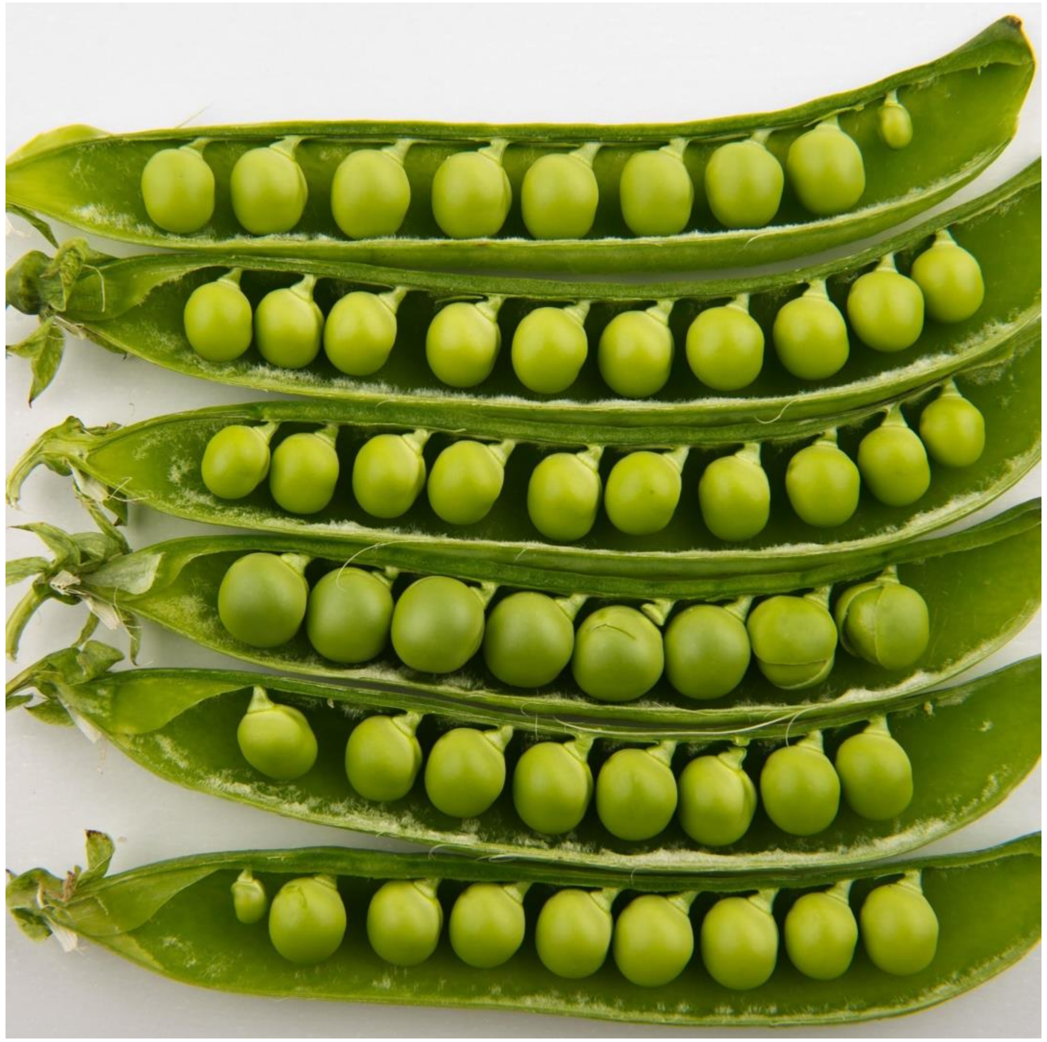
Recurring pattern in the system

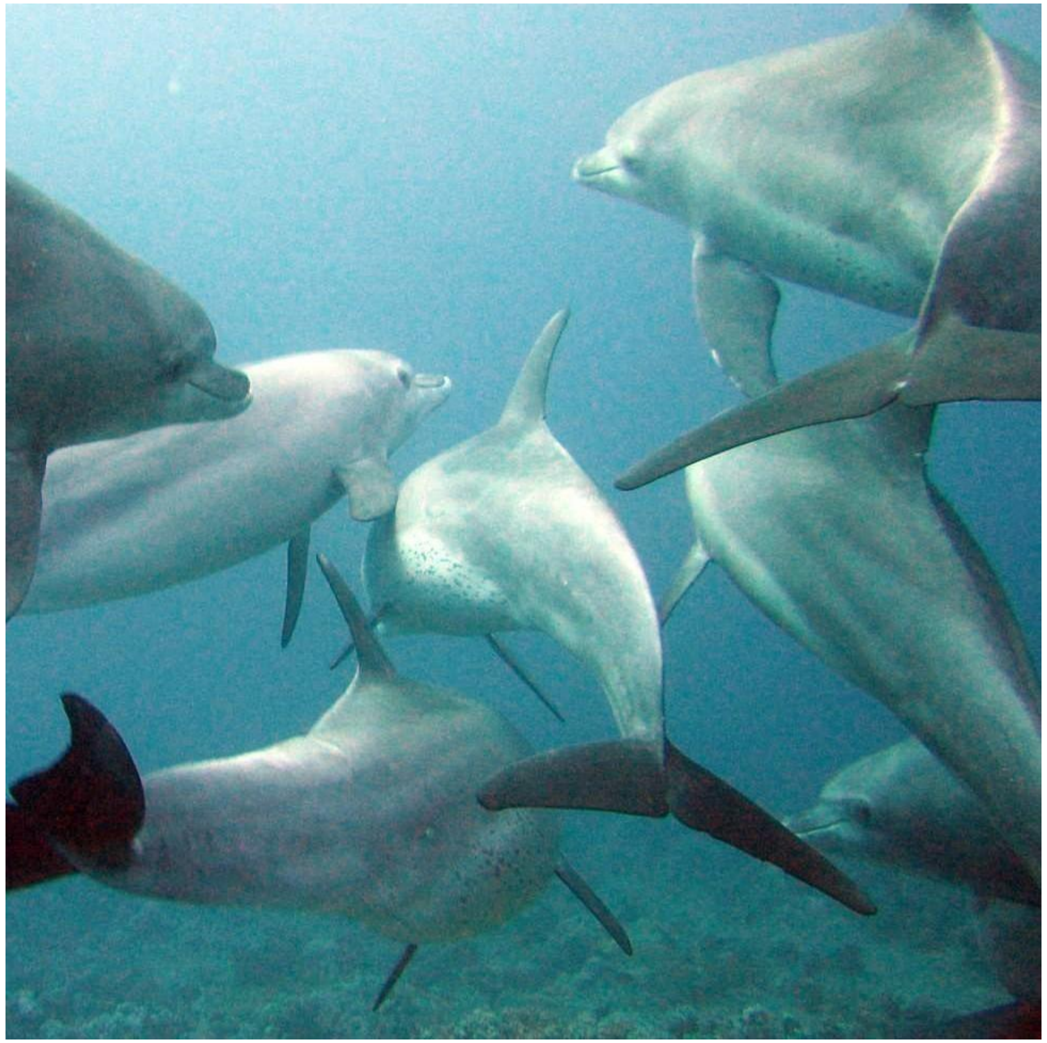
Example: Scheduler
Example: Controllers



Core primitives

Pods





Pods

Small group of containers & volumes

Tightly coupled

- the atom of replication & placement

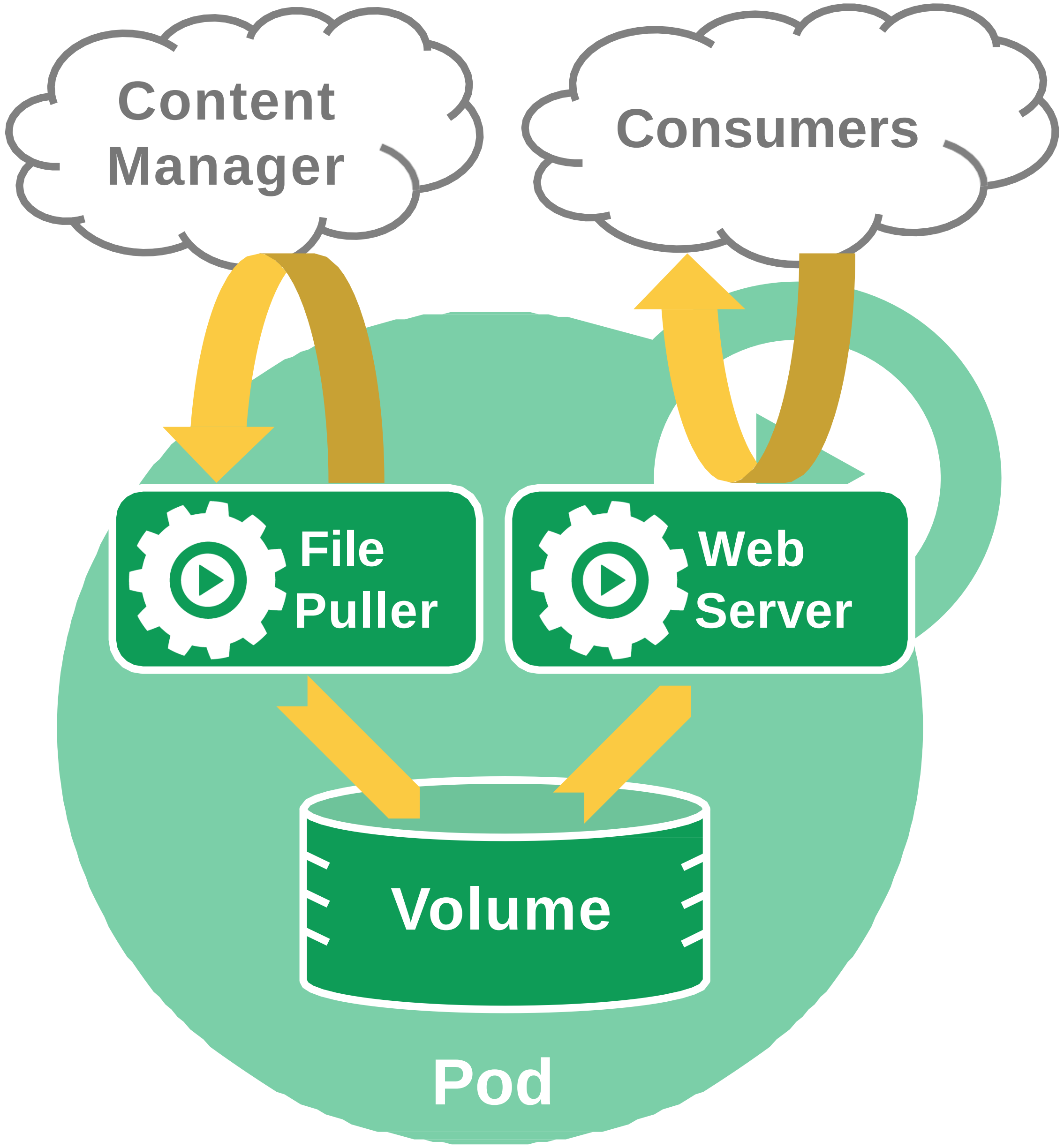
"Logical" host for containers

- each pod gets an IP address
- share data: localhost, volumes, IPC, etc.

Facilitates composite applications

- mix and match components, languages, etc.
- preserves 1:1 app to image

Example: data puller & web server



Volumes

Storage automatically attached to pod

- Local scratch directories created on demand
- Cloud block storage
  - GCE Persistent Disk
  - AWS Elastic Block Storage
- Cluster storage
  - File: NFS, Gluster, Ceph
  - Block: iSCSI, Cinder, Ceph
- Special volumes
  - Git repository
  - Secret

Critical building block for higher-level automation

Secrets

How to grant a pod access to a secured *something?*

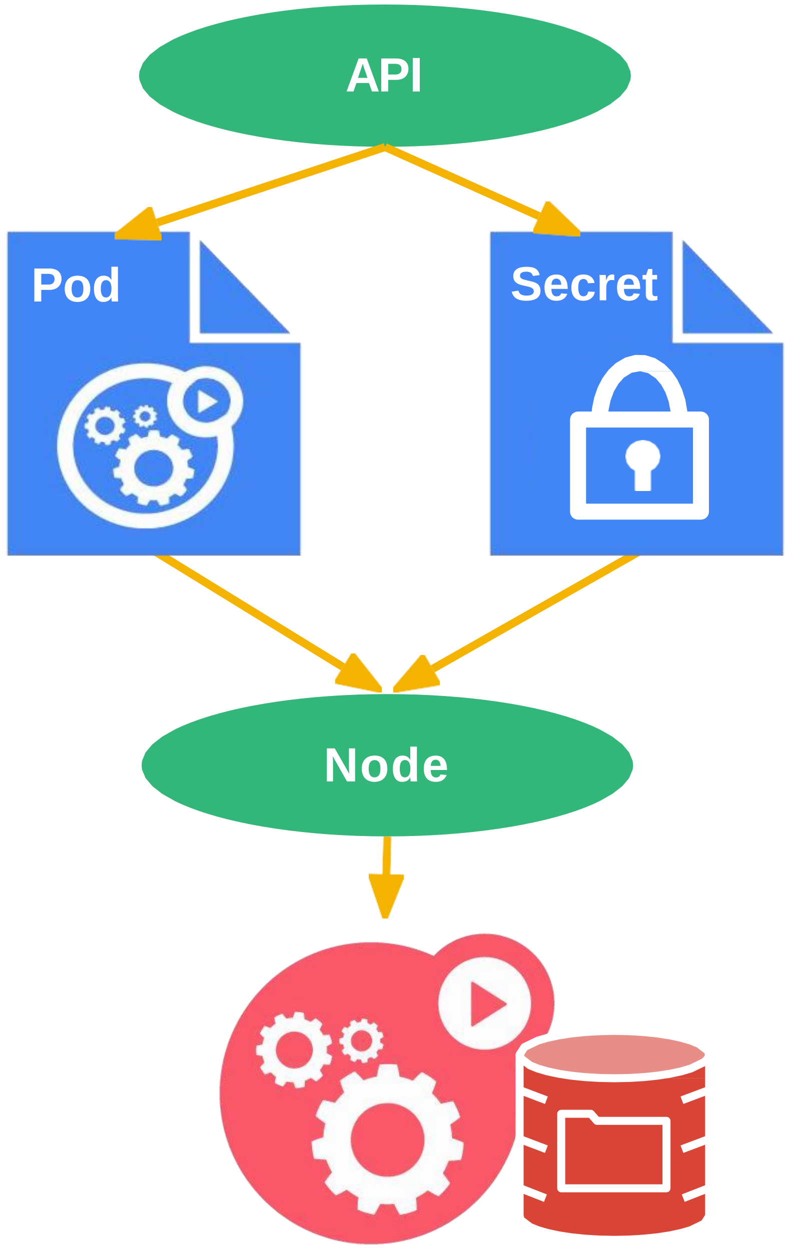
- **secrets**: credentials, tokens, passwords, ...
- don't put them in the container image!

12-factor says should come from the environment

Inject them as "virtual volumes" into Pods

- not baked into images nor pod configs
- kept in memory - never touches disk
- not coupled to non-portable metadata API

Manage secrets via the Kubernetes API



Labels

User-provided key-value attributes

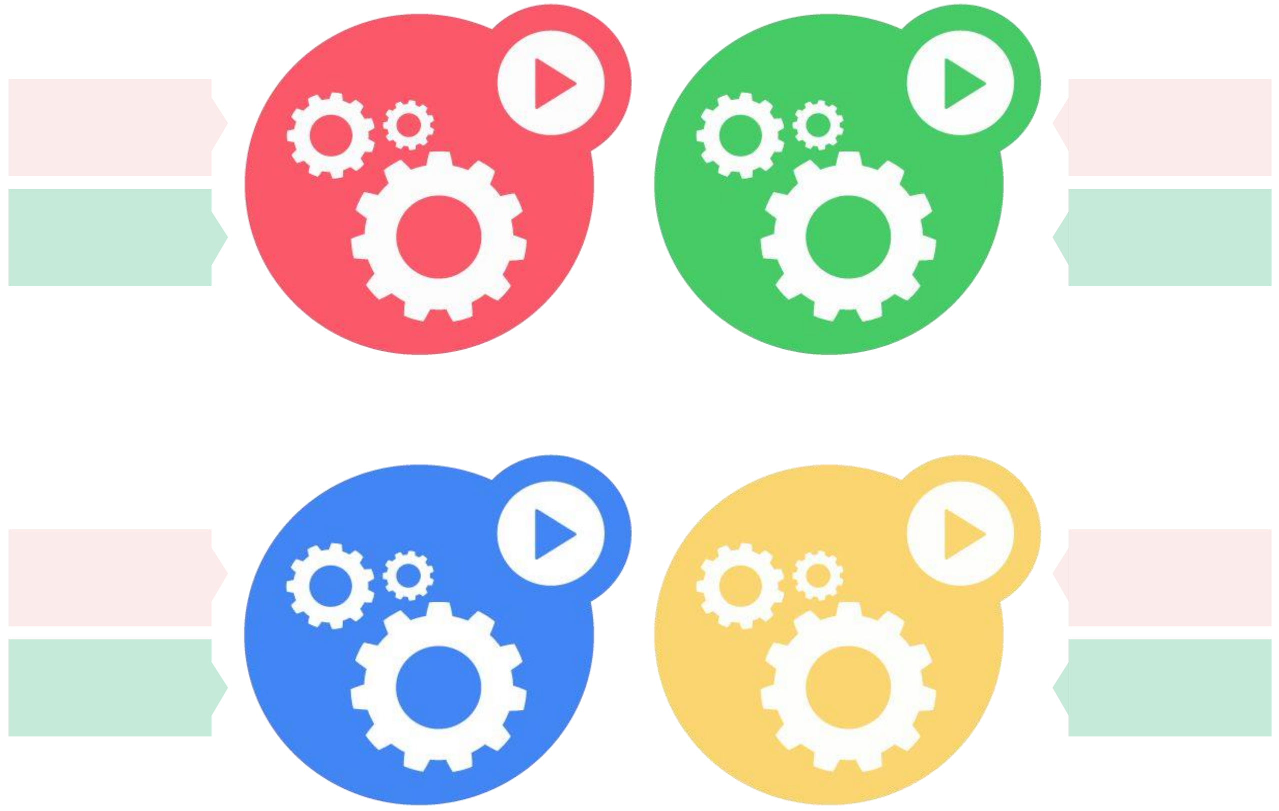
Attached to any API object

Generally represent **identity**

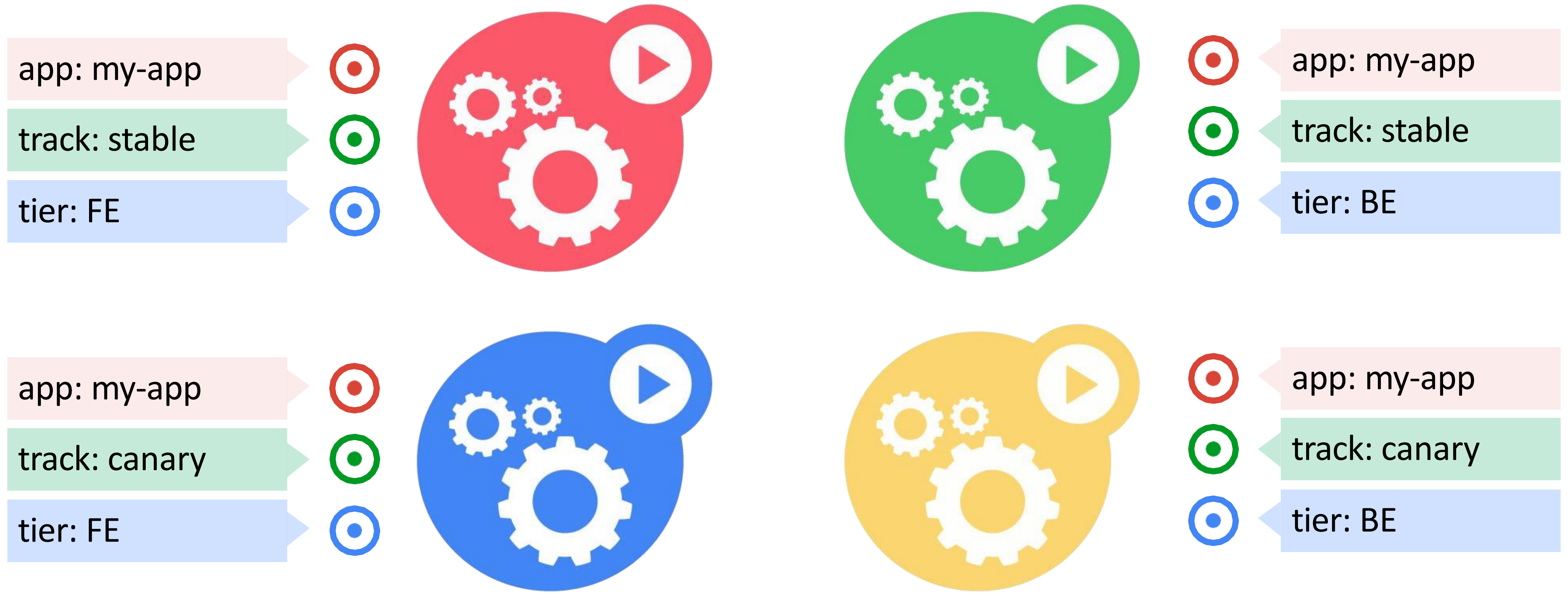
Queryable by **selectors**

- think SQL *'select ... where ...'*

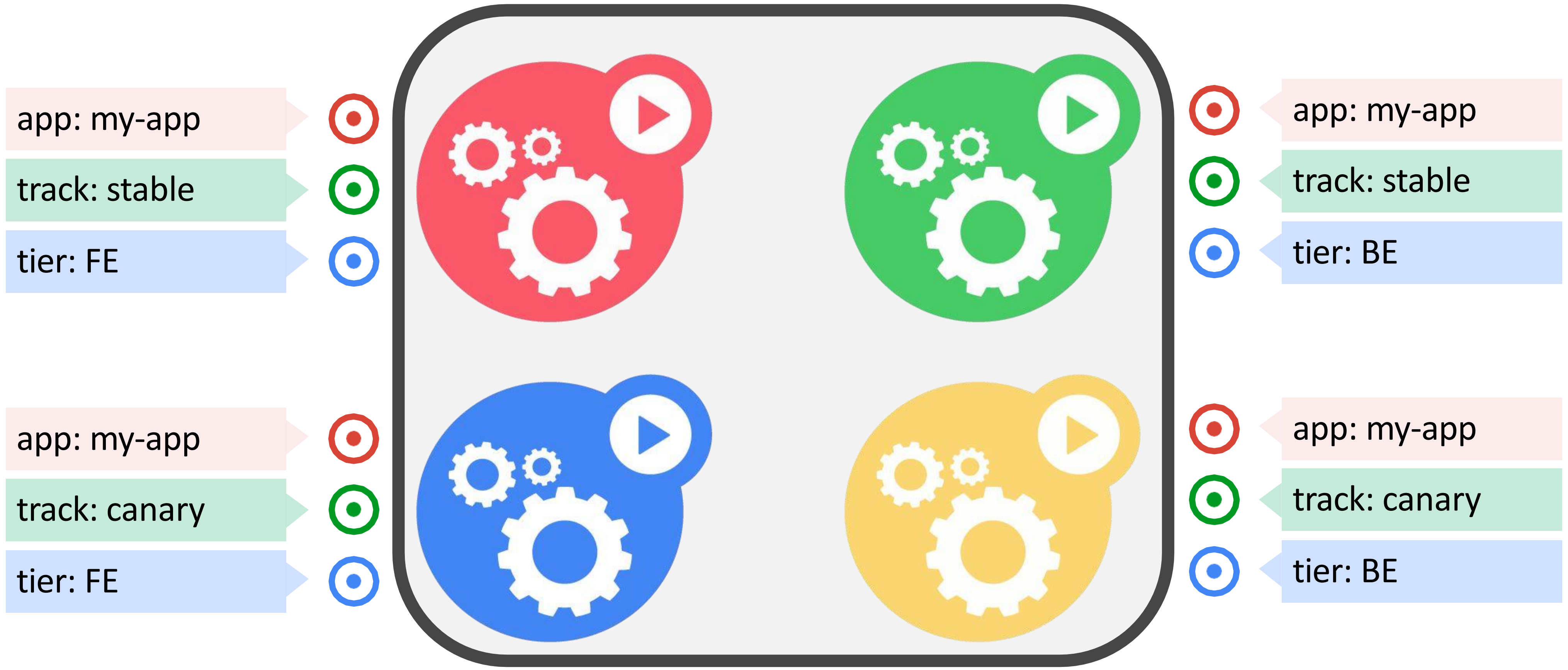
The **only** grouping mechanism



Selectors

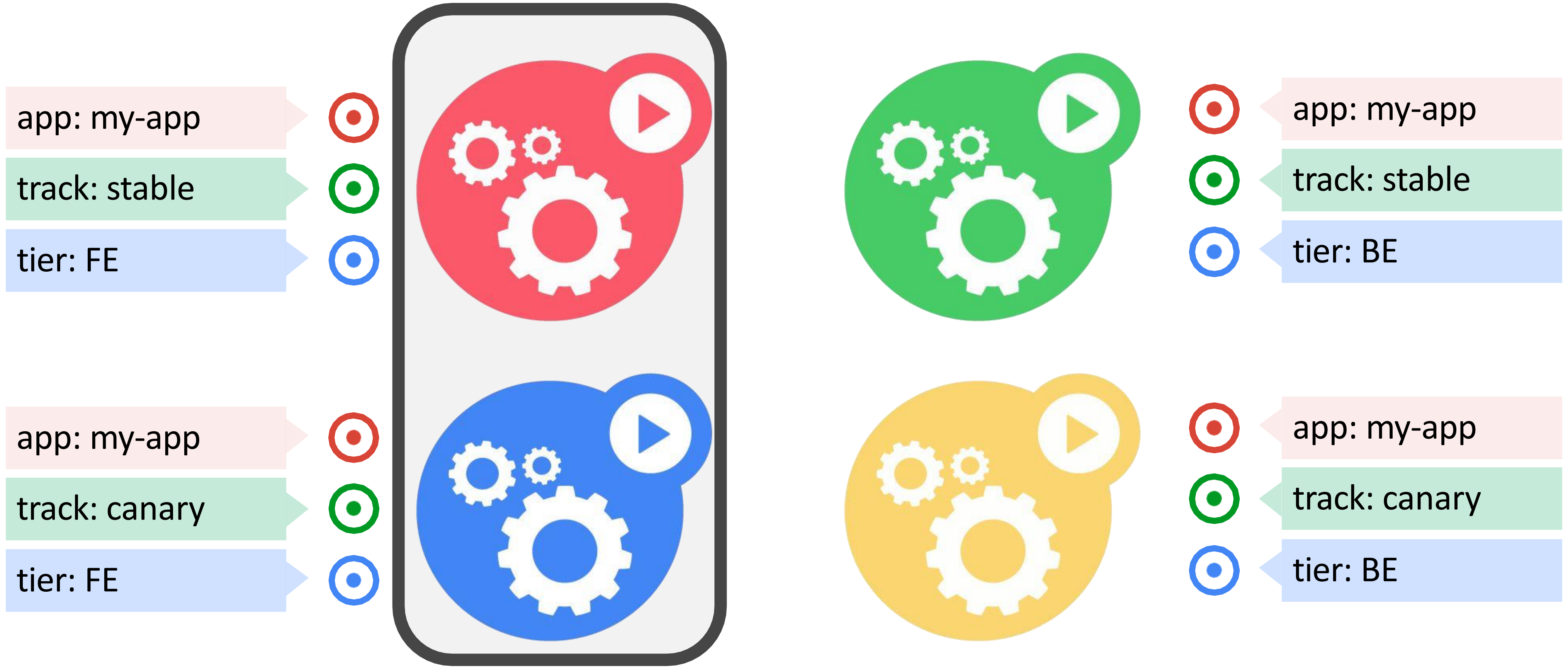

app: my-app
track: stable
tier: FE
app: my-app
track: stable
tier: BE
app: my-app
track: canary
tier: FE
app: my-app
track: canary
tier: BE

Selectors



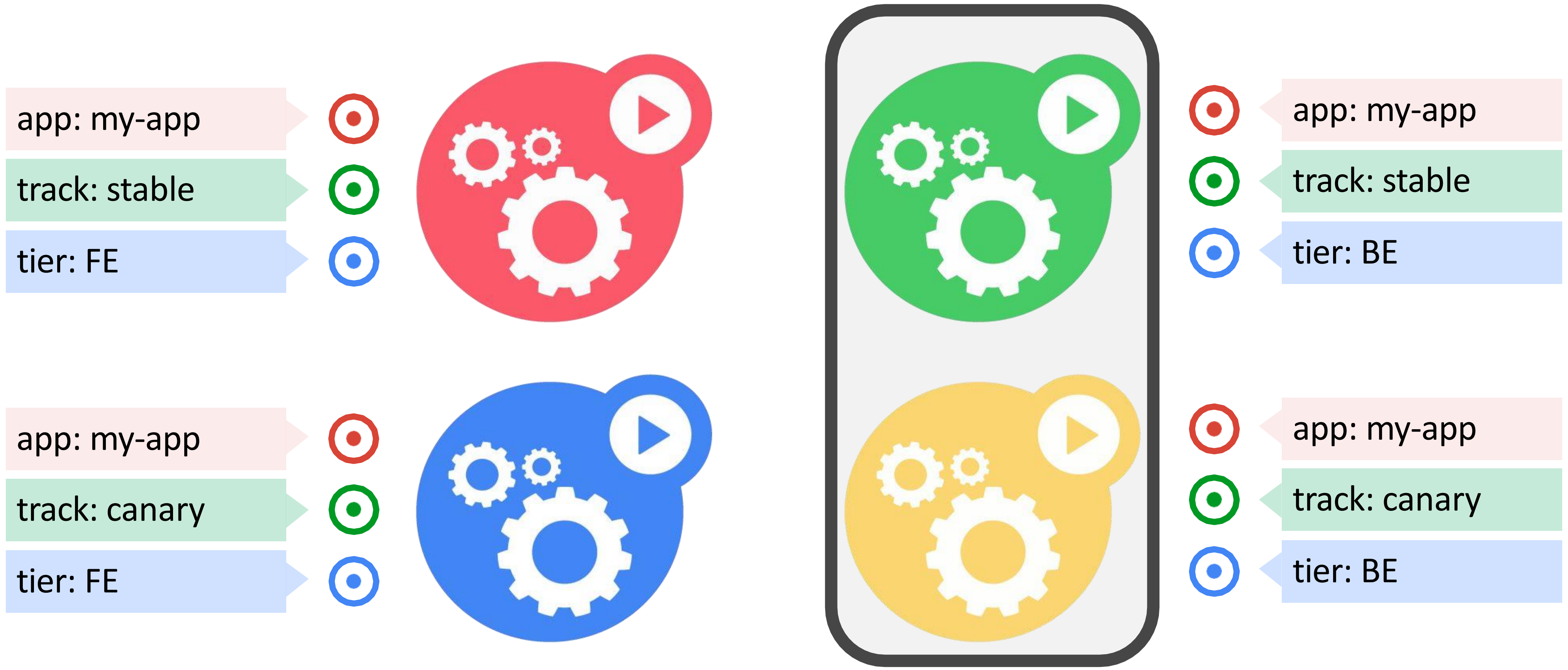
app = my-app

Selectors



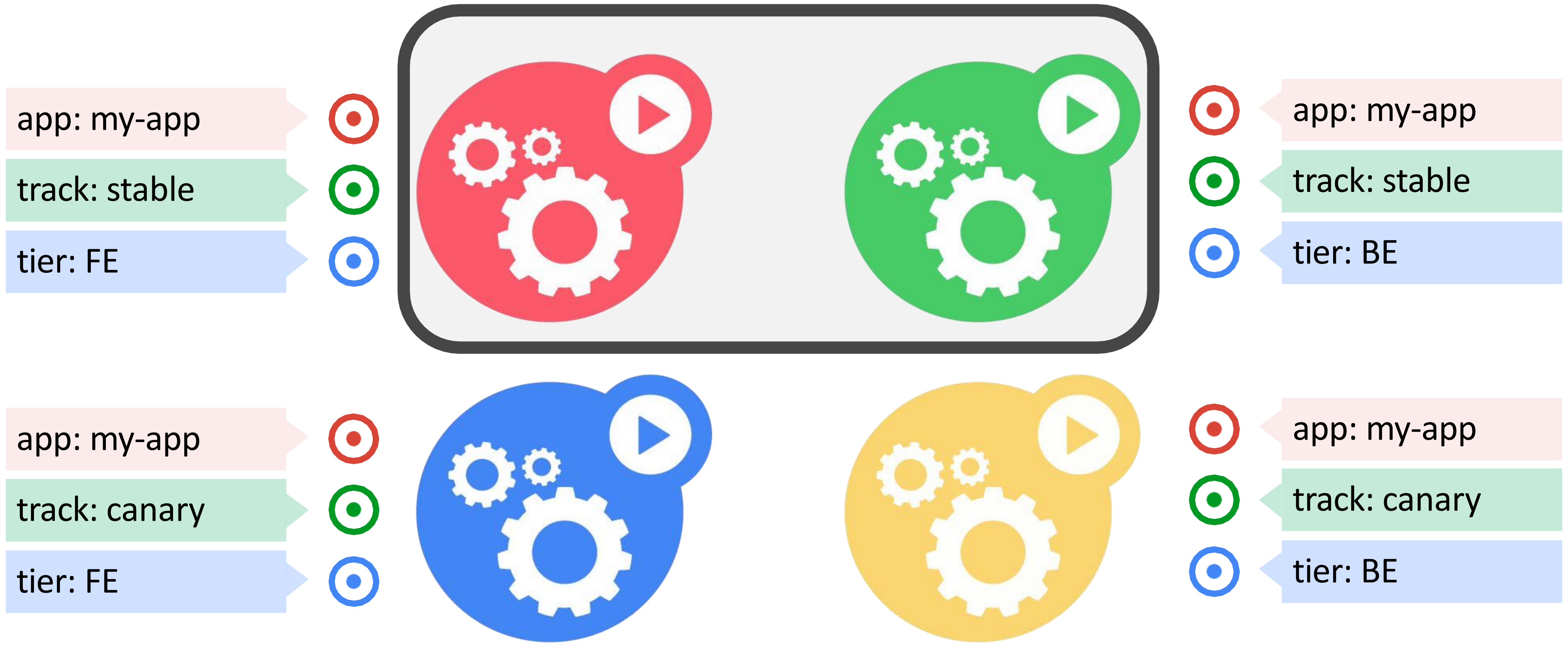
app = my-app, tier = FE

Selectors



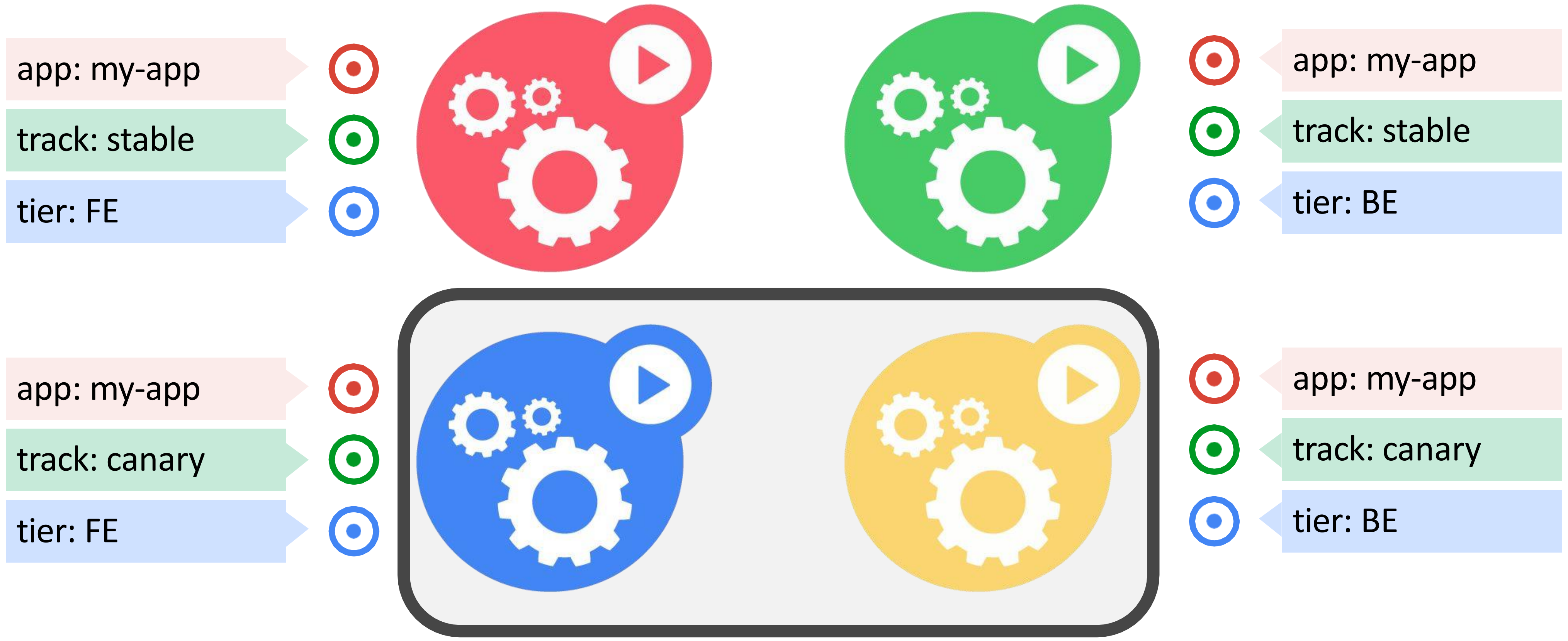
app = my-app, tier = BE

Selectors



app = my-app, track =stable

Selectors



app = my-app, track = canary

Running Microservices

ReplicationControllers

Ensures N copies of a Pod

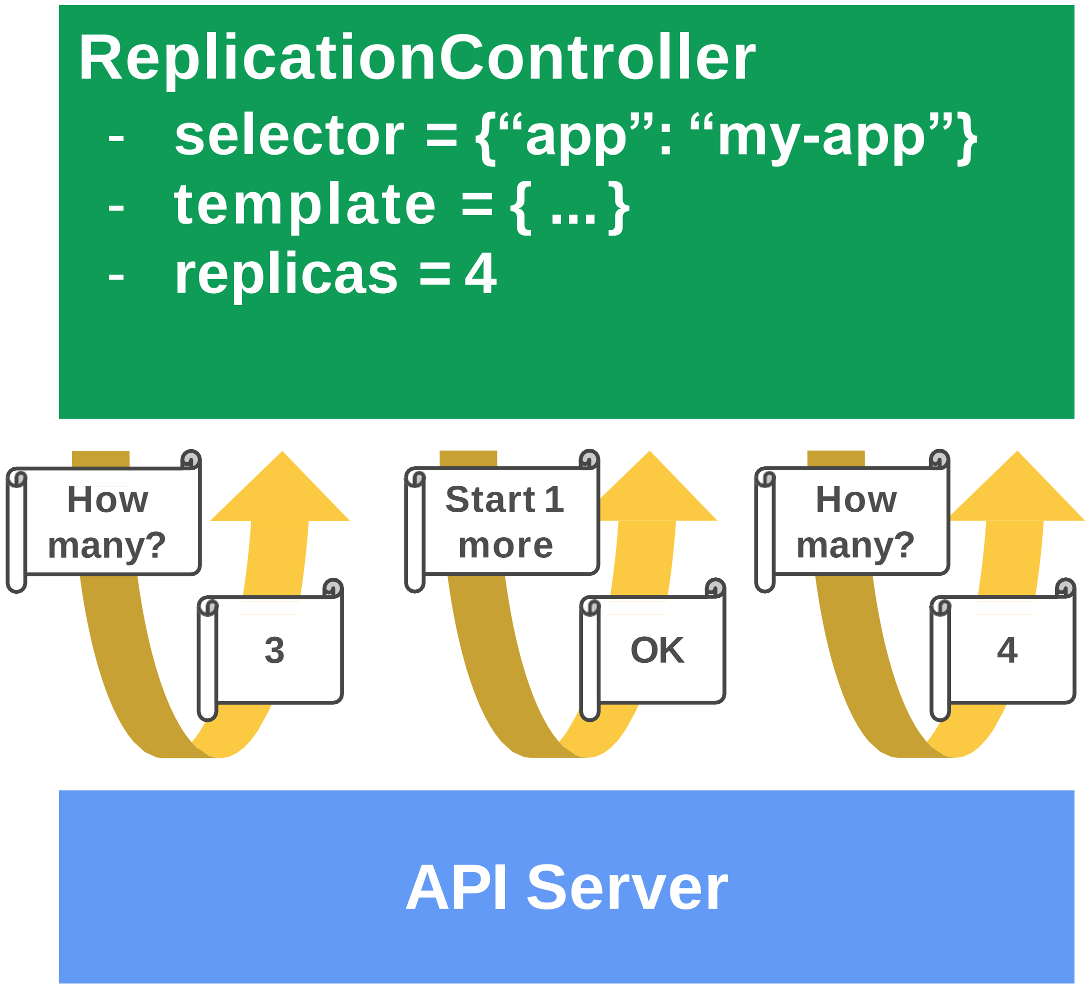
- if too few, start new ones
- if too many, kill some
- grouped by a label selector

Explicit specification of desired scale

- client doesn't just create N copies
- enables self-healing
- facilitates auto-scaling

An example of a controller

- calls public APIs



Services

A group of pods that **work together**

- grouped by a label selector

Publishes how to access the service

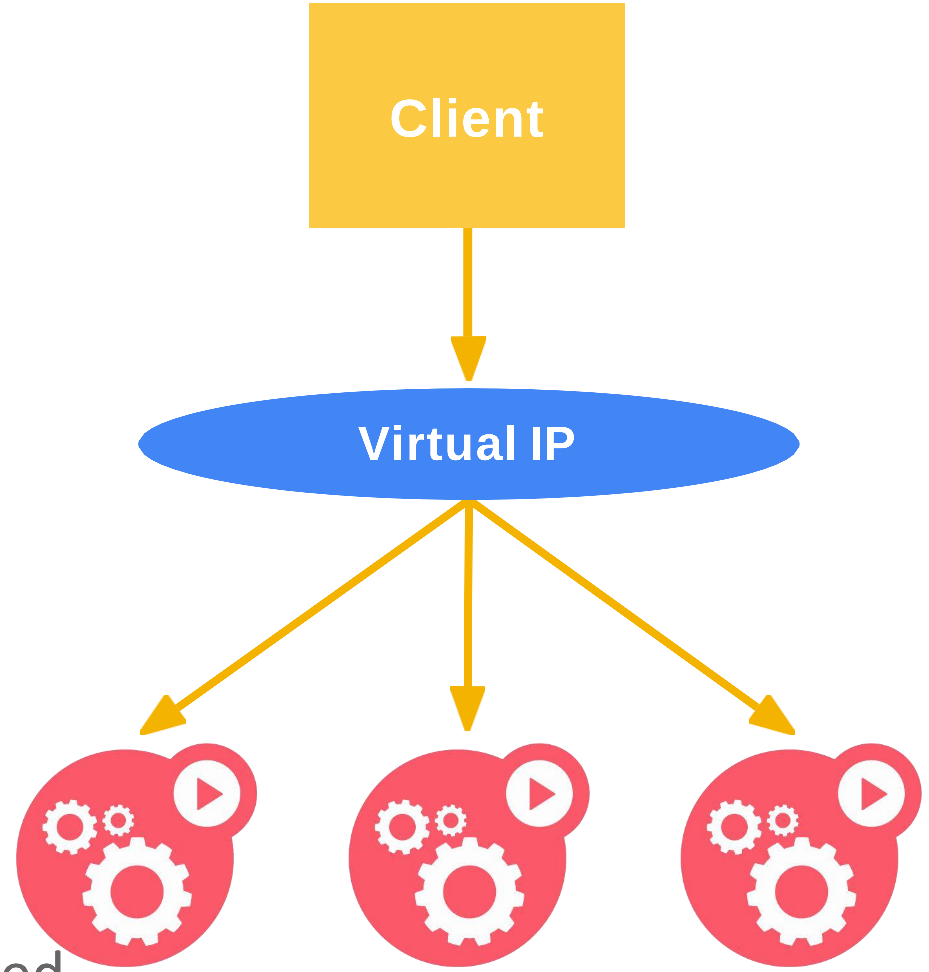
- DNS name
- DNS SRV records for ports (well known ports work, too)
- Kubernetes Endpoints API

Defines access policy

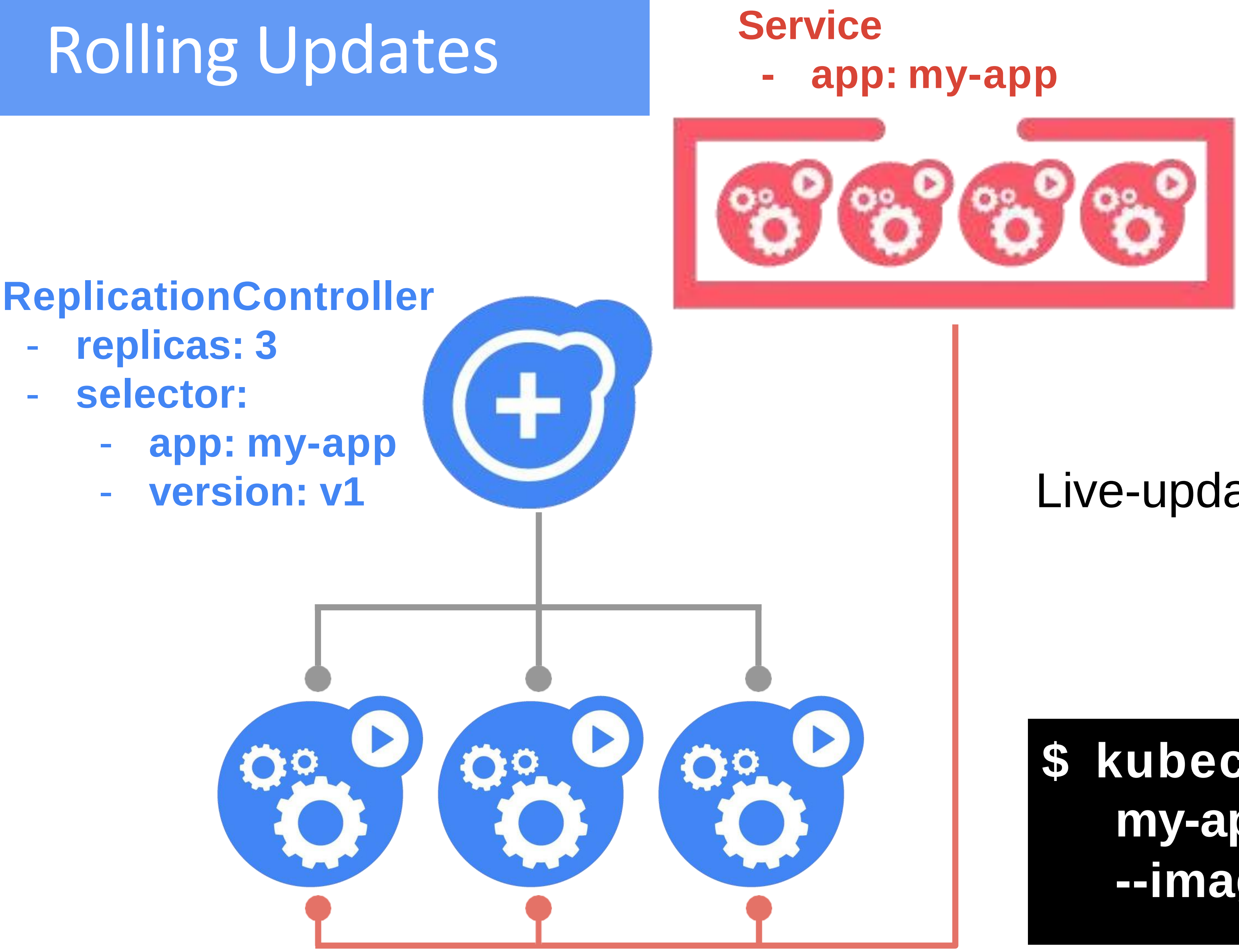
- Load-balanced: name maps to stable **virtual IP**
- “Headless”: name maps to set of pod IPs

Hides complexity - ideal for non-native apps Decoupled

from Pods and ReplicationControllers



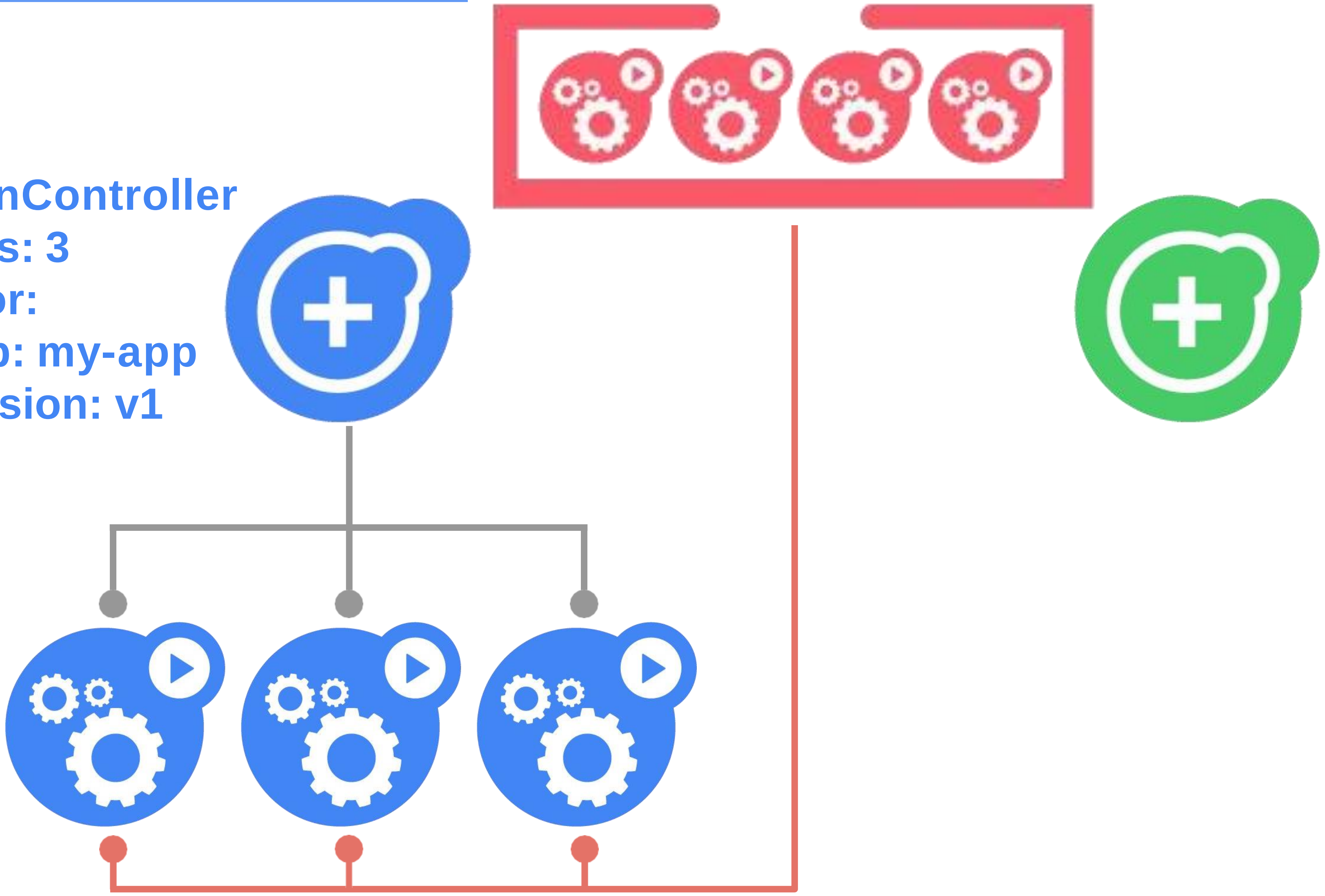
Rolling Updates



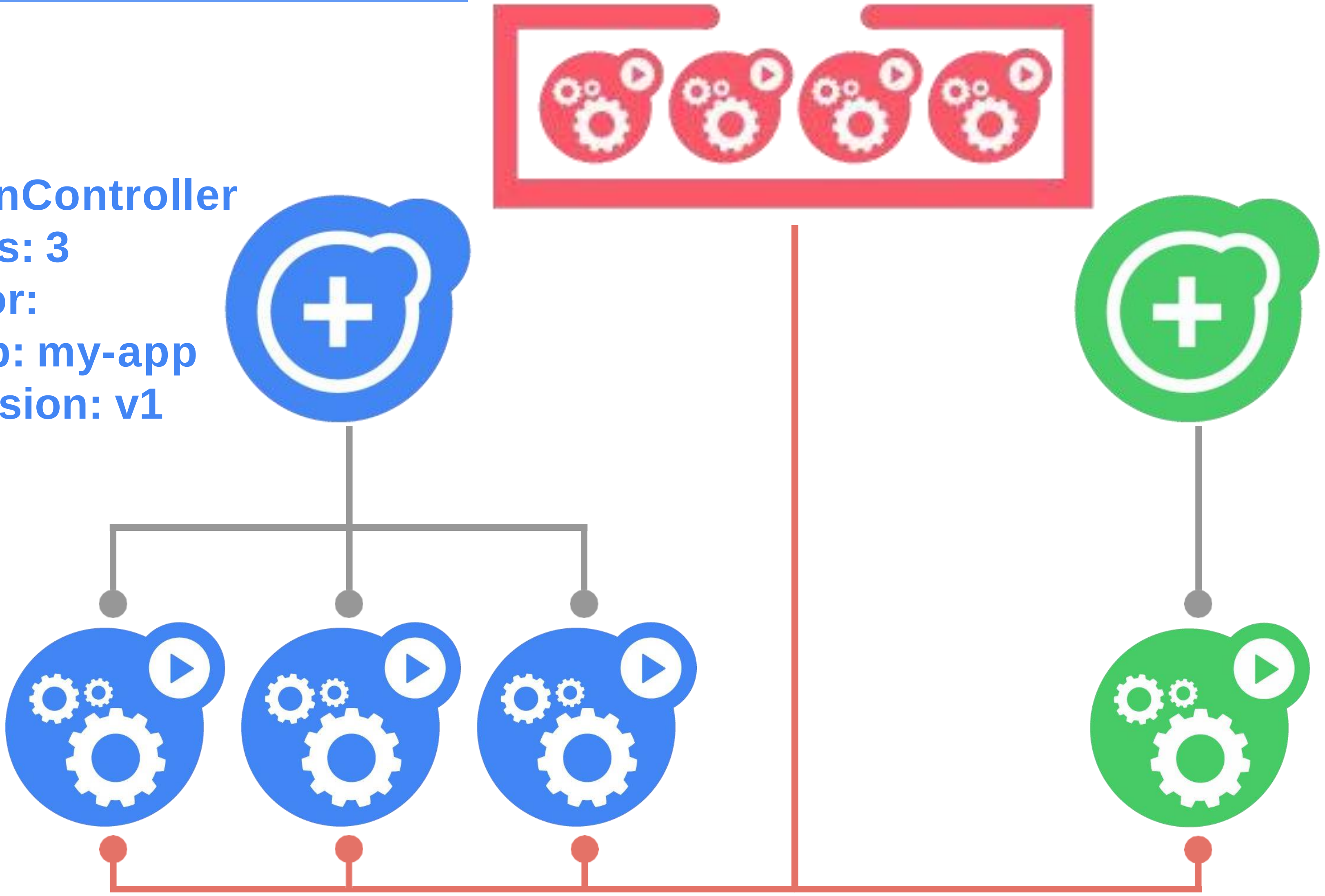
Live-update an application

```
$ kubectl rolling-update \
    my-app-v1 my-app-v2 \
    --image=image:v2
```

Rolling Updates



Rolling Updates



Service
- app: my-app

ReplicationController
- replicas: 3
- selector:
  - app: my-app
  - version: v1

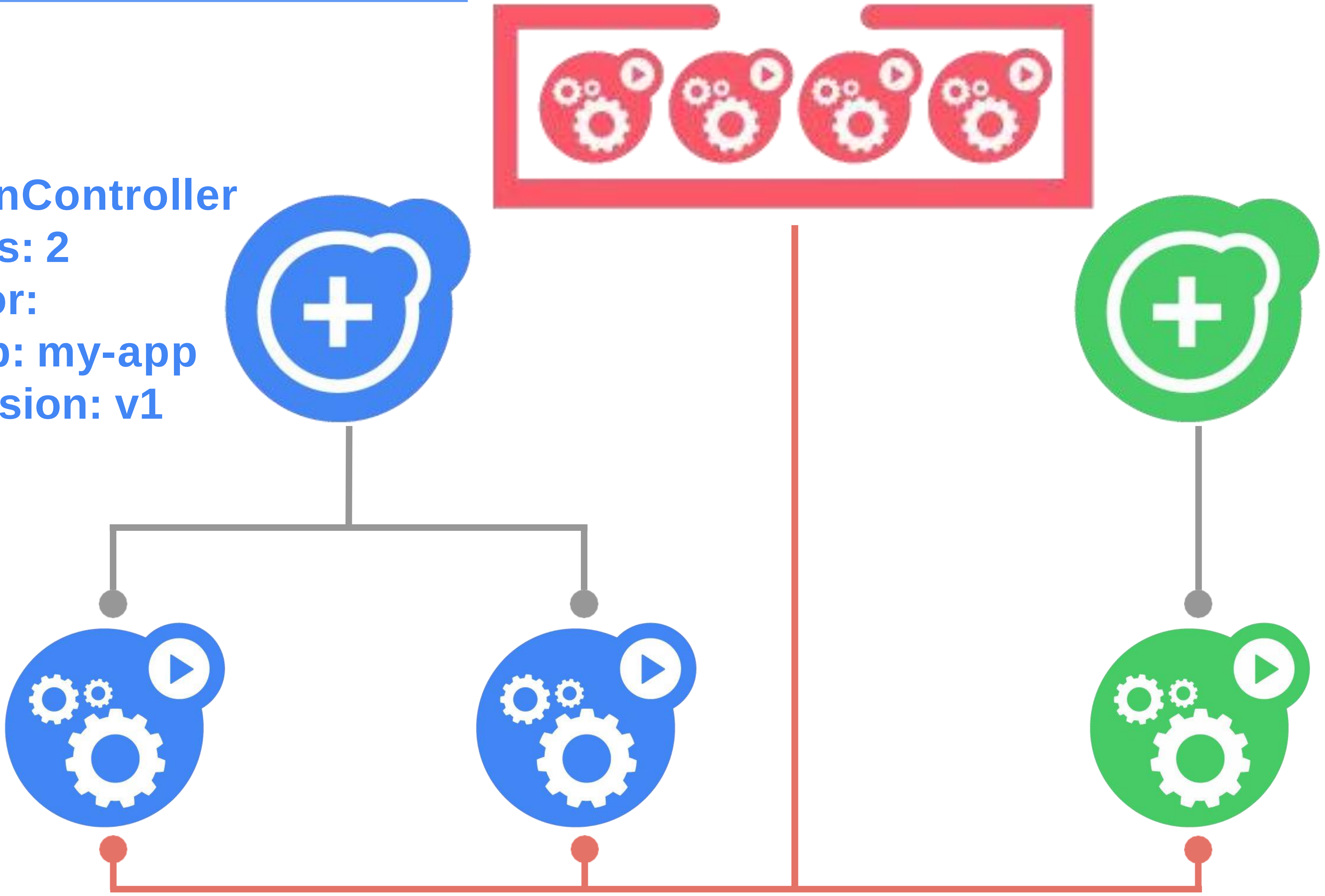
ReplicationController
- replicas: 1
- selector:
  - app: my-app
  - version: v2

Rolling Updates

Service
- app: my-app

ReplicationController
- replicas: 2
- selector:
  - app: my-app
  - version: v1

ReplicationController
- replicas: 1
- selector:
  - app: my-app
  - version: v2

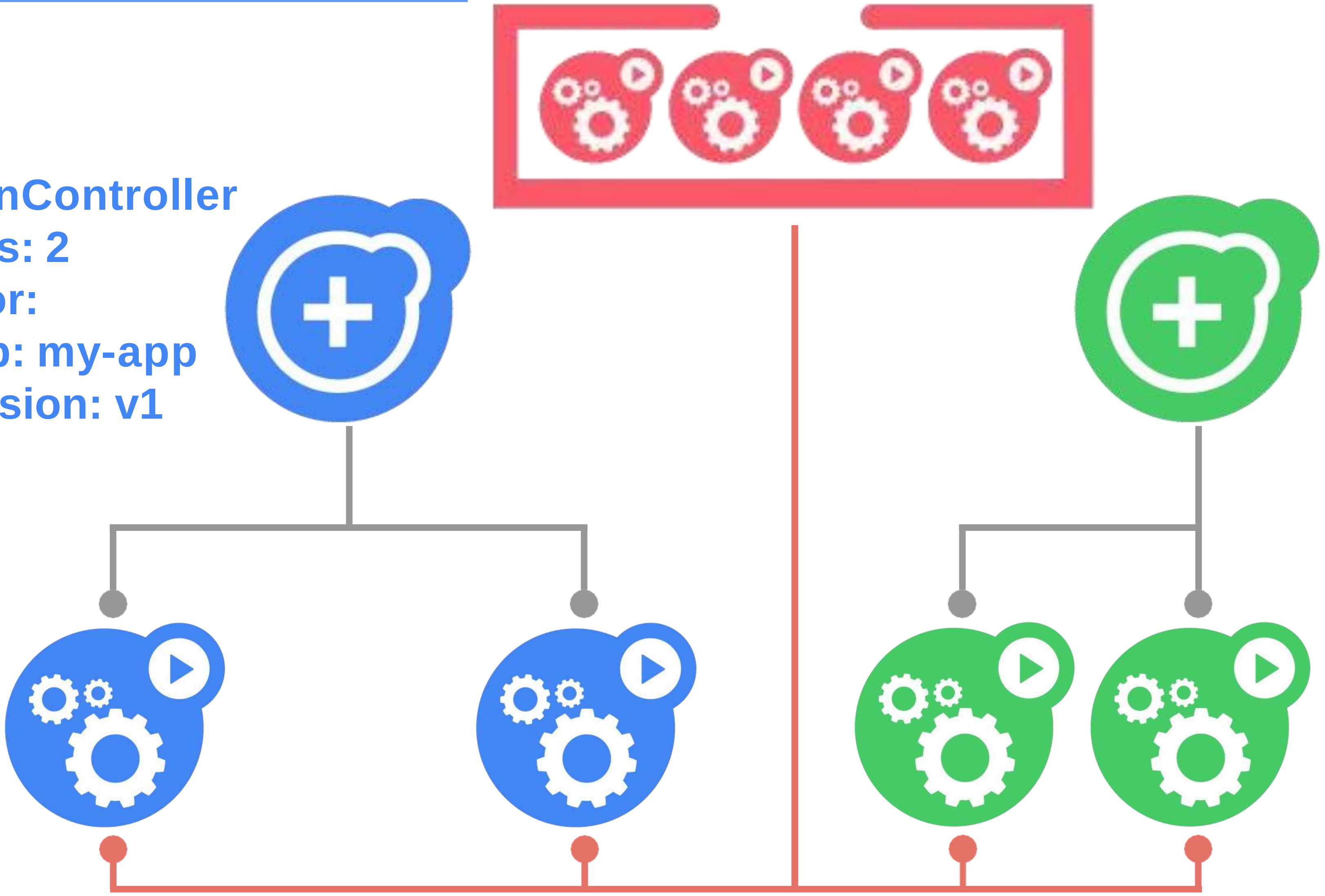


Rolling Updates

Service
- **app: my-app**

ReplicationController
- **replicas: 2**
- **selector:**
    - **app: my-app**
    - **version: v1**

ReplicationController
- **replicas: 2**
- **selector:**
    - **app: my-app**
    - **version: v2**



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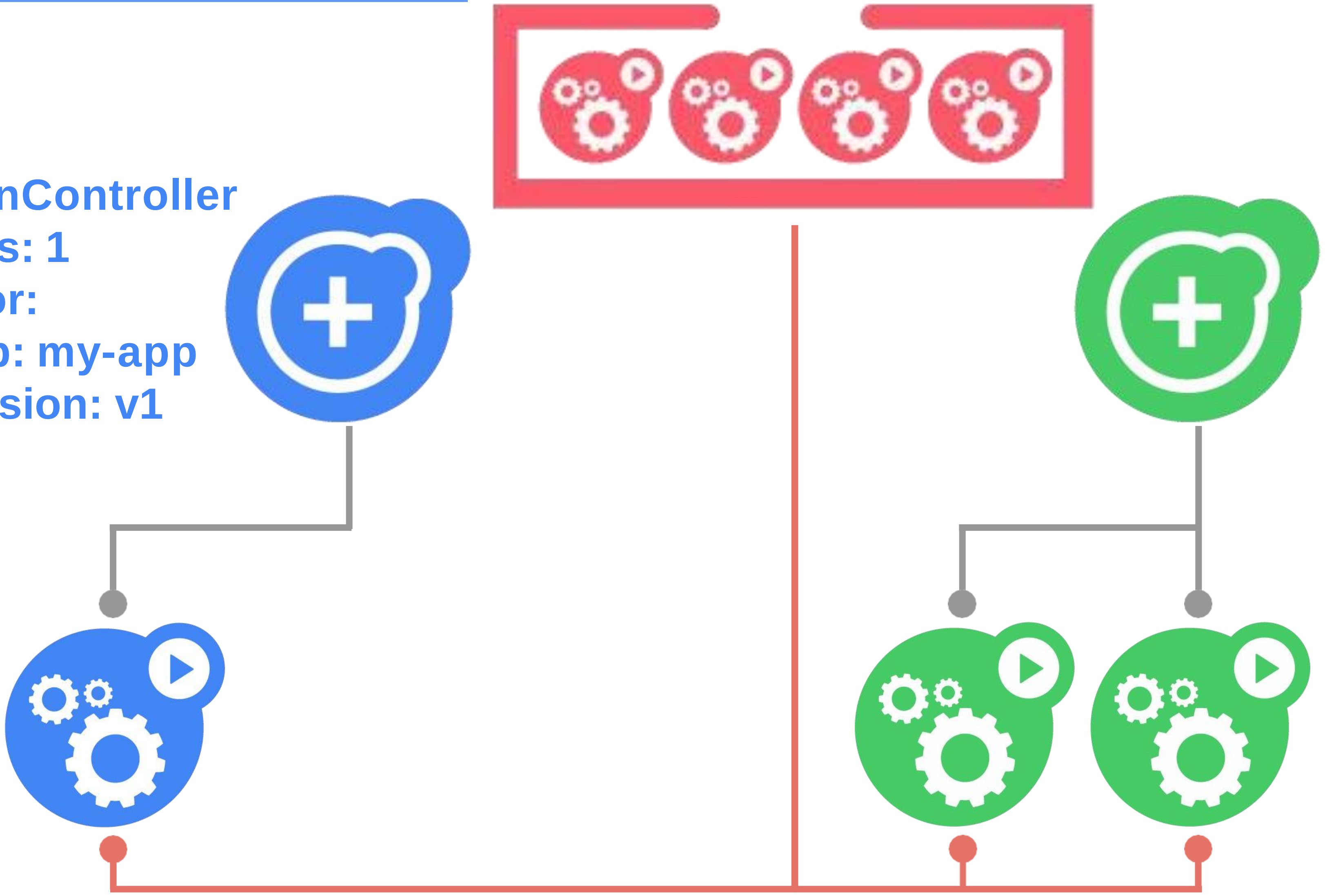

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ReplicationController
- replicas: 1
- selector:
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ReplicationController
- replicas: 2
- selector:
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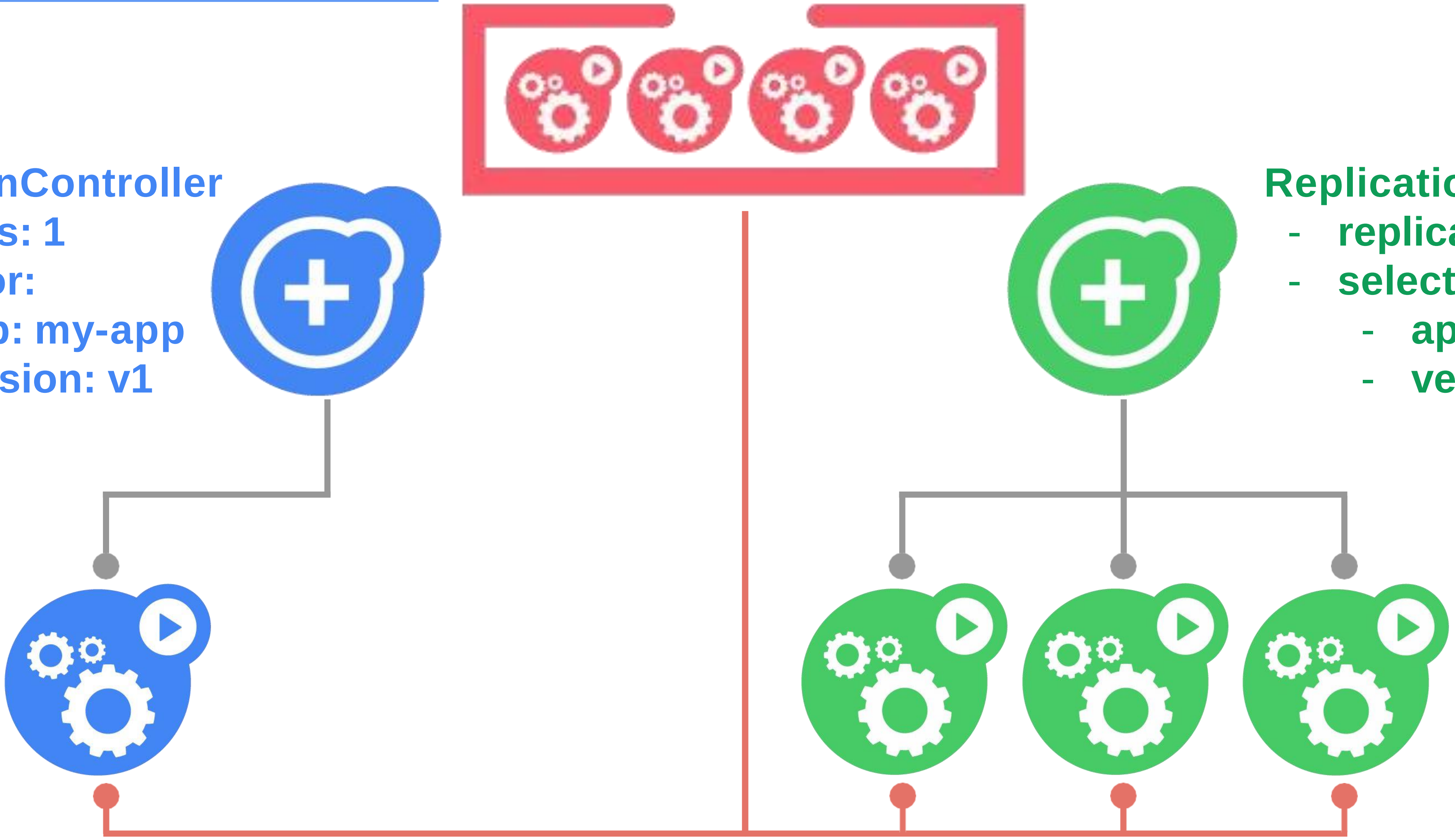
  - version: v2

Rolling Updates



Service
- app: my-app

ReplicationController
- replicas: 1
- selector:
  - app: my-app
  - version: v1

ReplicationController
- replicas: 3
- selector:
  - app: my-app
  - version: v2

Rolling Updates

Service

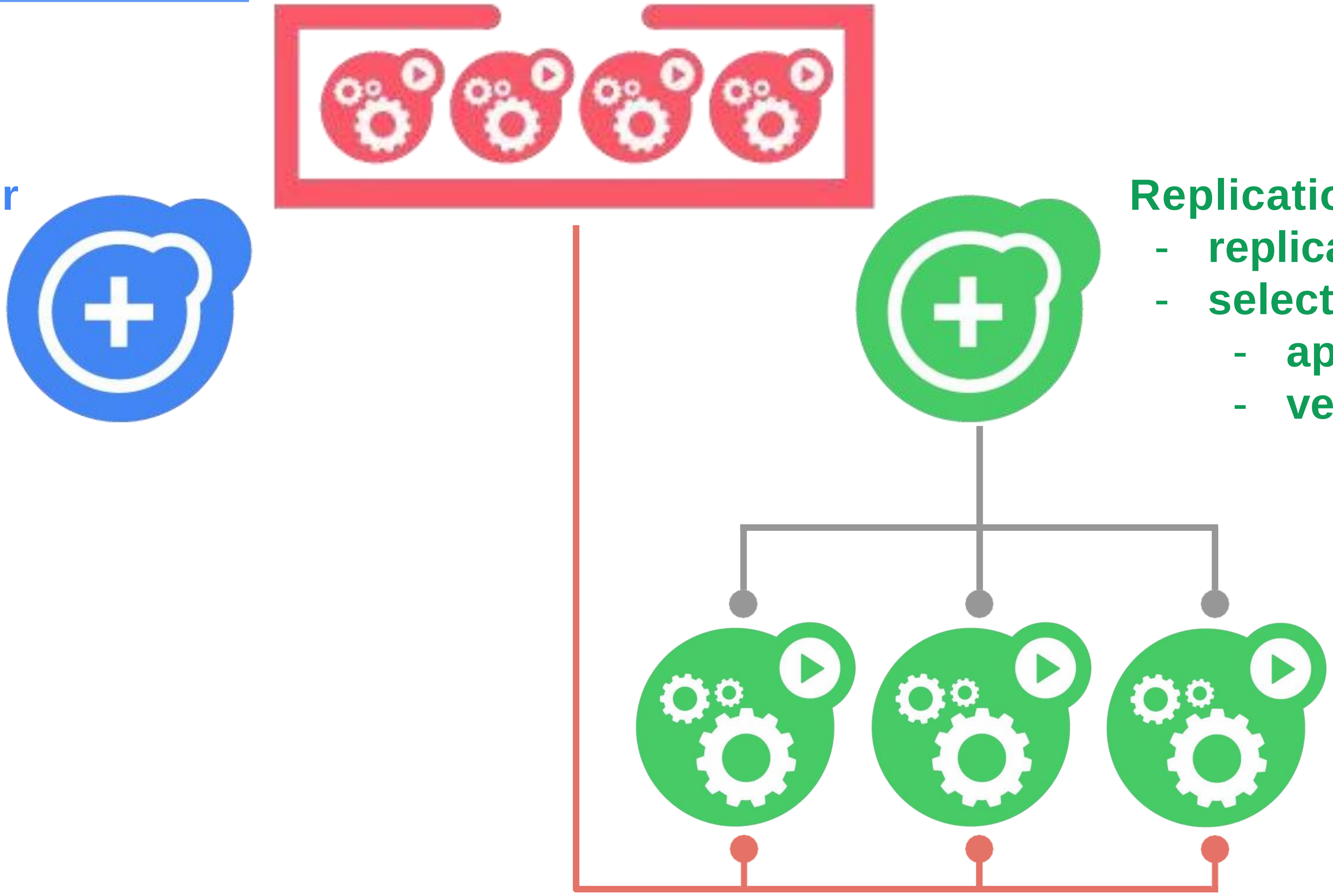
- **app: my-app**

ReplicationController

- **replicas: 0**
- **selector:**
    - **app: my-app**
    - **version: v1**

ReplicationController

- **replicas: 3**
- **selector:**
    - **app: my-app**
    - **version: v2**



New controllers in v1.1

Jobs

Manages pods that run to completion

- differentiates number running at any one time from the total number of completed runs

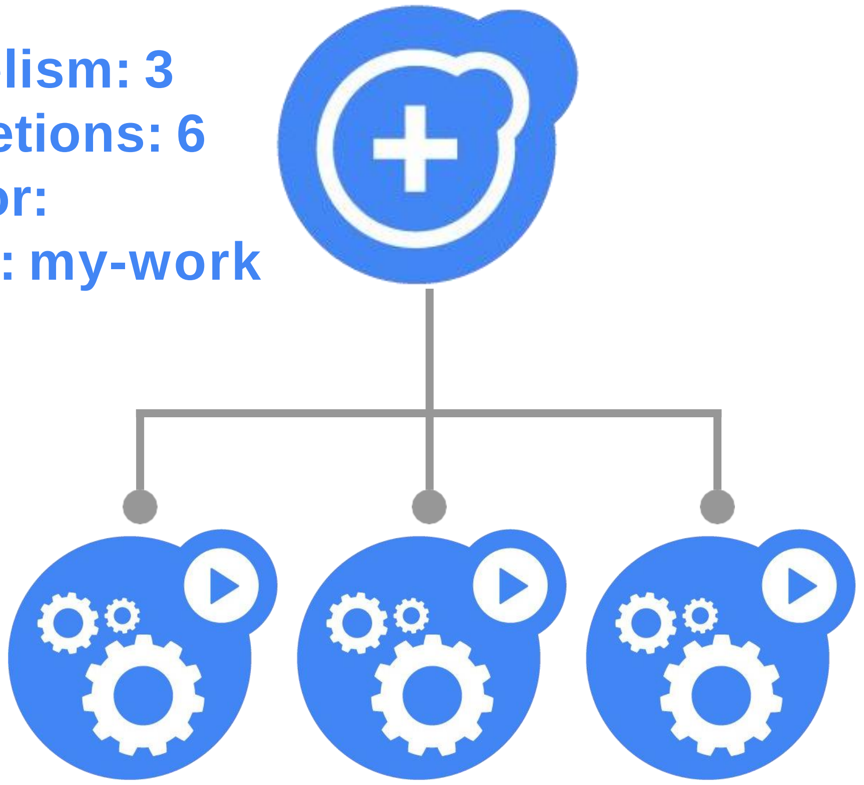
Similar to ReplicationController, but for pods that don't always restart

- workflow: restart on failure
- build/test: don't restart on app. failure

Principle: do one thing, don't overload

Status: **BETA** in Kubernetes v1.1

Job
- parallelism: 3
- completions: 6
- selector:
  - job: my-work



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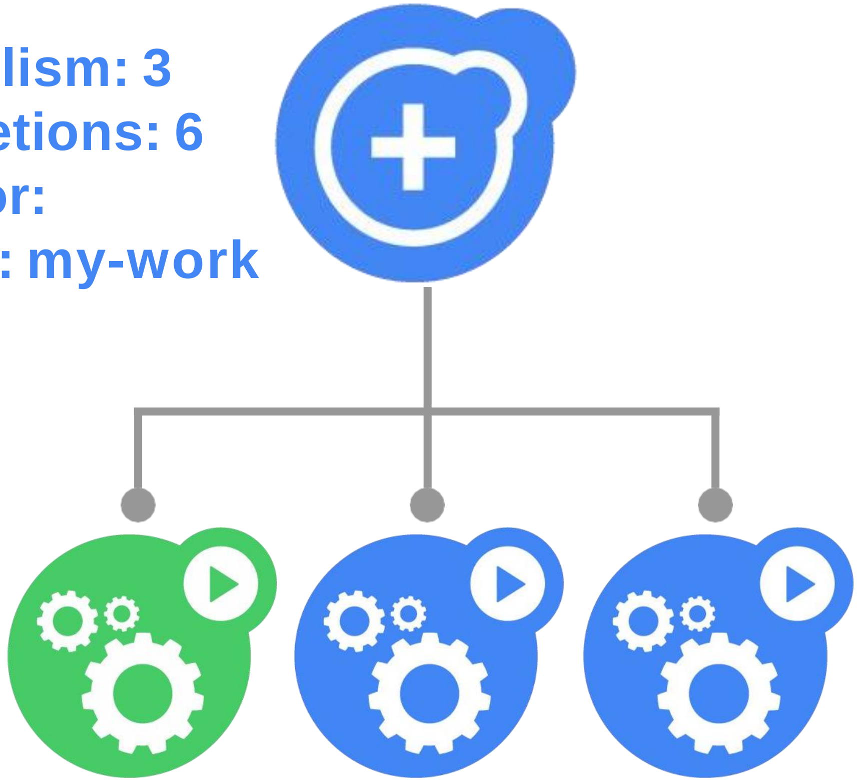

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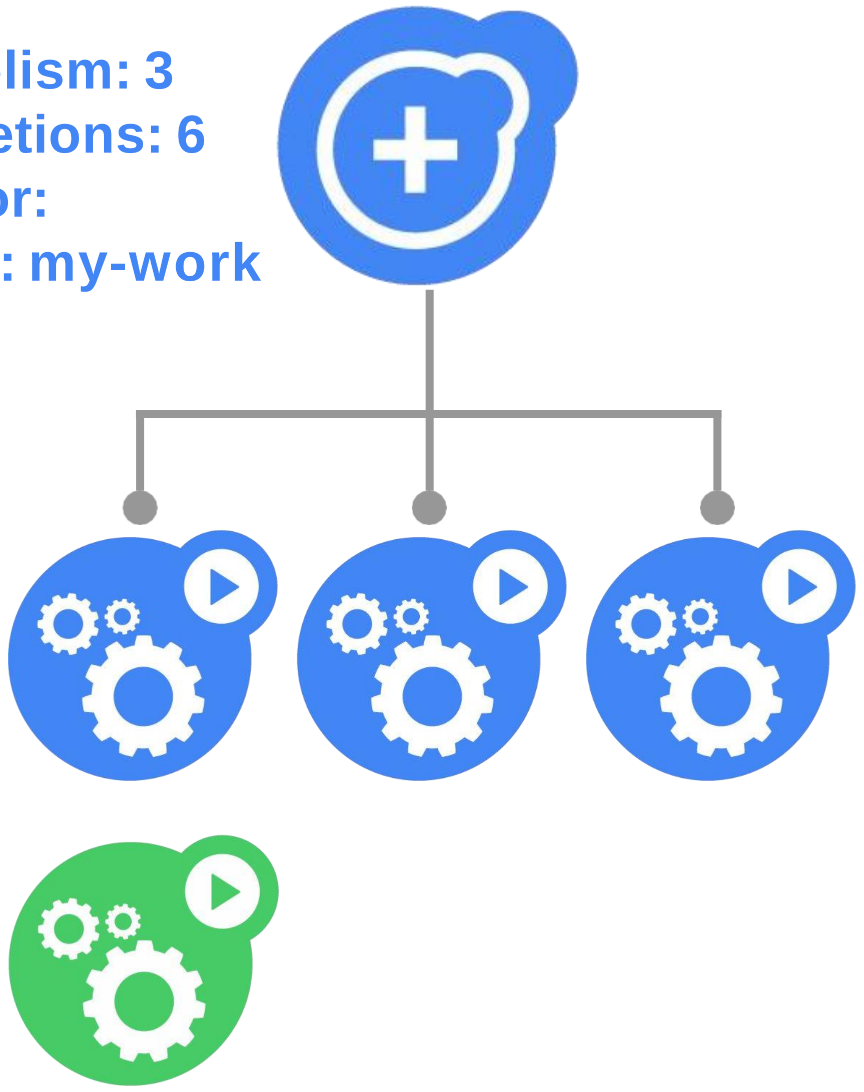

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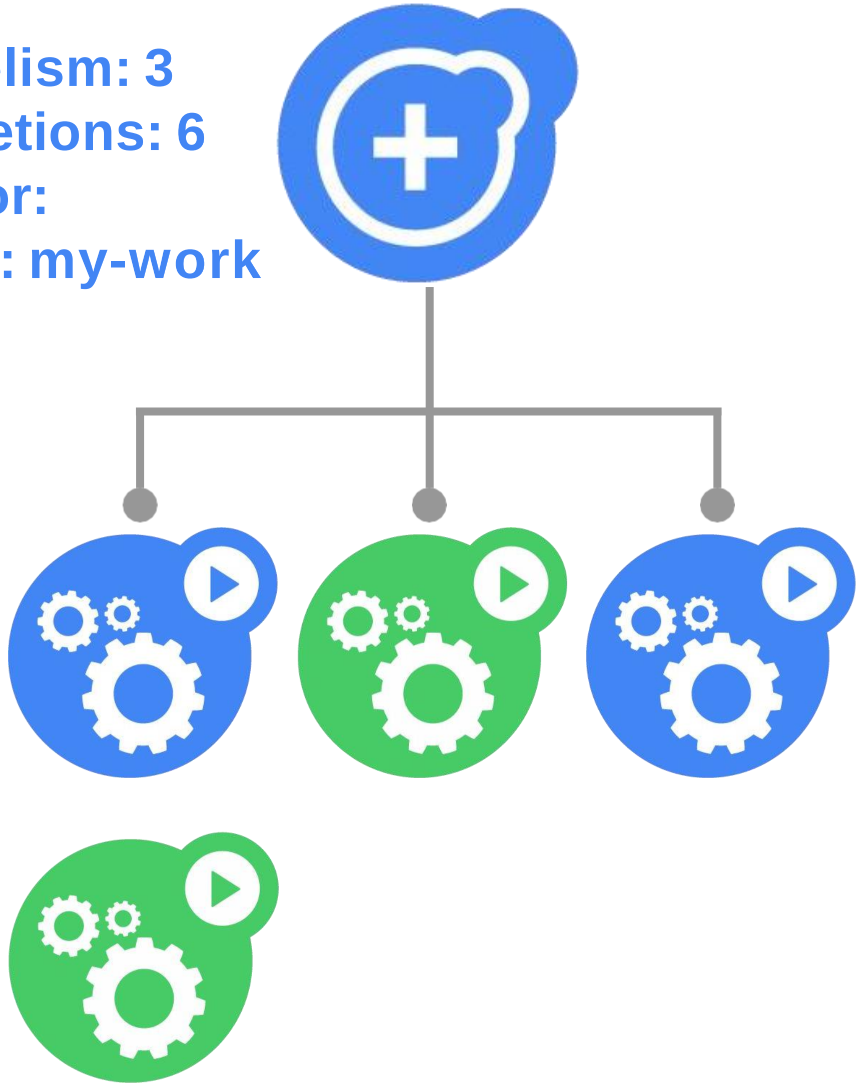

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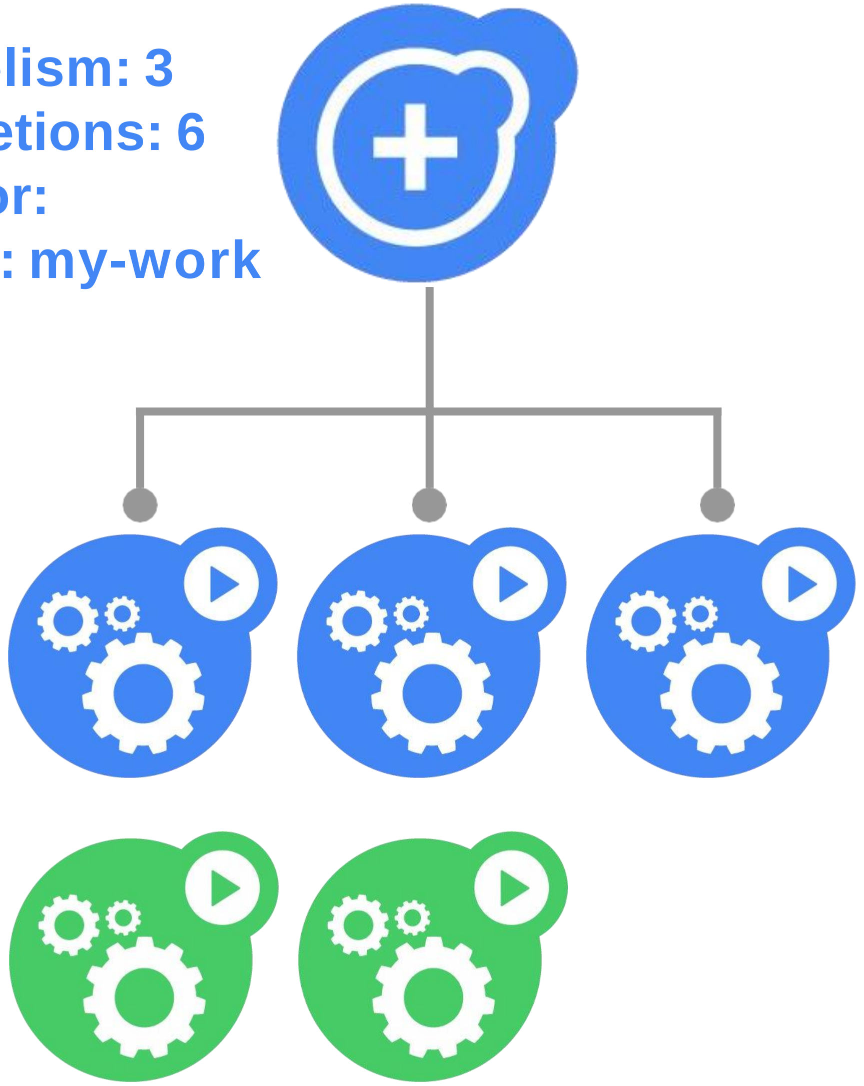

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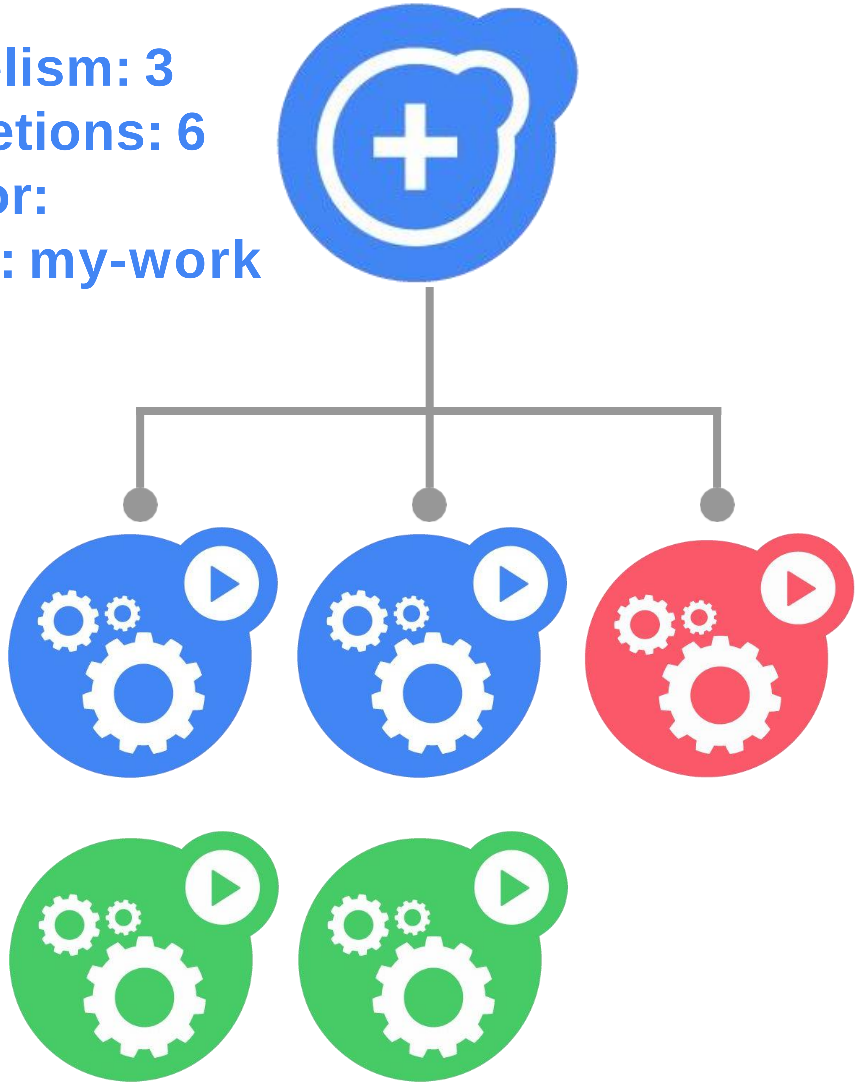

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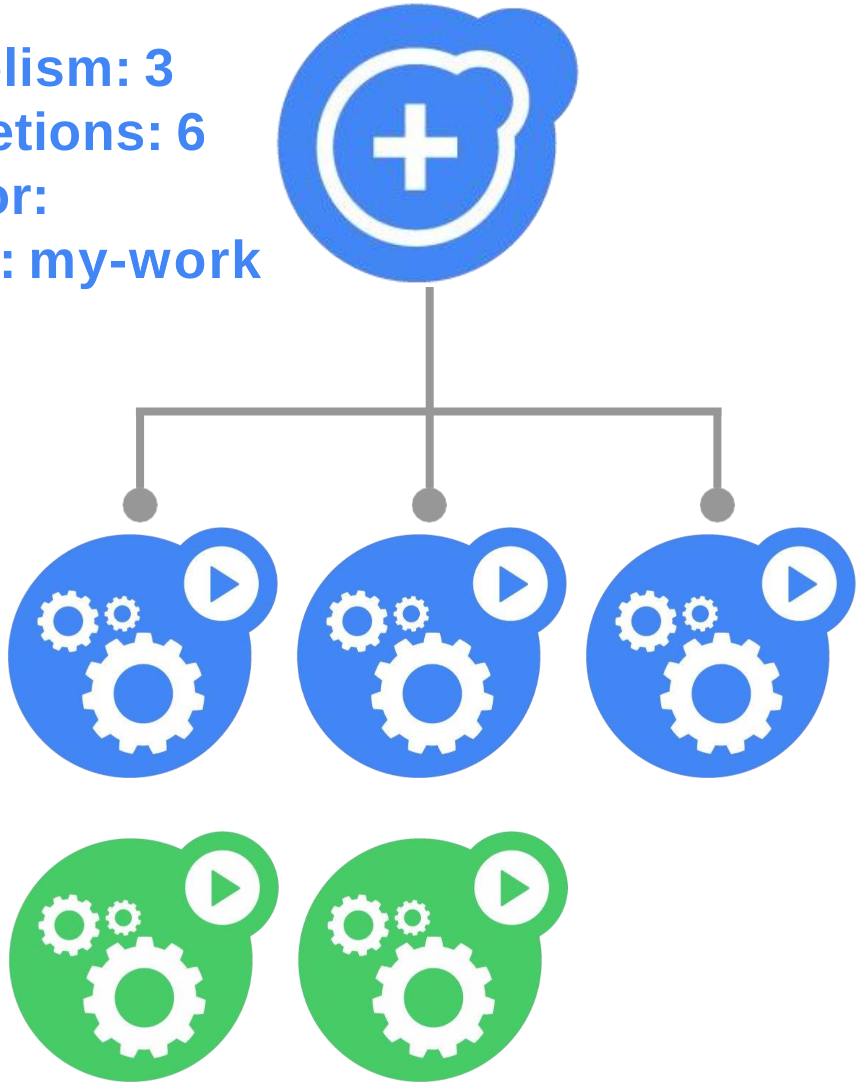

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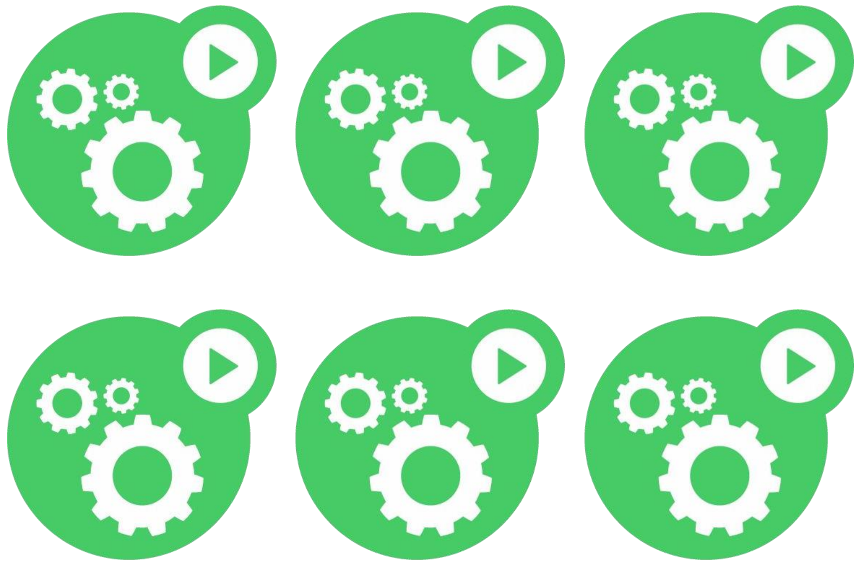


DaemonSets

Runs a Pod on every node

- or a selected subset of nodes

Not a fixed number of replicas

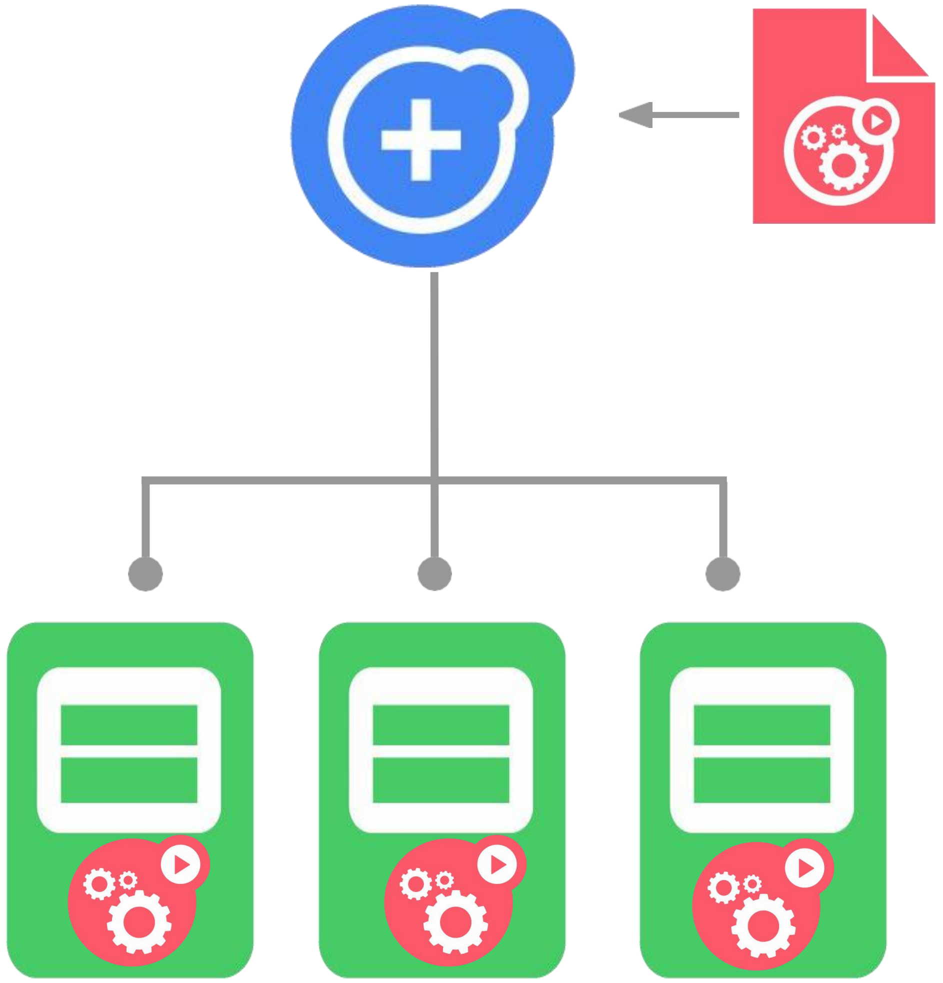
- created and deleted as nodes come and go

Useful for running cluster-wide services

- logging agents
- storage systems

DaemonSet manager is both a controller and scheduler

Status: **ALPHA** in Kubernetes v1.1



Deployment

Rollouts as a service

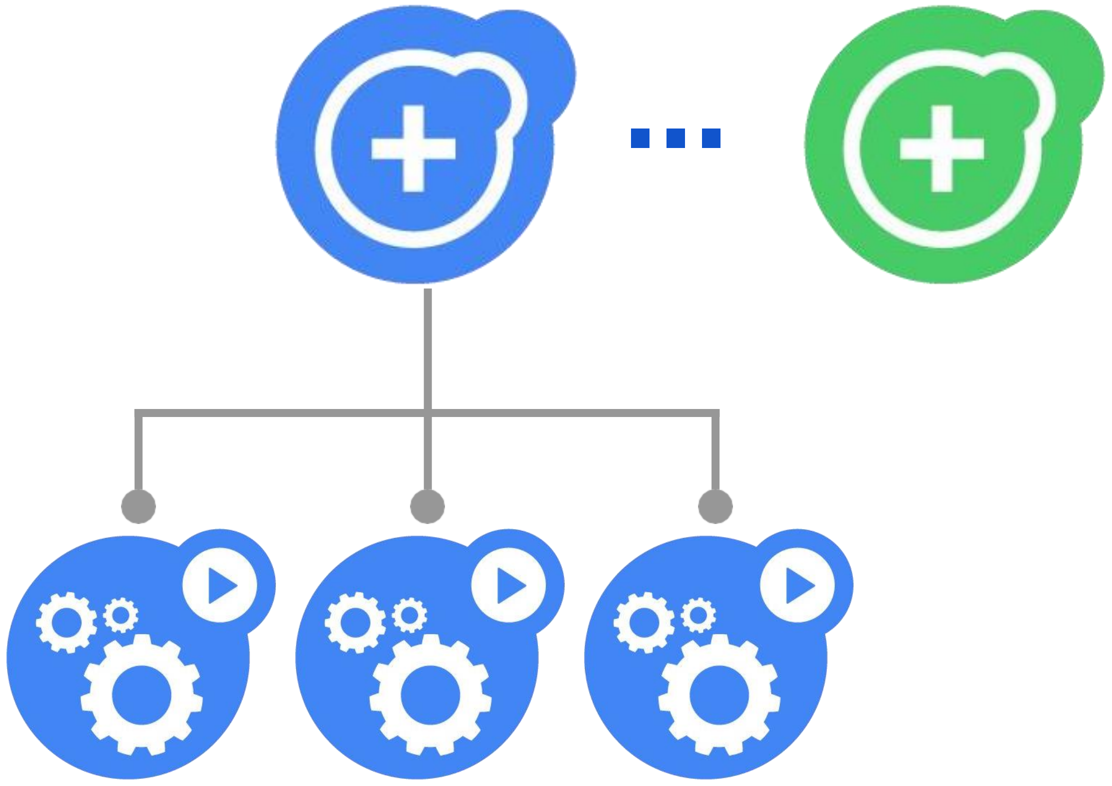
- updates to pod template will be rolled out by controller
- can choose between rolling update and recreate

Enables declarative updates

- manipulates replication controllers and pods so clients don't have to

Status: **ALPHA** in Kubernetes v1. 1

Deployment
- **strategy: {type: RollingUpdate}**
- **replicas: 3**
- **selector:**
  - **app: my-app**



Conclusion

Take away

- Decoupling applications from infrastructure creates new opportunities
- Kubernetes
    - is container-centric infrastructure
        - which includes a lot more than just running containers
    - facilitates management of containers in production
    - provides a foundation for building a workload-management ecosystem
- This has enabled Platform as a Service systems to be built on Kubernetes
    - Apache Stratos
    - Openshift 3: co-designed and co-developed with Kubernetes
    - Deis: Heroku-inspired Docker-based PaaS
    - Gondor: Python-aaS

Kubernetes is **Open**

- open community
- open design
- open source
- open to ideas

http://kubernetes.io
https://github.com/kubernetes/kubernetes slack: kubernetes
twitter: @kubernetesio

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Thank You

Design principle summary

Declarative > imperative: State your desired results, let the system actuate

Control loops: Observe, rectify, repeat

Simple > Complex: Try to do as little as possible

Modularity: Components, interfaces, & plugins

Legacy compatible: Requiring apps to change is a <u>non-starter</u>

Network-centric: IP addresses are cheap **No**

grouping: Labels are the <u>only</u> groups **Cattle >**

Pets: Manage your workload in bulk

Open > Closed: Open Source, standards, REST, JSON, etc.