Kubernetes 101/201

邓德源 才云科技

Kubernetes API design

API definition

```
apiVersion: v1
kind: Pod
metadata:
    namespace: default
spec:
    containers:
    dnsPolicy: ClusterFirst
    nodeName: i-2zea47skez7ye2xr438v
    restartPolicy: Always
    securityContext: {}
    serviceAccount: default
    serviceAccountName: default
    terminationGracePeriodSeconds: 30
    volumes: xxx
status:
    conditions: xxx
    hostIP: 10.44.164.150
    phase: Running
    podIP: 192.168.79.9
    startTime: 2016-11-22T14:54:57Z
```

kubernetes 大版本号

```
apiVersion: v1
kind: Node
metadata:
    labels:
      beta.kubernetes.io/arch: amd64
      beta.kubernetes.io/os: linux
      kubernetes.io/hostname: minikube
    name: minikube
    resourceVersion: "1027609"
    selfLink: /api/v1/nodesminikube
    uid: 21ffcb42-0f69-11e7-a9ff-080027e561ba
spec:
    externalID: minikube
status:
    addresses:
    - address: 192.168.99.101
      type: LegacyHostIP
    - address: 192.168.99.101
      type: InternalIP
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资源类型

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资源说明书，配置

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资源状态

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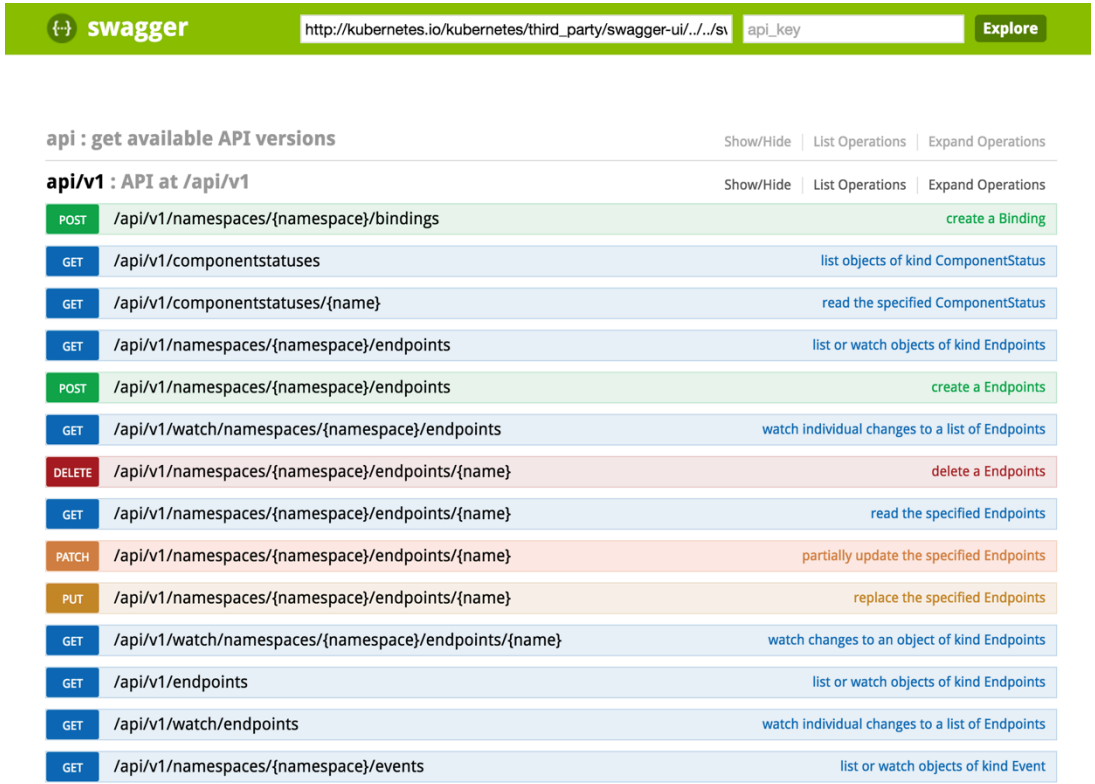
API endpoints

http://kubernetes.io/kubernetes/third_party/swagger-ui/#/



API group

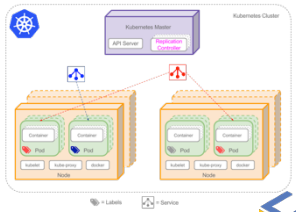
- 每个 API group 中的资源可以单独的 enable/disable
- 每个 API group 有不同的版本，单独开发维护


```
{
  "paths": [
    "/api",
    "/api/v1",
    "/apis",
    "/apis/apps",
    "/apis/apps/v1alpha1",
    "/apis/authentication.k8s.io",
    "/apis/authentication.k8s.io/v1beta1",
    "/apis/authorization.k8s.io",
    "/apis/authorization.k8s.io/v1beta1",
    "/apis/autoscaling",
    "/apis/autoscaling/v1",
    "/apis/batch",
    "/apis/batch/v1",
    "/apis/batch/v2alpha1",
    "/apis/certificates.k8s.io",
    "/apis/certificates.k8s.io/v1alpha1",
    "/apis/extensions",
    "/apis/extensions/v1beta1",
    "/apis/k8s.io",
    "/apis/k8s.io/v1",
    "/apis/policy",
    "/apis/policy/v1alpha1",
    "/apis/rbac.authorization.k8s.io",
    "/apis/rbac.authorization.k8s.io/v1alpha1",
    "/apis/storage.k8s.io",
    "/apis/storage.k8s.io/v1beta1",
    "/healthz",
    "/healthz/ping",
    "/logs",
    "/metrics",
    "/swaggerapi/",
    "/ui/",
    "/version"
  ]
}
```

API example: Pod Health Check

```yaml
apiVersion: extensions/v1beta1
kind: Deployment
metadata:
  name: nginx
spec:
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
      - name: nginx
        image: nginx
        ports:
        - containerPort: 80
        livenessProbe:
          httpGet:
            # Path to probe; should be cheap, but representative of typical behavior
            path: /index.html
            port: 80
          initialDelaySeconds: 30
          timeoutSeconds: 1
```

POST to “/api/v1/namespaces/default/pods”

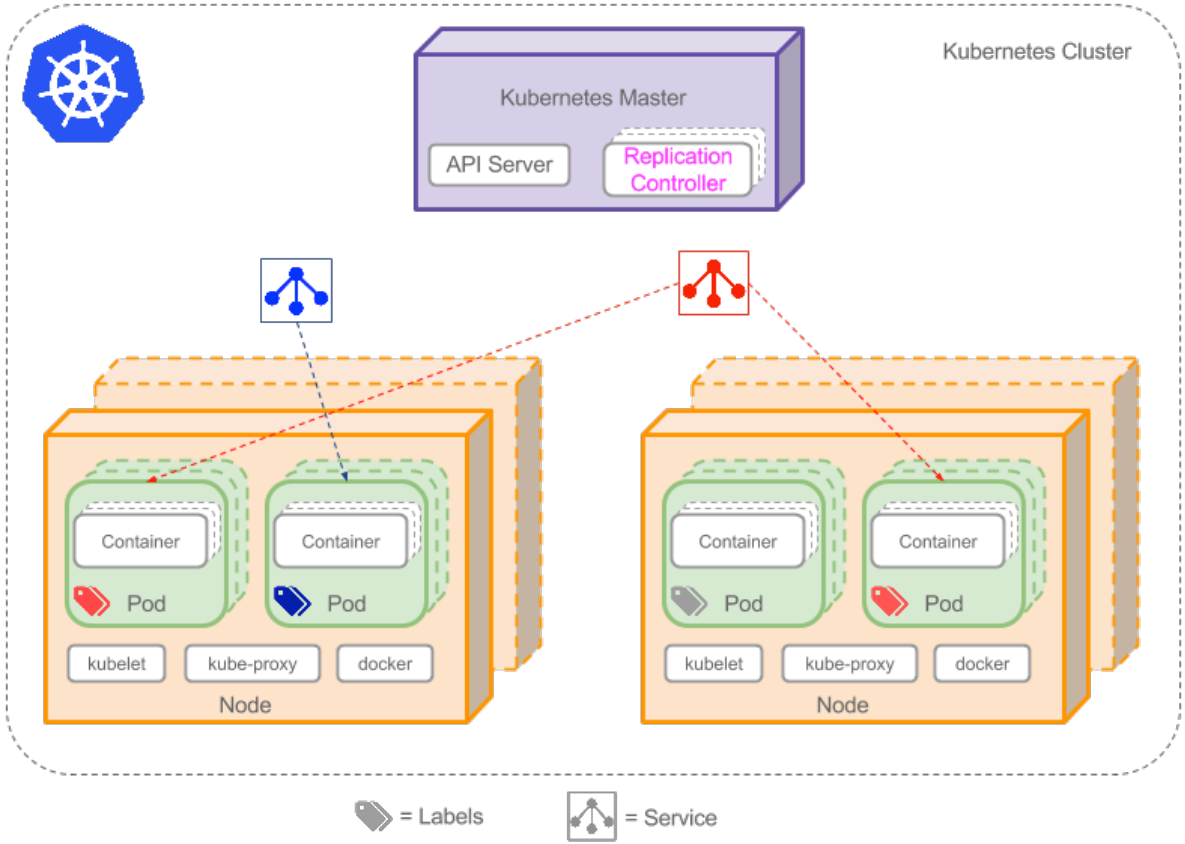


Kubernetes 架构与工作流程

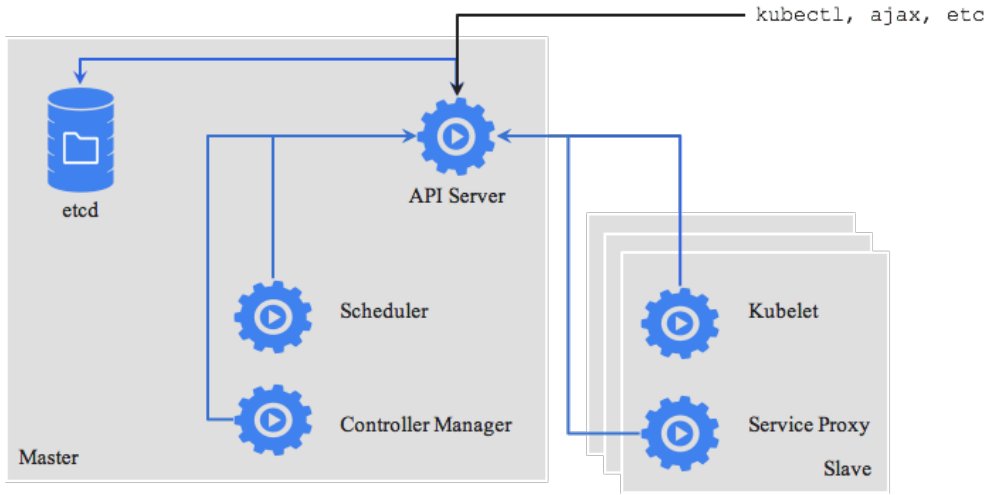
Kubernetes provides rich functionality set that can serve as building blocks to construct end to end solutions, and sky is the limit.

-- Xin Zhang

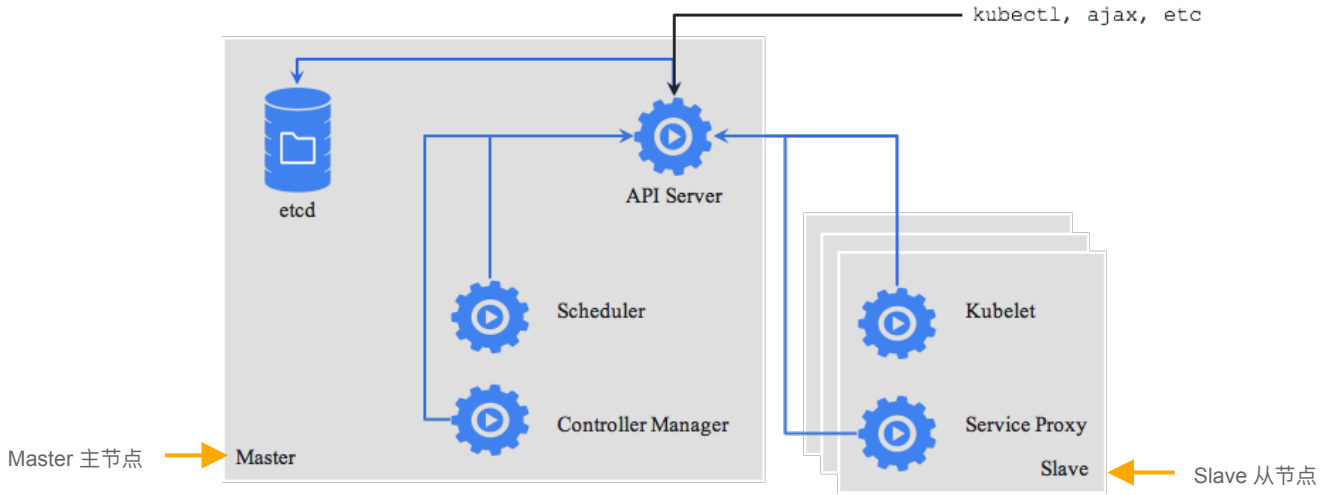
Kubernetes 架构



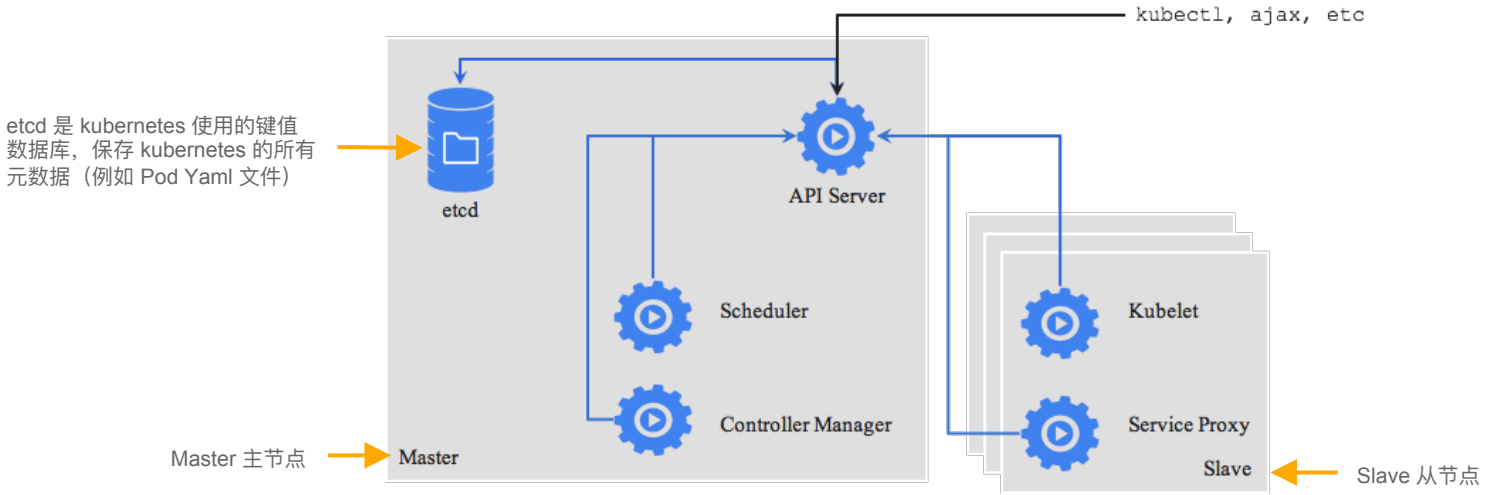
Kubernetes 架构



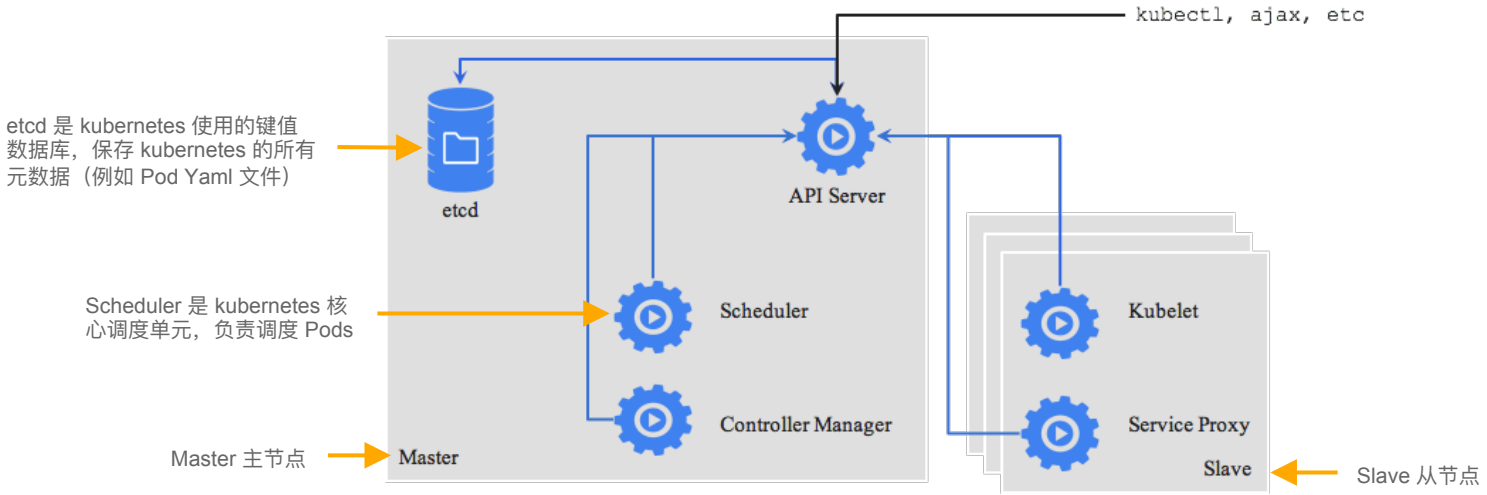
Kubernetes 架构



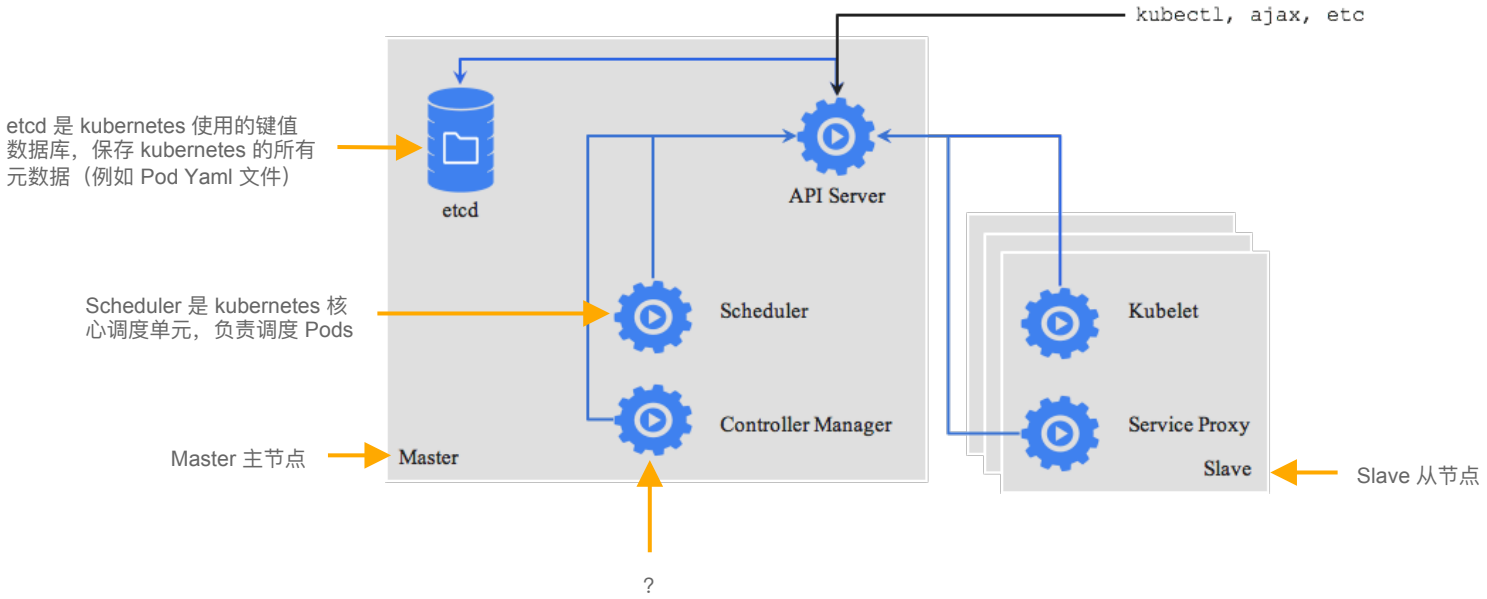
Kubernetes 架构



Kubernetes 架构



Kubernetes 架构



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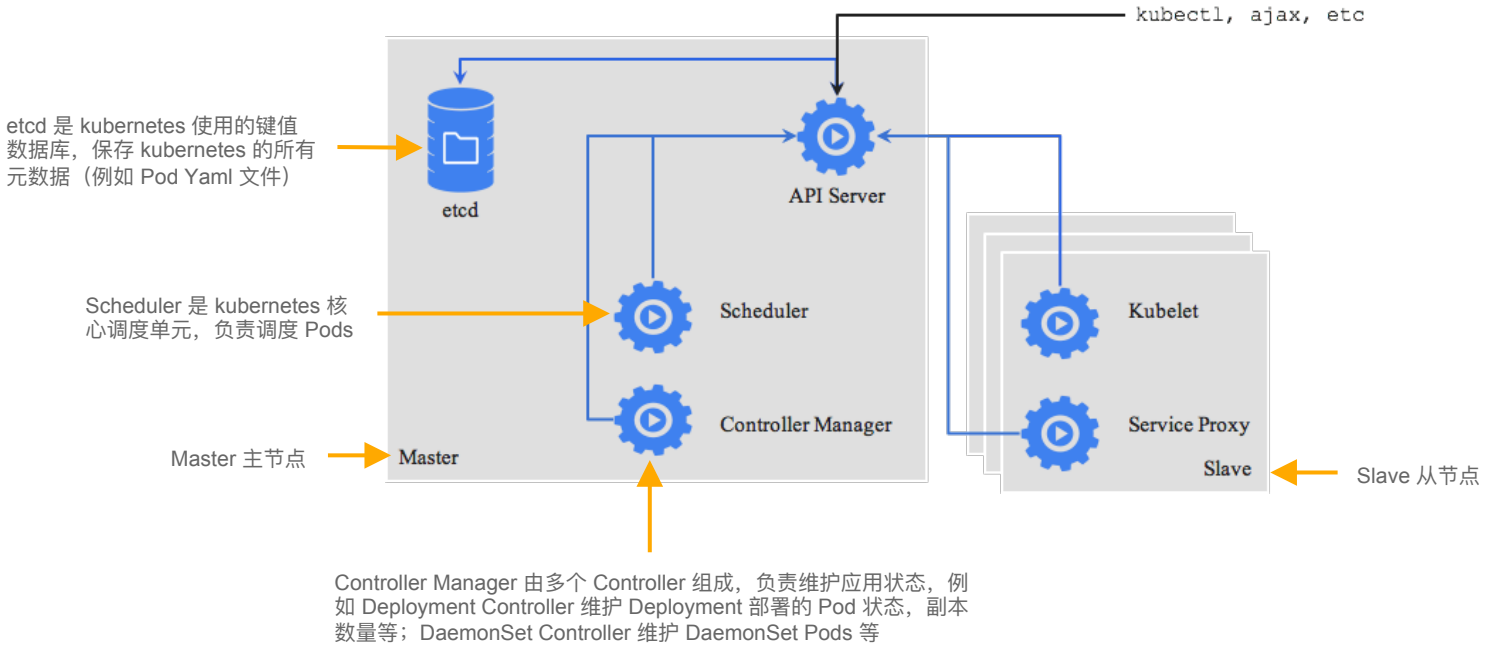

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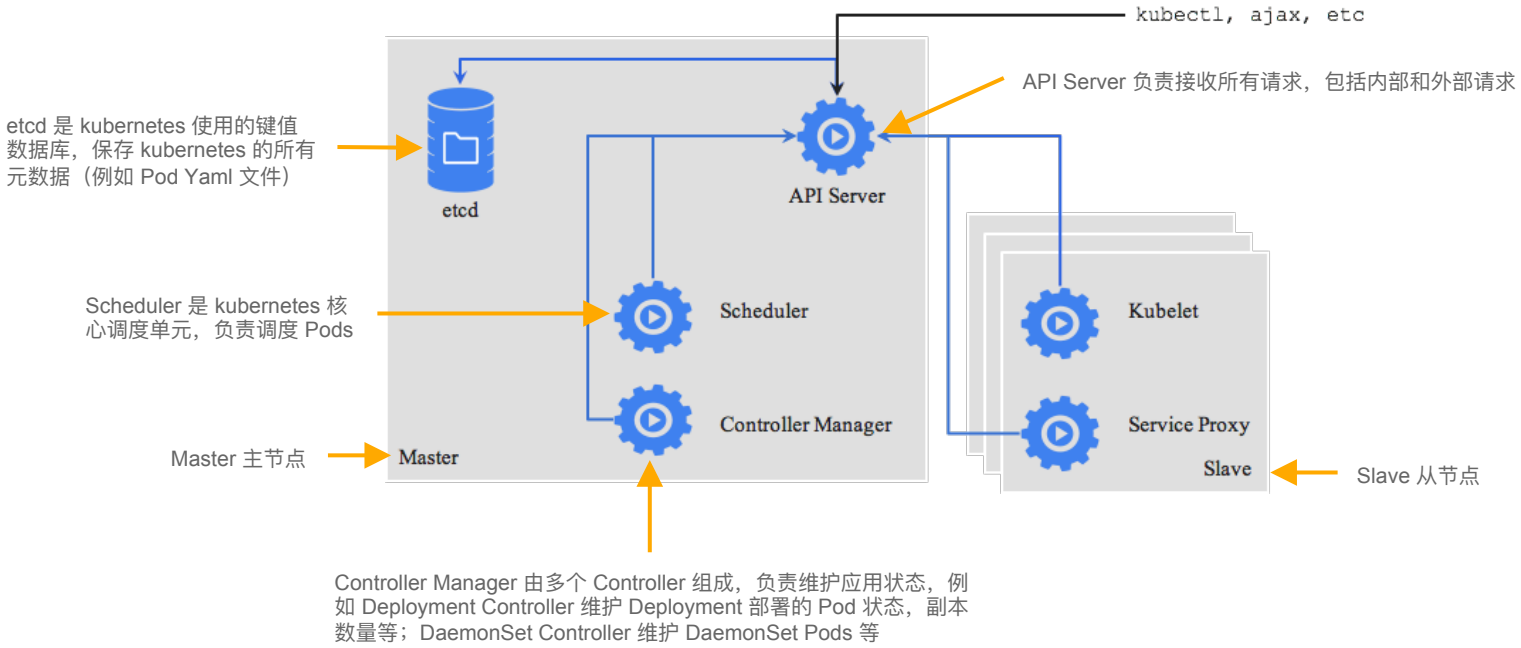

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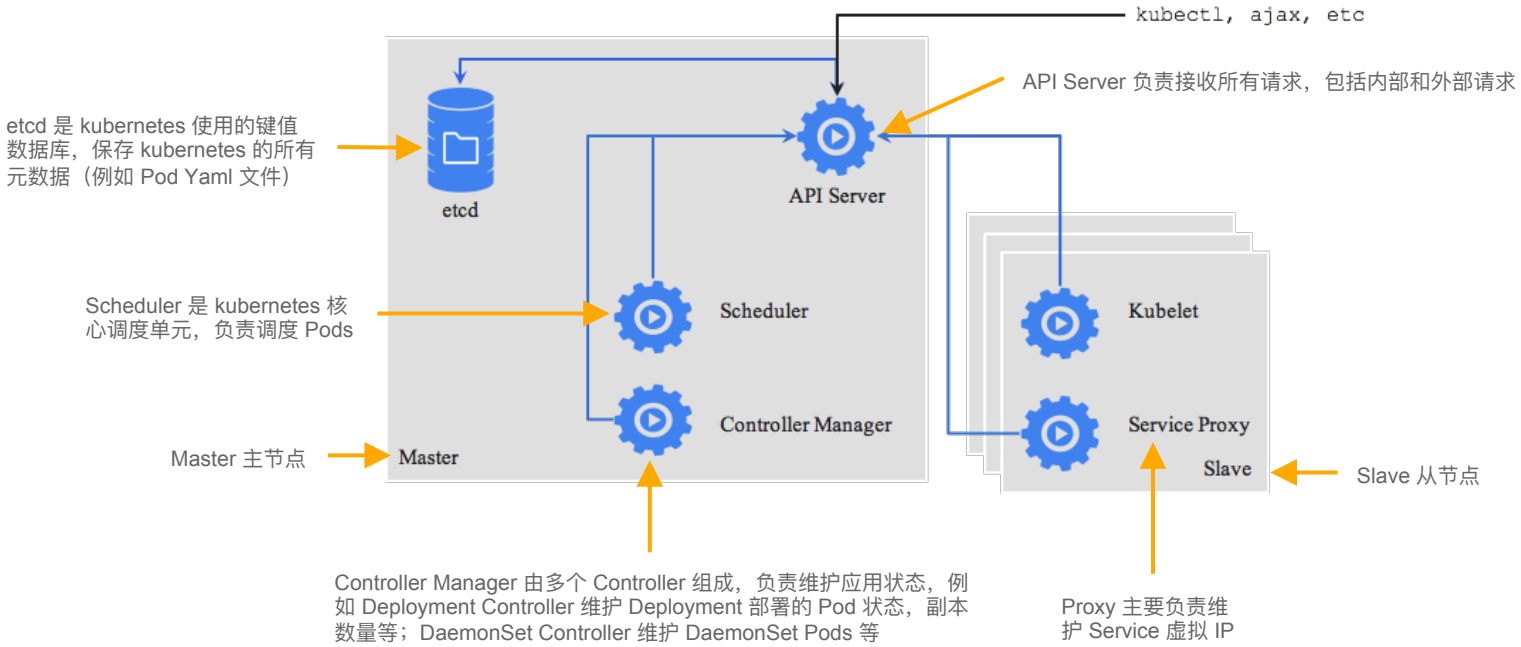
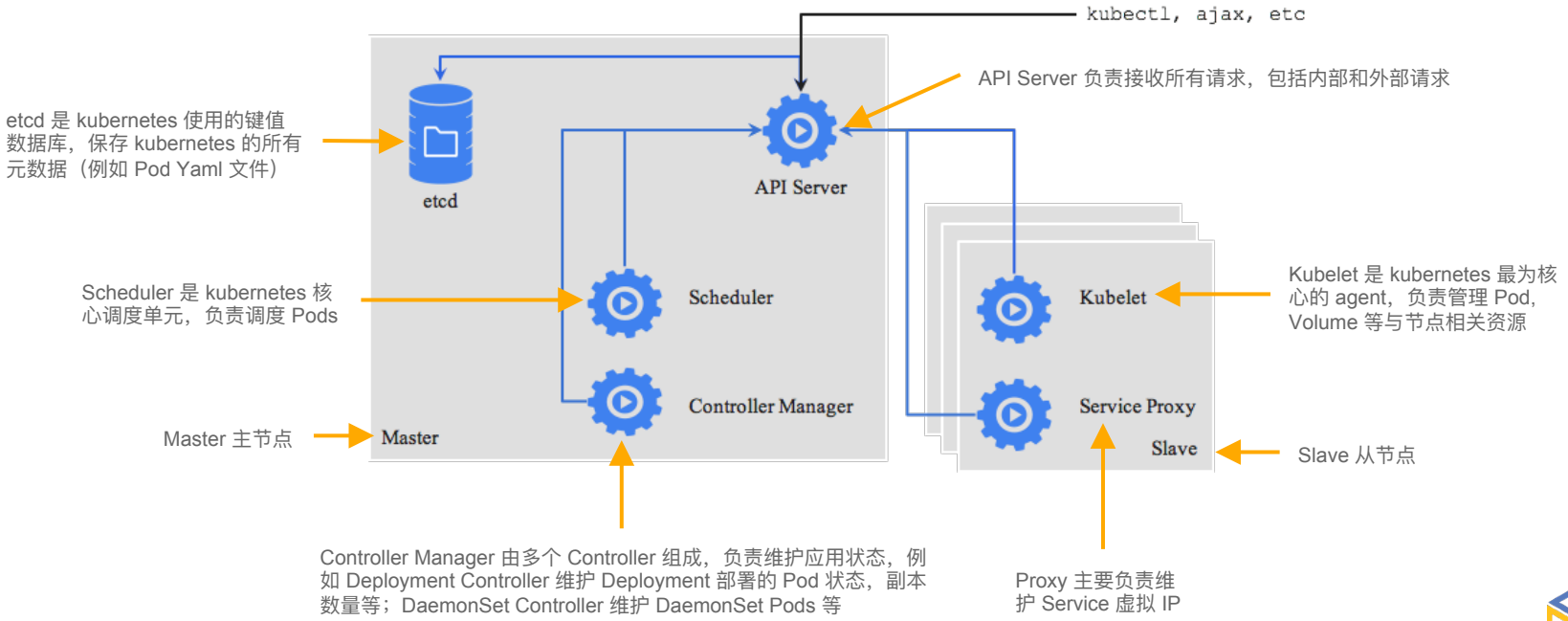


Kubernetes 架构



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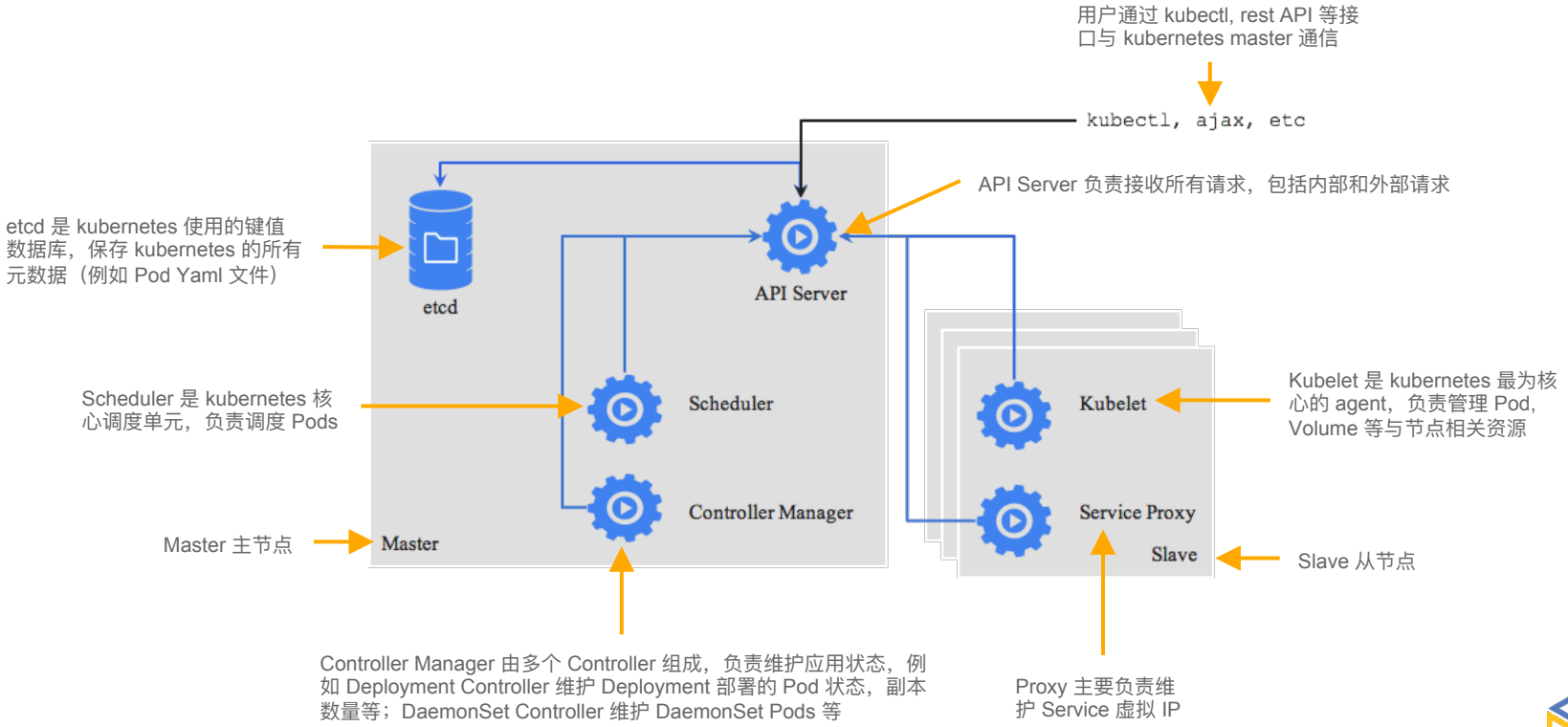

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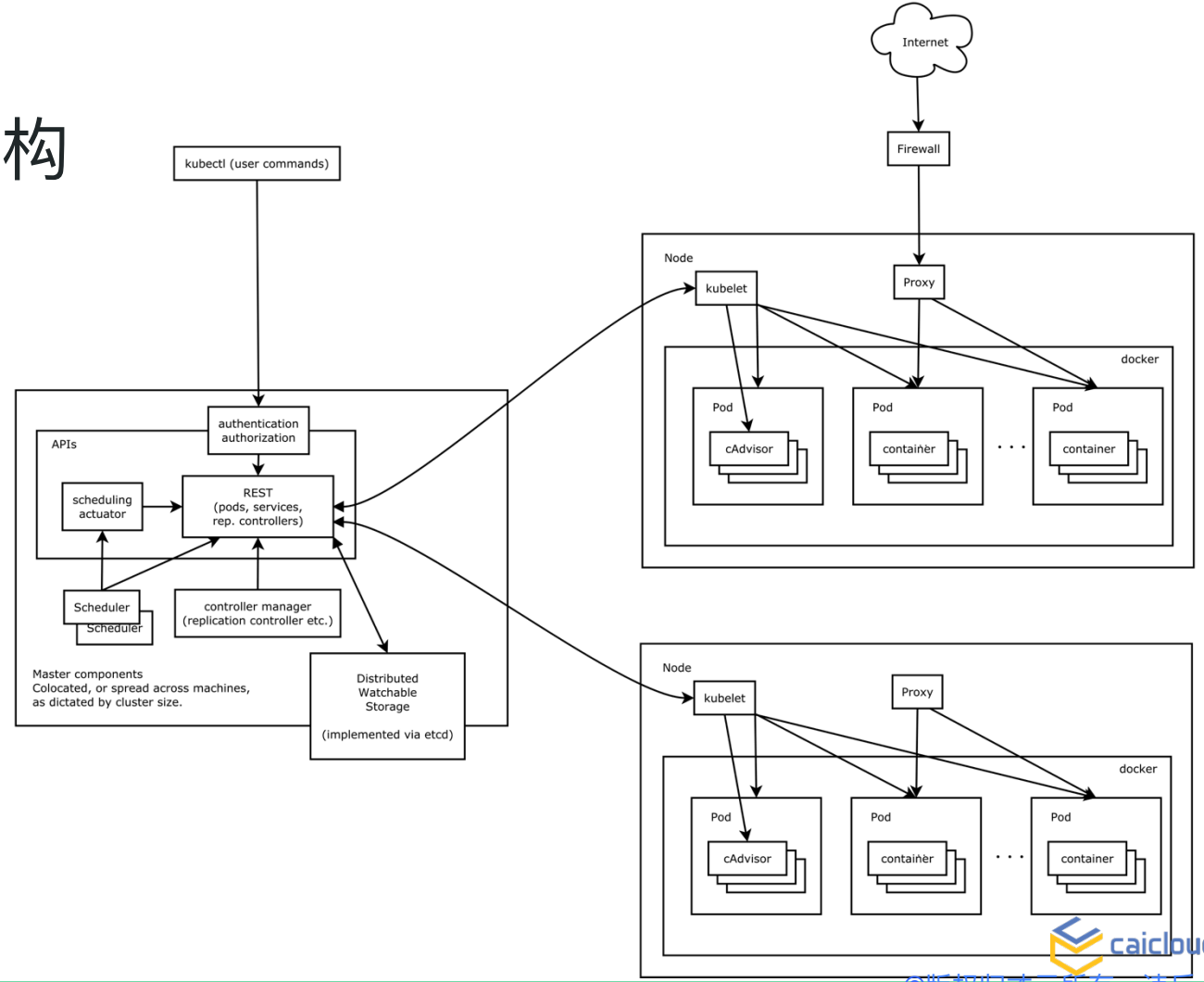


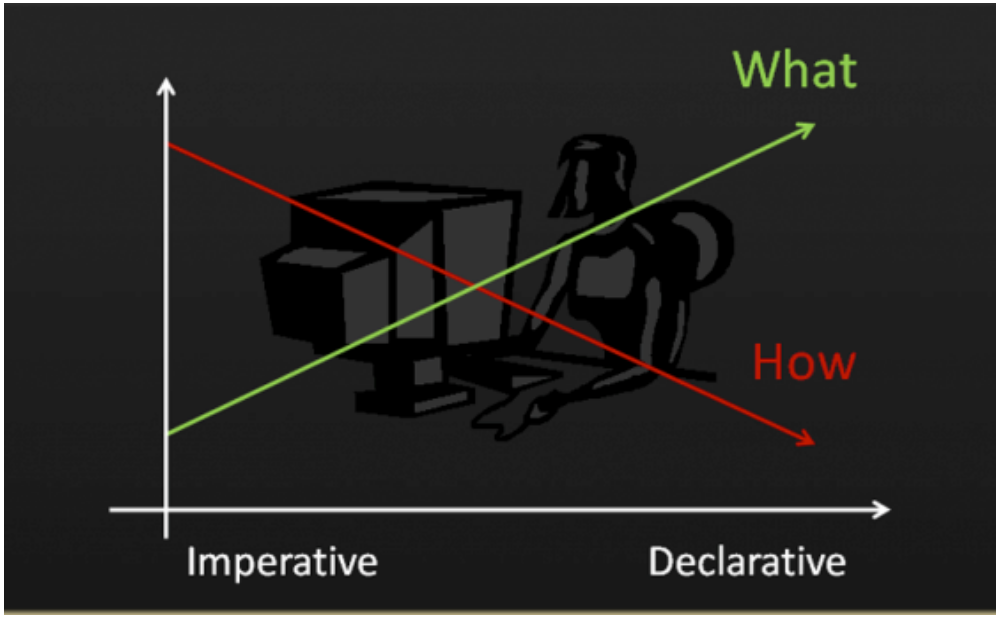
官方 Official 架构图

声明式 VS 命令式

声明式：告诉“机器”你想要的是什么(what)，让机器想出如何去做(how)。

命令式：命令“机器”如何去做(how)，这样不管你想要的是什么(what)，它都会按照你的命令实现。

- Example
  - Map 函数：将直接遍历整个数组的过程归纳抽离出来，让我们专注于描述我们想要的是什么(what)
  - Reduce 函数：抽离如何遍历数组和状态管理部分的实现，提供一个通用的方式把一个 list 合并成一个值。我们需要做的只是指明我们想要的是什么(what)

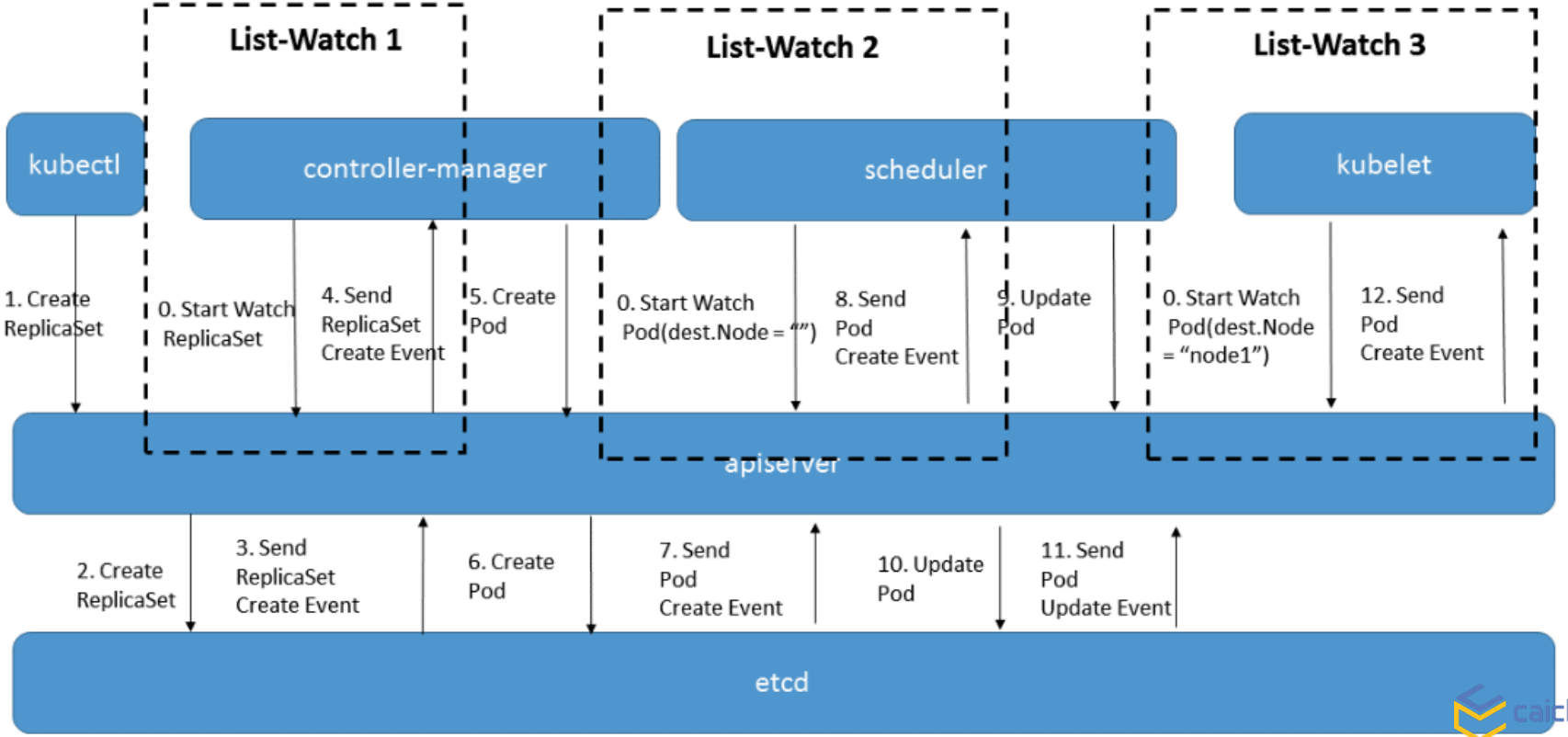


声明式操作在分布式系统中的好处：稳定，不怕丢操作或运行多次

Kubernetes 架构解析

- K8S 集群组成
  - 分布式存储（Etcd）
  - 控制节点（Master）
  - 工作节点（Node）
- 只有 apiserver 与存储通信
  - 用户直接访问 apiserver
  - 内部进程，包括 kubelet, controller 均通过 apiserver 访问存储
  - 出于安全考虑
- 配置管理操作声明式而非命令式

Apiserver list-watch



Kubernetes 工作流程

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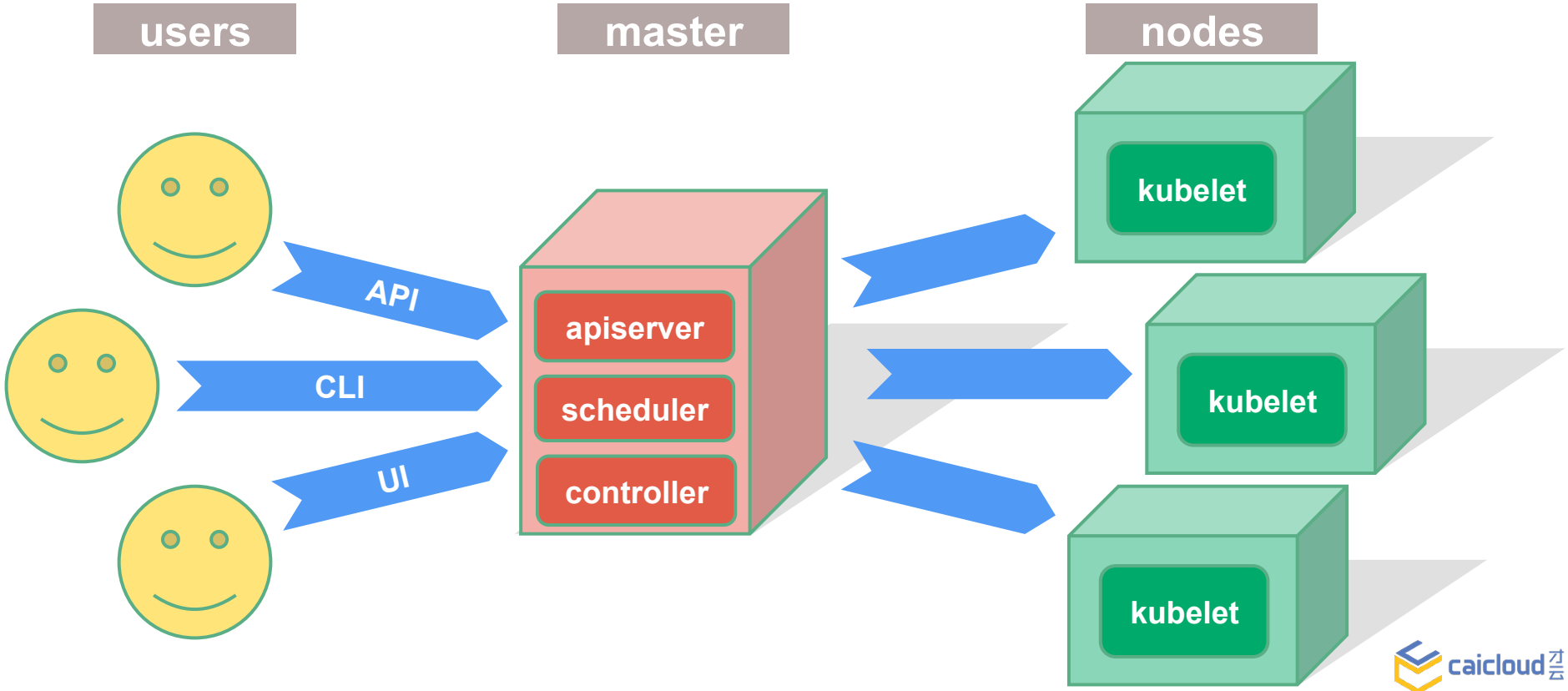

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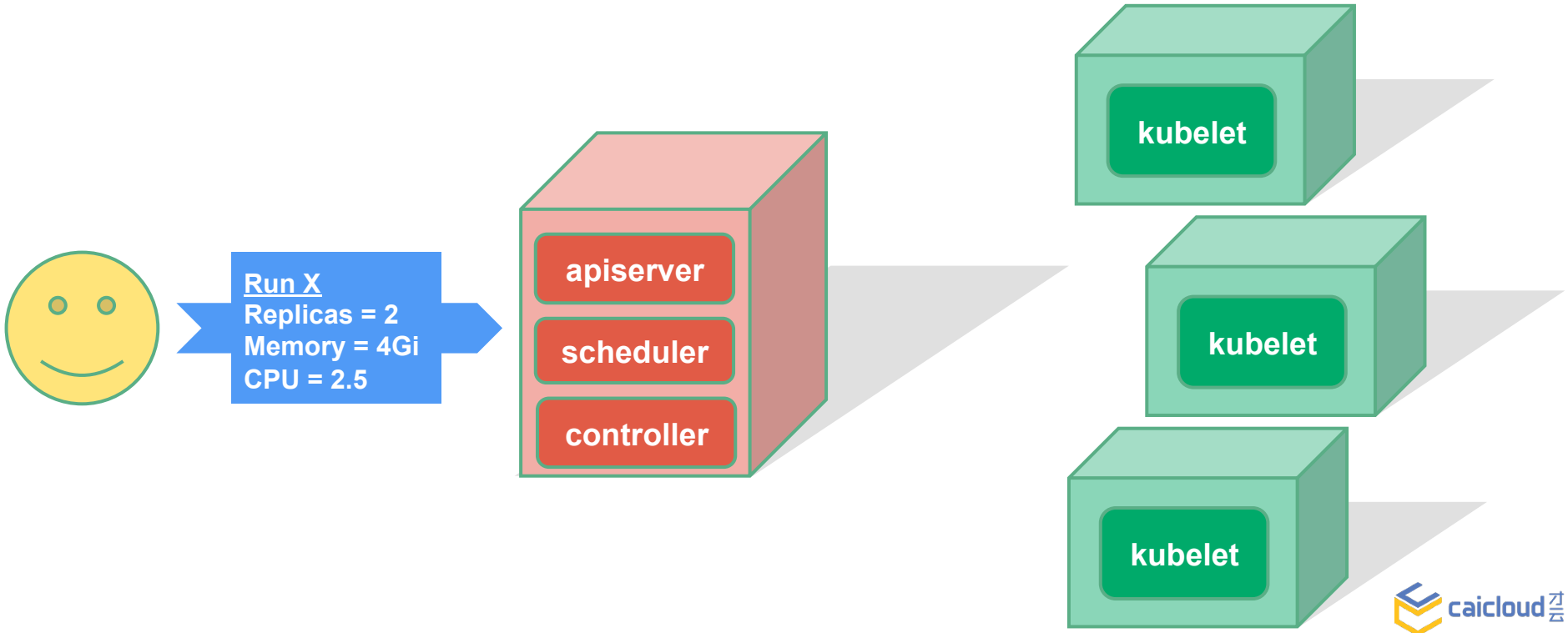

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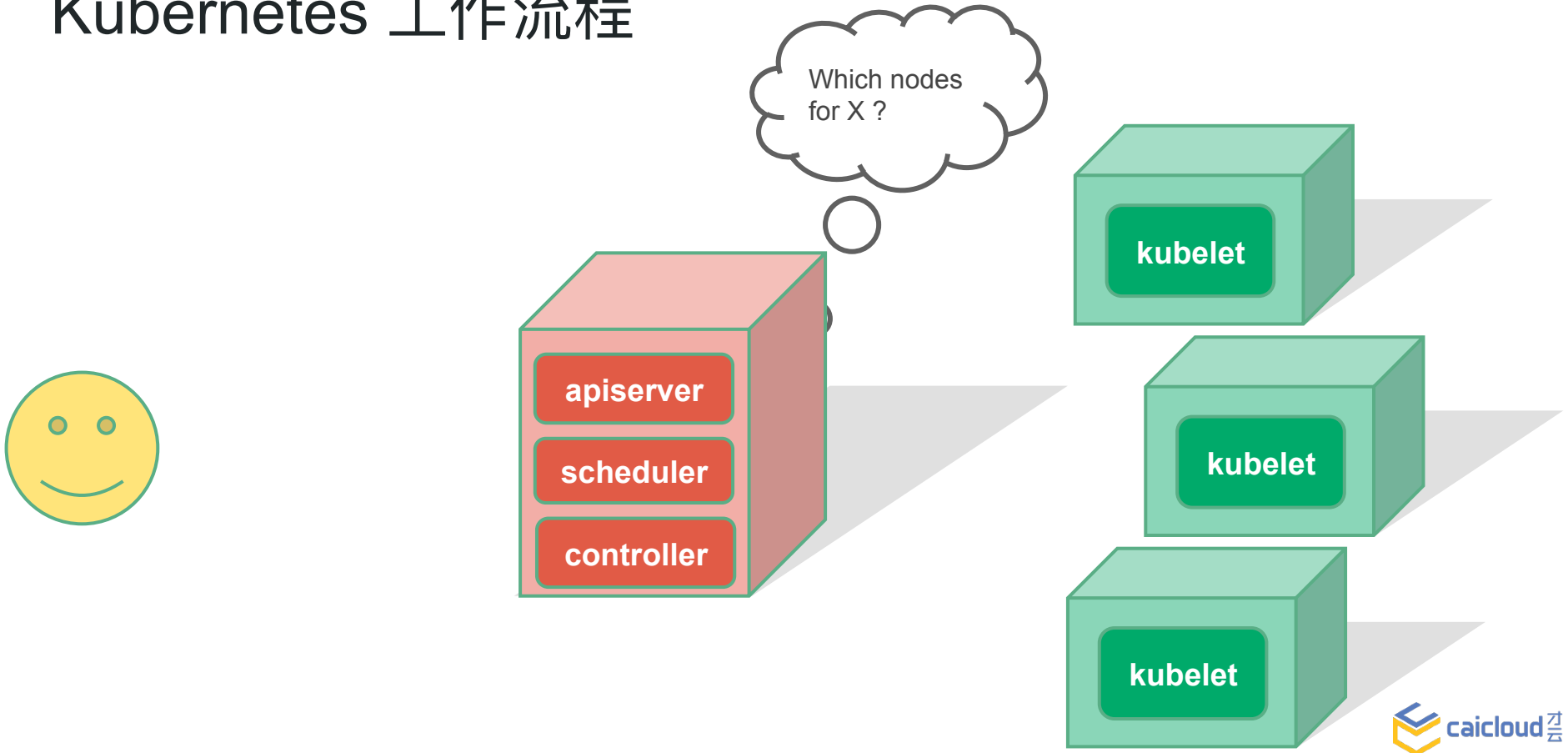

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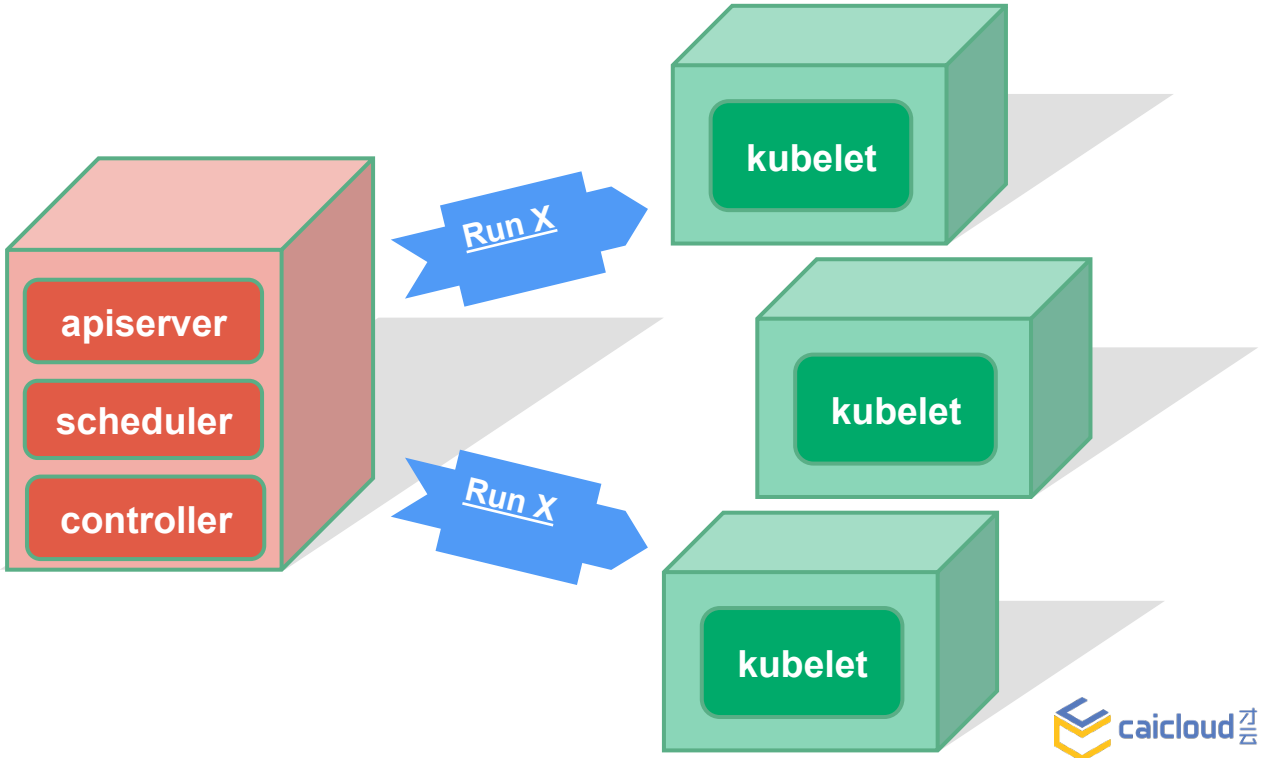

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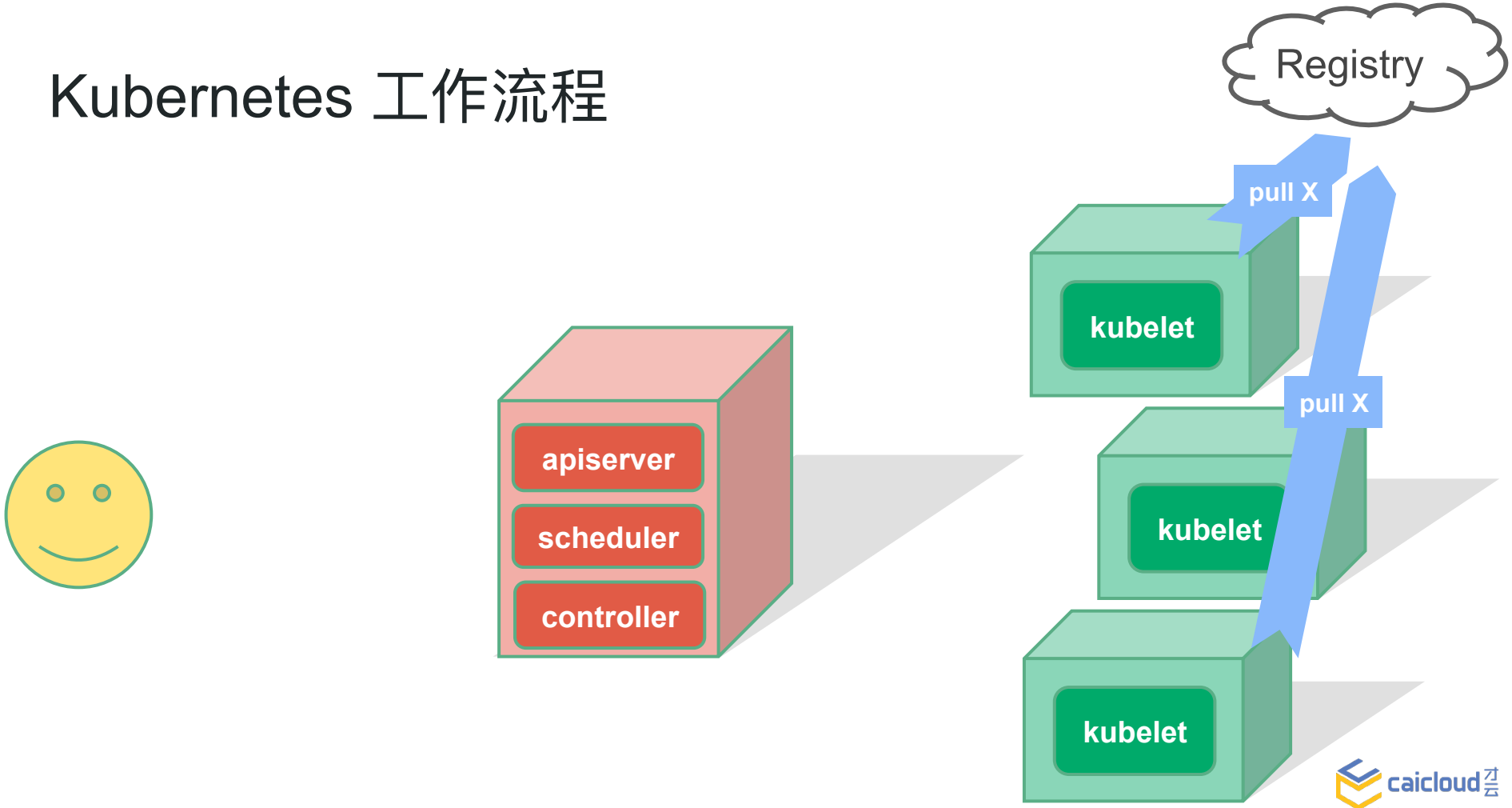

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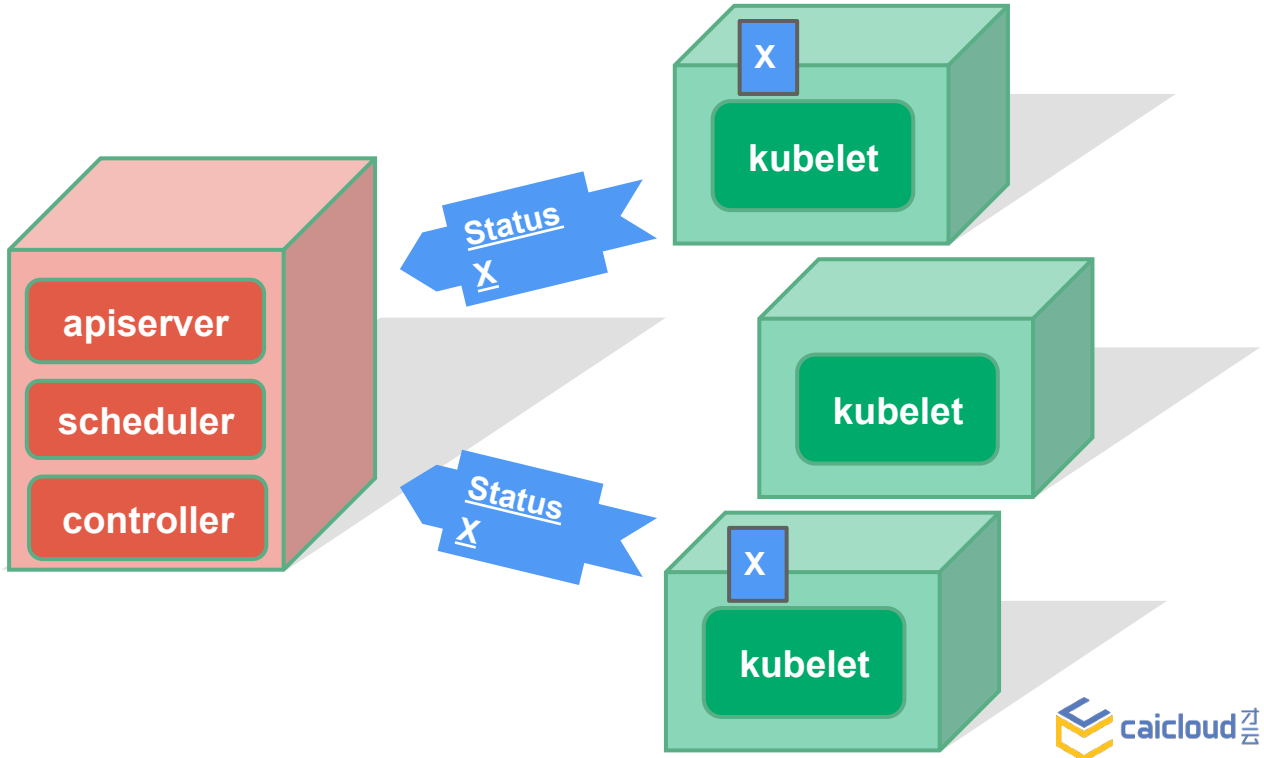

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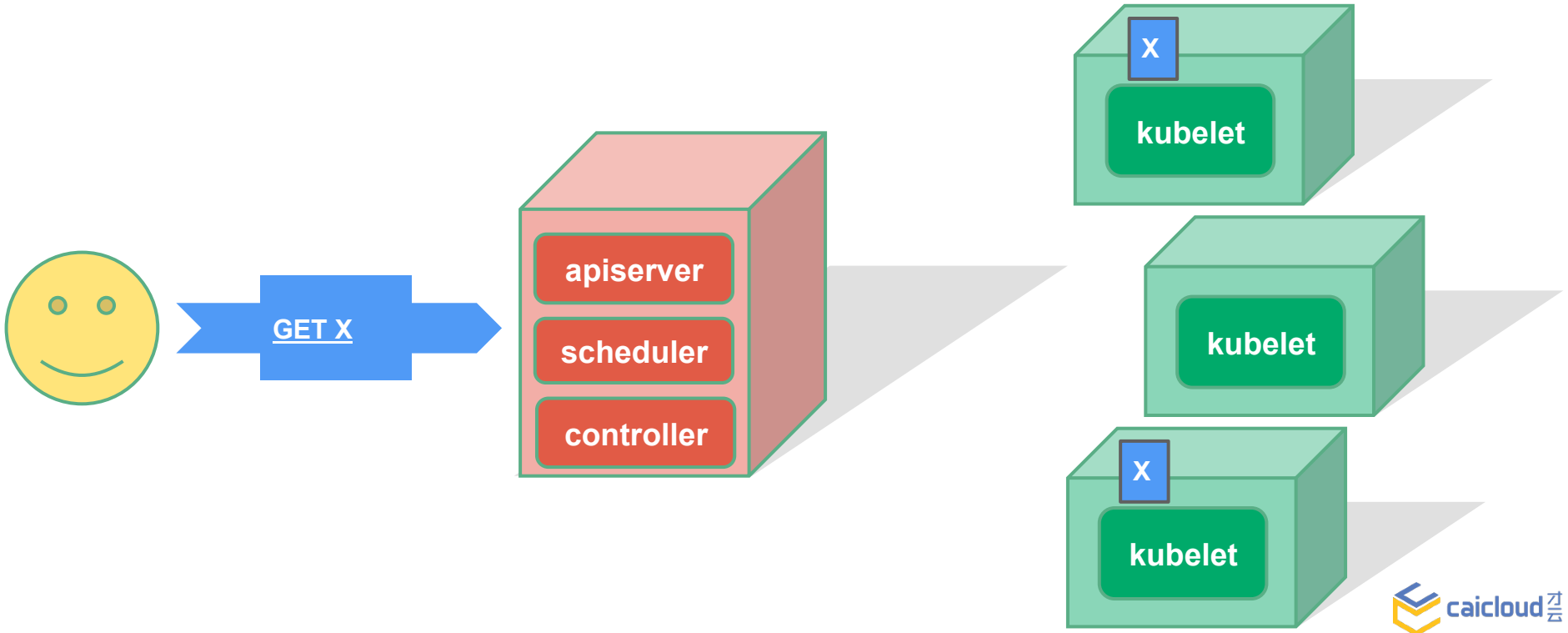

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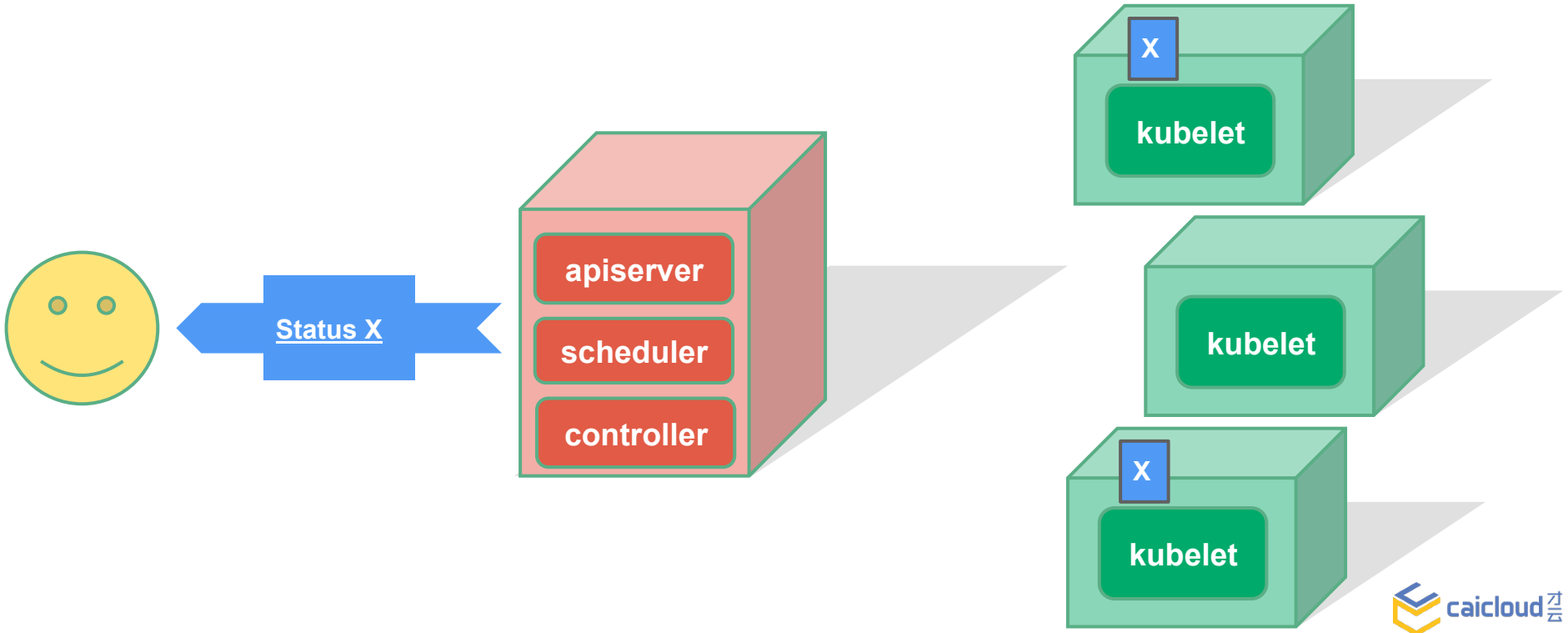
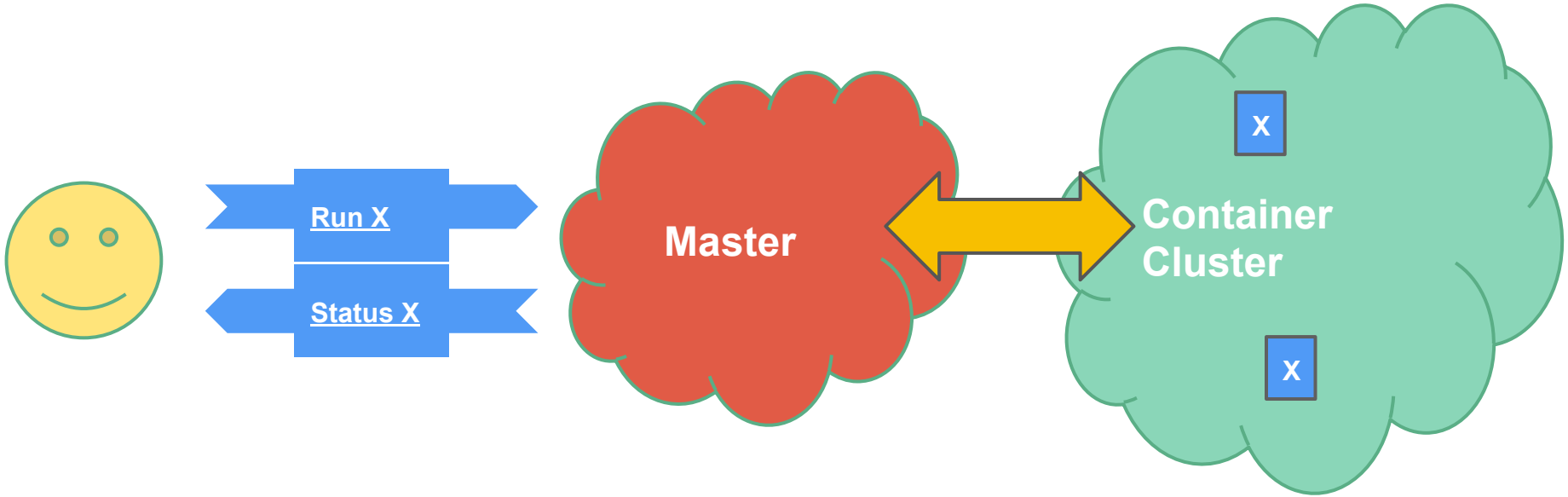


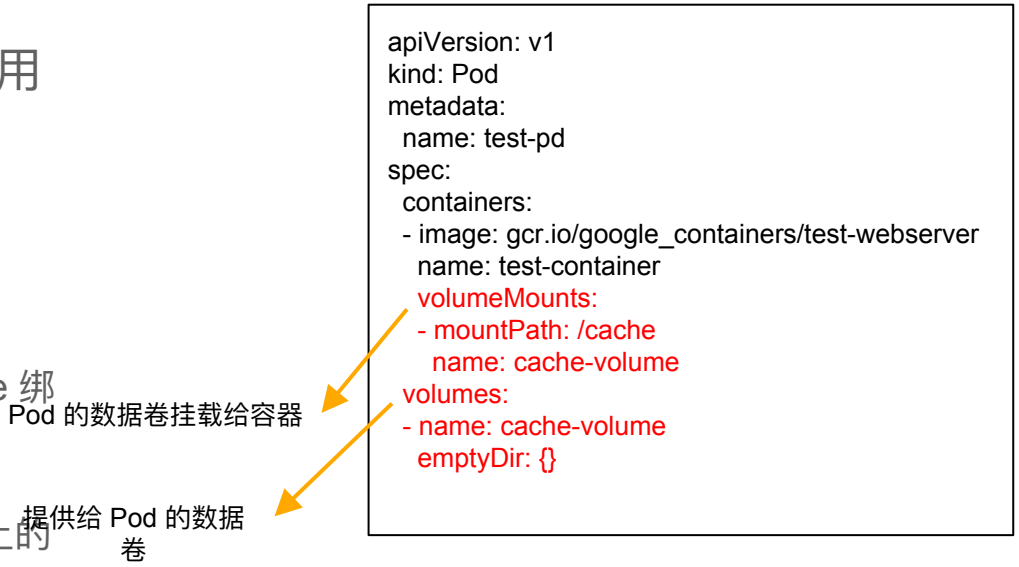
Kubernetes 工作流程 - 用户角度



Kubernetes advanced concepts (optional)

Volumes

- Pod 生命周期内一直可用
- Pod 内容器共享
- 当前支持的类型
  - emptyDir：Pod 与 Node 绑定/解绑时创建/删除
  - hostPath：挂载 Node 上的目录
  - gcePersistentDisk
  - nfs



Namespace, ResourceQuota

- Namespace
  - 物理集群上的虚拟集群
  - 用户级别的资源限制，用户只需关注 namespace 上的资源情况
  - 默认没有资源限制，需要通过 ResourceQuota 来配额
- ResourceQuota： Namespace 资源配额
  - 计算资源配额
    - CPU，MEM
  - k8s 元素数量配额

```
apiVersion: v1
kind: ResourceQuota
metadata:
  name: quota
spec:
  hard:
    cpu: "20"
    memory: 1Gi
    pods: "10"
    replicationcontrollers: "20"
    resourcequotas: "1"
    services: "5"
```

LimitRange

- LimitRange：默认 Pod，Container 资源配额
  - 计算资源配额
    - CPU，MEM
- 另外，可以在 Pod 中设置 Container 资源配额

```
apiVersion: v1
kind: ReplicationController
...
spec:
  containers:
  - name: nginx
    image: nginx
    resources:
      limits:
        cpu: 100m
        memory: 100Mi
```

1. 一个Pod的所有容器内存使用必须在6Mi ~ 1Gi
2. 一个Pod的所有容器的CPU使用必须在250m ~ 2 cores
3. 一个容器的内存使用必须在6Mi ~ 1Gi， 默认是100Mi
4. 一个容器的CPU使用必须在250m ~ 2 cores， 默认是250m

```
apiVersion: v1
kind: LimitRange
metadata:
  name: mylimits
spec:
  limits:
  - type: Pod
    max:
      cpu: "2"
      memory: 1Gi
    min:
      cpu: 250m
      memory: 6Mi
  - type: Container
    default:
      cpu: 250m
      memory: 100Mi
    max:
      cpu: "2"
      memory: 1Gi
    min:
      cpu: 250m
      memory: 6Mi
```

HPA (Horizontal Pod Autoscaler)

- 基于 CPU 利用率自动增加或者减少 Pod 副本数
- 支持 RS/RC/Deployment

```
apiVersion: autoscaling/v1
kind: HorizontalPodAutoscaler
metadata:
 name: frontend-scaler
spec:
 scaleTargetRef:
   kind: ReplicaSet/ReplicationController/
Deployment
   name: frontend
 minReplicas: 3
 maxReplicas: 10
 targetCPUUtilizationPercentage: 50
```

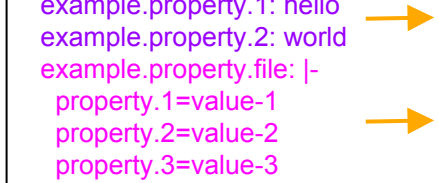
还可以通过 kubectl 设置 HPA：

kubectl autoscale deployment frontend --cpu-percent=50 --min=3 --max=10

ConfigMap

- 应用镜像和配置分离
- 数据类型为键值对
- Pod 使用 ConfigMap 的三种方式
  - 命令行参数
  - 环境变量
  - 数据卷文件

```
kind: ConfigMap
apiVersion: v1
metadata:
  creationTimestamp: 2016-02-18T19:14:38Z
  name: example-config
  namespace: default
data:
  example.property.1: hello
  example.property.2: world
  example.property.file: |-
    property.1=value-1
    property.2=value-2
    property.3=value-3
```



ConfigMap 作为环境变量和命令行参数

```yaml
apiVersion: v1
kind: ConfigMap
metadata:
  name: special-config
  namespace: default
data:
  special.how: very
  special.type: charm
```

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: dapi-test-pod
spec:
  containers:
    - name: test-container
      image: gcr.io/google_containers/busybox
      command: [ "/bin/sh", "-c", "echo $(SPECIAL_LEVEL_KEY) $(SPECIAL_TYPE_KEY)" ]
      env:
        - name: SPECIAL_LEVEL_KEY
          valueFrom:
            configMapKeyRef:
              name: special-config
              key: special.how
        - name: SPECIAL_TYPE_KEY
          valueFrom:
            configMapKeyRef:
              name: special-config
              key: special.type
  restartPolicy: Never
```

命令行参数

环境变量

ConfigMap 作为数据卷文件

```yaml
apiVersion: v1
kind: ConfigMap
metadata:
  name: special-config
  namespace: default
data:
  special.how: very
  special.type: charm
```

2

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: dapi-test-pod
spec:
  containers:
    - name: test-container
      image: gcr.io/google_containers/busybox
      command: [ "/bin/sh","-c","cat /etc/config/path/to/special-key" ]
      volumeMounts:
      - name: config-volume
        mountPath: /etc/config
  volumes:
    - name: config-volume
      configMap:
        name: special-config
        items:
        - key: special.how
          path: path/to/special-key
  restartPolicy: Never
```

key 指定文件路径名
value 作为文件内容

1

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: dapi-test-pod
spec:
  containers:
    - name: test-container
      image: gcr.io/google_containers/busybox
      command: [ "/bin/sh", "-c", "cat /etc/config/special.how" ]
      volumeMounts:
      - name: config-volume
        mountPath: /etc/config
  volumes:
    - name: config-volume
      configMap:
        name: special-config
  restartPolicy: Never
```

key 作为文件名
value 作为文件内容

ConfigMap 配置 redis 实例

创建配置:

```
$ cat redis-config.txt
maxmemory 2mb
maxmemory-policy allkeys-lru

$ kubectl create configmap example-redis-config --from-file=redis-config.txt

$ kubectl get configmap example-redis-config -o yaml

apiVersion: v1
data:
  redis-config: |
    maxmemory 2mb
    maxmemory-policy allkeys-lru
kind: ConfigMap
metadata:
  creationTimestamp: 2016-03-30T18:14:41Z
  name: example-redis-config
  namespace: default
  resourceVersion: "24686"
  selfLink: /api/v1/namespaces/default/configmaps/example-redis-config
  uid: 460a2b6e-f6a3-11e5-8ae5-42010af00002
```

使用配置:

```
apiVersion: v1
kind: Pod
metadata:
  name: redis
spec:
  containers:
  - name: redis
    image: kubernetes/redis:v1
    env:
    - name: MASTER
      value: "true"
    ports:
    - containerPort: 6379
    resources:
      limits:
        cpu: "0.1"
    volumeMounts:
    - mountPath: /redis-master-data
      name: data
    - mountPath: /redis-master
      name: config
  volumes:
    - name: data
      emptyDir: {}
    - name: config
      configMap:
        name: example-redis-config
        items:
        - key: redis-config
          path: redis.conf
```

From ReplicationController to ReplicaSet to Deployment

- From Replication Controller to Replica Set
  - Changes in label selector matching
  - From equality matching to set matching
- From Replica Set to Deployment
  - Declarative update
  - Rollout version control & history
  - Quick roll back to multiple revisions
  - Multiple tunable parameters
  - Server0side

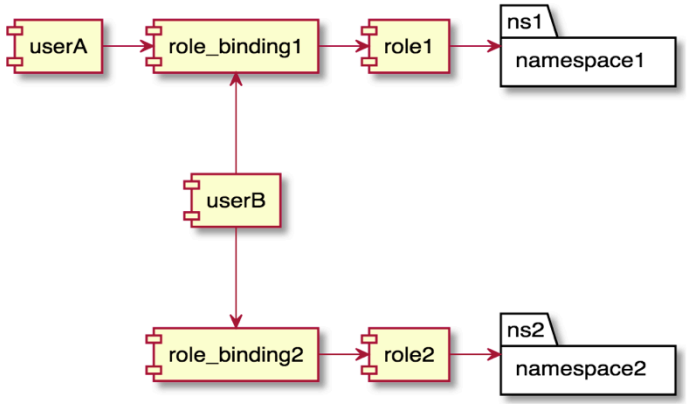
Replica Set

- 下一代的 Replication Controller
  - RC 支持 “kubectl rolling-update”
  - RC 只支持 Equality-based 选择器
  - RS 支持 Set-based 和 Equality-based 选择器
- 如何使用
  - 一般不单独使用
  - Deployment
  - HPA（Horizontal Pod Autoscaler）

Role-Based Access Control（RBAC）

```
kind: Role
apiVersion: rbac.authorization.k8s.io/v1alpha1
metadata:
 namespace: default
 name: pod-reader
rules:
 - apiGroups: [""] # The default API Group.
   resources: ["pods"]
   verbs: ["get", "watch", "list"]
   nonResourceURLs: []
```

```
kind: RoleBinding
apiVersion: rbac.authorization.k8s.io/v1alpha1
metadata:
 name: read-pods
 namespace: default
subjects:
 - kind: User # May be "User", "Group" or "ServiceAccount"
   name: jane
roleRef:
 kind: Role
 namespace: default
 name: pod-reader
 apiVersion: rbac.authorization.k8s.io/v1alpha1
```



- RBAC 引入角色（Role）和角色绑定（RoleBinding）抽象概念
- 访问策略可以跟某个或者多个角色关联

```
kube-apiserver    --authorization-mode=RBAC    --runtime-config=extensions/v1beta1/
networkpolicies=true,rbac.authorization.k8s.io/v1alpha1
--authorization-rbac-super-user=caicloud-admin
  ...
```

Attribute-Based Access Control（ABAC）

```
{
   "apiVersion":"abac.authorization.kubernetes.io/
v1beta1",
   "kind":"Policy",
   "spec":{
      "user":"alice",
      "namespace":"*",
      "resource":"*",
      "apiGroup":"*"
   }
}
```

Alice can do anything to all resources

```
{
   "apiVersion":"abac.authorization.kubernetes.io/v1beta1",
   "kind":"Policy",
   "spec":{
      "user":"bob",
      "namespace":"test",
      "resource":"pods",
      "readonly":true
   }
}
```

Bob can just read pods in namespace ‘test’

- ABAC 配置不同用户的访问权限
- 缺点：
  - 对权限做修改，必须重启 apiserver

    kube-apiserver --authorization-mode=ABAC --authorization-policy-file=/etc/kubernetes/tokens/abac.json ...
  - 访问策略只能跟用户直接关联

PersistentVolume (PV) 和 PersistentVolumeClaim (PVC)

- PV（持久卷）
  - 集群中的一块网络存储
  - 独立于 Pod 的生命周期
  - 支持的 PV 类型
    - GCEPersistentDisk
    - AWSElasticBlockStore
    - NFS
    - Cinder
    - iSCSI

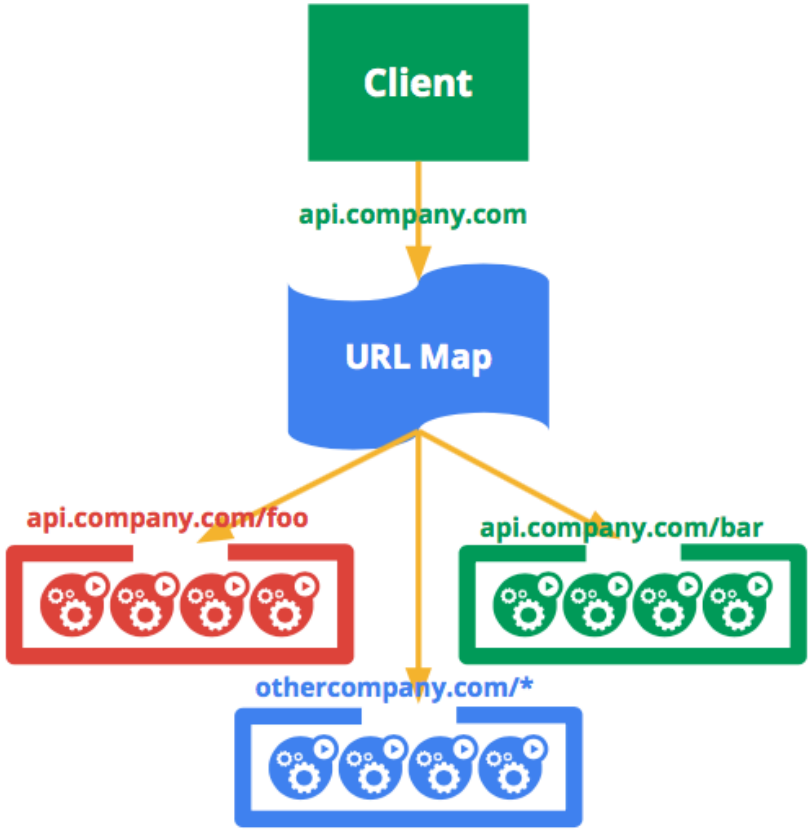
```
apiVersion: v1
kind: PersistentVolume
metadata:
 name: nfs
spec:
 capacity:
   storage: 1Mi
 accessModes:
   - ReadWriteMany
 nfs:
   # FIXME: use the right IP
   server: 10.244.1.4
   path: "/exports"
```

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
 name: nfs
spec:
 accessModes:
   - ReadWriteMany
 resources:
   requests:
     storage: 1Mi
```

```
apiVersion: v1
kind: ReplicationController
metadata:
 name: nfs-web
spec:
 replicas: 2
 template:
   metadata:
     labels:
       role: web-frontend
   spec:
     containers:
     - name: web
       image: nginx
       ports:
         - name: web
           containerPort: 80
       volumeMounts:
           - name: nfs
             mountPath: "/usr/share/nginx/html"
     volumes:
     - name: nfs
       persistentVolumeClaim:
         claimName: nfs
```

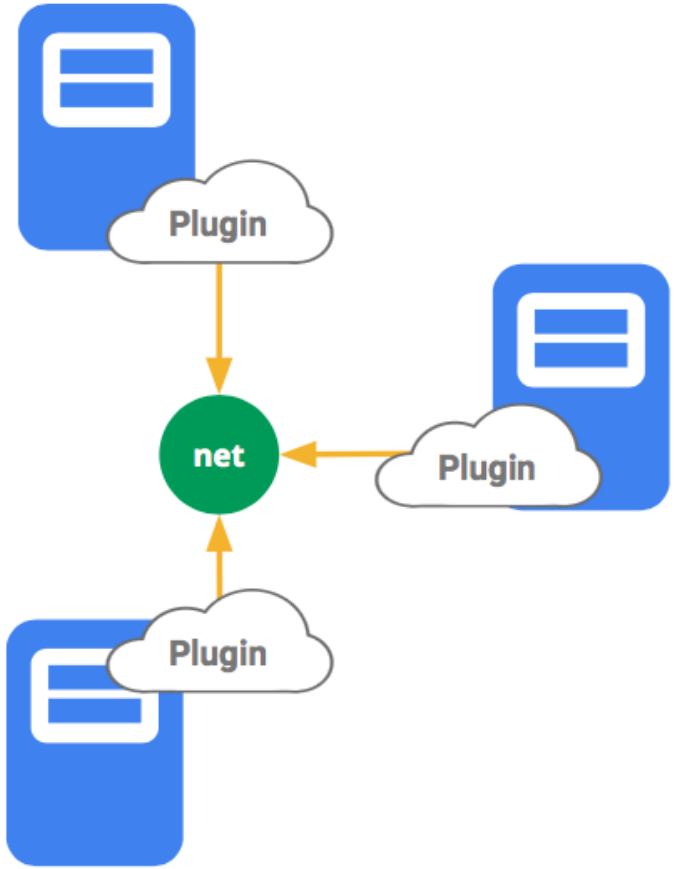
Ingress (L7)

- Services are assumed L3/L4
- Lots of apps want HTTP/HTTPS
- Ingress maps incoming traffic to backend services
  - by HTTP host headers
  - by HTTP URL paths
- Nginx, HAProxy and GCE implementation



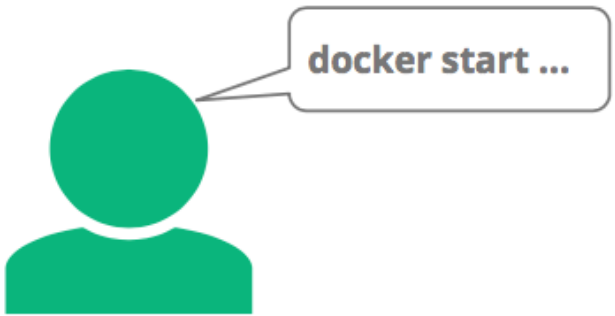
Network Plugins

- Introduced in Kubernetes v1.0
  - very experimental
- Uses CNI (From CoreOS) in v1.1
  - simple exec interface
  - not using docker libnetwork
- Cluster admins can customize their installs
  - DHCP, MacVlan, Flannel, custom plugin

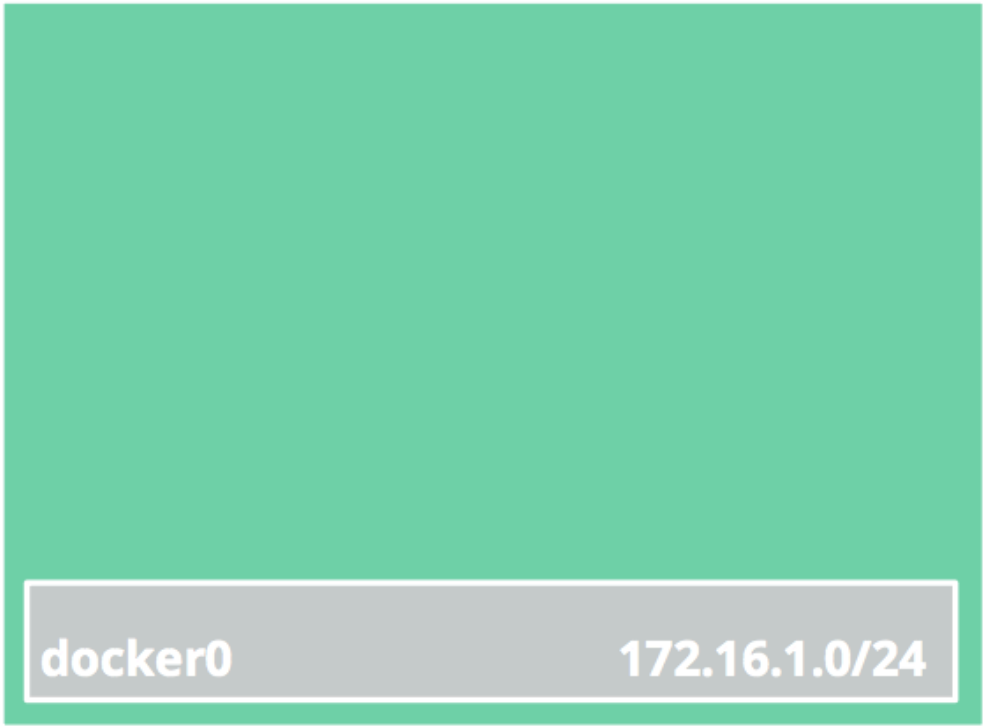


Kubernetes 网络模型

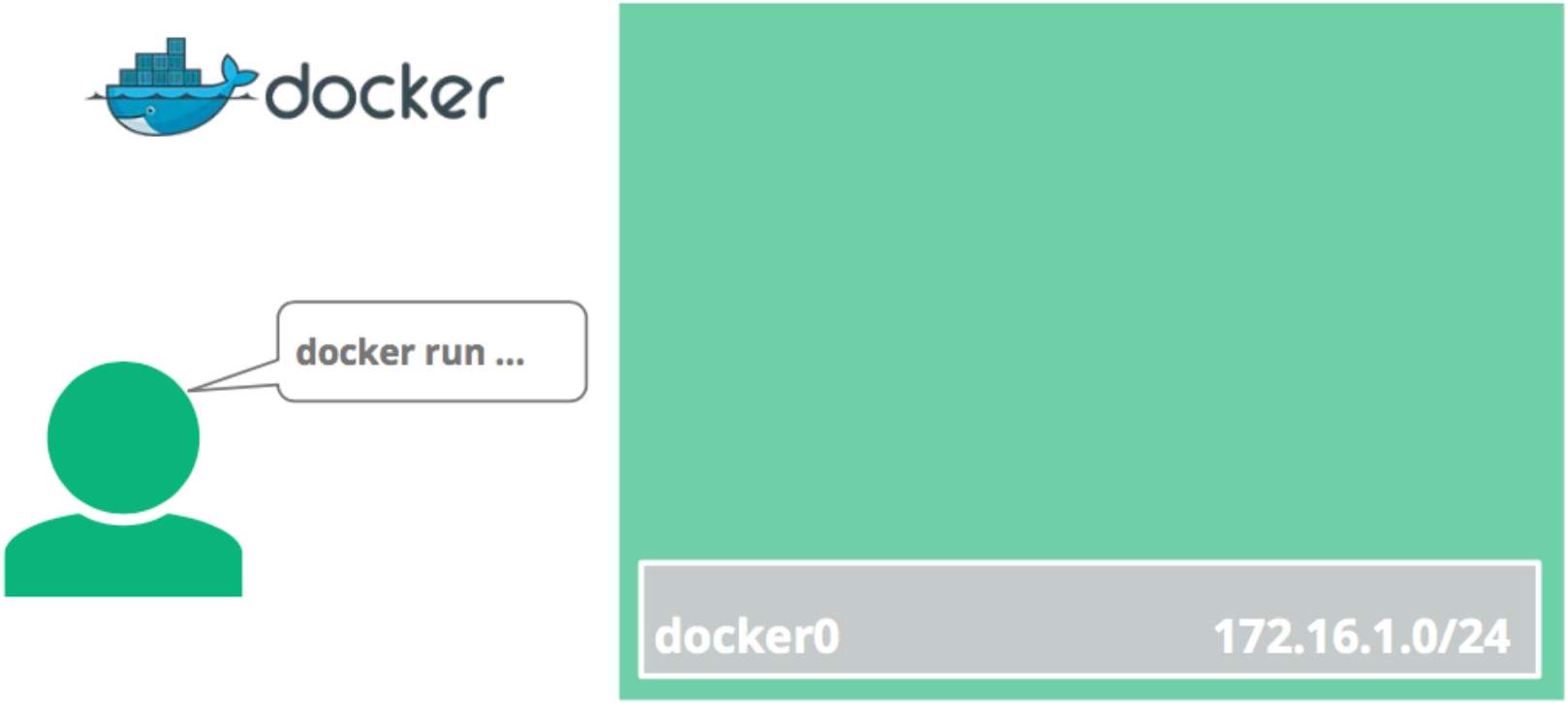
Docker Networking



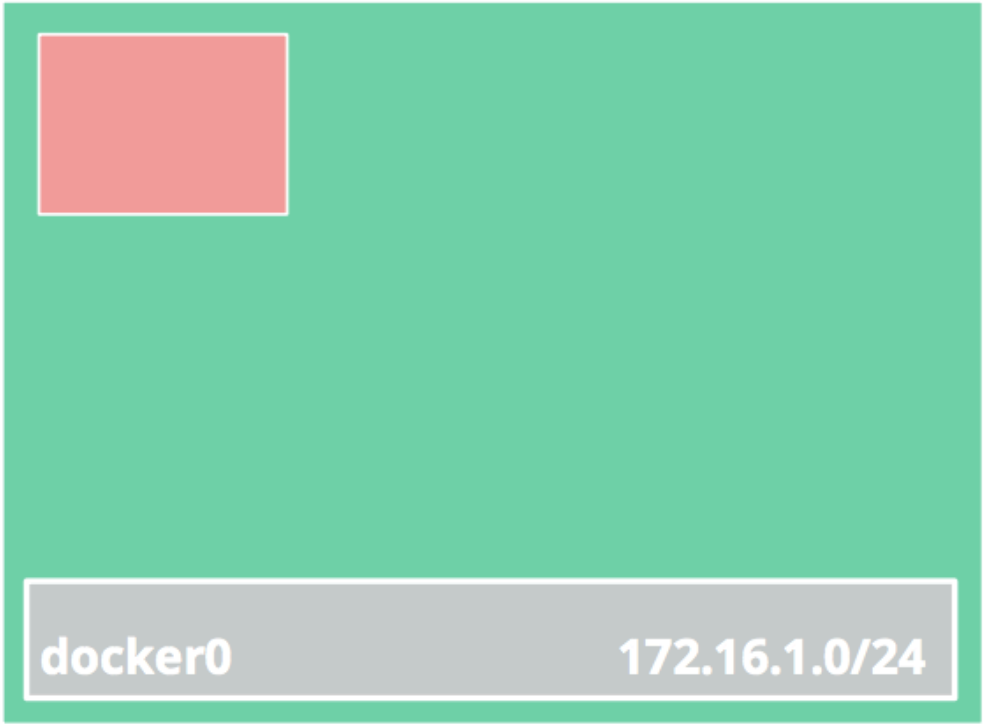
Docker Networking



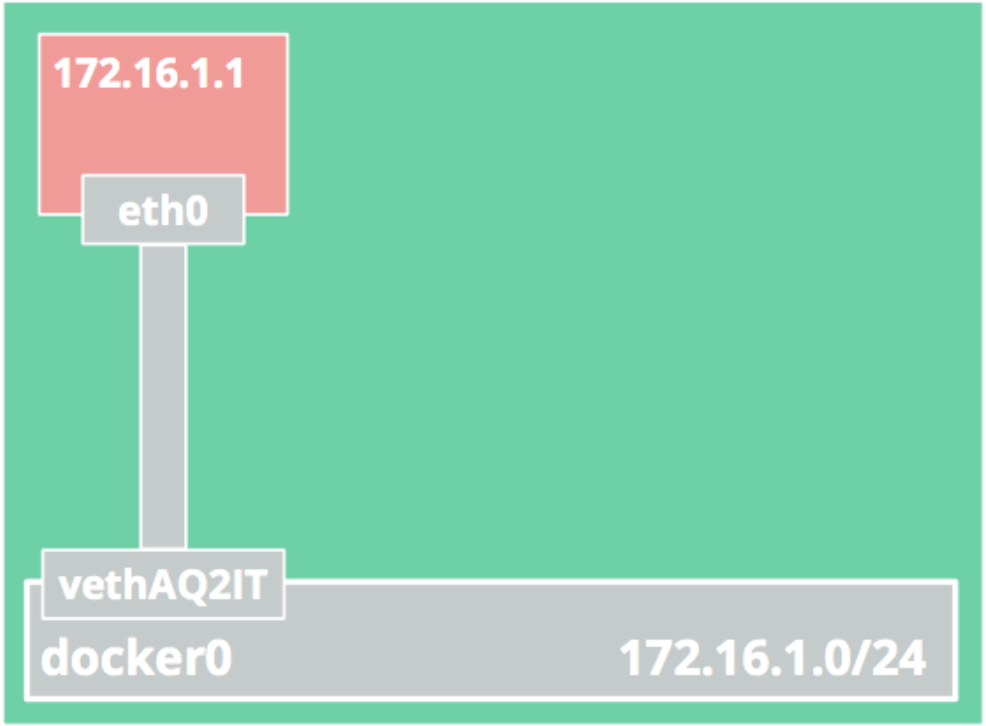
Docker Networking



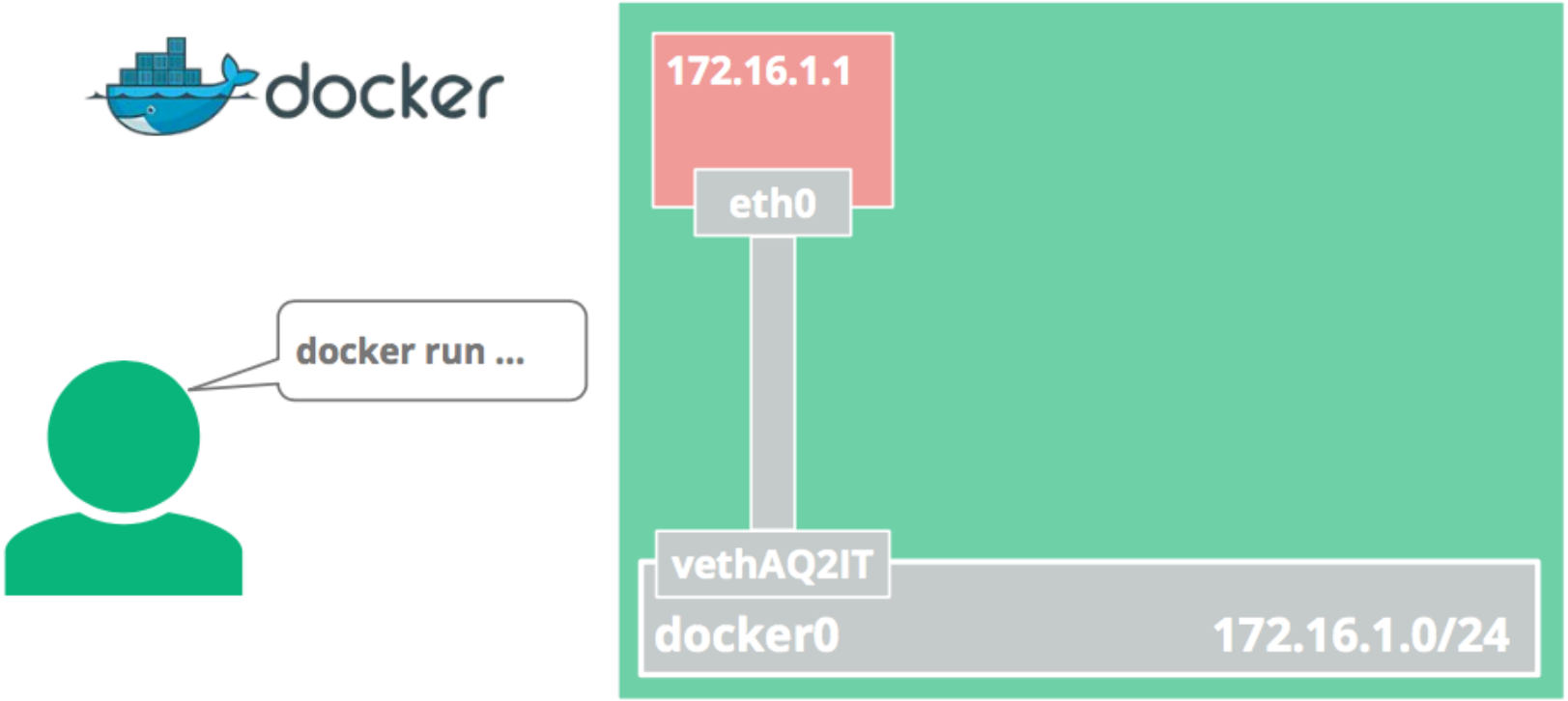
Docker Networking



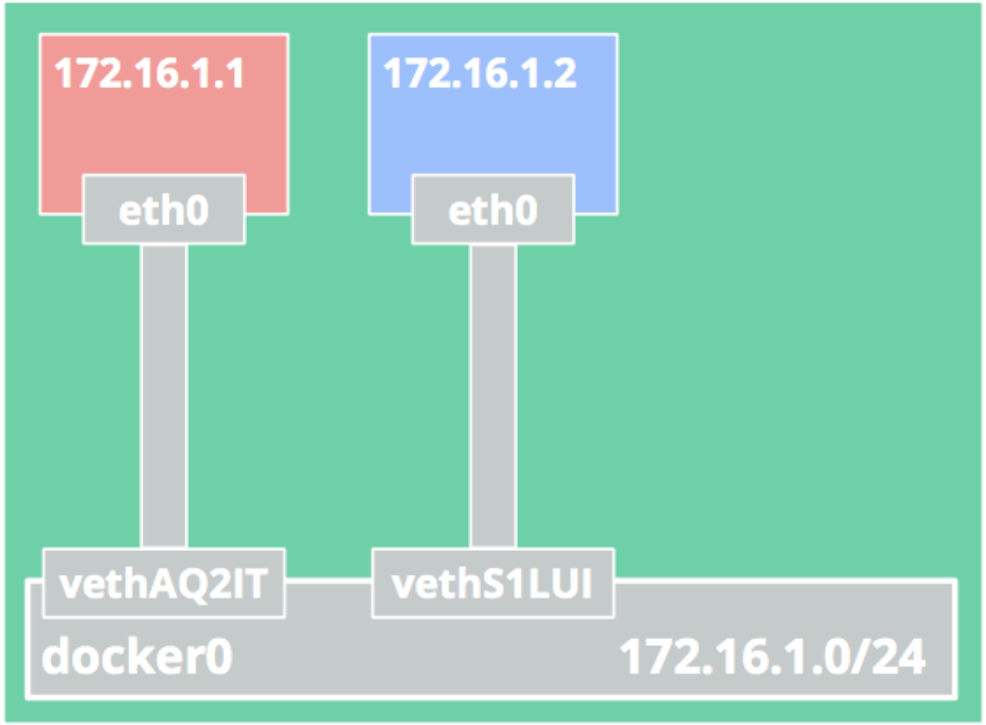
Docker Networking



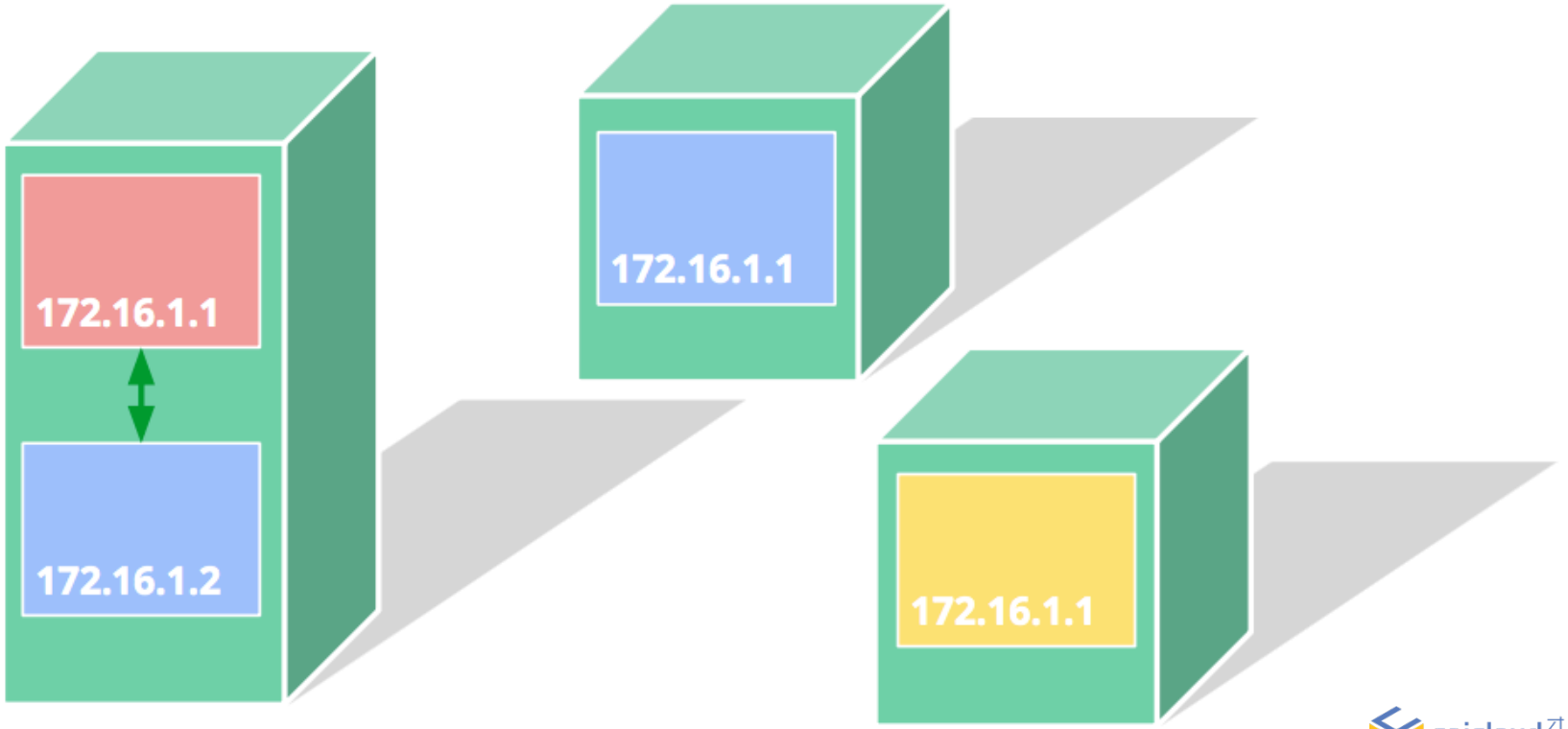
Docker Networking



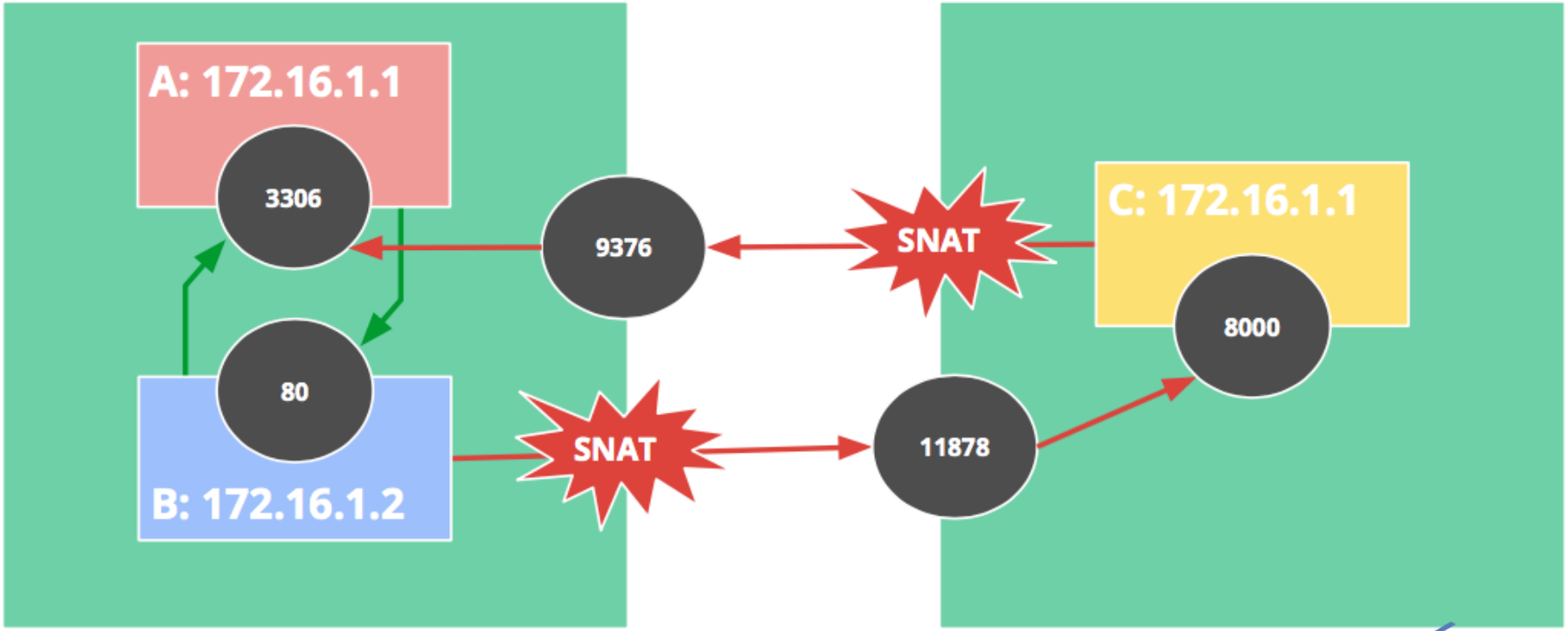
Docker Networking



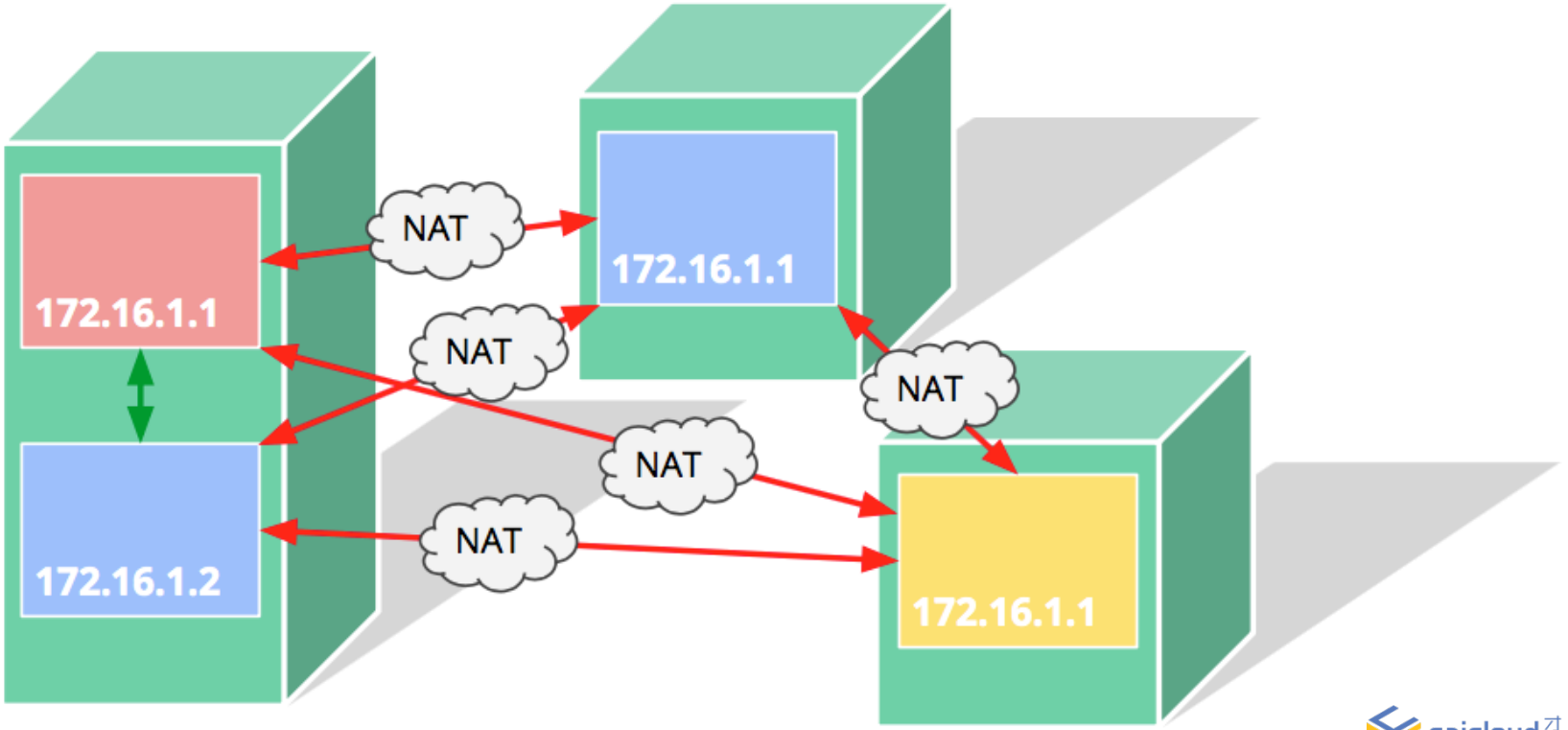
Docker Networking



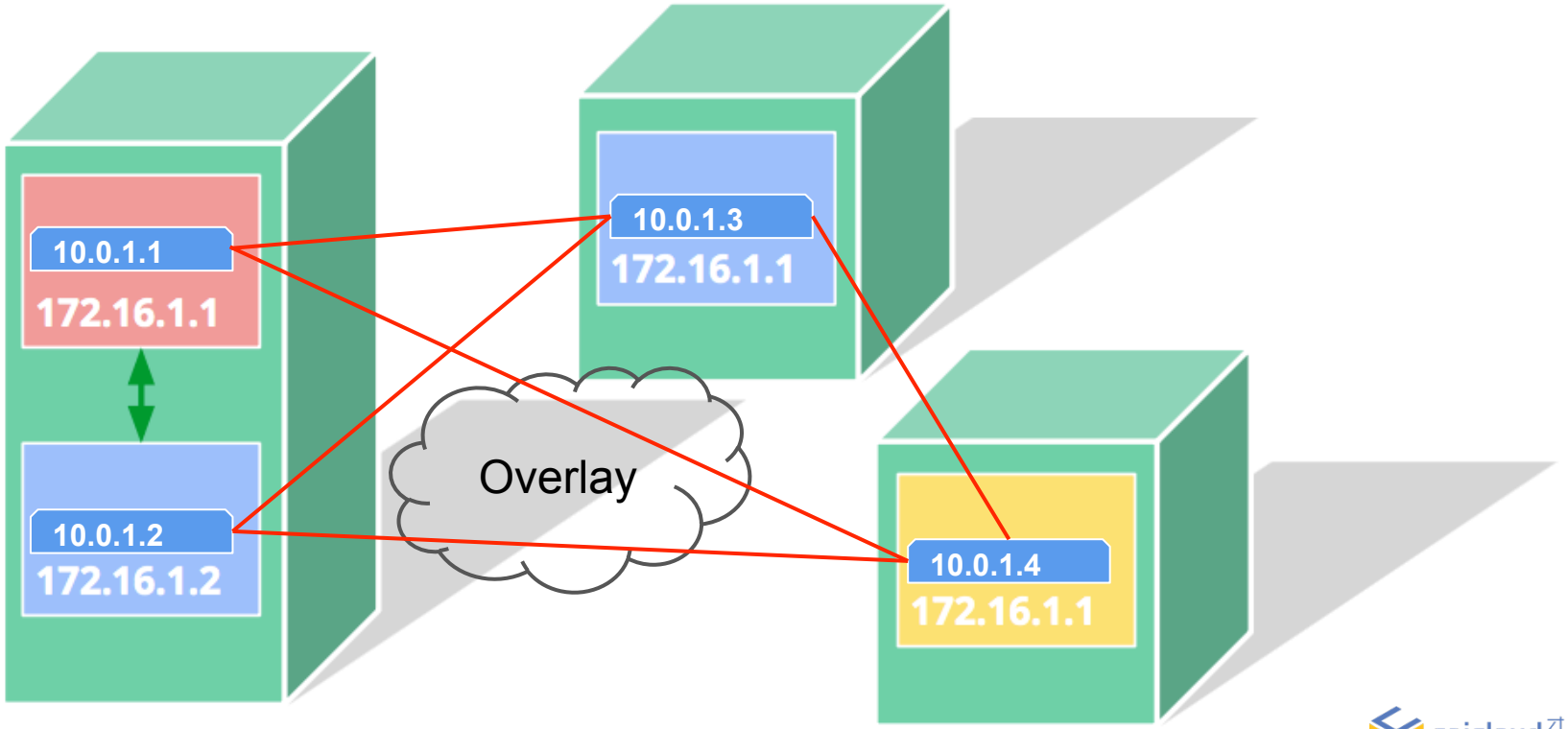
Docker Networking - HostPort



Docker Networking

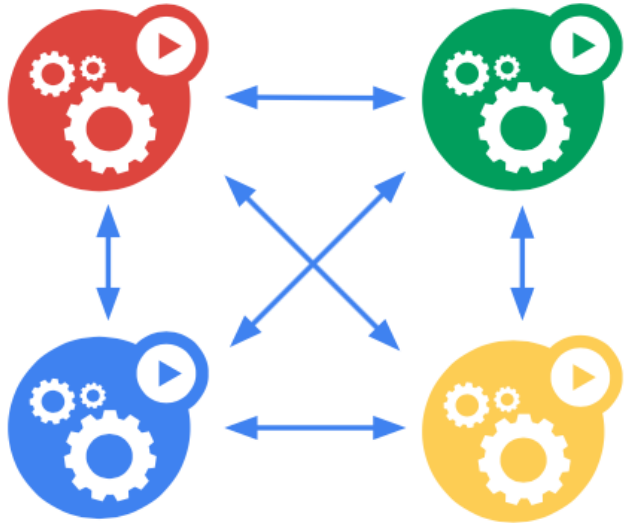


Docker Networking - Overlay

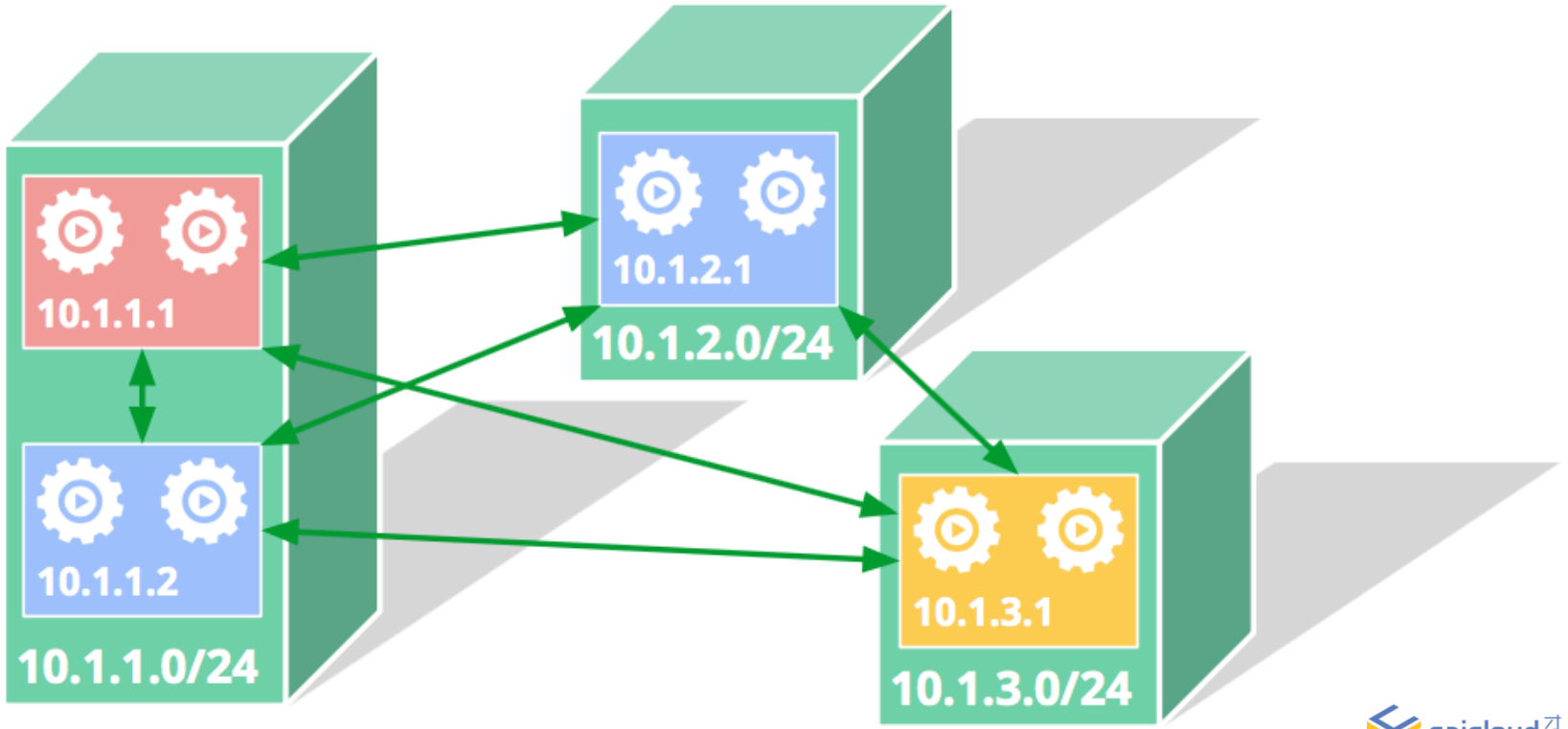


Kubernetes Networking

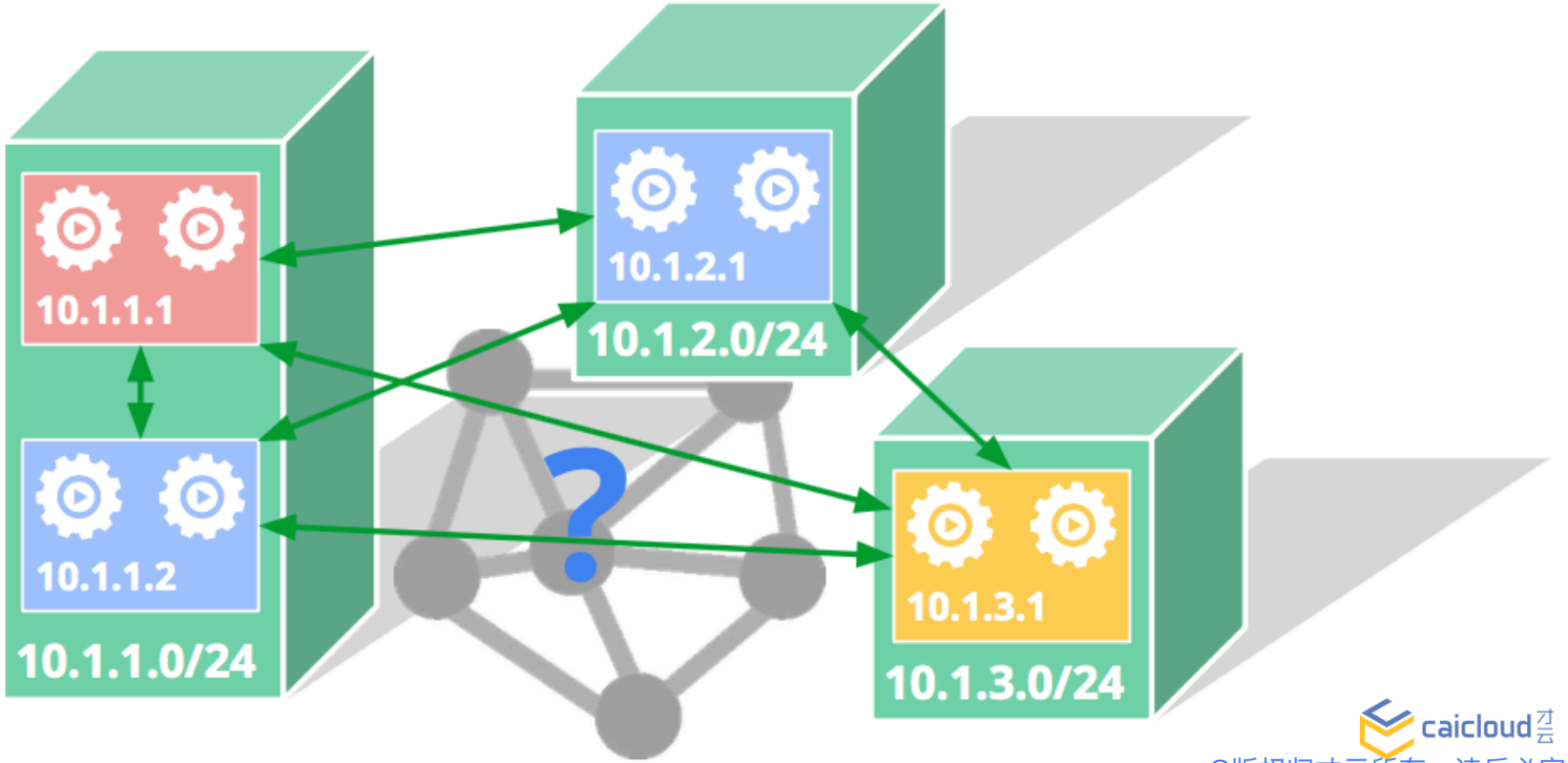
- IPs are routable
  - vs docker default private IP
- Pods can reach each other without NAT
  - even across nodes
- No brokering of port numbers
  - Too complex, why bother?
- Every host is assigned a subnet
- This is a fundamental requirement



Kubernetes Networking



Kubernetes Networking



Kubernetes Networking

- On GCE/GKE
  - GCE advanced routes (program the fabric)
  - Everything to “10.1.1.0/24”, send to this VM
- On AWS
  - Route table
- Plenty of other ways
  - Weave
  - Calico
  - Flannel