Networking in Containers and Container Clusters

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Containers

Isolate and **package** application

“Lightweight VMs”

Isolates a machine’s

- Resources (CPU, memory, IO)
- Namespaces (PIDs, users, network)
- Filesystem
- Capabilities

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Shipping Containers At Clyde, by Steve Gibson

Containers

Today's focus: **networking**

UTS namespace

- Isolate hostname

Network namespace

- Network interface
- Loopback device
- Routing table
- iptable rules

net cgroups: mostly **unused** today

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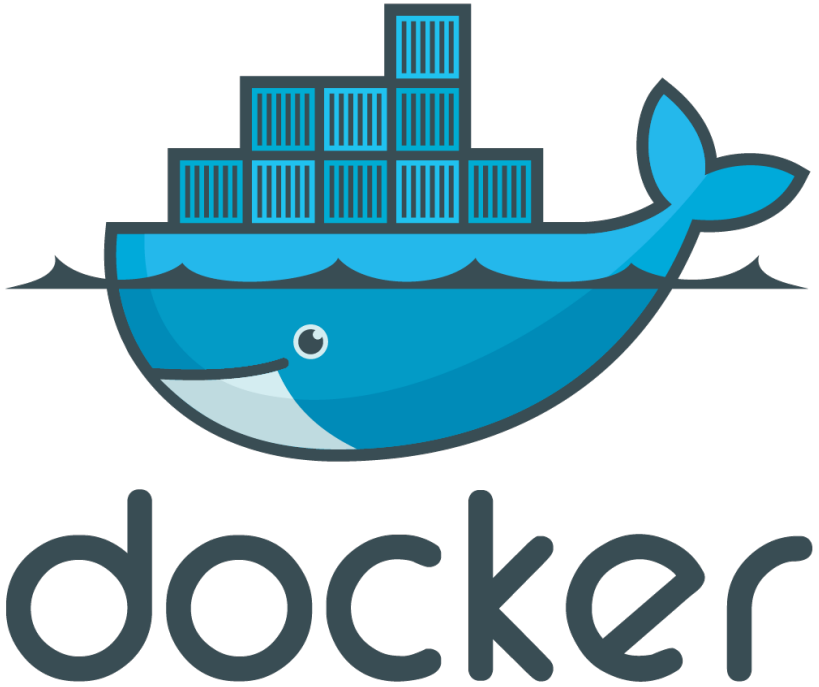
Containers - Docker

Docker

- Popular **implementation** of Linux containers
- **Open source**, written in **Go**
- Hardware and platform agnostic
- Easy management of **filesystem images**

libcontainer

- Sub-project of Docker
- Written in **Go**, with some bits in **C**
- Implements the **container abstraction**
- **Today:** container == libcontainer container



https://github.com/docker/docker
https://github.com/docker/libcontainer

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Networking in Docker - Configuration

Hostname

Networks

- How container is **exposed** to the network
- MAC and IP address
- Gateway, MTU, queue length, ...

Routes

- Route table entries inside the namespace

```
type Config struct {
        // Hostname optionally sets the container's
        // hostname if provided
        Hostname string

        // Networks specifies the container's network
        // setup to be created
        Networks []*Network

        // Routes can be specified to create entries
        // in the route table as the container is started
        Routes []*Route
}
```

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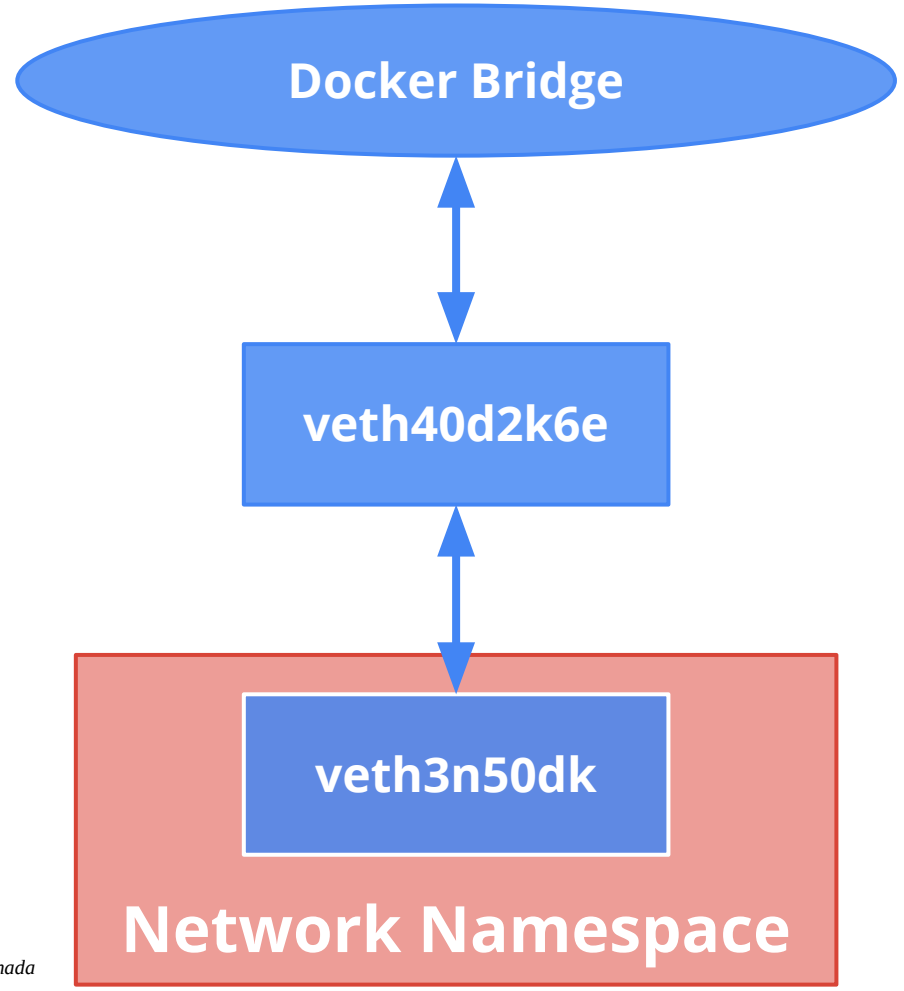
Networking in Docker - Strategies

loopback

- Loopback device included in all containers
- **No external** networking

veth

- **Default** strategy in Docker
- veth pair used inside/outside container
- Attached to Docker bridge
- iptables connect to outside world
- Measured **performance hit** is significant



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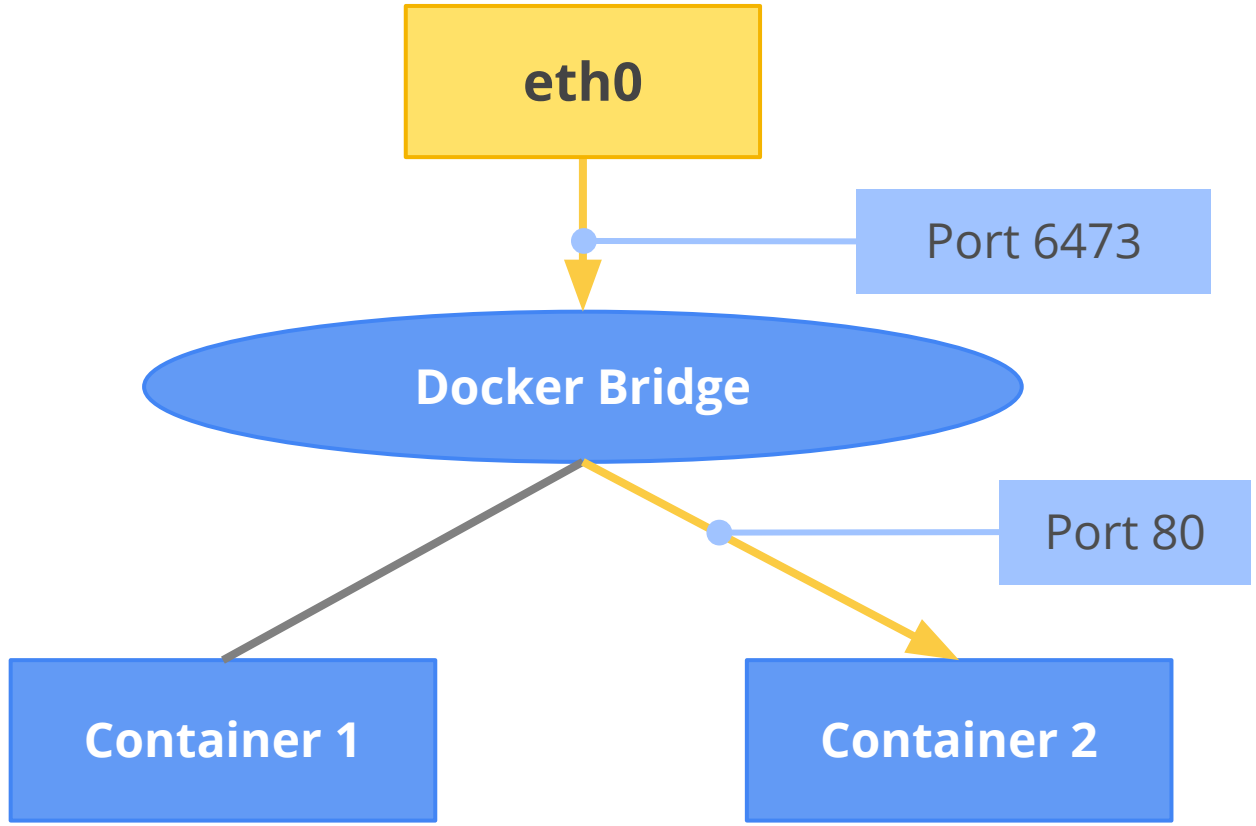
Networking in Docker - veth Strategy

Connections **IN**

- By default: blocked
- Unless port is exposed
- Mapping: host <-> container ports



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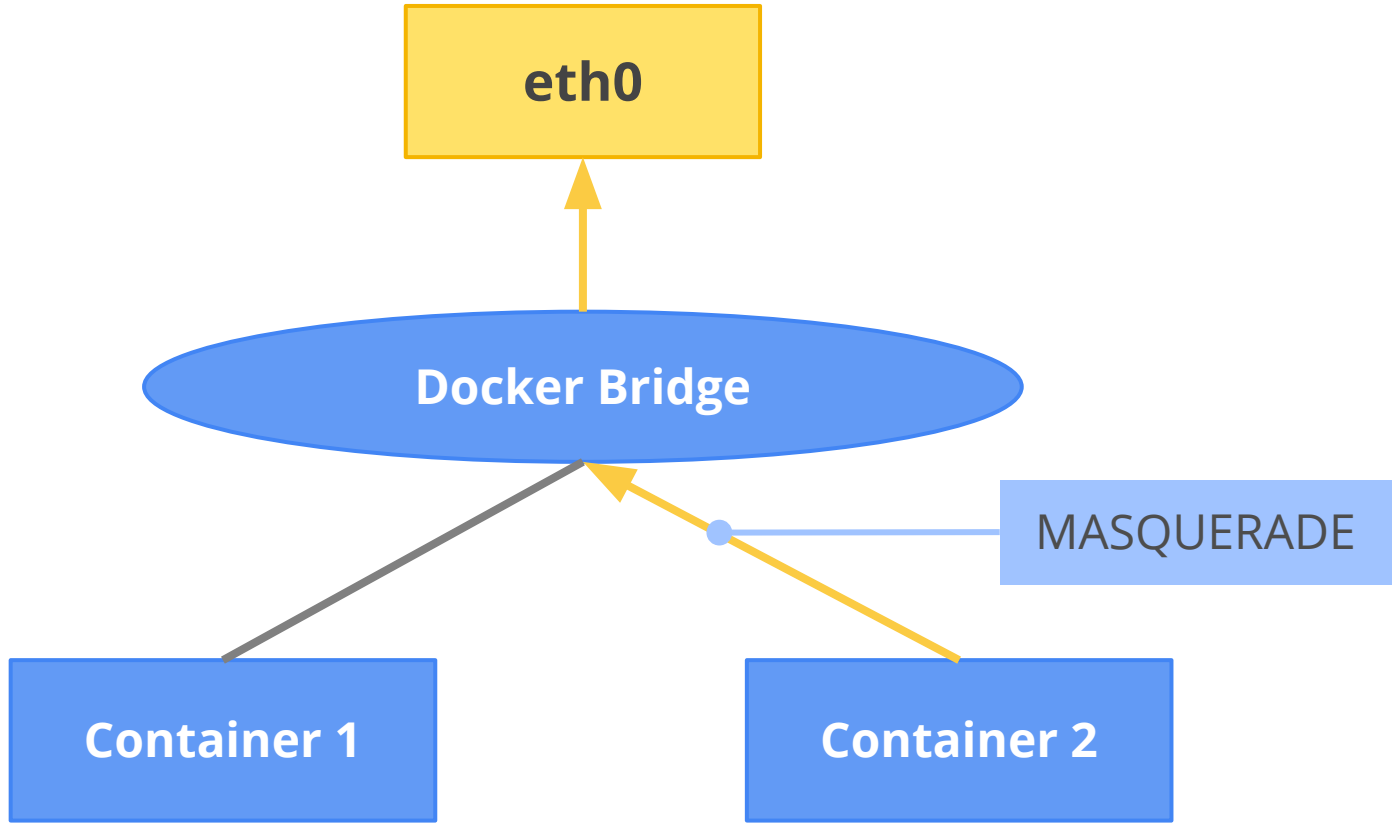
Networking in Docker - veth Strategy

Connections **OUT**

- To other containers: blocked
- Unless through host-exposed port
- To internet: MASQUERADE as host



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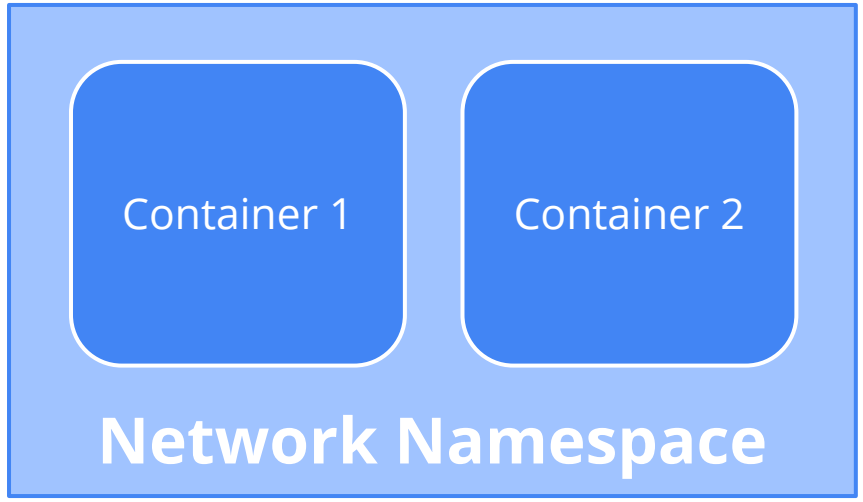
Networking in Docker - Strategies

netns

- Allows **sharing** of network namespaces
- Can use **host namespace** for native performance

MACVLAN/VLAN

- In the works
- Great performance
- IPVLAN support coming too



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Networking in Docker - Future Work

Support more network strategies

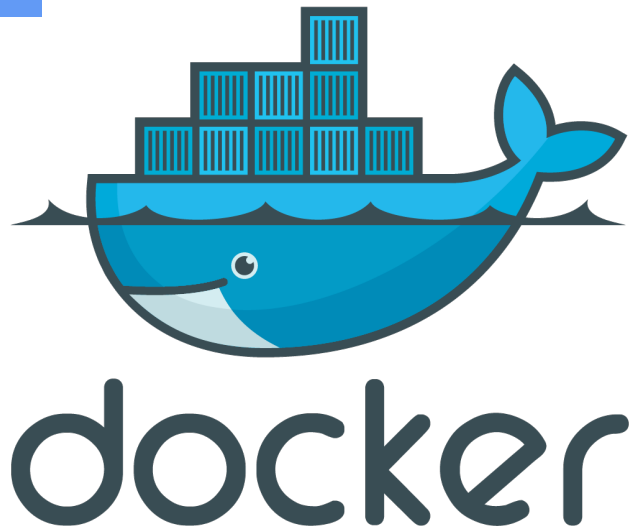
- **Pluggable** network options

Better **performing** networking options

- MACVLAN
- IPVLAN

Native checkpoint restore

- Using **CRIU**



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Networking in Container Clusters

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Images by Connie Zhou

Networking in Container Clusters - Kubernetes

Greek for *“Helmsman”*; also the root of the word *“Governor”*

- Container orchestrator
- Schedules and runs Docker containers
- Supports **multiple** cloud and bare-metal environments
- Inspired and informed by Google’s experiences
- **Open source**, written in **Go**

Manage **applications**, not machines

https://github.com/GoogleCloudPlatform/kubernetes

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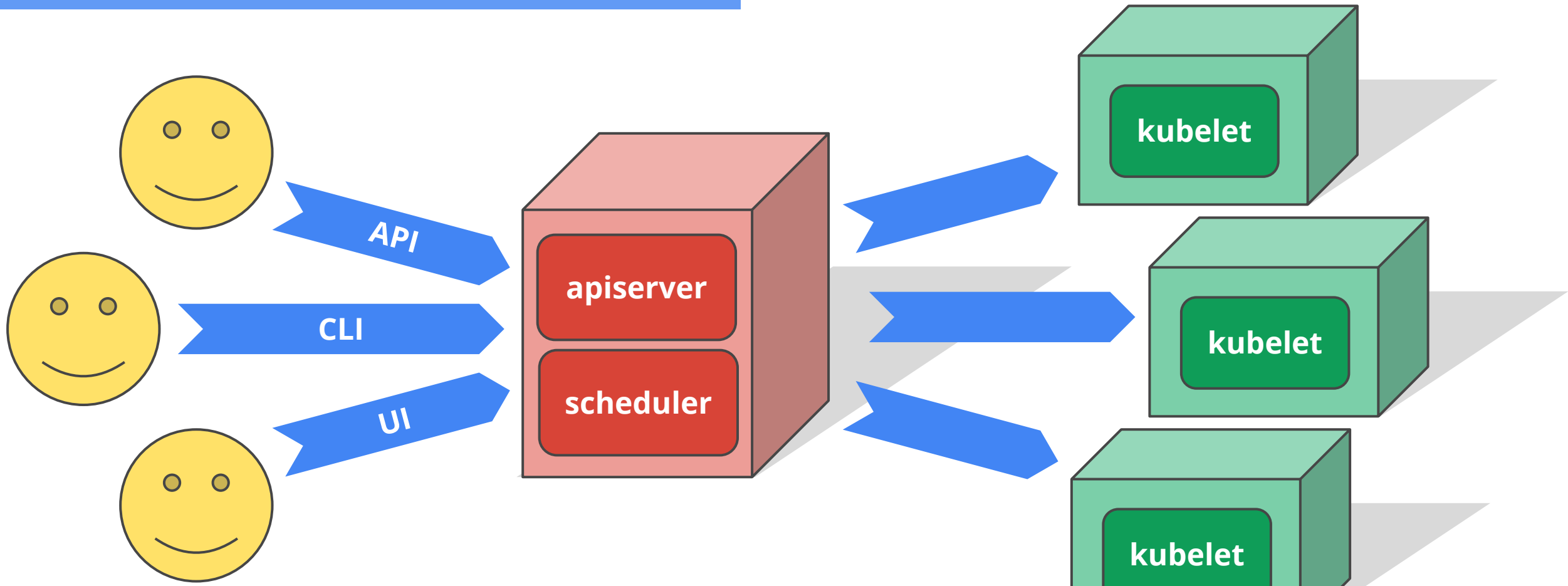
Kubernetes - Overview



Kubernetes - Pods

Small group of containers

Tightly coupled

- Run together on same machine
- Shared resources and fate

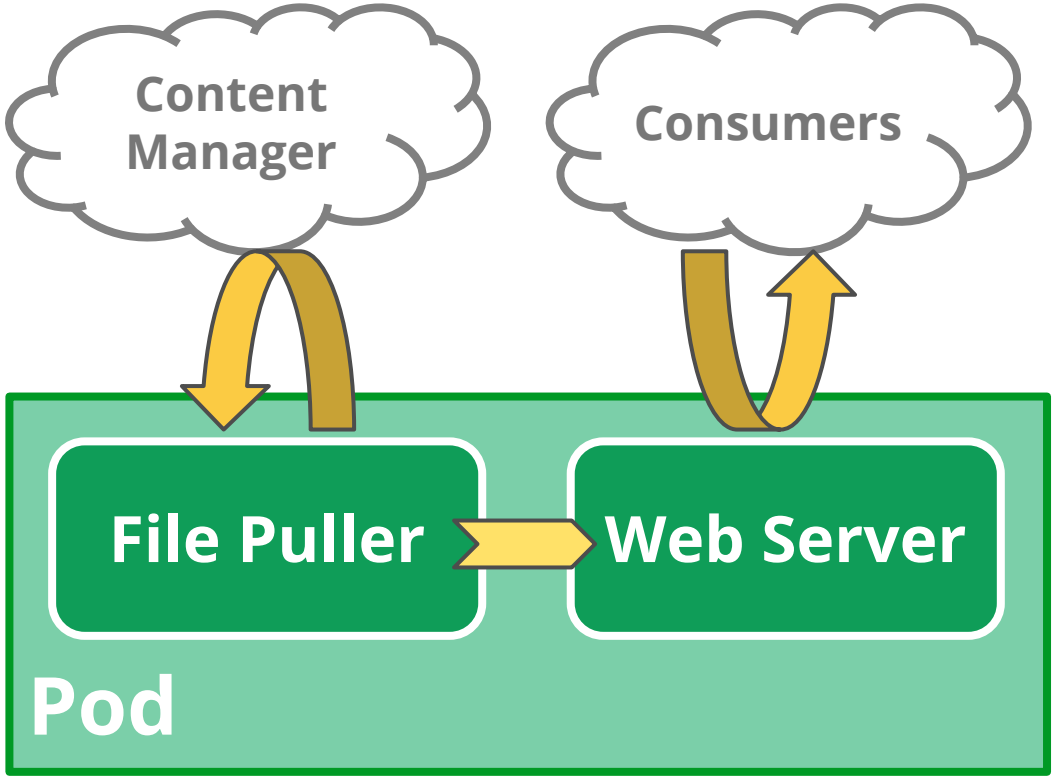
Scheduling atom

Assigned an IP

Shared network namespace

- **Share IP** address & localhost

Example: data puller & web server



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Kubernetes - Pods

Pod IPs are **routable**

- Docker default is private IP

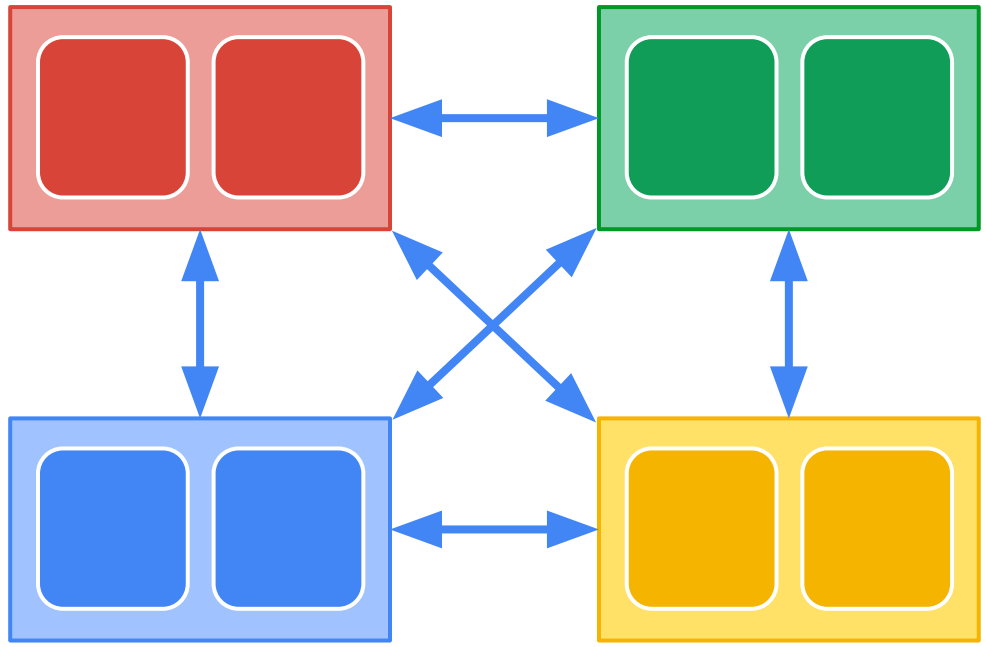
Pods can reach each other without NAT

- Even across nodes

Pods can egress traffic

- If allowed by cloud environment

No brokering of port numbers



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Kubernetes - Services

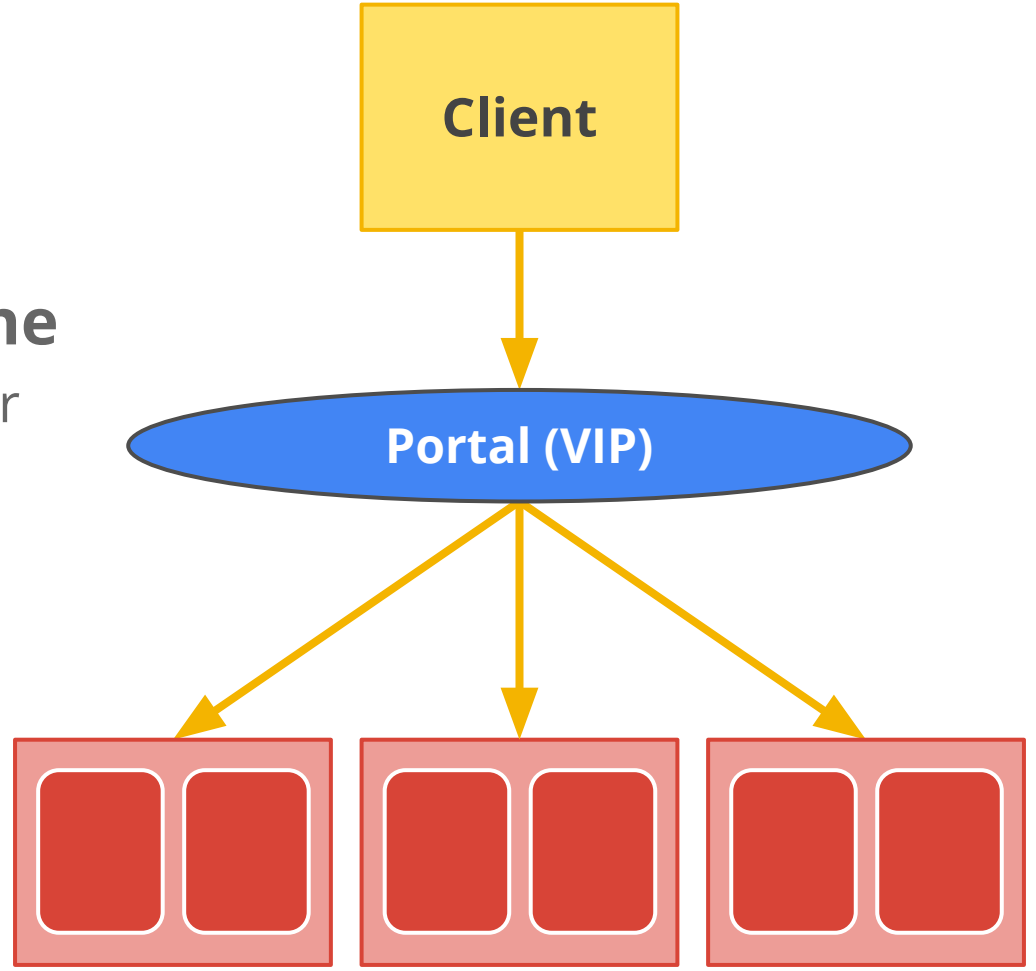
Pods are **ephemeral** they come and go

- Incorrect to talk to one of them directly

Services are groups of pods that **act as one**

- Like a group of pods in front of a load-balancer

Gets a **stable** virtual IP and port



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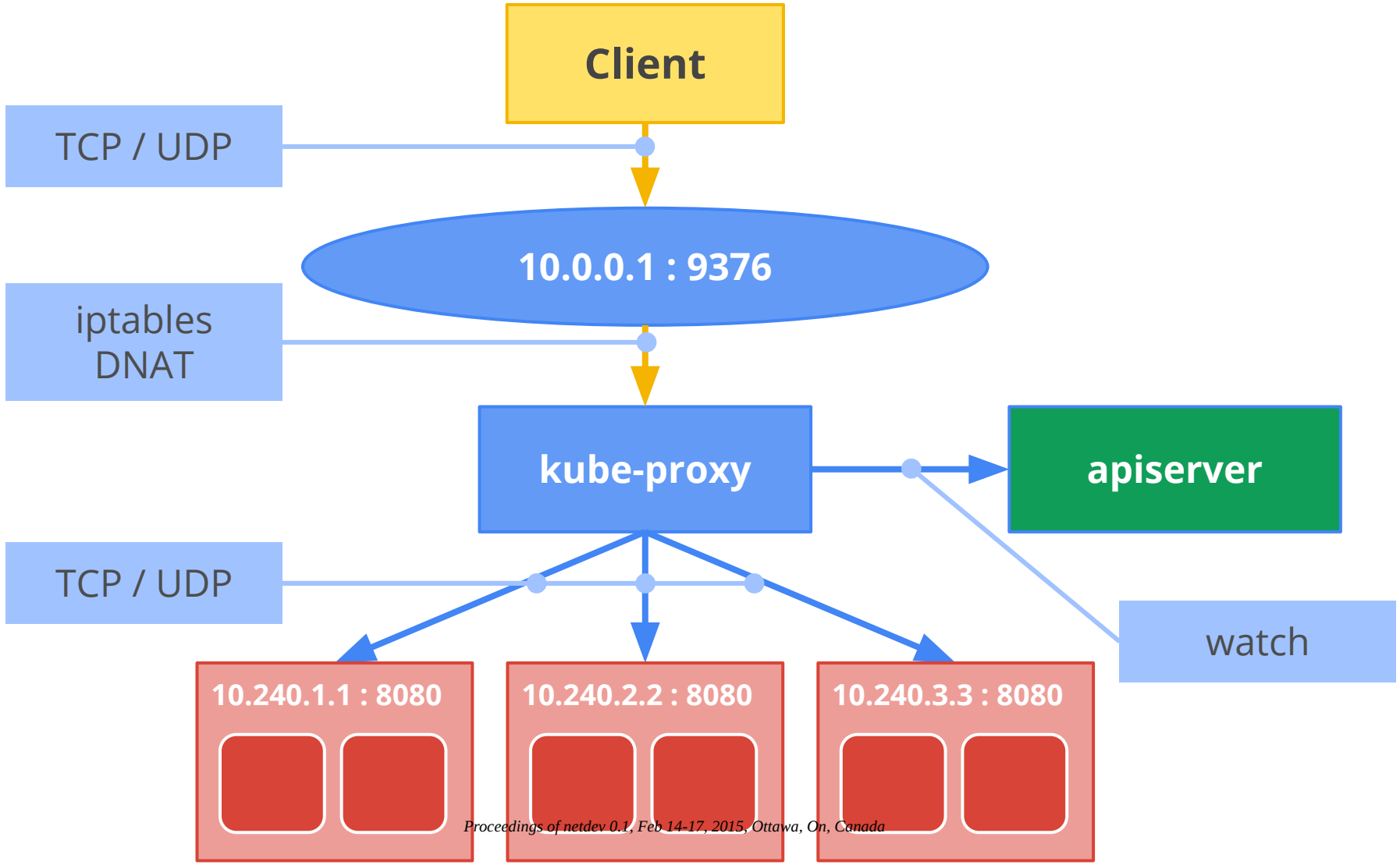
Kubernetes - Services



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Kubernetes - Service Discovery

Environment variables

- Exposed inside pod containers
- Difficult to scale

```
KUBERNETES_RO_SERVICE=10.0.0.1
MONITORING_SERVICE=10.0.0.10
FOO_SERVICE=10.0.0.11
BAR_SERVICE=10.0.0.4
```

NEW: Internal cluster DNS

- Service IPs are stable

```
kubernetes_ro
monitoring
foo
bar
```

Kubernetes - Configurations

Andromeda

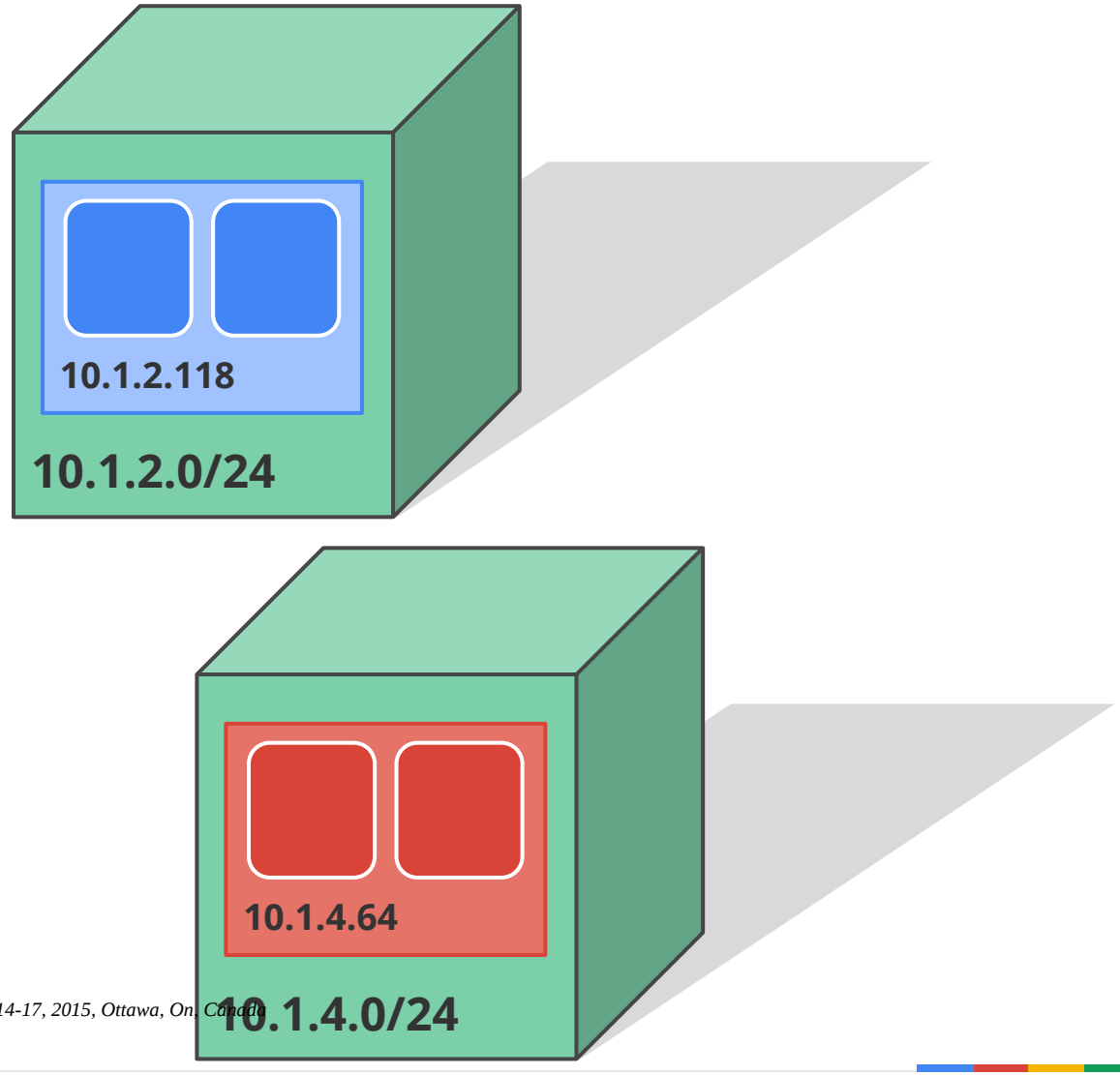
- Google's **SDN**
- Program underlying network fabric

Flannel

- **Overlay** network
- UDP packet encapsulation

Others

- OVS-based
- More overlays



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Kubernetes - Future Work

Resource management

- Cap network at node
- Cap cluster flows

Migratable IPs

- Enable **container migration**

Real load balancing

- Cluster-wide
- Use utilization and pod health

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Questions?

http://docker.io
http://kubernetes.io

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