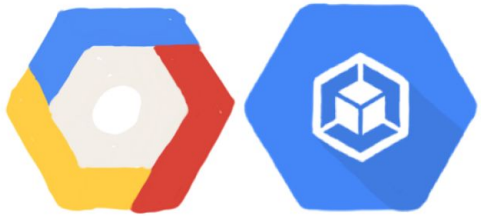
SECURING CLUSTERS WITH

Kubernetes Network Policies

@ahmetb

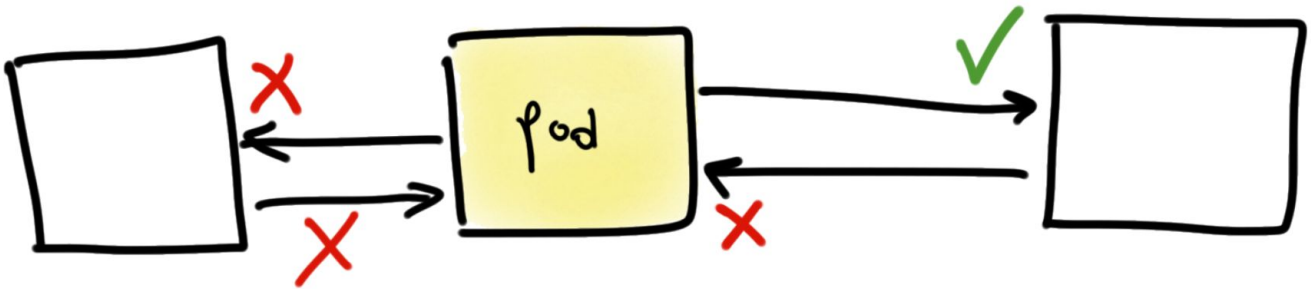
software engineer @ Google Cloud



AGENDA

1. what are Network Policies
2. how to write them
3. how do they work
4. go home and use them

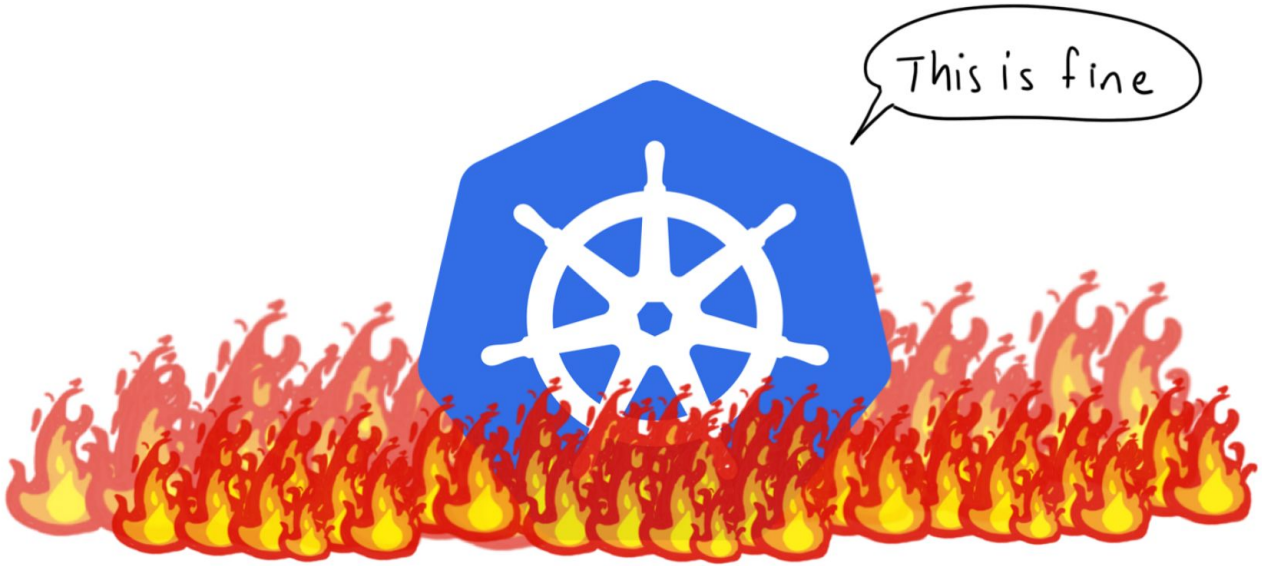
network policies control traffic from/to pods



STRAW POLL

Who is using Network Policies?

Kubernetes clusters without Network Policies



pre-work ⟶ late 2015

alpha ⟶ v1.2 (March 2016)

beta ⟶ v1.3 (July 2016)

stable ⟶ v1.7 (June 2017)

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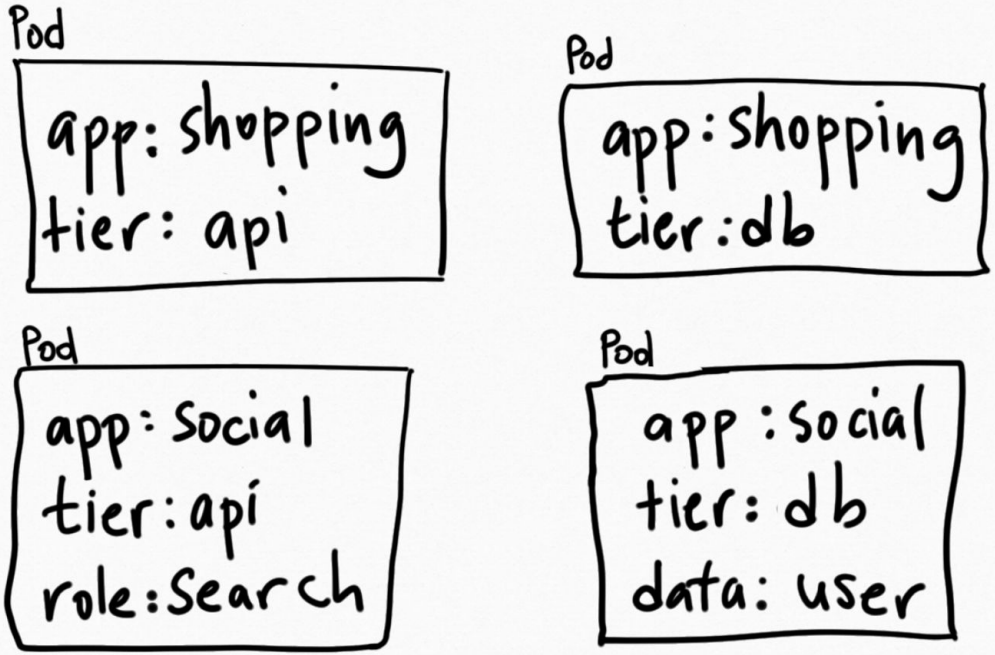
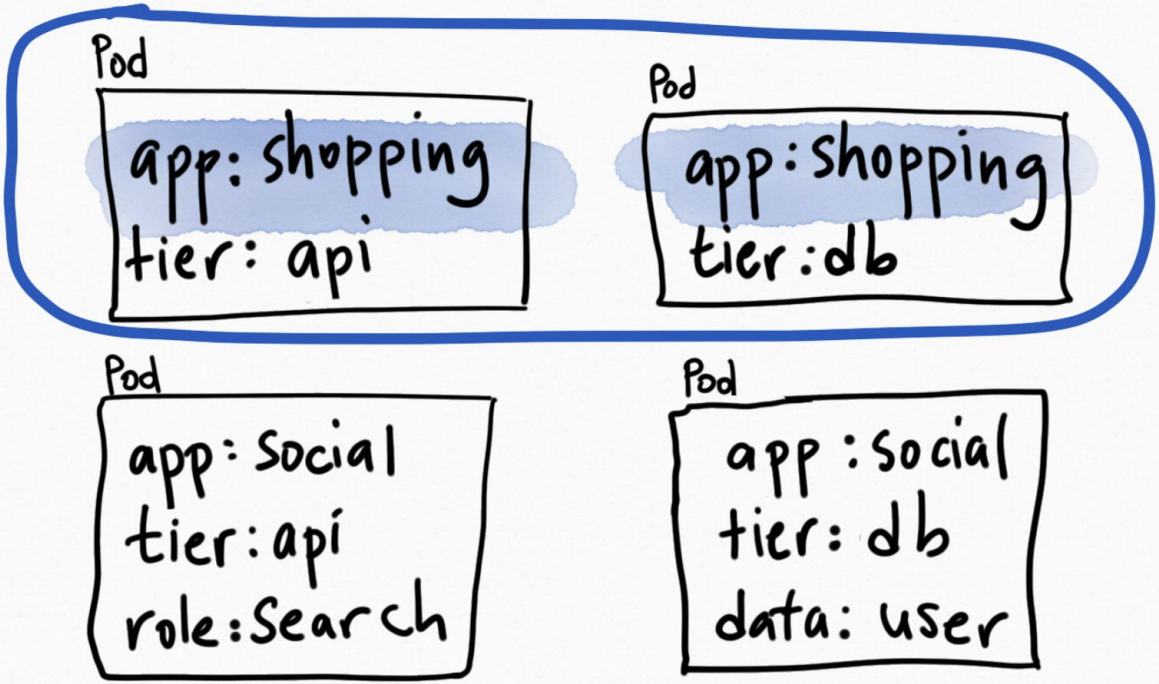
thanks to: Casey Davenport (Tigera), Christopher Luciano (IBM), Dan Winship (Red Hat)

writing network policies

but first, you need to know: **labels**



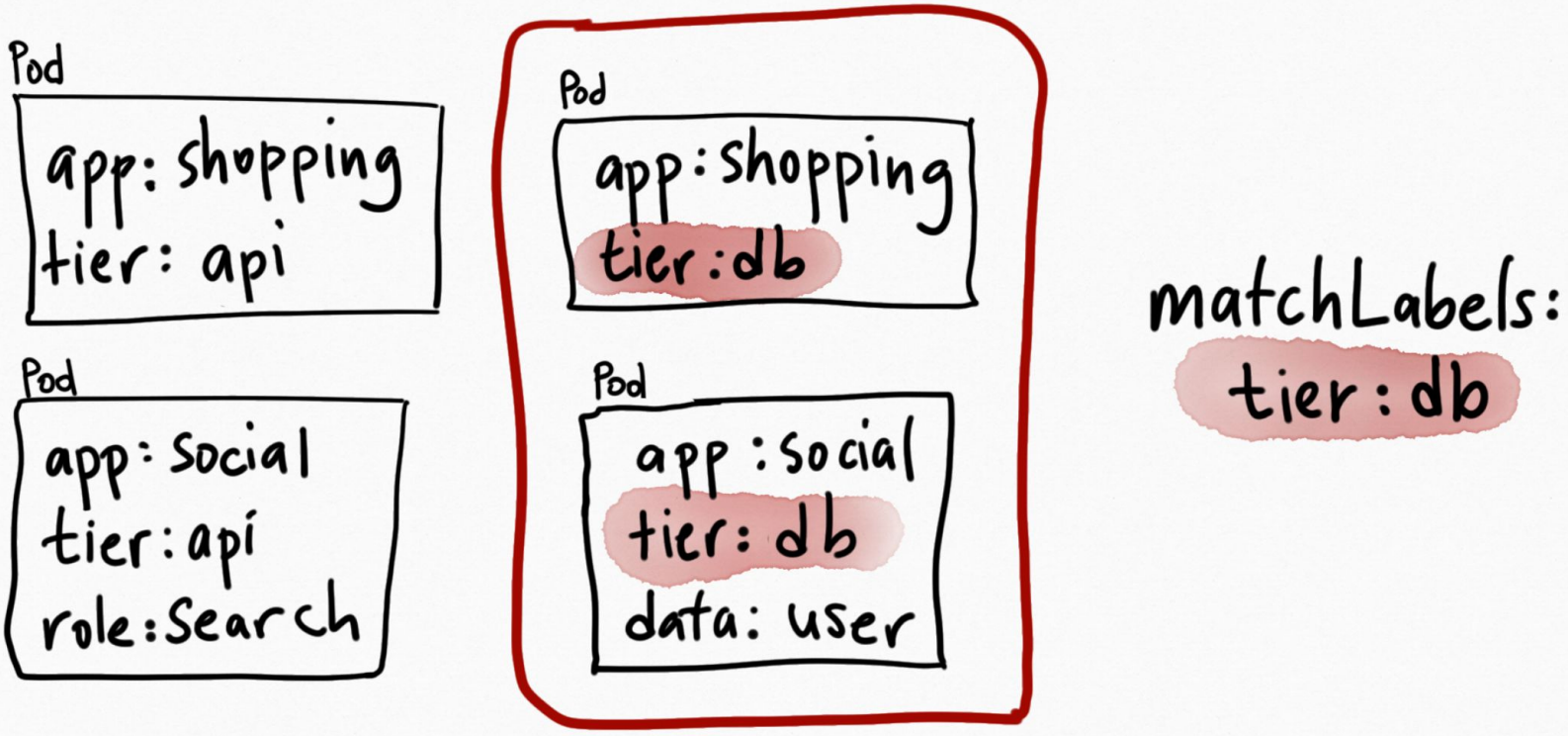
label selectors



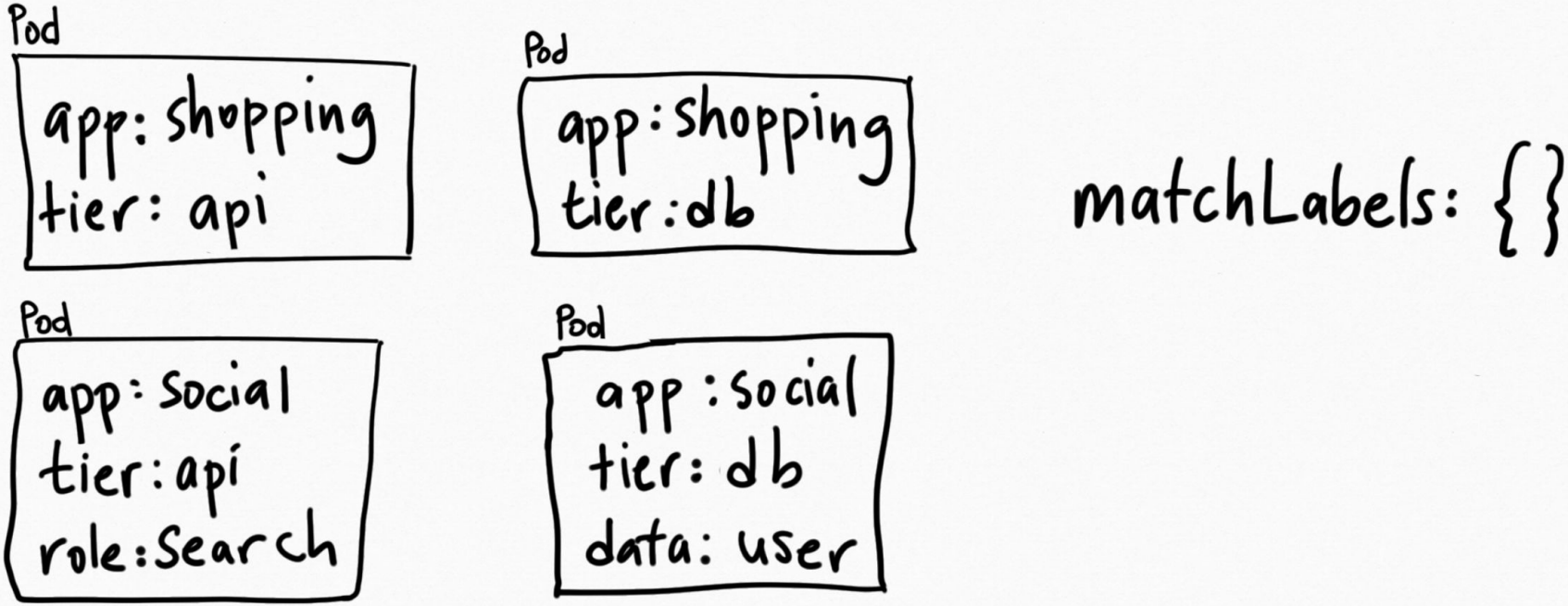
matchLabels:

app: shopping

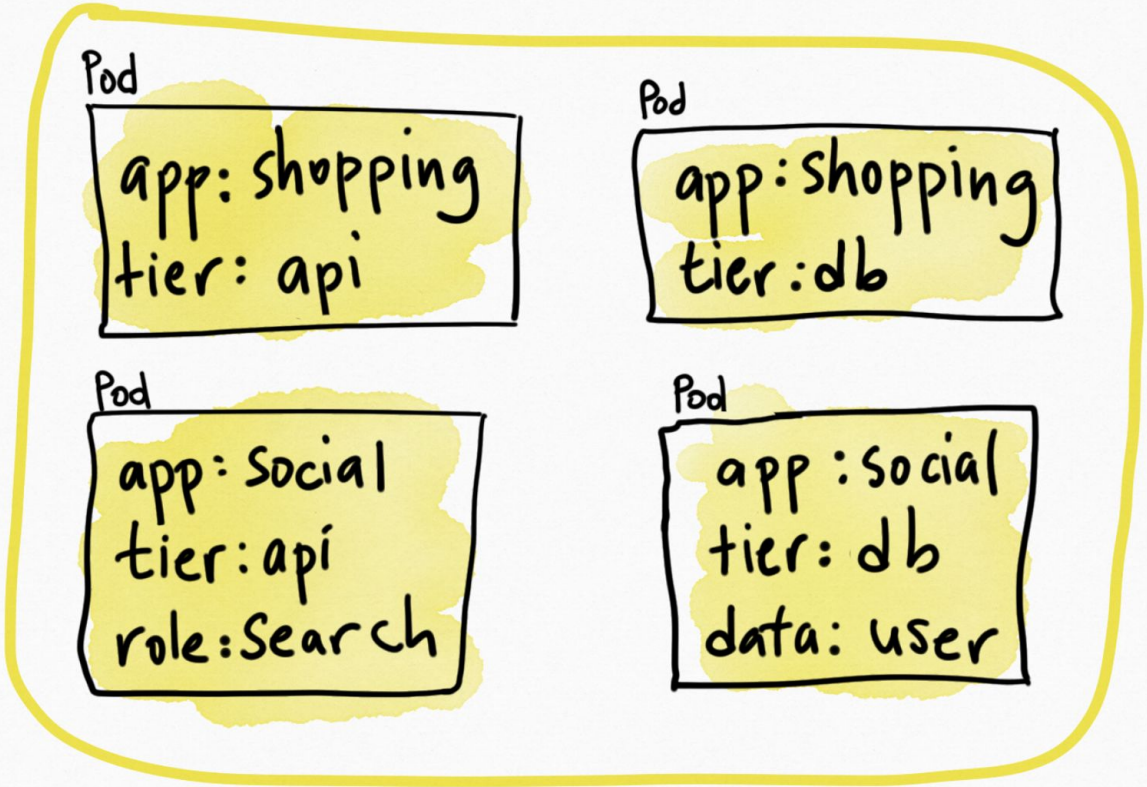
label selectors



empty label selector



empty label selector



matchLabels: {}

anatomy of a Network Policy

① which pods does it apply to

anatomy of a Network Policy

1. which pods does it apply to
2. for which direction?
   - Ingress: → Pod
   - Egress: Pod →

anatomy of a Network Policy

1. which pods does it apply to
2. for which direction?
   - Ingress: → Pod
   - Egress: Pod →
3. rules for allowing:
   - Ingress → who can connect to this Pod?
   - Egress → where can this pod connect to?

```
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: ...
  namespace: ...
  ...
spec:
  podSelector: ...
  ingress:
  - ...
  - ...
  egress:
  - ...
  - ...
```

RULE ①

traffic is allowed
unless there is a Network Policy
selecting the pod

RULE ②

traffic is denied

if there are policies selecting the pod,

but none of them have any rules allowing it.

(RULE ① + ②)

You can only write rules
that allow traffic.

Denying all traffic by matching to it

```yaml
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: default-deny-all
spec:
  podSelector: {}
  ingress: []
```

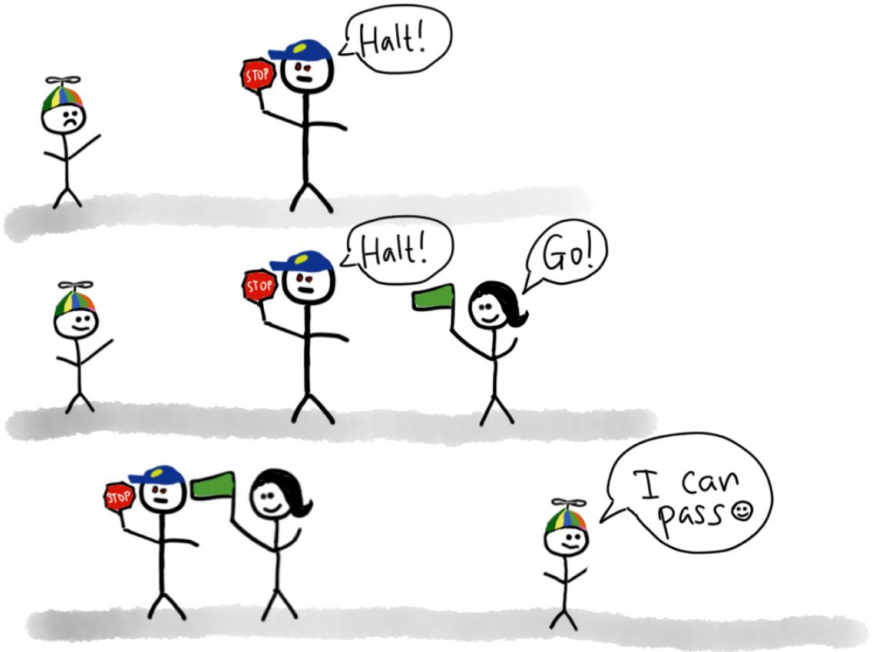
→ select all pods

→ empty array indicates nothing is whitelisted

RESULT: all ingress traffic is blocked by matching, and not allowing.

RULE 3

traffic is allowed if there is at least one policy allowing it



Example : allowing some traffic

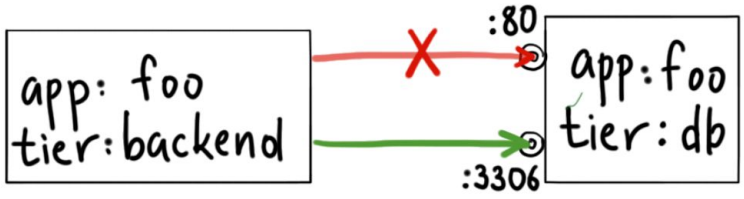
Example : allowing some traffic


```yaml
kind: NetworkPolicy
spec:
  podSelector:
    matchLabels:
      app: foo
      tier: db
  ingress:
  - from:
    - podSelector:
        matchLabels:
          app: foo
          tier: backend
```

for these pods

allow traffic from these

restricting port numbers




```
- from:
  - podSelector:
      matchLabels:
        app: foo
        tier: backend
  ports:
  - port: 3306
    protocol: TCP
```

Specifying port numbers

- Can't use Service ports in policies, yet.
- Use containerPort in the PodSpec.

RULE ④

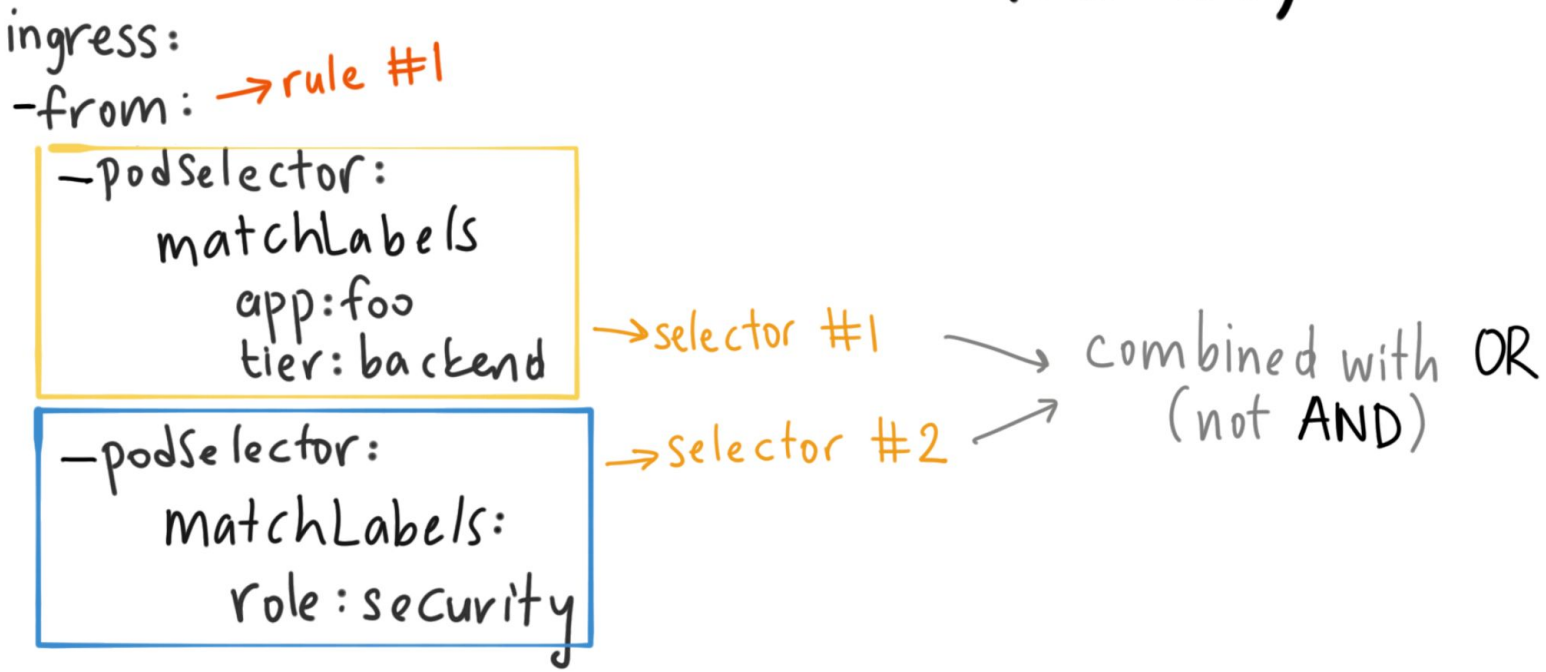
Policy rules are additive.

They are OR'ed with each other.

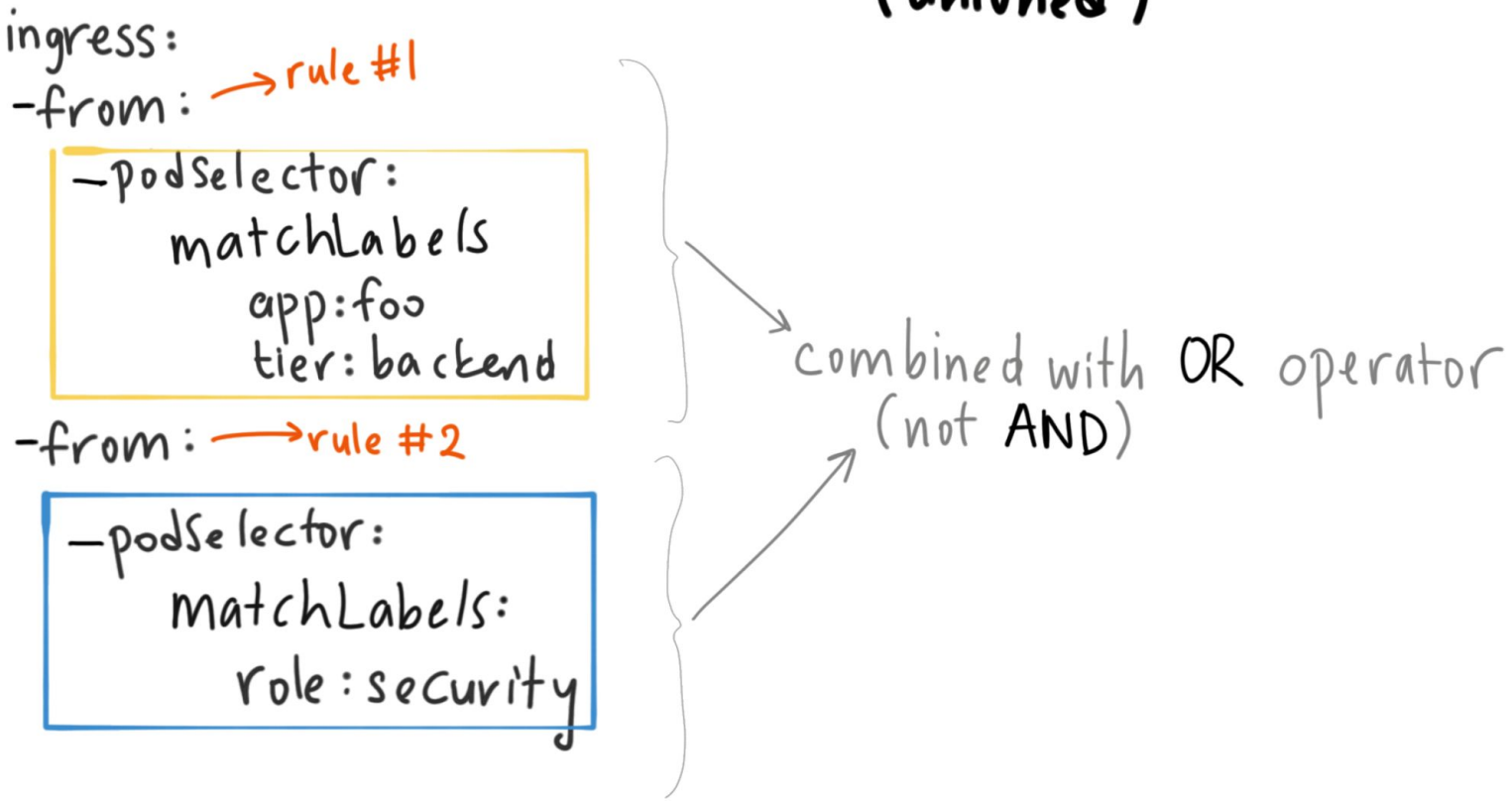
```
def allowed(traffic):
    return role1.allows(traffic) ||
           role2.allows(traffic) ||
           ...
           roleN.allows(traffic)
```

example

multiple selectors are combined (unioned)



multiple rules are combined, too (unioned)



Using empty selectors

"allow all monitoring pods to connect port 5000 of all pods."

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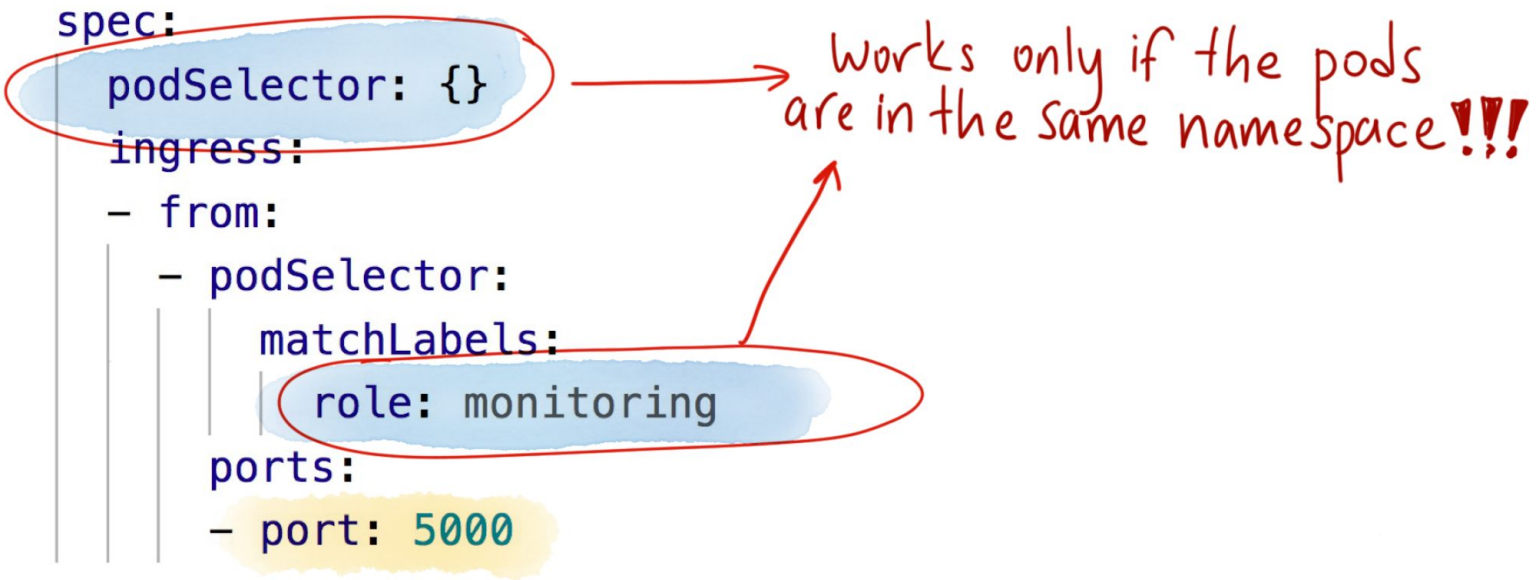
"allow all monitoring pods to connect port 5000 of all pods."

```
spec:
  podSelector: {}
  ingress:
  - from:
    - podSelector:
        matchLabels:
          role: monitoring
      ports:
      - port: 5000
```

Using empty selectors

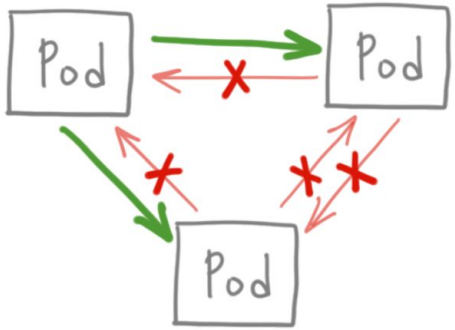
"allow all monitoring pods to connect port 5000 of all pods."



RULE ⑤

Network policies are scoped to the namespace they're deployed to.

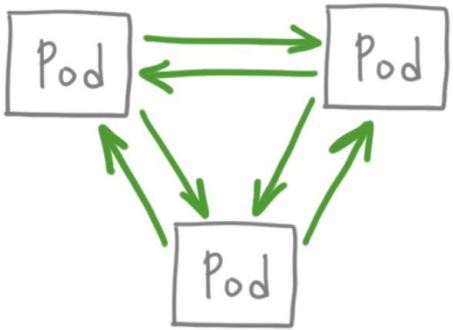
→ "spec.podSelector" does not select pods from other namespaces



namespace: foo

---

namespace: bar



(no policy enforcement)

allowing traffic from other namespaces

* `from.podSelector` matches only to pods in the current namespace
* need a new kind of selector to choose pods from other namespaces.

allowing traffic from other namespaces

- from.podSelector matches only to pods in the current namespace
- need a new kind of selector to choose pods from other namespaces.

namespaceSelector

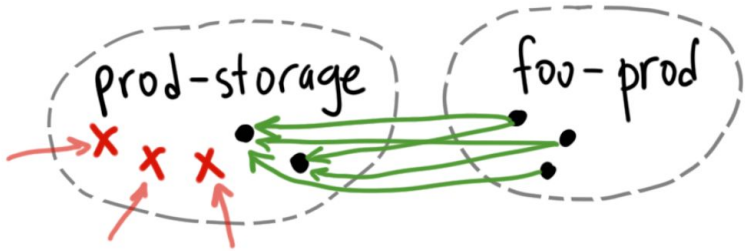
- like podSelector
- selects namespaces, using labels

who is labeling their namespaces?

allowing traffic from other namespaces

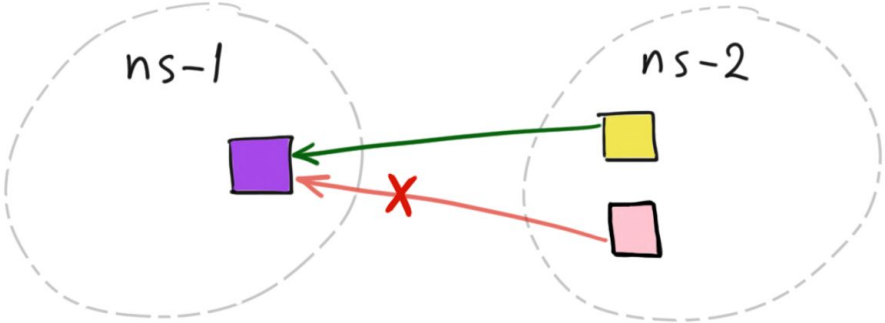
```yaml
metadata:
  namespace: prod-storage
  name: allow-prod-apps
spec:
  podSelector: {}
  ingress:
  - from:
    - namespaceSelector:
        matchLabels:
          purpose: prod
```

```yaml
apiVersion: v1
kind: Namespace
metadata:
  name: foo-prod
  labels:
    purpose: prod
    product: foo
```



limitation

allowing some pods from other namespaces



(this is not possible today)

3 ways to specify where the traffic can
- come from 
- go to 

1. podSelector ✓
2. namespaceSelector ✓
3. ipBlock ?

the "ipBlock" selector

CIDR refresher	
10.0.0.0/8	10.x.x.x
192.1.2.0/24	192.1.2.x
0.0.0.0/0	x.x.x.x

allow 10.56.x.x

```yaml
from:
- ipBlock:
    cidr: 10.56.0.0/16
```

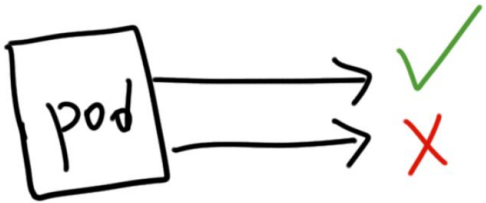
allow 10.x.x.x
but deny 10.11.12.x

```yaml
from:
- ipBlock:
    cidr: 10.0.0.0/8
    except:
    - 10.11.12.0/24
```

egress rules

almost identical to ingress rules

controls the traffic from selected pods



Denying all egress traffic

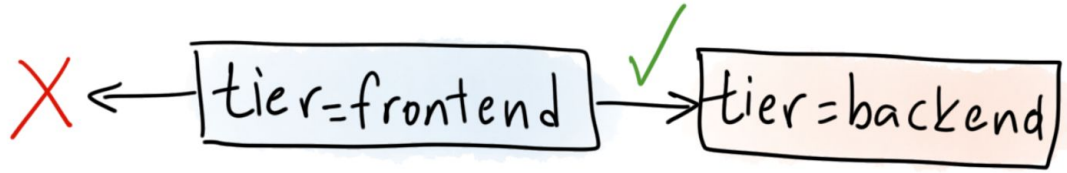
```yaml
kind: NetworkPolicy
metadata:
  name: default-deny-all-egress
spec:
  podSelector: {}
  policyTypes:
  - Egress
  egress: []
```

→ select all pods in the namespace

→ need this if you have egress rules

→ empty array = no rules.
nothing is whitelisted

allowing some egress traffic




```yaml
spec:
  podSelector:
    matchLabels:
      tier: frontend
  policyTypes:
  - Egress
  egress:
  - to:
    - podSelector:
        matchLabels:
          tier: backend
```

allowing some egress traffic

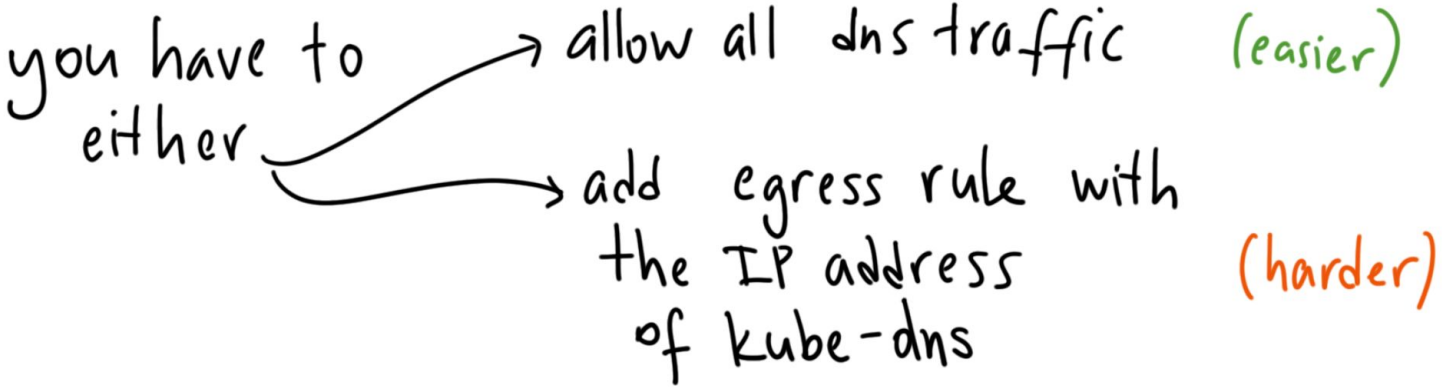

```yaml
spec:
  podSelector:
    matchLabels:
      tier: frontend
  policyTypes:
  - Egress
  egress:
  - to:
    - podSelector:
        matchLabels:
          tier: backend
```

(on frontend Pod)

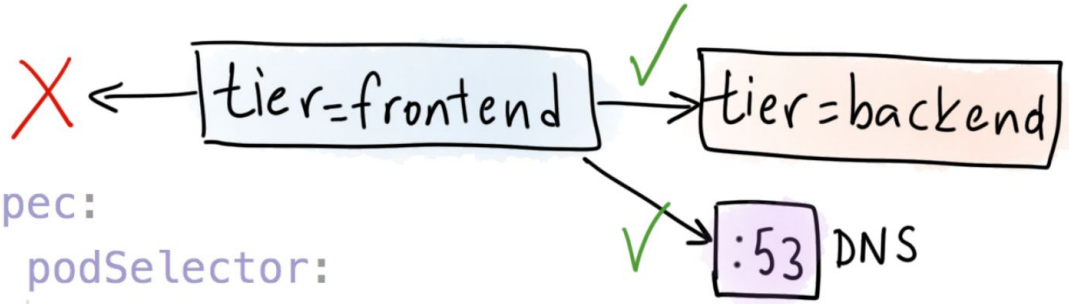
```
$ curl http://backend
cannot resolve host: 'backend'
```

????

egress policies actually block dns resolution



allowing some egress traffic & dns




```yaml
spec:
  podSelector:
    matchLabels:
      tier: frontend
  policyTypes:
  - Egress
  egress:
  - to:
    - podSelector:
        matchLabels:
          tier: backend
```

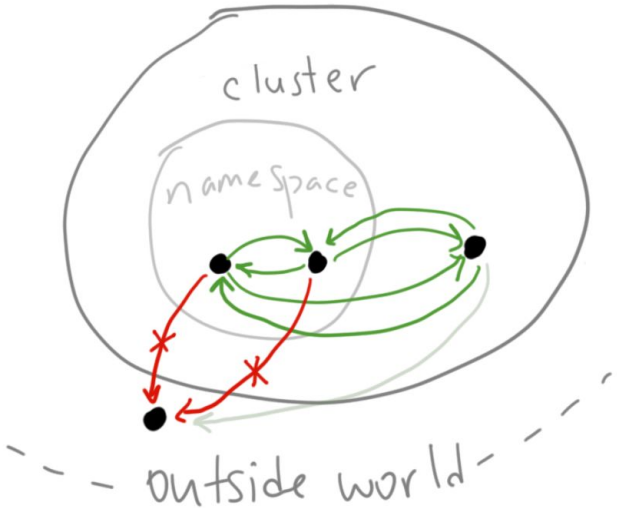
rule #1

rule #2

```yaml
  - ports:
    - port: 53
      protocol: "UDP"
    - port: 53
      protocol: "TCP"
```

more fun with egress

blocking external traffic




```yaml
metadata:
  name: allow-local-egress
spec:
  podSelector: {}
  policyTypes:
  - Egress
  egress:
  - to:
    - namespaceSelector: {}
```

enforce policy for all pods in this namespace

all namespaces (with all their pods)

how are

network policies

enforced

surprise!

without a networking plugin
that enforces policies,
NetworkPolicy objects are
Silently ignored

install a plugin like Calico, WeaveNet or Romana
(not an endorsement)

GKE network policy (beta)

powered by Calico

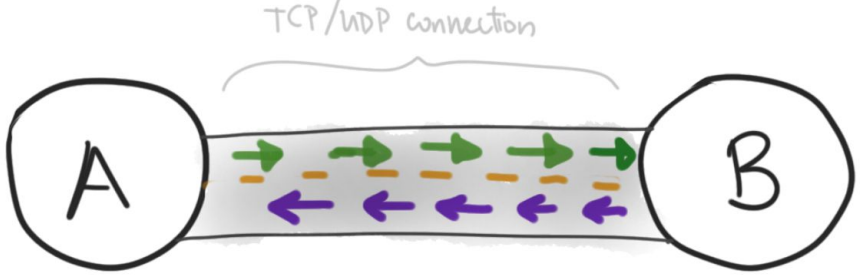
```
$ gcloud beta container clusters create
    --enable-network-policy
```

→ installs Calico network plugin
→ in partnership with Tigera
→ releases managed by Google

→ cloud.google.com/kubernetes-engine

Connections are duplex (2-way)

once A connects B, B can send data to A, on the same connection.

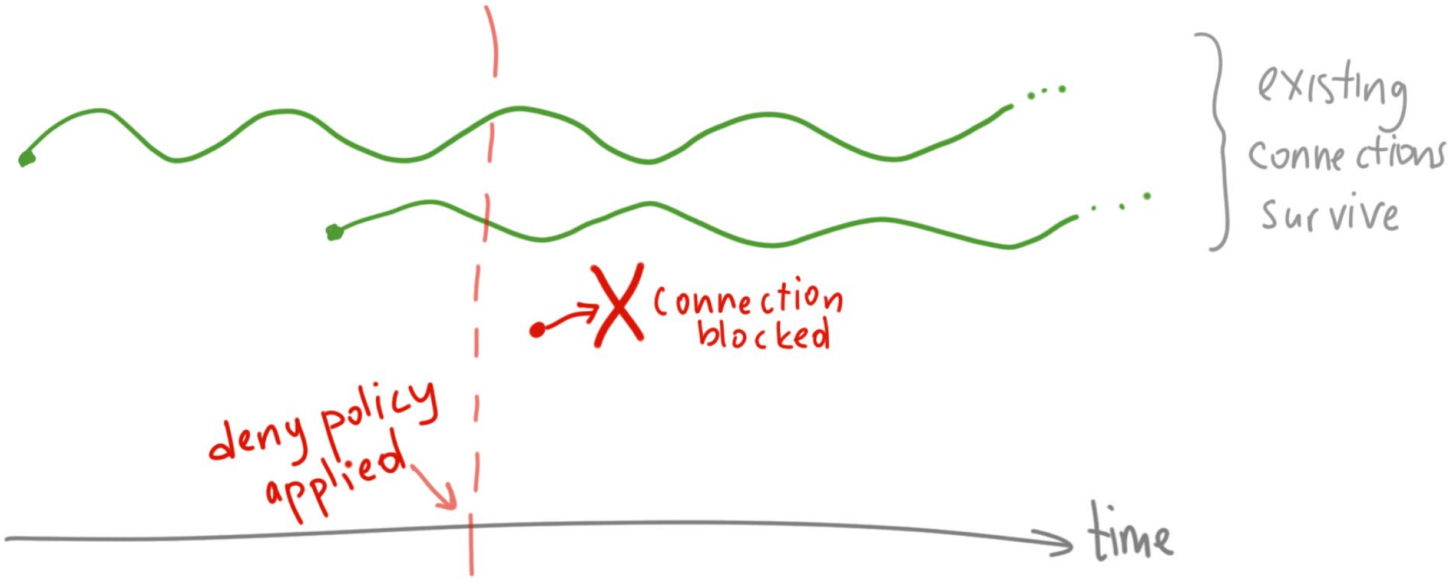


(does not mean B can connect to A)

network policy is a connection filter

→ does not apply to packets

→ does not terminate established connections



Network policies add minimal latency

→ depends on the network plugin
- iptables vs overlay
- implementation, caching differences

→ can depend on number of policies deployed

→ sub-1ms. overhead [1]

[1] http://blog.kubernetes.io/2016/09/high-performance-network-policies-kubernetes.html

best practices

use "default-deny-all" rules

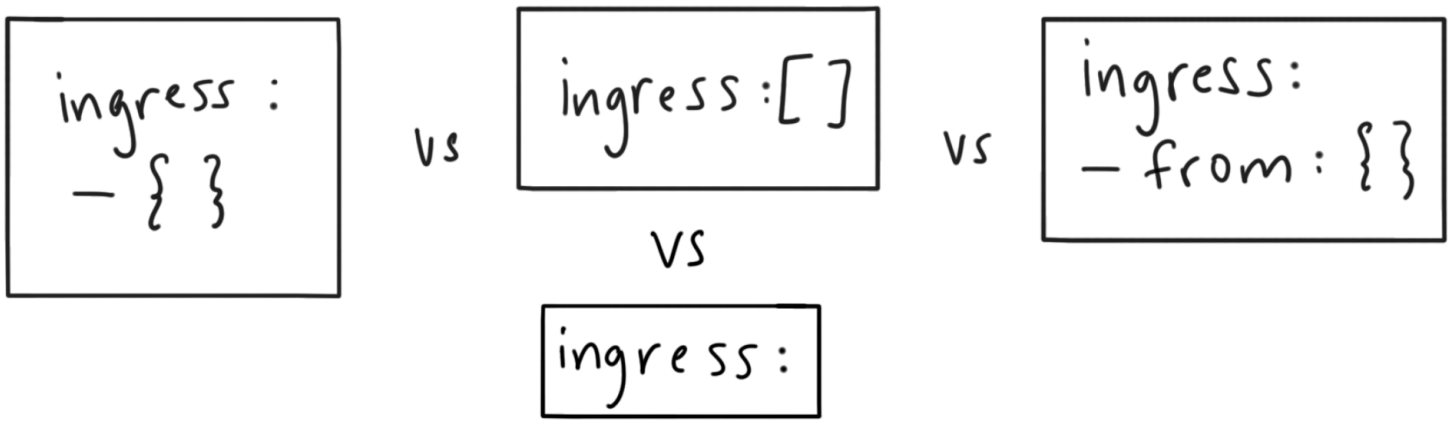
first block all ingress/egress in a namespace

then start whitelisting for each application

understand rule evaluation

* rules are OR'ed (not ANDed)
  → additivity may cause unexpected results

* be explicit about empty vs null fields

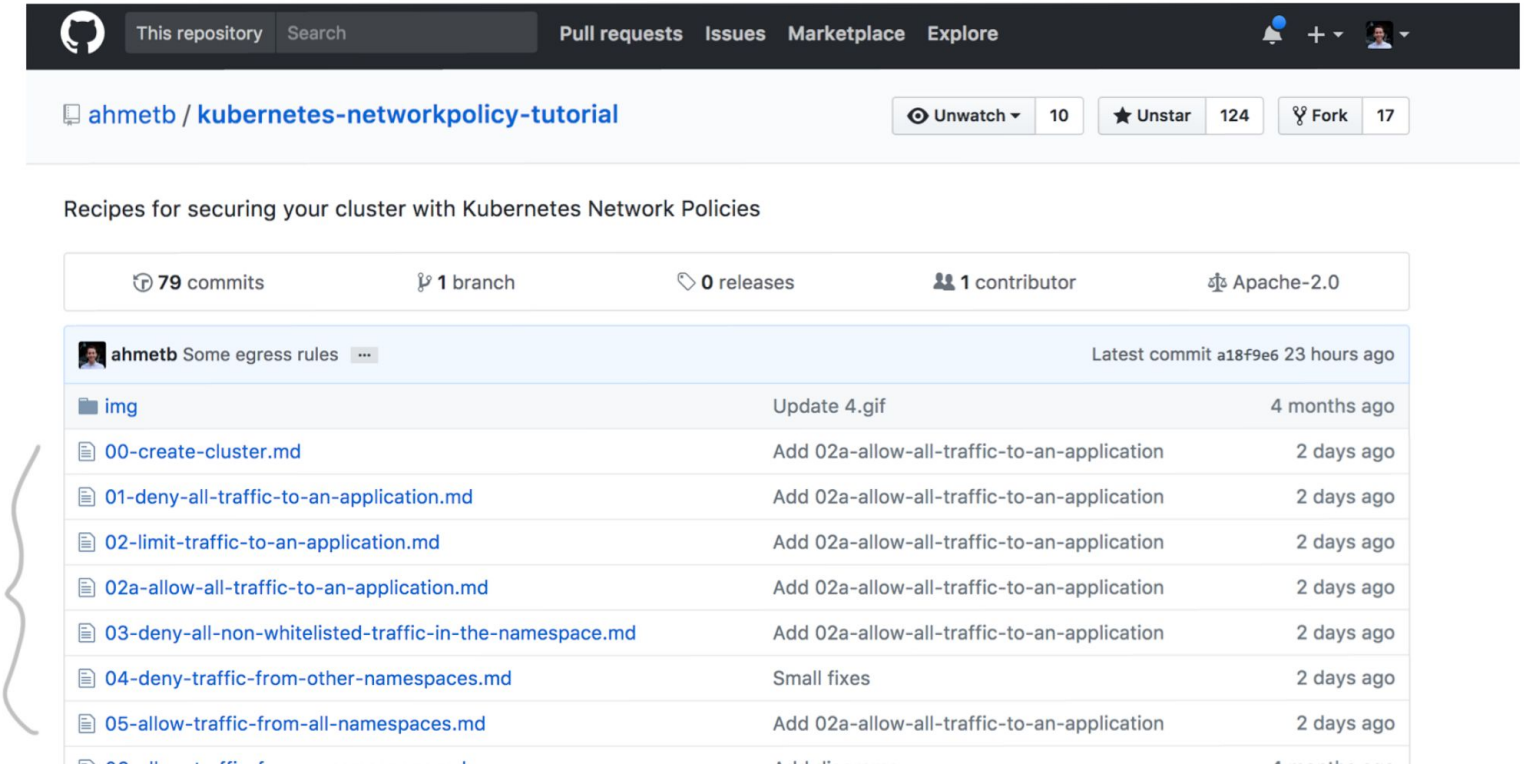


test your policies

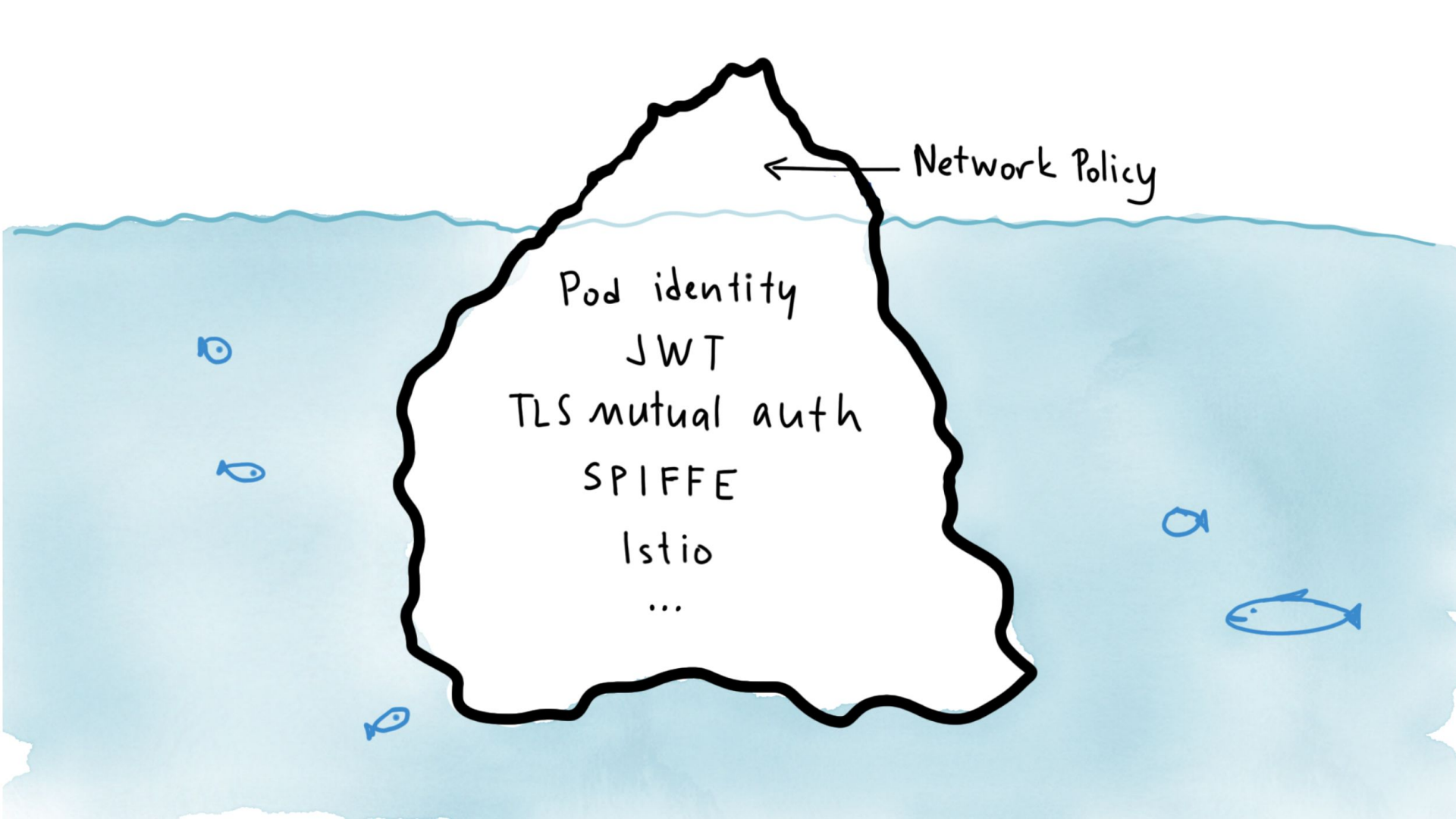
* try what's allowed/blocked
* test external connectivity
  - ingress: should I allow traffic from external LB?
  - egress: should I allow connections to external?
* test with other namespaces
  - allow connections from/to another namespace?
* use "kubectl describe" to verify rule syntax

learn more

github.com/ahmetb/kubernetes-networkpolicy-tutorial



recipes


Network Policy
Pod identity
JWT
TLS mutual auth
SPIFFE
Istio
...

thank you!

@ahmetb

software engineer @ Google Cloud

github.com/ahmetb/kubernetes-networkpolicy-tutorial

cloud.google.com/kubernetes-engine