Network Security for Containerized Applications

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Agenda

Kubernetes and SDN Choices

OpenShift and OpenShift SDN

Typical network security questions on an Enterprise Cluster

- Restricting traffic across tiers
- Handling network zones and isolation
- Securing Egress
- Securing Ingress
- Securing communications between Nodes
- Application Network Security

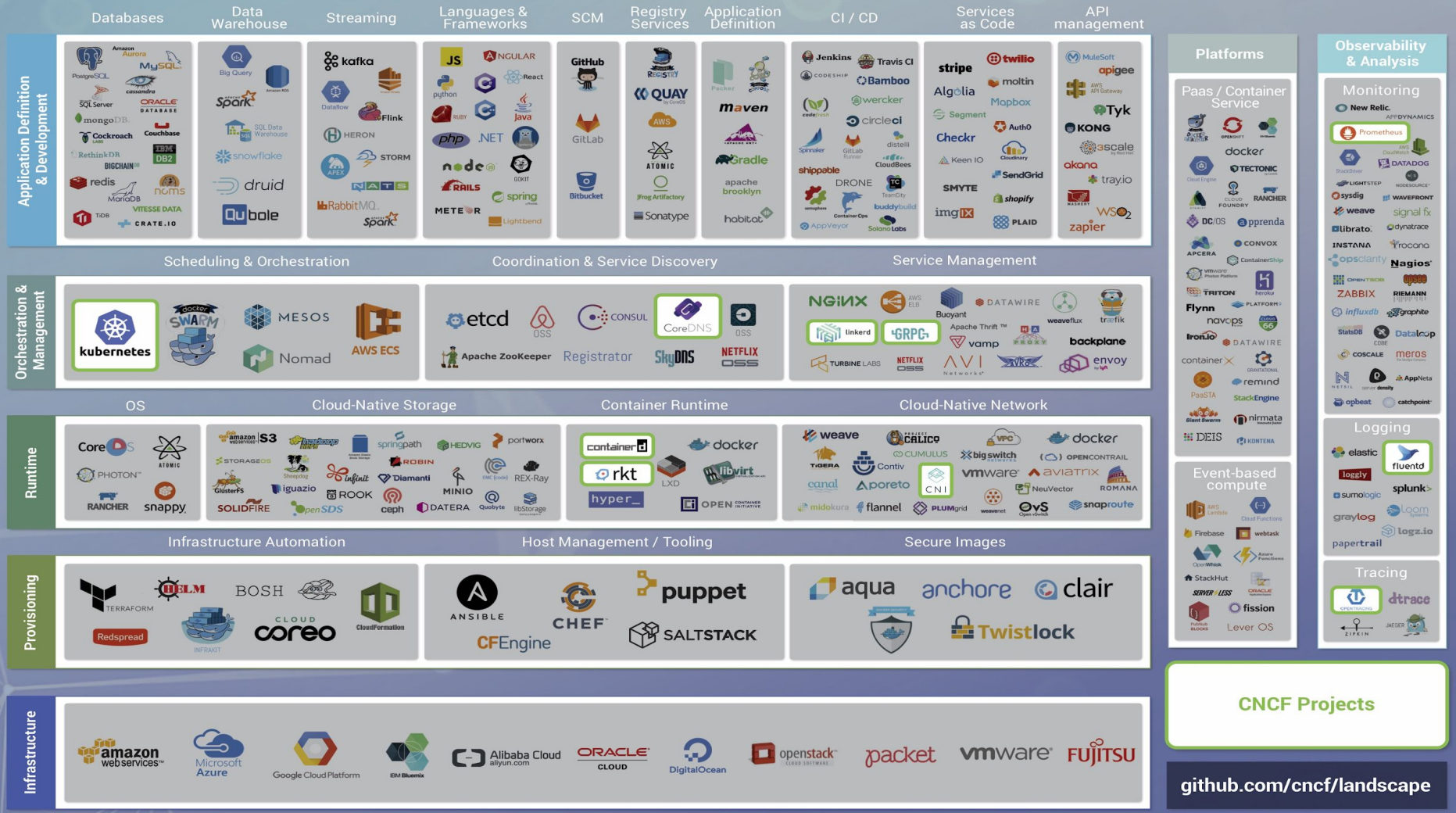
Kubernetes is a clear winner in the world of Container Orchestration and Management

WHAT DOES IT TAKE TO MAKE K8S ENTERPRISE READY?

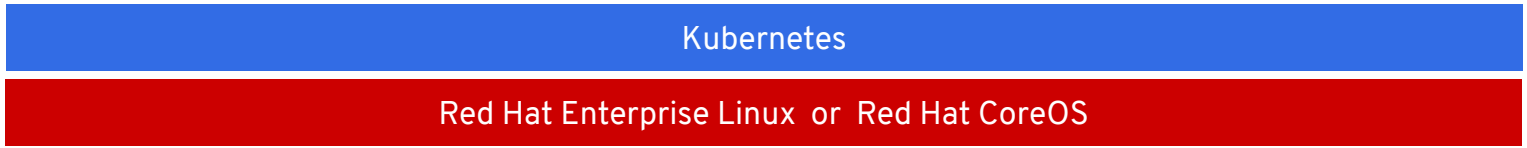
How do I support my K8S cluster? version upgrades, fixes/patches etc

You'll need a lot more on your cluster than Kubernetes itself..

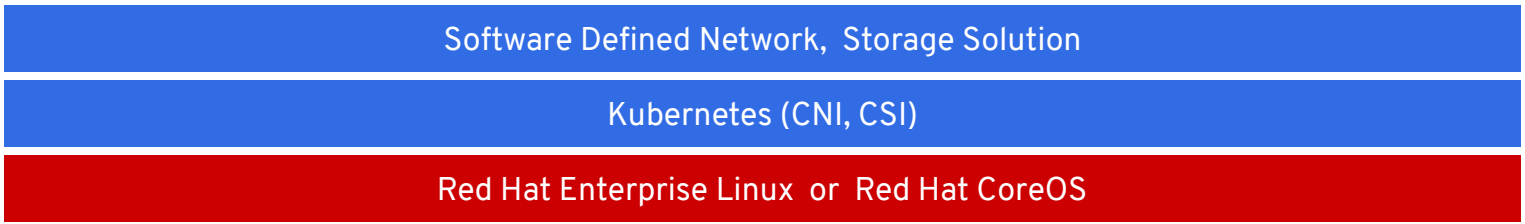
Kubernetes

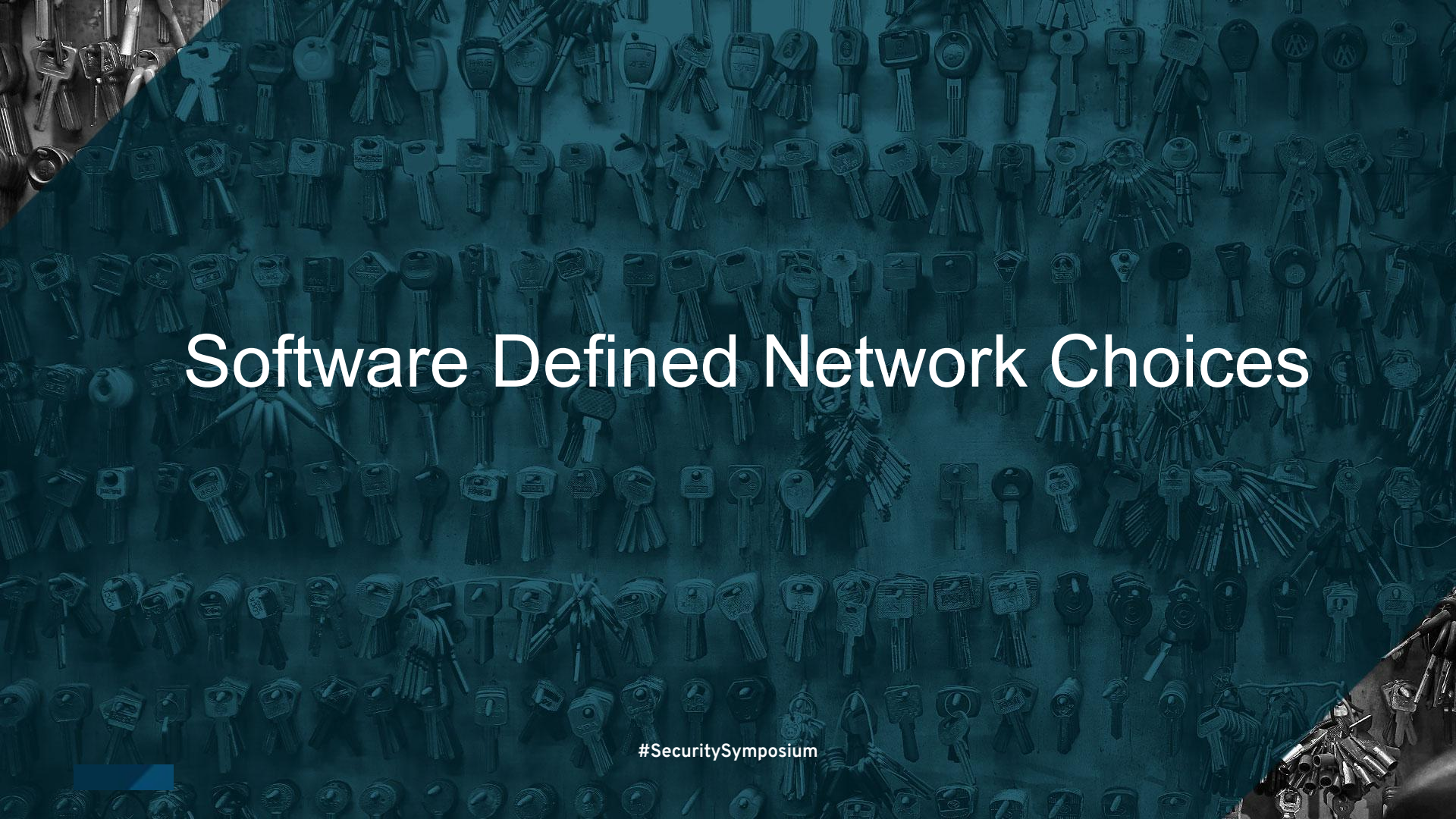

Databases
Data Warehouse
Streaming
Languages & Frameworks
SCM
Registry Services
Application Definition
CI / CD
Services as Code
API management
Application Definition & Development
Scheduling & Orchestration
Coordination & Service Discovery
Service Management
Orchestration & Management
kubernetes
MESOS
Nomad
AWS ECS
etcd
CONSUL
CoreDNS
Apache ZooKeeper
Registrator
SkyDNS
NETFLIX OSS
NGINX
linkerd
gRPC
Buoyant
DATAWIRE
Apache Thrift
vamp
backplane
envoy
OS
Cloud-Native Storage
Container Runtime
Cloud-Native Network
Runtime
RANCHER
container
rkt
hyper_
docker
LXD
libvirt
OPEN CONTAINER INITIATIVE
weave
CALICO
CUMULUS
big switch
OPENCONTRAIL
Contiv
VMware
aviatrix
CNI
NeuVector
ROMANA
Aporeto
canal
flannel
PLUMgrid
OvS
snaproute
Infrastructure Automation
Host Management / Tooling
Secure Images
Provisioning
TERRAFORM
HELM
BOSH
CLOUD FOUNDRY
Redspread
CloudFormation
ANSIBLE
CHEF
CFEngine
puppet
SALTSTACK
aqua
anchore
clair
Twistlock
Infrastructure
amazon web services
Microsoft Azure
Google Cloud Platform
IBM Bluemix
Alibaba Cloud
ORACLE CLOUD
DigitalOcean
openstack
packet
vmware
FUJITSU
Platforms
Paas / Container Service
Event-based compute
Observability & Analysis
Monitoring
New Relic.
Prometheus
DATADOG
sysdig
WAVEFRONT
weave
signal fx
Nagios
ZABBIX
RIEMANN
graphite
Logging
elastic
fluentd
loggly
splunk
sumologic
graylog
papertrail
Tracing
OPENTRACING
dtrace
JAEGER
ZIPKIN
CNCF Projects
github.com/cncf/landscape

K8S REQUIRES A SECURE ENTERPRISE GRADE LINUX CONTAINER HOST



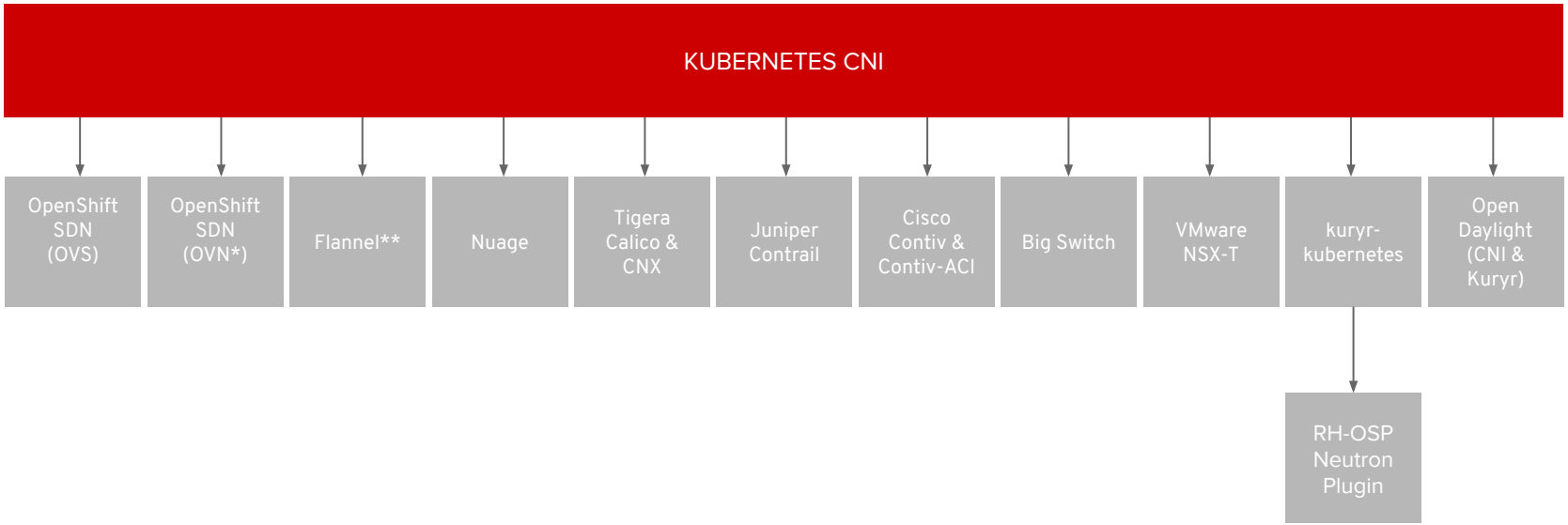
K8S CLUSTER REQUIRES NETWORKING AND STORAGE SOLUTIONS



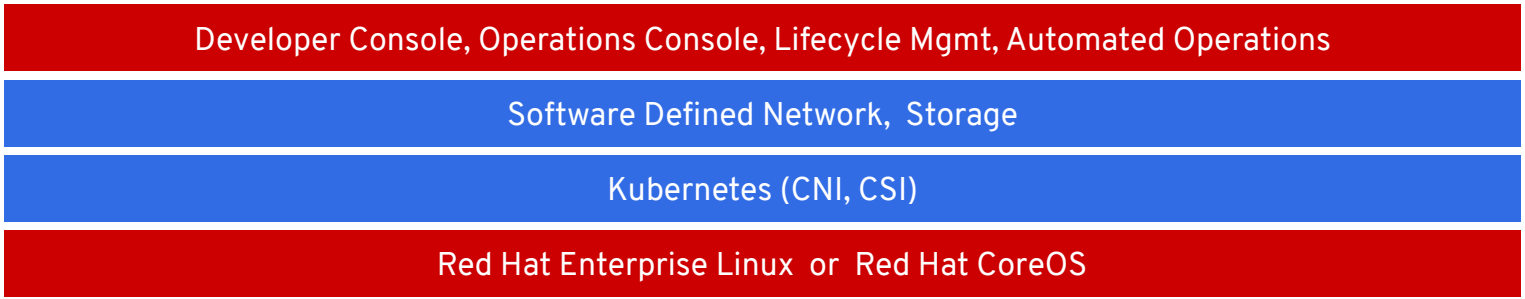


Software Defined Network Choices

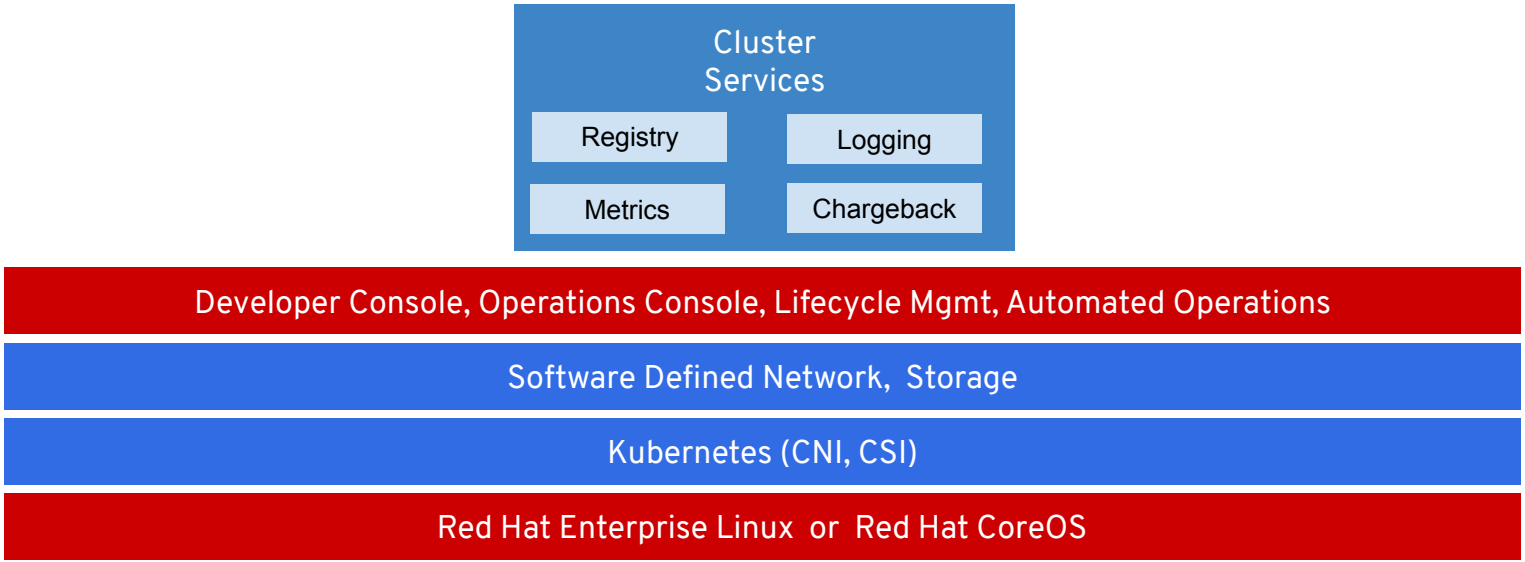
For Network solution, K8S uses CNI



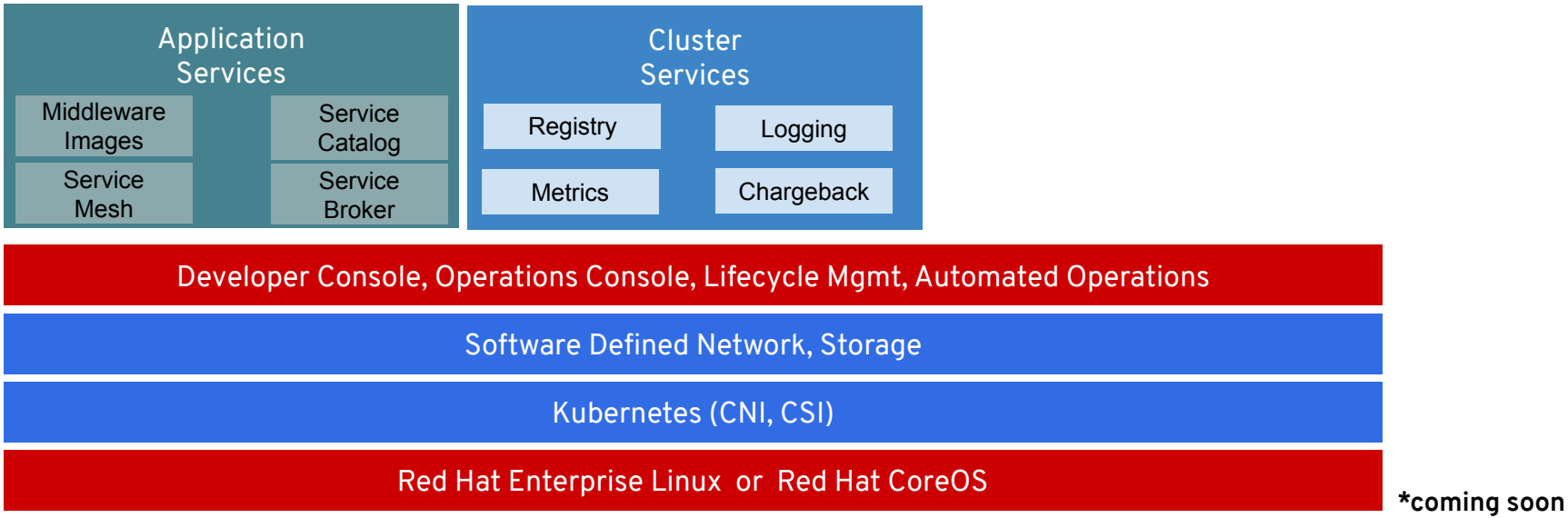
K8S CLUSTER REQUIRES LIFECYCLE MGMT FOR DEVELOPERS AND OPERATORS



YOU'LL NEED CONTAINER REGISTRY, LOGGING, METRICS, CHARGEBACK CAPABILITIES

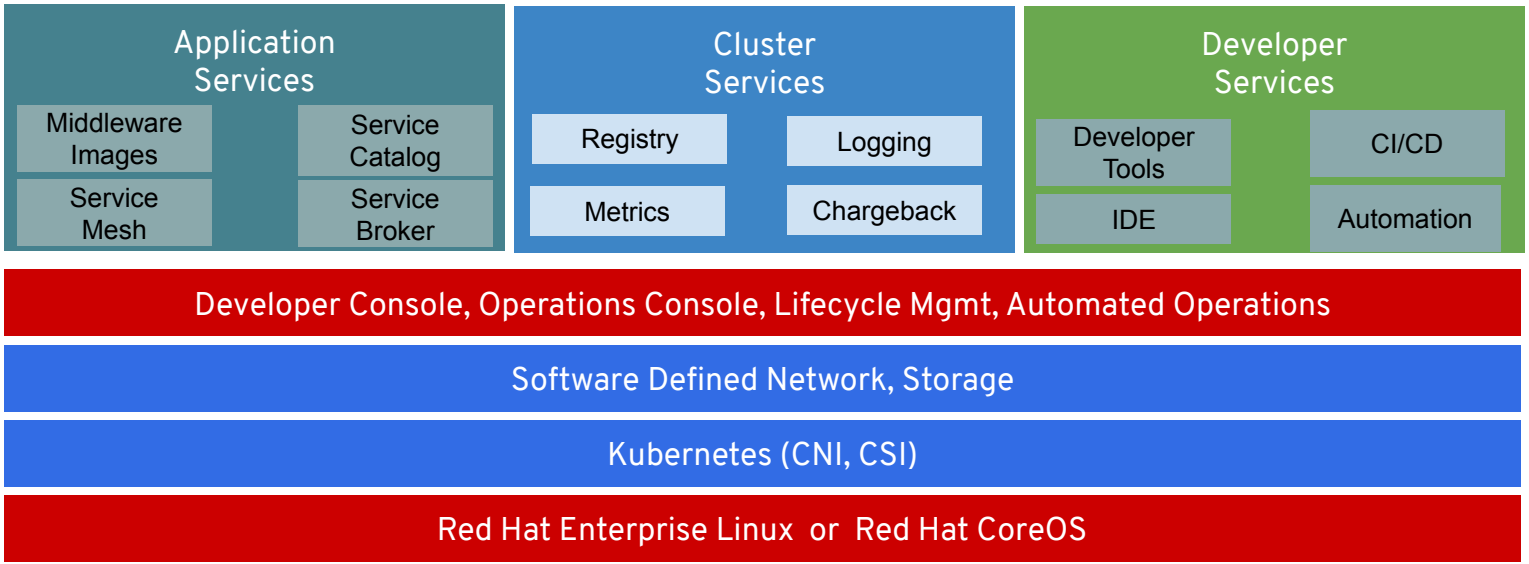


YOU'LL NEED TO STANDARDIZE ON MIDDLEWARE, A SERVICE CATALOG, AND MICROSERVICE MGMT

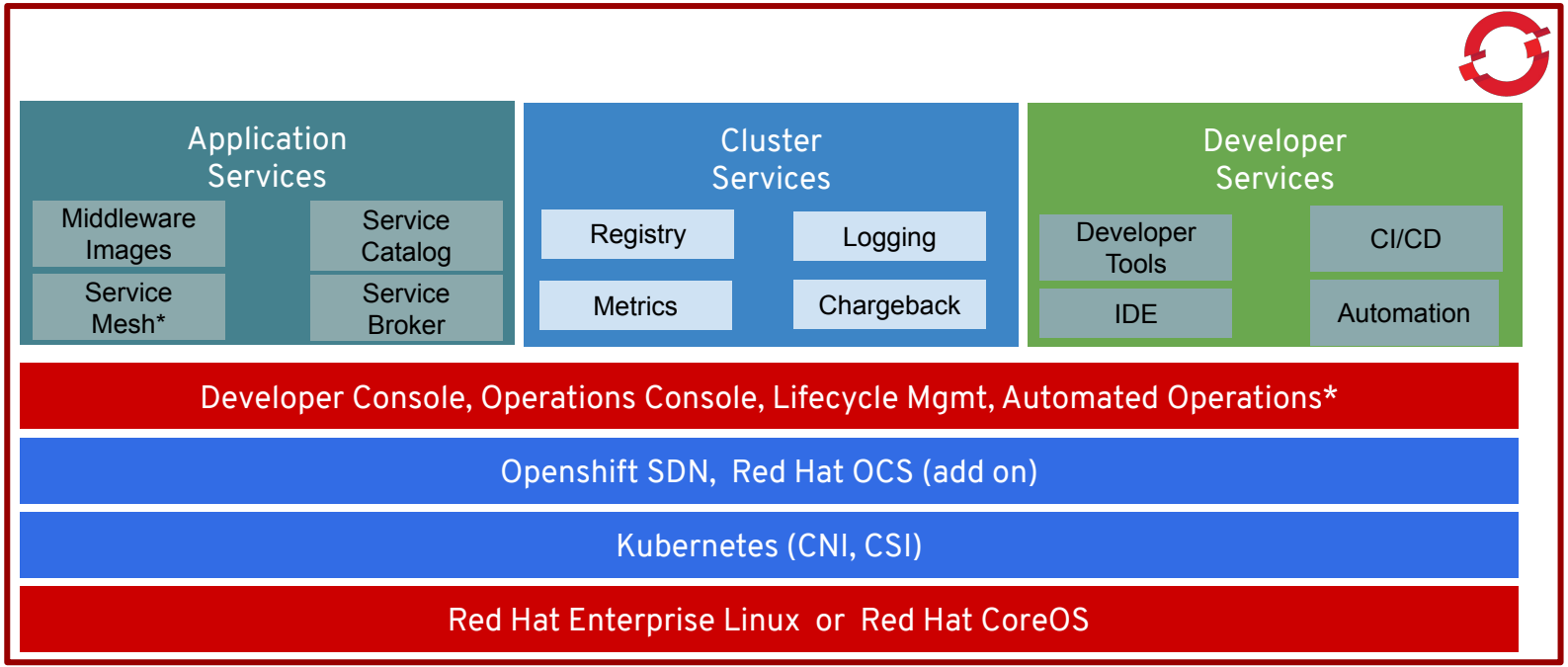


*coming soon

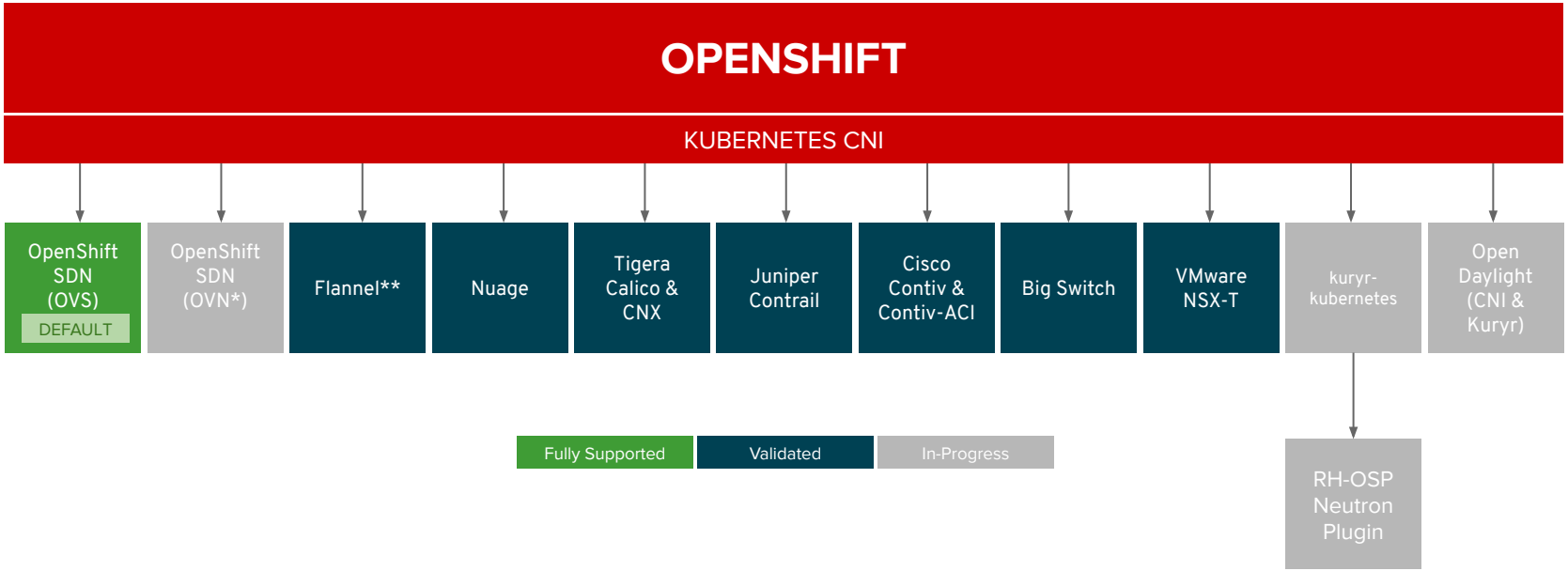
DEVELOPERS NEED IDEs, BUILD MGMT, CICD, DEBUGGING FEATURES AND MORE..



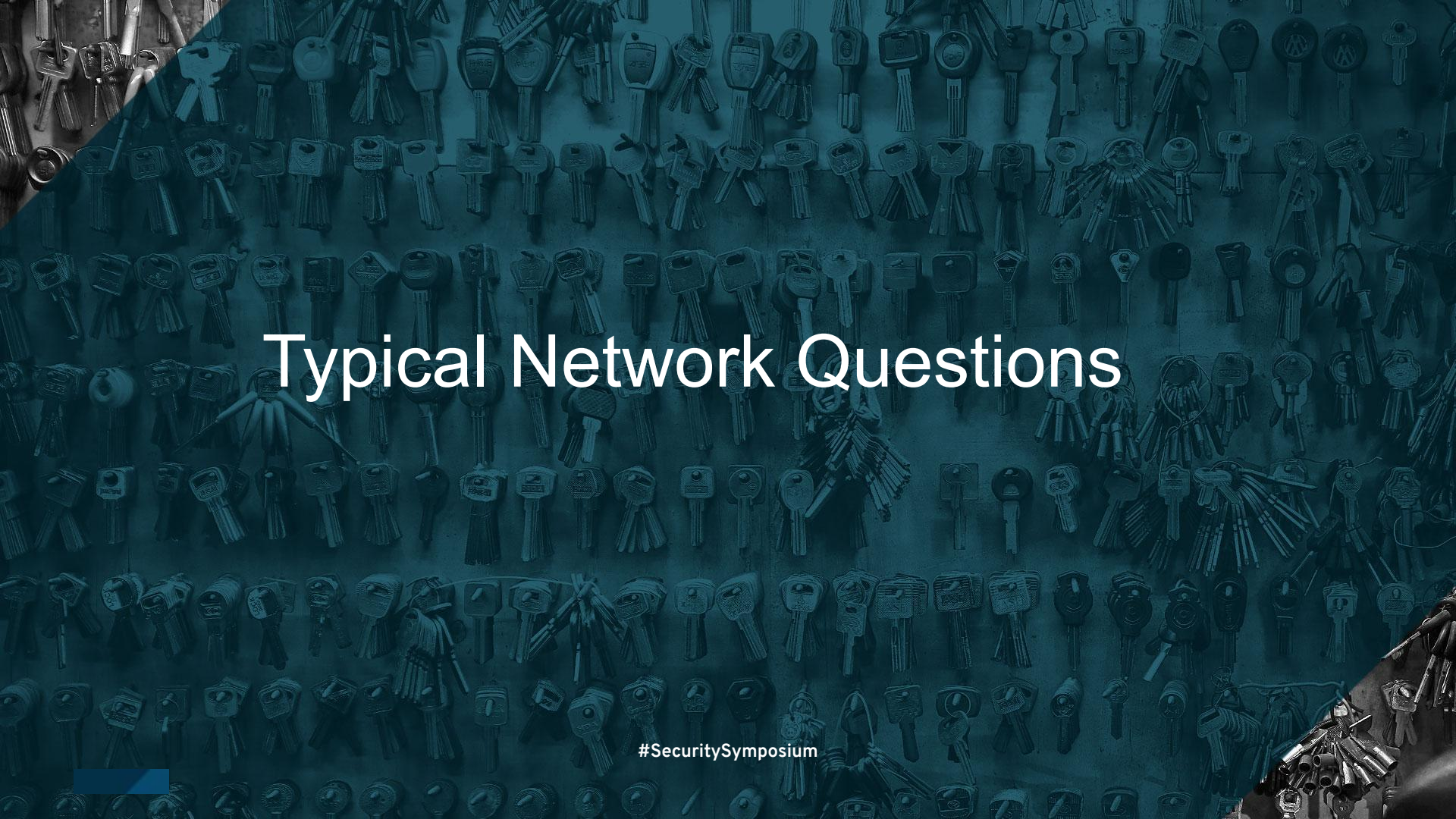
THIS MAKES A REFERENCE ARCHITECTURE FOR ENTERPRISE KUBERNETES aka OPENSHIFT



OPENSHIFT NETWORK PLUGINS



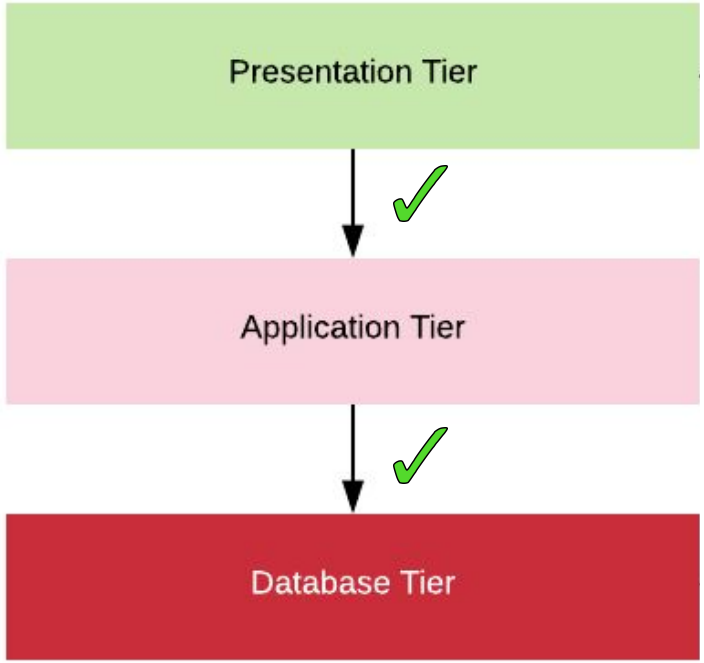
* Coming as default in OCP 4.1
** Flannel is minimally verified and is supported only and exactly as deployed in the OpenShift on OpenStack reference architecture



Typical Network Questions

1. Restricting traffic across tiers

Traffic Restrictions Across Application Tiers



Allowed connections

Disallowed connections

How can we restrict traffic across Application Tiers?

Network Policy Objects

Enables **Microsegmentation**

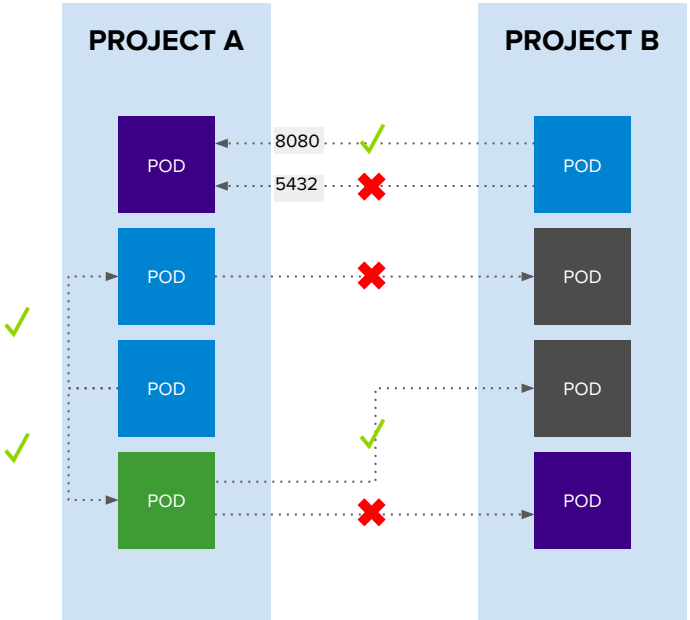
Allows configuring individual policies at the Pod Level

Apply to ingress traffic for pods and services

Allows restricting traffic between the pods within a project/namespace

Allows traffic to specific pods from other projects/namespaces

Network Policy Objects

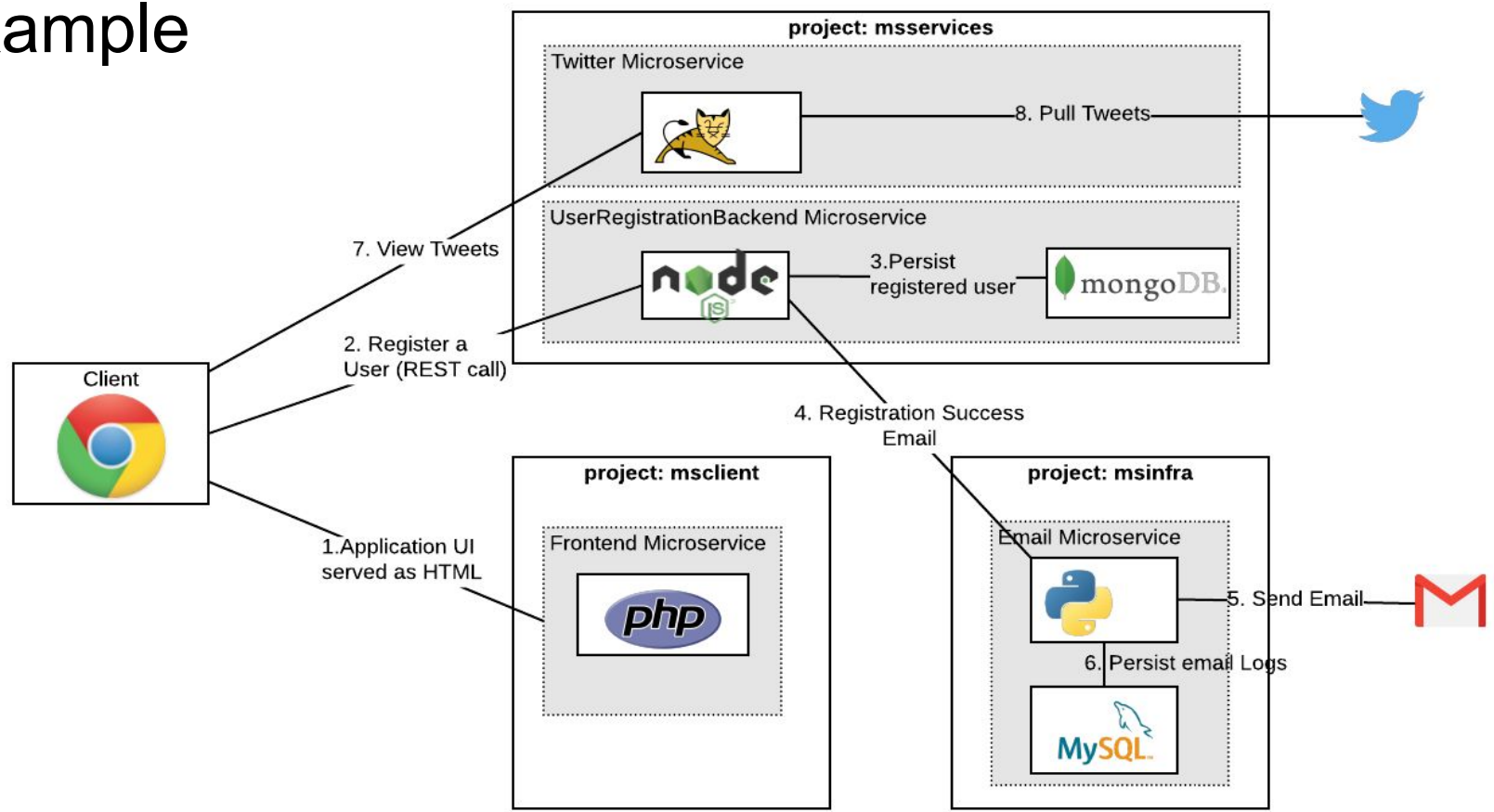


Example Policies

- Allow all traffic inside the project
- Allow traffic from green to gray
- Allow traffic to purple on 8080

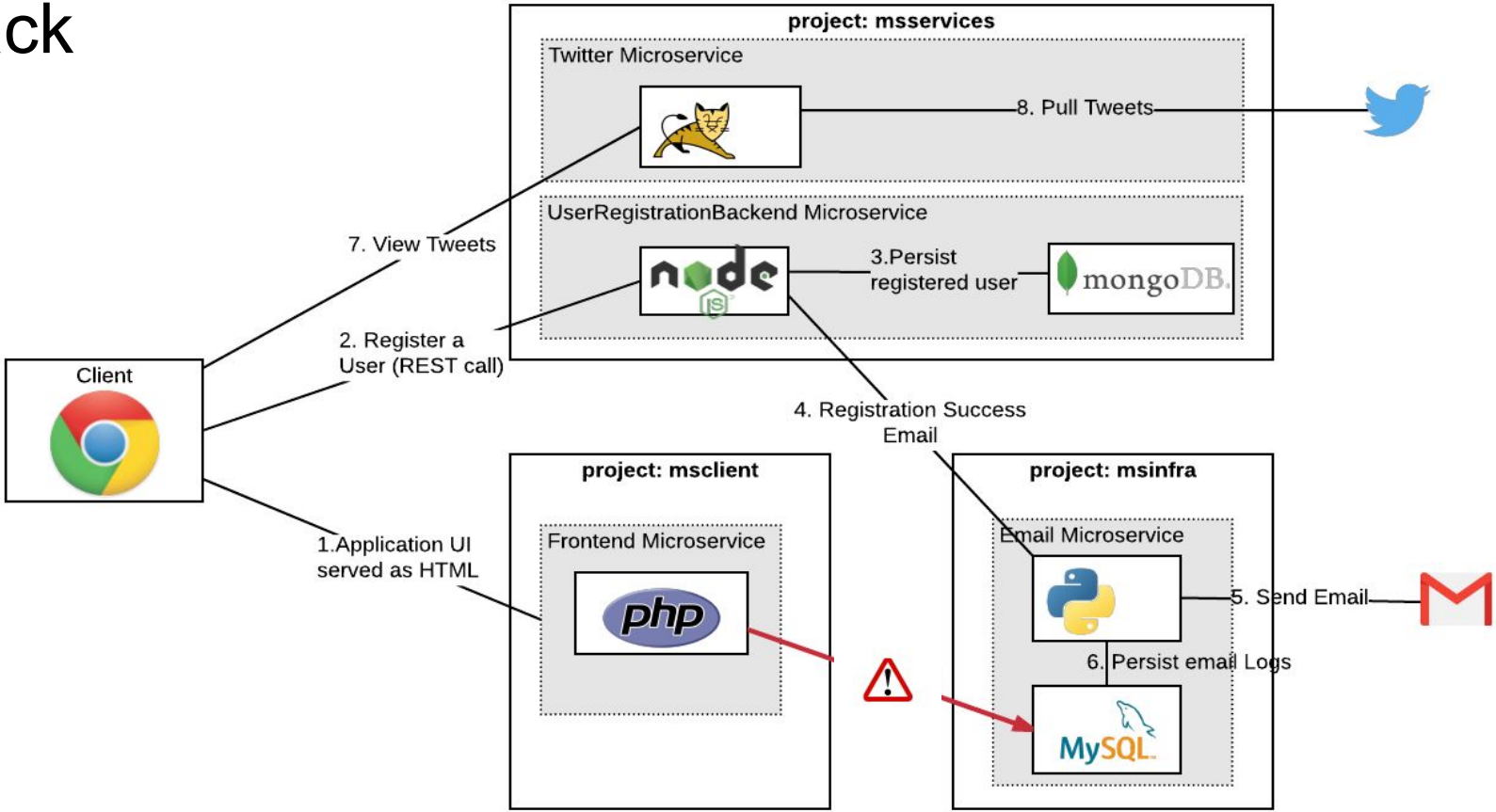
```
apiVersion: extensions/v1beta1
kind: NetworkPolicy
metadata:
  name: allow-to-purple-on-8080
spec:
  podSelector:
    matchLabels:
      color: purple
  ingress:
  - ports:
    - protocol: tcp
      port: 8080
```

Example

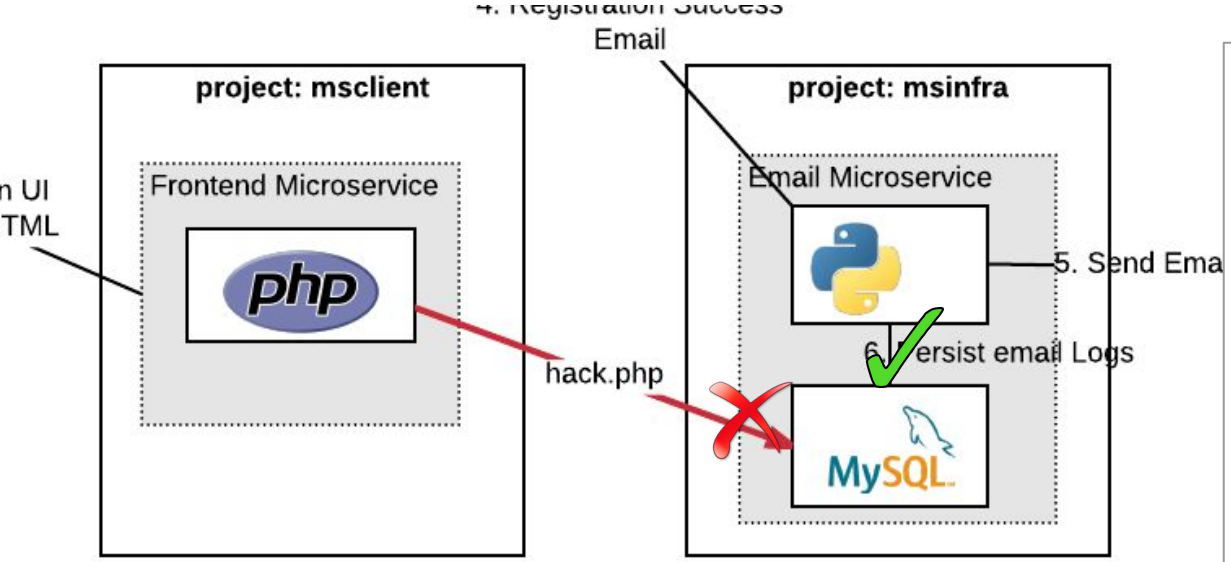


Video: https://blog.openshift.com/network-policy-objects-action/

Hack


project: msservices
Twitter Microservice
8. Pull Tweets
UserRegistrationBackend Microservice
3.Persist
registered user
mongoDB.
7. View Tweets
2. Register a
User (REST call)
Client
4. Registration Success
Email
project: msclient
Frontend Microservice
php
1.Application UI
served as HTML
project: msinfra
Email Microservice
5. Send Email
6. Persist email Logs
MySQL

Network Policy Objects to Rescue

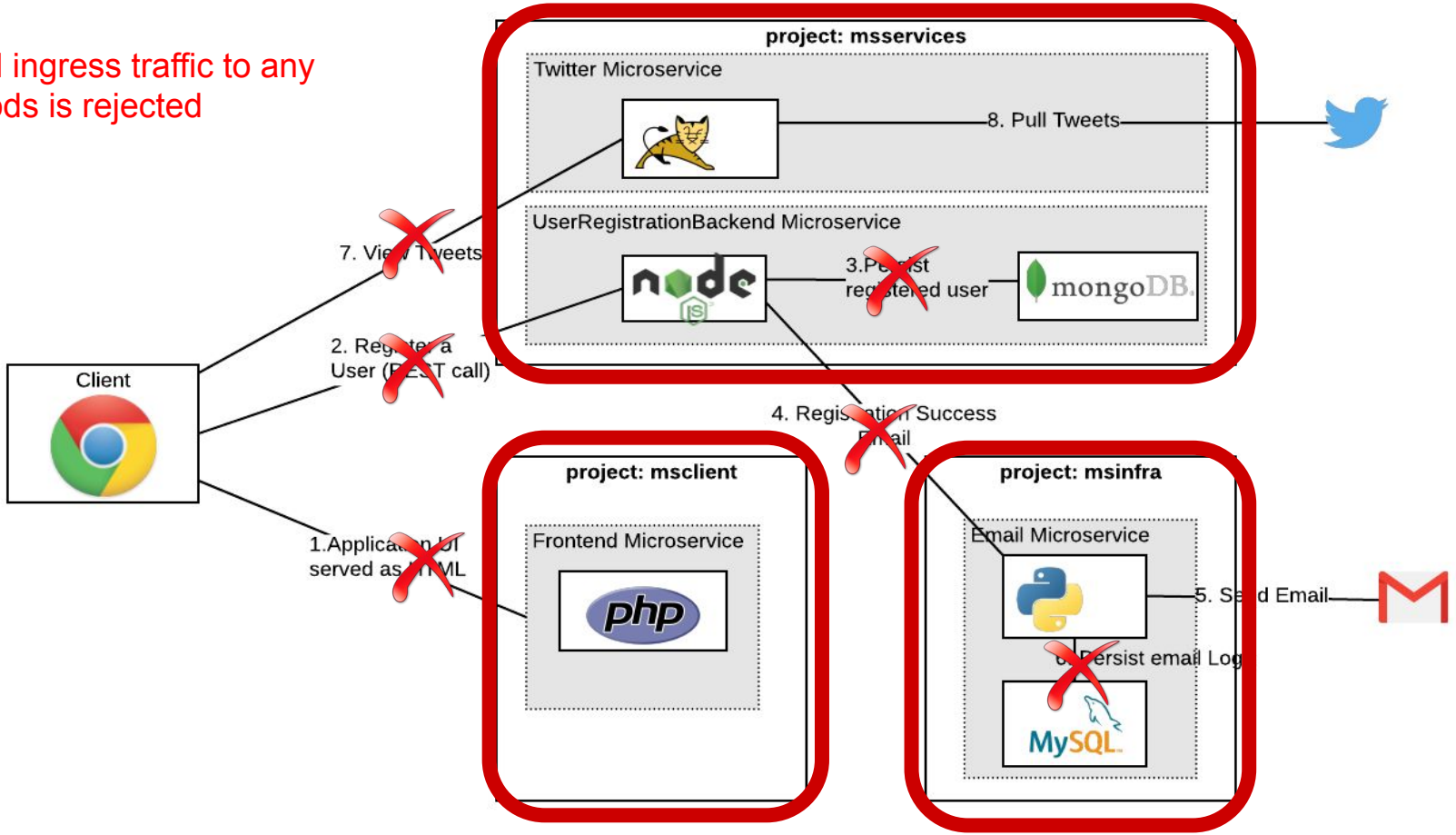


Allow MySQLDB connection from Email Service

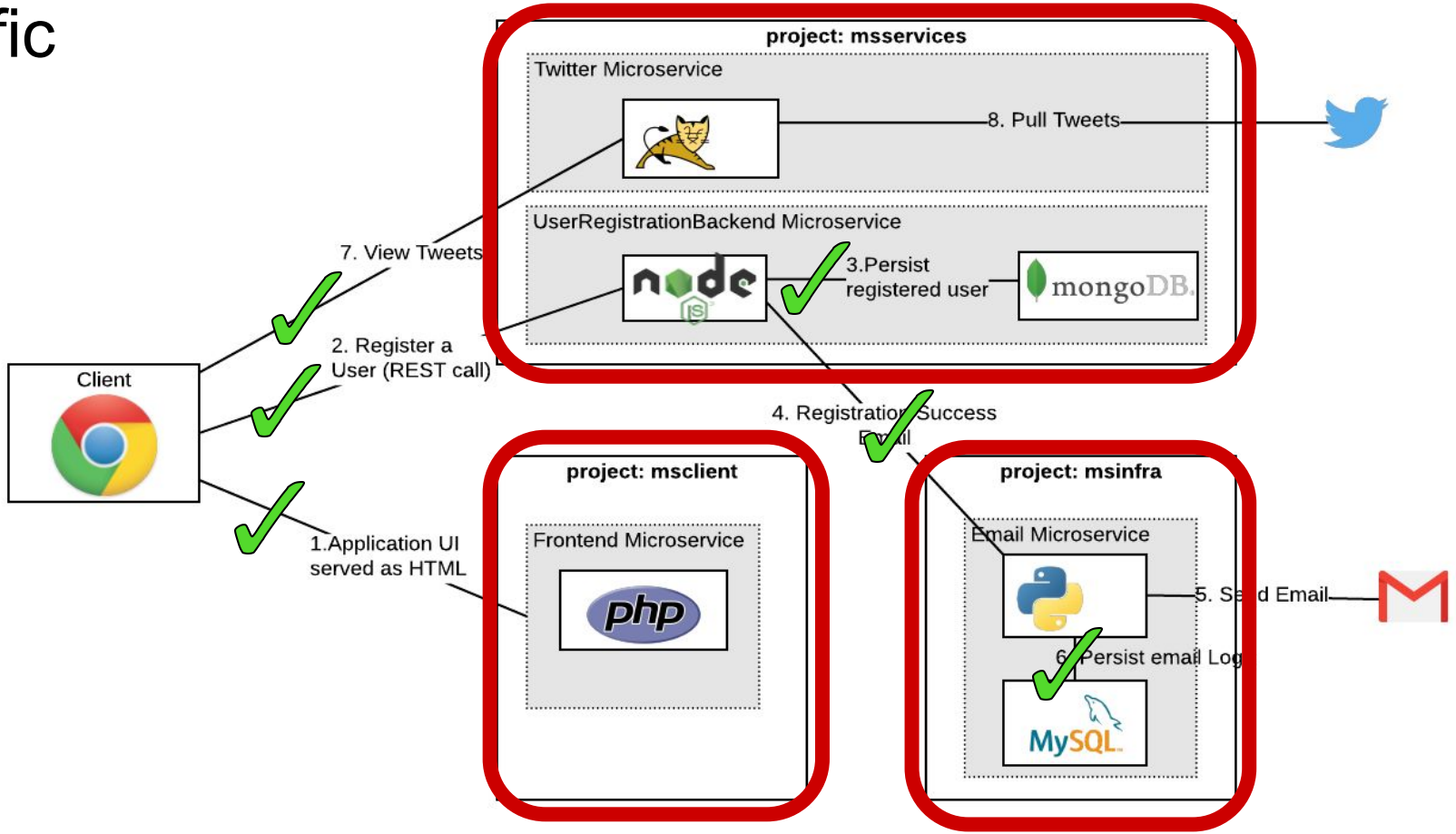
```
kind: NetworkPolicy
apiVersion: extensions/v1beta1
metadata:
  name: allow-3306
spec:
 podSelector:
   matchLabels:
     app: mysql
 ingress:
 - from:
   - podSelector:
       matchLabels:
         app: emailsvc
   ports:
   - protocol: TCP
     port: 3306
```

Start with Default Deny

All ingress traffic to any pods is rejected

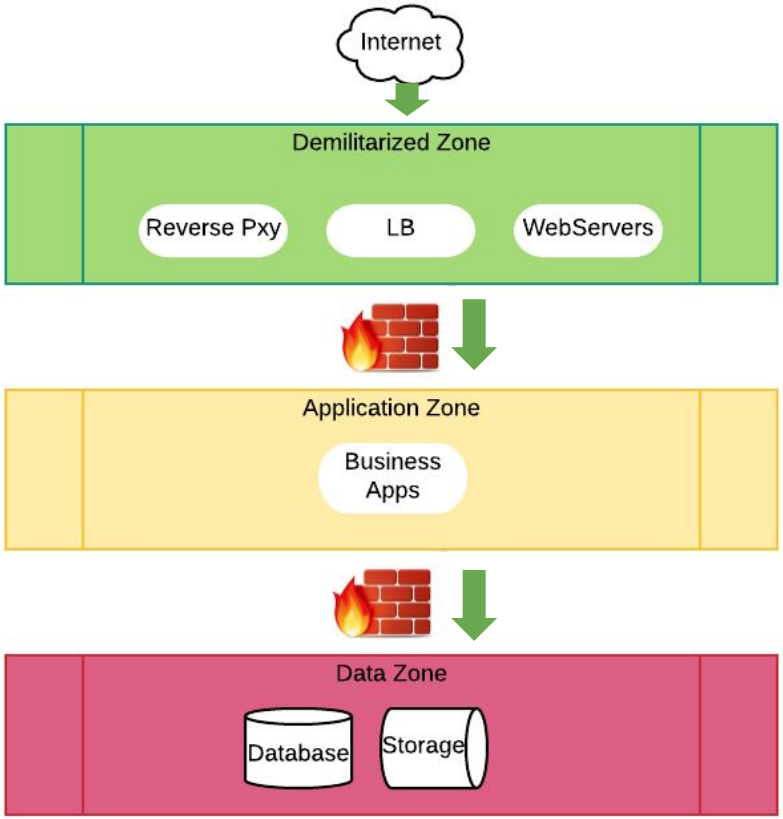


Add Network Policies To Allow Specific Incoming Traffic



2. Isolating zones

Network Zones separated by Firewalls



External traffic allowed to touch DMZ

Holes punched in firewalls to allow specific traffic from

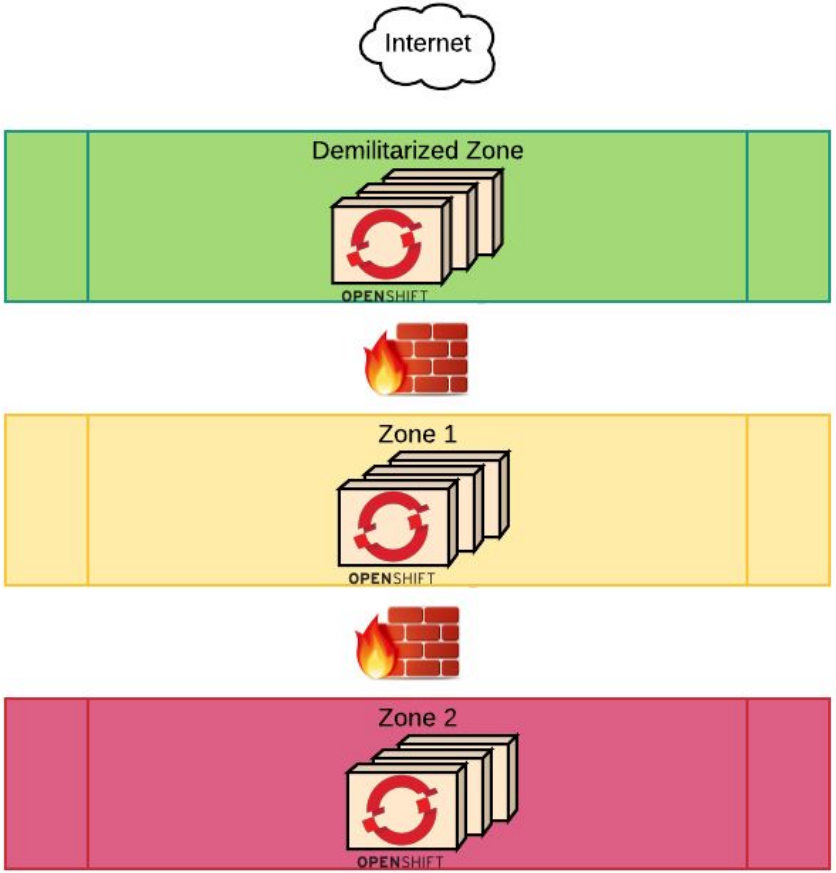
DMZ to Application Zone

and from

Application Zone to Data Zone

How do I setup K8S/OpenShift here?

Option 1: OpenShift cluster per Zone

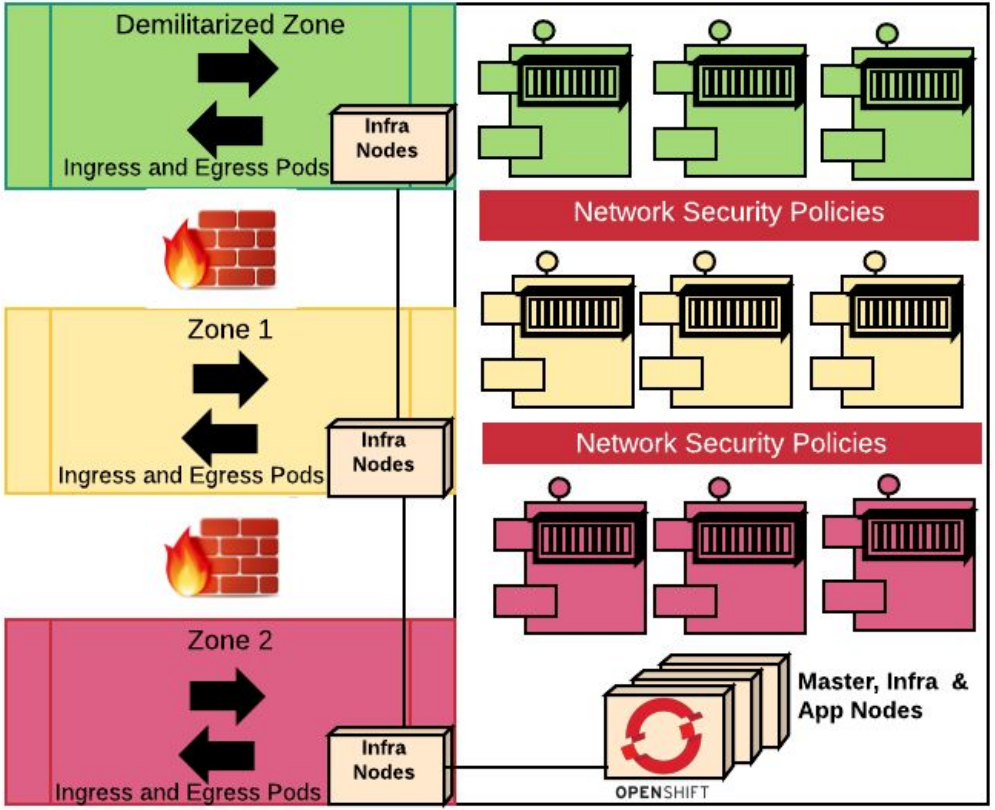


Useful to demonstrate compliance with Security Standards and Regulations

Additional actions needed to protect Master APIs, and other URLs in DMZ that are not supposed to be exposed to Internet

Cost of maintenance is high

Option 2: OpenShift Cluster covering Multiple Zones



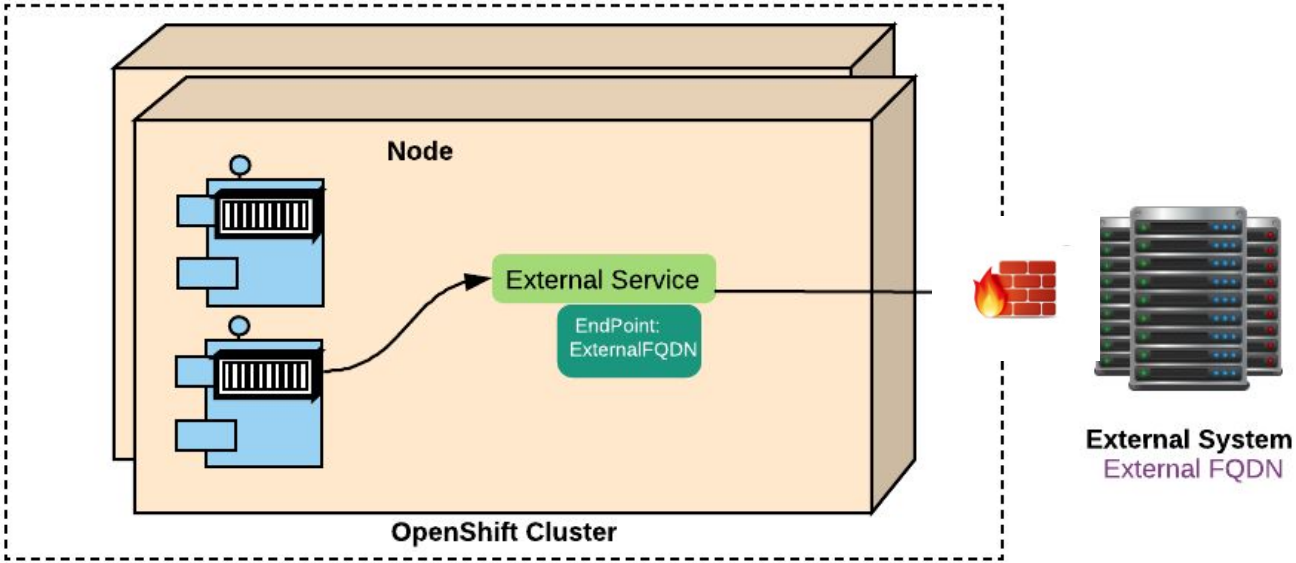
Application pods run on one Cluster. Microsegmented with Network Security policies.

Infra Nodes in each zone run Ingress and Egress pods for specific zones

If required, physical isolation of pods to specific nodes is possible with node-selectors. But that defeats the purpose of a shared cluster. Microsegmentation with SDN is the way to go.

3. Securing Egress

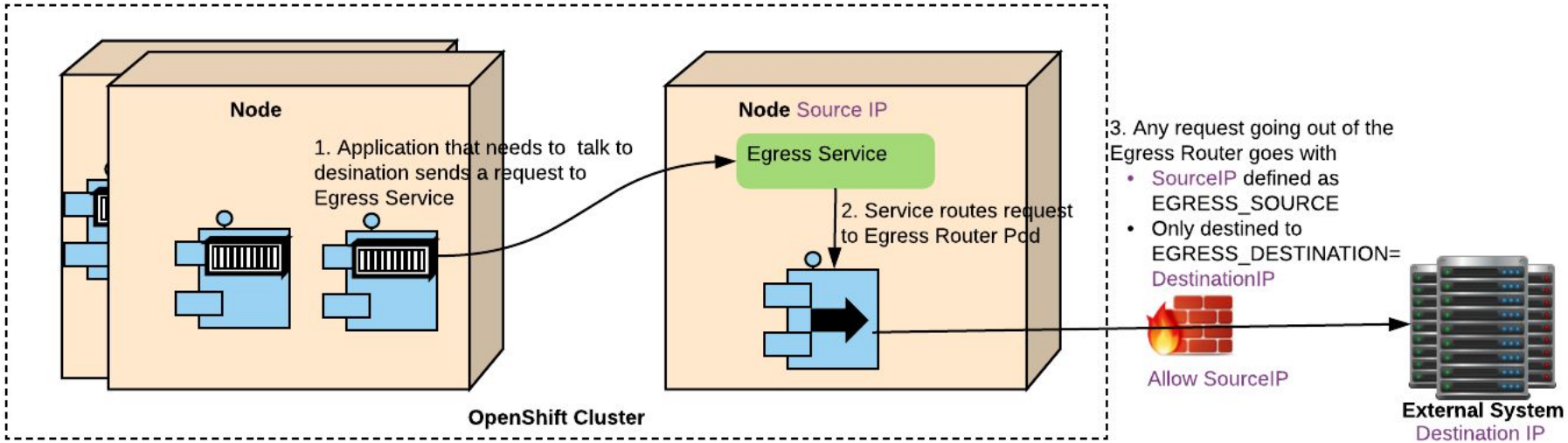
Connecting via External Service



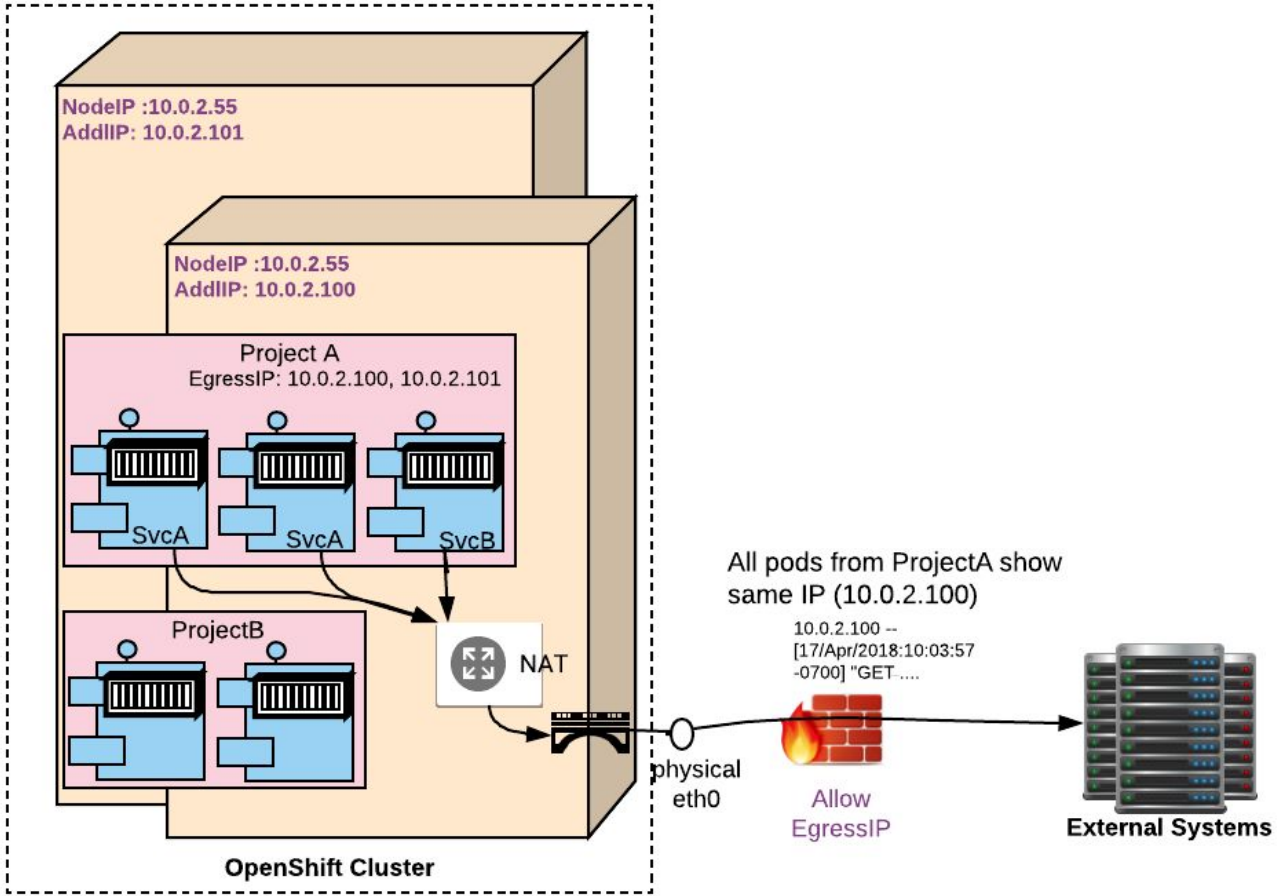
Application connecting to External System talks to an External Service whose Endpoint is set as Destination IP & Port
Or a Fully qualified domain name (FQDN) of the external system and port

But, what if we have a firewall in front of the External System that allows only Specific IPs?

Connecting via Egress Router



Static IP for all traffic from a Project



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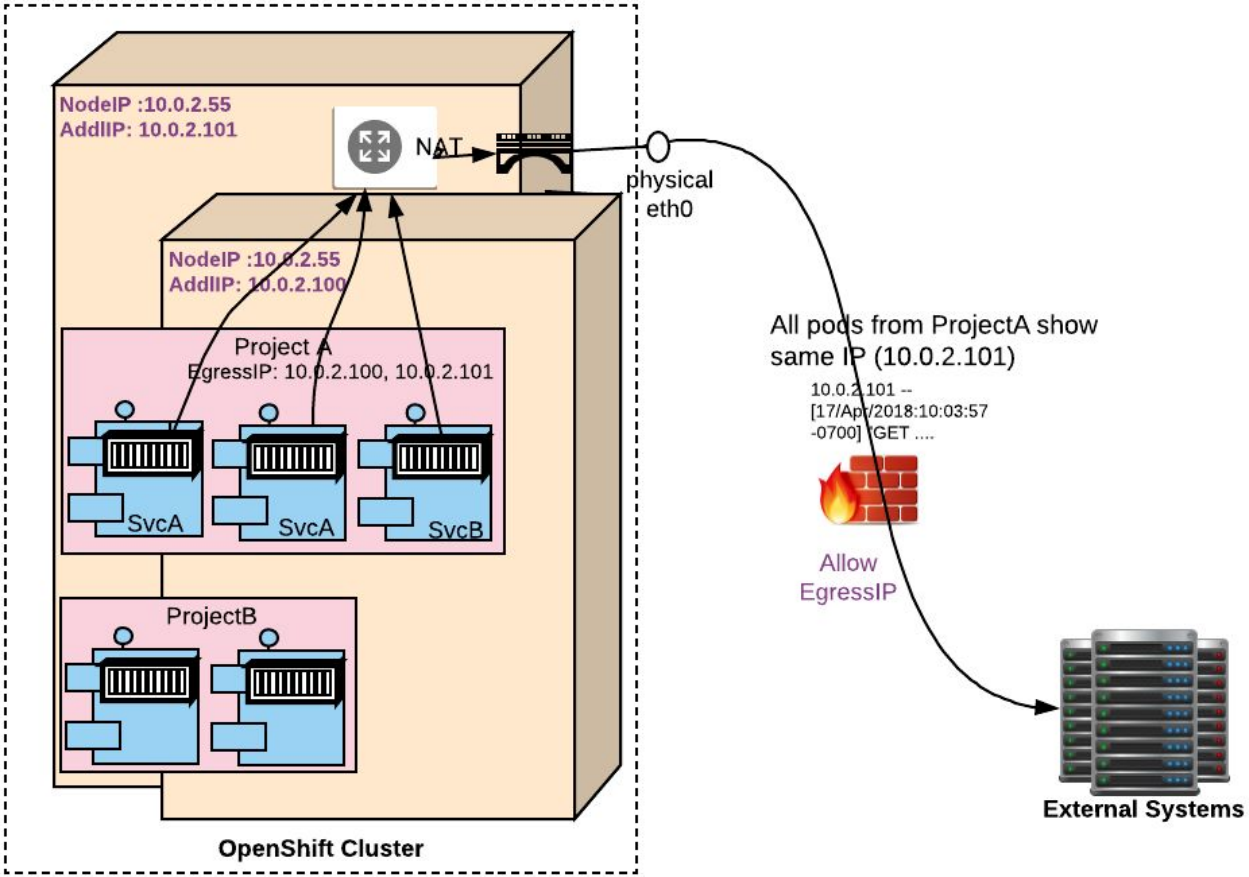
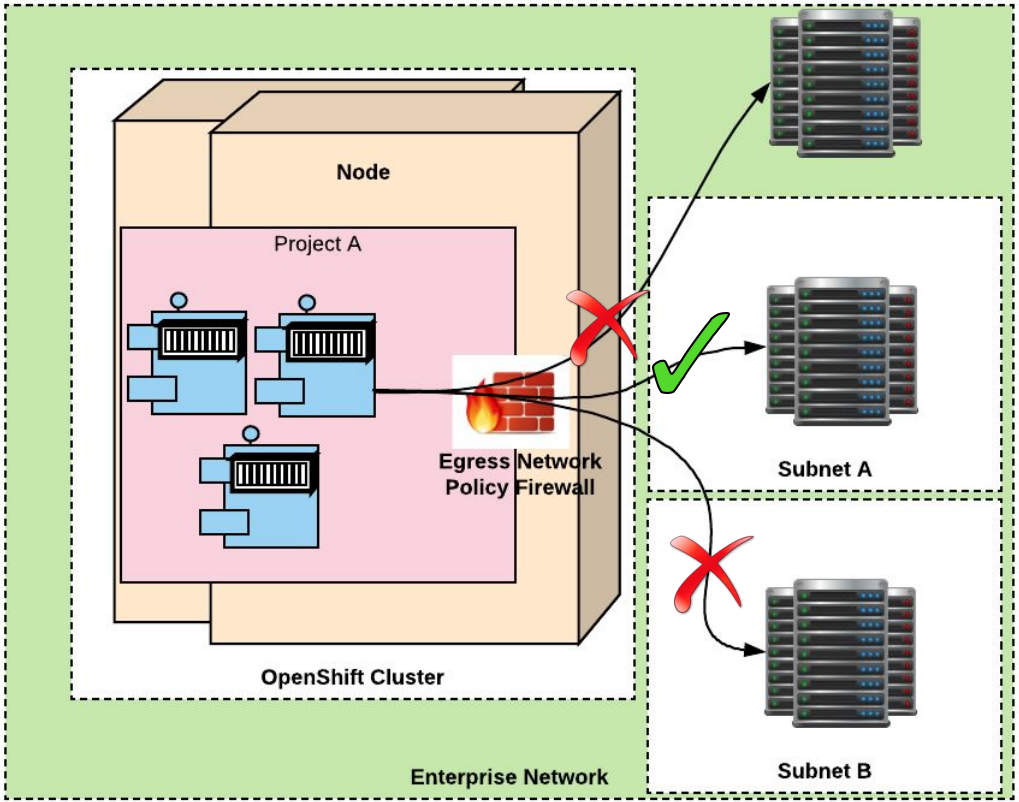


High availability scenario

Egress Firewall to Limit Access

Cluster admin can limit the external addresses accessed by some or all pods



Examples:

A pod can talk to hosts (outside OpenShift cluster) but cannot connect to public internet

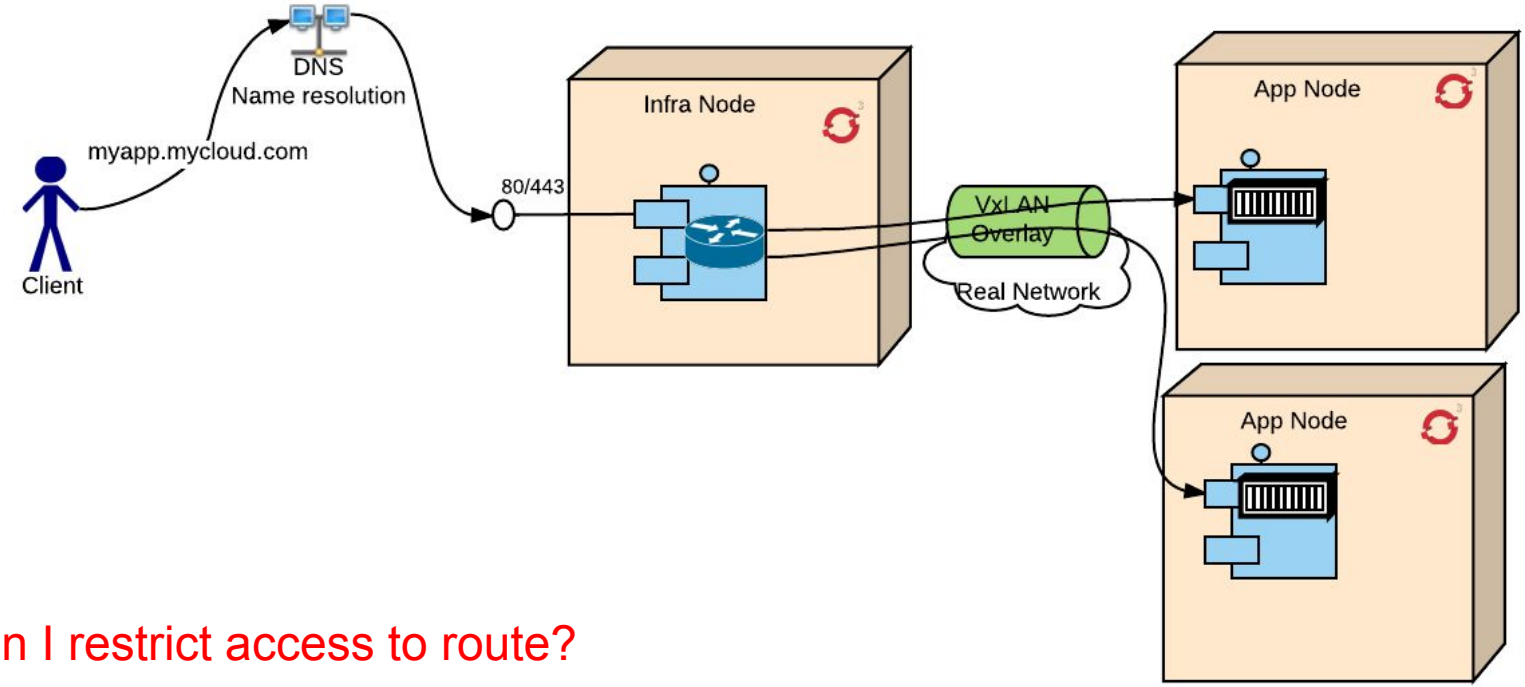
A pod can talk to public internet, but cannot connect to hosts (outside OpenShift cluster)

Public Internet

A pod cannot reach specific subnets/hosts

4. Securing Ingress

OpenShift Router as Ingress



Can I restrict access to route?

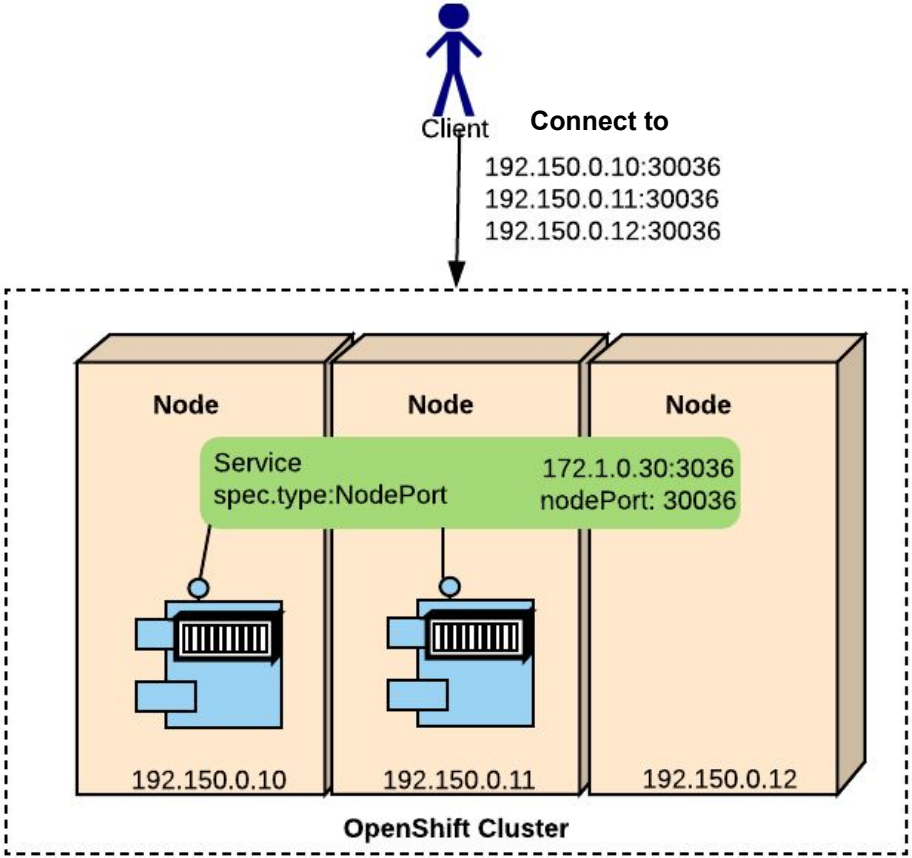
Route Specific IP Whitelists

- Restrict access to a route to a select IP address(es)
- Annotate the route with the whitelisted/allowed IP addresses
- Connections from any other IPs are blocked

```
metadata:
  annotations:
    haproxy.router.openshift.io/ip_whitelist: 192.168.1.10 192.168.1.11
```

What about ingress traffic on ports that are not 80 or 443?

Using NodePort as Ingress to Service



Binds service to a unique port on every node in the cluster

Port randomly assigned or optionally picked from port range 30000-32767

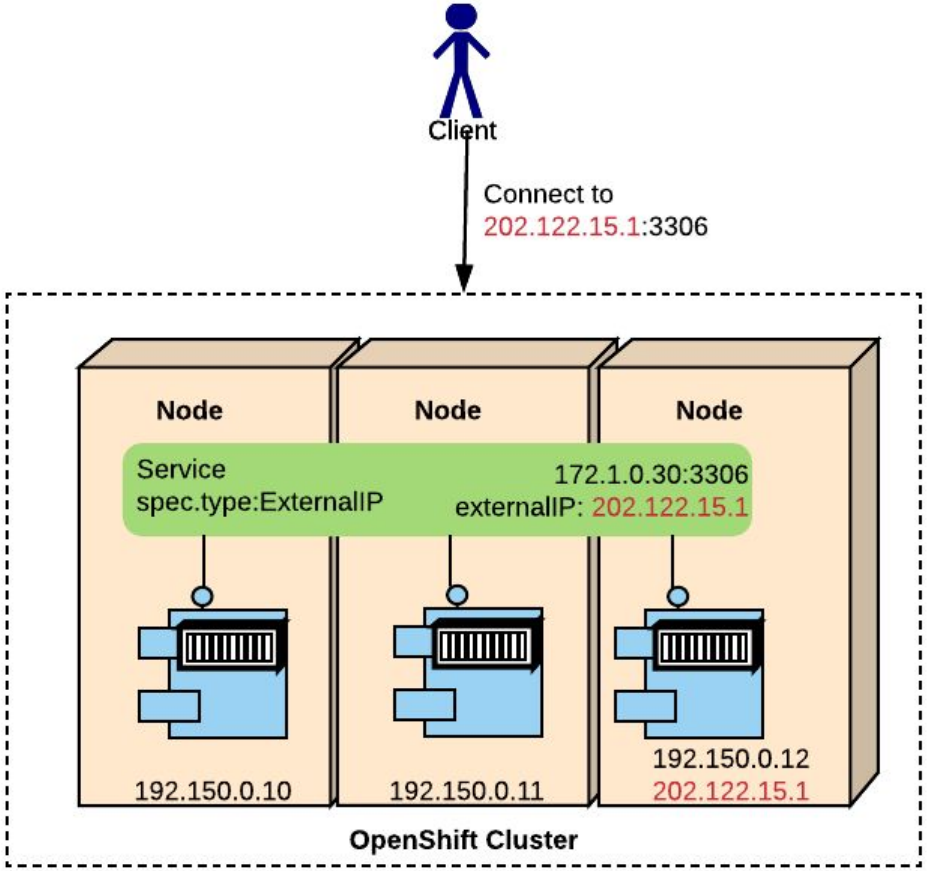
All nodes act as ingress point at the port assigned

Every node in the cluster redirects traffic to service service endpoints even if a corresponding pod is not running on that node

Firewall rules should not prevent nodes listening on these ports

Every exposed service uses up a port on all the nodes in a cluster. Are there alternatives?

Assigning External IP to a Service with Ingress

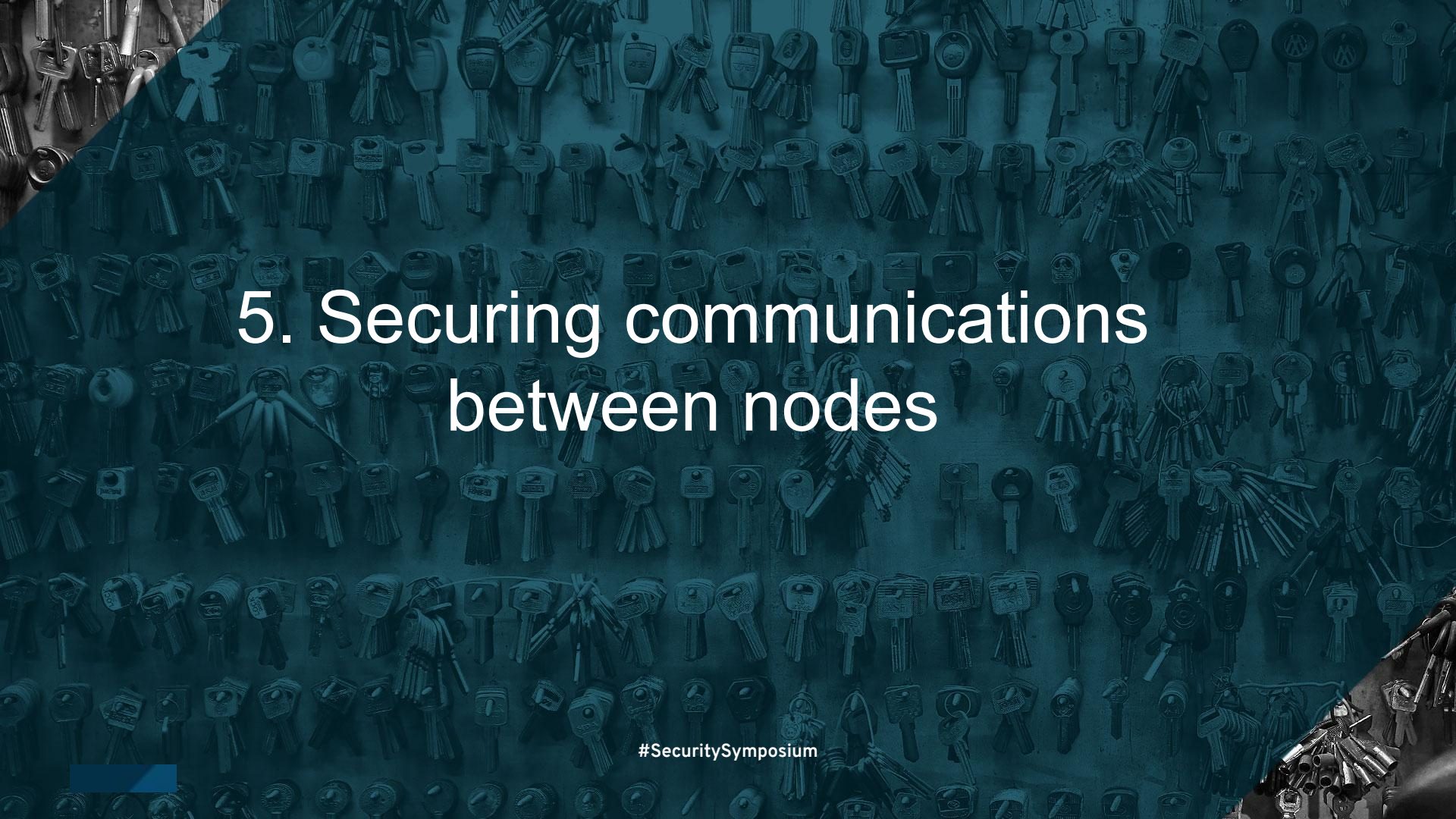


Admin defines ExternalIP address range. Assigns these extra IPs to nodes.

OpenShift assigns both internal IP and external IP to a service. Or a specific External IP can be chosen.

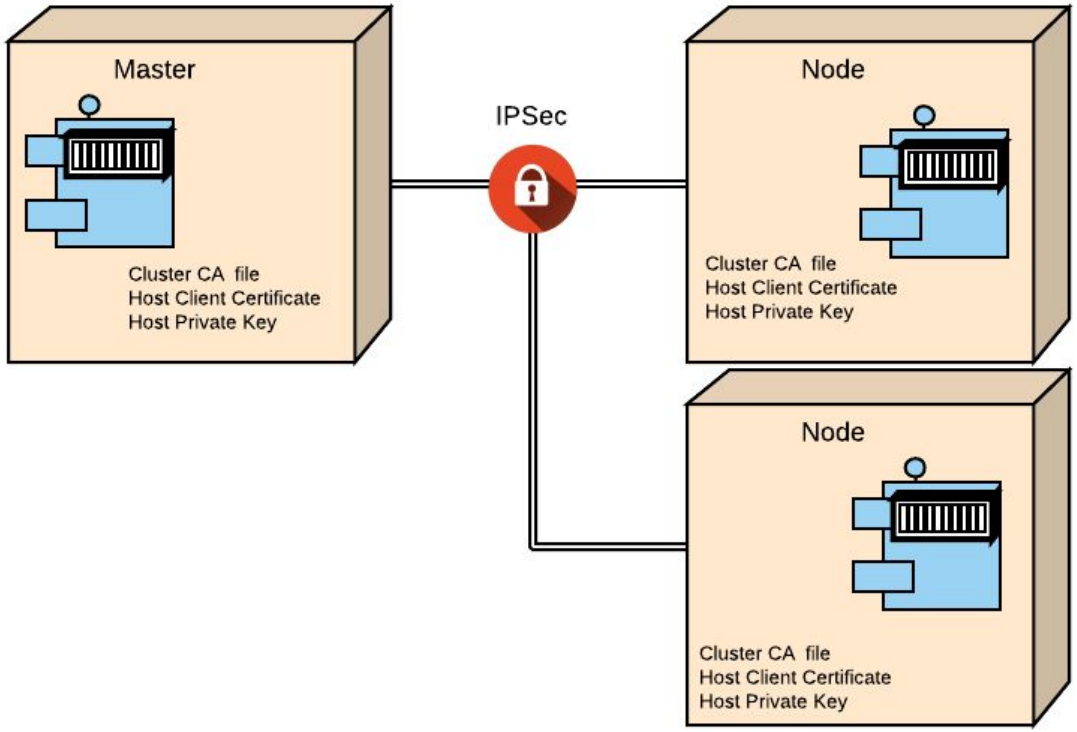
Node to which ExternalIP is assigned acts as the ingress point to the service.

ExternalIP can be a VIP. You can set up ipfailover to reassign VIP to other nodes. Ipfailover runs as a privileged pod and handles VIP assignment.



5. Securing communications between nodes

Secured Communications between Hosts

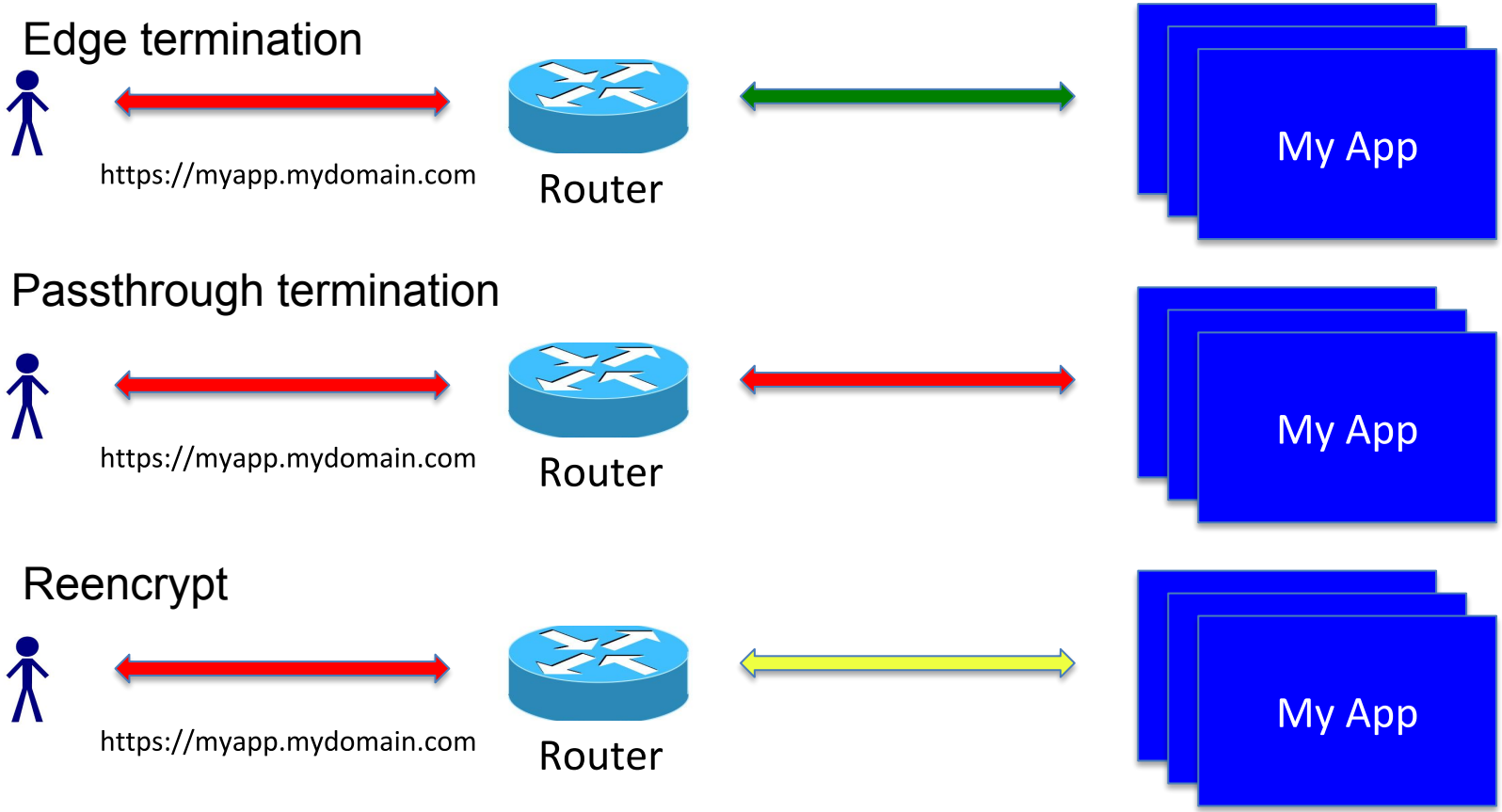


Secures cluster communications with IPsec

- Encryption between all Master and Node hosts (L3)
- Uses OpenShift CA and existing certificates
- Simple setup via policy defn
  - Groups (e.g. subnets)
  - Individual hosts

6. Security at Application Level

SSL at Ingress (with OpenShift Routes)



Layer 7 Application Security

Application specific monitoring East-West container traffic

Web Application Firewalls

Granular traffic control, Packet Inspections

Denial of Service, Ransomware, Viruses Detection and Mitigation

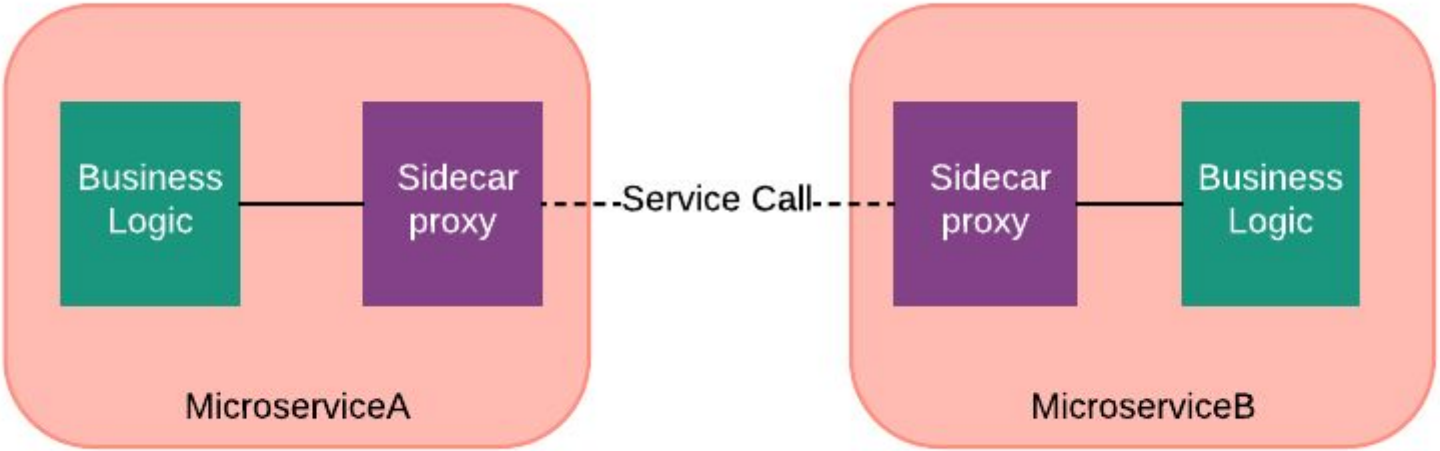
Runtime Security, Forensics, Incident capture, Audits, Alerts

Container runtime monitoring

Partner Solutions

7. (Tech Preview) Application network security with Istio

Istio Concepts - Sidecar Proxy

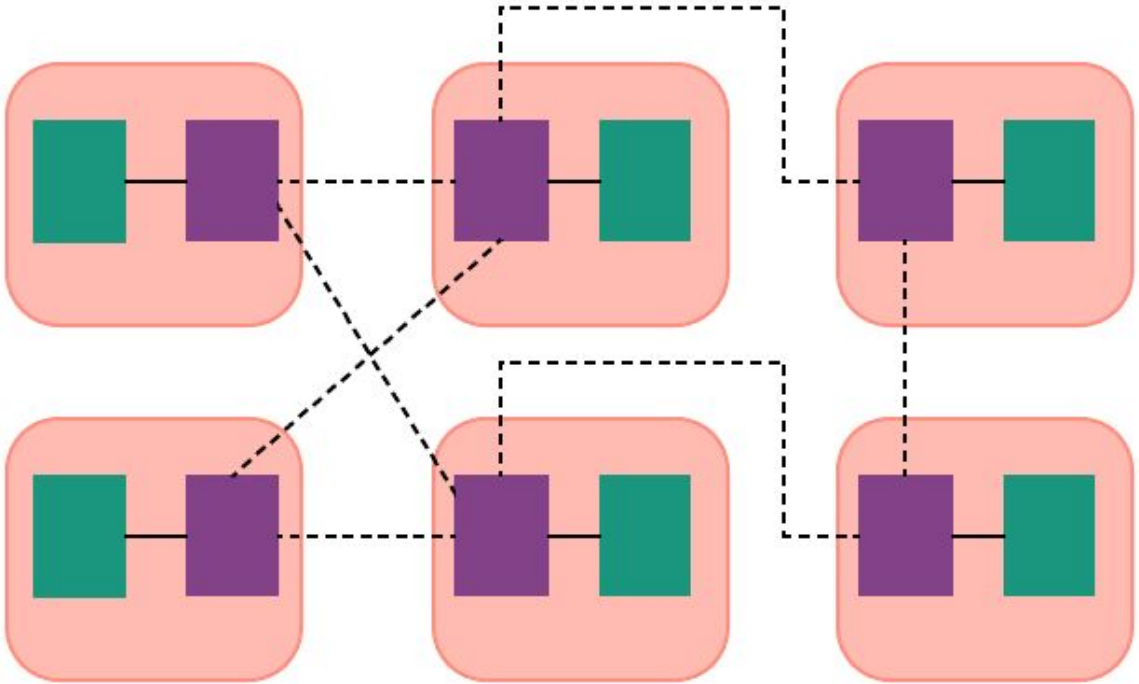


SideCar Proxy

- Intercepts all network communication between microservices
- Encapsulates Service Infrastructure code
- Application code (business logic) unaware of Sidecar proxy
- Examples - Linkerd, Envoy

Istio Concepts - Service Mesh

Network of Microservices

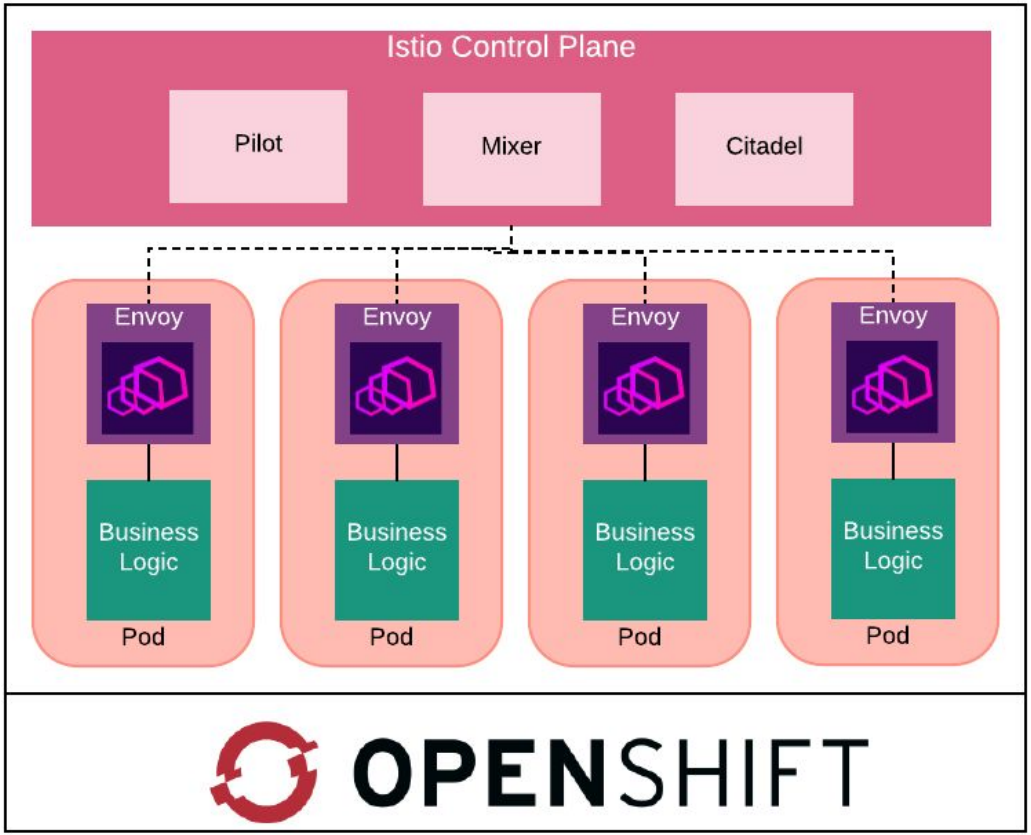


Service Mesh is a dedicated infrastructure layer to handle service-service communications

Typically implemented as an array of lightweight network proxies deployed alongside application code

Interconnected Proxies form a mesh network

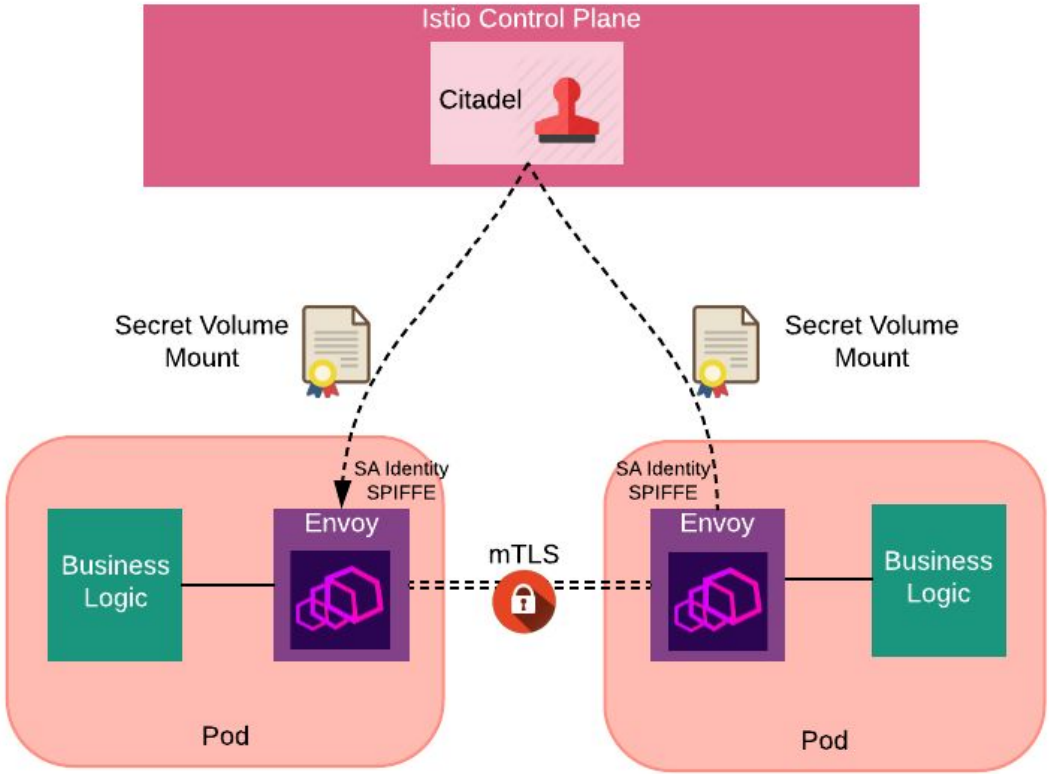
Istio Service Mesh on OpenShift



Connect, Manage, and Secure Microservices, transparently

- Intelligent Routing
- Load Balancing
- Service Resilience
- Telemetry and Reporting
- Policy Enforcement
- Content based Filtering (Layer 7)
- mTLS between services
- East-West traffic control

Application Traffic Encryption with Istio Auth (Future)



Uses Service Account as Identity. SPIFFE Id format

spiffe://<*domain*>/ns/<*namespace*>/sa/<*serviceaccount*>

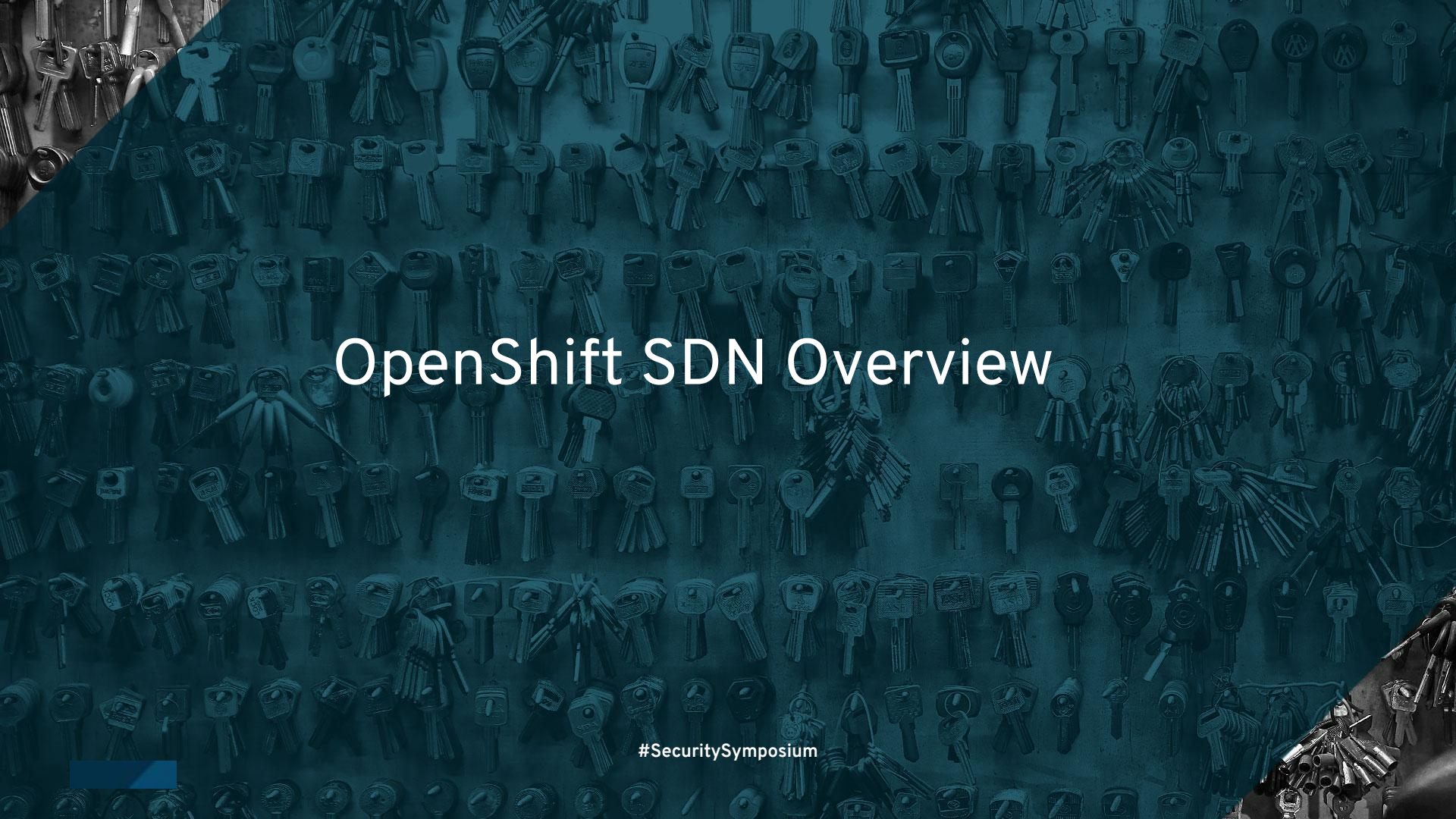
Mutual TLS between sidecars

Istio CA

- Generate cert pair and SPIFFE key for each SA
- Distribute key and cert pairs
- Rotate keys and certs periodically
- Revoke key and cert when need

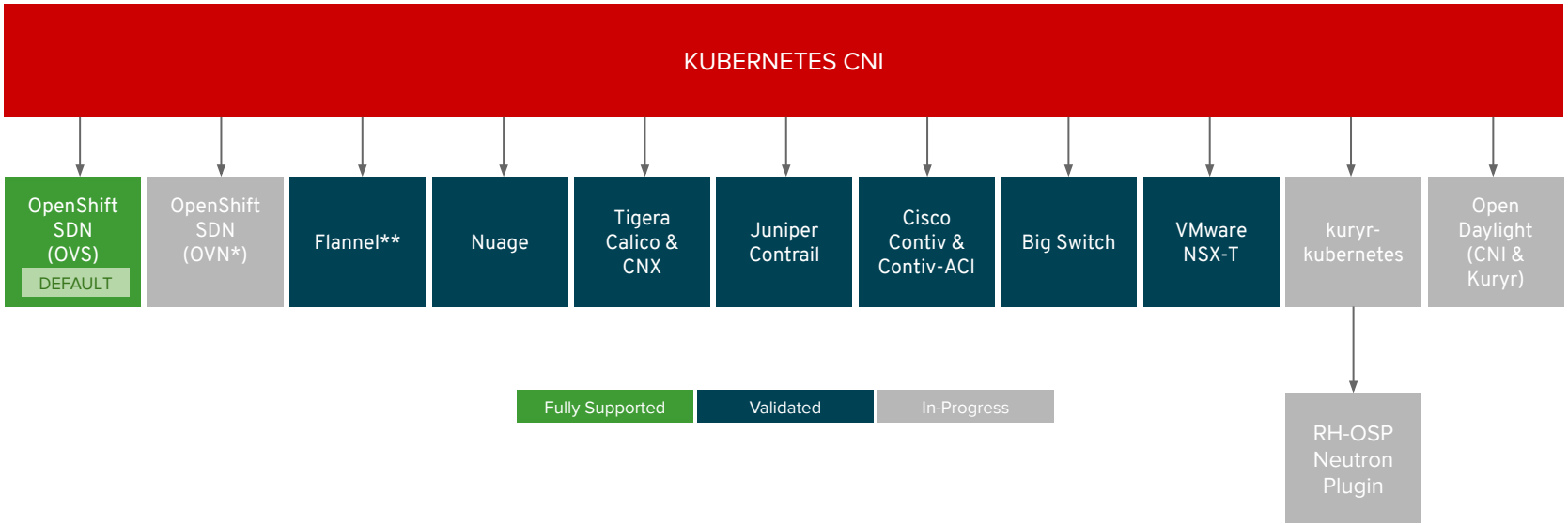

Questions?
#SecuritySymposium


redhat.
intel
THANK YOU
#SecuritySymposium



OpenShift SDN Overview

Kubernetes uses CNI



* Coming as default in OCP 4.1
** Flannel is minimally verified and is supported only and exactly as deployed in the OpenShift on OpenStack reference architecture

OpenShift Networking

Software Defined Networking (SDN) for pod-pod communication

- Configures overlay network using Open vSwitch (OVS)
- Three types of plugins
  - **ovs-subnet** : flat network every pod can talk to every other pod
  - **ovs-multitenant**: project level isolation for pod-pod communication. Unique VNID per project

    You can join projects to get them the same VNID

    ‘default’ project (VNID 0) privileged to communicate with other pods

  - **ovs-networkpolicy**: fine-grained isolation using network policy objects

OpenShift Installation Defaults

Cluster network CIDR: 10.128.0.0/14

Gives 32-14=18 bits or the ip address range of 10.128.0.0 - 10.131.255.255

Host subnet length: 9 bits (32-9=23)

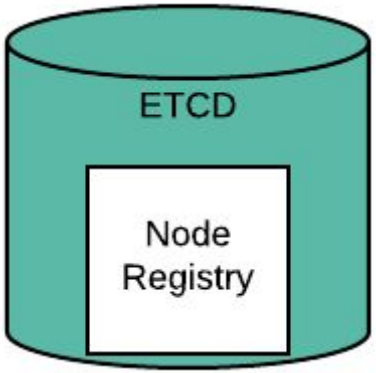
Subnet for each node is /23. Gets 512 ip addresses per node.

Leaves 9 bits for nodes ((32-9)-14=9). Allows 2^9=512 subnets that can be assigned to nodes

Subnets: 10.128.0.0/23, 10.128.2.0/23, …10.131.254.0/23

Master Portal Net (services): 172.30.0.0/16

OpenShift SDN manages Node Registry



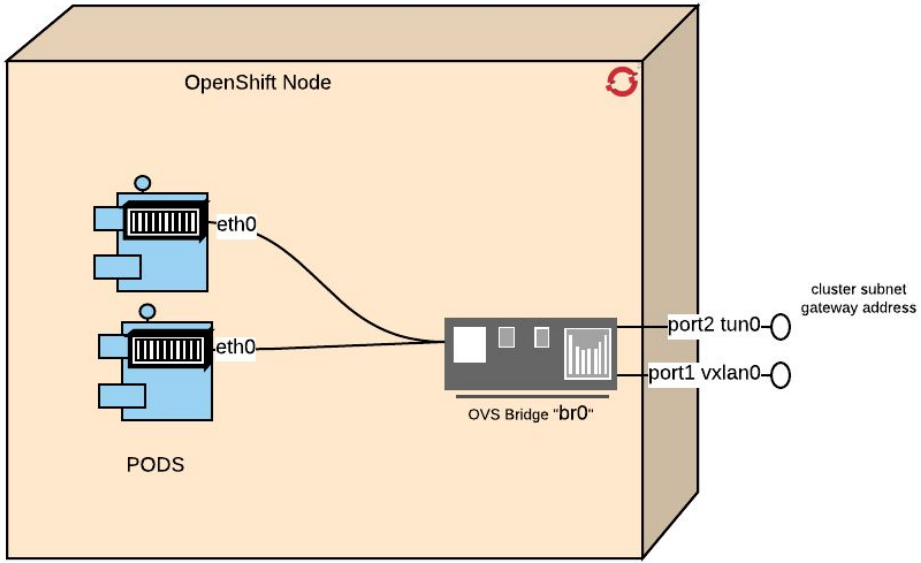
Master allocates a subnet to the node.

Node creation - Allocated subnet added to Node Registry

Node deletion - subnet removed from the Node Registry

On node creation,SDN registers the host with the SDN master

OpenShift SDN configures network devices on Node



br0 Pod containers attached to this ovs bridge device. Non subnet specific flow rules on br0

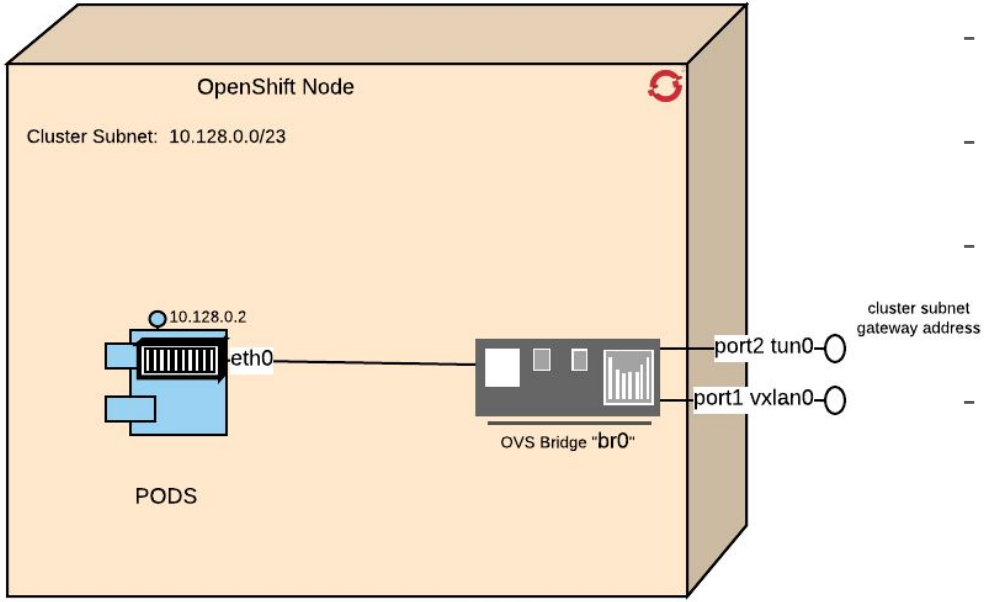
tun0 For external network access via NAT. Cluster subnet gateway address assigned. Configures netfilter and routing rules.

vxlan0 Access to other nodes. OVS VxLAN device

additional node added:

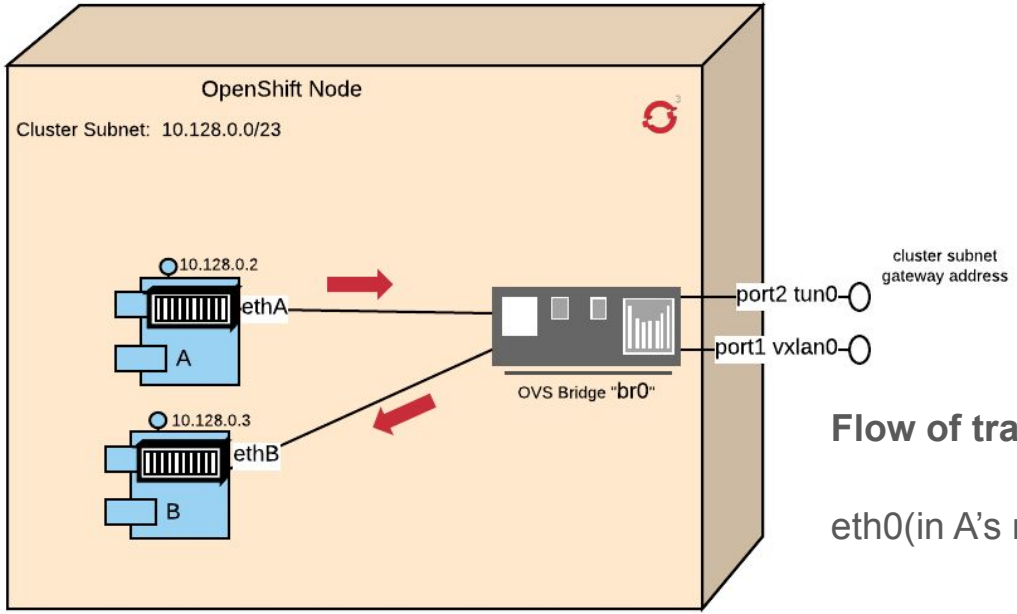
- Watch subnet updates from master
- Add OpenFlow rules on br0 to push traffic to the newly added subnet go to vxlan0

OpenShift SDN Pod Creation



- Assigns an available ip address from the node's cluster subnet to the pod
- Attaches host side of pod's veth interface pair to br0
- Adds OpenFlow rules to OVS DB to route traffic addressed to the new pod to correct OVS port
- For ovs-multitenant, adds OpenFlow rules
  - to attach pod's VNID to outgoing traffic
  - allow traffic to pod when VNID matches

Pod to Pod Traffic - Both pods on the same Node



Flow of traffic

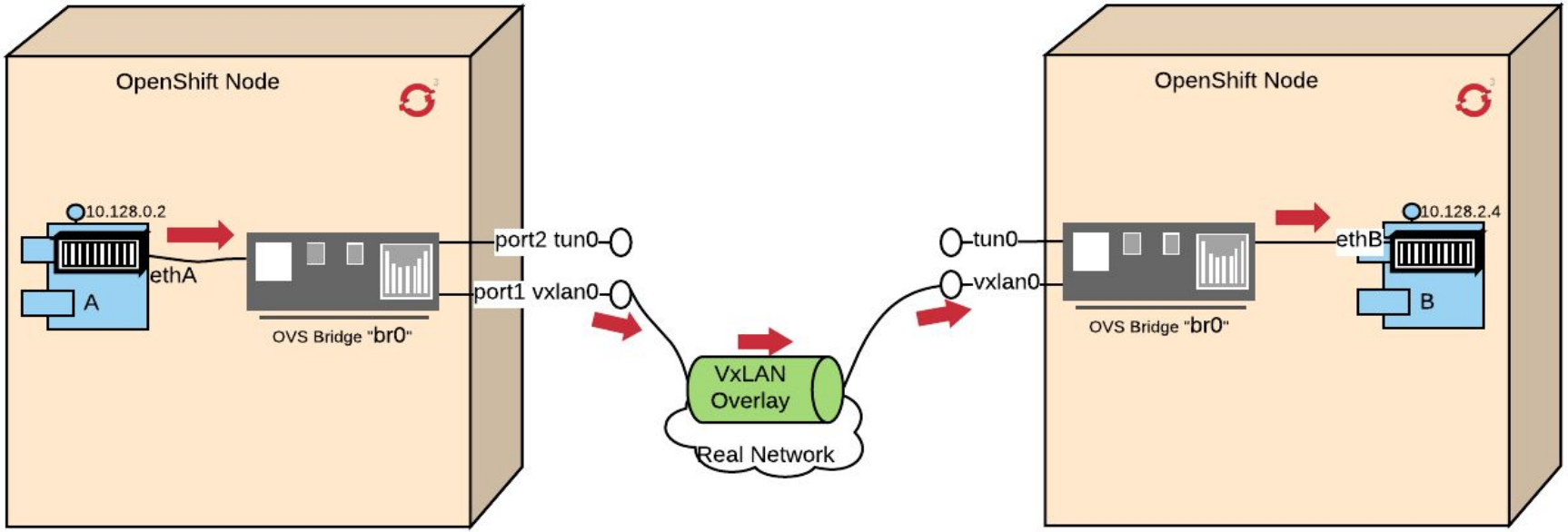
eth0(in A's netns) - vethA - br0 - vethB - eth0(in B's netns)

* Peer vEthernet device for container A is named ethA and for container B is named ethB

Pod to Pod Traffic - Pods on two different Nodes

Flow of traffic

eth0(in A's netns) - vethA - br0 - vxlan0 - network - vxlan0 - br0- vethB - eth0(in B's netns)

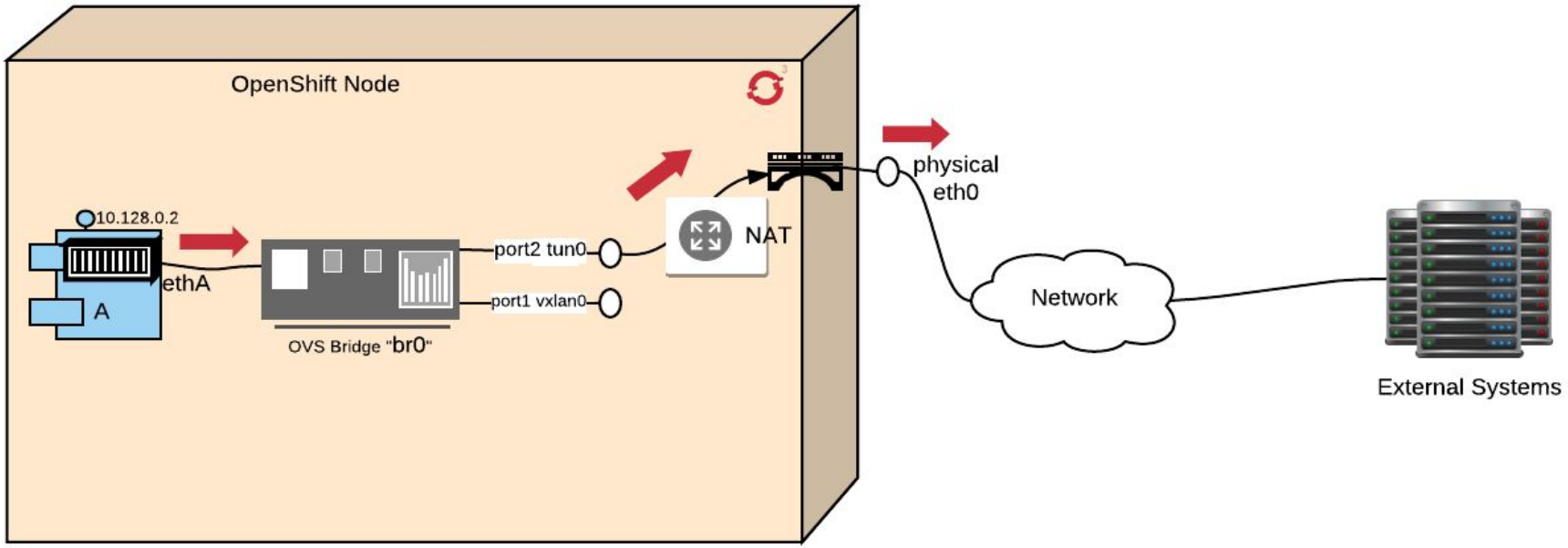


* Peer vEthernet device for container A is named ethA and for container B is named ethB

Pod to External Systems outside OpenShift

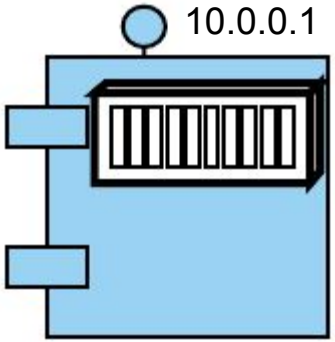
Flow of traffic

eth0(in A's netns) - vethA - br0 - tun0 - (NAT) - eth0(physical device) - Internet



Kubernetes/OpenShift
Core Concepts

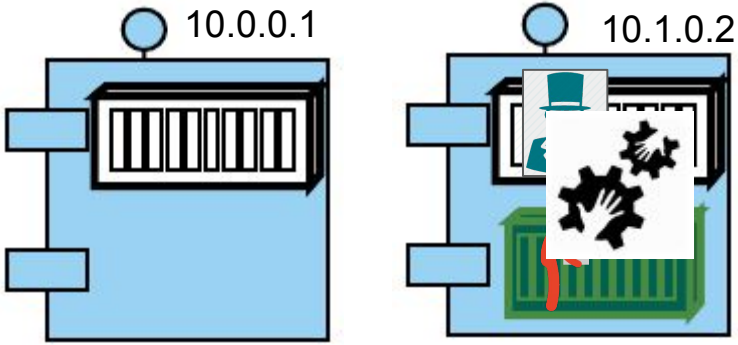
Pods



Openshift/K8S runs containers in Pods. Pod is a wrapper

Each pod gets an IP address. Container adopts Pod's IP.

Containers in Pods



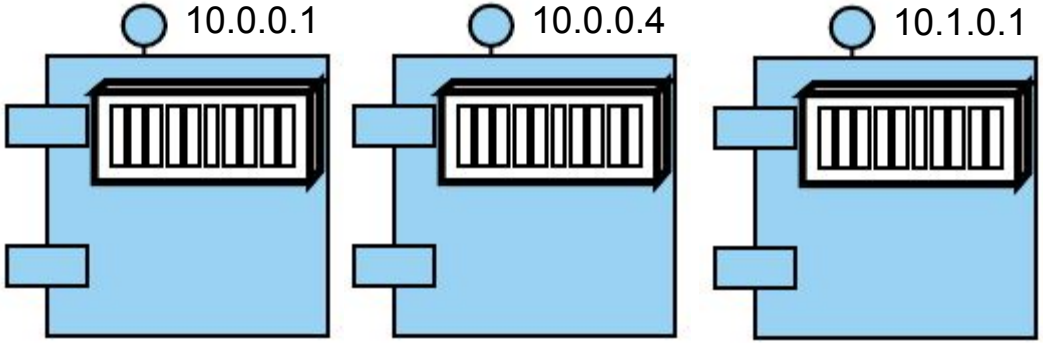
Some pods may have more than one container.. that's a special case though!!

Usually these containers are dependent like a master and slave or **side-car** pattern

And they have a very tight married relationship

All the containers in a pod die along with a pod.

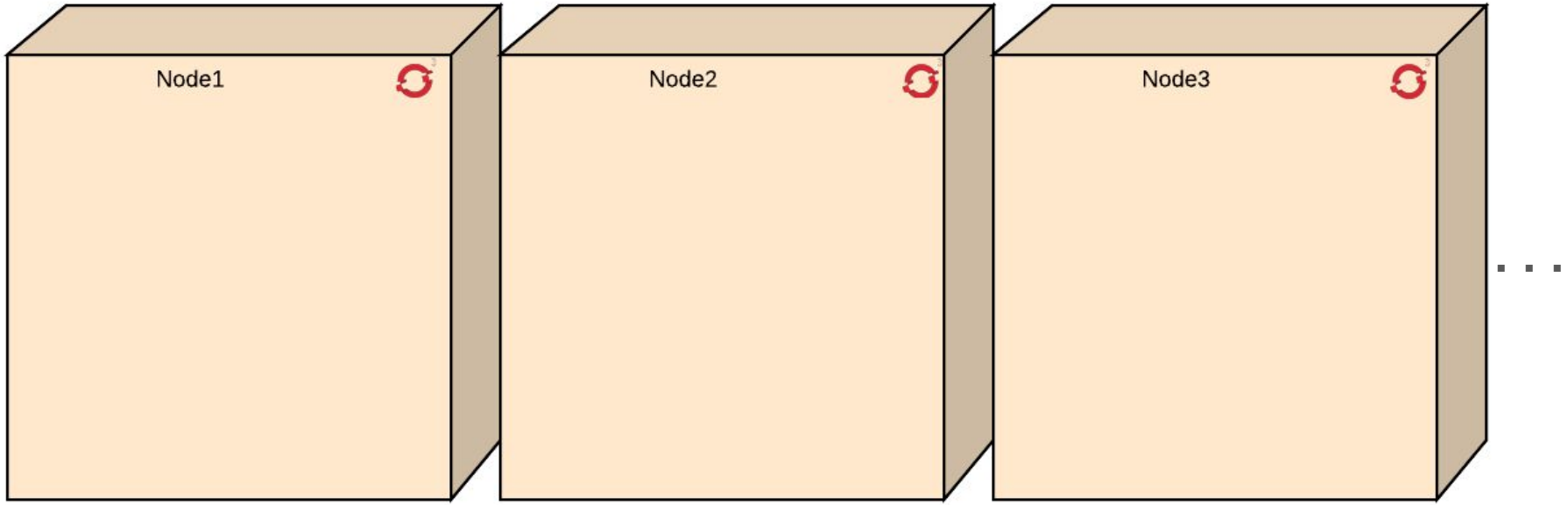
Pod Scaling

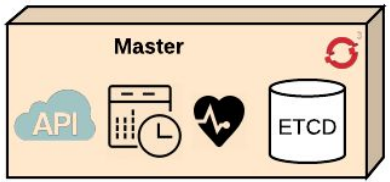


When you scale up your application, you are scaling up pods.

Each Pod has its own IP.

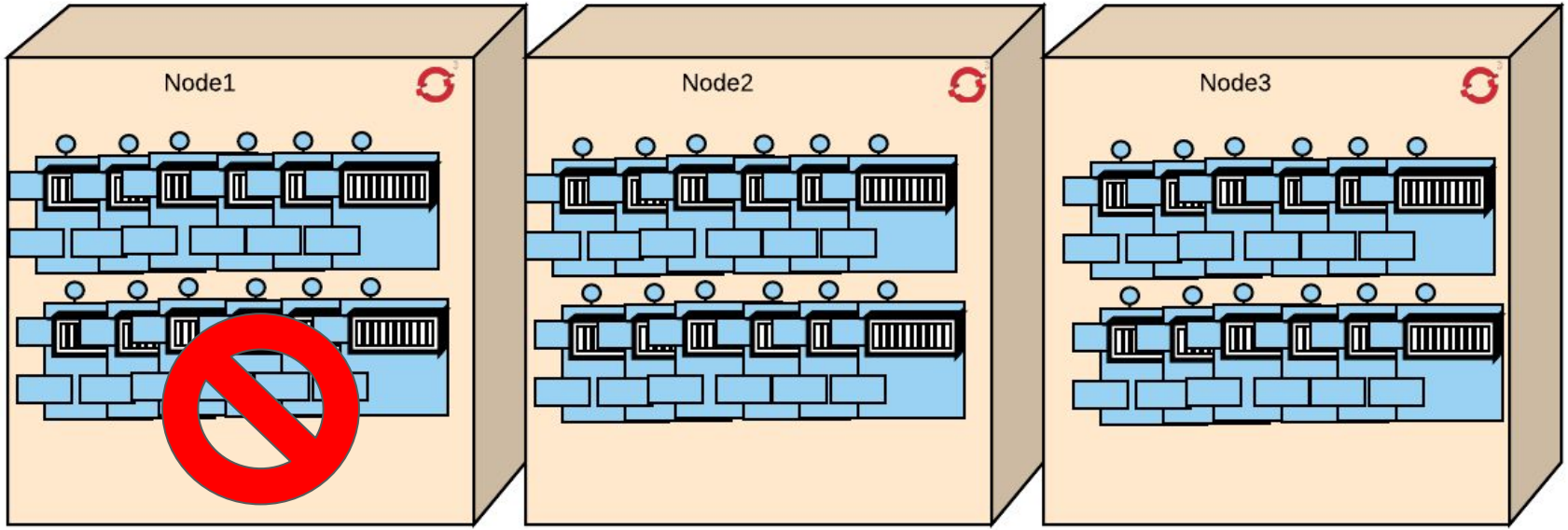
Nodes





Nodes are the application hosts that make up a openshift/K8S cluster. They run docker and openshift. Master controls where the pods are deployed on the nodes, and ensures cluster health.

High Availability

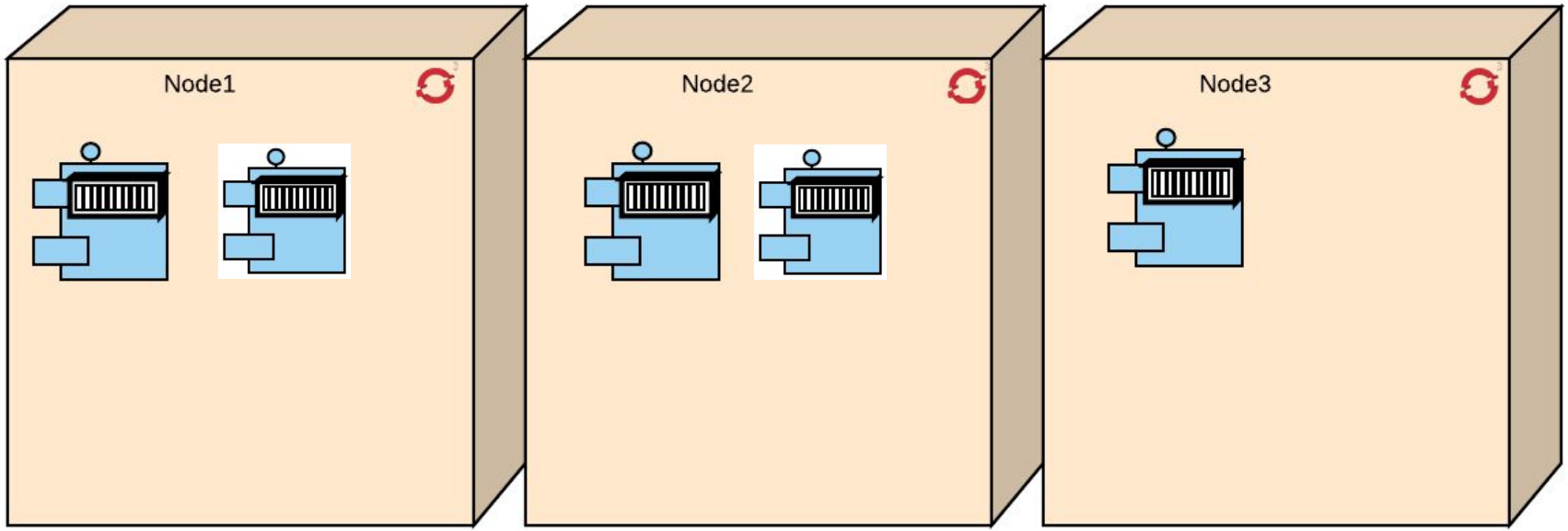


. . .

when you scale up, pods are distributed across nodes following scheduler policies defined by the administrator.

So even if a node fails, the application is still available

Health Management

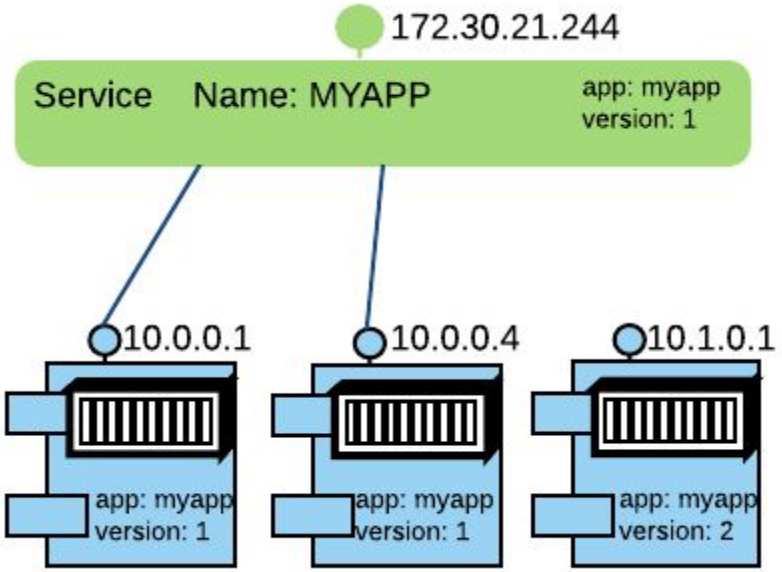


Not just that, if a pod dies for some reason, another pod will come in its place

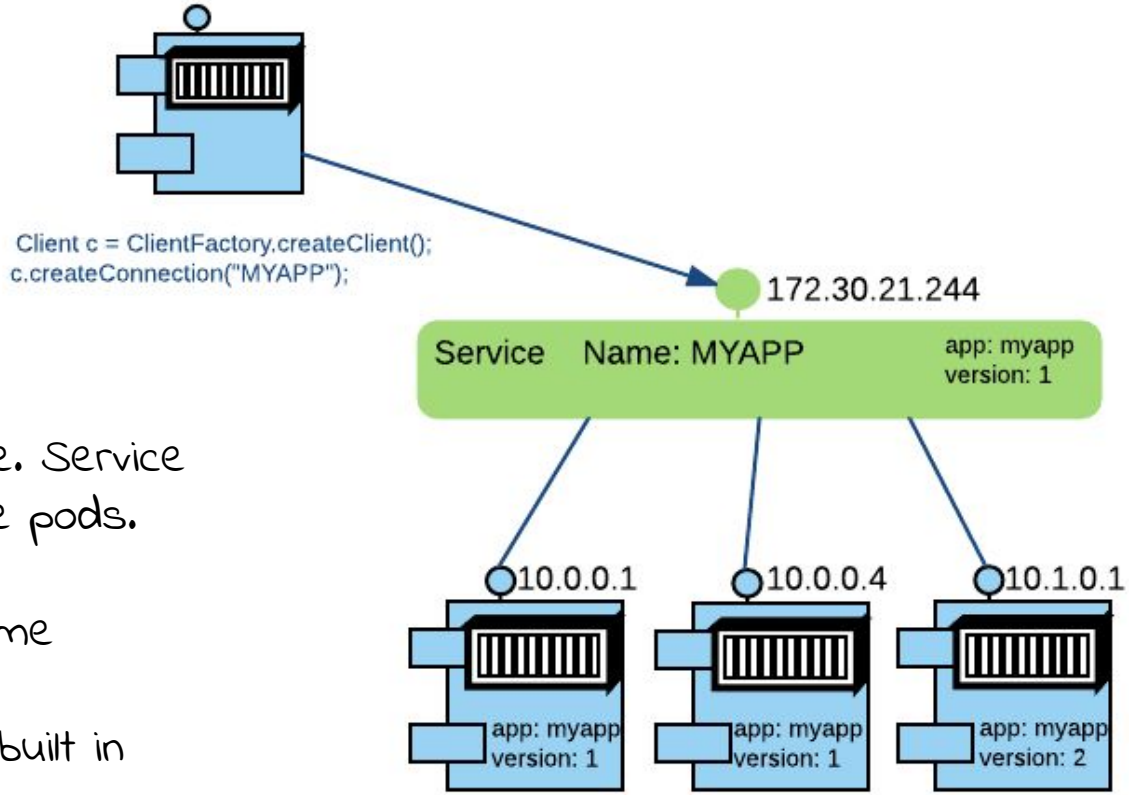
Flexibility of architecture with Openshift/ K8S Services

Pods can be front-ended by a Service. Service is a proxy.. Every node knows about it. Service gets an IP

Service knows which pods to frontend based on the labels.



Built-in Service Discovery

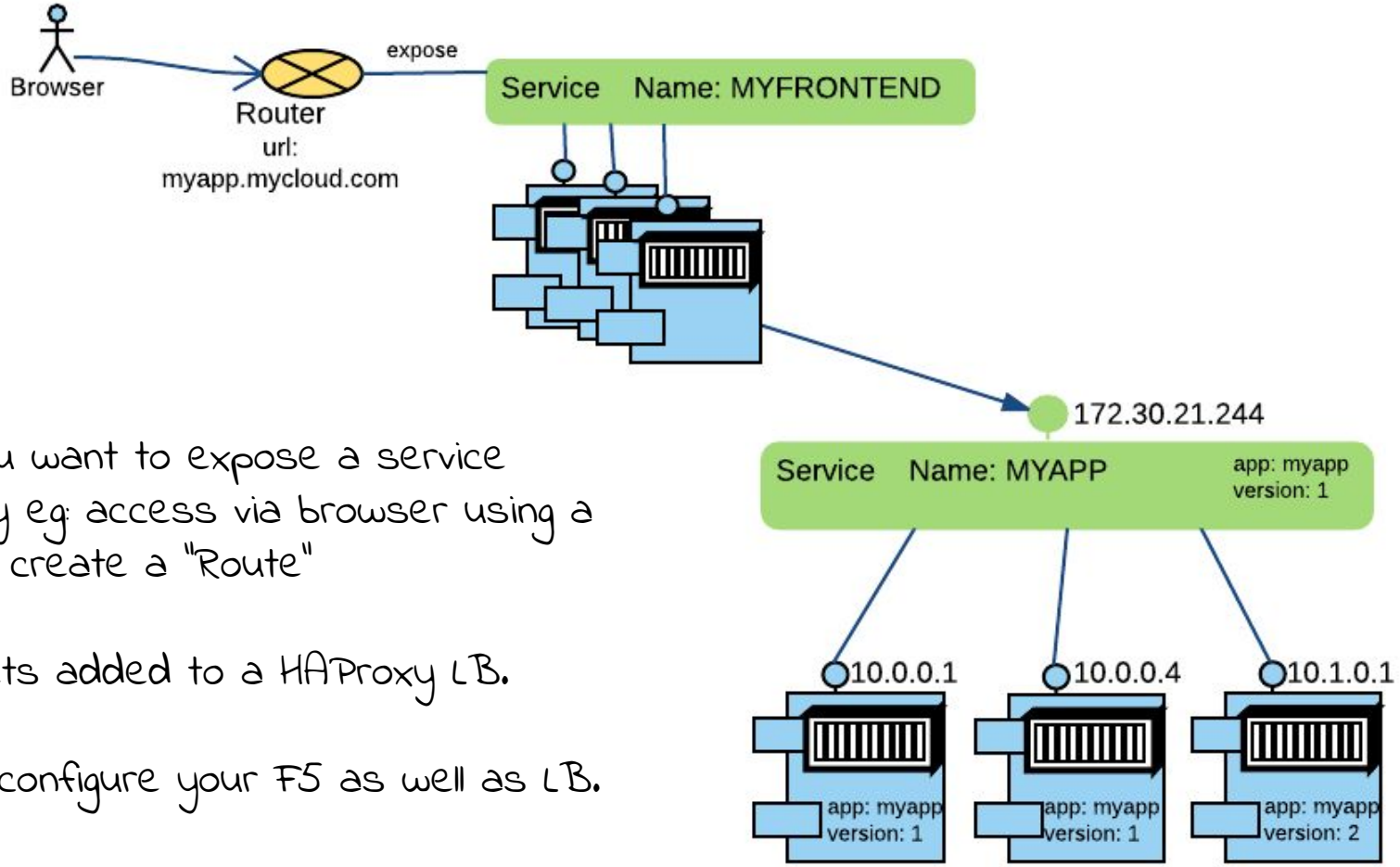


Clients can talk to the service. Service redirects the requests to the pods.

Service also gets a DNS Name

Client can discover service... built in service discovery!!

Accessing your Application



When you want to expose a service externally eg: access via browser using a URL, you create a "Route"

Route gets added to a HAProxy LB.

You can configure your F5 as well as LB.