Kubernetes Networking and Istio

Apurva Bhandari

$whoami

Apurva Bhandari, CKAD
SRE / DevOps
Docker & Kubernetes Enthusiast
Speaker at Meetups
Email: apurvbhandari@gmail.com
LinkedIn: https://www.linkedin.com/in/apurvabhandari-linux
GitHub: https://github.com/apurvabhandari/Kubernetes

Agenda

1. Kubernetes Networking Basic
2. Advance routing
3. Introduction to Service Mesh Istio
4. Traffic Routing by Istio
5. Networking with and without Istio

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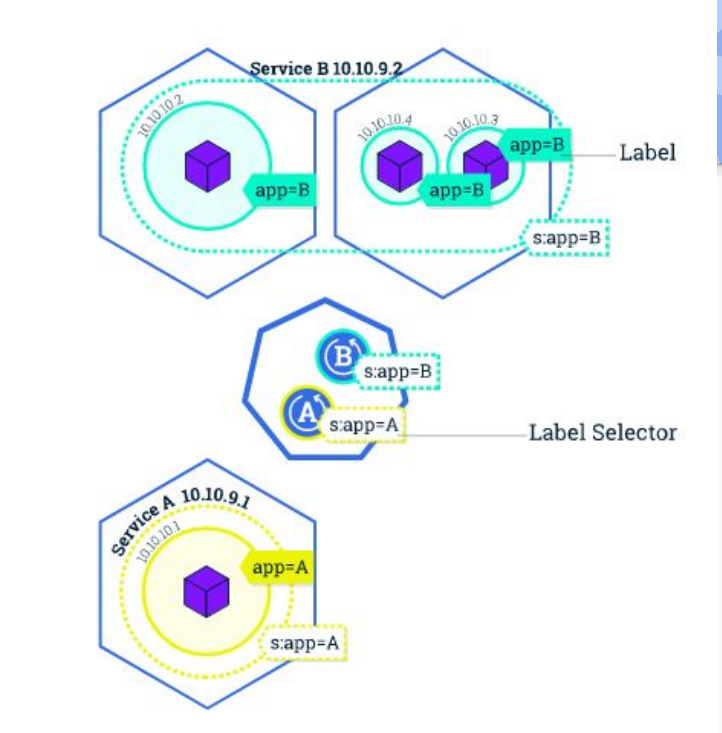
Services

Types of Services

1. ClusterIP (Default)
2. NodePort
3. LoadBalancer
4. ExternalName



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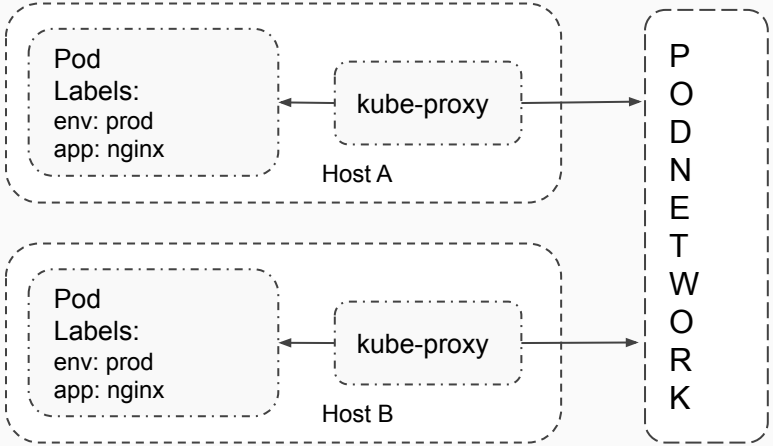
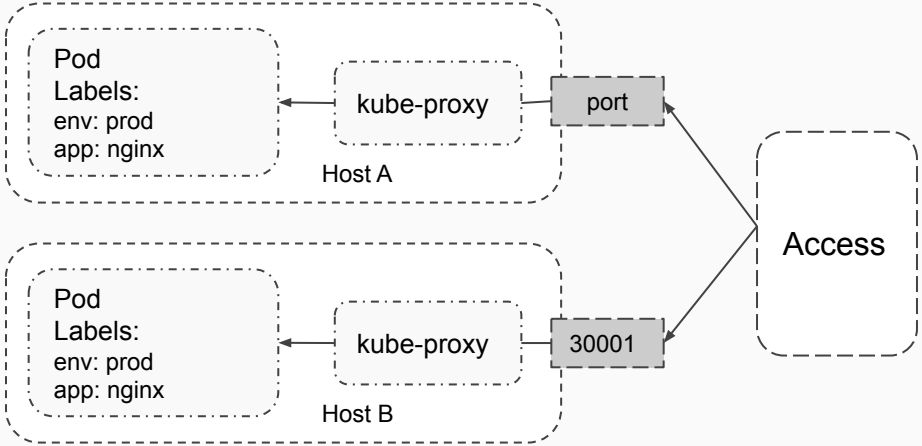
kubernetes

a. ClusterIP



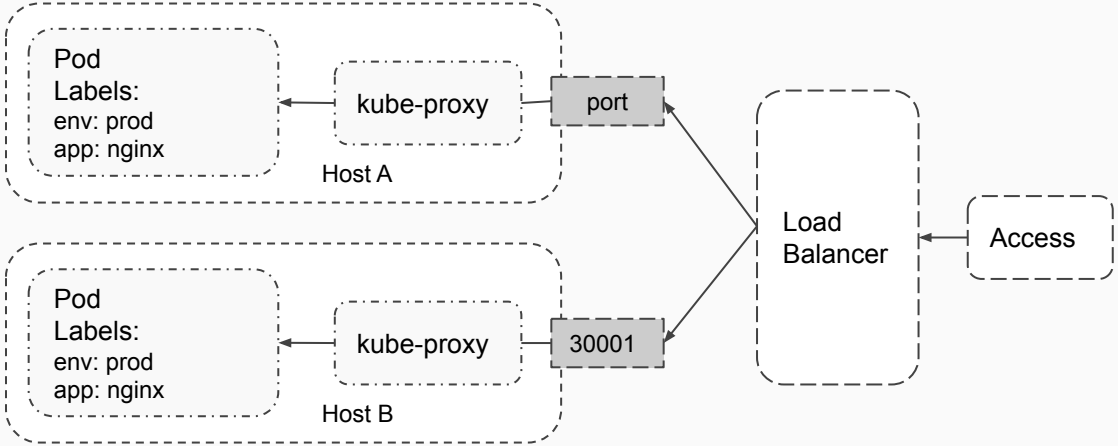

```yaml
apiVersion: v1
kind: Service
metadata:
  name: example-prod
spec:
 selector:
  app: nginx
  env: prod
 ports:
 - protocol: TCP
   port: 80
   targetPort: 80
 type: ClusterIP
```

b. NodePort




```yaml
apiVersion: v1
kind: Service
metadata:
  name: nginx
  namespace: default
spec:
  ports:
   - port: 80
     protocol: TCP
     targetPort: 80
     nodePort: 30001
  selector:
    run: nginx
  type: NodePort
```

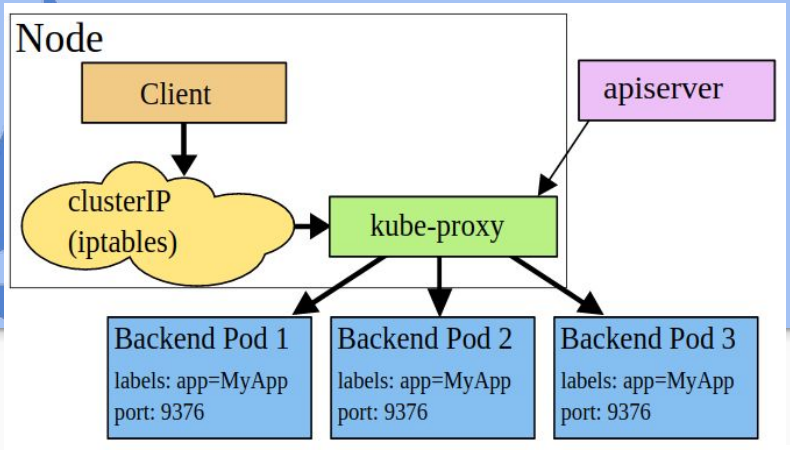
c. LoadBalancer



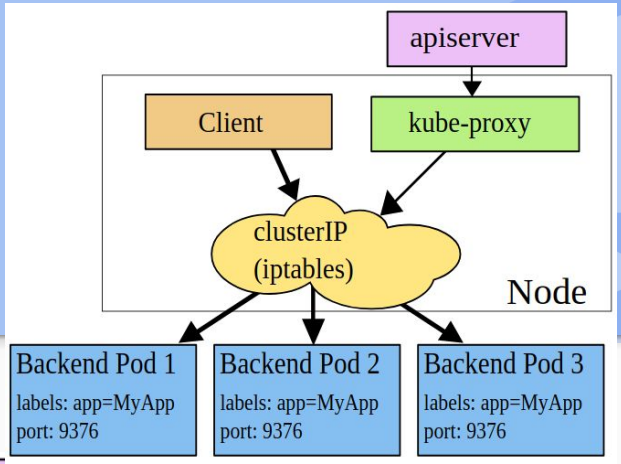

```yaml
apiVersion: v1
kind: Service
metadata:
  name: tomcat
  namespace: default
spec:
  ports:
  - name: healthz
    nodePort: 31768
    port: 8080
    protocol: TCP
    targetPort: 8080
  selector:
    run: tomcat
  type: LoadBalancer
```

d. ExternalName

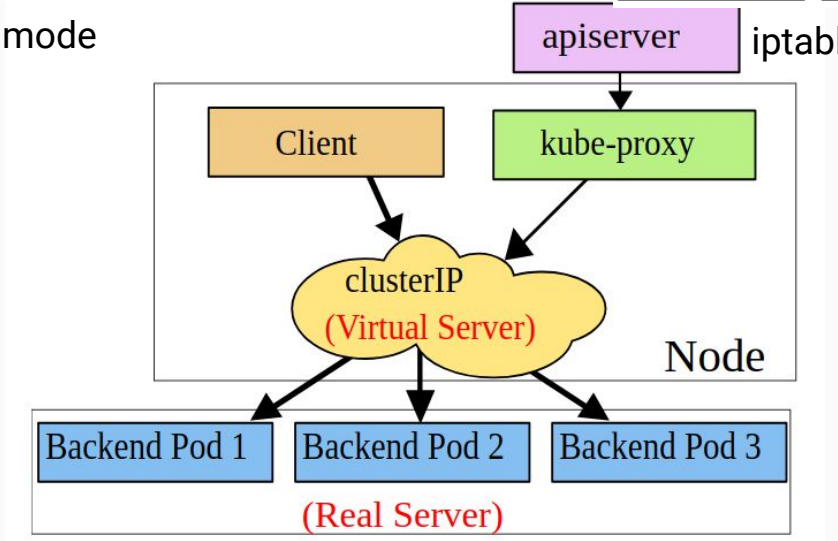
```yaml
apiVersion: v1
kind: Service
metadata:
  name: my-service
  namespace: prod
spec:
  type: ExternalName
  externalName: my.database.example.com
```



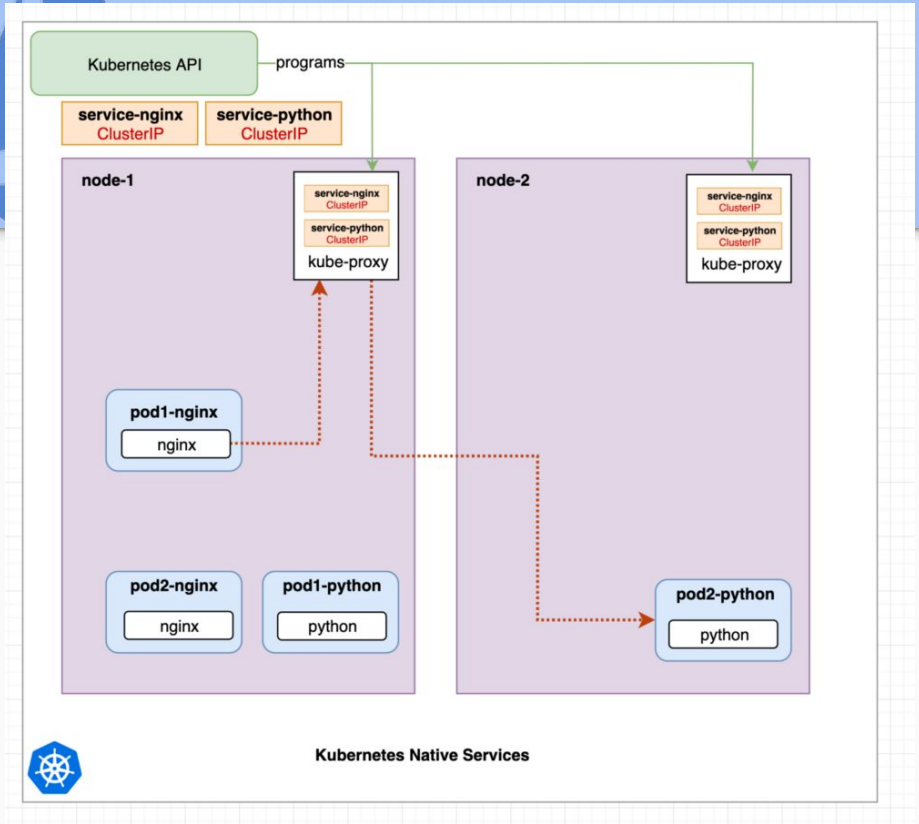
User space proxy mode

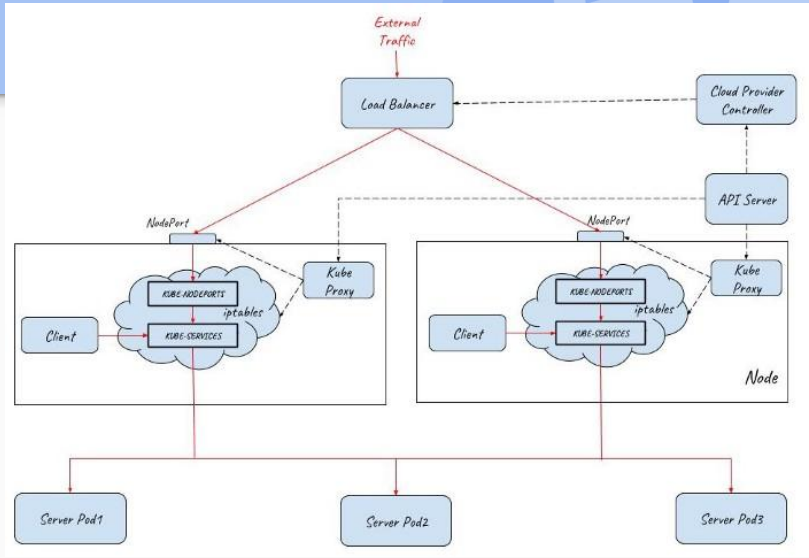


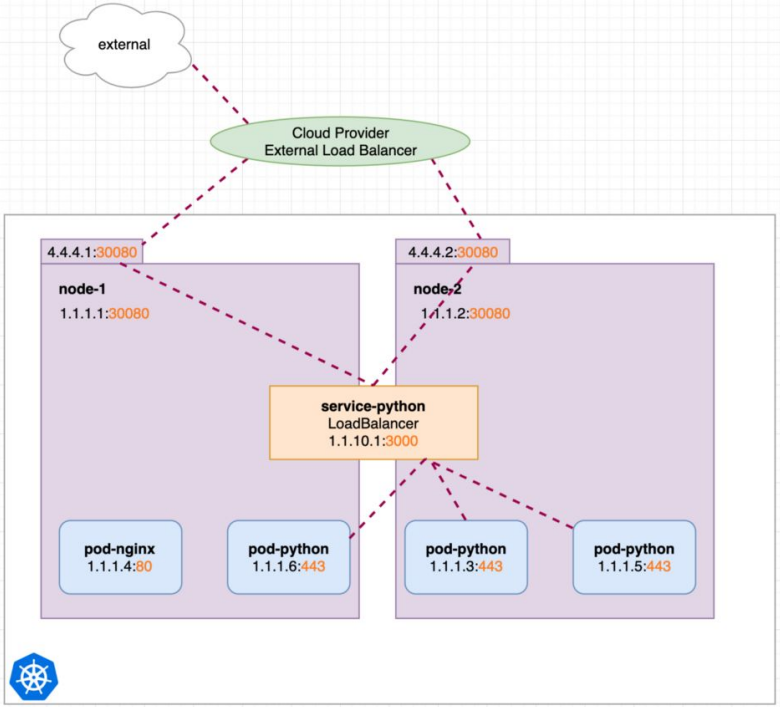
iptables proxy mode

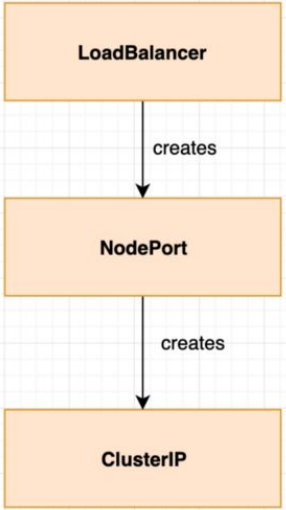


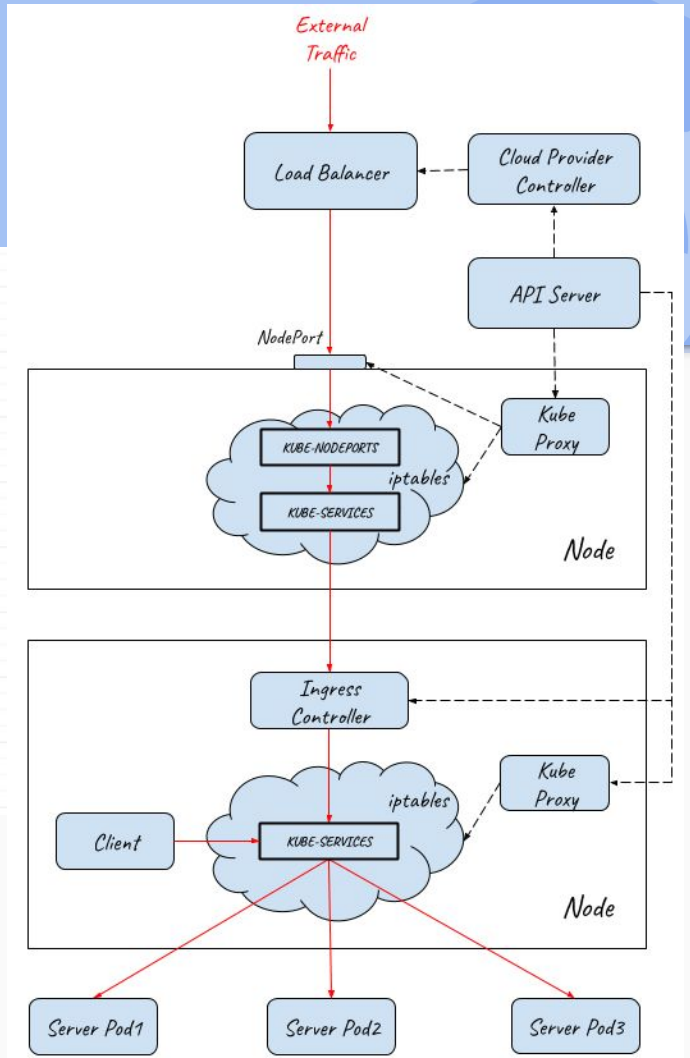
IPVS proxy mode


Kubernetes API
programs
service-nginx
ClusterIP
service-python
ClusterIP
node-1
service-nginx
ClusterIP
service-python
ClusterIP
kube-proxy
pod1-nginx
nginx
pod2-nginx
nginx
pod1-python
python
node-2
service-nginx
ClusterIP
service-python
ClusterIP
kube-proxy
pod2-python
python
Kubernetes Native Services


External Traffic
Load Balancer
Cloud Provider Controller
API Server
NodePort
NodePort
Kube Proxy
KUBE-NODEPORTS
iptables
KUBE-SERVICES
Client
Kube Proxy
KUBE-NODEPORTS
iptables
KUBE-SERVICES
Client
Node
Server Pod1
Server Pod2
Server Pod3


external
Cloud Provider
External Load Balancer
4.4.4.1:30080
4.4.4.2:30080
node-1
1.1.1.1:30080
node-2
1.1.1.2:30080
service-python
LoadBalancer
1.1.10.1:3000
pod-nginx
1.1.1.4:80
pod-python
1.1.1.6:443
pod-python
1.1.1.3:443
pod-python
1.1.1.5:443


LoadBalancer
creates
NodePort
creates
ClusterIP


External
Traffic
Load Balancer
Cloud Provider
Controller
API Server
NodePort
Kube
Proxy
KUBE-NODEPORTS
iptables
KUBE-SERVICES
Node
Ingress
Controller
Kube
Proxy
iptables
Client
KUBE-SERVICES
Node
Server Pod1
Server Pod2
Server Pod3

Introduction to Service Mesh - Istio

Secure, monitor and manage services

Intelligent routing

Control traffic between services with **dynamic route configuration**, conduct **A/B tests**, release **canaries**, and **gradually upgrade versions** using red/black deployments.

Resilience

Increase reliability by shielding applications from flaky networks and cascading failures in adverse conditions. **Timeouts**, **retries**, **health checks** and **circuit breakers** -- all applied regardless of language, across the fleet.

Security & policy

Transparently inject **mutual TLS** on each call, securing and encrypting traffic. Apply **organizational policy** to the interaction between services, ensure **access policies** are enforced and resources are fairly distributed among consumers.

Telemetry

Understand the **dependencies between services**, the nature and **flow of traffic** between them, and quickly identify issues with **distributed tracing**

Istio Value Proposition

Securing service communications

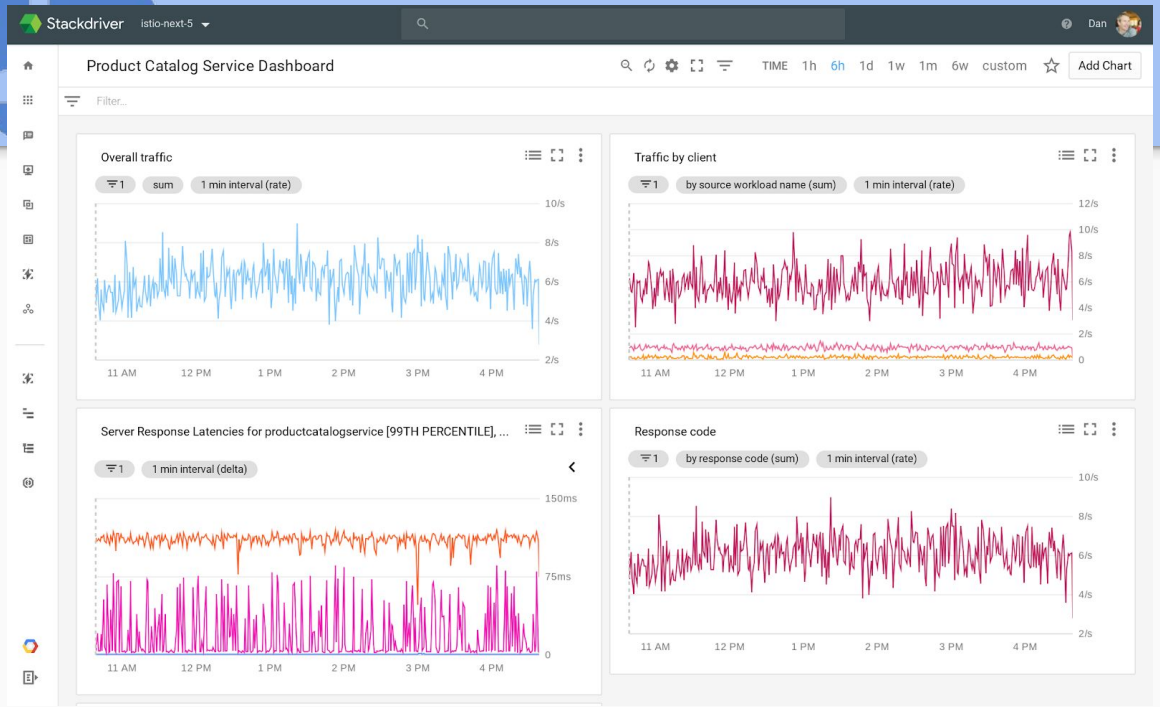
Strongly **authenticate services** (not hosts) across heterogeneous deployment environments. Limit access of sensitive data to authorized services **without relying on L3** controls. Understand security posture of production environment through **service dependency graphs.**

Uniform service-level **observability**

Monitor the "**golden signals**" (traffic, error rates and latency) for all services, and **collect logs** on all calls. Use distributed tracing for in-depth **performance analysis**. Service dependency graphs make it easy to debug and to understand latency and hotspots.

Traffic management and operational agility

Send inter-cluster and inter-environment without manually provisioning ingress, egress, edge layers or hardware LBs. Change **service behavior** and **traffic flow** without redeploying or change of code. Control which services can talk to whom via **policy and routing rules**.



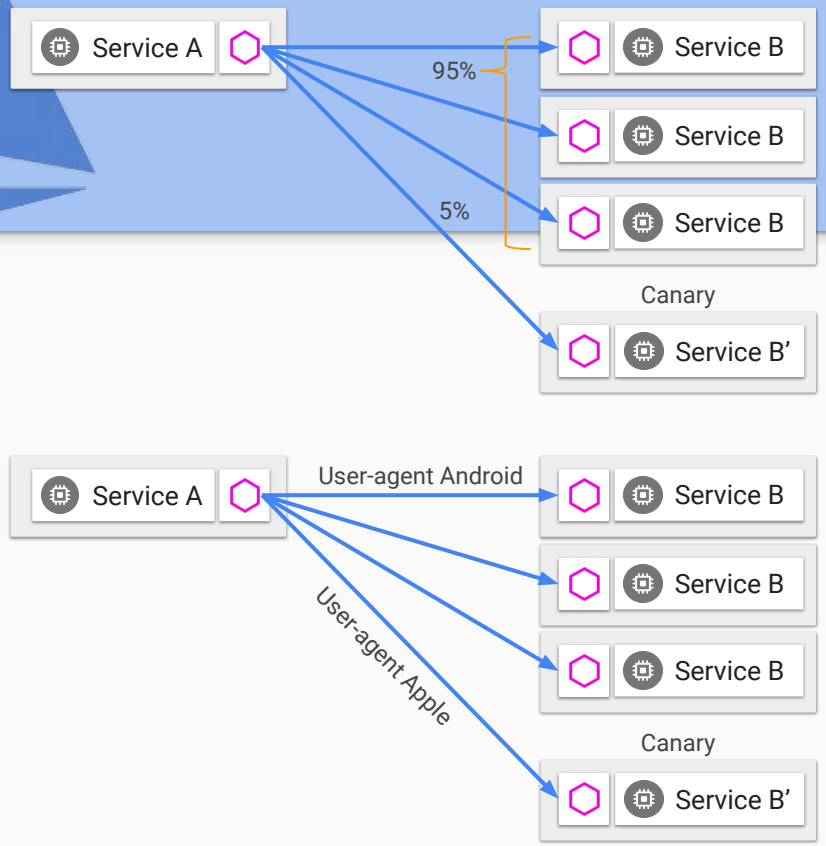
Uniform observability

Collect the **golden signals** for every service and logs for every call.

Understand services and their **dependencies**.

Set, monitor and **enforce SLOs** on services

Bird's eye view of service behavior for issue triage, **reduce time to detect, triage**



Operational agility

Scale by directing traffic to multiple versions

Roll out new versions without worrying about ops challenges

Apply access control, rate limiting policies to **protect services** from bad behavior

Policy driven security

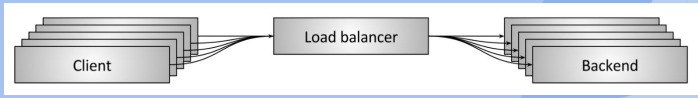
Defence in depth - security does not stop at the edge.

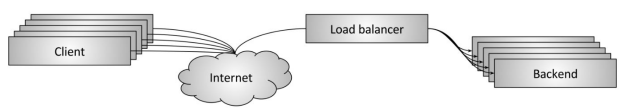
Enable mTLS for authentication and encryption.

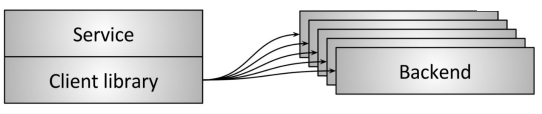
Authorize access based on service identity or any channel attribute.

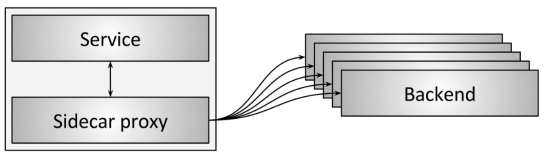
Configure finer grained RPC-level access control for REST and gRPC.

Networking proxy types







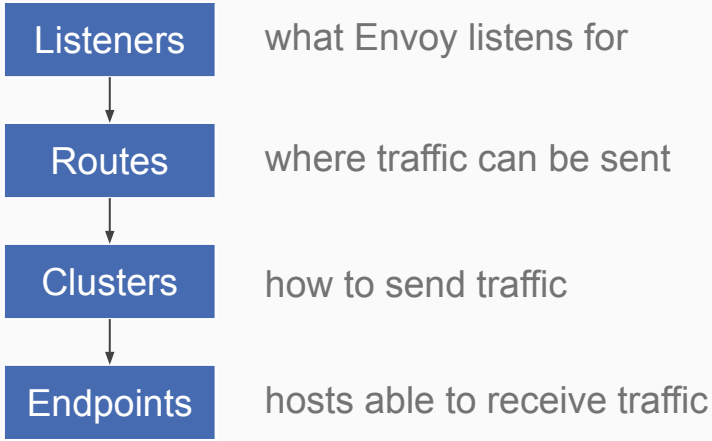


- Middle Proxy
- Edge Proxy
- Embedded Client Library
- Client Side / Sidecar Proxy

- Client Side Load Balancing, no SPoF
- Traditional Load Balancer is Layer 4
- Lightweight sidecars to manage traffic between services
- Scaling capabilities + polyglot aspect
- Sidecars can do much more than just load balancing!

The magic of the sidecar!

- Deployed with every workload
- Proxies all traffic into and out of a service
- Directs traffic (including routing rules)
- Enforces policy
- Reports telemetry
- All with no embedded client library



Envoy

- A C++ based L4/L7 proxy
- Lightweight, low memory footprint
- Battle-tested @ Lyft
  - 100+ services
  - 10,000+ VMs
  - 2M req/s

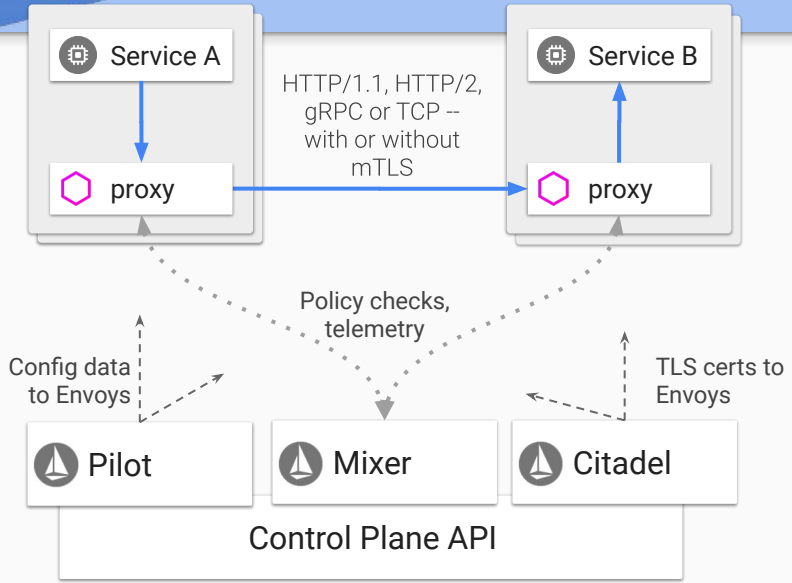
Goodies:

- HTTP/2 & gRPC
- Zone-aware load balancing w/ failover
- Health checks, circuit breakers, timeouts, retry budgets
- No hot reloads - API driven config updates

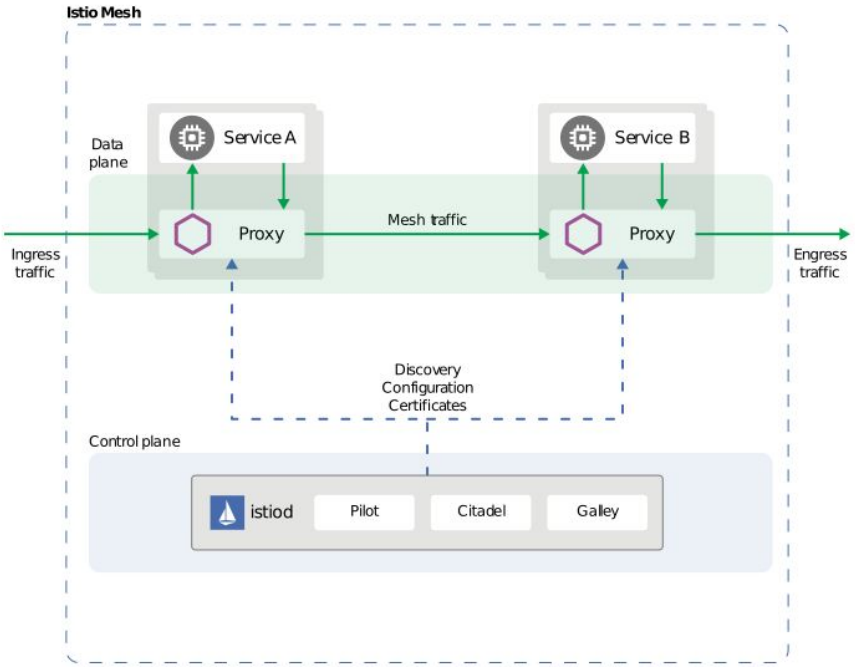
Istio's contributions:

- Transparent proxying w/ SO_ORIGINAL_DST
- Traffic routing and splitting
- Request tracing using Zipkin
- Fault injection

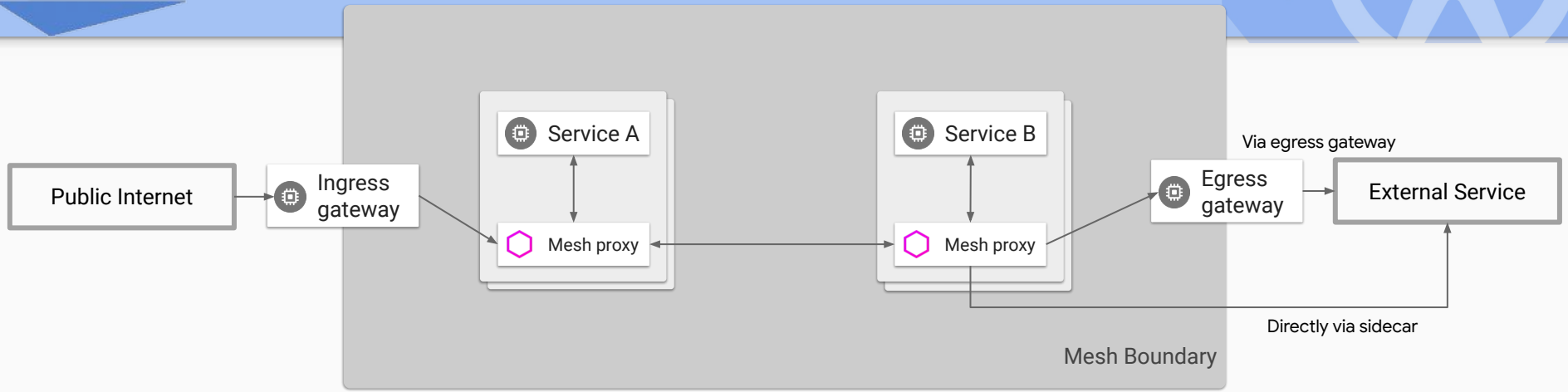
Architectural components

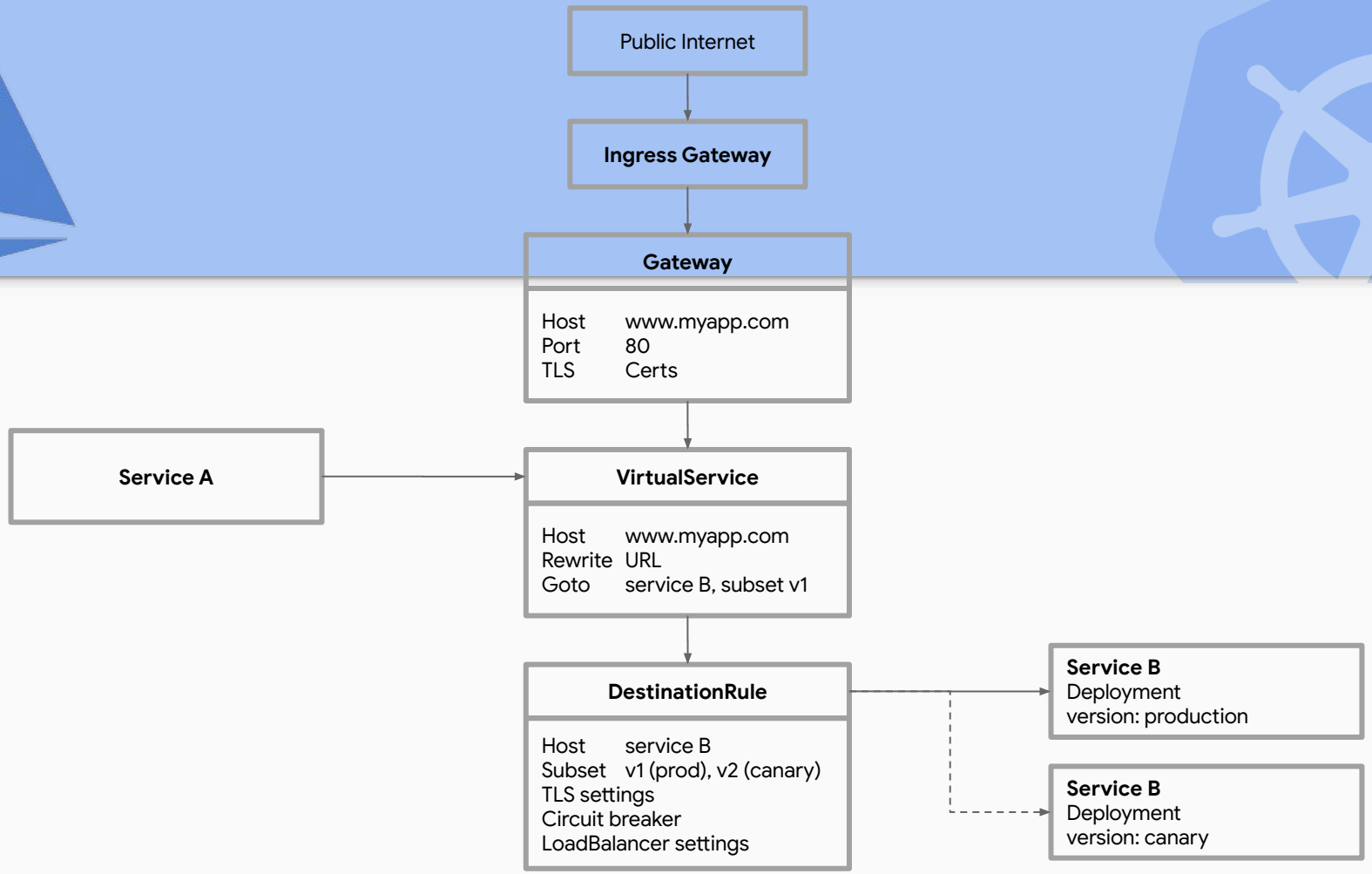


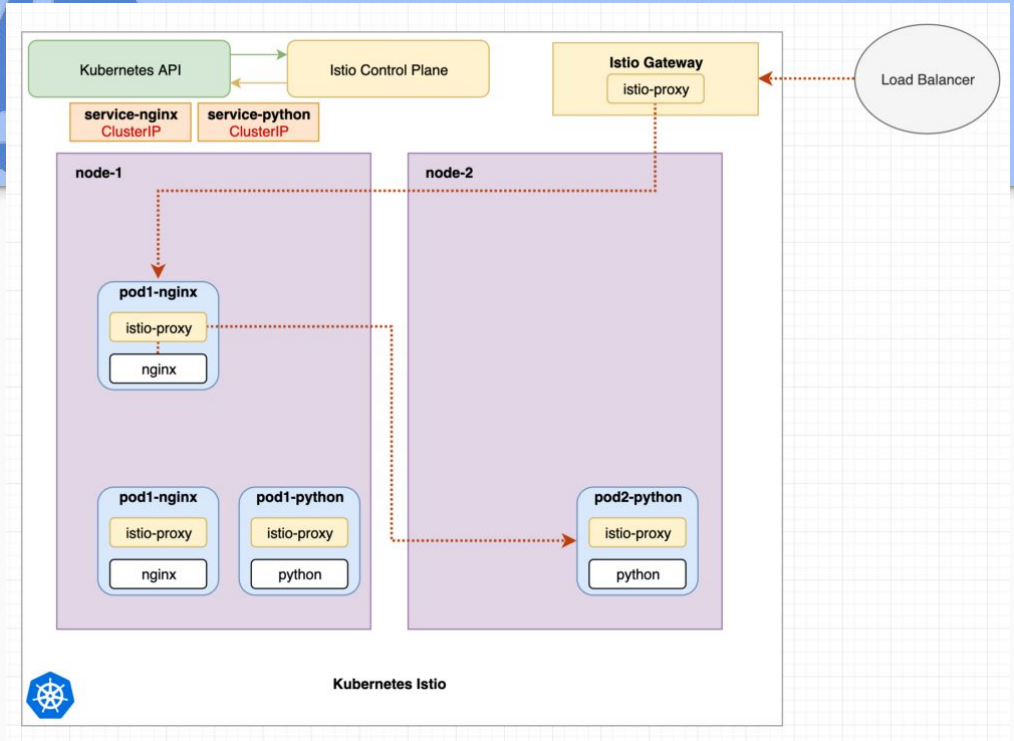
- **Envoy:** Network proxy to intercept communication and apply policies.
- **Pilot**: Control plane to configure and push service communication policies
- **Mixer:** Policy enforcement with a flexible plugin model for providers for a policy.
- **Istio Auth:** Service-to-service auth[n,z] using mutual TLS, with built-in identity and credential management.

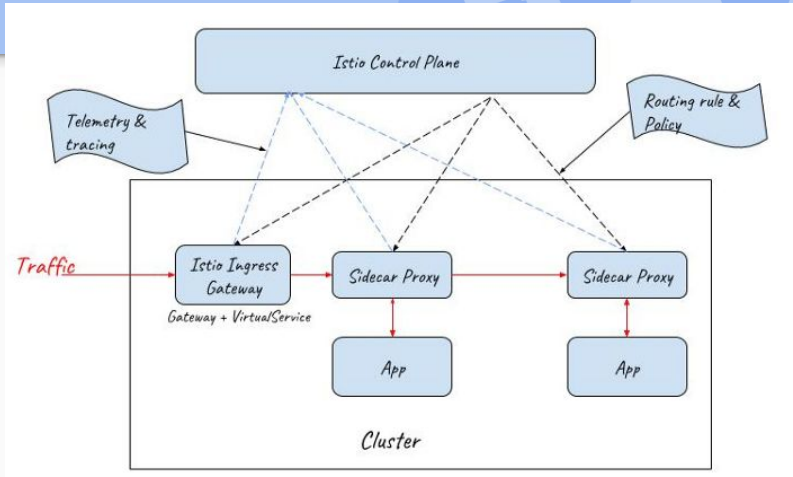


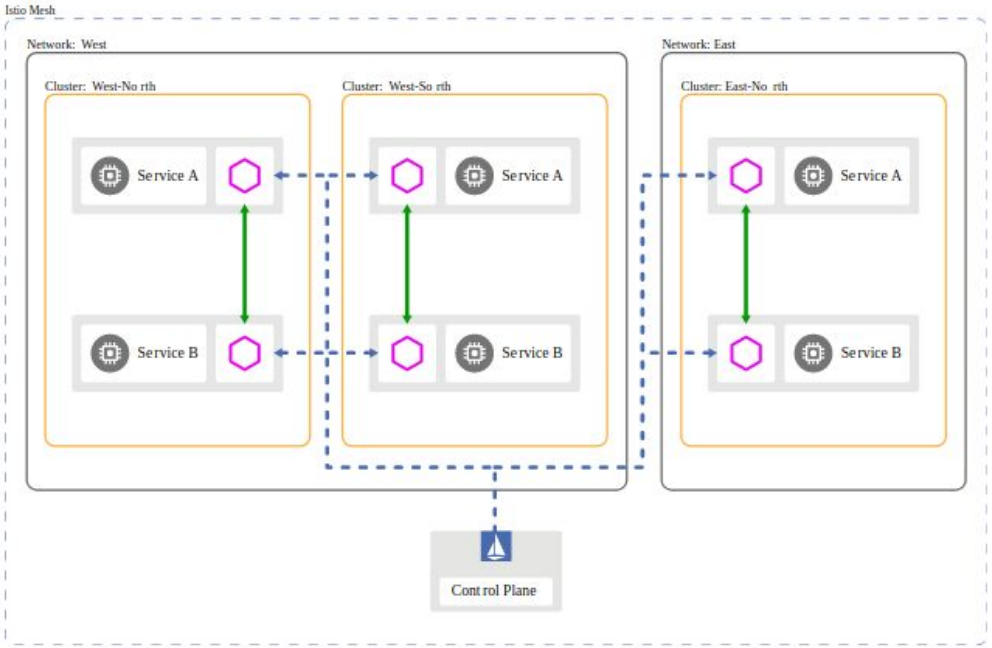
Istio Architecture


Public Internet
Ingress gateway
Service A
Mesh proxy
Service B
Mesh proxy
Egress gateway
Via egress gateway
External Service
Directly via sidecar
Mesh Boundary


Public Internet
Ingress Gateway
Gateway
Host www.myapp.com
Port 80
TLS Certs
Service A
VirtualService
Host www.myapp.com
Rewrite URL
Goto service B, subset v1
DestinationRule
Host service B
Subset v1 (prod), v2 (canary)
TLS settings
Circuit breaker
LoadBalancer settings
Service B
Deployment
version: production
Service B
Deployment
version: canary


Kubernetes API
Istio Control Plane
Istio Gateway
istio-proxy
Load Balancer
service-nginx
ClusterIP
service-python
ClusterIP
node-1
node-2
pod1-nginx
istio-proxy
nginx
pod1-nginx
istio-proxy
nginx
pod1-python
istio-proxy
python
pod2-python
istio-proxy
python
Kubernetes Istio


Istio Control Plane
Telemetry & tracing
Routing rule & Policy
Traffic
Istio Ingress Gateway
Gateway + VirtualService
Sidecar Proxy
Sidecar Proxy
App
App
Cluster



A service mesh with multiple clusters

Traffic Management

- Application rollout (in percentage distribution)
- Traffic steering (content based)
- Resiliency
- Efficiency

Thank You