IBM Cloud Private
Istio – Microservice Mesh

IBM Cloud

Service Mesh

Architecture

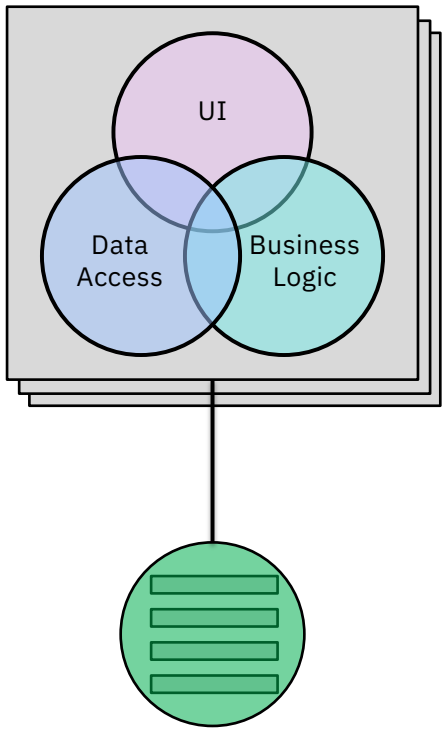
Managing Traffic

Operations

Microservice Application Architecture

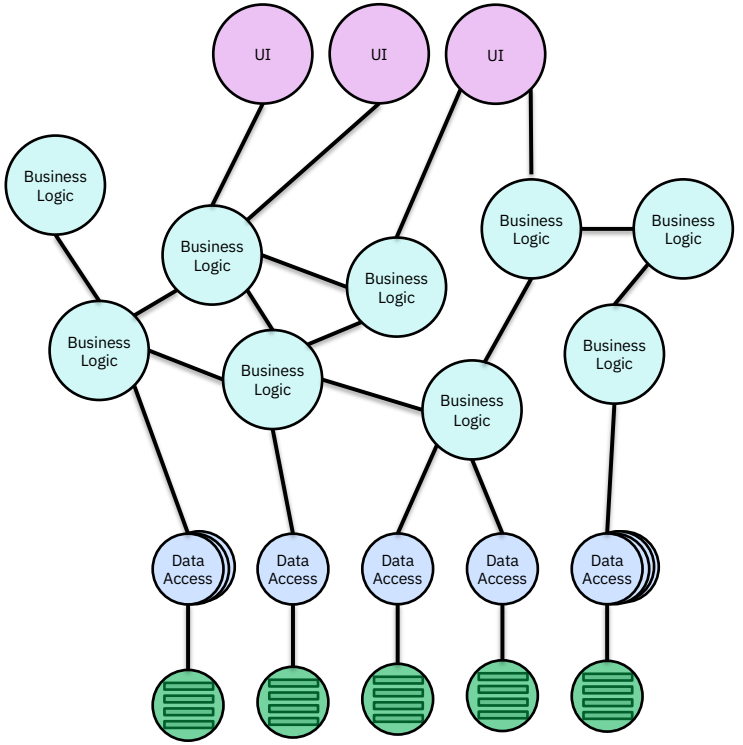
An **engineering approach** focused on decomposing an application into **single function** modules with **well defined interfaces** which are **independently** deployed and operated by a **small team** who owns the **entire lifecycle** of the service

Monolithic



versus

Microservices



Weighing the Microservice Investment

Improved delivery velocity and agility

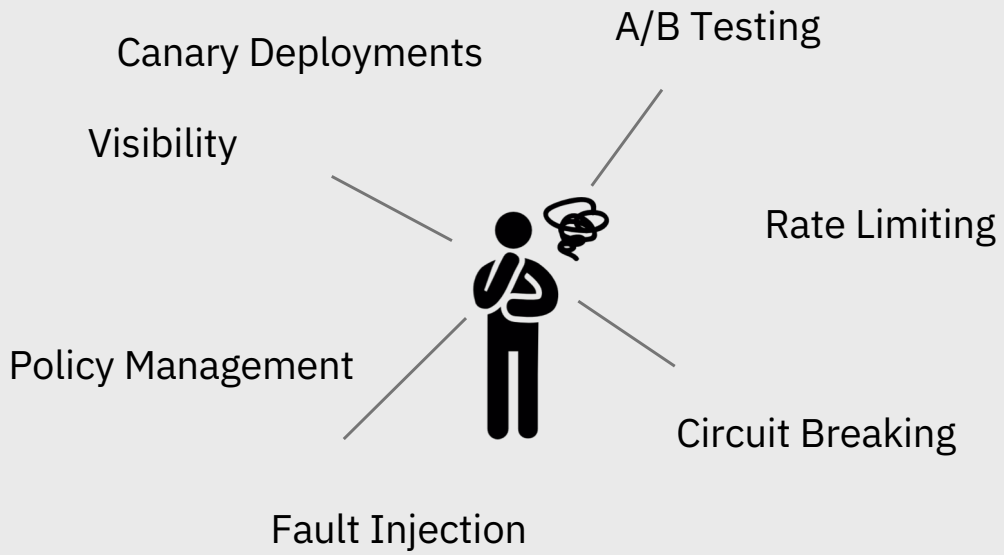
Increased operational complexity

IBM Cloud Private / Kubernetes enables the microservice design goals of clean packaging, consistency, scalability and rapid deployment

Kubernetes alone does not address all of the complexities of the challenge

Microservice Adoption Considerations

Deploying microservice applications is not necessarily easy, the network layer is challenging and tooling is essential

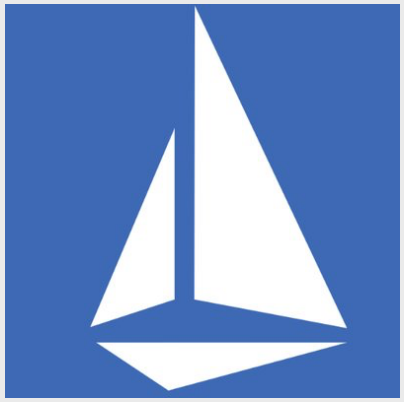


Service mesh describes the **network of microservices** that make up applications and the corresponding **interactions** between them.

Istio

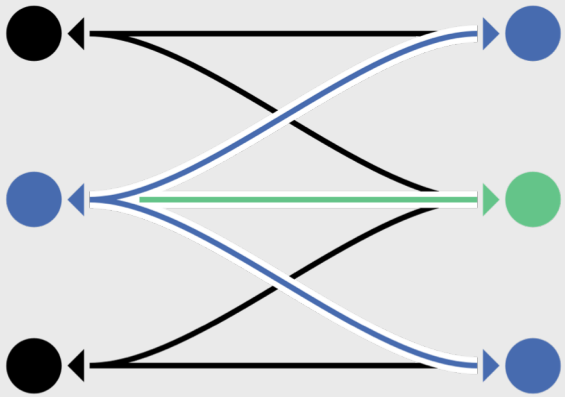
Connect, secure, control and observe services

Why Istio?



- Automatic load balancing for HTTP, gRPC, WebSocket, and TCP traffic
- Fine-grained control of traffic behavior with rich routing rules, retries, failovers, and fault injection
- A pluggable policy layer and configuration API supporting access controls, rate limits and quotas
- Automatic metrics, logs, and traces for all traffic within a cluster, including cluster ingress and egress
- Secure service-to-service communication in a cluster with strong identity-based authentication and authorization

Connect

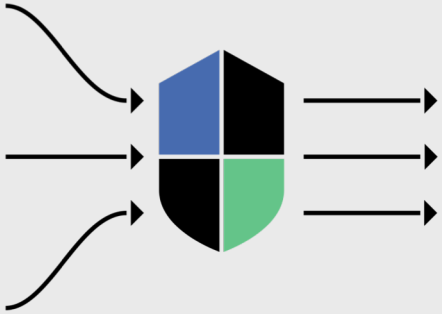


Intelligently control the flow of traffic and API calls between services, conduct a range of tests and upgrade gradually with red / black deployments

Secure

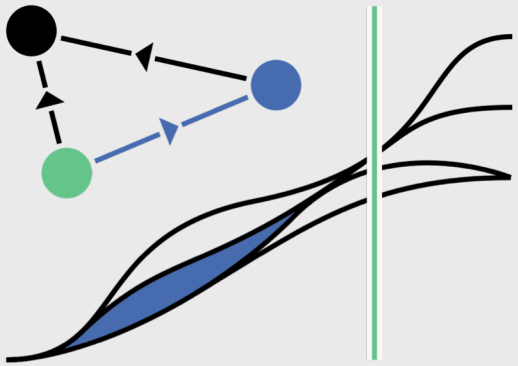
Automatically secure your services through managed authentication, authorization and encryption of communication between services

Control



Apply policies and ensure that they are enforced and that resources are fairly distributed among consumers

Observe



See what’s happening with rich automatic tracing, monitoring and logging of all your services

Istio Core Features and Value

Traffic management
- Easy-to-Configure routing and traffic control
- Simplified configuration of circuit breakers, timeouts, and retries supporting A/B testing, canary and staged rollouts
- High visibility into your traffic

Security
- Free developers to focus on security at the application level
- Istio manages authentication, authorization, and encryption of service communication at scale
- Service communications are secured by default with little or no changes to the application
- Via integration with the platform secure pod-to-pod or service-to-service communication at the network AND application layers

Observability
- Rich tracing, monitoring, and logging provide deep insights into the service mesh
- Understand upstream and downstream performance effects
- Out of the box dashboards provide deep visibility into service usage and performance
- Enables fine-grained control over all interactions between the mesh and infrastructure backends
- Detect, diagnose and fix issues with greater speed and agility

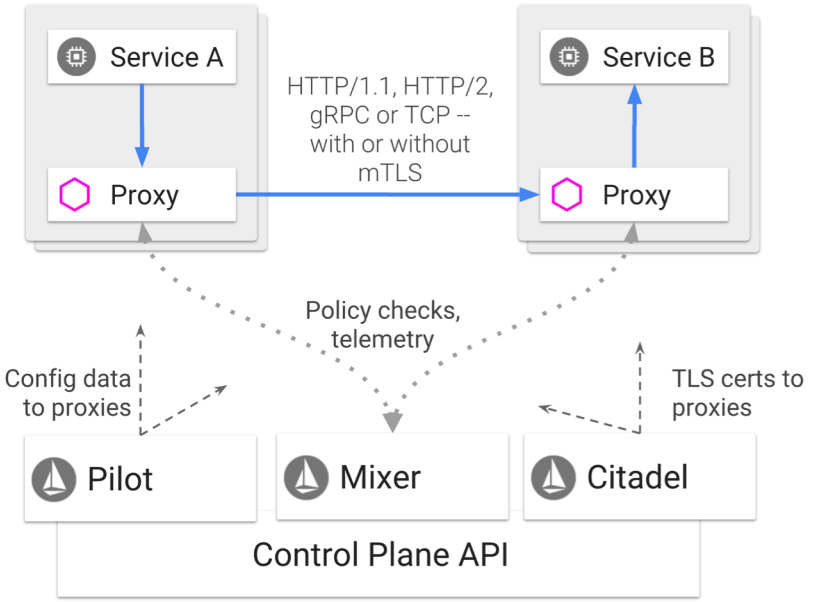
Platform support
- Platform independence
- Deploy across services running in IBM Cloud Private (Kubernetes) and hosted on Virtual Machines

Istio Architecture
Data Plane & Control Plane

Istio is logically composed from a data plane and a control plane

Data Plane
- Intelligent proxies are deployed as sidecars within the service pods
- The proxies mediate and control communication between microservices
- Proxies interface with the Mixer to provide telemetry data and enforce policy

Control Plane
- Configures the proxies for traffic routing
- Configures Mixers for policy enforcement and telemetry collection



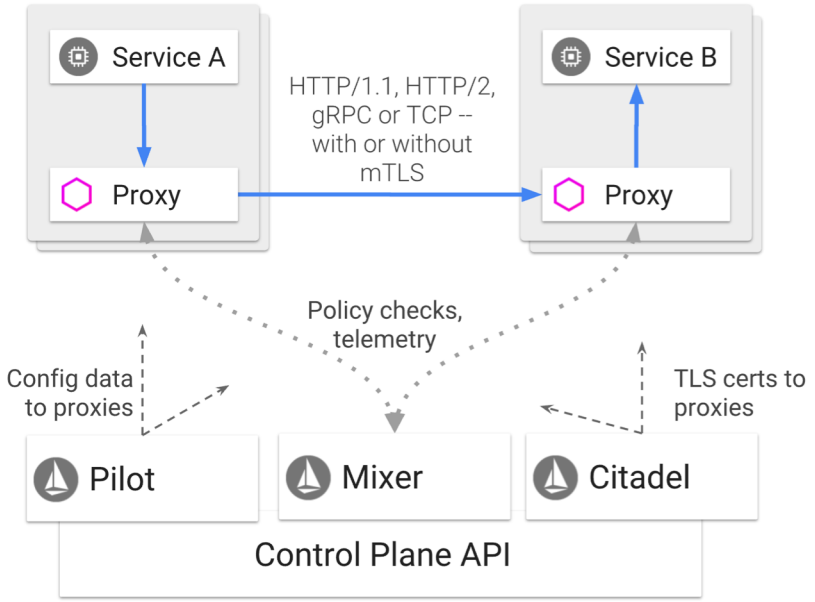
Istio Architecture
Envoy Proxy

A proxy that mediates all inbound and outbound network traffic for the service mesh services

The proxy provides dynamic service discovery, load balancing, TLS termination, HTTP/2 and gRPC proxies, circuit breakers, health checks, staged rollouts with including percentage based traffic split, fault injection and rich metrics

Deployed as a sidecar (container sharing the pod) of the service that is included as part of the mesh

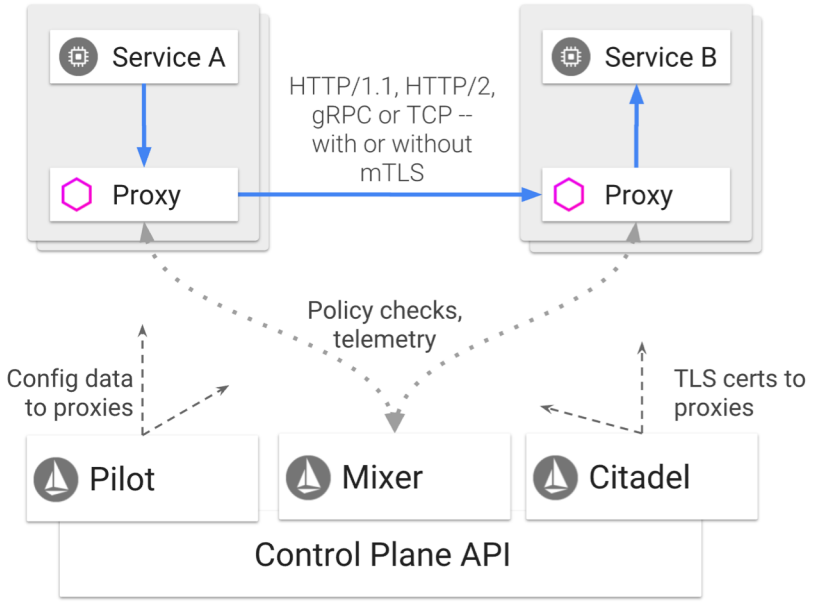
Enables Istio to add capabilities to a deployment without adding to the application code



Istio Architecture
Mixer

Mixer collects telemetry data and enforces usage policies and access control policies throughout the service mesh

The proxy (Envoy) extracts request level attributes and forwards them for evaluation by the Mixer



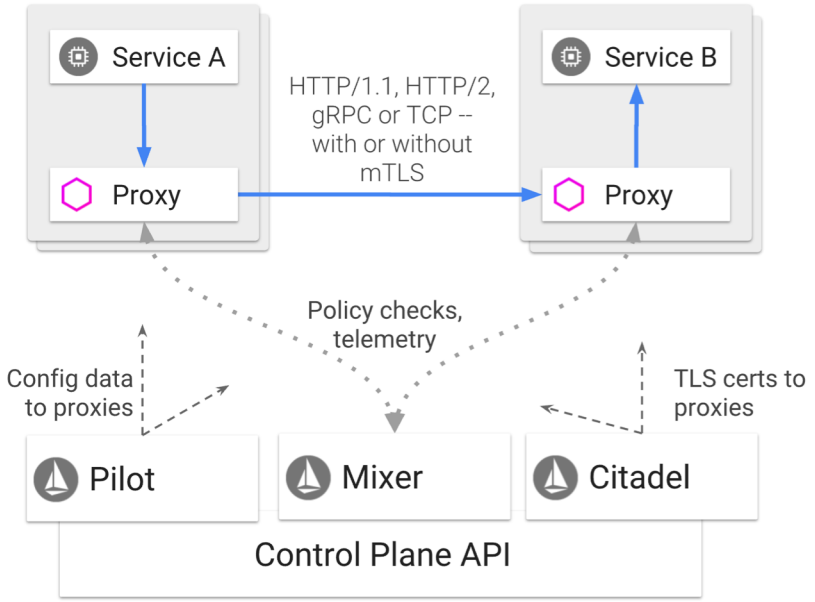
Istio Architecture
Pilot

Pilot performs service discovery for the proxy sidecars, traffic management for intelligent routing and network traffic resiliency

Intelligent routing and resiliency include A/B testing, canary deployments, timeouts, retries and circuit breaking

High-level routing rules are converted by pilot into Envoy configurations and used for traffic control

The framework used by Istio and the loose coupling allows Istio to extend beyond Kubernetes

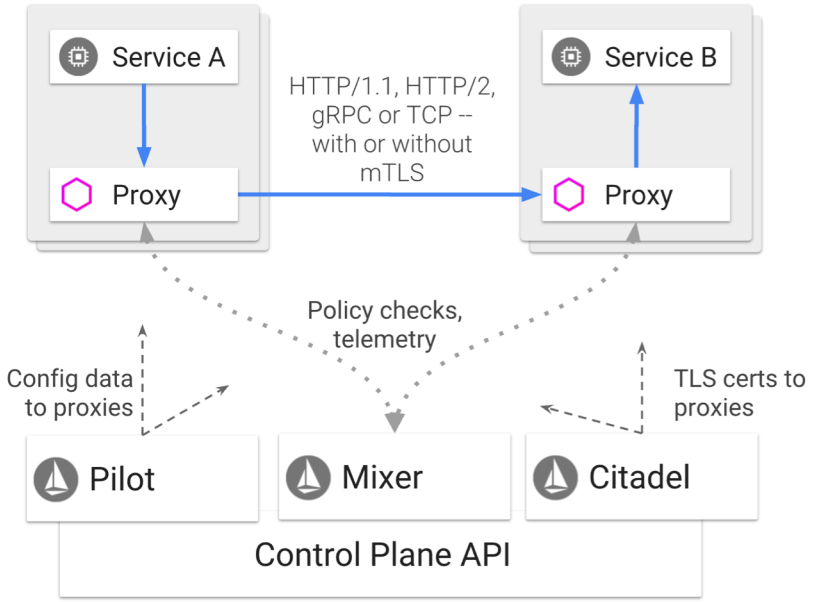


Istio Architecture
Citadel and Galley

Citadel uses its internal identity and credential management capacity provide strong service to service and end-user authentication

With the use of Citadel policy enforcement can be based upon the identity of a service rather than on network controls and the authorization feature controls who can access these services

Galley validates user authored Istio API configuration on behalf of the the control plane and will eventually become responsible as the top-level configuration ingestion, processing and distribution component



Istio

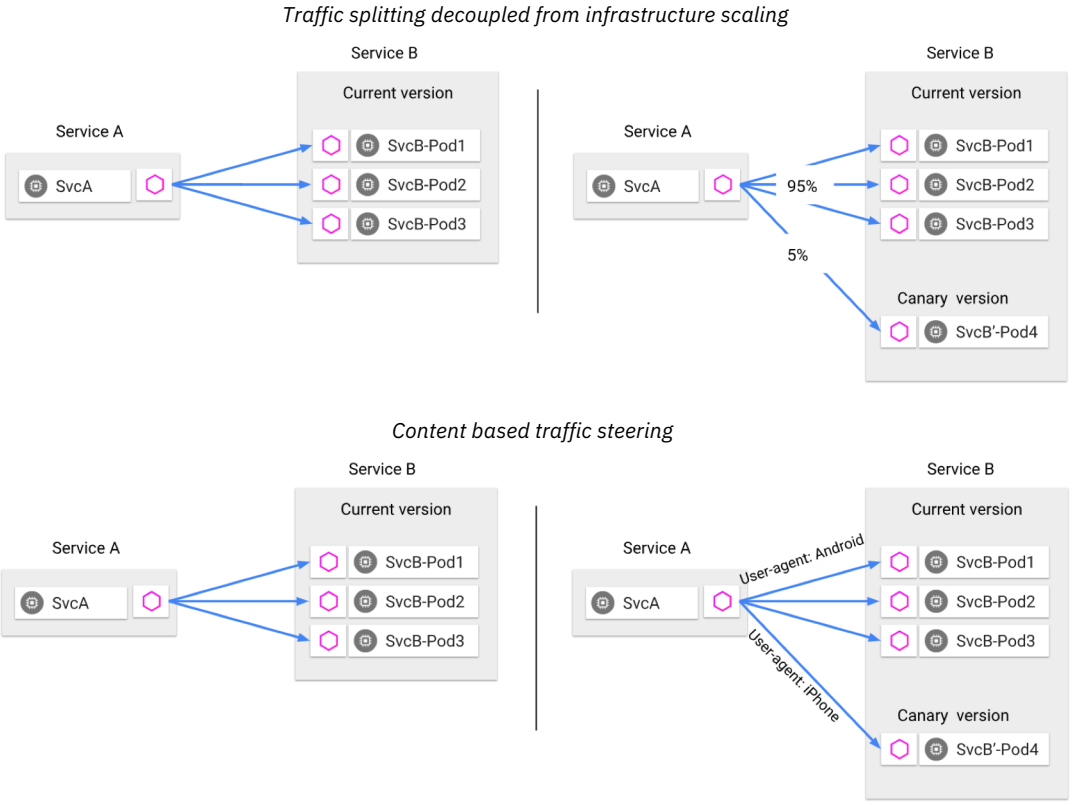
Managing Traffic

Istio Traffic Management Overview

The traffic management model decouples traffic flow and infrastructure scaling giving you the option of specifying via rules and Pilot how traffic should flow

For example, you can direct a percentage of traffic for a particular service to a canary service or only direct to the canary based upon the content of the request

Decoupling traffic flow from scaling of infrastructure allows for traffic management features outside of the application code including failure recovery via timeouts, retries, circuit breakers and fault injection to test failure recovery procedures



Pilot & Envoy

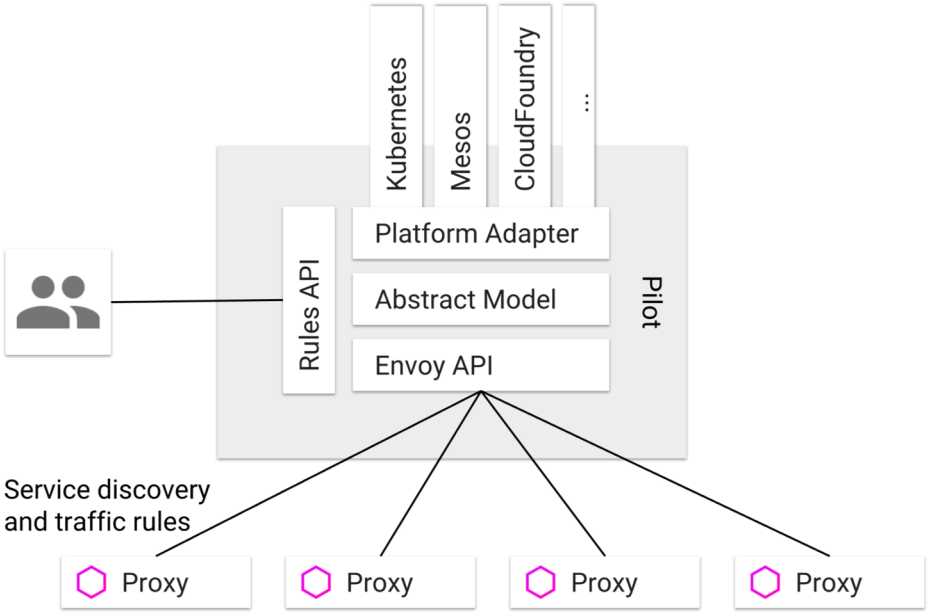
Pilot manages and configures the Envoy proxy instances

Pilot allows the operator to configure traffic routing rules and fault recovery features

Pilot maintains a canonical model of the services participating in the mesh and uses this information to inform each Envoy instance about the other Envoy instances

Each Envoy persists the load balancing information based upon periodic health-checks of the other pool members and information it gets from Pilot, allowing it to route traffic intelligently

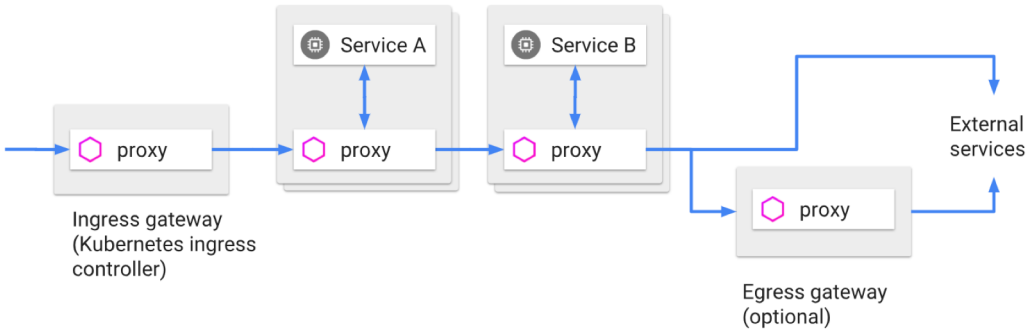
Pilot is manages the lifecycle of Envoy instances



Ingress & Egress

All traffic entering and leaving the mesh passes via Envoy proxies

By routing traffic to and from external web services via an Envoy you add the same failure recovery, timeouts, retries, circuit breakers etc. and can collect connection metrics for these external services (similar to internal to the mesh capabilities)



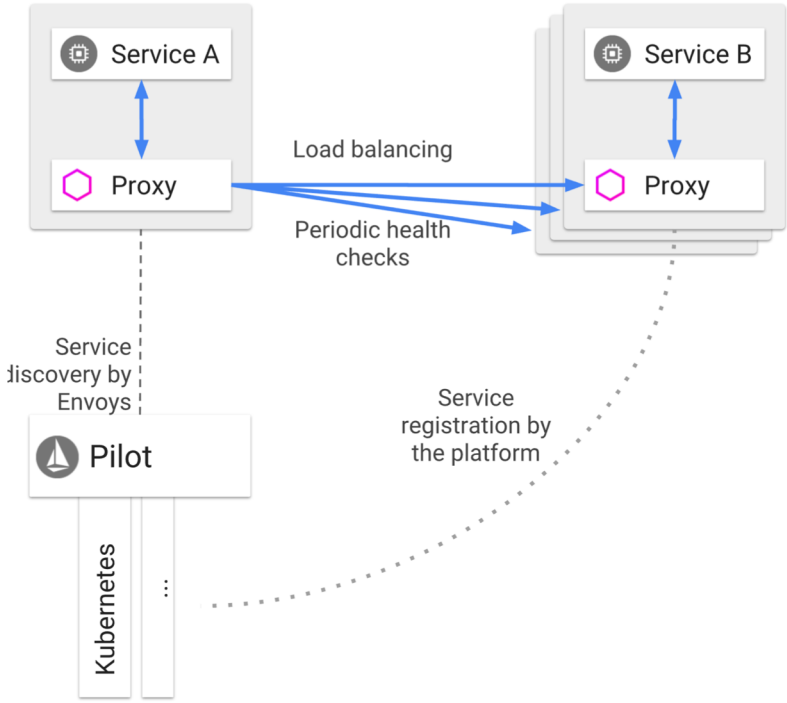
Discovery & Load Balancing

Istio load balancing across instances of a service

It uses the service registry to gain awareness of these application pools

It relies on Kubernetes to maintain the health of these pools

Envoy instances are also performing periodic health checking of the pools and update their load balancing accordingly



Security

Breaking down a monolithic application into atomic services offers various benefits, including better agility, better scalability and better ability to reuse services

However, microservices also have particular security needs:

- To defend against the man-in-the-middle attack, they need traffic encryption
- To provide flexible service access control, they need mutual TLS and fine-grained access policies
- To audit who did what at what time, they need auditing tools

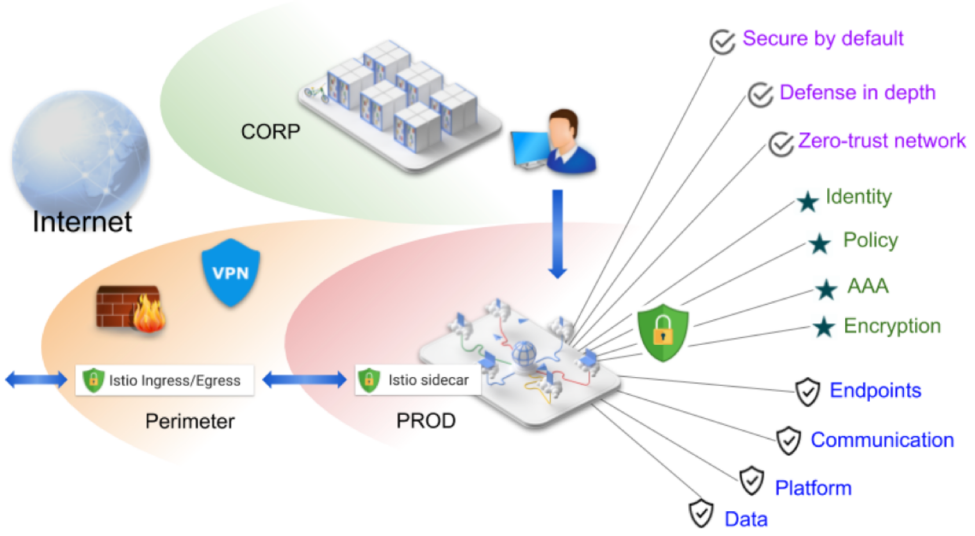
Istio Security tries to provide a comprehensive security solution to solve all these issues

Istio Security Features Overview

The Istio security features provide strong identity, powerful policy, transparent TLS encryption, authentication, authorization and audit (AAA) tools to protect your services and data.

The goals of Istio security are:

- **Security by default**: no changes needed for application code and infrastructure
- **Defense in depth**: integrate with existing security systems to provide multiple layers of defense
- **Zero-trust network**: build security solutions on untrusted networks



Rule Configuration

Istio provides a simple configuration model to control how API calls and layer-4 traffic flow across various services in an application deployment

The configuration model allows you to configure service-level properties such as circuit breakers, timeouts, and retries, as well as set up common continuous deployment tasks such as canary rollouts, A/B testing, staged rollouts with %-based traffic splits, etc.

There are four traffic management configuration resources in Istio VirtualService, DestinationRule, ServiceEntry, and Gateway:

- A VirtualService defines the rules that control how requests for a service are routed within an Istio service mesh
- A DestinationRule configures the set of policies to be applied to a request after VirtualService routing has occurred
- A ServiceEntry is commonly used to enable requests to services outside of an Istio service mesh
- A Gateway configures a load balancer for HTTP/TCP traffic, most commonly operating at the edge of the mesh to enable ingress traffic for an application

Example: You can implement a simple rule to send 100% of incoming traffic for a *reviews* service to version "v1" by using a VirtualService configuration as follows:

```
apiVersion: networking.istio.io/v1alpha3
kind: VirtualService
metadata:
  name: reviews
spec:
  hosts:
  - reviews
  http:
  - route:
    - destination:
        host: reviews
        subset: v1
```

Istio

Operations

Istio “Up and Running”

Install Istio in ICP by using the latest Helm chart and configure your namespaces for automatic sidecar injection
Note: *kube-apiserver process has the admission-control flag set with the MutatingAdmissionWebhook and ValidatingAdmissionWebhook admission controllers added and listed in the correct order and the admissionregistration API is enabled*

```
$ kubectl api-versions | grep admissionregistration
admissionregistration.k8s.io/v1alpha1 admissionregistration.k8s.io/v1beta1
```

Enable the injection by namespace label:

```
$ kubectl label namespace default istio-injection=enabled
$ kubectl get namespace -L istio-injection
NAME              STATUS    AGE       ISTIO-INJECTION
default           Active    1h        enabled
istio-system      Active    1h
kube-system       Active    1h
```

Alternatively inject at deployment time:

```
$ istioctl kube-inject –f your-deployment.yaml | kubectl apply –f -
```

Check your deployed workload to very successful injection:

```
$ kubectl get deployment your-dep -o wide
NAME     DESIRED CURRENT UP-TO-DATE AVAILABLE AGE CONTAINERS        IMAGES                              SELECTOR
your-dep 1       1       1          1         2h  sleep,istio-proxy tutum/curl,unknown/proxy:unknown app=sleep
```

Adding an Istio Gateway for Ingress

Assume you have an application running with the following services defined:

```
$ kubectl get services
NAME          CLUSTER-IP EXTERNAL-IP PORT(S)    AGE
docs          10.0.0.31  <none>      9080/TCP   6m
homepage      10.0.0.1   <none>      443/TCP    7d
my-app-base   10.0.0.120 <none>      9080/TCP   6m
blog          10.0.0.15  <none>      9080/TCP   6m
```

Create an ingress gateway for the service directing three URIs to the “my-app-base” service:

```
$ kubectl apply –f your-gateway.yaml
```

Retrieve the ingress IP and port:

```
$ kubectl get svc istio-ingressgateway -n istio-system
NAME                 TYPE CLUSTER-IP     EXTERNAL-IP    PORT(S)                                      AGE
istio-ingressgateway LB   172.21.109.129 130.211.10.121 80:31380/TCP,443:31390/TCP,31400:31400/TCP 17h
```

```
apiVersion: networking.istio.io/v1alpha3
kind: Gateway
metadata:
  name: my-app-gateway
spec:
  selector:
    istio: ingressgateway # use istio
default controller
  servers:
  - port:
      number: 80
      name: http
      protocol: HTTP
    hosts:
    - "*"
---
apiVersion: networking.istio.io/v1alpha3
kind: VirtualService
metadata:
  name: my-app
spec:
  hosts:
  - "*"
  gateways:
  - my-app-gateway
  http:
  - match:
    - uri:
        exact: /intropage
    - uri:
        exact: /login
    - uri:
        exact: /logout
    route:
    - destination:
        host: my-app-base
        port:
          number: 9080
```

Example: Injecting an HTTP Delay Fault

To test the an application's microservices for resiliency you could inject a delay between services for a specific user

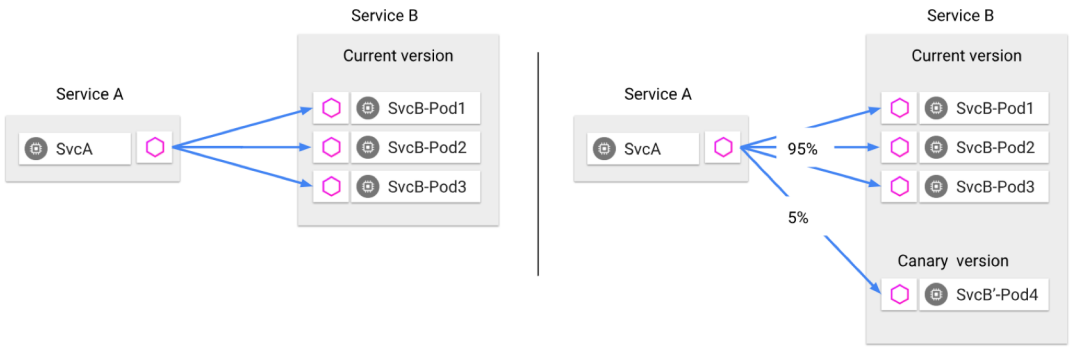
In the case shown here, traffic initiated by Jason to the ratings version 1 service will receive a 7 second delay

```
apiVersion: networking.istio.io/v1alpha3
kind: VirtualService
metadata:
  name: ratings
spec:
  hosts:
  - ratings
  http:
  - match:
    - headers:
        end-user:
          exact: jason
    fault:
      delay:
        percent: 100
        fixedDelay: 7s
    route:
    - destination:
        host: ratings
        subset: v1
  - route:
    - destination:
        host: ratings
        subset: v1
```

Example: Traffic Splitting

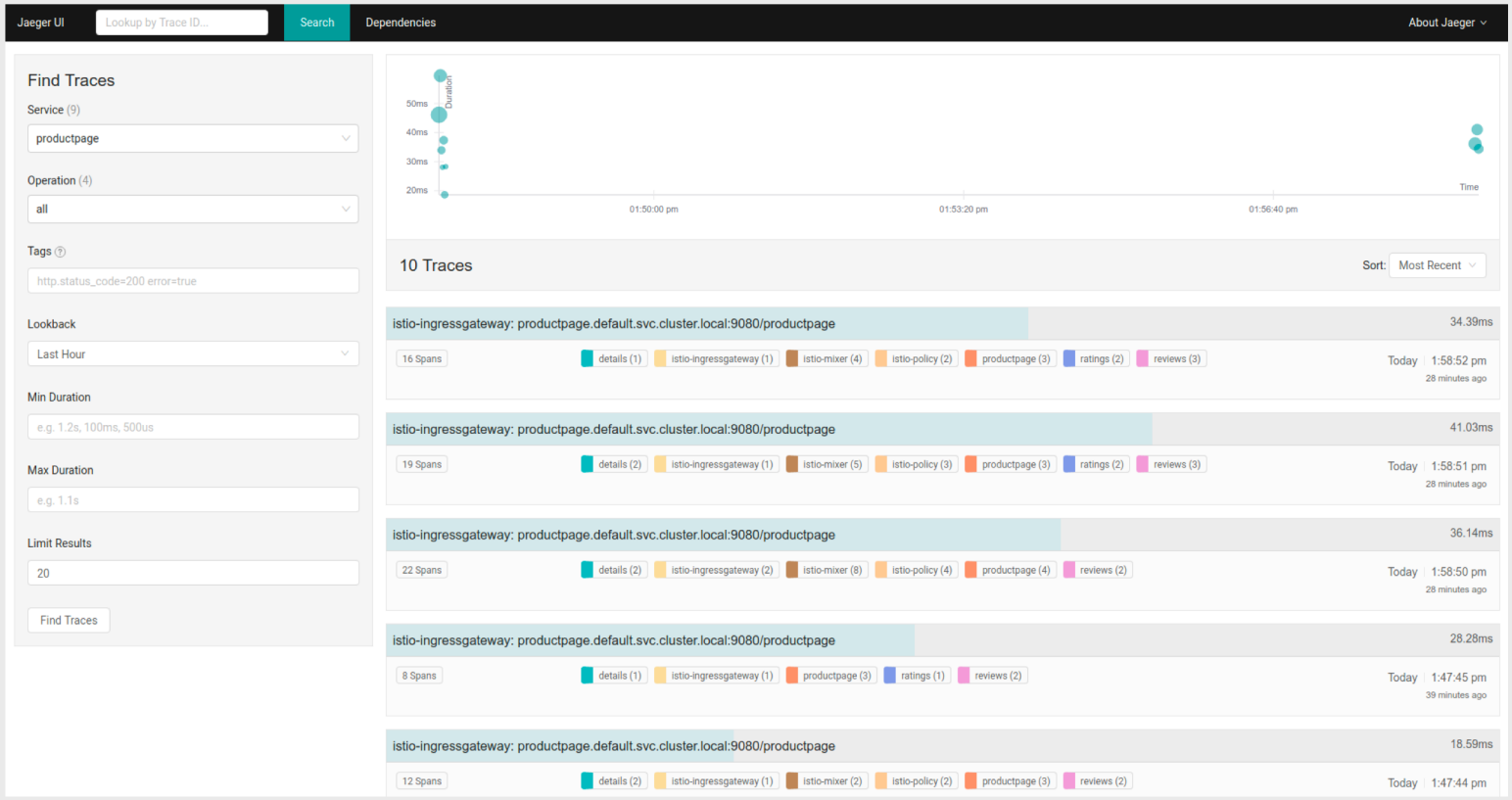
Traffic control is decoupled from infrastructure scaling

In this example we split the traffic between two application versions sending 5% to the new version

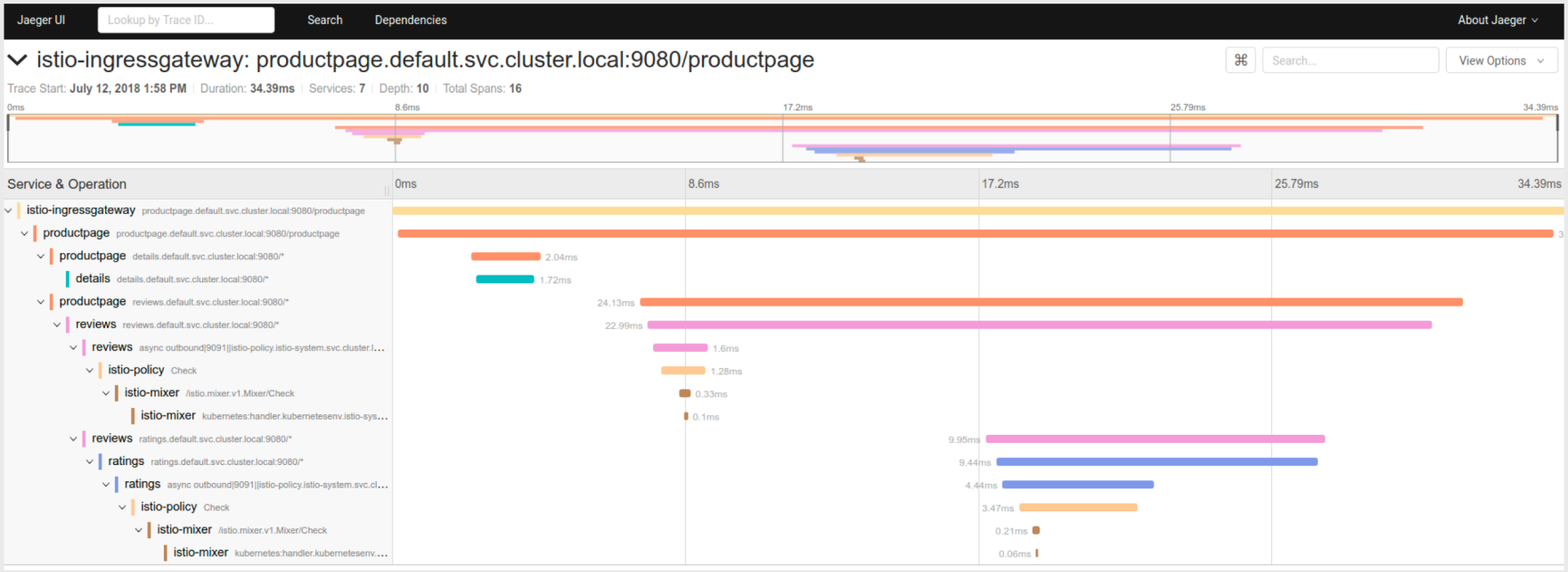



```
apiVersion: networking.istio.io/v1alpha3
kind: VirtualService
metadata:
  name: reviews
spec:
  hosts:
    - reviews
  http:
  - route:
    - destination:
        host: reviews
        subset: v1
      weight: 95
    - destination:
        host: reviews
        subset: v2
      weight: 5
```

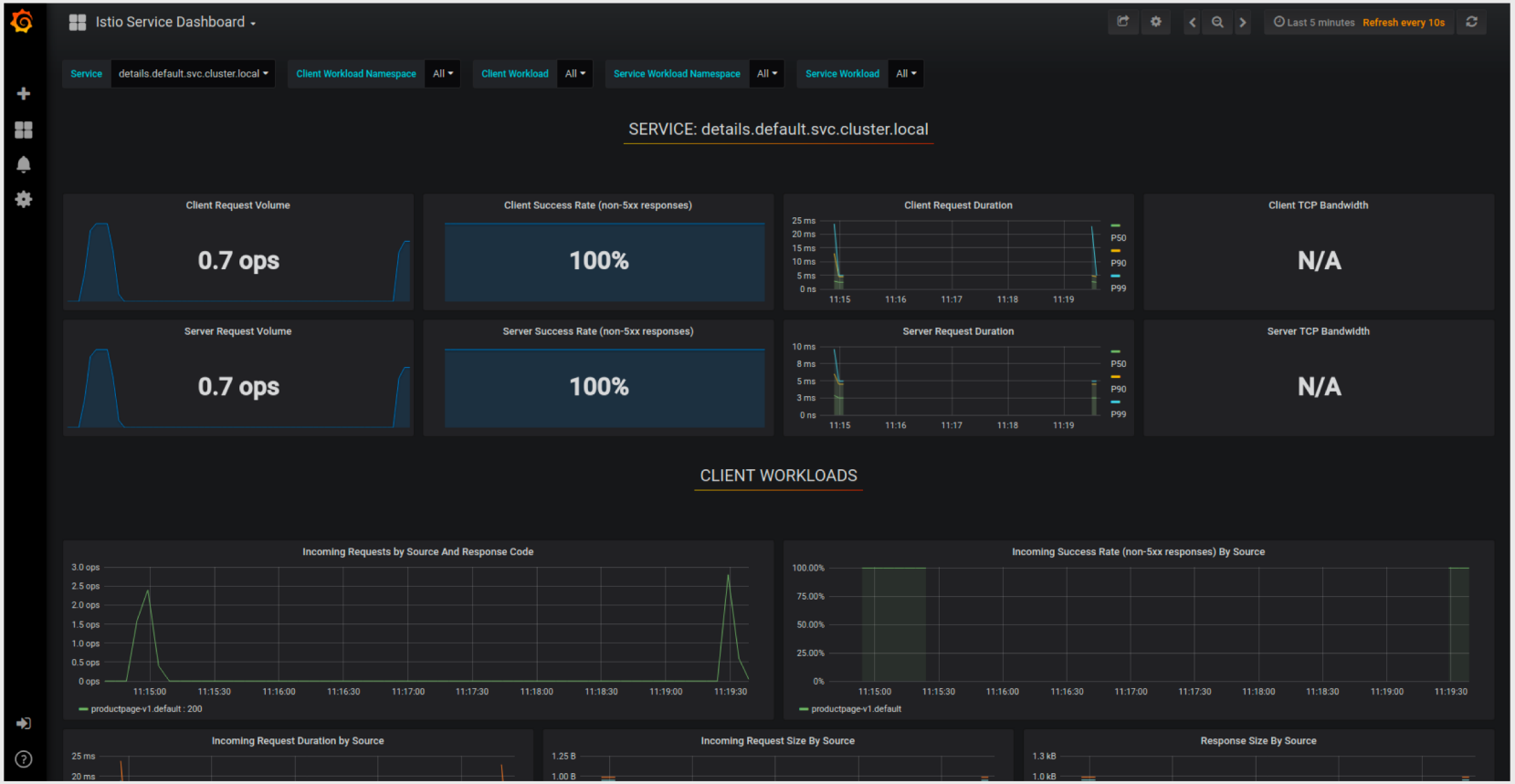
Telemetry: Tracing Dashboard



Telemetry: Tracing Detail



Telemetry: Visualize Service Dashboard



Telemetry: Tracing Detail