

Service MESH Architecture

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The screenshot shows the Certmetrics platform interface. On the left, there's a sidebar with navigation links like HOME, PROFILE, EXAM REGISTRATION, EXAM HISTORY, CERTIFICATIONS, BENEFITS, DIGITAL BADGES, and SUPPORT AND FAQS. The main area displays 'Certification status' for four categories: PROFESSIONAL, SPECIALTY, and two ASSOCIATE levels. Each category has a green 'Active' badge. Below this, under 'DIGITAL BADGES', there's a FOUNDATIONAL badge for 'AWS Certified Cloud Practitioner' (CLF) with an active date of 2024-06-27 and an expiration date of 2027-06-21.

CERTIFICATION	EXPIRATION DATE	EXPIRATION DATE
AWS Certified Solutions Architect - Professional	2024-06-19	2027-06-17
AWS Certified Security Specialty SCS	2024-06-19	2027-06-17
AWS Certified DevOps Engineer - Professional DOP	2024-06-19	2027-06-17
AWS Certified Solutions Architect - Associate SAA	2024-06-19	2027-06-17



Agenda

- What is service mesh, its capabilities and benefits? Types of
 - service mesh architectures Service meshes comparisons: features, visualization, performance
 - Open source
 - Commercial
- Service mesh pros and cons



What is a Service Mesh?

A service mesh is:

- A configurable infrastructure layer for a microservices application
- Makes communication between service instances flexible, reliable, and fast
- Provides a whole bunch of capabilities to relieve the developer from having to provide them each time uniquely.



What Capabilities Does a Service Mesh Provide?

- **Service Discovery** - Allows the different services to “discover” each other when needed. The Kubernetes framework keeps a list of instances that are healthy and ready to receive requests.
- **Load Balancing** - Places the least busy instances at the top of the stack, so that busier instances can get the most service without starving the least busy instances’ needs.
- **Encryption** - Instead of having each of the services provide their own encryption/decryption, the service mesh can encrypt and decrypt requests and responses instead.
- **Authentication and authorization.** The service mesh can validate requests BEFORE they are sent to the service instances.
- **Support for the circuit breaker pattern.** The service mesh can support the circuit breaker pattern, which can stop requests from ever being sent to an unhealthy instance. We will discuss this specific feature later.



Key Benefits of a Service Mesh

The combined use of the features and capabilities listed on the previous slide provides the means for **traffic shaping** or **QoS**:

- **Traffic shaping**, (a.k.a. packet shaping), is a type of network bandwidth management for the manipulation and prioritization of network traffic to reduce the impact of heavy use cases from affecting other users.
- **QoS** provides a uniform way to connect, secure, manage and monitor microservices and provides traffic shaping between microservices while capturing the telemetry of the traffic flow for prioritizing network traffic.



Key Benefits of a Service Mesh

Circuit-breaking helps to guard against partial or total cascading network communication failures of application service instances by maintaining a status of the health and viability of each service instance:

- The Service Mesh's **circuit-breaker feature** determines whether traffic should continue to be routed to a given service instance.

*NOTE: The **application developer** must determine **what to do** as a design consideration **when the service instance** has been marked as **not accepting requests**.*

Enterprises can create **application features** using **modular software development** across **disparate teams** of developers.

- Faster development, testing and deployment of applications.



Service Mesh Architectures

Library

- Needed services are sitting in a Library that your microservices applications import and use.

Node Agent

- The services are provided by a Node Agent or daemon. The daemon services all of the containers on a particular node/machine.

Sidecar

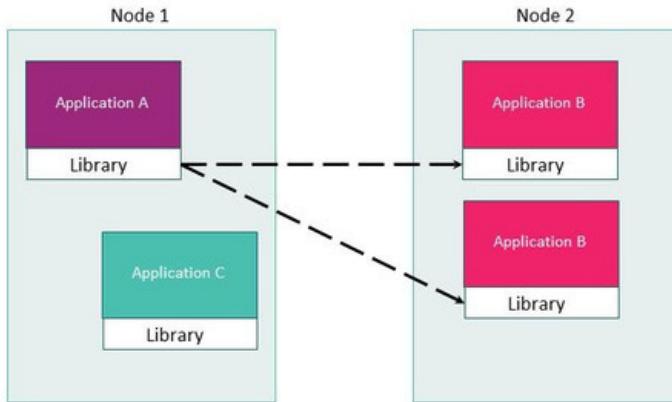
- The services are provided in a Sidecar container that runs alongside your application container.



The Types of Service Mesh Architectures

SMESH-ARCHS!

The Library Architecture



Each of the microservices carries a copy of the library that contains all of the desired Service Mesh functions. The Library architectural approach was:

- The first architecture to be adopted
- Simplest method to implement Has some drawbacks in performance
- More difficult to maintain

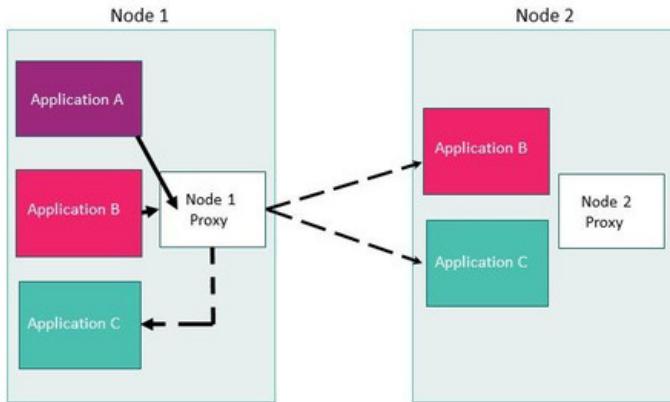
Separate copies are distributed with every microservice, which results in:

- Potential for version control issues in multi-cluster implementations
- Conflicting demand and performance is harder to determine and resolve quickly.

Examples:
Twitter Finagle
Netflix Hystrix
Netflix Ribbon



The Node Agent Architecture



The Node Agent architecture is **easier to manage and maintain** than the Library architecture:

- It distributes one copy of the configuration to each node, rather than one copy of the configuration to each pod on each node.

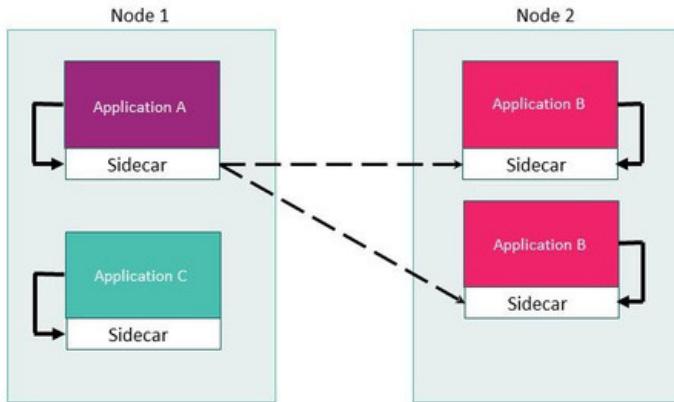
In the Node Agent service mesh architecture, **a separate agent is running on every worker node** of a cluster:

- Node Agent, usually running in user process space, services the heterogeneous mix of workloads hosted on that worker node.
- This architectural model emphasizes work resource sharing. This method can provide a great deal more efficiency than the Library model, but leaves a door open for resource abuse.
- Resource requests for memory and other components can be demanded and fulfilled immediately, starving other microservices. It is left up to the application developer to play nicely with others.

Examples:
Linkerd/Conduit
Consul



The Sidecar Architecture



Sidecar is the latest method developed for service meshing:

- The Sidecar service mesh deploys one adjacent container for every application container.
 - The sidecar container handles all the network traffic in and out of the application container.
 - To eliminate the potential for a network based attack, the sidecar has the same privileges as the application to which it is attached.
 - Most Sidecar implementations, founded on security best-practices, limit the scope of the authorities necessary to complete the required intercommunication and then end their own process.
- The Sidecar acts in closely secured proximity to the application, almost like a function call from a Library rather than having to traverse the network to an external Node Agent for each intercommunication.



Examples:
Istio Aspen
Mesh



Service Meshes to Compare

SMESH-COMPS!

Service Mesh Offerings for Kubernetes and Mesos

Open Source Offerings

- Envoy Istio
- Linkerd
- Linkerd2/Conduit
-

Commercial Offerings

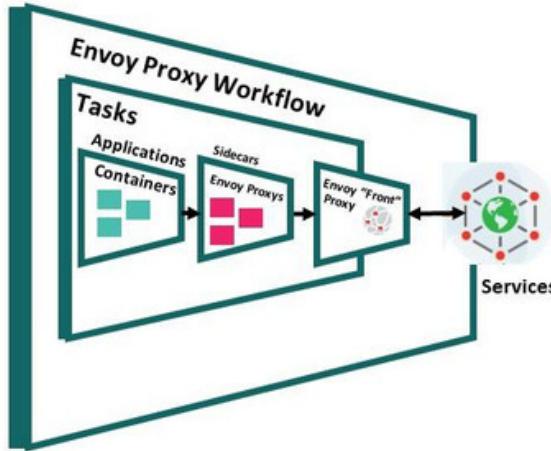
- Consul Aspen Mesh
- Kong Enterprise Mesh
- AWS App Mesh
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Open Source Service Meshes

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SMESH!

Envoy's Sidecar Architecture



Envoy is a high performance C++ distributed proxy designed for single services and applications:

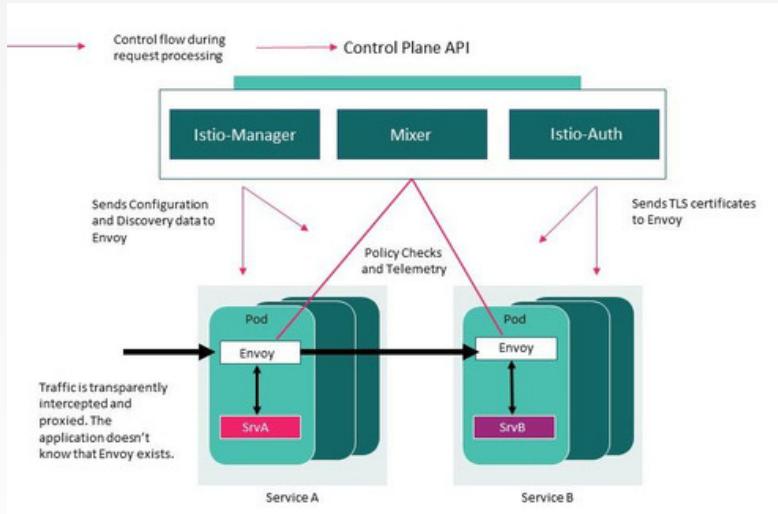
- Originally designed by Lyft Proxy architecture provides two key pieces missing in most stacks transitioning from legacy systems to a more Software Oriented Architecture (SOA.) Envoy's two features:
 - Robust observability
 - Easy debugging
- Envoy uses gRPC bridge to unlock Python gevent clients

But the primary focus of Envoy is raw PERFORMANCE! To do this, Envoy broke its threading model down into three categories:

- **MAIN:** The main thread coordinates all the most critical process functionality
- **WORKER:** Each worker thread spawned processes all IO for the connection's it accepts for the lifetime of the connection
- **FILE FLUSHER:** Worker writes to files are buffered to memory and then physically written by the file flush process thread.



Istio's Sidecar Architecture and Integration with Envoy



Istio provides a uniform way to connect, secure, manage and monitor microservices and provides traffic shaping between microservices in a multi-cluster scenario:

- Originally developed by Netflix, includes the capability of *circuit-breaking* to the app development process. Guards against partial or total cascading
- network communication failures by maintaining a status of the health and viability of all service instances Envoy is integrated as the backend proxy for Istio

The Istio components and their functions are listed below:

Control plane:

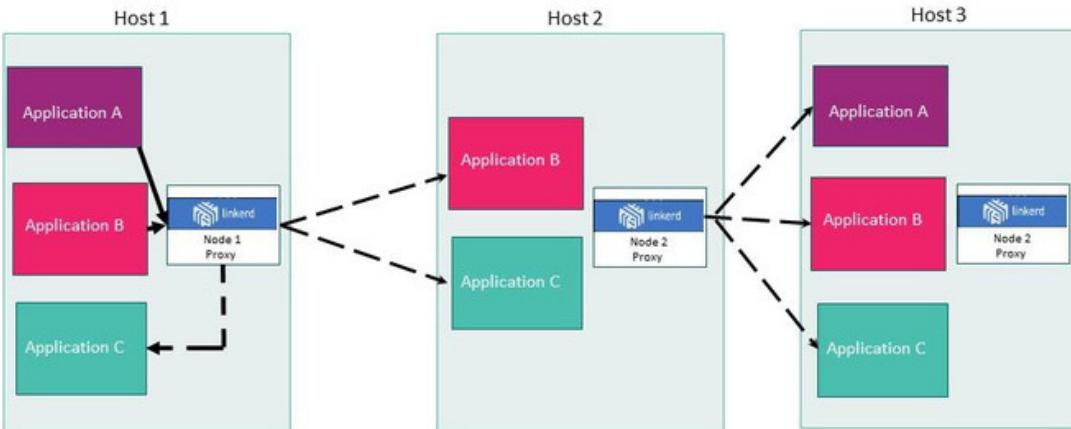
- Istio-Manager: provides routing rules & service discovery information to the Envoy proxies.
- Mixer: collects telemetry from each Envoy proxy and enforces access control policies.
- Istio-Auth: provides “service to service” and “user to service” authentication. This component also converts unencrypted traffic to TLS based traffic between services, as needed.

Data plane:

- Envoy: a feature rich proxy managed by control plane components. Envoy intercepts traffic to and from the service, applying routing and access policies following the rules set in the control plane.



Linkerd 1.0 Node Agent/Sidecar Architecture



Note: Could be implemented as either, but the weight of the Java engine was so heavy, it made it more resource effective as a node agent deployment.

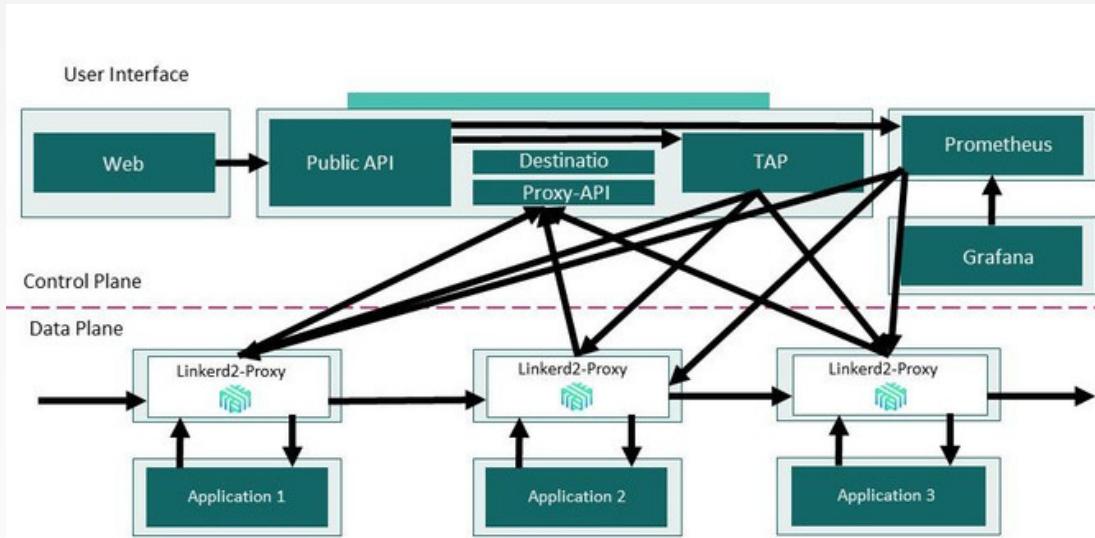


In the per-host deployment model for Linkerd, one Linkerd instance is deployed per host (whether physical or virtual):

- Originally developed by Buoyant. All app service instances on that host route traffic through the single instance. This model is useful for deployments that are primarily host-based. Each service instance on the host can address its corresponding Linkerd instance at a fixed location (typically, localhost:4140)
- Eliminates the need for any significant client-side logic. Since this model requires high concurrency of Linkerd instances, a larger resource profile is usually appropriate. In this model, the loss of an individual Linkerd instance is equivalent to losing the host itself.



Linkerd2 / Conduit Sidecar Architecture



Linkerd 2 transitioned to deploying a sidecar methodology that eliminates the single point of failure per host.

Linkerd 2 has three basic components:

- User Interface
- Control Plane
- Data Plane

The control plane is made up of four components:

- Controller - In multiple containers Web -
- Dashboard for telemetry data display
- Prometheus - Telemetry data storage
- Grafana - Used to display the Dashboard

The data plane consists of the sidecar Proxy processes injected into each Pod

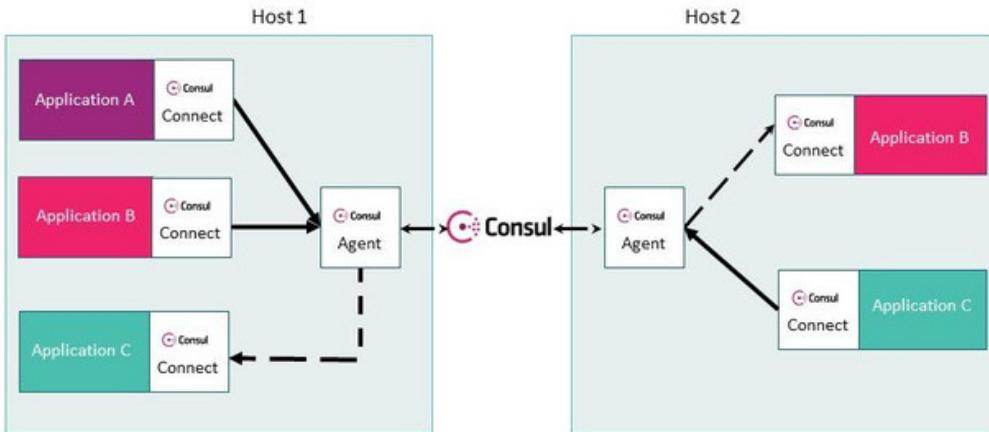
The Dashboard UI provides telemetry and QoS data for each service



Commercial Service Meshes

COMMS -
SMESH!

Consul Node Agent Architecture

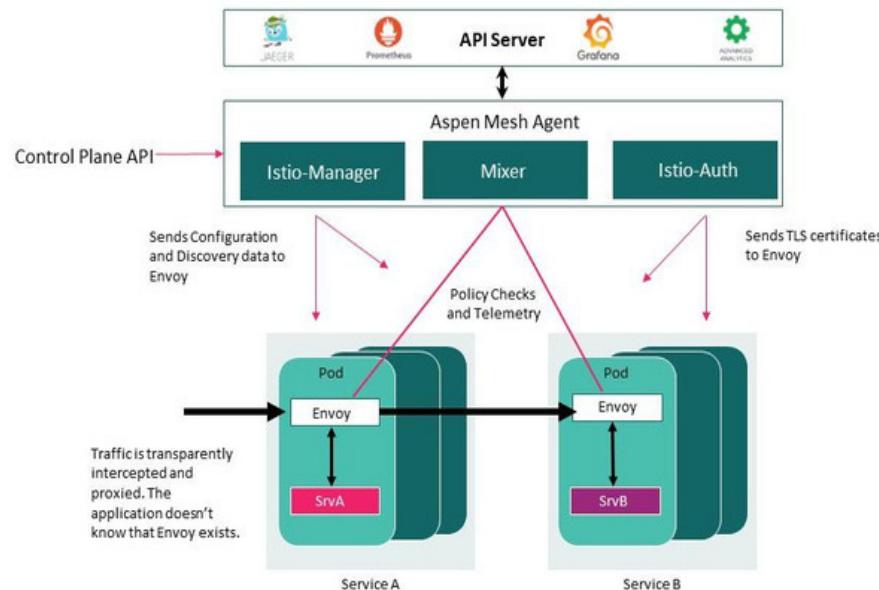


Consul is an ideal service to support control plane service mesh activities, whether you employ a “dumb pipe” or a “smart network”:

- Originally developed by Hashicorp The
- Consul architecture ensures it is highly available, and extends beyond a single data center. Consul provides service discovery for both Dumb Pipe and Smart Network scenarios.
- Applications can use Consul’s key-value store to store retries, timeouts and circuit breaking settings and request them when needed.
- The Consul K/V store can be used for persistent state storage such as network policies as well.



Aspen Mesh Sidecar Architecture & Integration with Istio

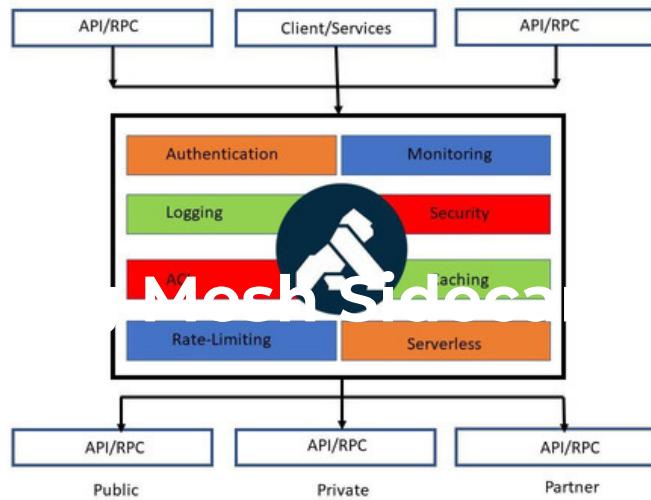


Aspen Mesh is built on Istio and includes all the features you get with Istio plus:

- Intuitive UI Multi Cluster and Hybrid
- Cloud Analytics and Alerting Pre-configured Canary Testing Advanced
- Policy Management Isolated
- Management Platform with SLA A fully tested and hardened version Enterprise-level Support
-



Kong Enterprise Monolith, Microservice, Service Mesh, & Serverless Architecture



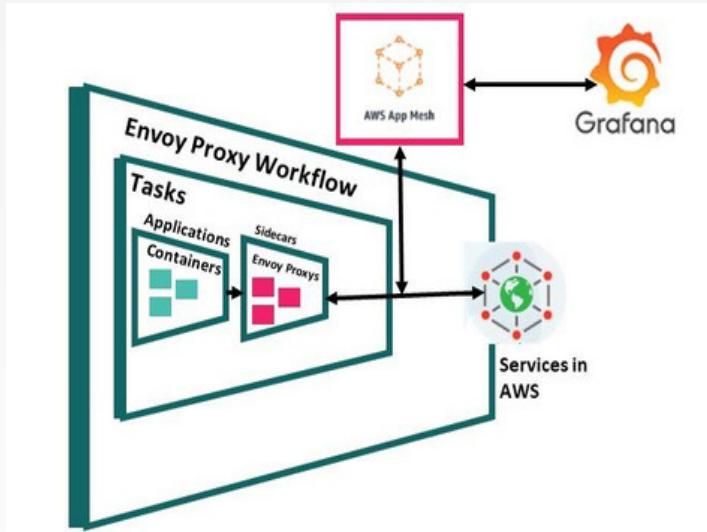
Kong Ingress Controller is a dynamic and highly available Ingress Controller which configures Kong using Ingress resources created in your Kubernetes cluster:

- Kong can configure plugins, load balancing, health checking on your services running in Kubernetes.
- Kong Ingress Controller is a Go application that listens to events from the API-server of your Kubernetes cluster
- The Ingress Controller sets up Kong to handle your configuration accordingly. You never have to configure Kong manually.
- The controller can configure any Kong cluster via a Kong node running either in a control-plane mode or running both, control and data planes.
- Kong's state is stored in Postgres or Cassandra.
 - The database should be deployed as a StatefulSet.
 - All Kong nodes in your Kubernetes cluster should be able to connect to it.

If Kong is deployed in Control-plane and Data-plane mode, then Kong proxy can be scaled



AWS APP MESH Sidecar Architecture & Integration with Envoy



AWS App Mesh is a service mesh based on the Envoy proxy that makes it easy to monitor and control microservices: App Mesh standardizes how your microservices communicate: End-to-end visibility

Helps to ensure high-availability

- App Mesh is made up of the following components:

- **Service mesh**
- **Virtual services**
- **Virtual nodes**
- **Envoy proxy**
- **Virtual routers**
- **Routes**

To use App Mesh, you must have an existing application running on AWS Fargate, Amazon ECS, Amazon EKS, Kubernetes on AWS, or Amazon EC2.



Comparing Service Mesh Features

COMPS -SMESH!

Some Service Mesh Feature Comparative Data

- Envoy

- Low p99 tail latencies at scale when running under load, Acts as a L3/L4
- filter at its core with many L7 filters provided out of the box, Support for
- gRPC, and HTTP/2 (upstream/downstream), API-driven, dynamic
- configuration, hot reloads, Strong focus on metric collection, tracing, and
- overall observability.

- Istio

- Security features including identity, key management, and RBAC,
- Fault injection, Support for gRPC, HTTP/2, HTTP/1.x, WebSockets, and
- all TCP traffic, Sophisticated policy, quota, and rate limiting, Multi-
- platform, hybrid deployment.

-



Some Service Mesh Feature Comparative Data (Continued)

**Linkerd was rewritten from Java to Rust - Data Plane / Go - Control plane about 1 ½ years ago.
They are striving to reach feature parity between the two versions and are currently very close:**

Linkerd and Linkerd2/Conduit Features

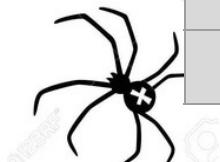
- Support for multiple platforms (Docker, Kubernetes, DC/OS, Amazon ECS, or any stand-alone machine),
- Built-in service discovery abstractions to unite multiple systems,
- Support for gRPC, HTTP/2, and HTTP/1.x requests + all TCP traffic.

*Note: Linkerd 2 is much faster than Linkerd as the Data Plane Proxy was rewritten in Rust.
Conduit was folded into the Linkerd Project to form the basis for Linkerd 2! Conduit's lightning-fast Rust proxies are ~10mb per instance, have sub-millisecond p99 latencies, and support HTTP/1.x, HTTP/2, and gRPC.*



Linkerd 1 and Linkerd 2/Conduit Feature Comparison

	Linkerd 1.x (latest: 1.6.2.1)	Linkerd 2.x (latest: 2.3)
Theme	Powerful, highly configurable, “industrial strength”	Lightweight, minimalist, zero config
Observability	Automatic, non-aggregated	Automatic, aggregated, live, per-path
Reliability	Load balancing, retries, circuit breaking	Load balancing, retries, circuit breaking*, rate limiting*
Security	TLS, cert validation	TLS, cert validation, cert management, policy enforcement*
Protocol support	HTTP/1.x, HTTP/2, gRPC, Thrift	HTTP/1.x, HTTP/2, gRPC
Installation	Cluster-wide	Per service, per namespace or cluster-wide (incremental)
Resource footprint	100--150mb per proxy	<10mb per proxy
Latency introduced	<5ms p99	<1ms p99
License, building blocks	CNCF, Apache v2, Finagle, Netty, Scala	CNCF, Apache v2, Rust, Go
Supported platforms	Kubernetes, DC/OS, Mesos, bare metal, ECS, ...	Just Kubernetes... for now! (*roadmap)



Some Service Mesh Feature Comparative Data (Continued)

● Consul

- Consul is a single binary providing both server and client capabilities
- includes all functionality for service catalog
- Includes configuration capabilities, TLS certificates, Authorization
- Consul optionally supports external systems such as Vault to augment behavior
- No additional systems are required to deploy Consul
-

● Aspen Mesh

- Provides an intuitive UI that brings the most important information to the forefront
- Easy-to-understand real-time status information
- Allows for the display of multiple clusters in a single pane of glass
- Helps the user to monitor their entire architecture in one place
- Allows the user to sort, search and drill into individual services details
-



Some Service Mesh Feature Comparative Data (Continued)

- Kong Enterprise 1.0

- Engineers can make a change in a centralised location that will be reflected across multiple Kong clusters
- Includes an implementation of the Plugin Development Kit (PDK) All Kong plugins require a standard set
- of functionality, which the PDK provides out of the box PDK based on the ngx_lua API A Kong cluster
- deployment requires the installation of a Cassandra or PostgreSQL to act as the datastore
-

- AWS App Mesh

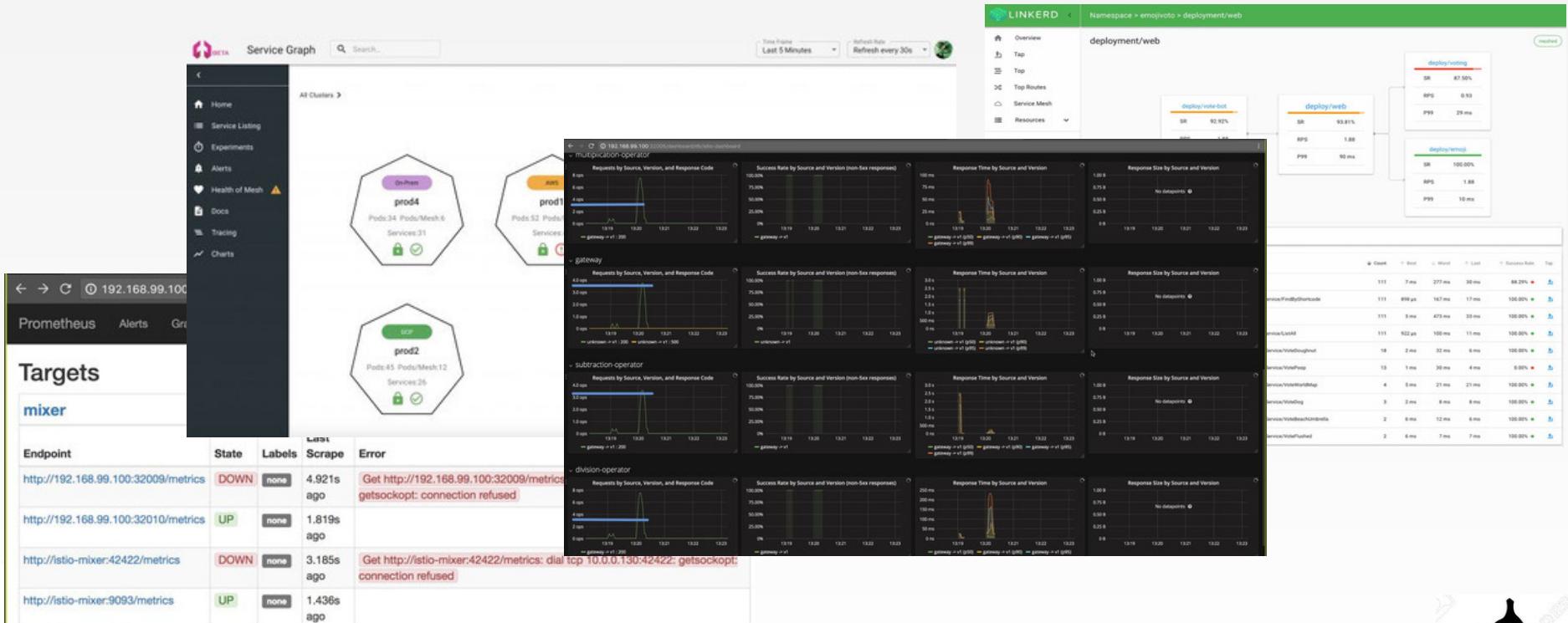
- App Mesh separates the logic for monitoring and controlling communications into a proxy that manages all network traffic for each service App Mesh uses the open source Envoy proxy to manage all traffic into and out of a service's containers Integrated with Amazon CloudWatch – monitoring & logging service for complete visibility of resources and applications. Developers configure services to connect directly to each other instead of requiring code within the application or using a load balancer App Mesh works with services managed by Amazon ECS, Amazon EKS, AWS Fargate, Kubernetes running on EC2, and services running directly on EC2



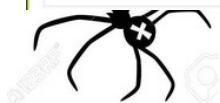
Service Mesh Visualization

SMESH-VIS!

Most Service Meshes use Prometheus with Grafana



NOTE: Commercial offerings provide a greater variety of templates and statistics to choose from for traffic shaping analysis.



Comparing Service Mesh Performance

PERF-SMESH!

Some Service Mesh Performance Factors

- Control Plane performance factors include:
 - The rate of deployment changes. The rate of configuration changes. The number of proxies connecting to the service gateway.
- Data Plane performance factors include:
 - Number of client connections
 - Target request rate Request size
 - and Response size Number of proxy worker threads Protocol
 - CPU cores Number and types of proxy filters
 -
- Benchmarking Tools:
 - fortio.org - a constant throughput load testing tool.
 - [blueperf](https://blueperf.io/) - a realistic cloud native application.

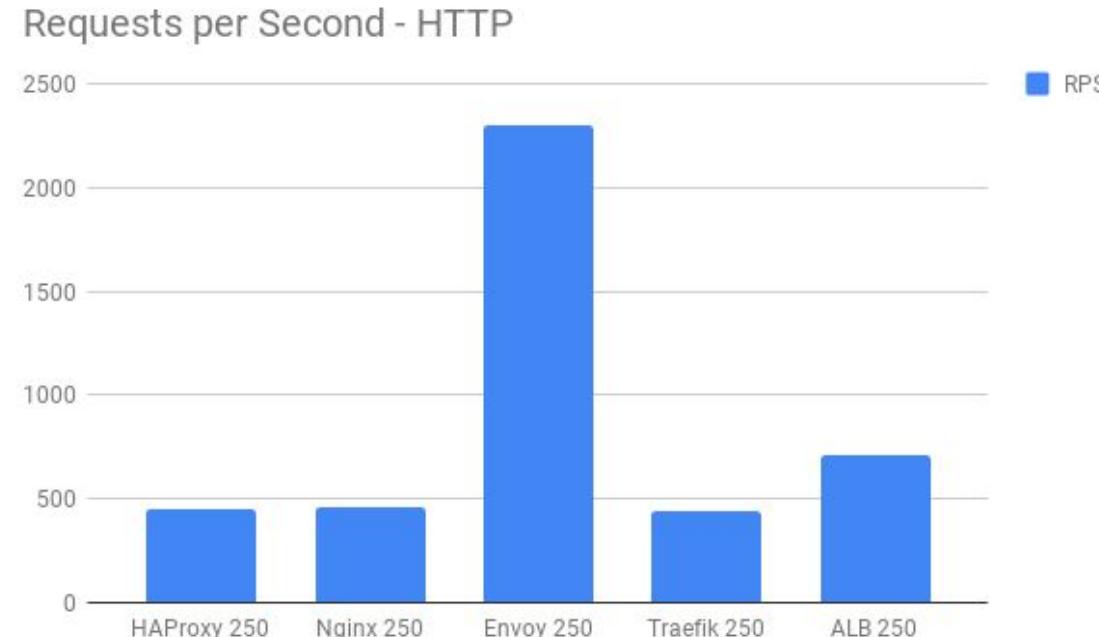


Some Service Mesh Comparative Performance Data

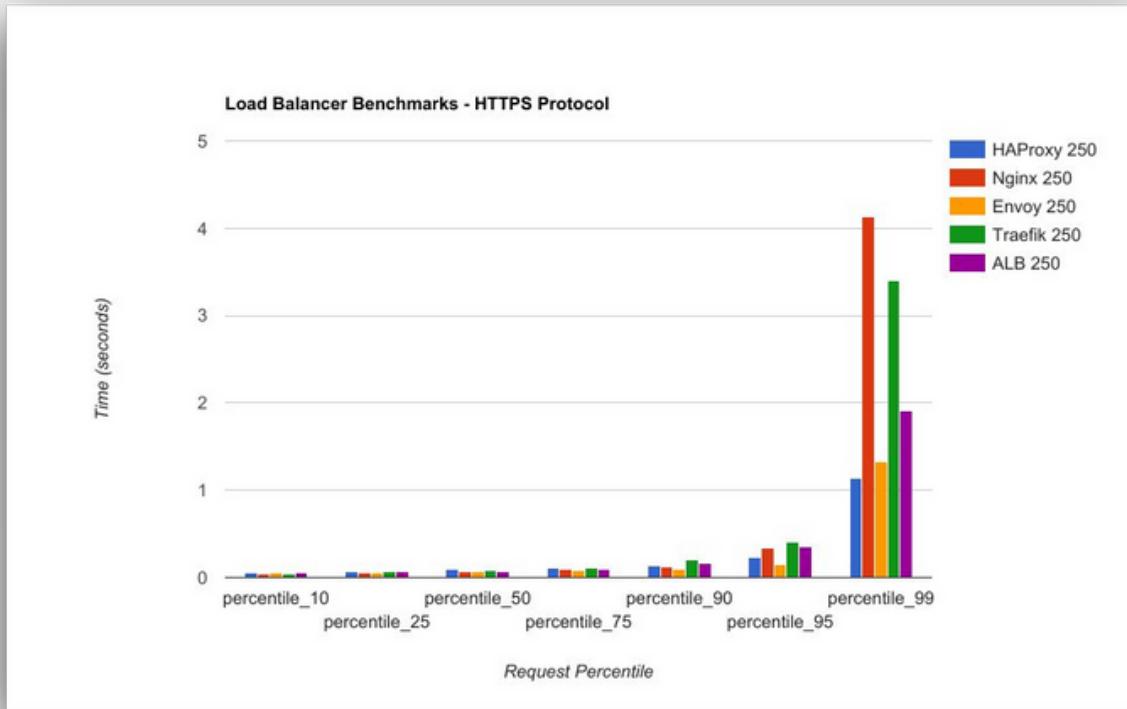
- Load Balancing Throughput and Latency
 - One of the key features of a service mesh is to provide a load balancing capability.
 - Some of the more popular load balancers that can be integrated with the Service Meshes compared in this presentation are:
 - NGINX
 - HAProxy
 - Envoy
 - Traefik
 - Amazon ALB
 - [Redacted]
 - [Redacted]
 - [Redacted]
 - [Redacted]



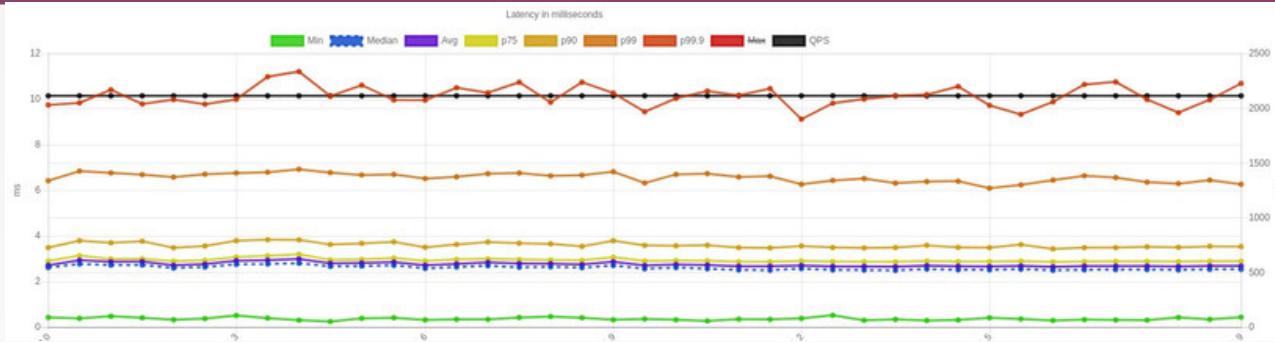
Load Balancer Requests-per-Second Performance Data



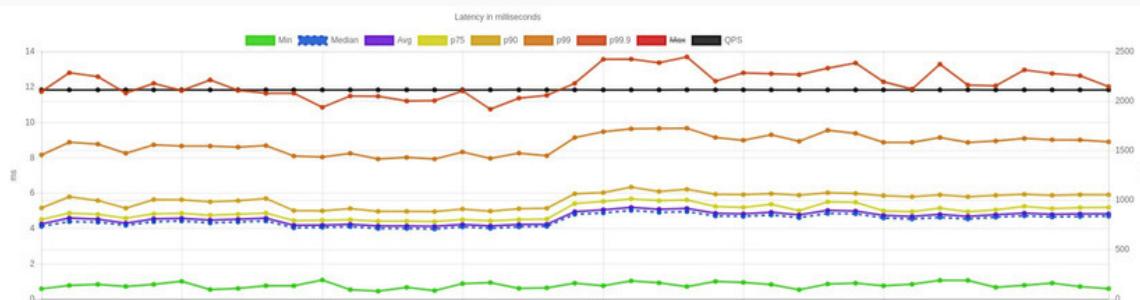
Load Balancer Latency and Concurrency Performance Data



Load Balancer CPU and Latency and Concurrency Performance Data - Disagreement



The latency observed in the Linkerd2-meshed setup ranged from 11.0 ms to almost 14.0 ms.



The latency observed in Istio-meshed setup ranged from 36.0 ms to 45.0 ms.



Service Mesh Pros & Cons

Pro-SMESH-Cons!

Service Meshes Architecture Pros and Cons

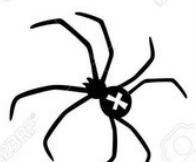
Library Architecture

Advantages:

- Resources are locally accounted for each and every service
- Self-service adoption for developers

Disadvantages:

- Strong coupling is a significant drawback
- Non-uniform; upgrades are challenging in large environments



Node Agent Architecture

Advantages:

- Less overhead (especially memory) for things that could be shared across a node
- Easier to scale distribution of configuration information than it is with sidecar proxies (if you're not using a control plane)
- This model is useful for deployments that are primarily physical or virtual server based.
- Good for large monolithic apps

Disadvantages:

- Coarse support for encryption of service-to-service communication, instead host-to-host encryption and authentication policies
- Blast radius of a proxy failure includes all applications on the node, which is essentially equivalent to losing the node itself
- Not a transparent entity, services must be aware of its existence

Sidecar Architecture

Advantages:

- Granular encryption of service-to-service communication
- Can be gradually added to an existing cluster without central coordination
- App-to-sidecar communication is easier to secure
- than app-to-node proxy
- Resources consumed for a service are attributed to that service
- Blast radius of a proxy failure is limited to the sidecar app

-

Disadvantages:

- Lack of central coordination.
- Difficult to scale operationally
- Sidecar footprint—per service overhead of running a service proxy sidecar



Service Mesh Comparison Final Thoughts

- Istio was presented to the CNCF Technical Oversight Committee in November 2017. This represented an early step for the project to join CNCF.
 - We suspect they will become a full project member in 2019.
 - Linkerd is already a member of CNCF.
- There are both fully Open Source and Commercial implementations of Istio available
 - This will be a key to widespread adoption which will be key to the long-term success of Istio
- The following question will be answered in 2019: “What are the real world benefits I will receive by adopting service mesh as a standard?”
 - The answer will come from use cases stimulating adoption.



Service Mesh Comparison Final Thoughts

Bottom Line:

- A service mesh will be mandatory by 2020 for any organization running microservices in production.
 - If you're currently using a service mesh, you already know the value it brings. If
 - you're considering using a service mesh, make sure you stay in tune with what is going on with this technology!
 - If your company has not yet decided on whether you need a service mesh or not, read the recent industry reports on microservices!





Thank You