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Multi Cluster Service Mesh Patterns, Operations, and Extensibility with WebAssembly

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Challenges in Adopting Microservices

- Improve velocity of teams building and delivering code
- Decentralized implementations vs centralized operations
- Connect and include existing systems and investments
- Improve security posture
- Stay within regulations and compliance

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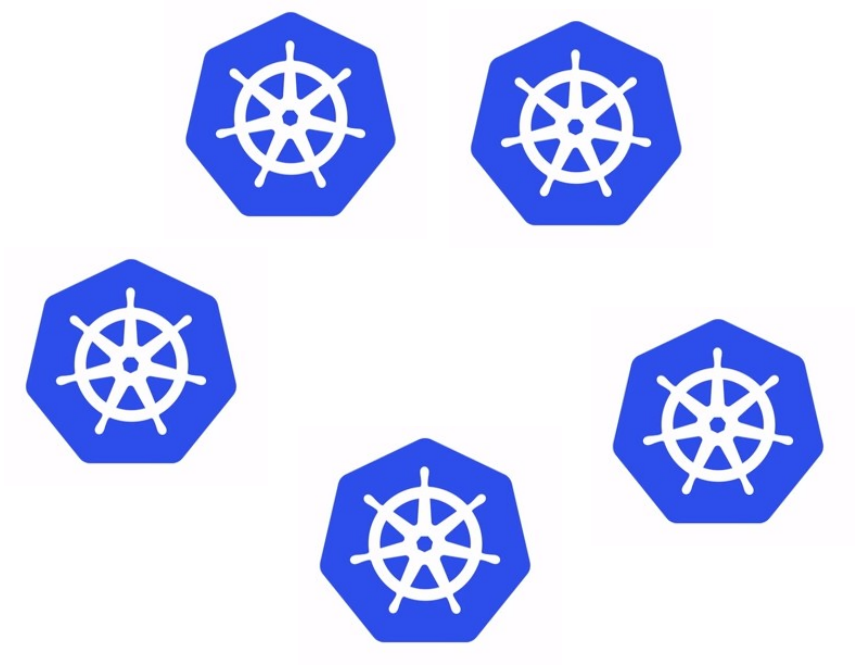
A Solution is many, smaller clusters

- High availability
- Compliance
- Isolation / Autonomy
- Scale
- Data locality, cost
- Public / DMZ / Private networks



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Considerations for multiple clusters

- Exact replicas of each other, same fleet?
- Separate, non-uniform deployments?
- Single operational/administrative control
- Segmented by network? Segmented by team?
- Independent administration?
- Cluster federation? Independent clusters, which services are shared?

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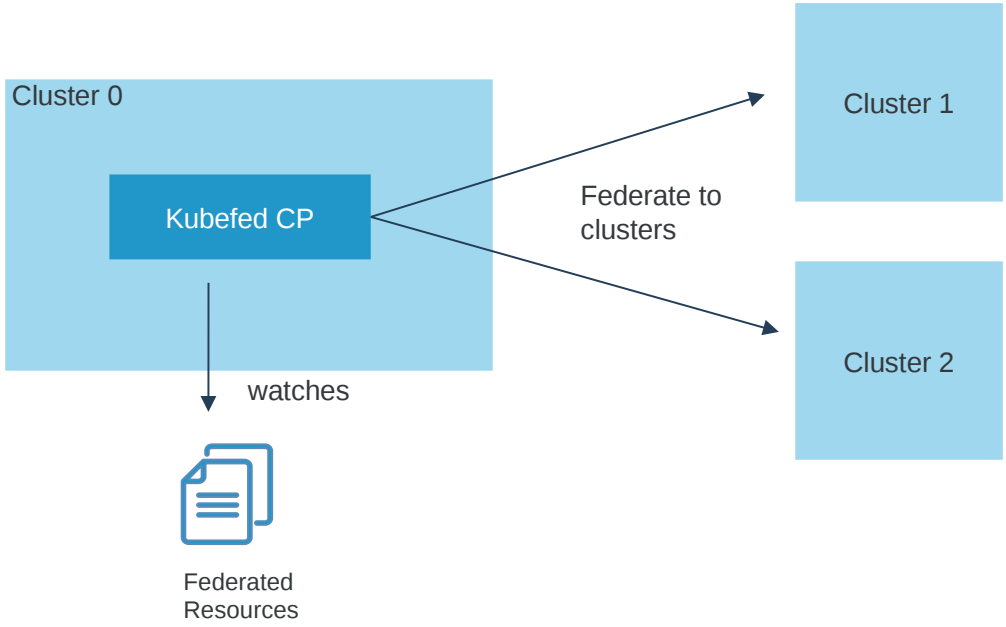
Example: Kubefed




```
apiVersion:
types.kubefed.io/v1beta1
kind: FederatedService
metadata:
  name: echo-server
spec:
  placement:
    clusterSelector:
      matchLabels: {}
  template:
    metadata:
      labels:
        app: echo-server
    spec:
      ports:
      - name: http
        port: 8080
      selector:
        app: echo-server
```

  https://github.com/kubernetes-sigs/kubefed

Services Need to Communicate with Each Other

Patterns within and outside of Kubernetes

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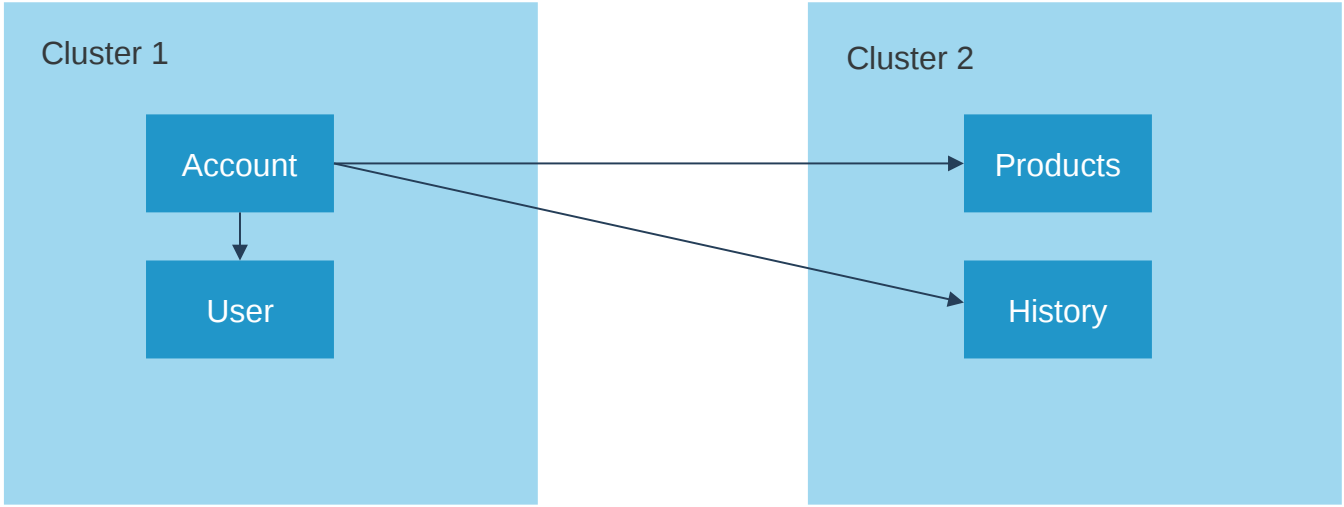
Pattern: Flat network across pods



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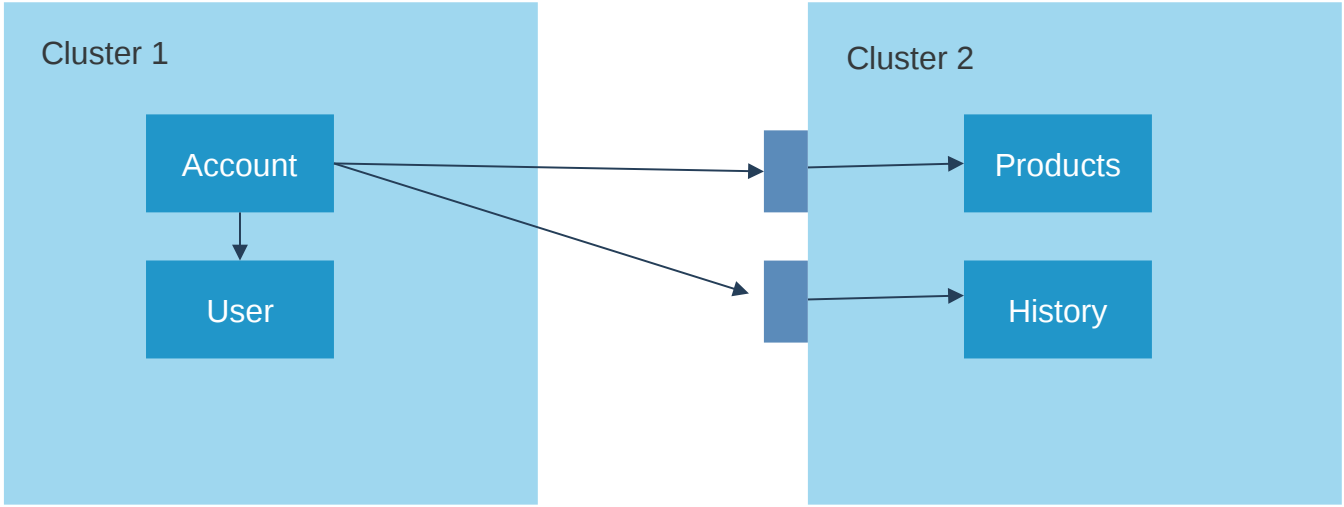
Pattern: Different network, expose all services



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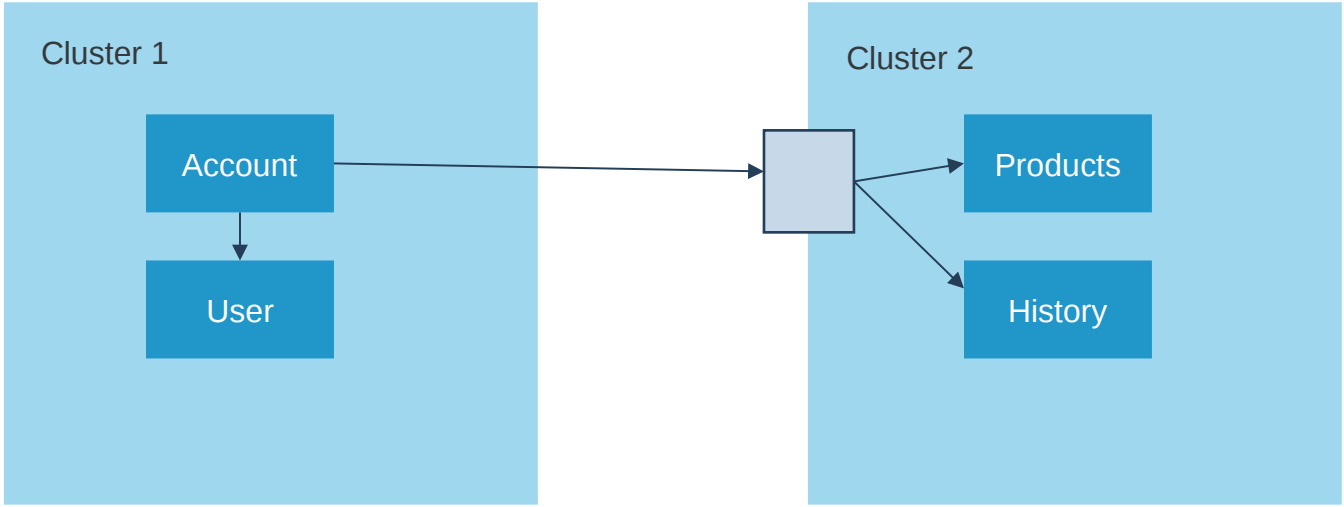
Pattern: Different network, controlled gateway



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Forces to balance

- Security (AuthN/Z, encryption, identity)
- Service discovery
- Failover / traffic shifting / transparent routing
- Observability
- Separate networks
- Well-defined fault domains
- Building for scale

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Can you build these patterns *just* using Kubernetes?

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Service Mesh can help

Envoy Proxy is the magic behind service mesh

Envoy Implements the following:

- Zone aware, priority/locality load balancing
- Circuit breaking, outlier detection
- Timeouts, retries, retry budgets
- Traffic shadowing
- Request racing
- Rate limiting
- RBAC, TLS origination/termination
- Access logging, statistics collection

http://envoyproxy.io

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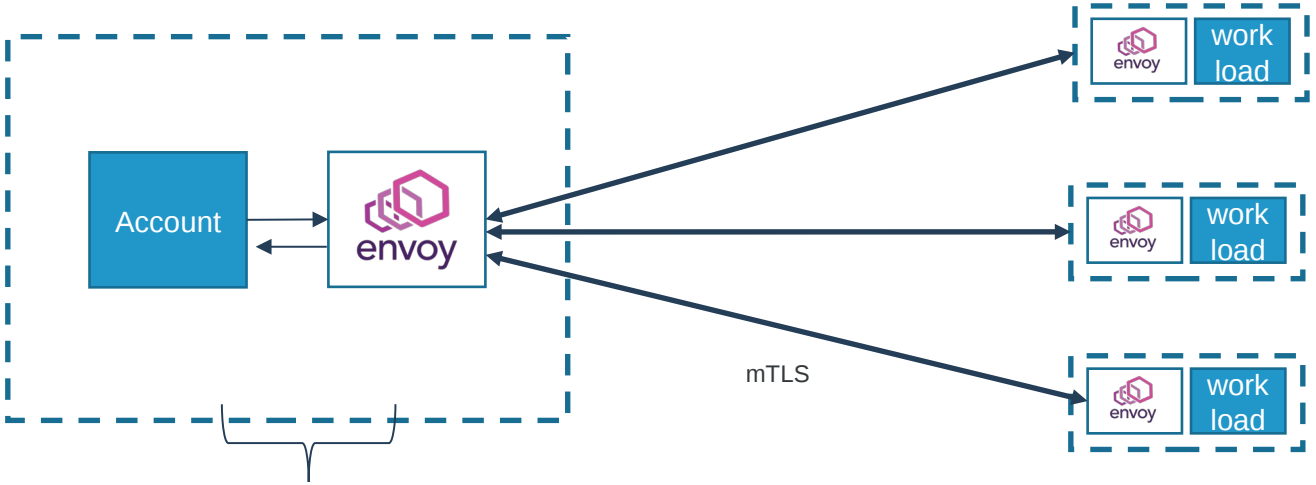
Envoy Proxy to do application networking heavy lifting



- Transparent client-side routing decisions
- TLS orig/termination
- Circuit breaking
- Stats collection

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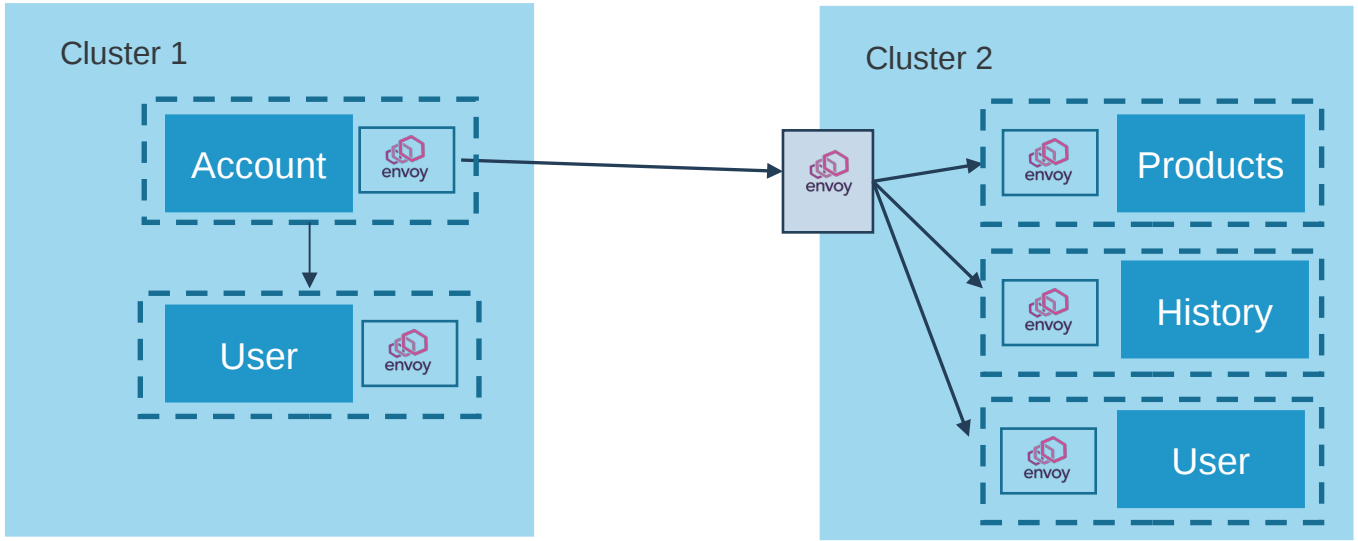
Envoy Proxy as backbone for multi-cluster communication federation



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Other key Envoy Proxy features

- Request hedging
- Retry Budgets
- Load balancing priorities
- Locality weighted load balancing
- Zone aware routing
- Degraded endpoints (fallback)
- Aggregated clusters

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Multi-Cluster Examples

Service Mesh examples using Envoy Proxy

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Three Examples and Considerations

1

Shared Service Mesh Control Plane with Flat Network

2

Shared Service Mesh Control Plane with Separate Networks

3

Separate Service Mesh Control Planes with Separate Networks

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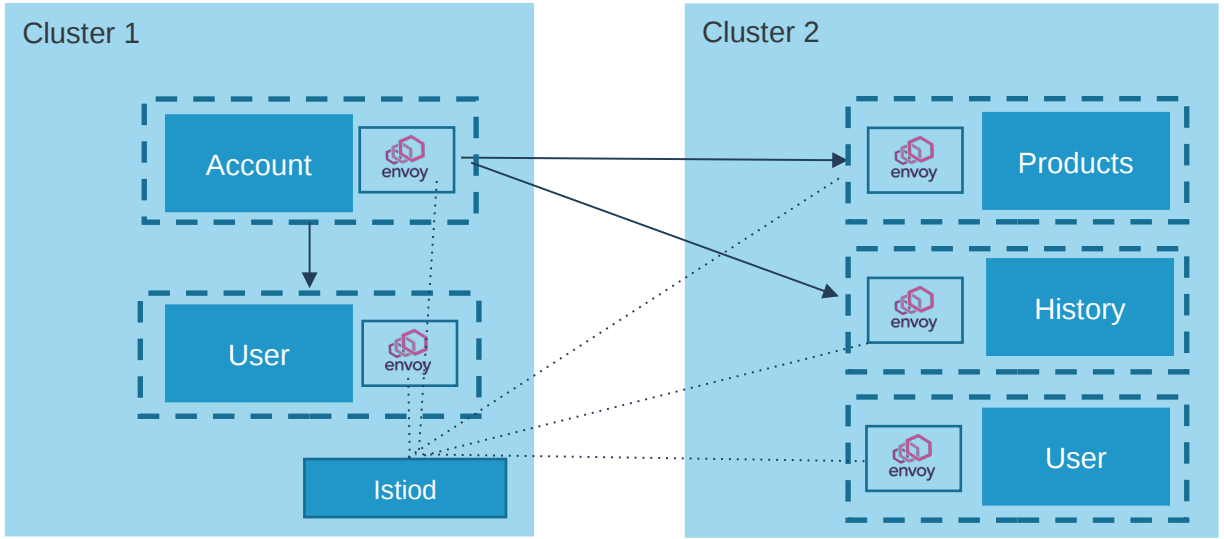
1 - Istio **shared** control plane, **flat** network



- Simplest setup for multi-cluster
- No special Envoy routing (though may use zone-aware)
- Shared control plane increases the failure domain to multiple clusters
- Use simpler, flat networking if possible
- No special considerations for identity (identity domain is shared)
- Still need to federate telemetry collection

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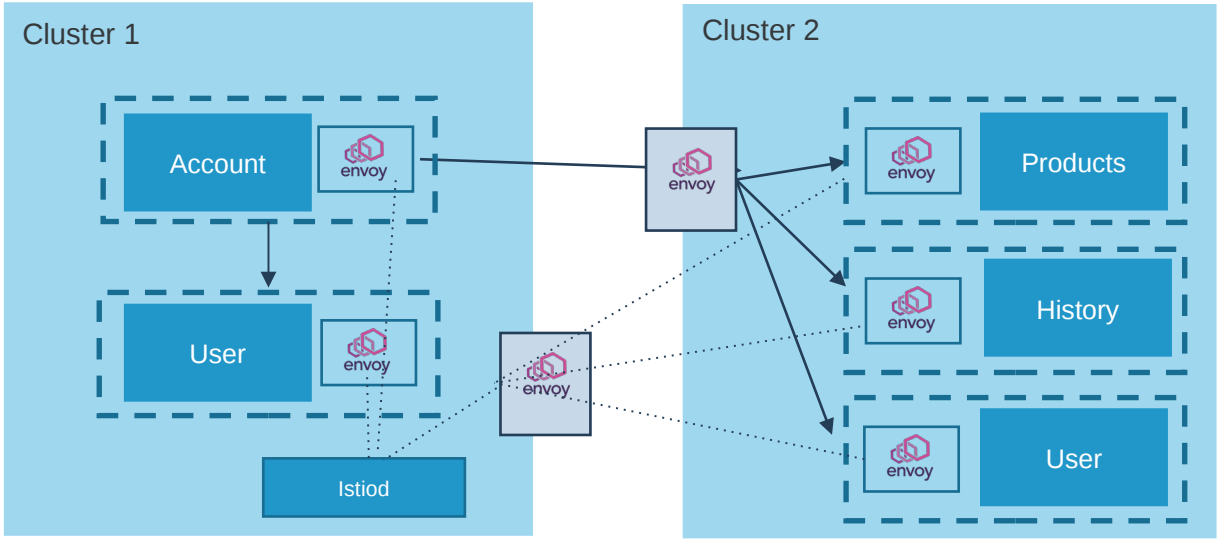
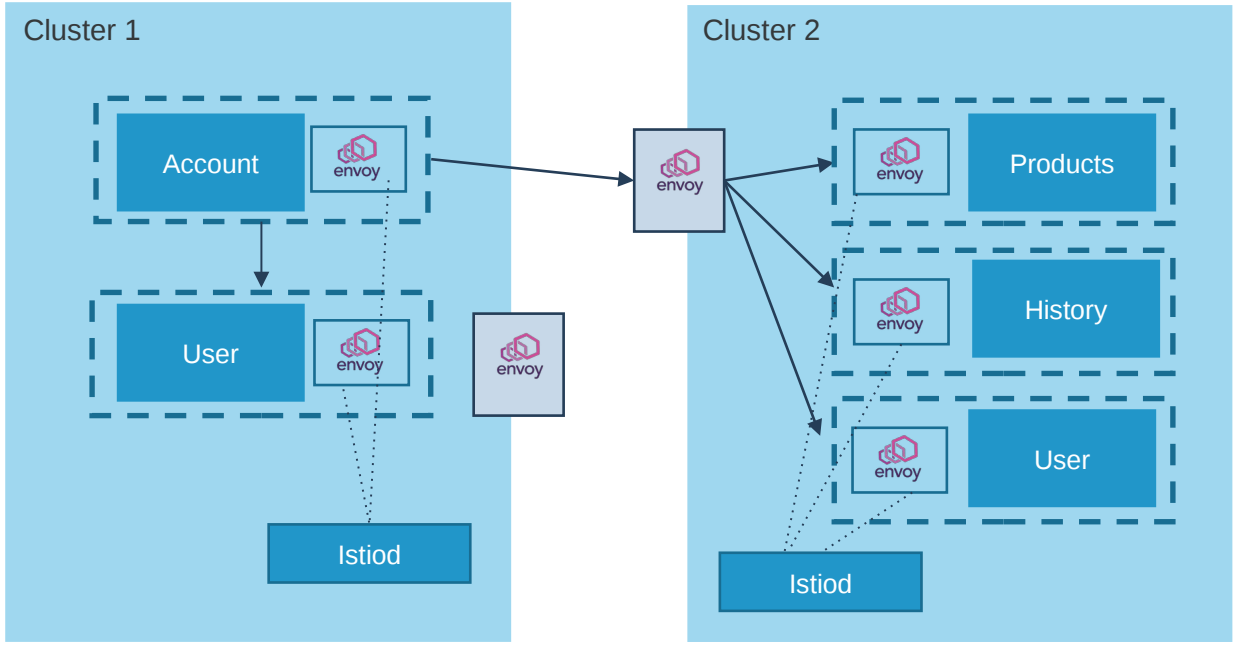
2 - Istio **shared** control plane, **separate** networks



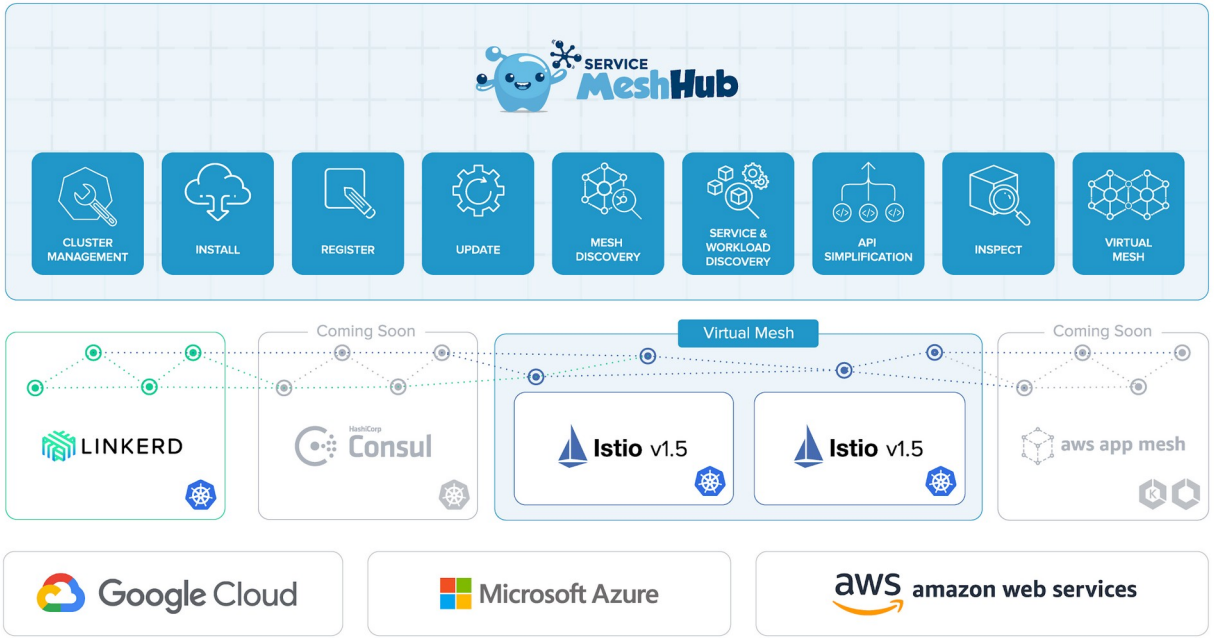
- Gateway allows communication between networks
- Envoy Locality Weighted LB (for the gateway endpoints). Istio calls this “split horizon EDS”.
- Shares same failure domain across all clusters
- Gateways facilitate communication AND control plane
- Slight increase in burden on operator to label networks and gateway endpoints correctly so Istio has that information

3 - Istio **separate** control plane, **separate** networks



- Gateway allows communication between networks
- Uses Istio ServiceEntry to enable cross-network discovery
- Independent control planes
- Separate, independent failure domains
- Doesn’t solve where trust domains MUST be separate (with federation at the boundaries)
- Increased operator burden to maintain service discovery, identity federation, and configuration across meshes

Open Source Service Mesh Hub



- Open Source
- Install & Configure
- Discovery
- Unified API
- Virtual Mesh
- Shared Identity
- Developer friendly tooling

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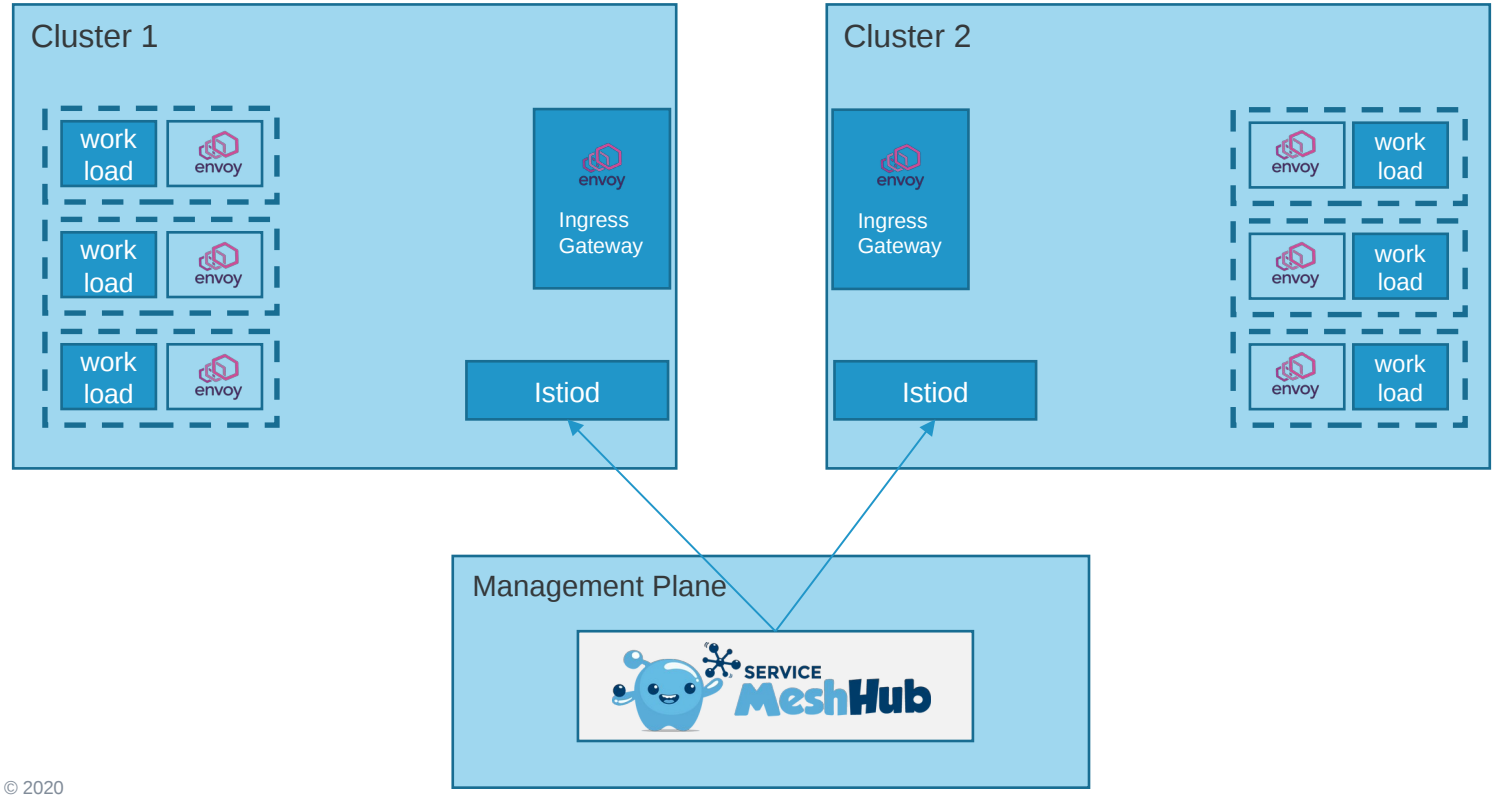
Open Source Service Mesh Hub



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Demo

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Extending the Service Mesh Data Plane with WebAssembly

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What is WebAssembly? It’s neither web nor assembly

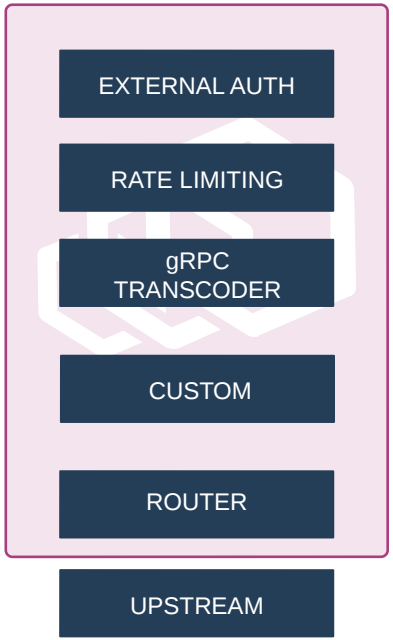
WebAssembly (abbreviated Wasm) is a binary instruction format for a stack-based virtual machine. Wasm is designed as a portable target for compilation of high-level languages like C/C++/Rust, enabling deployment on the web for client and server applications.

-> No Assembly -> Binary Instruction Format

-> No Web -> WASI

PORTABLE | **SECURE** | **FAST** | **ANY LANGUAGE**

Challenges in customizing Envoy Proxy



- Must maintain efficient performance for the data plane
- Writing custom filters is difficult and limited to C++
- Changes built into Envoy, maintain separate distro
- Hard dependencies, cascading failures
- Must stop and recompile

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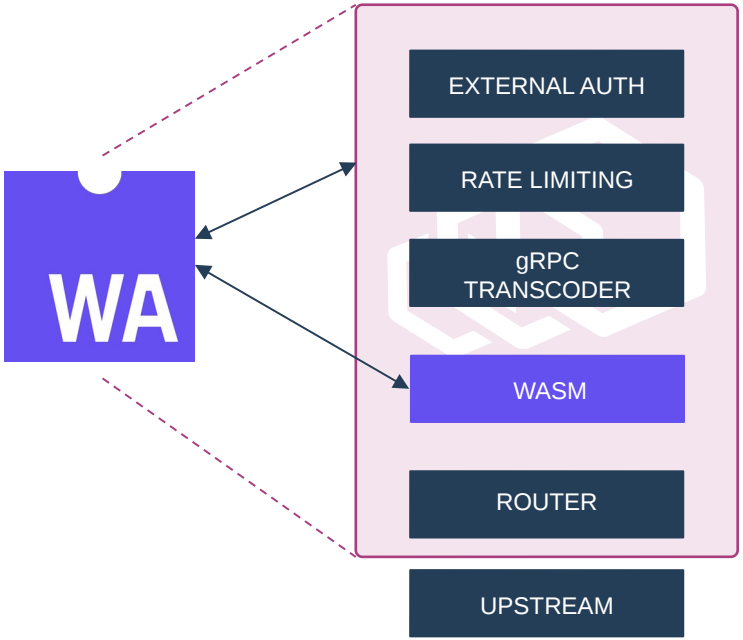
WebAssembly in Envoy Proxy



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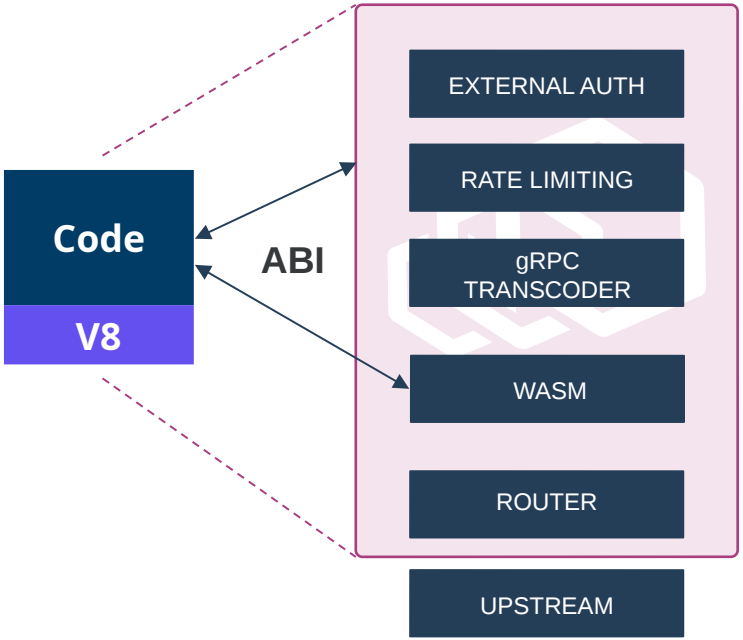
WebAssembly in Envoy Proxy



ABI: Application Binary Interface

HTTP (L7) extensions

`proxy_on_http_request_headers`

- params:
  - `i32 (uint32_t) context_id`
  - `i32 (size_t) num_headers`
  - `i32 (bool) end_of_stream`
- returns:
  - `i32 (proxy_action_t) next_action`

Called when HTTP request headers are received from the client. Headers can be retrieved using `proxy_get_map` and/or `proxy_get_map_value`.

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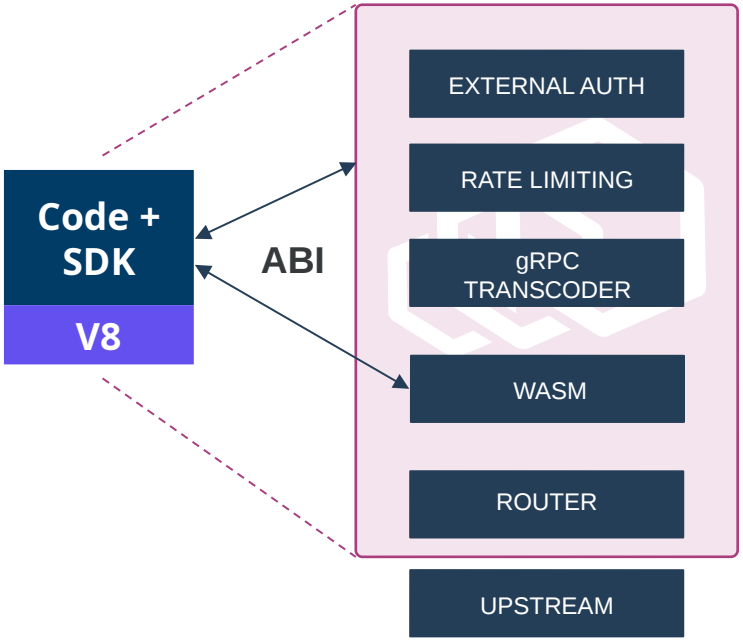
WebAssembly in Envoy Proxy



SDK Includes the following with more coming soon.

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WebAssembly Hub

- Developer and operator workflow to build, share, and deploy
- Team and user management
- Operator uses declarative CRD
- Modules are OCI images
  https://github.com/solo-io/wasm-image-spec

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Demo

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About Us - We're Hiring!
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WebAssembly Hub
webassemblyhub.io

Service Mesh Hub - Community meetings starting June 17th
github.com/solo-io/service-mesh-hub

Join the Community
slack.solo.io