Calico Ingress Gateway

Month Year

Presented by *Solutions Architect*

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Agenda

- Recapitulative
- Configuration options
    - Traffic routing
    - Traffic shaping
    - Other traffic functions

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01

Recapitulative

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Kubernetes Native vs Ingress Gateway

- Kubernetes provides three core service types for exposing apps:
    - ClusterIP - Internally only
    - NodePort - Inflexible, manual, conflictual
    - LoadBalancer - Costly (1 per service)
- Native Kubernetes services handle L4 exposure but lack L7 flexibility, security, and portability. Ingress/Gateway API fills these gaps with standardised, feature-rich traffic management.
- Each solves a piece of the puzzle, but gaps remain.

Feature	Native Kubernetes (ClusterIP/NodePort/LoadBalancer)	Ingress/Gateway API
External Access	Limited (NodePort: manual port management, LoadBalancer: cloud-specific).	Standardized L7 (HTTP/HTTPS) routing.
Traffic Routing	L4 only (no host/path rules).	Path-based (/api), host-based (app.example.com), headers, traffic splitting.
TLS Termination	Manual cert management (e.g., Service Mesh needed).	Built-in TLS termination (e.g., cert-manager integration).
API Gateway Features	None (requires third-party tools).	Rate limiting, auth (OIDC/JWT), request rewriting, retries.
Multi-Tenancy	No namespace isolation for routing.	HTTPRoute scoped to namespaces (Gateway API).
Cloud Portability	Tied to cloud LoadBalancers (AWS ALB, GCP LB).	Vendor-neutral configuration.
Security	Basic NetworkPolicy (L3/L4).	mTLS, WAF integration, L7 policies.
Observability	Limited (service metrics only).	Envoy access logs, Prometheus metrics, distributed tracing.

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Configurations options

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Critical Gaps in Kubernetes Traffic Control

"How do you roll out new features without downtime or risk?"

- *What happens if the new version has a critical bug?*
- *How can we minimize user impact during deployments?*
- *Is there a way to automatically roll back if errors occur?*

"How do we handle failures gracefully without manual intervention?"

- *What if a backend becomes unhealthy—does traffic automatically shift away?*
- *Can we define SLA-based routing (e.g., route away if latency > 500ms)?*
- *Is there circuit-breaking to prevent cascading failures?*

"How do we support multi-cluster and hybrid-cloud routing?"

- *Can we split traffic across clusters (e.g., 80% in AWS, 20% in GCP)?*
- *How do we handle failover if a cluster goes down?*
- *Is there geo-aware routing to direct users to the nearest region?*

"How do we monitor and troubleshoot traffic routing in real-time?"

- *Can we see live traffic distribution between versions?*
- *Are there detailed metrics (success rate, latency, errors) per route?*
- *How do we trace a request path for debugging?*

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Where Legacy Routing Falls Short

- **No native Kubernetes support for canary/blue-green deployments**
  - Manual scripting or external tools required.
  - No fine-grained control over traffic shifting (e.g., 5% → 10% → 50%).
- **Hard-coded routing rules in legacy Ingress**
  - Static configurations require redeployment for changes.
  - No dynamic traffic splitting based on conditions.
- **Lack of observability in traffic routing**
  - Difficulty tracking which requests go to which version.
  - No built-in metrics for success/failure rates per backend.
- **Security and compliance risks**
  - No built-in way to enforce zero-trust policies during traffic shifts.
  - Risk of exposing unfinished features to unintended users.

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2.1 Traffic Routing

Solution: Traffic Splitting

1. **Weighted** Splitting
   - Percentage-based distribution (e.g., 70/30)

2. **Header-Based** Routing
   - Split based on HTTP headers (e.g., `x-user-type: premium`)

3. **Path-Based** Routing
   - Route by URL path (e.g., `/v1/` → `v1-service`)

4. **Query Parameter** Routing
   - Split by URL query params (e.g., `?version=beta`)

5. **Cookie-Based** Routing
   - Direct traffic using session cookies

6. **Geolocation** Routing
   - Route by client IP/country (e.g., EU → `europe-service`)

7. Traffic **Mirroring** (**Shadowing**)
   - Copy traffic to another cluster without affecting responses

8. **Canary** Deployments
   - Subset-based splitting (e.g., 5% to new version)

9. **Runtime Fractional** Routing
   - Dynamic splits controlled by runtime configuration

10. **Priority-Based** Routing
    - Route to clusters based on priority levels

11. **Load Balancer Subsets**
    - Split traffic to endpoint subsets (e.g., by zone/version)

Each type can be combined (e.g., **weighted + header-based) for advanced use cases.**

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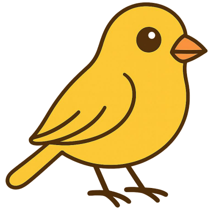
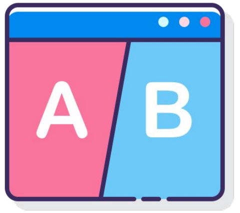
Common Deployment Strategies with Calico Gateway

gRPC





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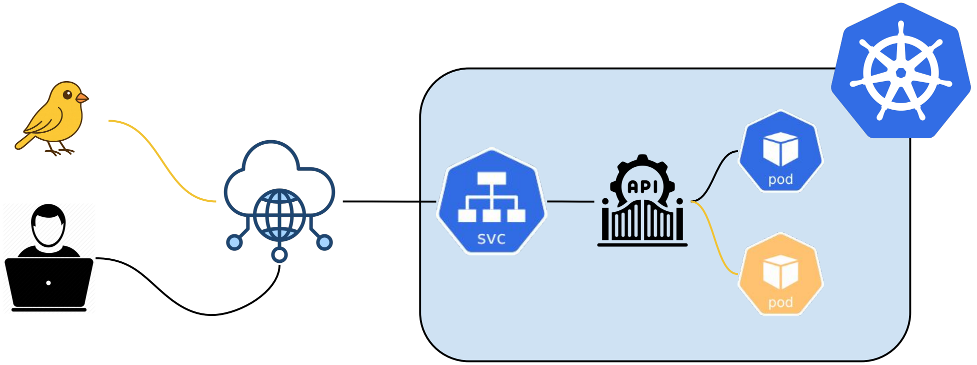
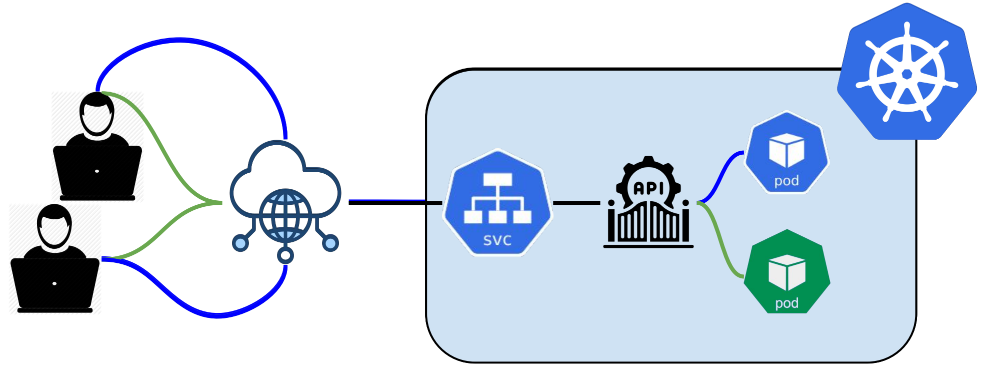
Canary Deployments



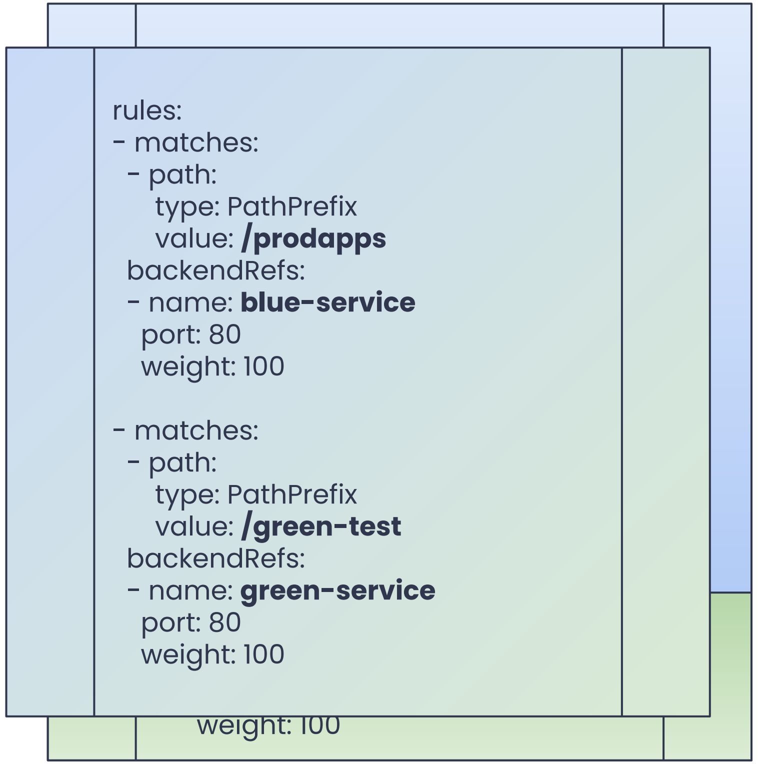
- Gradually roll out new versions to a subset of users
- Traffic splitting based on weight 90/10
- Often used for testing new features with minimal risk

```yaml
apiVersion: gateway.networking.k8s.io/v1
kind: HTTPRoute
metadata:
  name: canary-demo
  namespace: prodapps
spec:
  parentRefs:
  - name: calico-gateway
    kind: Gateway
  hostnames:
  - "prodapps.com"
  rules:
  - matches:
    - path:
        type: PathPrefix
        value: /prodapps
    backendRefs:
    - name: canary-service
      port: 80
      weight: 10
    - name: primary-service
      port: 80
      weight: 90
```

Blue Green Deployments



- Maintain two identical production environments
- Switch all traffic from "blue" (old) to "green" (new) at once
- Enables instant rollback if issues occur

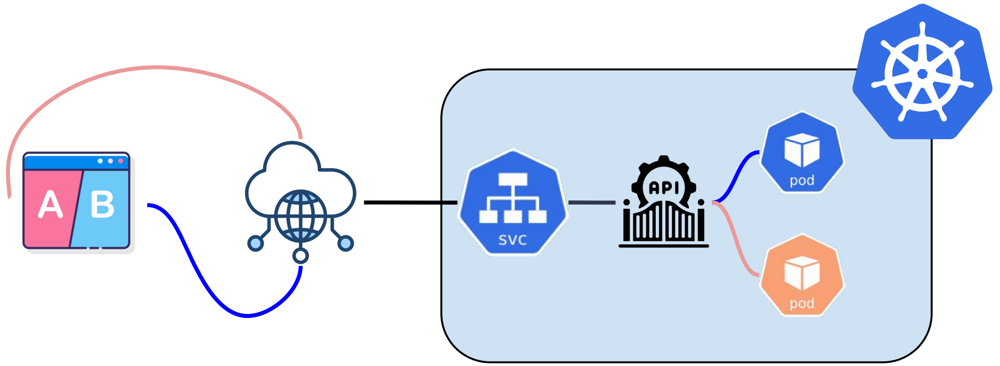


```
rules:
- matches:
  - path:
      type: PathPrefix
      value: /prodapps
  backendRefs:
  - name: blue-service
    port: 80
    weight: 100

- matches:
  - path:
      type: PathPrefix
      value: /green-test
  backendRefs:
  - name: green-service
    port: 80
    weight: 100
```

weight: 100

A/B Testing



- Route traffic based on request attributes (headers, cookies, etc.)
- Useful for testing different versions with specific user segments (example: Mobile vs PC browsers)
- More sophisticated than simple percentage-based split

```
''''''''''''''''''''''''''''
rules:
#B group: if header "x-ab-group: B" is
present
 - matches:
   - path:
      type: PathPrefix
      value: /prodapps
    headers:
    - name: x-ab-group
      value: B
   backendRefs:
   - name: ab-version-b
    port: 80
    weight: 100

 #Default group A — all other traffic
 - matches:
   - path:
      type: PathPrefix
      value: /prodapps
   backendRefs:
   - name: ab-version-a
    port: 80
    weight: 100
```

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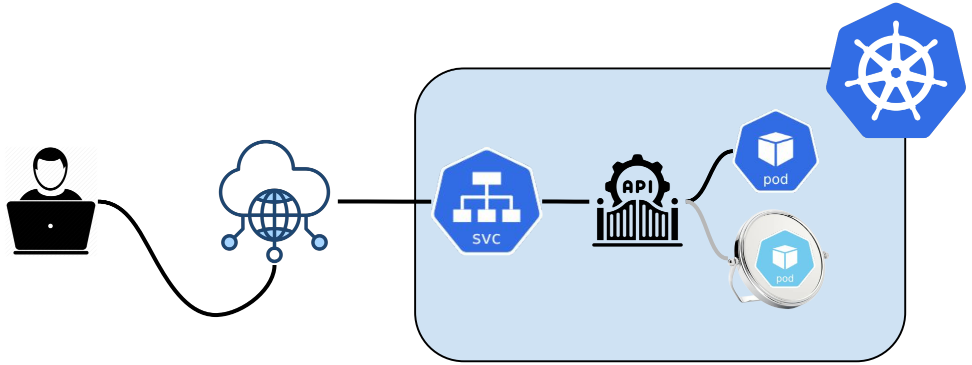
Traffic Mirroring (Shadowing)



- Send a copy of production traffic to new version
- Doesn't affect live users while testing real traffic patterns
- Helps validate performance before actual cutover

```yaml
apiVersion: gateway.networking.k8s.io/v1
kind: HTTPRoute
metadata:
 name: mirroring-example
 namespace: default
 spec:
 parentRefs:
 - name: calico-envoy-gateway
  kind: Gateway
  namespace: tigera-gateway
 hostnames:
 - "app.example.com"
 rules:
 - matches:
  - path:
    type: PathPrefix
    value: /myapp
  filters:
  - type: RequestMirror
   requestMirror:
    backendRef:
     name: shadow-service
     port: 8080
     group: ""
     kind: Service
  backendRefs:
  - name: primary-service
   port: 8080
```

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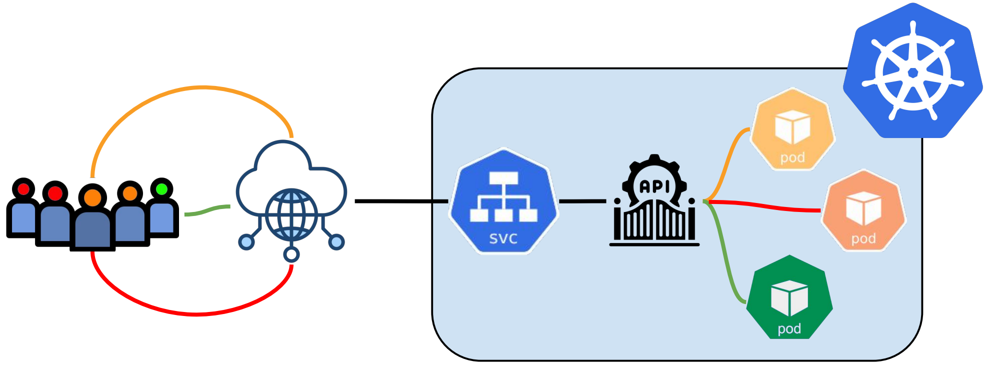
Header-Based Routing



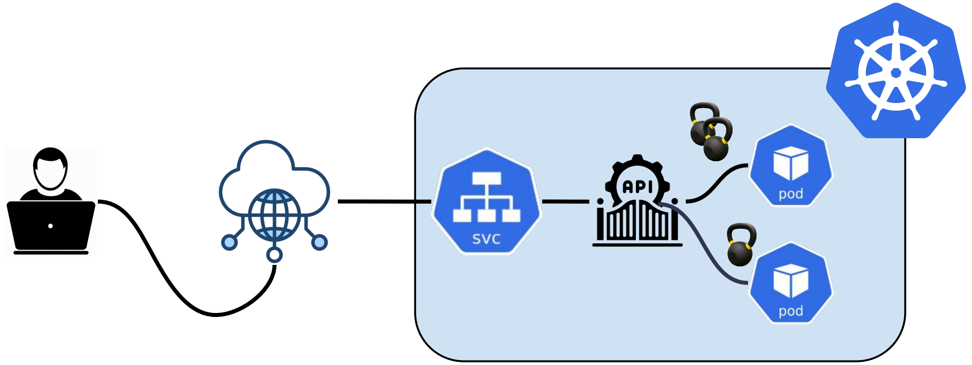
- Route traffic based on HTTP headers
- Useful for internal testing or feature flags
- Example: Route employees to new version while customers stay on stable

```
# Rule 1: Green users (new features)
 - matches:
   - headers:
     - type: Exact
       name: x-user-color
       value: green
   filters:
   - type: RequestHeaderModifier
     requestHeaderModifier:
       set:
       - name: x-routed-color
         value: green
   backendRefs:
   - name: green-service
     port: 8080
     weight: 100

# Rule 2: Yellow users (beta features)
 - matches:
   - headers:
     - type: Exact
       name: x-user-color
       value: yellow
   backendRefs:
   - name: yellow-service
     port: 8080

# Rule 3: Red users (default stable)
 - backendRefs:
   - name: red-service
     port: 8080
```

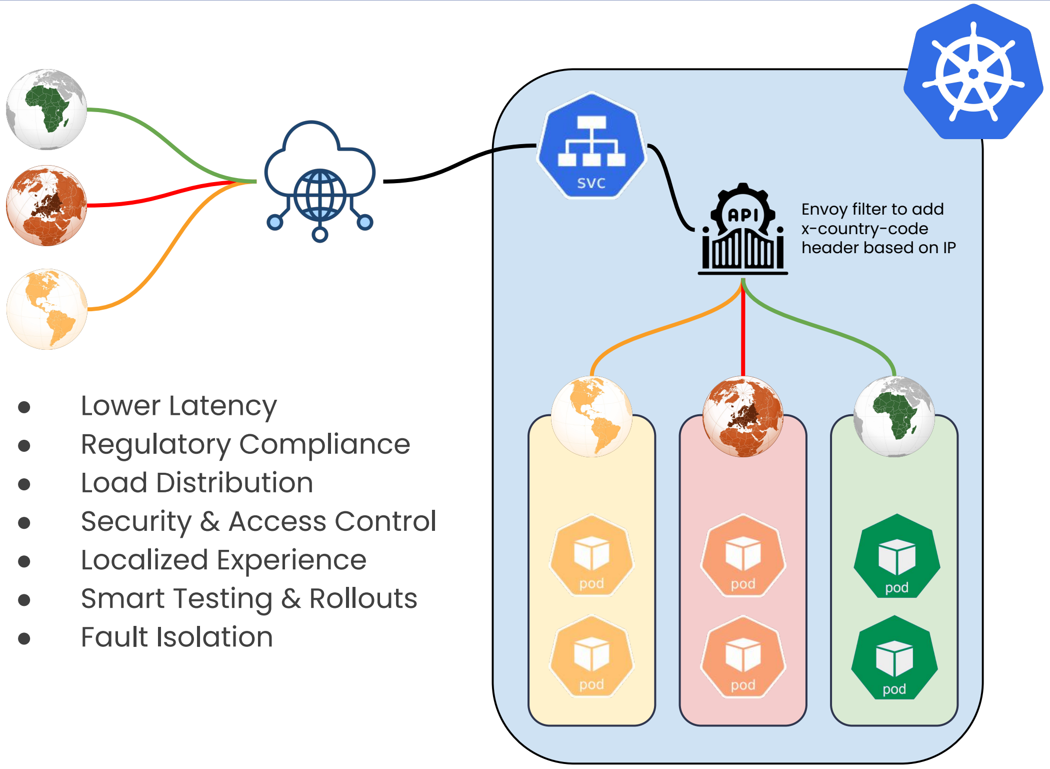
Weighted Traffic Splitting



- Distribute traffic across multiple service versions
- More flexible than simple canary (can split across multiple versions)
- Example: 70% v1 and 30% v2

```
apiVersion: gateway.networking.k8s.io/v1
kind: HTTPRoute
metadata:
  name: basic-weighted-split
spec:
  parentRefs:
  - name: envoy-gateway
  rules:
  - backendRefs:
    - name: service-v1
      port: 80
      weight: 70
    - name: service-v2
      port: 80
      weight: 30
```

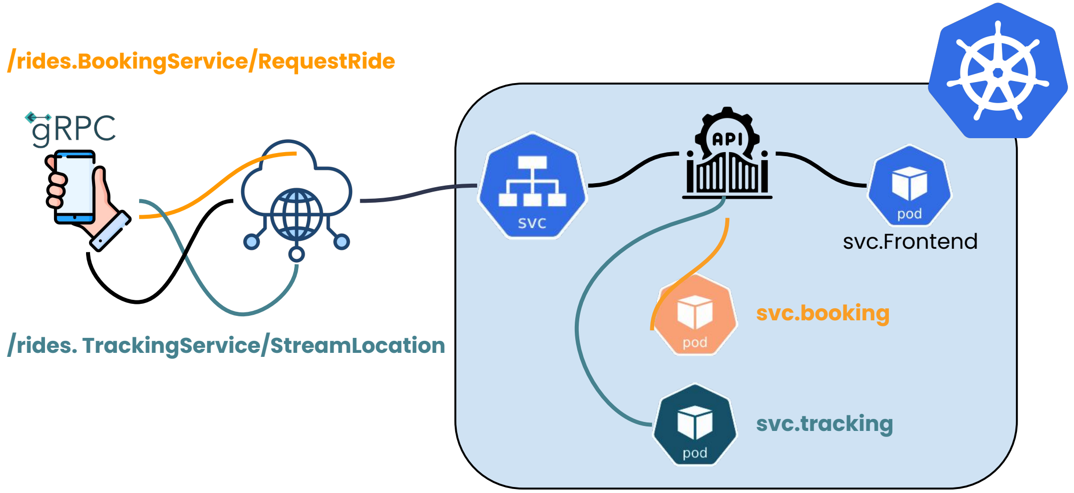
Geographic Routing



- Lower Latency
- Regulatory Compliance
- Load Distribution
- Security & Access Control
- Localized Experience
- Smart Testing & Rollouts
- Fault Isolation

```
apiVersion: gateway.networking.k8s.io/v1
kind: HTTPRoute
metadata:
  name: geo-routing
spec:
  parentRefs:
  - name: envoy-gateway
  rules:
  - matches:
    - headers:
      - name: "x-geo-region"
        value: "africa"
    backendRefs:
    - name: africa-service
      port: 80
  - matches:
    - headers:
      - name: "x-geo-region"
        value: "europe"
    backendRefs:
    - name: europe-service
      port: 80
  - matches:
    - headers:
      - name: "x-geo-region"
        value: "america"
    backendRefs:
    - name: america-service
      port: 80
  - backendRefs:  # Default route
    - name: default-service
      port: 80
```

GRPC Routing


/rides.BookingService/RequestRide
gRPC
/rides. TrackingService/StreamLocation
API
svc
pod
svc.Frontend
pod
svc.booking
pod
svc.tracking

```
hostnames:
- "api.rideshare.com"
rules:
- matches:
  - method:
      service: "rides.BookingService"
      method: "RequestRide"
  backendRefs:
  - name: booking-service
    port: 50051
    weight: 100  # 100% to
booking-service

- matches:
  - method:
      service: "rides.TrackingService"
      method: "StreamLocation"
  backendRefs:
  - name: tracking-service
    port: 50052
    weight: 100  # 100% to
tracking-service
```

- Your mobile app sends gRPC requests directly to Envoy Gateway.
- Envoy routes each method to the right microservice (no frontend involved).
- Result: Faster, more efficient, and scalable than traditional REST-through-frontend approaches.
- gRPC also supports all the previous http deployments we have covered and many more.

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2.2

Traffic Shaping

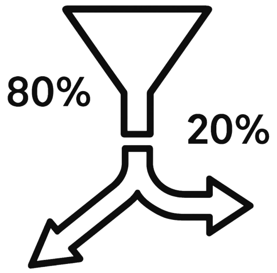
Traffic Shaping

Rate Limiting
Global (external service) and local (in-process) request throttling.
Supports requests per second (RPS) or connection limits.

Circuit Breaking
Automatically blocks traffic to overwhelmed services (based on errors/timeouts).
Configurable thresholds for max connections, pending requests, etc.

Retry Policies
Controls retry attempts for failed requests (with backoff strategies).
Can filter retries based on status codes/gRPC codes.

Timeouts
Sets deadlines for requests (global, per-route, or per-cluster).



Load Shedding
Drops or queues requests when upstream services are overloaded.

Request Buffering
Delays or buffers requests (e.g., for streaming or batch processing).

Bandwidth Limits
Throttles bandwidth for HTTP/TCP streams (bytes per second).

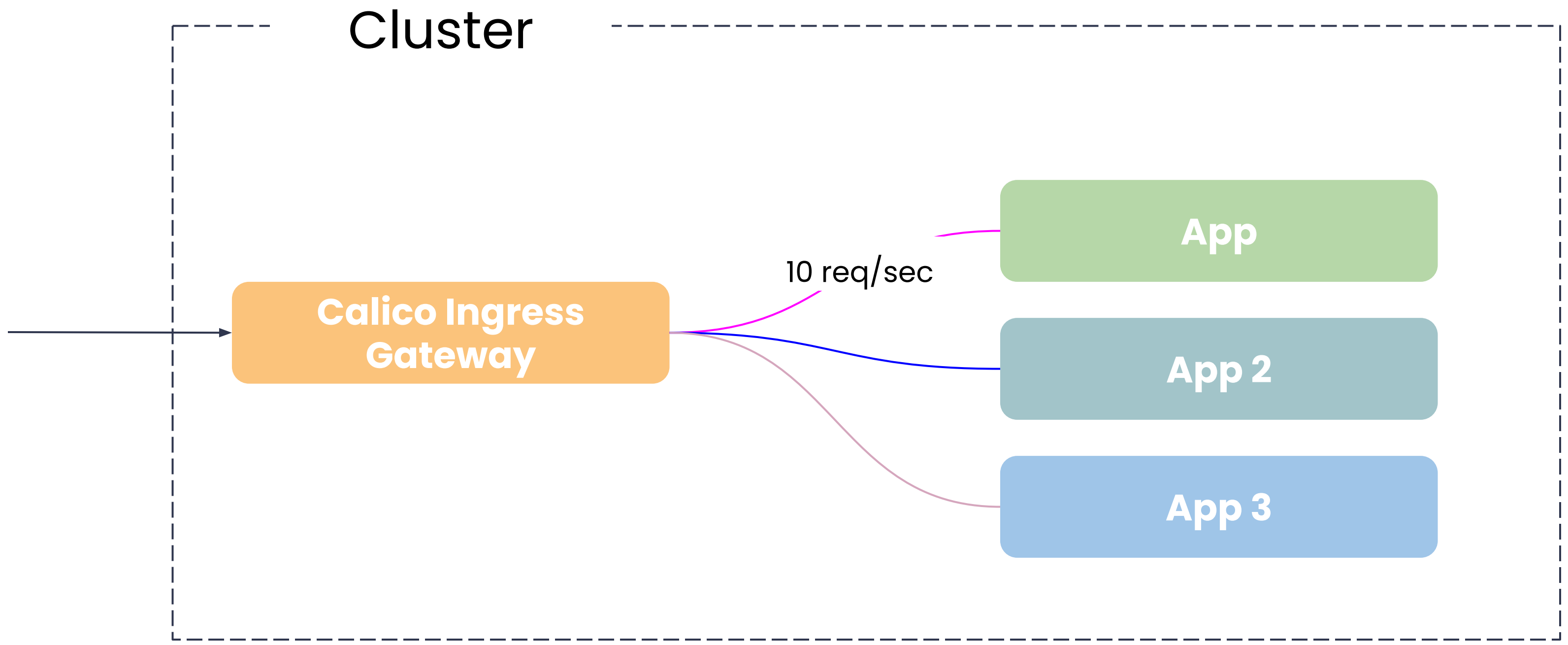
Fault Injection
Simulates failures (aborts/delays) to test resilience.

Priority-Based Routing
Directs traffic to high/low-priority clusters based on load.

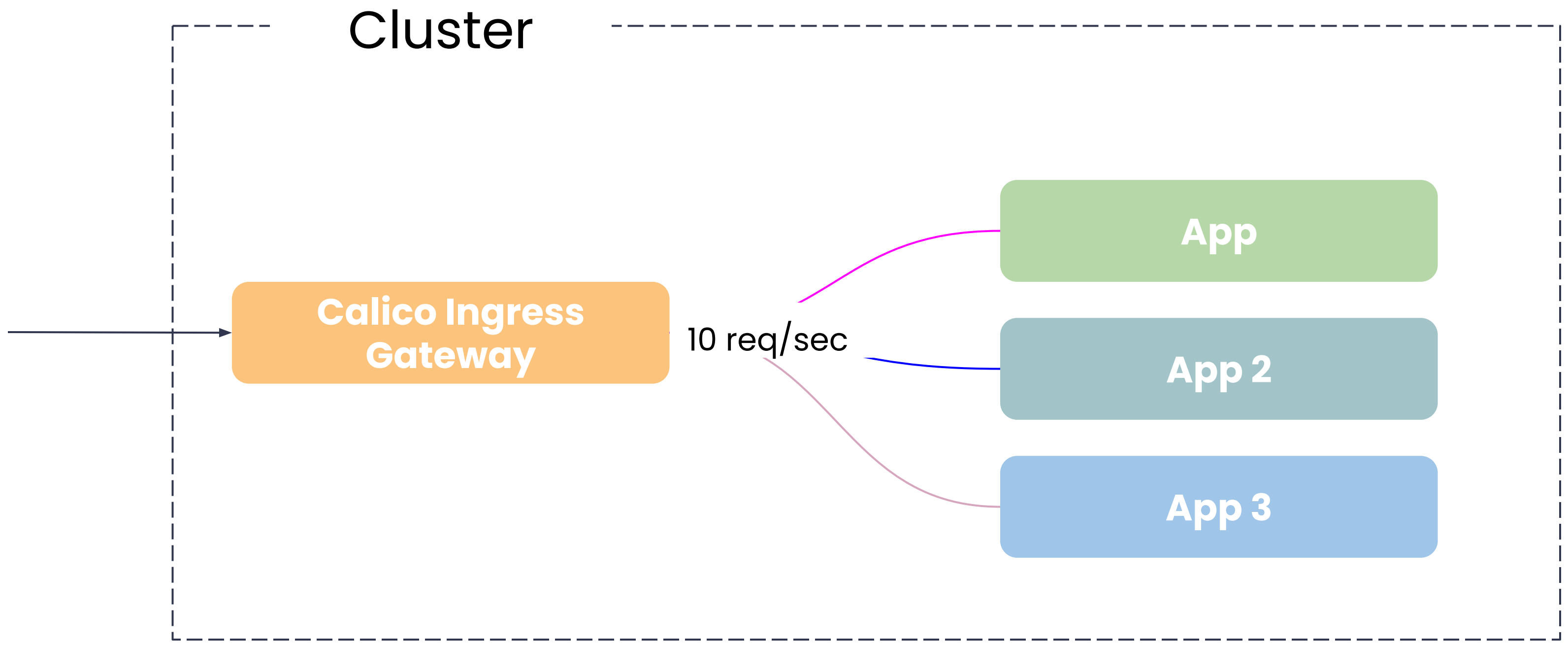
Adaptive Concurrency
Dynamically adjusts request limits based on latency metrics.

Quota Management
Enforces usage quotas (e.g., API calls/user).

Local Rate Limiting



Global Rate Limiting



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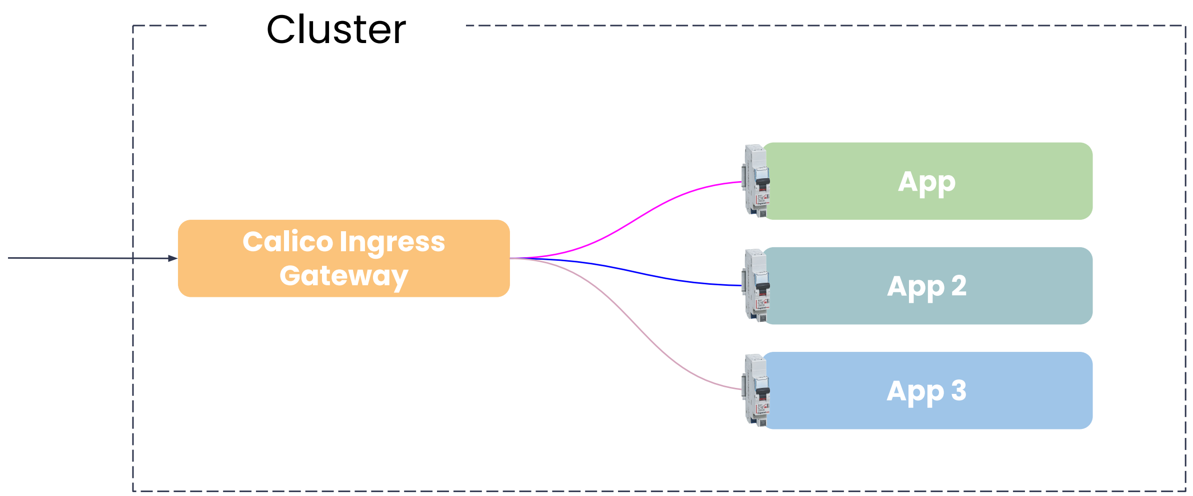
Circuit Breaking



2.3

Other Traffic Functions

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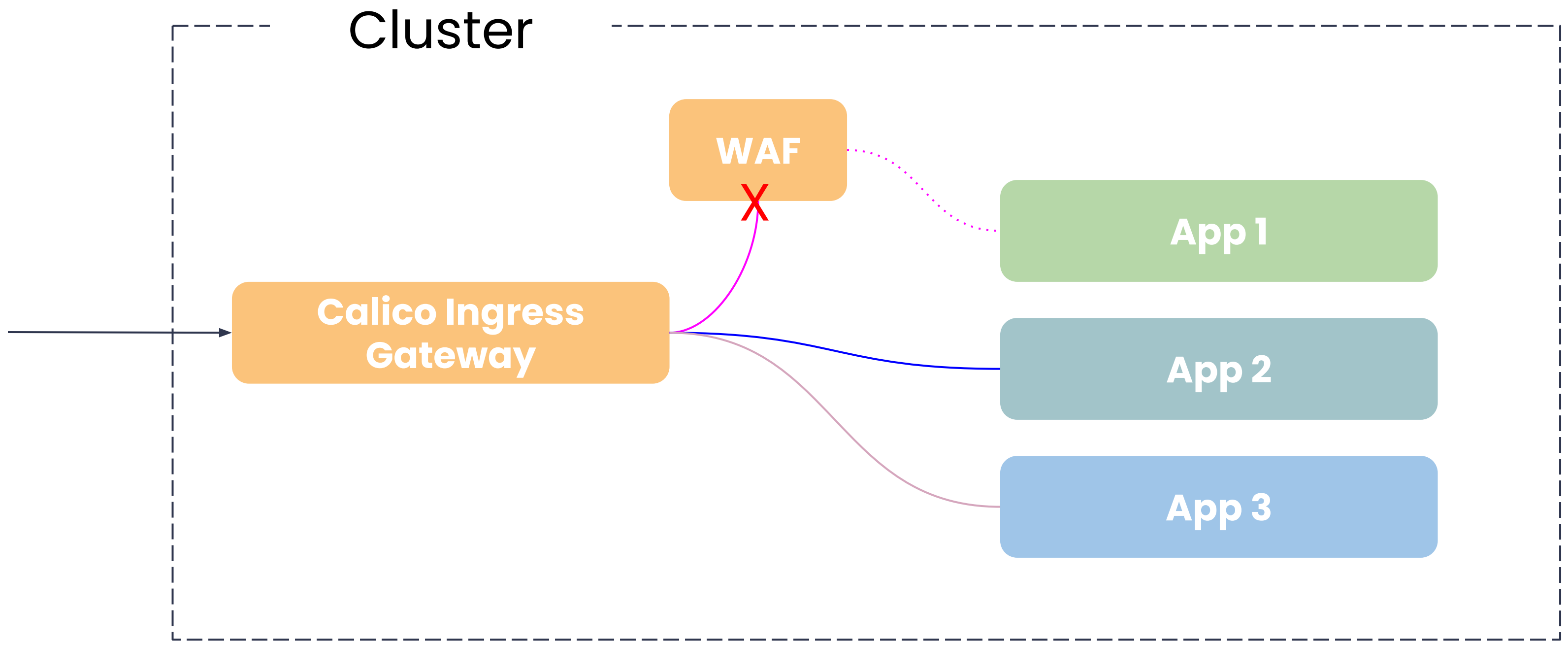
Coming Soon – WAF



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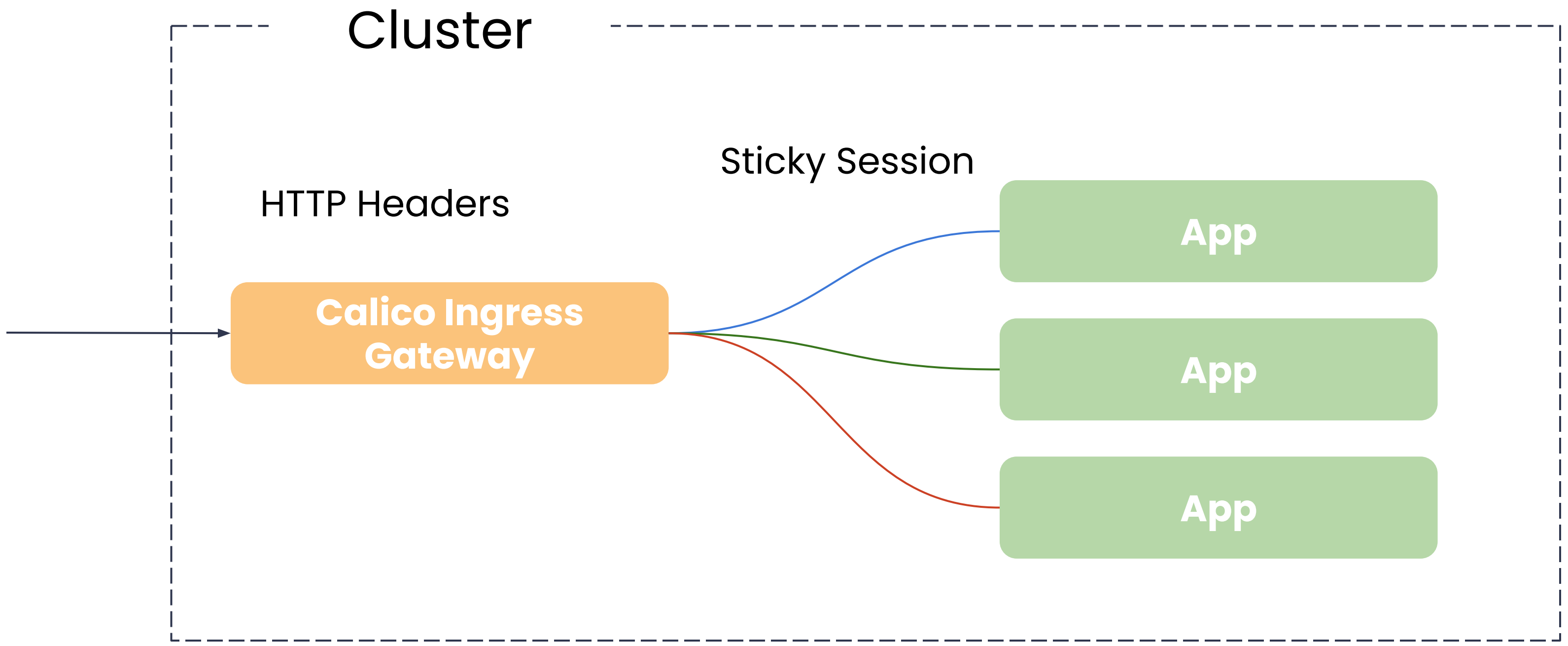
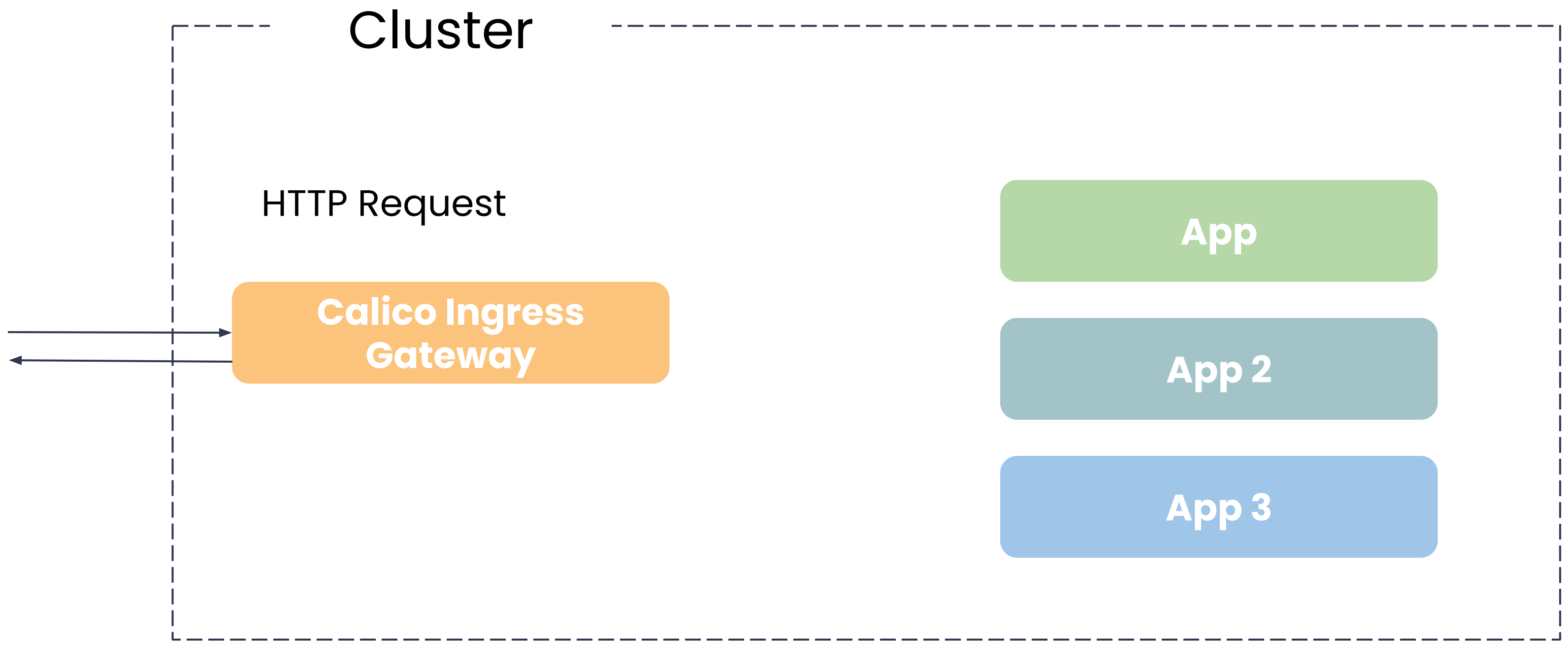
Advanced Load Balancing - Consistent Hash



Direct Response



And lots and lots more...

- Circuit Breaker
- Backend Routing
- Client Traffic Policy
- Connection Limit
- Direct Response
- Failover
- Fault Injection
- GRPC Routing
- HTTP Redirects
- HTTP Request Headers
- HTTP Response Headers
- HTTP Timeouts
- HTTP URL Rewrite
- HTTP Request Mirroring
- Multicluster Service Routing
- Response Compression
- Response Override
- Retry

- Accelerated TLS Handshakes
- API Key Authentication
- Backend Mutual TLS: Gateway to Backend
- Backend TLS: Gateway to Backend
- Basic Authentication
- CORS
- External Authorization
- IP Allowlist/Denylist
- JWT Authentication
- JWT Claim-Based Authorization
- Mutual TLS: External Clients to the Gateway
- OIDC Authentication
- Threat Model
- TLS Passthrough
- TLS Termination for TCP

Thank you

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