CANONICAL LIVING OVERVIEW GUIDE

Service Mesh, API Gateway, and East-West Traffic Engineering

A traffic-platform guide covering gateways, proxies, service mesh, Gateway API, Envoy, Istio, workload identity, mTLS, routing, resilience, policy, telemetry, ambient and sidecar architectures, multi-cluster, egress, and emerging agent-aware gateways.

PERMANENT ID
MYTHOS-FG-CLD-0005

PUBLICATION CLASS
FIELD GUIDE

VERSION / STATUS
1.0.0-candidate / CANDIDATE

PERMANENT PUBLICATION IDENTITY

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Version
1.0.0-candidate

Status
Candidate Focused Field Guide

Review date
2026-10-26

Publication position
This is a living field guide. It is designed for frequent revision while retaining a stable permanent identity. Candidate status means the content is ready for structured use and review but is not represented as an external certification or authority publication.

LEVEL	CLASS	CADENCE	EVIDENCE
L1-L4	FIELD GUIDE	QUARTERLY	SOURCE-BOUND
Foundational through frontier	Practical and educational	Interim updates as needed	Limitations remain visible

Reader orientation

Dimension	Engineering position
Primary domain	MYTHOS-CLD - Cloud, Platform & Distributed Systems
Secondary domain	MYTHOS-NET; MYTHOS-SEC; MYTHOS-AI
Audience	Platform, network, cloud, security, API, SRE, and AI-infrastructure engineers.
Prerequisites	TCP/IP, HTTP, TLS, Kubernetes, identity, distributed systems, APIs, and observability.
Publisher / owner	Mythos Systems / Aaron Stovall
Public classification	Public technical guidance

Expected outcomes

Differentiate API management, ingress, gateway, load balancing, service mesh, and application policy.

Design north-south and east-west traffic using role-oriented APIs and explicit ownership.

Apply workload identity, mTLS, authorization, routing, resilience, rate limits, and egress controls.

Operate sidecar, ambient, gateway, and proxyless patterns with measurable failure and upgrade behavior.

Prepare traffic platforms for agent, model, MCP, A2A, streaming, and long-running AI workloads.

How to use this guide

Read the guide as a progressive system rather than a disconnected encyclopedia. Foundational material establishes the mental model; practitioner sections convert it into repeatable implementation and operations; advanced sections expose architecture, scale, security, and failure behavior; frontier sections describe technologies whose evidence or maturity is still evolving.

Suggested reading path
New practitioners should follow the chapters in order and complete the laboratories. Experienced engineers may begin with the architecture, failure, validation, or frontier sections, then use the related-document map to deepen a specific topic.

Learning and assurance model

Level	Reader outcome
L1 - Foundational	Terminology, first principles, component roles, packet or state flow, and simple working examples.
L2 - Practitioner	Implementation, configuration, automation, testing, troubleshooting, and operational evidence.
L3 - Advanced	Architecture, scale, concurrency, resilience, threat models, performance, and complex migrations.
L4 - Frontier	Emerging systems, research directions, technical uncertainty, readiness gates, and adoption signals.

Contents

CHAPTER 01

Traffic architecture and control boundaries

Define which layer owns routing, identity, policy, and reliability.

Chapter operating position
Define which layer owns routing, identity, policy, and reliability.

1.1 North-south and east-west traffic

North-south and east-west traffic must be engineered as a governed distributed-system mechanism, not a product label, agent persona, YAML object, or diagram. Distinguish client ingress, partner APIs, service calls, cluster gateways, egress, and cross-region paths. The design should identify authoritative state, workload identities, typed contracts, resource and token budgets, trust boundaries, failure domains, telemetry, rollback, and acceptance evidence.

This guide traces the subject through the client, gateway, route, proxy, identity, policy, upstream, service, return path, telemetry, and agent or user outcome chain. A running agent, reconciled object, successful API call, healthy proxy, or completed function is not proof of the intended outcome. Desired state must be compared with applied state, external effects, negative tests, degraded behavior, causal evidence, cost, and user or mission results.

Production engineering begins with a minimal known-good control plane and explicit invariants. Add one worker class, model route, controller, policy, event source, gateway, or platform feature at a time; preserve before-state evidence; test authorized and prohibited behavior; inject realistic failures; and retain a tested compensation or rollback path.

Troubleshooting locates the first divergence from the expected state machine. Account for stale watches, leases, retries, eventual consistency, duplicated work, cache state, identity rotation, partial external effects, version skew, prompt injection, overload, network partitions, and missing telemetry. Closure requires causal explanation, reproducibility, validated recovery, and residual limitations.

Engineering practices

- Define authority, ownership, desired state, dependencies, limits, and evidence for north-south and east-west traffic.
- Use typed APIs, stable identities, explicit state machines, idempotency, and bounded effects.
- Separate control plane, execution plane, data plane, evidence plane, and human decision authority.
- Test nominal, prohibited, overloaded, partitioned, partially failed, recovery, upgrade, and rollback cases.
- Preserve configuration, policy, model, source, trace, event, artifact, approval, and user-outcome evidence.
- Scale through quotas, queues, backpressure, fairness, isolation, canaries, and deterministic fan-in.

Failure patterns

- Treating north-south and east-west traffic as a feature rather than an end-to-end stateful system.
- Scaling worker count or deployment scope before bounding queues, budgets, retries, and fan-in.
- Trusting controller, agent, or proxy status without validating external state and user outcome.
- Sharing credentials, workspaces, caches, or context across tenants and roles without explicit policy.
- Allowing AI-generated plans, policies, or changes to bypass deterministic validation and human authority.
- Declaring recovery after process restart without reconciling orphan effects, leases, artifacts, and evidence.

Validation and evidence

Method	Expected evidence
Examine	Requirements, APIs, identities, state machines, policies, versions, resources, and dependencies for north-south and east-west traffic.
Observe	Queue, task, controller, model, tool, route, proxy, event, resource, trace, artifact, and user-visible state.
Test	Expected, prohibited, malformed, duplicate, overloaded, partitioned, failed, recovery, upgrade, and rollback conditions.
Measure	Task success, reliability, latency, throughput, fairness, cost, token and compute use, blast radius, and operator burden.
Reconcile	Desired and planned state against actual cloud, cluster, agent, network, data, external-effect, and evidence state.

1.2 Gateway, proxy, and mesh roles

Gateway, proxy, and mesh roles must be engineered as a governed distributed-system mechanism, not a product label, agent persona, YAML object, or diagram. Separate API management, load balancing, ingress, edge gateway, service mesh, and application logic. The design should identify authoritative state, workload identities, typed contracts, resource and token budgets, trust boundaries, failure domains, telemetry, rollback, and acceptance evidence.

This guide traces the subject through the client, gateway, route, proxy, identity, policy, upstream, service, return path, telemetry, and agent or user outcome chain. A running agent, reconciled object, successful API call, healthy proxy, or completed function is not proof of the intended outcome. Desired state must be compared with applied state, external effects, negative tests, degraded behavior, causal evidence, cost, and user or mission results.

Production engineering begins with a minimal known-good control plane and explicit invariants. Add one worker class, model route, controller, policy, event source, gateway, or platform feature at a time; preserve before-state evidence; test authorized and prohibited behavior; inject realistic failures; and retain a tested compensation or rollback path.

Troubleshooting locates the first divergence from the expected state machine. Account for stale watches, leases, retries, eventual consistency, duplicated work, cache state, identity rotation, partial external effects, version skew, prompt injection, overload, network partitions, and missing telemetry. Closure requires causal explanation, reproducibility, validated recovery, and residual limitations.

Engineering practices

- Define authority, ownership, desired state, dependencies, limits, and evidence for gateway, proxy, and mesh roles.
- Use typed APIs, stable identities, explicit state machines, idempotency, and bounded effects.
- Separate control plane, execution plane, data plane, evidence plane, and human decision authority.
- Test nominal, prohibited, overloaded, partitioned, partially failed, recovery, upgrade, and rollback cases.
- Preserve configuration, policy, model, source, trace, event, artifact, approval, and user-outcome evidence.
- Scale through quotas, queues, backpressure, fairness, isolation, canaries, and deterministic fan-in.

Implementation sketch

```
traffic_policy:
  source_identity: spiffe://mythos/agent/planner
  destination: mcp://deployment-tools
  protocol: http2-streaming
  authorization:
    scopes: [deploy:canary]
  routing:
    model_backend: capability-aware
    retry_budget: 0.05
    timeout_seconds: 300
  safety:
    prompt_injection_filter: enabled
    production_confirmation: required
  telemetry:
    trace_mission_and_tool_effects: true
```

Failure patterns

Treating gateway, proxy, and mesh roles as a feature rather than an end-to-end stateful system.

Scaling worker count or deployment scope before bounding queues, budgets, retries, and fan-in.

Trusting controller, agent, or proxy status without validating external state and user outcome.

Sharing credentials, workspaces, caches, or context across tenants and roles without explicit policy.

Allowing AI-generated plans, policies, or changes to bypass deterministic validation and human authority.

Declaring recovery after process restart without reconciling orphan effects, leases, artifacts, and evidence.

Validation and evidence

Method	Expected evidence
Examine	Requirements, APIs, identities, state machines, policies, versions, resources, and dependencies for gateway, proxy, and mesh roles.
Observe	Queue, task, controller, model, tool, route, proxy, event, resource, trace, artifact, and user-visible state.
Test	Expected, prohibited, malformed, duplicate, overloaded, partitioned, failed, recovery, upgrade, and rollback conditions.
Measure	Task success, reliability, latency, throughput, fairness, cost, token and compute use, blast radius, and operator burden.
Reconcile	Desired and planned state against actual cloud, cluster, agent, network, data, external-effect, and evidence state.

1.3 Control and data planes

Control and data planes must be engineered as a governed distributed-system mechanism, not a product label, agent persona, YAML object, or diagram. Understand configuration, discovery, policy, certificate, telemetry, proxy state, and traffic processing. The design should identify authoritative state, workload identities, typed contracts, resource and token budgets, trust boundaries, failure domains, telemetry, rollback, and acceptance evidence.

This guide traces the subject through the client, gateway, route, proxy, identity, policy, upstream, service, return path, telemetry, and agent or user outcome chain. A running agent, reconciled object, successful API call, healthy proxy, or completed function is not proof of the intended outcome. Desired state must be compared with applied state, external effects, negative tests, degraded behavior, causal evidence, cost, and user or mission results.

Production engineering begins with a minimal known-good control plane and explicit invariants. Add one worker class, model route, controller, policy, event source, gateway, or platform feature at a time; preserve before-state evidence; test authorized and prohibited behavior; inject realistic failures; and retain a tested compensation or rollback path.

Troubleshooting locates the first divergence from the expected state machine. Account for stale watches, leases, retries, eventual consistency, duplicated work, cache state, identity rotation, partial external effects, version skew, prompt injection, overload, network partitions, and missing telemetry. Closure requires causal explanation, reproducibility, validated recovery, and residual limitations.

Engineering practices

Define authority, ownership, desired state, dependencies, limits, and evidence for control and data planes.

Use typed APIs, stable identities, explicit state machines, idempotency, and bounded effects.

Separate control plane, execution plane, data plane, evidence plane, and human decision authority.

Test nominal, prohibited, overloaded, partitioned, partially failed, recovery, upgrade, and rollback cases.

Preserve configuration, policy, model, source, trace, event, artifact, approval, and user-outcome evidence.

Scale through quotas, queues, backpressure, fairness, isolation, canaries, and deterministic fan-in.

Failure patterns

Treating control and data planes as a feature rather than an end-to-end stateful system.

Scaling worker count or deployment scope before bounding queues, budgets, retries, and fan-in.

Trusting controller, agent, or proxy status without validating external state and user outcome.

Sharing credentials, workspaces, caches, or context across tenants and roles without explicit policy.

Allowing AI-generated plans, policies, or changes to bypass deterministic validation and human authority.

Declaring recovery after process restart without reconciling orphan effects, leases, artifacts, and evidence.

Validation and evidence

Method	Expected evidence
Examine	Requirements, APIs, identities, state machines, policies, versions, resources, and dependencies for control and data planes.
Observe	Queue, task, controller, model, tool, route, proxy, event, resource, trace, artifact, and user-visible state.
Test	Expected, prohibited, malformed, duplicate, overloaded, partitioned, failed, recovery, upgrade, and rollback conditions.
Measure	Task success, reliability, latency, throughput, fairness, cost, token and compute use, blast radius, and operator burden.
Reconcile	Desired and planned state against actual cloud, cluster, agent, network, data, external-effect, and evidence state.

1.4 Ownership and multi-tenancy

Ownership and multi-tenancy must be engineered as a governed distributed-system mechanism, not a product label, agent persona, YAML object, or diagram. Assign infrastructure, platform, application, security, network, tenant, and operator responsibilities. The design should identify authoritative state, workload identities, typed contracts, resource and token budgets, trust boundaries, failure domains, telemetry, rollback, and acceptance evidence.

This guide traces the subject through the client, gateway, route, proxy, identity, policy, upstream, service, return path, telemetry, and agent or user outcome chain. A running agent, reconciled object, successful API call, healthy proxy, or completed function is not proof of the intended outcome. Desired state must be compared with applied state, external effects, negative tests, degraded behavior, causal evidence, cost, and user or mission results.

Production engineering begins with a minimal known-good control plane and explicit invariants. Add one worker class, model route, controller, policy, event source, gateway, or platform feature at a time; preserve before-state evidence; test authorized and prohibited behavior; inject realistic failures; and retain a tested compensation or rollback path.

Troubleshooting locates the first divergence from the expected state machine. Account for stale watches, leases, retries, eventual consistency, duplicated work, cache state, identity rotation, partial external effects, version skew, prompt injection, overload, network partitions, and missing telemetry. Closure requires causal explanation, reproducibility, validated recovery, and residual limitations.

Engineering practices

Define authority, ownership, desired state, dependencies, limits, and evidence for ownership and multi-tenancy.

Use typed APIs, stable identities, explicit state machines, idempotency, and bounded effects.

Separate control plane, execution plane, data plane, evidence plane, and human decision authority.

Test nominal, prohibited, overloaded, partitioned, partially failed, recovery, upgrade, and rollback cases.

Preserve configuration, policy, model, source, trace, event, artifact, approval, and user-outcome evidence.

Scale through quotas, queues, backpressure, fairness, isolation, canaries, and deterministic fan-in.

Failure patterns

Treating ownership and multi-tenancy as a feature rather than an end-to-end stateful system.

Scaling worker count or deployment scope before bounding queues, budgets, retries, and fan-in.

Trusting controller, agent, or proxy status without validating external state and user outcome.

Sharing credentials, workspaces, caches, or context across tenants and roles without explicit policy.

Allowing AI-generated plans, policies, or changes to bypass deterministic validation and human authority.

Declaring recovery after process restart without reconciling orphan effects, leases, artifacts, and evidence.

Validation and evidence

Method	Expected evidence
Examine	Requirements, APIs, identities, state machines, policies, versions, resources, and dependencies for ownership and multi-tenancy.
Observe	Queue, task, controller, model, tool, route, proxy, event, resource, trace, artifact, and user-visible state.
Test	Expected, prohibited, malformed, duplicate, overloaded, partitioned, failed, recovery, upgrade, and rollback conditions.
Measure	Task success, reliability, latency, throughput, fairness, cost, token and compute use, blast radius, and operator burden.
Reconcile	Desired and planned state against actual cloud, cluster, agent, network, data, external-effect, and evidence state.

Chapter 01 laboratory and review

Practical laboratory
Map one request from external client through gateway, services, database, and egress with every control owner.

Laboratory evidence package

- Architecture or topology showing boundaries, identities, dependencies, and authoritative inputs.
- Versioned configuration or code with explanatory comments and reproducible setup instructions.
- Nominal-path validation plus at least two injected failure or boundary conditions.
- Structured logs, traces, metrics, packet captures, test output, or other appropriate evidence.
- A concise decision record covering findings, limitations, residual risks, and next actions.

Frontier extension

Explore unified traffic control planes for humans, services, agents, models, and devices.

Review gate
Advance only when another engineer can reproduce the result, explain the architecture, identify the failure boundary, and distinguish measured evidence from assumptions or projections.

CHAPTER 02

Gateway API and declarative traffic policy

Use role-oriented resources for infrastructure and application routing.

Chapter operating position
Use role-oriented resources for infrastructure and application routing.

2.1 GatewayClass, Gateway, and listeners

GatewayClass, Gateway, and listeners must be engineered as a governed distributed-system mechanism, not a product label, agent persona, YAML object, or diagram. Define implementation, infrastructure lifecycle, addresses, ports, protocols, certificates, and allowed routes. The design should identify authoritative state, workload identities, typed contracts, resource and token budgets, trust boundaries, failure domains, telemetry, rollback, and acceptance evidence.

This guide traces the subject through the client, gateway, route, proxy, identity, policy, upstream, service, return path, telemetry, and agent or user outcome chain. A running agent, reconciled object, successful API call, healthy proxy, or completed function is not proof of the intended outcome. Desired state must be compared with applied state, external effects, negative tests, degraded behavior, causal evidence, cost, and user or mission results.

Production engineering begins with a minimal known-good control plane and explicit invariants. Add one worker class, model route, controller, policy, event source, gateway, or platform feature at a time; preserve before-state evidence; test authorized and prohibited behavior; inject realistic failures; and retain a tested compensation or rollback path.

Troubleshooting locates the first divergence from the expected state machine. Account for stale watches, leases, retries, eventual consistency, duplicated work, cache state, identity rotation, partial external effects, version skew, prompt injection, overload, network partitions, and missing telemetry. Closure requires causal explanation, reproducibility, validated recovery, and residual limitations.

Engineering practices

- Define authority, ownership, desired state, dependencies, limits, and evidence for gatewayclass, gateway, and listeners.
- Use typed APIs, stable identities, explicit state machines, idempotency, and bounded effects.
- Separate control plane, execution plane, data plane, evidence plane, and human decision authority.
- Test nominal, prohibited, overloaded, partitioned, partially failed, recovery, upgrade, and rollback cases.
- Preserve configuration, policy, model, source, trace, event, artifact, approval, and user-outcome evidence.
- Scale through quotas, queues, backpressure, fairness, isolation, canaries, and deterministic fan-in.

Failure patterns

- Treating gatewayclass, gateway, and listeners as a feature rather than an end-to-end stateful system.
- Scaling worker count or deployment scope before bounding queues, budgets, retries, and fan-in.
- Trusting controller, agent, or proxy status without validating external state and user outcome.
- Sharing credentials, workspaces, caches, or context across tenants and roles without explicit policy.
- Allowing AI-generated plans, policies, or changes to bypass deterministic validation and human authority.
- Declaring recovery after process restart without reconciling orphan effects, leases, artifacts, and evidence.

Validation and evidence

Method	Expected evidence
Examine	Requirements, APIs, identities, state machines, policies, versions, resources, and dependencies for gatewayclass, gateway, and listeners.
Observe	Queue, task, controller, model, tool, route, proxy, event, resource, trace, artifact, and user-visible state.
Test	Expected, prohibited, malformed, duplicate, overloaded, partitioned, failed, recovery, upgrade, and rollback conditions.
Measure	Task success, reliability, latency, throughput, fairness, cost, token and compute use, blast radius, and operator burden.
Reconcile	Desired and planned state against actual cloud, cluster, agent, network, data, external-effect, and evidence state.

2.2 HTTPRoute, GRPCRoute, and other routes

HTTPRoute, GRPCRoute, and other routes must be engineered as a governed distributed-system mechanism, not a product label, agent persona, YAML object, or diagram. Match hosts, paths, headers, methods, backends, weights, filters, and references. The design should identify authoritative state, workload identities, typed contracts, resource and token budgets, trust boundaries, failure domains, telemetry, rollback, and acceptance evidence.

This guide traces the subject through the client, gateway, route, proxy, identity, policy, upstream, service, return path, telemetry, and agent or user outcome chain. A running agent, reconciled object, successful API call, healthy proxy, or completed function is not proof of the intended outcome. Desired state must be compared with applied state, external effects, negative tests, degraded behavior, causal evidence, cost, and user or mission results.

Production engineering begins with a minimal known-good control plane and explicit invariants. Add one worker class, model route, controller, policy, event source, gateway, or platform feature at a time; preserve before-state evidence; test authorized and prohibited behavior; inject realistic failures; and retain a tested compensation or rollback path.

Troubleshooting locates the first divergence from the expected state machine. Account for stale watches, leases, retries, eventual consistency, duplicated work, cache state, identity rotation, partial external effects, version skew, prompt injection, overload, network partitions, and missing telemetry. Closure requires causal explanation, reproducibility, validated recovery, and residual limitations.

Engineering practices

- Define authority, ownership, desired state, dependencies, limits, and evidence for httproute, grpcroute, and other routes.
- Use typed APIs, stable identities, explicit state machines, idempotency, and bounded effects.
- Separate control plane, execution plane, data plane, evidence plane, and human decision authority.
- Test nominal, prohibited, overloaded, partitioned, partially failed, recovery, upgrade, and rollback cases.
- Preserve configuration, policy, model, source, trace, event, artifact, approval, and user-outcome evidence.
- Scale through quotas, queues, backpressure, fairness, isolation, canaries, and deterministic fan-in.

Implementation sketch

```
traffic_policy:
  source_identity: spiffe://mythos/agent/planner
  destination: mcp://deployment-tools
  protocol: http2-streaming
  authorization:
    scopes: [deploy:canary]
  routing:
    model_backend: capability-aware
    retry_budget: 0.05
    timeout_seconds: 300
  safety:
    prompt_injection_filter: enabled
    production_confirmation: required
  telemetry:
    trace_mission_and_tool_effects: true
```

Failure patterns

Treating httproute, grpcroute, and other routes as a feature rather than an end-to-end stateful system.

Scaling worker count or deployment scope before bounding queues, budgets, retries, and fan-in.

Trusting controller, agent, or proxy status without validating external state and user outcome.

Sharing credentials, workspaces, caches, or context across tenants and roles without explicit policy.

Allowing AI-generated plans, policies, or changes to bypass deterministic validation and human authority.

Declaring recovery after process restart without reconciling orphan effects, leases, artifacts, and evidence.

Validation and evidence

Method	Expected evidence
Examine	Requirements, APIs, identities, state machines, policies, versions, resources, and dependencies for httproute, grpcroute, and other routes.
Observe	Queue, task, controller, model, tool, route, proxy, event, resource, trace, artifact, and user-visible state.
Test	Expected, prohibited, malformed, duplicate, overloaded, partitioned, failed, recovery, upgrade, and rollback conditions.
Measure	Task success, reliability, latency, throughput, fairness, cost, token and compute use, blast radius, and operator burden.
Reconcile	Desired and planned state against actual cloud, cluster, agent, network, data, external-effect, and evidence state.

2.3 Policies and attachment

Policies and attachment must be engineered as a governed distributed-system mechanism, not a product label, agent persona, YAML object, or diagram. Apply backend, security, timeout, retry, session, rate, and implementation-specific policy with clear scope. The design should identify authoritative state, workload identities, typed contracts, resource and token budgets, trust boundaries, failure domains, telemetry, rollback, and acceptance evidence.

This guide traces the subject through the client, gateway, route, proxy, identity, policy, upstream, service, return path, telemetry, and agent or user outcome chain. A running agent, reconciled object, successful API call, healthy proxy, or completed function is not proof of the intended outcome. Desired state must be compared with applied state, external effects, negative tests, degraded behavior, causal evidence, cost, and user or mission results.

Production engineering begins with a minimal known-good control plane and explicit invariants. Add one worker class, model route, controller, policy, event source, gateway, or platform feature at a time; preserve before-state evidence; test authorized and prohibited behavior; inject realistic failures; and retain a tested compensation or rollback path.

Troubleshooting locates the first divergence from the expected state machine. Account for stale watches, leases, retries, eventual consistency, duplicated work, cache state, identity rotation, partial external effects, version skew, prompt injection, overload, network partitions, and missing telemetry. Closure requires causal explanation, reproducibility, validated recovery, and residual limitations.

Engineering practices

Define authority, ownership, desired state, dependencies, limits, and evidence for policies and attachment.

Use typed APIs, stable identities, explicit state machines, idempotency, and bounded effects.

Separate control plane, execution plane, data plane, evidence plane, and human decision authority.

Test nominal, prohibited, overloaded, partitioned, partially failed, recovery, upgrade, and rollback cases.

Preserve configuration, policy, model, source, trace, event, artifact, approval, and user-outcome evidence.

Scale through quotas, queues, backpressure, fairness, isolation, canaries, and deterministic fan-in.

Failure patterns

Treating policies and attachment as a feature rather than an end-to-end stateful system.

Scaling worker count or deployment scope before bounding queues, budgets, retries, and fan-in.

Trusting controller, agent, or proxy status without validating external state and user outcome.

Sharing credentials, workspaces, caches, or context across tenants and roles without explicit policy.

Allowing AI-generated plans, policies, or changes to bypass deterministic validation and human authority.

Declaring recovery after process restart without reconciling orphan effects, leases, artifacts, and evidence.

Validation and evidence

Method	Expected evidence
Examine	Requirements, APIs, identities, state machines, policies, versions, resources, and dependencies for policies and attachment.
Observe	Queue, task, controller, model, tool, route, proxy, event, resource, trace, artifact, and user-visible state.
Test	Expected, prohibited, malformed, duplicate, overloaded, partitioned, failed, recovery, upgrade, and rollback conditions.
Measure	Task success, reliability, latency, throughput, fairness, cost, token and compute use, blast radius, and operator burden.
Reconcile	Desired and planned state against actual cloud, cluster, agent, network, data, external-effect, and evidence state.

2.4 GAMMA and service mesh

GAMMA and service mesh must be engineered as a governed distributed-system mechanism, not a product label, agent persona, YAML object, or diagram. Use service-attached routes and policies for east-west communication. The design should identify authoritative state, workload identities, typed contracts, resource and token budgets, trust boundaries, failure domains, telemetry, rollback, and acceptance evidence.

This guide traces the subject through the client, gateway, route, proxy, identity, policy, upstream, service, return path, telemetry, and agent or user outcome chain. A running agent, reconciled object, successful API call, healthy proxy, or completed function is not proof of the intended outcome. Desired state must be compared with applied state, external effects, negative tests, degraded behavior, causal evidence, cost, and user or mission results.

Production engineering begins with a minimal known-good control plane and explicit invariants. Add one worker class, model route, controller, policy, event source, gateway, or platform feature at a time; preserve before-state evidence; test authorized and prohibited behavior; inject realistic failures; and retain a tested compensation or rollback path.

Troubleshooting locates the first divergence from the expected state machine. Account for stale watches, leases, retries, eventual consistency, duplicated work, cache state, identity rotation, partial external effects, version skew, prompt injection, overload, network partitions, and missing telemetry. Closure requires causal explanation, reproducibility, validated recovery, and residual limitations.

Engineering practices

Define authority, ownership, desired state, dependencies, limits, and evidence for gamma and service mesh.

Use typed APIs, stable identities, explicit state machines, idempotency, and bounded effects.

Separate control plane, execution plane, data plane, evidence plane, and human decision authority.

Test nominal, prohibited, overloaded, partitioned, partially failed, recovery, upgrade, and rollback cases.

Preserve configuration, policy, model, source, trace, event, artifact, approval, and user-outcome evidence.

Scale through quotas, queues, backpressure, fairness, isolation, canaries, and deterministic fan-in.

Failure patterns

Treating gamma and service mesh as a feature rather than an end-to-end stateful system.

Scaling worker count or deployment scope before bounding queues, budgets, retries, and fan-in.

Trusting controller, agent, or proxy status without validating external state and user outcome.

Sharing credentials, workspaces, caches, or context across tenants and roles without explicit policy.

Allowing AI-generated plans, policies, or changes to bypass deterministic validation and human authority.

Declaring recovery after process restart without reconciling orphan effects, leases, artifacts, and evidence.

Validation and evidence

Method	Expected evidence
Examine	Requirements, APIs, identities, state machines, policies, versions, resources, and dependencies for gamma and service mesh.
Observe	Queue, task, controller, model, tool, route, proxy, event, resource, trace, artifact, and user-visible state.
Test	Expected, prohibited, malformed, duplicate, overloaded, partitioned, failed, recovery, upgrade, and rollback conditions.
Measure	Task success, reliability, latency, throughput, fairness, cost, token and compute use, blast radius, and operator burden.
Reconcile	Desired and planned state against actual cloud, cluster, agent, network, data, external-effect, and evidence state.

Chapter 02 laboratory and review

Practical laboratory
Build a Gateway API design with separate infrastructure and application ownership, canary routing, and denied cross-namespace references.

Laboratory evidence package

- Architecture or topology showing boundaries, identities, dependencies, and authoritative inputs.
- Versioned configuration or code with explanatory comments and reproducible setup instructions.
- Nominal-path validation plus at least two injected failure or boundary conditions.
- Structured logs, traces, metrics, packet captures, test output, or other appropriate evidence.
- A concise decision record covering findings, limitations, residual risks, and next actions.

Frontier extension

Explore Gateway API as a common contract for ingress, mesh, egress, and agent gateways.

Review gate
Advance only when another engineer can reproduce the result, explain the architecture, identify the failure boundary, and distinguish measured evidence from assumptions or projections.

CHAPTER 03

Envoy, xDS, and data-plane engineering

Understand how dynamic proxies receive configuration and process traffic.

Chapter operating position
Understand how dynamic proxies receive configuration and process traffic.

3.1 Listeners, filters, clusters, and endpoints

Listeners, filters, clusters, and endpoints must be engineered as a governed distributed-system mechanism, not a product label, agent persona, YAML object, or diagram. Trace connections through filter chains, routing, upstream pools, health, and load balancing. The design should identify authoritative state, workload identities, typed contracts, resource and token budgets, trust boundaries, failure domains, telemetry, rollback, and acceptance evidence.

This guide traces the subject through the client, gateway, route, proxy, identity, policy, upstream, service, return path, telemetry, and agent or user outcome chain. A running agent, reconciled object, successful API call, healthy proxy, or completed function is not proof of the intended outcome. Desired state must be compared with applied state, external effects, negative tests, degraded behavior, causal evidence, cost, and user or mission results.

Production engineering begins with a minimal known-good control plane and explicit invariants. Add one worker class, model route, controller, policy, event source, gateway, or platform feature at a time; preserve before-state evidence; test authorized and prohibited behavior; inject realistic failures; and retain a tested compensation or rollback path.

Troubleshooting locates the first divergence from the expected state machine. Account for stale watches, leases, retries, eventual consistency, duplicated work, cache state, identity rotation, partial external effects, version skew, prompt injection, overload, network partitions, and missing telemetry. Closure requires causal explanation, reproducibility, validated recovery, and residual limitations.

Engineering practices

- Define authority, ownership, desired state, dependencies, limits, and evidence for listeners, filters, clusters, and endpoints.
- Use typed APIs, stable identities, explicit state machines, idempotency, and bounded effects.
- Separate control plane, execution plane, data plane, evidence plane, and human decision authority.
- Test nominal, prohibited, overloaded, partitioned, partially failed, recovery, upgrade, and rollback cases.
- Preserve configuration, policy, model, source, trace, event, artifact, approval, and user-outcome evidence.
- Scale through quotas, queues, backpressure, fairness, isolation, canaries, and deterministic fan-in.

Failure patterns

- Treating listeners, filters, clusters, and endpoints as a feature rather than an end-to-end stateful system.
- Scaling worker count or deployment scope before bounding queues, budgets, retries, and fan-in.
- Trusting controller, agent, or proxy status without validating external state and user outcome.
- Sharing credentials, workspaces, caches, or context across tenants and roles without explicit policy.
- Allowing AI-generated plans, policies, or changes to bypass deterministic validation and human authority.
- Declaring recovery after process restart without reconciling orphan effects, leases, artifacts, and evidence.

Validation and evidence

Method	Expected evidence
Examine	Requirements, APIs, identities, state machines, policies, versions, resources, and dependencies for listeners, filters, clusters, and endpoints.
Observe	Queue, task, controller, model, tool, route, proxy, event, resource, trace, artifact, and user-visible state.
Test	Expected, prohibited, malformed, duplicate, overloaded, partitioned, failed, recovery, upgrade, and rollback conditions.
Measure	Task success, reliability, latency, throughput, fairness, cost, token and compute use, blast radius, and operator burden.
Reconcile	Desired and planned state against actual cloud, cluster, agent, network, data, external-effect, and evidence state.

3.2 xDS configuration

xDS configuration must be engineered as a governed distributed-system mechanism, not a product label, agent persona, YAML object, or diagram. Use discovery, versions, nonces, ACK/NACK, incremental updates, consistency, and failure behavior. The design should identify authoritative state, workload identities, typed contracts, resource and token budgets, trust boundaries, failure domains, telemetry, rollback, and acceptance evidence.

This guide traces the subject through the client, gateway, route, proxy, identity, policy, upstream, service, return path, telemetry, and agent or user outcome chain. A running agent, reconciled object, successful API call, healthy proxy, or completed function is not proof of the intended outcome. Desired state must be compared with applied state, external effects, negative tests, degraded behavior, causal evidence, cost, and user or mission results.

Production engineering begins with a minimal known-good control plane and explicit invariants. Add one worker class, model route, controller, policy, event source, gateway, or platform feature at a time; preserve before-state evidence; test authorized and prohibited behavior; inject realistic failures; and retain a tested compensation or rollback path.

Troubleshooting locates the first divergence from the expected state machine. Account for stale watches, leases, retries, eventual consistency, duplicated work, cache state, identity rotation, partial external effects, version skew, prompt injection, overload, network partitions, and missing telemetry. Closure requires causal explanation, reproducibility, validated recovery, and residual limitations.

Engineering practices

- Define authority, ownership, desired state, dependencies, limits, and evidence for xds configuration.
- Use typed APIs, stable identities, explicit state machines, idempotency, and bounded effects.
- Separate control plane, execution plane, data plane, evidence plane, and human decision authority.
- Test nominal, prohibited, overloaded, partitioned, partially failed, recovery, upgrade, and rollback cases.
- Preserve configuration, policy, model, source, trace, event, artifact, approval, and user-outcome evidence.
- Scale through quotas, queues, backpressure, fairness, isolation, canaries, and deterministic fan-in.

Implementation sketch

```
traffic_policy:
  source_identity: spiffe://mythos/agent/planner
  destination: mcp://deployment-tools
  protocol: http2-streaming
  authorization:
    scopes: [deploy:canary]
  routing:
    model_backend: capability-aware
    retry_budget: 0.05
    timeout_seconds: 300
  safety:
    prompt_injection_filter: enabled
    production_confirmation: required
  telemetry:
    trace_mission_and_tool_effects: true
```

Failure patterns

Treating xds configuration as a feature rather than an end-to-end stateful system.

Scaling worker count or deployment scope before bounding queues, budgets, retries, and fan-in.

Trusting controller, agent, or proxy status without validating external state and user outcome.

Sharing credentials, workspaces, caches, or context across tenants and roles without explicit policy.

Allowing AI-generated plans, policies, or changes to bypass deterministic validation and human authority.

Declaring recovery after process restart without reconciling orphan effects, leases, artifacts, and evidence.

Validation and evidence

Method	Expected evidence
Examine	Requirements, APIs, identities, state machines, policies, versions, resources, and dependencies for xds configuration.
Observe	Queue, task, controller, model, tool, route, proxy, event, resource, trace, artifact, and user-visible state.
Test	Expected, prohibited, malformed, duplicate, overloaded, partitioned, failed, recovery, upgrade, and rollback conditions.
Measure	Task success, reliability, latency, throughput, fairness, cost, token and compute use, blast radius, and operator burden.
Reconcile	Desired and planned state against actual cloud, cluster, agent, network, data, external-effect, and evidence state.

3.3 HTTP and transport behavior

HTTP and transport behavior must be engineered as a governed distributed-system mechanism, not a product label, agent persona, YAML object, or diagram. Handle HTTP/1.1, HTTP/2, HTTP/3, gRPC, WebSockets, CONNECT, TLS, retries, and streaming. The design should identify authoritative state, workload identities, typed contracts, resource and token budgets, trust boundaries, failure domains, telemetry, rollback, and acceptance evidence.

This guide traces the subject through the client, gateway, route, proxy, identity, policy, upstream, service, return path, telemetry, and agent or user outcome chain. A running agent, reconciled object, successful API call, healthy proxy, or completed function is not proof of the intended outcome. Desired state must be compared with applied state, external effects, negative tests, degraded behavior, causal evidence, cost, and user or mission results.

Production engineering begins with a minimal known-good control plane and explicit invariants. Add one worker class, model route, controller, policy, event source, gateway, or platform feature at a time; preserve before-state evidence; test authorized and prohibited behavior; inject realistic failures; and retain a tested compensation or rollback path.

Troubleshooting locates the first divergence from the expected state machine. Account for stale watches, leases, retries, eventual consistency, duplicated work, cache state, identity rotation, partial external effects, version skew, prompt injection, overload, network partitions, and missing telemetry. Closure requires causal explanation, reproducibility, validated recovery, and residual limitations.

Engineering practices

Define authority, ownership, desired state, dependencies, limits, and evidence for http and transport behavior.

Use typed APIs, stable identities, explicit state machines, idempotency, and bounded effects.

Separate control plane, execution plane, data plane, evidence plane, and human decision authority.

Test nominal, prohibited, overloaded, partitioned, partially failed, recovery, upgrade, and rollback cases.

Preserve configuration, policy, model, source, trace, event, artifact, approval, and user-outcome evidence.

Scale through quotas, queues, backpressure, fairness, isolation, canaries, and deterministic fan-in.

Failure patterns

Treating http and transport behavior as a feature rather than an end-to-end stateful system.

Scaling worker count or deployment scope before bounding queues, budgets, retries, and fan-in.

Trusting controller, agent, or proxy status without validating external state and user outcome.

Sharing credentials, workspaces, caches, or context across tenants and roles without explicit policy.

Allowing AI-generated plans, policies, or changes to bypass deterministic validation and human authority.

Declaring recovery after process restart without reconciling orphan effects, leases, artifacts, and evidence.

Validation and evidence

Method	Expected evidence
Examine	Requirements, APIs, identities, state machines, policies, versions, resources, and dependencies for http and transport behavior.
Observe	Queue, task, controller, model, tool, route, proxy, event, resource, trace, artifact, and user-visible state.
Test	Expected, prohibited, malformed, duplicate, overloaded, partitioned, failed, recovery, upgrade, and rollback conditions.
Measure	Task success, reliability, latency, throughput, fairness, cost, token and compute use, blast radius, and operator burden.
Reconcile	Desired and planned state against actual cloud, cluster, agent, network, data, external-effect, and evidence state.

3.4 Performance and capacity

Performance and capacity must be engineered as a governed distributed-system mechanism, not a product label, agent persona, YAML object, or diagram. Measure connections, requests, streams, buffers, memory, CPU, TLS, logs, and overload. The design should identify authoritative state, workload identities, typed contracts, resource and token budgets, trust boundaries, failure domains, telemetry, rollback, and acceptance evidence.

This guide traces the subject through the client, gateway, route, proxy, identity, policy, upstream, service, return path, telemetry, and agent or user outcome chain. A running agent, reconciled object, successful API call, healthy proxy, or completed function is not proof of the intended outcome. Desired state must be compared with applied state, external effects, negative tests, degraded behavior, causal evidence, cost, and user or mission results.

Production engineering begins with a minimal known-good control plane and explicit invariants. Add one worker class, model route, controller, policy, event source, gateway, or platform feature at a time; preserve before-state evidence; test authorized and prohibited behavior; inject realistic failures; and retain a tested compensation or rollback path.

Troubleshooting locates the first divergence from the expected state machine. Account for stale watches, leases, retries, eventual consistency, duplicated work, cache state, identity rotation, partial external effects, version skew, prompt injection, overload, network partitions, and missing telemetry. Closure requires causal explanation, reproducibility, validated recovery, and residual limitations.

Engineering practices

Define authority, ownership, desired state, dependencies, limits, and evidence for performance and capacity.

Use typed APIs, stable identities, explicit state machines, idempotency, and bounded effects.

Separate control plane, execution plane, data plane, evidence plane, and human decision authority.

Test nominal, prohibited, overloaded, partitioned, partially failed, recovery, upgrade, and rollback cases.

Preserve configuration, policy, model, source, trace, event, artifact, approval, and user-outcome evidence.

Scale through quotas, queues, backpressure, fairness, isolation, canaries, and deterministic fan-in.

Failure patterns

Treating performance and capacity as a feature rather than an end-to-end stateful system.

Scaling worker count or deployment scope before bounding queues, budgets, retries, and fan-in.

Trusting controller, agent, or proxy status without validating external state and user outcome.

Sharing credentials, workspaces, caches, or context across tenants and roles without explicit policy.

Allowing AI-generated plans, policies, or changes to bypass deterministic validation and human authority.

Declaring recovery after process restart without reconciling orphan effects, leases, artifacts, and evidence.

Validation and evidence

Method	Expected evidence
Examine	Requirements, APIs, identities, state machines, policies, versions, resources, and dependencies for performance and capacity.
Observe	Queue, task, controller, model, tool, route, proxy, event, resource, trace, artifact, and user-visible state.
Test	Expected, prohibited, malformed, duplicate, overloaded, partitioned, failed, recovery, upgrade, and rollback conditions.
Measure	Task success, reliability, latency, throughput, fairness, cost, token and compute use, blast radius, and operator burden.
Reconcile	Desired and planned state against actual cloud, cluster, agent, network, data, external-effect, and evidence state.

Chapter 03 laboratory and review

Practical laboratory

Inspect or simulate an xDS update and identify how invalid configuration, stale endpoints, and proxy overload appear.

Laboratory evidence package

- Architecture or topology showing boundaries, identities, dependencies, and authoritative inputs.
- Versioned configuration or code with explanatory comments and reproducible setup instructions.
- Nominal-path validation plus at least two injected failure or boundary conditions.
- Structured logs, traces, metrics, packet captures, test output, or other appropriate evidence.
- A concise decision record covering findings, limitations, residual risks, and next actions.

Frontier extension

Explore programmable data planes and hardware-accelerated proxy processing.

Review gate

Advance only when another engineer can reproduce the result, explain the architecture, identify the failure boundary, and distinguish measured evidence from assumptions or projections.

CHAPTER 04

Service identity, mTLS, and authorization

Establish workload trust independent of network location.

Chapter operating position
Establish workload trust independent of network location.

4.1 SPIFFE identities and trust domains

SPIFFE identities and trust domains must be engineered as a governed distributed-system mechanism, not a product label, agent persona, YAML object, or diagram. Issue short-lived SVIDs, use Workload API, rotate trust bundles, and federate domains. The design should identify authoritative state, workload identities, typed contracts, resource and token budgets, trust boundaries, failure domains, telemetry, rollback, and acceptance evidence.

This guide traces the subject through the client, gateway, route, proxy, identity, policy, upstream, service, return path, telemetry, and agent or user outcome chain. A running agent, reconciled object, successful API call, healthy proxy, or completed function is not proof of the intended outcome. Desired state must be compared with applied state, external effects, negative tests, degraded behavior, causal evidence, cost, and user or mission results.

Production engineering begins with a minimal known-good control plane and explicit invariants. Add one worker class, model route, controller, policy, event source, gateway, or platform feature at a time; preserve before-state evidence; test authorized and prohibited behavior; inject realistic failures; and retain a tested compensation or rollback path.

Troubleshooting locates the first divergence from the expected state machine. Account for stale watches, leases, retries, eventual consistency, duplicated work, cache state, identity rotation, partial external effects, version skew, prompt injection, overload, network partitions, and missing telemetry. Closure requires causal explanation, reproducibility, validated recovery, and residual limitations.

Engineering practices

- Define authority, ownership, desired state, dependencies, limits, and evidence for spiffe identities and trust domains.
- Use typed APIs, stable identities, explicit state machines, idempotency, and bounded effects.
- Separate control plane, execution plane, data plane, evidence plane, and human decision authority.
- Test nominal, prohibited, overloaded, partitioned, partially failed, recovery, upgrade, and rollback cases.
- Preserve configuration, policy, model, source, trace, event, artifact, approval, and user-outcome evidence.
- Scale through quotas, queues, backpressure, fairness, isolation, canaries, and deterministic fan-in.

Failure patterns

- Treating spiffe identities and trust domains as a feature rather than an end-to-end stateful system.
- Scaling worker count or deployment scope before bounding queues, budgets, retries, and fan-in.
- Trusting controller, agent, or proxy status without validating external state and user outcome.
- Sharing credentials, workspaces, caches, or context across tenants and roles without explicit policy.
- Allowing AI-generated plans, policies, or changes to bypass deterministic validation and human authority.
- Declaring recovery after process restart without reconciling orphan effects, leases, artifacts, and evidence.

Validation and evidence

Method	Expected evidence
Examine	Requirements, APIs, identities, state machines, policies, versions, resources, and dependencies for spiffe identities and trust domains.
Observe	Queue, task, controller, model, tool, route, proxy, event, resource, trace, artifact, and user-visible state.
Test	Expected, prohibited, malformed, duplicate, overloaded, partitioned, failed, recovery, upgrade, and rollback conditions.
Measure	Task success, reliability, latency, throughput, fairness, cost, token and compute use, blast radius, and operator burden.
Reconcile	Desired and planned state against actual cloud, cluster, agent, network, data, external-effect, and evidence state.

4.2 Mutual TLS and peer authentication

Mutual TLS and peer authentication must be engineered as a governed distributed-system mechanism, not a product label, agent persona, YAML object, or diagram. Establish identity, encryption, certificate validation, mode, exceptions, and migration. The design should identify authoritative state, workload identities, typed contracts, resource and token budgets, trust boundaries, failure domains, telemetry, rollback, and acceptance evidence.

This guide traces the subject through the client, gateway, route, proxy, identity, policy, upstream, service, return path, telemetry, and agent or user outcome chain. A running agent, reconciled object, successful API call, healthy proxy, or completed function is not proof of the intended outcome. Desired state must be compared with applied state, external effects, negative tests, degraded behavior, causal evidence, cost, and user or mission results.

Production engineering begins with a minimal known-good control plane and explicit invariants. Add one worker class, model route, controller, policy, event source, gateway, or platform feature at a time; preserve before-state evidence; test authorized and prohibited behavior; inject realistic failures; and retain a tested compensation or rollback path.

Troubleshooting locates the first divergence from the expected state machine. Account for stale watches, leases, retries, eventual consistency, duplicated work, cache state, identity rotation, partial external effects, version skew, prompt injection, overload, network partitions, and missing telemetry. Closure requires causal explanation, reproducibility, validated recovery, and residual limitations.

Engineering practices

- Define authority, ownership, desired state, dependencies, limits, and evidence for mutual tls and peer authentication.
- Use typed APIs, stable identities, explicit state machines, idempotency, and bounded effects.
- Separate control plane, execution plane, data plane, evidence plane, and human decision authority.
- Test nominal, prohibited, overloaded, partitioned, partially failed, recovery, upgrade, and rollback cases.
- Preserve configuration, policy, model, source, trace, event, artifact, approval, and user-outcome evidence.
- Scale through quotas, queues, backpressure, fairness, isolation, canaries, and deterministic fan-in.

Implementation sketch

```
traffic_policy:
  source_identity: spiffe://mythos/agent/planner
  destination: mcp://deployment-tools
  protocol: http2-streaming
  authorization:
    scopes: [deploy:canary]
  routing:
    model_backend: capability-aware
    retry_budget: 0.05
    timeout_seconds: 300
  safety:
    prompt_injection_filter: enabled
    production_confirmation: required
  telemetry:
    trace_mission_and_tool_effects: true
```

Failure patterns

Treating mutual tls and peer authentication as a feature rather than an end-to-end stateful system.

Scaling worker count or deployment scope before bounding queues, budgets, retries, and fan-in.

Trusting controller, agent, or proxy status without validating external state and user outcome.

Sharing credentials, workspaces, caches, or context across tenants and roles without explicit policy.

Allowing AI-generated plans, policies, or changes to bypass deterministic validation and human authority.

Declaring recovery after process restart without reconciling orphan effects, leases, artifacts, and evidence.

Validation and evidence

Method	Expected evidence
Examine	Requirements, APIs, identities, state machines, policies, versions, resources, and dependencies for mutual tls and peer authentication.
Observe	Queue, task, controller, model, tool, route, proxy, event, resource, trace, artifact, and user-visible state.
Test	Expected, prohibited, malformed, duplicate, overloaded, partitioned, failed, recovery, upgrade, and rollback conditions.
Measure	Task success, reliability, latency, throughput, fairness, cost, token and compute use, blast radius, and operator burden.
Reconcile	Desired and planned state against actual cloud, cluster, agent, network, data, external-effect, and evidence state.

4.3 Service authorization

Service authorization must be engineered as a governed distributed-system mechanism, not a product label, agent persona, YAML object, or diagram. Apply identity, namespace, service account, method, path, claims, network, and environmental policy. The design should identify authoritative state, workload identities, typed contracts, resource and token budgets, trust boundaries, failure domains, telemetry, rollback, and acceptance evidence.

This guide traces the subject through the client, gateway, route, proxy, identity, policy, upstream, service, return path, telemetry, and agent or user outcome chain. A running agent, reconciled object, successful API call, healthy proxy, or completed function is not proof of the intended outcome. Desired state must be compared with applied state, external effects, negative tests, degraded behavior, causal evidence, cost, and user or mission results.

Production engineering begins with a minimal known-good control plane and explicit invariants. Add one worker class, model route, controller, policy, event source, gateway, or platform feature at a time; preserve before-state evidence; test authorized and prohibited behavior; inject realistic failures; and retain a tested compensation or rollback path.

Troubleshooting locates the first divergence from the expected state machine. Account for stale watches, leases, retries, eventual consistency, duplicated work, cache state, identity rotation, partial external effects, version skew, prompt injection, overload, network partitions, and missing telemetry. Closure requires causal explanation, reproducibility, validated recovery, and residual limitations.

Engineering practices

Define authority, ownership, desired state, dependencies, limits, and evidence for service authorization.

Use typed APIs, stable identities, explicit state machines, idempotency, and bounded effects.

Separate control plane, execution plane, data plane, evidence plane, and human decision authority.

Test nominal, prohibited, overloaded, partitioned, partially failed, recovery, upgrade, and rollback cases.

Preserve configuration, policy, model, source, trace, event, artifact, approval, and user-outcome evidence.

Scale through quotas, queues, backpressure, fairness, isolation, canaries, and deterministic fan-in.

Failure patterns

Treating service authorization as a feature rather than an end-to-end stateful system.

Scaling worker count or deployment scope before bounding queues, budgets, retries, and fan-in.

Trusting controller, agent, or proxy status without validating external state and user outcome.

Sharing credentials, workspaces, caches, or context across tenants and roles without explicit policy.

Allowing AI-generated plans, policies, or changes to bypass deterministic validation and human authority.

Declaring recovery after process restart without reconciling orphan effects, leases, artifacts, and evidence.

Validation and evidence

Method	Expected evidence
Examine	Requirements, APIs, identities, state machines, policies, versions, resources, and dependencies for service authorization.
Observe	Queue, task, controller, model, tool, route, proxy, event, resource, trace, artifact, and user-visible state.
Test	Expected, prohibited, malformed, duplicate, overloaded, partitioned, failed, recovery, upgrade, and rollback conditions.
Measure	Task success, reliability, latency, throughput, fairness, cost, token and compute use, blast radius, and operator burden.
Reconcile	Desired and planned state against actual cloud, cluster, agent, network, data, external-effect, and evidence state.

4.4 Credential and certificate operations

Credential and certificate operations must be engineered as a governed distributed-system mechanism, not a product label, agent persona, YAML object, or diagram. Monitor issuance, expiry, rotation, revocation, clock, CA health, and disaster recovery. The design should identify authoritative state, workload identities, typed contracts, resource and token budgets, trust boundaries, failure domains, telemetry, rollback, and acceptance evidence.

This guide traces the subject through the client, gateway, route, proxy, identity, policy, upstream, service, return path, telemetry, and agent or user outcome chain. A running agent, reconciled object, successful API call, healthy proxy, or completed function is not proof of the intended outcome. Desired state must be compared with applied state, external effects, negative tests, degraded behavior, causal evidence, cost, and user or mission results.

Production engineering begins with a minimal known-good control plane and explicit invariants. Add one worker class, model route, controller, policy, event source, gateway, or platform feature at a time; preserve before-state evidence; test authorized and prohibited behavior; inject realistic failures; and retain a tested compensation or rollback path.

Troubleshooting locates the first divergence from the expected state machine. Account for stale watches, leases, retries, eventual consistency, duplicated work, cache state, identity rotation, partial external effects, version skew, prompt injection, overload, network partitions, and missing telemetry. Closure requires causal explanation, reproducibility, validated recovery, and residual limitations.

Engineering practices

Define authority, ownership, desired state, dependencies, limits, and evidence for credential and certificate operations.

Use typed APIs, stable identities, explicit state machines, idempotency, and bounded effects.

Separate control plane, execution plane, data plane, evidence plane, and human decision authority.

Test nominal, prohibited, overloaded, partitioned, partially failed, recovery, upgrade, and rollback cases.

Preserve configuration, policy, model, source, trace, event, artifact, approval, and user-outcome evidence.

Scale through quotas, queues, backpressure, fairness, isolation, canaries, and deterministic fan-in.

Failure patterns

Treating credential and certificate operations as a feature rather than an end-to-end stateful system.

Scaling worker count or deployment scope before bounding queues, budgets, retries, and fan-in.

Trusting controller, agent, or proxy status without validating external state and user outcome.

Sharing credentials, workspaces, caches, or context across tenants and roles without explicit policy.

Allowing AI-generated plans, policies, or changes to bypass deterministic validation and human authority.

Declaring recovery after process restart without reconciling orphan effects, leases, artifacts, and evidence.

Validation and evidence

Method	Expected evidence
Examine	Requirements, APIs, identities, state machines, policies, versions, resources, and dependencies for credential and certificate operations.
Observe	Queue, task, controller, model, tool, route, proxy, event, resource, trace, artifact, and user-visible state.
Test	Expected, prohibited, malformed, duplicate, overloaded, partitioned, failed, recovery, upgrade, and rollback conditions.
Measure	Task success, reliability, latency, throughput, fairness, cost, token and compute use, blast radius, and operator burden.
Reconcile	Desired and planned state against actual cloud, cluster, agent, network, data, external-effect, and evidence state.

Chapter 04 laboratory and review

Practical laboratory
Deploy or model service identity and mTLS, then test stale identity, wrong trust domain, expired SVID, and policy denial.

Laboratory evidence package

- Architecture or topology showing boundaries, identities, dependencies, and authoritative inputs.
- Versioned configuration or code with explanatory comments and reproducible setup instructions.
- Nominal-path validation plus at least two injected failure or boundary conditions.
- Structured logs, traces, metrics, packet captures, test output, or other appropriate evidence.
- A concise decision record covering findings, limitations, residual risks, and next actions.

Frontier extension

Explore post-quantum workload identity and attested service authorization.

Review gate
Advance only when another engineer can reproduce the result, explain the architecture, identify the failure boundary, and distinguish measured evidence from assumptions or projections.

CHAPTER 05

Routing, resilience, and traffic policy

Use traffic controls without amplifying failure.

Chapter operating position
Use traffic controls without amplifying failure.

5.1 Load balancing and locality

Load balancing and locality must be engineered as a governed distributed-system mechanism, not a product label, agent persona, YAML object, or diagram. Choose algorithms, zones, priorities, health, panic thresholds, failover, and outlier ejection. The design should identify authoritative state, workload identities, typed contracts, resource and token budgets, trust boundaries, failure domains, telemetry, rollback, and acceptance evidence.

This guide traces the subject through the client, gateway, route, proxy, identity, policy, upstream, service, return path, telemetry, and agent or user outcome chain. A running agent, reconciled object, successful API call, healthy proxy, or completed function is not proof of the intended outcome. Desired state must be compared with applied state, external effects, negative tests, degraded behavior, causal evidence, cost, and user or mission results.

Production engineering begins with a minimal known-good control plane and explicit invariants. Add one worker class, model route, controller, policy, event source, gateway, or platform feature at a time; preserve before-state evidence; test authorized and prohibited behavior; inject realistic failures; and retain a tested compensation or rollback path.

Troubleshooting locates the first divergence from the expected state machine. Account for stale watches, leases, retries, eventual consistency, duplicated work, cache state, identity rotation, partial external effects, version skew, prompt injection, overload, network partitions, and missing telemetry. Closure requires causal explanation, reproducibility, validated recovery, and residual limitations.

Engineering practices

- Define authority, ownership, desired state, dependencies, limits, and evidence for load balancing and locality.
- Use typed APIs, stable identities, explicit state machines, idempotency, and bounded effects.
- Separate control plane, execution plane, data plane, evidence plane, and human decision authority.
- Test nominal, prohibited, overloaded, partitioned, partially failed, recovery, upgrade, and rollback cases.
- Preserve configuration, policy, model, source, trace, event, artifact, approval, and user-outcome evidence.
- Scale through quotas, queues, backpressure, fairness, isolation, canaries, and deterministic fan-in.

Failure patterns

- Treating load balancing and locality as a feature rather than an end-to-end stateful system.
- Scaling worker count or deployment scope before bounding queues, budgets, retries, and fan-in.
- Trusting controller, agent, or proxy status without validating external state and user outcome.
- Sharing credentials, workspaces, caches, or context across tenants and roles without explicit policy.
- Allowing AI-generated plans, policies, or changes to bypass deterministic validation and human authority.
- Declaring recovery after process restart without reconciling orphan effects, leases, artifacts, and evidence.

Validation and evidence

Method	Expected evidence
Examine	Requirements, APIs, identities, state machines, policies, versions, resources, and dependencies for load balancing and locality.
Observe	Queue, task, controller, model, tool, route, proxy, event, resource, trace, artifact, and user-visible state.
Test	Expected, prohibited, malformed, duplicate, overloaded, partitioned, failed, recovery, upgrade, and rollback conditions.
Measure	Task success, reliability, latency, throughput, fairness, cost, token and compute use, blast radius, and operator burden.
Reconcile	Desired and planned state against actual cloud, cluster, agent, network, data, external-effect, and evidence state.

5.2 Timeouts, retries, and hedging

Timeouts, retries, and hedging must be engineered as a governed distributed-system mechanism, not a product label, agent persona, YAML object, or diagram. Set deadlines, retryable conditions, budgets, backoff, idempotency, and amplification limits. The design should identify authoritative state, workload identities, typed contracts, resource and token budgets, trust boundaries, failure domains, telemetry, rollback, and acceptance evidence.

This guide traces the subject through the client, gateway, route, proxy, identity, policy, upstream, service, return path, telemetry, and agent or user outcome chain. A running agent, reconciled object, successful API call, healthy proxy, or completed function is not proof of the intended outcome. Desired state must be compared with applied state, external effects, negative tests, degraded behavior, causal evidence, cost, and user or mission results.

Production engineering begins with a minimal known-good control plane and explicit invariants. Add one worker class, model route, controller, policy, event source, gateway, or platform feature at a time; preserve before-state evidence; test authorized and prohibited behavior; inject realistic failures; and retain a tested compensation or rollback path.

Troubleshooting locates the first divergence from the expected state machine. Account for stale watches, leases, retries, eventual consistency, duplicated work, cache state, identity rotation, partial external effects, version skew, prompt injection, overload, network partitions, and missing telemetry. Closure requires causal explanation, reproducibility, validated recovery, and residual limitations.

Engineering practices

- Define authority, ownership, desired state, dependencies, limits, and evidence for timeouts, retries, and hedging.
- Use typed APIs, stable identities, explicit state machines, idempotency, and bounded effects.
- Separate control plane, execution plane, data plane, evidence plane, and human decision authority.
- Test nominal, prohibited, overloaded, partitioned, partially failed, recovery, upgrade, and rollback cases.
- Preserve configuration, policy, model, source, trace, event, artifact, approval, and user-outcome evidence.
- Scale through quotas, queues, backpressure, fairness, isolation, canaries, and deterministic fan-in.

Implementation sketch

```
traffic_policy:
  source_identity: spiffe://mythos/agent/planner
  destination: mcp://deployment-tools
  protocol: http2-streaming
  authorization:
    scopes: [deploy:canary]
  routing:
    model_backend: capability-aware
    retry_budget: 0.05
    timeout_seconds: 300
  safety:
    prompt_injection_filter: enabled
    production_confirmation: required
  telemetry:
    trace_mission_and_tool_effects: true
```

Failure patterns

Treating timeouts, retries, and hedging as a feature rather than an end-to-end stateful system.

Scaling worker count or deployment scope before bounding queues, budgets, retries, and fan-in.

Trusting controller, agent, or proxy status without validating external state and user outcome.

Sharing credentials, workspaces, caches, or context across tenants and roles without explicit policy.

Allowing AI-generated plans, policies, or changes to bypass deterministic validation and human authority.

Declaring recovery after process restart without reconciling orphan effects, leases, artifacts, and evidence.

Validation and evidence

Method	Expected evidence
Examine	Requirements, APIs, identities, state machines, policies, versions, resources, and dependencies for timeouts, retries, and hedging.
Observe	Queue, task, controller, model, tool, route, proxy, event, resource, trace, artifact, and user-visible state.
Test	Expected, prohibited, malformed, duplicate, overloaded, partitioned, failed, recovery, upgrade, and rollback conditions.
Measure	Task success, reliability, latency, throughput, fairness, cost, token and compute use, blast radius, and operator burden.
Reconcile	Desired and planned state against actual cloud, cluster, agent, network, data, external-effect, and evidence state.

5.3 Circuit breaking and overload

Circuit breaking and overload must be engineered as a governed distributed-system mechanism, not a product label, agent persona, YAML object, or diagram. Bound connections, requests, queues, pending work, rate, memory, and downstream saturation. The design should identify authoritative state, workload identities, typed contracts, resource and token budgets, trust boundaries, failure domains, telemetry, rollback, and acceptance evidence.

This guide traces the subject through the client, gateway, route, proxy, identity, policy, upstream, service, return path, telemetry, and agent or user outcome chain. A running agent, reconciled object, successful API call, healthy proxy, or completed function is not proof of the intended outcome. Desired state must be compared with applied state, external effects, negative tests, degraded behavior, causal evidence, cost, and user or mission results.

Production engineering begins with a minimal known-good control plane and explicit invariants. Add one worker class, model route, controller, policy, event source, gateway, or platform feature at a time; preserve before-state evidence; test authorized and prohibited behavior; inject realistic failures; and retain a tested compensation or rollback path.

Troubleshooting locates the first divergence from the expected state machine. Account for stale watches, leases, retries, eventual consistency, duplicated work, cache state, identity rotation, partial external effects, version skew, prompt injection, overload, network partitions, and missing telemetry. Closure requires causal explanation, reproducibility, validated recovery, and residual limitations.

Engineering practices

Define authority, ownership, desired state, dependencies, limits, and evidence for circuit breaking and overload.

Use typed APIs, stable identities, explicit state machines, idempotency, and bounded effects.

Separate control plane, execution plane, data plane, evidence plane, and human decision authority.

Test nominal, prohibited, overloaded, partitioned, partially failed, recovery, upgrade, and rollback cases.

Preserve configuration, policy, model, source, trace, event, artifact, approval, and user-outcome evidence.

Scale through quotas, queues, backpressure, fairness, isolation, canaries, and deterministic fan-in.

Failure patterns

Treating circuit breaking and overload as a feature rather than an end-to-end stateful system.

Scaling worker count or deployment scope before bounding queues, budgets, retries, and fan-in.

Trusting controller, agent, or proxy status without validating external state and user outcome.

Sharing credentials, workspaces, caches, or context across tenants and roles without explicit policy.

Allowing AI-generated plans, policies, or changes to bypass deterministic validation and human authority.

Declaring recovery after process restart without reconciling orphan effects, leases, artifacts, and evidence.

Validation and evidence

Method	Expected evidence
Examine	Requirements, APIs, identities, state machines, policies, versions, resources, and dependencies for circuit breaking and overload.
Observe	Queue, task, controller, model, tool, route, proxy, event, resource, trace, artifact, and user-visible state.
Test	Expected, prohibited, malformed, duplicate, overloaded, partitioned, failed, recovery, upgrade, and rollback conditions.
Measure	Task success, reliability, latency, throughput, fairness, cost, token and compute use, blast radius, and operator burden.
Reconcile	Desired and planned state against actual cloud, cluster, agent, network, data, external-effect, and evidence state.

5.4 Progressive delivery and experimentation

Progressive delivery and experimentation must be engineered as a governed distributed-system mechanism, not a product label, agent persona, YAML object, or diagram. Use weighted routes, headers, mirrors, canaries, A/B tests, metrics, and rollback. The design should identify authoritative state, workload identities, typed contracts, resource and token budgets, trust boundaries, failure domains, telemetry, rollback, and acceptance evidence.

This guide traces the subject through the client, gateway, route, proxy, identity, policy, upstream, service, return path, telemetry, and agent or user outcome chain. A running agent, reconciled object, successful API call, healthy proxy, or completed function is not proof of the intended outcome. Desired state must be compared with applied state, external effects, negative tests, degraded behavior, causal evidence, cost, and user or mission results.

Production engineering begins with a minimal known-good control plane and explicit invariants. Add one worker class, model route, controller, policy, event source, gateway, or platform feature at a time; preserve before-state evidence; test authorized and prohibited behavior; inject realistic failures; and retain a tested compensation or rollback path.

Troubleshooting locates the first divergence from the expected state machine. Account for stale watches, leases, retries, eventual consistency, duplicated work, cache state, identity rotation, partial external effects, version skew, prompt injection, overload, network partitions, and missing telemetry. Closure requires causal explanation, reproducibility, validated recovery, and residual limitations.

Engineering practices

Define authority, ownership, desired state, dependencies, limits, and evidence for progressive delivery and experimentation.

Use typed APIs, stable identities, explicit state machines, idempotency, and bounded effects.

Separate control plane, execution plane, data plane, evidence plane, and human decision authority.

Test nominal, prohibited, overloaded, partitioned, partially failed, recovery, upgrade, and rollback cases.

Preserve configuration, policy, model, source, trace, event, artifact, approval, and user-outcome evidence.

Scale through quotas, queues, backpressure, fairness, isolation, canaries, and deterministic fan-in.

Failure patterns

Treating progressive delivery and experimentation as a feature rather than an end-to-end stateful system.

Scaling worker count or deployment scope before bounding queues, budgets, retries, and fan-in.

Trusting controller, agent, or proxy status without validating external state and user outcome.

Sharing credentials, workspaces, caches, or context across tenants and roles without explicit policy.

Allowing AI-generated plans, policies, or changes to bypass deterministic validation and human authority.

Declaring recovery after process restart without reconciling orphan effects, leases, artifacts, and evidence.

Validation and evidence

Method	Expected evidence
Examine	Requirements, APIs, identities, state machines, policies, versions, resources, and dependencies for progressive delivery and experimentation.
Observe	Queue, task, controller, model, tool, route, proxy, event, resource, trace, artifact, and user-visible state.
Test	Expected, prohibited, malformed, duplicate, overloaded, partitioned, failed, recovery, upgrade, and rollback conditions.
Measure	Task success, reliability, latency, throughput, fairness, cost, token and compute use, blast radius, and operator burden.
Reconcile	Desired and planned state against actual cloud, cluster, agent, network, data, external-effect, and evidence state.

Chapter 05 laboratory and review

Practical laboratory
Run a service failure test comparing safe retry budgets with an uncontrolled retry storm.

Laboratory evidence package

- Architecture or topology showing boundaries, identities, dependencies, and authoritative inputs.
- Versioned configuration or code with explanatory comments and reproducible setup instructions.
- Nominal-path validation plus at least two injected failure or boundary conditions.
- Structured logs, traces, metrics, packet captures, test output, or other appropriate evidence.
- A concise decision record covering findings, limitations, residual risks, and next actions.

Frontier extension

Explore adaptive traffic policy driven by causal SLO evidence.

Review gate
Advance only when another engineer can reproduce the result, explain the architecture, identify the failure boundary, and distinguish measured evidence from assumptions or projections.

CHAPTER 06

Mesh deployment patterns and lifecycle

Choose sidecar, ambient, gateway, or proxyless integration according to constraints.

Chapter operating position
Choose sidecar, ambient, gateway, or proxyless integration according to constraints.

6.1 Sidecar architecture

Sidecar architecture must be engineered as a governed distributed-system mechanism, not a product label, agent persona, YAML object, or diagram. Understand injection, per-pod proxy, resource cost, interception, ordering, upgrades, and failure. The design should identify authoritative state, workload identities, typed contracts, resource and token budgets, trust boundaries, failure domains, telemetry, rollback, and acceptance evidence.

This guide traces the subject through the client, gateway, route, proxy, identity, policy, upstream, service, return path, telemetry, and agent or user outcome chain. A running agent, reconciled object, successful API call, healthy proxy, or completed function is not proof of the intended outcome. Desired state must be compared with applied state, external effects, negative tests, degraded behavior, causal evidence, cost, and user or mission results.

Production engineering begins with a minimal known-good control plane and explicit invariants. Add one worker class, model route, controller, policy, event source, gateway, or platform feature at a time; preserve before-state evidence; test authorized and prohibited behavior; inject realistic failures; and retain a tested compensation or rollback path.

Troubleshooting locates the first divergence from the expected state machine. Account for stale watches, leases, retries, eventual consistency, duplicated work, cache state, identity rotation, partial external effects, version skew, prompt injection, overload, network partitions, and missing telemetry. Closure requires causal explanation, reproducibility, validated recovery, and residual limitations.

Engineering practices

- Define authority, ownership, desired state, dependencies, limits, and evidence for sidecar architecture.
- Use typed APIs, stable identities, explicit state machines, idempotency, and bounded effects.
- Separate control plane, execution plane, data plane, evidence plane, and human decision authority.
- Test nominal, prohibited, overloaded, partitioned, partially failed, recovery, upgrade, and rollback cases.
- Preserve configuration, policy, model, source, trace, event, artifact, approval, and user-outcome evidence.
- Scale through quotas, queues, backpressure, fairness, isolation, canaries, and deterministic fan-in.

Failure patterns

- Treating sidecar architecture as a feature rather than an end-to-end stateful system.
- Scaling worker count or deployment scope before bounding queues, budgets, retries, and fan-in.
- Trusting controller, agent, or proxy status without validating external state and user outcome.
- Sharing credentials, workspaces, caches, or context across tenants and roles without explicit policy.
- Allowing AI-generated plans, policies, or changes to bypass deterministic validation and human authority.
- Declaring recovery after process restart without reconciling orphan effects, leases, artifacts, and evidence.

Validation and evidence

Method	Expected evidence
Examine	Requirements, APIs, identities, state machines, policies, versions, resources, and dependencies for sidecar architecture.
Observe	Queue, task, controller, model, tool, route, proxy, event, resource, trace, artifact, and user-visible state.
Test	Expected, prohibited, malformed, duplicate, overloaded, partitioned, failed, recovery, upgrade, and rollback conditions.
Measure	Task success, reliability, latency, throughput, fairness, cost, token and compute use, blast radius, and operator burden.
Reconcile	Desired and planned state against actual cloud, cluster, agent, network, data, external-effect, and evidence state.

6.2 Ambient and node-level data planes

Ambient and node-level data planes must be engineered as a governed distributed-system mechanism, not a product label, agent persona, YAML object, or diagram. Separate secure transport from L7 policy and evaluate blast radius, visibility, and operations. The design should identify authoritative state, workload identities, typed contracts, resource and token budgets, trust boundaries, failure domains, telemetry, rollback, and acceptance evidence.

This guide traces the subject through the client, gateway, route, proxy, identity, policy, upstream, service, return path, telemetry, and agent or user outcome chain. A running agent, reconciled object, successful API call, healthy proxy, or completed function is not proof of the intended outcome. Desired state must be compared with applied state, external effects, negative tests, degraded behavior, causal evidence, cost, and user or mission results.

Production engineering begins with a minimal known-good control plane and explicit invariants. Add one worker class, model route, controller, policy, event source, gateway, or platform feature at a time; preserve before-state evidence; test authorized and prohibited behavior; inject realistic failures; and retain a tested compensation or rollback path.

Troubleshooting locates the first divergence from the expected state machine. Account for stale watches, leases, retries, eventual consistency, duplicated work, cache state, identity rotation, partial external effects, version skew, prompt injection, overload, network partitions, and missing telemetry. Closure requires causal explanation, reproducibility, validated recovery, and residual limitations.

Engineering practices

- Define authority, ownership, desired state, dependencies, limits, and evidence for ambient and node-level data planes.
- Use typed APIs, stable identities, explicit state machines, idempotency, and bounded effects.
- Separate control plane, execution plane, data plane, evidence plane, and human decision authority.
- Test nominal, prohibited, overloaded, partitioned, partially failed, recovery, upgrade, and rollback cases.
- Preserve configuration, policy, model, source, trace, event, artifact, approval, and user-outcome evidence.
- Scale through quotas, queues, backpressure, fairness, isolation, canaries, and deterministic fan-in.

Implementation sketch

```
traffic_policy:
  source_identity: spiffe://mythos/agent/planner
  destination: mcp://deployment-tools
  protocol: http2-streaming
  authorization:
    scopes: [deploy:canary]
  routing:
    model_backend: capability-aware
    retry_budget: 0.05
    timeout_seconds: 300
  safety:
    prompt_injection_filter: enabled
    production_confirmation: required
  telemetry:
    trace_mission_and_tool_effects: true
```

Failure patterns

- Treating ambient and node-level data planes as a feature rather than an end-to-end stateful system.

Scaling worker count or deployment scope before bounding queues, budgets, retries, and fan-in.

Trusting controller, agent, or proxy status without validating external state and user outcome.

Sharing credentials, workspaces, caches, or context across tenants and roles without explicit policy.

Allowing AI-generated plans, policies, or changes to bypass deterministic validation and human authority.

Declaring recovery after process restart without reconciling orphan effects, leases, artifacts, and evidence.

Validation and evidence

Method	Expected evidence
Examine	Requirements, APIs, identities, state machines, policies, versions, resources, and dependencies for ambient and node-level data planes.
Observe	Queue, task, controller, model, tool, route, proxy, event, resource, trace, artifact, and user-visible state.
Test	Expected, prohibited, malformed, duplicate, overloaded, partitioned, failed, recovery, upgrade, and rollback conditions.
Measure	Task success, reliability, latency, throughput, fairness, cost, token and compute use, blast radius, and operator burden.
Reconcile	Desired and planned state against actual cloud, cluster, agent, network, data, external-effect, and evidence state.

6.3 Gateway and proxyless patterns

Gateway and proxyless patterns must be engineered as a governed distributed-system mechanism, not a product label, agent persona, YAML object, or diagram. Use shared proxies, client libraries, service discovery, and application integration. The design should identify authoritative state, workload identities, typed contracts, resource and token budgets, trust boundaries, failure domains, telemetry, rollback, and acceptance evidence.

This guide traces the subject through the client, gateway, route, proxy, identity, policy, upstream, service, return path, telemetry, and agent or user outcome chain. A running agent, reconciled object, successful API call, healthy proxy, or completed function is not proof of the intended outcome. Desired state must be compared with applied state, external effects, negative tests, degraded behavior, causal evidence, cost, and user or mission results.

Production engineering begins with a minimal known-good control plane and explicit invariants. Add one worker class, model route, controller, policy, event source, gateway, or platform feature at a time; preserve before-state evidence; test authorized and prohibited behavior; inject realistic failures; and retain a tested compensation or rollback path.

Troubleshooting locates the first divergence from the expected state machine. Account for stale watches, leases, retries, eventual consistency, duplicated work, cache state, identity rotation, partial external effects, version skew, prompt injection, overload, network partitions, and missing telemetry. Closure requires causal explanation, reproducibility, validated recovery, and residual limitations.

Engineering practices

Define authority, ownership, desired state, dependencies, limits, and evidence for gateway and proxyless patterns.

Use typed APIs, stable identities, explicit state machines, idempotency, and bounded effects.

Separate control plane, execution plane, data plane, evidence plane, and human decision authority.

Test nominal, prohibited, overloaded, partitioned, partially failed, recovery, upgrade, and rollback cases.

Preserve configuration, policy, model, source, trace, event, artifact, approval, and user-outcome evidence.

Scale through quotas, queues, backpressure, fairness, isolation, canaries, and deterministic fan-in.

Failure patterns

Treating gateway and proxyless patterns as a feature rather than an end-to-end stateful system.

Scaling worker count or deployment scope before bounding queues, budgets, retries, and fan-in.

Trusting controller, agent, or proxy status without validating external state and user outcome.

Sharing credentials, workspaces, caches, or context across tenants and roles without explicit policy.

Allowing AI-generated plans, policies, or changes to bypass deterministic validation and human authority.

Declaring recovery after process restart without reconciling orphan effects, leases, artifacts, and evidence.

Validation and evidence

Method	Expected evidence
Examine	Requirements, APIs, identities, state machines, policies, versions, resources, and dependencies for gateway and proxyless patterns.
Observe	Queue, task, controller, model, tool, route, proxy, event, resource, trace, artifact, and user-visible state.
Test	Expected, prohibited, malformed, duplicate, overloaded, partitioned, failed, recovery, upgrade, and rollback conditions.
Measure	Task success, reliability, latency, throughput, fairness, cost, token and compute use, blast radius, and operator burden.
Reconcile	Desired and planned state against actual cloud, cluster, agent, network, data, external-effect, and evidence state.

6.4 Upgrade and compatibility

Upgrade and compatibility must be engineered as a governed distributed-system mechanism, not a product label, agent persona, YAML object, or diagram. Manage control/data-plane skew, revisions, canaries, CRDs, APIs, certificates, rollback, and workload disruption. The design should identify authoritative state, workload identities, typed contracts, resource and token budgets, trust boundaries, failure domains, telemetry, rollback, and acceptance evidence.

This guide traces the subject through the client, gateway, route, proxy, identity, policy, upstream, service, return path, telemetry, and agent or user outcome chain. A running agent, reconciled object, successful API call, healthy proxy, or completed function is not proof of the intended outcome. Desired state must be compared with applied state, external effects, negative tests, degraded behavior, causal evidence, cost, and user or mission results.

Production engineering begins with a minimal known-good control plane and explicit invariants. Add one worker class, model route, controller, policy, event source, gateway, or platform feature at a time; preserve before-state evidence; test authorized and prohibited behavior; inject realistic failures; and retain a tested compensation or rollback path.

Troubleshooting locates the first divergence from the expected state machine. Account for stale watches, leases, retries, eventual consistency, duplicated work, cache state, identity rotation, partial external effects, version skew, prompt injection, overload, network partitions, and missing telemetry. Closure requires causal explanation, reproducibility, validated recovery, and residual limitations.

Engineering practices

Define authority, ownership, desired state, dependencies, limits, and evidence for upgrade and compatibility.

Use typed APIs, stable identities, explicit state machines, idempotency, and bounded effects.

Separate control plane, execution plane, data plane, evidence plane, and human decision authority.

Test nominal, prohibited, overloaded, partitioned, partially failed, recovery, upgrade, and rollback cases.

Preserve configuration, policy, model, source, trace, event, artifact, approval, and user-outcome evidence.

Scale through quotas, queues, backpressure, fairness, isolation, canaries, and deterministic fan-in.

Failure patterns

Treating upgrade and compatibility as a feature rather than an end-to-end stateful system.

Scaling worker count or deployment scope before bounding queues, budgets, retries, and fan-in.

Trusting controller, agent, or proxy status without validating external state and user outcome.

Sharing credentials, workspaces, caches, or context across tenants and roles without explicit policy.

Allowing AI-generated plans, policies, or changes to bypass deterministic validation and human authority.

Declaring recovery after process restart without reconciling orphan effects, leases, artifacts, and evidence.

Validation and evidence

Method	Expected evidence
Examine	Requirements, APIs, identities, state machines, policies, versions, resources, and dependencies for upgrade and compatibility.
Observe	Queue, task, controller, model, tool, route, proxy, event, resource, trace, artifact, and user-visible state.
Test	Expected, prohibited, malformed, duplicate, overloaded, partitioned, failed, recovery, upgrade, and rollback conditions.
Measure	Task success, reliability, latency, throughput, fairness, cost, token and compute use, blast radius, and operator burden.
Reconcile	Desired and planned state against actual cloud, cluster, agent, network, data, external-effect, and evidence state.

Chapter 06 laboratory and review

Practical laboratory
Create an upgrade plan comparing sidecar and ambient meshes across two Kubernetes versions and mixed workloads.

Laboratory evidence package

- Architecture or topology showing boundaries, identities, dependencies, and authoritative inputs.
- Versioned configuration or code with explanatory comments and reproducible setup instructions.
- Nominal-path validation plus at least two injected failure or boundary conditions.
- Structured logs, traces, metrics, packet captures, test output, or other appropriate evidence.
- A concise decision record covering findings, limitations, residual risks, and next actions.

Frontier extension

Explore dynamically selected traffic enforcement per service and request.

Review gate
Advance only when another engineer can reproduce the result, explain the architecture, identify the failure boundary, and distinguish measured evidence from assumptions or projections.

CHAPTER 07

Observability, troubleshooting, and multi-cluster

Correlate application symptoms with proxy, policy, identity, network, and control state.

Chapter operating position
Correlate application symptoms with proxy, policy, identity, network, and control state.

7.1 Traffic telemetry

Traffic telemetry must be engineered as a governed distributed-system mechanism, not a product label, agent persona, YAML object, or diagram. Collect traces, metrics, access logs, flow, TLS, routing, retry, policy, and upstream health. The design should identify authoritative state, workload identities, typed contracts, resource and token budgets, trust boundaries, failure domains, telemetry, rollback, and acceptance evidence.

This guide traces the subject through the client, gateway, route, proxy, identity, policy, upstream, service, return path, telemetry, and agent or user outcome chain. A running agent, reconciled object, successful API call, healthy proxy, or completed function is not proof of the intended outcome. Desired state must be compared with applied state, external effects, negative tests, degraded behavior, causal evidence, cost, and user or mission results.

Production engineering begins with a minimal known-good control plane and explicit invariants. Add one worker class, model route, controller, policy, event source, gateway, or platform feature at a time; preserve before-state evidence; test authorized and prohibited behavior; inject realistic failures; and retain a tested compensation or rollback path.

Troubleshooting locates the first divergence from the expected state machine. Account for stale watches, leases, retries, eventual consistency, duplicated work, cache state, identity rotation, partial external effects, version skew, prompt injection, overload, network partitions, and missing telemetry. Closure requires causal explanation, reproducibility, validated recovery, and residual limitations.

Engineering practices

- Define authority, ownership, desired state, dependencies, limits, and evidence for traffic telemetry.
- Use typed APIs, stable identities, explicit state machines, idempotency, and bounded effects.
- Separate control plane, execution plane, data plane, evidence plane, and human decision authority.
- Test nominal, prohibited, overloaded, partitioned, partially failed, recovery, upgrade, and rollback cases.
- Preserve configuration, policy, model, source, trace, event, artifact, approval, and user-outcome evidence.
- Scale through quotas, queues, backpressure, fairness, isolation, canaries, and deterministic fan-in.

Failure patterns

- Treating traffic telemetry as a feature rather than an end-to-end stateful system.
- Scaling worker count or deployment scope before bounding queues, budgets, retries, and fan-in.
- Trusting controller, agent, or proxy status without validating external state and user outcome.
- Sharing credentials, workspaces, caches, or context across tenants and roles without explicit policy.
- Allowing AI-generated plans, policies, or changes to bypass deterministic validation and human authority.
- Declaring recovery after process restart without reconciling orphan effects, leases, artifacts, and evidence.

Validation and evidence

Method	Expected evidence
Examine	Requirements, APIs, identities, state machines, policies, versions, resources, and dependencies for traffic telemetry.
Observe	Queue, task, controller, model, tool, route, proxy, event, resource, trace, artifact, and user-visible state.
Test	Expected, prohibited, malformed, duplicate, overloaded, partitioned, failed, recovery, upgrade, and rollback conditions.
Measure	Task success, reliability, latency, throughput, fairness, cost, token and compute use, blast radius, and operator burden.
Reconcile	Desired and planned state against actual cloud, cluster, agent, network, data, external-effect, and evidence state.

7.2 Troubleshooting workflow

Troubleshooting workflow must be engineered as a governed distributed-system mechanism, not a product label, agent persona, YAML object, or diagram. Verify client, gateway, DNS, route, proxy config, identity, policy, endpoint, network, application, and return. The design should identify authoritative state, workload identities, typed contracts, resource and token budgets, trust boundaries, failure domains, telemetry, rollback, and acceptance evidence.

This guide traces the subject through the client, gateway, route, proxy, identity, policy, upstream, service, return path, telemetry, and agent or user outcome chain. A running agent, reconciled object, successful API call, healthy proxy, or completed function is not proof of the intended outcome. Desired state must be compared with applied state, external effects, negative tests, degraded behavior, causal evidence, cost, and user or mission results.

Production engineering begins with a minimal known-good control plane and explicit invariants. Add one worker class, model route, controller, policy, event source, gateway, or platform feature at a time; preserve before-state evidence; test authorized and prohibited behavior; inject realistic failures; and retain a tested compensation or rollback path.

Troubleshooting locates the first divergence from the expected state machine. Account for stale watches, leases, retries, eventual consistency, duplicated work, cache state, identity rotation, partial external effects, version skew, prompt injection, overload, network partitions, and missing telemetry. Closure requires causal explanation, reproducibility, validated recovery, and residual limitations.

Engineering practices

- Define authority, ownership, desired state, dependencies, limits, and evidence for troubleshooting workflow.
- Use typed APIs, stable identities, explicit state machines, idempotency, and bounded effects.
- Separate control plane, execution plane, data plane, evidence plane, and human decision authority.
- Test nominal, prohibited, overloaded, partitioned, partially failed, recovery, upgrade, and rollback cases.
- Preserve configuration, policy, model, source, trace, event, artifact, approval, and user-outcome evidence.
- Scale through quotas, queues, backpressure, fairness, isolation, canaries, and deterministic fan-in.

Implementation sketch

```
traffic_policy:
  source_identity: spiffe://mythos/agent/planner
  destination: mcp://deployment-tools
  protocol: http2-streaming
  authorization:
    scopes: [deploy:canary]
  routing:
    model_backend: capability-aware
    retry_budget: 0.05
    timeout_seconds: 300
  safety:
    prompt_injection_filter: enabled
    production_confirmation: required
  telemetry:
    trace_mission_and_tool_effects: true
```

Failure patterns

- Treating troubleshooting workflow as a feature rather than an end-to-end stateful system.

Scaling worker count or deployment scope before bounding queues, budgets, retries, and fan-in.

Trusting controller, agent, or proxy status without validating external state and user outcome.

Sharing credentials, workspaces, caches, or context across tenants and roles without explicit policy.

Allowing AI-generated plans, policies, or changes to bypass deterministic validation and human authority.

Declaring recovery after process restart without reconciling orphan effects, leases, artifacts, and evidence.

Validation and evidence

Method	Expected evidence
Examine	Requirements, APIs, identities, state machines, policies, versions, resources, and dependencies for troubleshooting workflow.
Observe	Queue, task, controller, model, tool, route, proxy, event, resource, trace, artifact, and user-visible state.
Test	Expected, prohibited, malformed, duplicate, overloaded, partitioned, failed, recovery, upgrade, and rollback conditions.
Measure	Task success, reliability, latency, throughput, fairness, cost, token and compute use, blast radius, and operator burden.
Reconcile	Desired and planned state against actual cloud, cluster, agent, network, data, external-effect, and evidence state.

7.3 Multi-cluster and multi-network

Multi-cluster and multi-network must be engineered as a governed distributed-system mechanism, not a product label, agent persona, YAML object, or diagram. Design discovery, gateways, trust, routing, failover, locality, sovereignty, and split brain. The design should identify authoritative state, workload identities, typed contracts, resource and token budgets, trust boundaries, failure domains, telemetry, rollback, and acceptance evidence.

This guide traces the subject through the client, gateway, route, proxy, identity, policy, upstream, service, return path, telemetry, and agent or user outcome chain. A running agent, reconciled object, successful API call, healthy proxy, or completed function is not proof of the intended outcome. Desired state must be compared with applied state, external effects, negative tests, degraded behavior, causal evidence, cost, and user or mission results.

Production engineering begins with a minimal known-good control plane and explicit invariants. Add one worker class, model route, controller, policy, event source, gateway, or platform feature at a time; preserve before-state evidence; test authorized and prohibited behavior; inject realistic failures; and retain a tested compensation or rollback path.

Troubleshooting locates the first divergence from the expected state machine. Account for stale watches, leases, retries, eventual consistency, duplicated work, cache state, identity rotation, partial external effects, version skew, prompt injection, overload, network partitions, and missing telemetry. Closure requires causal explanation, reproducibility, validated recovery, and residual limitations.

Engineering practices

Define authority, ownership, desired state, dependencies, limits, and evidence for multi-cluster and multi-network.

Use typed APIs, stable identities, explicit state machines, idempotency, and bounded effects.

Separate control plane, execution plane, data plane, evidence plane, and human decision authority.

Test nominal, prohibited, overloaded, partitioned, partially failed, recovery, upgrade, and rollback cases.

Preserve configuration, policy, model, source, trace, event, artifact, approval, and user-outcome evidence.

Scale through quotas, queues, backpressure, fairness, isolation, canaries, and deterministic fan-in.

Failure patterns

Treating multi-cluster and multi-network as a feature rather than an end-to-end stateful system.

Scaling worker count or deployment scope before bounding queues, budgets, retries, and fan-in.

Trusting controller, agent, or proxy status without validating external state and user outcome.

Sharing credentials, workspaces, caches, or context across tenants and roles without explicit policy.

Allowing AI-generated plans, policies, or changes to bypass deterministic validation and human authority.

Declaring recovery after process restart without reconciling orphan effects, leases, artifacts, and evidence.

Validation and evidence

Method	Expected evidence
Examine	Requirements, APIs, identities, state machines, policies, versions, resources, and dependencies for multi-cluster and multi-network.
Observe	Queue, task, controller, model, tool, route, proxy, event, resource, trace, artifact, and user-visible state.
Test	Expected, prohibited, malformed, duplicate, overloaded, partitioned, failed, recovery, upgrade, and rollback conditions.
Measure	Task success, reliability, latency, throughput, fairness, cost, token and compute use, blast radius, and operator burden.
Reconcile	Desired and planned state against actual cloud, cluster, agent, network, data, external-effect, and evidence state.

7.4 Egress and external services

Egress and external services must be engineered as a governed distributed-system mechanism, not a product label, agent persona, YAML object, or diagram. Control DNS, service entries, gateways, TLS origination, allowlists, data loss, and third parties. The design should identify authoritative state, workload identities, typed contracts, resource and token budgets, trust boundaries, failure domains, telemetry, rollback, and acceptance evidence.

This guide traces the subject through the client, gateway, route, proxy, identity, policy, upstream, service, return path, telemetry, and agent or user outcome chain. A running agent, reconciled object, successful API call, healthy proxy, or completed function is not proof of the intended outcome. Desired state must be compared with applied state, external effects, negative tests, degraded behavior, causal evidence, cost, and user or mission results.

Production engineering begins with a minimal known-good control plane and explicit invariants. Add one worker class, model route, controller, policy, event source, gateway, or platform feature at a time; preserve before-state evidence; test authorized and prohibited behavior; inject realistic failures; and retain a tested compensation or rollback path.

Troubleshooting locates the first divergence from the expected state machine. Account for stale watches, leases, retries, eventual consistency, duplicated work, cache state, identity rotation, partial external effects, version skew, prompt injection, overload, network partitions, and missing telemetry. Closure requires causal explanation, reproducibility, validated recovery, and residual limitations.

Engineering practices

Define authority, ownership, desired state, dependencies, limits, and evidence for egress and external services.

Use typed APIs, stable identities, explicit state machines, idempotency, and bounded effects.

Separate control plane, execution plane, data plane, evidence plane, and human decision authority.

Test nominal, prohibited, overloaded, partitioned, partially failed, recovery, upgrade, and rollback cases.

Preserve configuration, policy, model, source, trace, event, artifact, approval, and user-outcome evidence.

Scale through quotas, queues, backpressure, fairness, isolation, canaries, and deterministic fan-in.

Failure patterns

Treating egress and external services as a feature rather than an end-to-end stateful system.

Scaling worker count or deployment scope before bounding queues, budgets, retries, and fan-in.

Trusting controller, agent, or proxy status without validating external state and user outcome.

Sharing credentials, workspaces, caches, or context across tenants and roles without explicit policy.

Allowing AI-generated plans, policies, or changes to bypass deterministic validation and human authority.

Declaring recovery after process restart without reconciling orphan effects, leases, artifacts, and evidence.

Validation and evidence

Method	Expected evidence
Examine	Requirements, APIs, identities, state machines, policies, versions, resources, and dependencies for egress and external services.
Observe	Queue, task, controller, model, tool, route, proxy, event, resource, trace, artifact, and user-visible state.
Test	Expected, prohibited, malformed, duplicate, overloaded, partitioned, failed, recovery, upgrade, and rollback conditions.
Measure	Task success, reliability, latency, throughput, fairness, cost, token and compute use, blast radius, and operator burden.
Reconcile	Desired and planned state against actual cloud, cluster, agent, network, data, external-effect, and evidence state.

Chapter 07 laboratory and review

Practical laboratory
Troubleshoot an intermittent cross-cluster service caused by stale discovery, certificate skew, and locality failover.

Laboratory evidence package

- Architecture or topology showing boundaries, identities, dependencies, and authoritative inputs.
- Versioned configuration or code with explanatory comments and reproducible setup instructions.
- Nominal-path validation plus at least two injected failure or boundary conditions.
- Structured logs, traces, metrics, packet captures, test output, or other appropriate evidence.
- A concise decision record covering findings, limitations, residual risks, and next actions.

Frontier extension

Explore global mesh fabrics with sovereign policy and verifiable route intent.

Review gate
Advance only when another engineer can reproduce the result, explain the architecture, identify the failure boundary, and distinguish measured evidence from assumptions or projections.

CHAPTER 08

AI-agent and model traffic frontier

Extend traffic engineering to MCP, A2A, inference, and long-running agent interactions.

Chapter operating position
Extend traffic engineering to MCP, A2A, inference, and long-running agent interactions.

8.1 Inference and streaming traffic

Inference and streaming traffic must be engineered as a governed distributed-system mechanism, not a product label, agent persona, YAML object, or diagram. Handle large prompts, streaming responses, long requests, cancellations, retries, affinity, and model backends. The design should identify authoritative state, workload identities, typed contracts, resource and token budgets, trust boundaries, failure domains, telemetry, rollback, and acceptance evidence.

This guide traces the subject through the client, gateway, route, proxy, identity, policy, upstream, service, return path, telemetry, and agent or user outcome chain. A running agent, reconciled object, successful API call, healthy proxy, or completed function is not proof of the intended outcome. Desired state must be compared with applied state, external effects, negative tests, degraded behavior, causal evidence, cost, and user or mission results.

Production engineering begins with a minimal known-good control plane and explicit invariants. Add one worker class, model route, controller, policy, event source, gateway, or platform feature at a time; preserve before-state evidence; test authorized and prohibited behavior; inject realistic failures; and retain a tested compensation or rollback path.

Troubleshooting locates the first divergence from the expected state machine. Account for stale watches, leases, retries, eventual consistency, duplicated work, cache state, identity rotation, partial external effects, version skew, prompt injection, overload, network partitions, and missing telemetry. Closure requires causal explanation, reproducibility, validated recovery, and residual limitations.

Engineering practices

- Define authority, ownership, desired state, dependencies, limits, and evidence for inference and streaming traffic.
- Use typed APIs, stable identities, explicit state machines, idempotency, and bounded effects.
- Separate control plane, execution plane, data plane, evidence plane, and human decision authority.
- Test nominal, prohibited, overloaded, partitioned, partially failed, recovery, upgrade, and rollback cases.
- Preserve configuration, policy, model, source, trace, event, artifact, approval, and user-outcome evidence.
- Scale through quotas, queues, backpressure, fairness, isolation, canaries, and deterministic fan-in.

Failure patterns

- Treating inference and streaming traffic as a feature rather than an end-to-end stateful system.
- Scaling worker count or deployment scope before bounding queues, budgets, retries, and fan-in.
- Trusting controller, agent, or proxy status without validating external state and user outcome.
- Sharing credentials, workspaces, caches, or context across tenants and roles without explicit policy.
- Allowing AI-generated plans, policies, or changes to bypass deterministic validation and human authority.
- Declaring recovery after process restart without reconciling orphan effects, leases, artifacts, and evidence.

Validation and evidence

Method	Expected evidence
Examine	Requirements, APIs, identities, state machines, policies, versions, resources, and dependencies for inference and streaming traffic.
Observe	Queue, task, controller, model, tool, route, proxy, event, resource, trace, artifact, and user-visible state.
Test	Expected, prohibited, malformed, duplicate, overloaded, partitioned, failed, recovery, upgrade, and rollback conditions.
Measure	Task success, reliability, latency, throughput, fairness, cost, token and compute use, blast radius, and operator burden.
Reconcile	Desired and planned state against actual cloud, cluster, agent, network, data, external-effect, and evidence state.

8.2 MCP and capability gateways

MCP and capability gateways must be engineered as a governed distributed-system mechanism, not a product label, agent persona, YAML object, or diagram. Discover servers, authorize tools, inspect schemas, route tenants, limit effects, and preserve evidence. The design should identify authoritative state, workload identities, typed contracts, resource and token budgets, trust boundaries, failure domains, telemetry, rollback, and acceptance evidence.

This guide traces the subject through the client, gateway, route, proxy, identity, policy, upstream, service, return path, telemetry, and agent or user outcome chain. A running agent, reconciled object, successful API call, healthy proxy, or completed function is not proof of the intended outcome. Desired state must be compared with applied state, external effects, negative tests, degraded behavior, causal evidence, cost, and user or mission results.

Production engineering begins with a minimal known-good control plane and explicit invariants. Add one worker class, model route, controller, policy, event source, gateway, or platform feature at a time; preserve before-state evidence; test authorized and prohibited behavior; inject realistic failures; and retain a tested compensation or rollback path.

Troubleshooting locates the first divergence from the expected state machine. Account for stale watches, leases, retries, eventual consistency, duplicated work, cache state, identity rotation, partial external effects, version skew, prompt injection, overload, network partitions, and missing telemetry. Closure requires causal explanation, reproducibility, validated recovery, and residual limitations.

Engineering practices

- Define authority, ownership, desired state, dependencies, limits, and evidence for mcp and capability gateways.
- Use typed APIs, stable identities, explicit state machines, idempotency, and bounded effects.
- Separate control plane, execution plane, data plane, evidence plane, and human decision authority.
- Test nominal, prohibited, overloaded, partitioned, partially failed, recovery, upgrade, and rollback cases.
- Preserve configuration, policy, model, source, trace, event, artifact, approval, and user-outcome evidence.
- Scale through quotas, queues, backpressure, fairness, isolation, canaries, and deterministic fan-in.

Implementation sketch

```
traffic_policy:
  source_identity: spiffe://mythos/agent/planner
  destination: mcp://deployment-tools
  protocol: http2-streaming
  authorization:
    scopes: [deploy:canary]
  routing:
    model_backend: capability-aware
    retry_budget: 0.05
    timeout_seconds: 300
  safety:
    prompt_injection_filter: enabled
    production_confirmation: required
  telemetry:
    trace_mission_and_tool_effects: true
```

Failure patterns

Treating mcp and capability gateways as a feature rather than an end-to-end stateful system.

Scaling worker count or deployment scope before bounding queues, budgets, retries, and fan-in.

Trusting controller, agent, or proxy status without validating external state and user outcome.

Sharing credentials, workspaces, caches, or context across tenants and roles without explicit policy.

Allowing AI-generated plans, policies, or changes to bypass deterministic validation and human authority.

Declaring recovery after process restart without reconciling orphan effects, leases, artifacts, and evidence.

Validation and evidence

Method	Expected evidence
Examine	Requirements, APIs, identities, state machines, policies, versions, resources, and dependencies for mcp and capability gateways.
Observe	Queue, task, controller, model, tool, route, proxy, event, resource, trace, artifact, and user-visible state.
Test	Expected, prohibited, malformed, duplicate, overloaded, partitioned, failed, recovery, upgrade, and rollback conditions.
Measure	Task success, reliability, latency, throughput, fairness, cost, token and compute use, blast radius, and operator burden.
Reconcile	Desired and planned state against actual cloud, cluster, agent, network, data, external-effect, and evidence state.

8.3 A2A agent communication

A2A agent communication must be engineered as a governed distributed-system mechanism, not a product label, agent persona, YAML object, or diagram. Route agent cards, tasks, messages, artifacts, streaming updates, identity, and cross-organization policy. The design should identify authoritative state, workload identities, typed contracts, resource and token budgets, trust boundaries, failure domains, telemetry, rollback, and acceptance evidence.

This guide traces the subject through the client, gateway, route, proxy, identity, policy, upstream, service, return path, telemetry, and agent or user outcome chain. A running agent, reconciled object, successful API call, healthy proxy, or completed function is not proof of the intended outcome. Desired state must be compared with applied state, external effects, negative tests, degraded behavior, causal evidence, cost, and user or mission results.

Production engineering begins with a minimal known-good control plane and explicit invariants. Add one worker class, model route, controller, policy, event source, gateway, or platform feature at a time; preserve before-state evidence; test authorized and prohibited behavior; inject realistic failures; and retain a tested compensation or rollback path.

Troubleshooting locates the first divergence from the expected state machine. Account for stale watches, leases, retries, eventual consistency, duplicated work, cache state, identity rotation, partial external effects, version skew, prompt injection, overload, network partitions, and missing telemetry. Closure requires causal explanation, reproducibility, validated recovery, and residual limitations.

Engineering practices

Define authority, ownership, desired state, dependencies, limits, and evidence for a2a agent communication.

Use typed APIs, stable identities, explicit state machines, idempotency, and bounded effects.

Separate control plane, execution plane, data plane, evidence plane, and human decision authority.

Test nominal, prohibited, overloaded, partitioned, partially failed, recovery, upgrade, and rollback cases.

Preserve configuration, policy, model, source, trace, event, artifact, approval, and user-outcome evidence.

Scale through quotas, queues, backpressure, fairness, isolation, canaries, and deterministic fan-in.

Failure patterns

Treating a2a agent communication as a feature rather than an end-to-end stateful system.

Scaling worker count or deployment scope before bounding queues, budgets, retries, and fan-in.

Trusting controller, agent, or proxy status without validating external state and user outcome.

Sharing credentials, workspaces, caches, or context across tenants and roles without explicit policy.

Allowing AI-generated plans, policies, or changes to bypass deterministic validation and human authority.

Declaring recovery after process restart without reconciling orphan effects, leases, artifacts, and evidence.

Validation and evidence

Method	Expected evidence
Examine	Requirements, APIs, identities, state machines, policies, versions, resources, and dependencies for a2a agent communication.
Observe	Queue, task, controller, model, tool, route, proxy, event, resource, trace, artifact, and user-visible state.
Test	Expected, prohibited, malformed, duplicate, overloaded, partitioned, failed, recovery, upgrade, and rollback conditions.
Measure	Task success, reliability, latency, throughput, fairness, cost, token and compute use, blast radius, and operator burden.
Reconcile	Desired and planned state against actual cloud, cluster, agent, network, data, external-effect, and evidence state.

8.4 Agent-aware gateways

Agent-aware gateways must be engineered as a governed distributed-system mechanism, not a product label, agent persona, YAML object, or diagram. Apply model routing, token budgets, prompt-injection controls, semantic policy, observability, and safe fallbacks. The design should identify authoritative state, workload identities, typed contracts, resource and token budgets, trust boundaries, failure domains, telemetry, rollback, and acceptance evidence.

This guide traces the subject through the client, gateway, route, proxy, identity, policy, upstream, service, return path, telemetry, and agent or user outcome chain. A running agent, reconciled object, successful API call, healthy proxy, or completed function is not proof of the intended outcome. Desired state must be compared with applied state, external effects, negative tests, degraded behavior, causal evidence, cost, and user or mission results.

Production engineering begins with a minimal known-good control plane and explicit invariants. Add one worker class, model route, controller, policy, event source, gateway, or platform feature at a time; preserve before-state evidence; test authorized and prohibited behavior; inject realistic failures; and retain a tested compensation or rollback path.

Troubleshooting locates the first divergence from the expected state machine. Account for stale watches, leases, retries, eventual consistency, duplicated work, cache state, identity rotation, partial external effects, version skew, prompt injection, overload, network partitions, and missing telemetry. Closure requires causal explanation, reproducibility, validated recovery, and residual limitations.

Engineering practices

Define authority, ownership, desired state, dependencies, limits, and evidence for agent-aware gateways.

Use typed APIs, stable identities, explicit state machines, idempotency, and bounded effects.

Separate control plane, execution plane, data plane, evidence plane, and human decision authority.

Test nominal, prohibited, overloaded, partitioned, partially failed, recovery, upgrade, and rollback cases.

Preserve configuration, policy, model, source, trace, event, artifact, approval, and user-outcome evidence.

Scale through quotas, queues, backpressure, fairness, isolation, canaries, and deterministic fan-in.

Failure patterns

Treating agent-aware gateways as a feature rather than an end-to-end stateful system.

Scaling worker count or deployment scope before bounding queues, budgets, retries, and fan-in.

Trusting controller, agent, or proxy status without validating external state and user outcome.

Sharing credentials, workspaces, caches, or context across tenants and roles without explicit policy.

Allowing AI-generated plans, policies, or changes to bypass deterministic validation and human authority.

Declaring recovery after process restart without reconciling orphan effects, leases, artifacts, and evidence.

Validation and evidence

Method	Expected evidence
Examine	Requirements, APIs, identities, state machines, policies, versions, resources, and dependencies for agent-aware gateways.
Observe	Queue, task, controller, model, tool, route, proxy, event, resource, trace, artifact, and user-visible state.
Test	Expected, prohibited, malformed, duplicate, overloaded, partitioned, failed, recovery, upgrade, and rollback conditions.
Measure	Task success, reliability, latency, throughput, fairness, cost, token and compute use, blast radius, and operator burden.
Reconcile	Desired and planned state against actual cloud, cluster, agent, network, data, external-effect, and evidence state.

Chapter 08 laboratory and review

Practical laboratory
Design an agent gateway that fronts model inference, MCP servers, and A2A peers with identity, policy, streaming, and telemetry.

Laboratory evidence package

- Architecture or topology showing boundaries, identities, dependencies, and authoritative inputs.
- Versioned configuration or code with explanatory comments and reproducible setup instructions.
- Nominal-path validation plus at least two injected failure or boundary conditions.
- Structured logs, traces, metrics, packet captures, test output, or other appropriate evidence.
- A concise decision record covering findings, limitations, residual risks, and next actions.

Frontier extension

Explore agentgateway-style data planes and semantic traffic management as an experimental frontier.

Review gate
Advance only when another engineer can reproduce the result, explain the architecture, identify the failure boundary, and distinguish measured evidence from assumptions or projections.

Integrated learning roadmap

The guide is intended to be revisited. First establish fluency, then build a small implementation, operate it under failure, automate repeatable work, and finally evaluate emerging techniques against a stable baseline. Progress is demonstrated through evidence rather than reading completion alone.

Stage	Demonstrated capability
Foundation	Explain the system from first principles and trace its critical path without relying on product terminology.
Build	Implement the smallest representative system with explicit contracts, identities, telemetry, and tests.
Operate	Diagnose injected failures, recover safely, and preserve evidence of the causal chain.
Automate	Convert a proven manual workflow into bounded, idempotent, observable automation.
Architect	Design for scale, resilience, security, interoperability, and lifecycle change.
Explore	Evaluate frontier techniques using stated hypotheses, limitations, and adoption gates.

Source authority register

Source policy
Official standards, specifications, and project documentation remain with their issuing organizations. Mythos Systems provides original engineering interpretation, synthesis, implementation guidance, and relationship mapping. Source verification dates do not guarantee that an authority has not changed since review.

01. Kubernetes SIG Network - Gateway API
Role: Kubernetes-native role-oriented L4/L7 routing and service-mesh APIs.
Verified: 2026-07-26
Official source: https://gateway-api.sigs.k8s.io/docs/introduction/

02. Kubernetes SIG Network - Gateway API Specification
Role: Normative resource and field semantics.
Verified: 2026-07-26
Official source: https://gateway-api.sigs.k8s.io/reference/api-spec/

03. Istio - Istio Documentation
Role: Service-mesh traffic, security, telemetry, policy, and operations.
Verified: 2026-07-26
Official source: https://istio.io/latest/docs/

04. Istio - Istio 1.30 Release
Role: Current supported release including experimental agentgateway integration.
Verified: 2026-07-26
Official source: https://istio.io/latest/news/releases/1.30.x/announcing-1.30/

05. Envoy Proxy - Envoy Documentation
Role: L4/L7 data-plane proxy, xDS, routing, resilience, security, and telemetry.
Verified: 2026-07-26
Official source: https://www.envoyproxy.io/docs/envoy/latest/

06. Envoy Gateway - Envoy Gateway Documentation
Role: Gateway API implementation, traffic policy, security, and operations.
Verified: 2026-07-26
Official source: https://gateway.envoyproxy.io/latest/

07. SPIFFE - The SPIFFE Standard
Role: Workload identities, SVIDs, trust domains, federation, and Workload API.
Verified: 2026-07-26
Official source: https://spiffe.io/docs/latest/spiffe-specs/

08. Model Context Protocol - Model Context Protocol Specification 2025-11-25
Role: Stable protocol baseline for tool, resource, prompt, transport, authorization, lifecycle, and capability integration.
Verified: 2026-07-26
Official source: https://modelcontextprotocol.io/specification/2025-11-25

09. Agent2Agent Protocol - Agent2Agent Protocol Specification 1.0
Role: Open protocol for agent discovery, communication, task delegation, status, artifacts, and interoperability.
Verified: 2026-07-26
Official source: https://a2a-protocol.org/v1.0.0/

10. OpenTelemetry - OpenTelemetry
Role: Vendor-neutral telemetry APIs, SDKs, collectors, traces, metrics, and logs.
Verified: 2026-07-26
Official source: https://opentelemetry.io/

Authority application and refresh triggers

Authority class	Required library action
Protocols and specifications	Recheck interoperability, security considerations, defaults, and migration guidance when a referenced specification changes.
Security and assurance frameworks	Update control mappings, evidence expectations, risk language, and assessment procedures after material framework revision.
Languages, runtimes, and projects	Re-run examples, tests, deprecation checks, and operational recommendations against supported releases.
Benchmarks and evaluations	Re-execute claims when workloads, methods, models, compilers, drivers, hardware, or scoring rules change.
Operational evidence	Incorporate validated incidents, failure tests, reader corrections, and measured implementation outcomes into the next revision.

Limitations, freshness, and revision control

Boundary	Statement
Publication limitation	This guide synthesizes broad engineering practice. It does not replace product documentation, legal advice, safety certification, or environment-specific design review.
Evidence limitation	Not every pattern is benchmarked in every environment. Examples illustrate engineering methods and must be validated against actual versions, workloads, hardware, policy, and failure conditions.
Freshness limitation	Vendor behavior, software libraries, AI models, security threats, and emerging standards can change quickly. Volatile claims require source revalidation before operational adoption.
Adoption limitation	Frontier content is not an implicit adoption recommendation. Adoption requires defined value, qualification gates, controlled proof, rollback, ownership, and residual-risk acceptance.
Status boundary	Candidate Focused Field Guide describes the publication, not certification of a product, implementation, engineer, or organization.

Revision record

Version	Revision statement
1.0.0-candidate	Initial candidate living-guide edition. Published 2026-07-26; scheduled review 2026-10-26.

Search and relationship metadata

Dimension	Engineering position
Primary domain	MYTHOS-CLD - Cloud, Platform & Distributed Systems
Secondary domain	MYTHOS-NET; MYTHOS-SEC; MYTHOS-AI
Publication class	Field Guide / Canonical Living Overview Guide
Skill levels	L1 Foundational; L2 Practitioner; L3 Advanced; L4 Frontier
Tags	service mesh, API gateway, Gateway API, Istio, Envoy, SPIFFE, mTLS, east-west traffic, agent gateway, multi-cluster
Canonical route	/library/field-guides/mythos-fg-cld-0005/

Living publication

Corrections, expanded laboratories, improved diagrams, authority changes, and new engineering evidence should revise this permanent publication rather than create disconnected replacements.