



CANONICAL LIVING OVERVIEW GUIDE

Data-Center Networking, EVPN/VXLAN, and Fabric Architecture

An implementation-grade data-center networking guide covering leaf-spine fabrics, underlays, BGP EVPN, VXLAN, distributed gateways, multitenancy, multihoming, routing, DCI, automation, telemetry, security, capacity, and failure assurance.

PERMANENT PUBLICATION IDENTITY

Data-Center Networking, EVPN/VXLAN, and Fabric Architecture

Document ID
MYTHOS-FG-NET-0012

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 L1-L4

Foundational through frontier

CLASS FIELD GUIDE

Practical and educational

CADENCE QUARTERLY

Interim updates as needed

EVIDENCE SOURCE-BOUND

Limitations remain visible

Reader orientation

Dimension	Engineering position
Primary domain	MYTHOS-NET - Network Engineering & Architecture
Secondary domain	MYTHOS-CLD; MYTHOS-SEC; MYTHOS-DAT
Audience	Data-center, cloud, network, platform, security, and infrastructure automation engineers.
Prerequisites	Strong Ethernet, IP routing, BGP, and virtualization fundamentals.
Publisher / owner	Mythos Systems / Aaron Stovall
Public classification	Public technical guidance

Expected outcomes

Design scalable leaf-spine fabrics with explicit underlay, overlay, and service roles.

Trace EVPN routes, VXLAN encapsulation, MAC/IP learning, gateways, and multihoming.

Engineer multitenancy, DCI, cloud connectivity, and security without uncontrolled Layer-2 extension.

Automate fabric deployment and verify intended reachability before change.

Measure failure, convergence, scale, buffer, and application behavior under realistic load.

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

How to use this guide	3
Contents	3
Chapter 01 - Data-center requirements and traffic	5
Chapter 01 laboratory and review	10
Chapter 02 - Leaf-spine underlay design	11
Chapter 02 laboratory and review	16
Chapter 03 - EVPN control plane	17
Chapter 03 laboratory and review	22
Chapter 04 - VXLAN data plane and distributed gateways	23
Chapter 04 laboratory and review	28
Chapter 05 - Multihoming and endpoint attachment	29
Chapter 05 laboratory and review	34

Chapter 06 - Multitenancy, DCI, and cloud connectivity	35
Chapter 06 laboratory and review	40
Chapter 07 - Automation and observability	41
Chapter 07 laboratory and review	46
Chapter 08 - Scale, failure, and lifecycle assurance	47
Chapter 08 laboratory and review	52
Integrated learning roadmap	53
Source authority register	54
Limitations, freshness, and revision control	55

CHAPTER 01

Data-center requirements and traffic

Translate workload, storage, AI, virtualization, and operational requirements into fabric objectives.

Chapter operating position

Translate workload, storage, AI, virtualization, and operational requirements into fabric objectives.



1.1 East-west and north-south flows

East-west and north-south flows must be treated as an engineering mechanism rather than a product checkbox. Characterize workload communication, service chains, external access, replication, and failure dependencies. The design should name the authoritative inputs, state transitions, dependencies, limits, ownership, telemetry, expected output, and conditions that make the result unsafe or inconclusive.

The guide traces this subject through the underlay, EVPN route, VNI, gateway, multihoming, service, and forwarding chain. Configuration, controller health, or a green dashboard is never sufficient proof by itself. The engineer must reconcile intended state with protocol or platform state, installed forwarding or policy, real transactions, failure behavior, and the experience of the affected user, device, service, or application.

Implementation begins with a minimal, known-good baseline and explicit invariants. Introduce one capability or dependency at a time, validate positive and negative cases, inject realistic failures, measure recovery, and preserve before-and-after evidence. Automation must be idempotent, bounded, observable, reversible, and able to stop safely when inputs are stale or outcomes diverge.

Troubleshooting should locate the first divergence from the expected transaction or state machine. Inspect both directions and all authority boundaries; account for caching, eventual consistency, tunnels, load sharing, policy, identity, offload, time, and partial failure. Closure requires causal evidence, restored service, rollback proof, residual-risk disclosure, and prevention or monitoring actions.

Engineering practices

Define authority, ownership, scope, dependencies, and acceptance criteria for east-west and north-south flows.

Model the expected state and traffic path before implementation or troubleshooting.

Validate intent, control state, applied policy or forwarding state, and end-to-end service independently.

Test normal, denied, degraded, failed, recovery, upgrade, and rollback conditions.

Retain topology, configuration, packet, telemetry, log, identity, timing, and service evidence.

Automate through typed data, deterministic gates, canaries, bounded concurrency, and reversible changes.

Failure patterns

Treating east-west and north-south flows as a vendor feature instead of an end-to-end system.

Relying on intended configuration or controller state without proving applied and operational behavior.

Ignoring reverse paths, external dependencies, identity, time, or partial failure.

Changing several variables before preserving original evidence and stating a hypothesis.

Allowing automation or AI to act on stale, ambiguous, or unauthorized data.

Declaring success after one probe without negative tests, scale checks, rollback, and recurrence monitoring.

Validation and evidence

Method	Expected evidence
Examine	Requirements, topology, models, policy, configuration, ownership, and dependencies for east-west and north-south flows.
Observe	Control-plane or platform state, applied policy, forwarding state, telemetry, logs, and endpoint behavior.
Test	Expected traffic, prohibited traffic, dependency loss, partial failure, convergence, recovery, and rollback.
Measure	Availability, reachability, latency, loss, convergence, scale, resource use, change success, and user experience.
Reconcile	Intended state against observed platform, network, security, identity, application, and evidence records.

⊕ 1.2 Latency, bandwidth, and burst

Latency, bandwidth, and burst must be treated as an engineering mechanism rather than a product checkbox. Model oversubscription, elephant and mice flows, microbursts, RDMA, storage, and accelerator traffic. The design should name the authoritative inputs, state transitions, dependencies, limits, ownership, telemetry, expected output, and conditions that make the result unsafe or inconclusive.

The guide traces this subject through the underlay, EVPN route, VNI, gateway, multihoming, service, and forwarding chain. Configuration, controller health, or a green dashboard is never sufficient proof by itself. The engineer must reconcile intended state with protocol or platform state, installed forwarding or policy, real transactions, failure behavior, and the experience of the affected user, device, service, or application.

Implementation begins with a minimal, known-good baseline and explicit invariants. Introduce one capability or dependency at a time, validate positive and negative cases, inject realistic failures, measure recovery, and preserve before-and-after evidence. Automation must be idempotent, bounded, observable, reversible, and able to stop safely when inputs are stale or outcomes diverge.

Troubleshooting should locate the first divergence from the expected transaction or state machine. Inspect both directions and all authority boundaries; account for caching, eventual consistency, tunnels, load sharing, policy, identity, offload, time, and partial failure. Closure requires causal evidence, restored service, rollback proof, residual-risk disclosure, and prevention or monitoring actions.

Engineering practices

Define authority, ownership, scope, dependencies, and acceptance criteria for latency, bandwidth, and burst.

Model the expected state and traffic path before implementation or troubleshooting.

Validate intent, control state, applied policy or forwarding state, and end-to-end service independently.

Test normal, denied, degraded, failed, recovery, upgrade, and rollback conditions.

Retain topology, configuration, packet, telemetry, log, identity, timing, and service evidence.

Automate through typed data, deterministic gates, canaries, bounded concurrency, and reversible changes.

Implementation sketch

```
fabric:
  underlay: ebgp
  overlay: evpn-vxlan
  tenants:
    - name: payments
      vrf: PAYMENTS
      l3_vni: 50100
      route_targets: ["65000:50100"]
      segments:
        - {vlan: 110, l2_vni: 10110, gateway: 10.10.110.1/24}
  invariants:
    - no_route_target_leak
    - anycast_gateway_consistent
    - esi_multihoming_split_horizon
    - mtu_supports_vxlan
    - failure_paths_verified
```

Failure patterns

- Treating latency, bandwidth, and burst as a vendor feature instead of an end-to-end system.
- Relying on intended configuration or controller state without proving applied and operational behavior.
- Ignoring reverse paths, external dependencies, identity, time, or partial failure.
- Changing several variables before preserving original evidence and stating a hypothesis.
- Allowing automation or AI to act on stale, ambiguous, or unauthorized data.
- Declaring success after one probe without negative tests, scale checks, rollback, and recurrence monitoring.

Validation and evidence

Method	Expected evidence
Examine	Requirements, topology, models, policy, configuration, ownership, and dependencies for latency, bandwidth, and burst.
Observe	Control-plane or platform state, applied policy, forwarding state, telemetry, logs, and endpoint behavior.
Test	Expected traffic, prohibited traffic, dependency loss, partial failure, convergence, recovery, and rollback.
Measure	Availability, reachability, latency, loss, convergence, scale, resource use, change success, and user experience.
Reconcile	Intended state against observed platform, network, security, identity, application, and evidence records.

1.3 Tenancy and service boundaries

Tenancy and service boundaries must be treated as an engineering mechanism rather than a product checkbox. Define tenants, VRFs, segments, shared services, policy, observability, and lifecycle ownership. The design should name the authoritative inputs, state transitions, dependencies, limits, ownership, telemetry, expected output, and conditions that make the result unsafe or inconclusive.

The guide traces this subject through the underlay, EVPN route, VNI, gateway, multihoming, service, and forwarding chain. Configuration, controller health, or a green dashboard is never sufficient proof by itself. The engineer must reconcile intended state with protocol or platform state, installed forwarding or policy, real transactions, failure behavior, and the experience of the affected user, device, service, or application.

Implementation begins with a minimal, known-good baseline and explicit invariants. Introduce one capability or dependency at a time, validate positive and negative cases, inject realistic failures, measure recovery, and preserve before-and-after evidence. Automation must be idempotent, bounded, observable, reversible, and able to stop safely when inputs are stale or outcomes diverge.

Troubleshooting should locate the first divergence from the expected transaction or state machine. Inspect both directions and all authority boundaries; account for caching, eventual consistency, tunnels, load sharing, policy, identity, offload, time, and partial failure. Closure requires causal evidence, restored service, rollback proof, residual-risk disclosure, and prevention or monitoring actions.

Engineering practices

- Define authority, ownership, scope, dependencies, and acceptance criteria for tenancy and service boundaries.
- Model the expected state and traffic path before implementation or troubleshooting.
- Validate intent, control state, applied policy or forwarding state, and end-to-end service independently.
- Test normal, denied, degraded, failed, recovery, upgrade, and rollback conditions.
- Retain topology, configuration, packet, telemetry, log, identity, timing, and service evidence.
- Automate through typed data, deterministic gates, canaries, bounded concurrency, and reversible changes.

Failure patterns

- Treating tenancy and service boundaries as a vendor feature instead of an end-to-end system.
- Relying on intended configuration or controller state without proving applied and operational behavior.

Ignoring reverse paths, external dependencies, identity, time, or partial failure.

Changing several variables before preserving original evidence and stating a hypothesis.

Allowing automation or AI to act on stale, ambiguous, or unauthorized data.

Declaring success after one probe without negative tests, scale checks, rollback, and recurrence monitoring.

Validation and evidence

Method	Expected evidence
Examine	Requirements, topology, models, policy, configuration, ownership, and dependencies for tenancy and service boundaries.
Observe	Control-plane or platform state, applied policy, forwarding state, telemetry, logs, and endpoint behavior.
Test	Expected traffic, prohibited traffic, dependency loss, partial failure, convergence, recovery, and rollback.
Measure	Availability, reachability, latency, loss, convergence, scale, resource use, change success, and user experience.
Reconcile	Intended state against observed platform, network, security, identity, application, and evidence records.

1.4 Availability and maintenance

Availability and maintenance must be treated as an engineering mechanism rather than a product checkbox. Define rack, row, pod, fabric, controller, DCI, and service failure objectives. The design should name the authoritative inputs, state transitions, dependencies, limits, ownership, telemetry, expected output, and conditions that make the result unsafe or inconclusive.

The guide traces this subject through the underlay, EVPN route, VNI, gateway, multihoming, service, and forwarding chain. Configuration, controller health, or a green dashboard is never sufficient proof by itself. The engineer must reconcile intended state with protocol or platform state, installed forwarding or policy, real transactions, failure behavior, and the experience of the affected user, device, service, or application.

Implementation begins with a minimal, known-good baseline and explicit invariants. Introduce one capability or dependency at a time, validate positive and negative cases, inject realistic failures, measure recovery, and preserve before-and-after evidence. Automation must be idempotent, bounded, observable, reversible, and able to stop safely when inputs are stale or outcomes diverge.

Troubleshooting should locate the first divergence from the expected transaction or state machine. Inspect both directions and all authority boundaries; account for caching, eventual consistency, tunnels, load sharing, policy, identity, offload, time, and partial failure. Closure requires causal evidence, restored service, rollback proof, residual-risk disclosure, and prevention or monitoring actions.

Engineering practices

Define authority, ownership, scope, dependencies, and acceptance criteria for availability and maintenance.

Model the expected state and traffic path before implementation or troubleshooting.

Validate intent, control state, applied policy or forwarding state, and end-to-end service independently.

Test normal, denied, degraded, failed, recovery, upgrade, and rollback conditions.

Retain topology, configuration, packet, telemetry, log, identity, timing, and service evidence.

Automate through typed data, deterministic gates, canaries, bounded concurrency, and reversible changes.

Failure patterns

Treating availability and maintenance as a vendor feature instead of an end-to-end system.

Relying on intended configuration or controller state without proving applied and operational behavior.

Ignoring reverse paths, external dependencies, identity, time, or partial failure.

Changing several variables before preserving original evidence and stating a hypothesis.

Allowing automation or AI to act on stale, ambiguous, or unauthorized data.

Declaring success after one probe without negative tests, scale checks, rollback, and recurrence monitoring.

Validation and evidence

Method	Expected evidence
Examine	Requirements, topology, models, policy, configuration, ownership, and dependencies for availability and maintenance.
Observe	Control-plane or platform state, applied policy, forwarding state, telemetry, logs, and endpoint behavior.
Test	Expected traffic, prohibited traffic, dependency loss, partial failure, convergence, recovery, and rollback.
Measure	Availability, reachability, latency, loss, convergence, scale, resource use, change success, and user experience.
Reconcile	Intended state against observed platform, network, security, identity, application, and evidence records.

Chapter 01 laboratory and review

Practical laboratory

Create workload profiles for web, storage, virtualization, and AI clusters; derive topology, oversubscription, buffer, and failure requirements.

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

Extend the model to optical circuit switching, co-packaged optics, composable infrastructure, and AI-native fabrics.

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

Leaf-spine underlay design

Build simple, deterministic IP transport for overlay endpoints.

Chapter operating position

Build simple, deterministic IP transport for overlay endpoints.

2.1 Topology and addressing

Topology and addressing must be treated as an engineering mechanism rather than a product checkbox. Use point-to-point links, loopbacks, unnumbered options, summarization, and structured allocation. The design should name the authoritative inputs, state transitions, dependencies, limits, ownership, telemetry, expected output, and conditions that make the result unsafe or inconclusive.

The guide traces this subject through the underlay, EVPN route, VNI, gateway, multihoming, service, and forwarding chain. Configuration, controller health, or a green dashboard is never sufficient proof by itself. The engineer must reconcile intended state with protocol or platform state, installed forwarding or policy, real transactions, failure behavior, and the experience of the affected user, device, service, or application.

Implementation begins with a minimal, known-good baseline and explicit invariants. Introduce one capability or dependency at a time, validate positive and negative cases, inject realistic failures, measure recovery, and preserve before-and-after evidence. Automation must be idempotent, bounded, observable, reversible, and able to stop safely when inputs are stale or outcomes diverge.

Troubleshooting should locate the first divergence from the expected transaction or state machine. Inspect both directions and all authority boundaries; account for caching, eventual consistency, tunnels, load sharing, policy, identity, offload, time, and partial failure. Closure requires causal evidence, restored service, rollback proof, residual-risk disclosure, and prevention or monitoring actions.

Engineering practices

- Define authority, ownership, scope, dependencies, and acceptance criteria for topology and addressing.
- Model the expected state and traffic path before implementation or troubleshooting.
- Validate intent, control state, applied policy or forwarding state, and end-to-end service independently.
- Test normal, denied, degraded, failed, recovery, upgrade, and rollback conditions.
- Retain topology, configuration, packet, telemetry, log, identity, timing, and service evidence.
- Automate through typed data, deterministic gates, canaries, bounded concurrency, and reversible changes.

Failure patterns

- Treating topology and addressing as a vendor feature instead of an end-to-end system.
- Relying on intended configuration or controller state without proving applied and operational behavior.
- Ignoring reverse paths, external dependencies, identity, time, or partial failure.
- Changing several variables before preserving original evidence and stating a hypothesis.
- Allowing automation or AI to act on stale, ambiguous, or unauthorized data.
- Declaring success after one probe without negative tests, scale checks, rollback, and recurrence monitoring.

Validation and evidence

Method	Expected evidence
Examine	Requirements, topology, models, policy, configuration, ownership, and dependencies for topology and addressing.
Observe	Control-plane or platform state, applied policy, forwarding state, telemetry, logs, and endpoint behavior.
Test	Expected traffic, prohibited traffic, dependency loss, partial failure, convergence, recovery, and rollback.
Measure	Availability, reachability, latency, loss, convergence, scale, resource use, change success, and user experience.
Reconcile	Intended state against observed platform, network, security, identity, application, and evidence records.

2.2 Underlay routing

Underlay routing must be treated as an engineering mechanism rather than a product checkbox. Compare eBGP, OSPF, IS-IS, ECMP, BFD, graceful maintenance, and failure behavior. The design should name the authoritative inputs, state transitions, dependencies, limits, ownership, telemetry, expected output, and conditions that make the result unsafe or inconclusive.

The guide traces this subject through the underlay, EVPN route, VNI, gateway, multihoming, service, and forwarding chain. Configuration, controller health, or a green dashboard is never sufficient proof by itself. The engineer must reconcile intended state with protocol or platform state, installed forwarding or policy, real transactions, failure behavior, and the experience of the affected user, device, service, or application.

Implementation begins with a minimal, known-good baseline and explicit invariants. Introduce one capability or dependency at a time, validate positive and negative cases, inject realistic failures, measure recovery, and preserve before-and-after evidence. Automation must be idempotent, bounded, observable, reversible, and able to stop safely when inputs are stale or outcomes diverge.

Troubleshooting should locate the first divergence from the expected transaction or state machine. Inspect both directions and all authority boundaries; account for caching, eventual consistency, tunnels, load sharing, policy, identity, offload, time, and partial failure. Closure requires causal evidence, restored service, rollback proof, residual-risk disclosure, and prevention or monitoring actions.

Engineering practices

- Define authority, ownership, scope, dependencies, and acceptance criteria for underlay routing.
- Model the expected state and traffic path before implementation or troubleshooting.
- Validate intent, control state, applied policy or forwarding state, and end-to-end service independently.
- Test normal, denied, degraded, failed, recovery, upgrade, and rollback conditions.
- Retain topology, configuration, packet, telemetry, log, identity, timing, and service evidence.
- Automate through typed data, deterministic gates, canaries, bounded concurrency, and reversible changes.

Implementation sketch

```
fabric:
  underlay: ebgp
  overlay: evpn-vxlan
  tenants:
    - name: payments
      vrf: PAYMENTS
      l3_vni: 50100
      route_targets: ["65000:50100"]
      segments:
        - {vlan: 110, l2_vni: 10110, gateway: 10.10.110.1/24}
  invariants:
    - no_route_target_leak
    - anycast_gateway_consistent
    - esi_multihoming_split_horizon
    - mtu_supports_vxlan
    - failure_paths_verified
```

Failure patterns

Treating underlay routing as a vendor feature instead of an end-to-end system.

Relying on intended configuration or controller state without proving applied and operational behavior.

Ignoring reverse paths, external dependencies, identity, time, or partial failure.

Changing several variables before preserving original evidence and stating a hypothesis.

Allowing automation or AI to act on stale, ambiguous, or unauthorized data.

Declaring success after one probe without negative tests, scale checks, rollback, and recurrence monitoring.

Validation and evidence

Method	Expected evidence
Examine	Requirements, topology, models, policy, configuration, ownership, and dependencies for underlay routing.
Observe	Control-plane or platform state, applied policy, forwarding state, telemetry, logs, and endpoint behavior.
Test	Expected traffic, prohibited traffic, dependency loss, partial failure, convergence, recovery, and rollback.
Measure	Availability, reachability, latency, loss, convergence, scale, resource use, change success, and user experience.
Reconcile	Intended state against observed platform, network, security, identity, application, and evidence records.



2.3 MTU and transport

MTU and transport must be treated as an engineering mechanism rather than a product checkbox. Calculate VXLAN overhead, jumbo frames, path MTU, fragmentation risk, and host expectations. The design should name the authoritative inputs, state transitions, dependencies, limits, ownership, telemetry, expected output, and conditions that make the result unsafe or inconclusive.

The guide traces this subject through the underlay, EVPN route, VNI, gateway, multihoming, service, and forwarding chain. Configuration, controller health, or a green dashboard is never sufficient proof by itself. The engineer must reconcile intended state with protocol or platform state, installed forwarding or policy, real transactions, failure behavior, and the experience of the affected user, device, service, or application.

Implementation begins with a minimal, known-good baseline and explicit invariants. Introduce one capability or dependency at a time, validate positive and negative cases, inject realistic failures, measure recovery, and preserve before-and-after evidence. Automation must be idempotent, bounded, observable, reversible, and able to stop safely when inputs are stale or outcomes diverge.

Troubleshooting should locate the first divergence from the expected transaction or state machine. Inspect both directions and all authority boundaries; account for caching, eventual consistency, tunnels, load sharing, policy, identity, offload, time, and partial failure. Closure requires causal evidence, restored service, rollback proof, residual-risk disclosure, and prevention or monitoring actions.

Engineering practices

Define authority, ownership, scope, dependencies, and acceptance criteria for mtu and transport.

Model the expected state and traffic path before implementation or troubleshooting.

Validate intent, control state, applied policy or forwarding state, and end-to-end service independently.

Test normal, denied, degraded, failed, recovery, upgrade, and rollback conditions.

Retain topology, configuration, packet, telemetry, log, identity, timing, and service evidence.

Automate through typed data, deterministic gates, canaries, bounded concurrency, and reversible changes.

Failure patterns

Treating mtu and transport as a vendor feature instead of an end-to-end system.

Relying on intended configuration or controller state without proving applied and operational behavior.

Ignoring reverse paths, external dependencies, identity, time, or partial failure.

Changing several variables before preserving original evidence and stating a hypothesis.

Allowing automation or AI to act on stale, ambiguous, or unauthorized data.

Declaring success after one probe without negative tests, scale checks, rollback, and recurrence monitoring.

Validation and evidence

Method	Expected evidence
Examine	Requirements, topology, models, policy, configuration, ownership, and dependencies for mtu and transport.
Observe	Control-plane or platform state, applied policy, forwarding state, telemetry, logs, and endpoint behavior.
Test	Expected traffic, prohibited traffic, dependency loss, partial failure, convergence, recovery, and rollback.
Measure	Availability, reachability, latency, loss, convergence, scale, resource use, change success, and user experience.
Reconcile	Intended state against observed platform, network, security, identity, application, and evidence records.

2.4 Capacity and failure domains

Capacity and failure domains must be treated as an engineering mechanism rather than a product checkbox. Plan uplinks, oversubscription, link groups, diverse paths, spares, and maintenance headroom. The design should name the authoritative inputs, state transitions, dependencies, limits, ownership, telemetry, expected output, and conditions that make the result unsafe or inconclusive.

The guide traces this subject through the underlay, EVPN route, VNI, gateway, multihoming, service, and forwarding chain. Configuration, controller health, or a green dashboard is never sufficient proof by itself. The engineer must reconcile intended state with protocol or platform state, installed forwarding or policy, real transactions, failure behavior, and the experience of the affected user, device, service, or application.

Implementation begins with a minimal, known-good baseline and explicit invariants. Introduce one capability or dependency at a time, validate positive and negative cases, inject realistic failures, measure recovery, and preserve before-and-after evidence. Automation must be idempotent, bounded, observable, reversible, and able to stop safely when inputs are stale or outcomes diverge.

Troubleshooting should locate the first divergence from the expected transaction or state machine. Inspect both directions and all authority boundaries; account for caching, eventual consistency, tunnels, load sharing, policy, identity, offload, time, and partial failure. Closure requires causal evidence, restored service, rollback proof, residual-risk disclosure, and prevention or monitoring actions.

Engineering practices

Define authority, ownership, scope, dependencies, and acceptance criteria for capacity and failure domains.

Model the expected state and traffic path before implementation or troubleshooting.

Validate intent, control state, applied policy or forwarding state, and end-to-end service independently.

Test normal, denied, degraded, failed, recovery, upgrade, and rollback conditions.

Retain topology, configuration, packet, telemetry, log, identity, timing, and service evidence.

Automate through typed data, deterministic gates, canaries, bounded concurrency, and reversible changes.

Failure patterns

Treating capacity and failure domains as a vendor feature instead of an end-to-end system.

Relying on intended configuration or controller state without proving applied and operational behavior.

Ignoring reverse paths, external dependencies, identity, time, or partial failure.

Changing several variables before preserving original evidence and stating a hypothesis.

Allowing automation or AI to act on stale, ambiguous, or unauthorized data.

Declaring success after one probe without negative tests, scale checks, rollback, and recurrence monitoring.

Validation and evidence

Method	Expected evidence
Examine	Requirements, topology, models, policy, configuration, ownership, and dependencies for capacity and failure domains.
Observe	Control-plane or platform state, applied policy, forwarding state, telemetry, logs, and endpoint behavior.
Test	Expected traffic, prohibited traffic, dependency loss, partial failure, convergence, recovery, and rollback.
Measure	Availability, reachability, latency, loss, convergence, scale, resource use, change success, and user experience.
Reconcile	Intended state against observed platform, network, security, identity, application, and evidence records.

Chapter 02 laboratory and review

Practical laboratory

Build a four-leaf two-spine underlay, measure ECMP distribution and convergence, then introduce MTU, BFD, and route-policy faults.

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 IPv6-only underlays, SRv6 transport, adaptive routing, and photonic spine layers.

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

EVPN control plane

Understand the route types and state that replace or augment flood-and-learn behavior.

Chapter operating position

Understand the route types and state that replace or augment flood-and-learn behavior.



3.1 Ethernet auto-discovery and segments

Ethernet auto-discovery and segments must be treated as an engineering mechanism rather than a product checkbox. Use Ethernet segments, designated forwarders, aliasing, backup paths, and mass withdrawal. The design should name the authoritative inputs, state transitions, dependencies, limits, ownership, telemetry, expected output, and conditions that make the result unsafe or inconclusive.

The guide traces this subject through the underlay, EVPN route, VNI, gateway, multihoming, service, and forwarding chain. Configuration, controller health, or a green dashboard is never sufficient proof by itself. The engineer must reconcile intended state with protocol or platform state, installed forwarding or policy, real transactions, failure behavior, and the experience of the affected user, device, service, or application.

Implementation begins with a minimal, known-good baseline and explicit invariants. Introduce one capability or dependency at a time, validate positive and negative cases, inject realistic failures, measure recovery, and preserve before-and-after evidence. Automation must be idempotent, bounded, observable, reversible, and able to stop safely when inputs are stale or outcomes diverge.

Troubleshooting should locate the first divergence from the expected transaction or state machine. Inspect both directions and all authority boundaries; account for caching, eventual consistency, tunnels, load sharing, policy, identity, offload, time, and partial failure. Closure requires causal evidence, restored service, rollback proof, residual-risk disclosure, and prevention or monitoring actions.

Engineering practices

Define authority, ownership, scope, dependencies, and acceptance criteria for ethernet auto-discovery and segments.

Model the expected state and traffic path before implementation or troubleshooting.

Validate intent, control state, applied policy or forwarding state, and end-to-end service independently.

Test normal, denied, degraded, failed, recovery, upgrade, and rollback conditions.

Retain topology, configuration, packet, telemetry, log, identity, timing, and service evidence.

Automate through typed data, deterministic gates, canaries, bounded concurrency, and reversible changes.

Failure patterns

Treating ethernet auto-discovery and segments as a vendor feature instead of an end-to-end system.

Relying on intended configuration or controller state without proving applied and operational behavior.

Ignoring reverse paths, external dependencies, identity, time, or partial failure.

Changing several variables before preserving original evidence and stating a hypothesis.

Allowing automation or AI to act on stale, ambiguous, or unauthorized data.

Declaring success after one probe without negative tests, scale checks, rollback, and recurrence monitoring.

Validation and evidence

Method	Expected evidence
Examine	Requirements, topology, models, policy, configuration, ownership, and dependencies for ethernet auto-discovery and segments.
Observe	Control-plane or platform state, applied policy, forwarding state, telemetry, logs, and endpoint behavior.
Test	Expected traffic, prohibited traffic, dependency loss, partial failure, convergence, recovery, and rollback.
Measure	Availability, reachability, latency, loss, convergence, scale, resource use, change success, and user experience.
Reconcile	Intended state against observed platform, network, security, identity, application, and evidence records.

3.2 MAC/IP advertisement

MAC/IP advertisement must be treated as an engineering mechanism rather than a product checkbox. Trace route type 2, mobility sequence, ARP or ND suppression, proxy behavior, and duplicate detection. The design should name the authoritative inputs, state transitions, dependencies, limits, ownership, telemetry, expected output, and conditions that make the result unsafe or inconclusive.

The guide traces this subject through the underlay, EVPN route, VNI, gateway, multihoming, service, and forwarding chain. Configuration, controller health, or a green dashboard is never sufficient proof by itself. The engineer must reconcile intended state with protocol or platform state, installed forwarding or policy, real transactions, failure behavior, and the experience of the affected user, device, service, or application.

Implementation begins with a minimal, known-good baseline and explicit invariants. Introduce one capability or dependency at a time, validate positive and negative cases, inject realistic failures, measure recovery, and preserve before-and-after evidence. Automation must be idempotent, bounded, observable, reversible, and able to stop safely when inputs are stale or outcomes diverge.

Troubleshooting should locate the first divergence from the expected transaction or state machine. Inspect both directions and all authority boundaries; account for caching, eventual consistency, tunnels, load sharing, policy, identity, offload, time, and partial failure. Closure requires causal evidence, restored service, rollback proof, residual-risk disclosure, and prevention or monitoring actions.

Engineering practices

Define authority, ownership, scope, dependencies, and acceptance criteria for mac/ip advertisement.

Model the expected state and traffic path before implementation or troubleshooting.

Validate intent, control state, applied policy or forwarding state, and end-to-end service independently.

Test normal, denied, degraded, failed, recovery, upgrade, and rollback conditions.

Retain topology, configuration, packet, telemetry, log, identity, timing, and service evidence.

Automate through typed data, deterministic gates, canaries, bounded concurrency, and reversible changes.

Implementation sketch

```
fabric:
  underlay: ebgp
  overlay: evpn-vxlan
  tenants:
    - name: payments
      vrf: PAYMENTS
      l3_vni: 50100
      route_targets: ["65000:50100"]
      segments:
        - {vlan: 110, l2_vni: 10110, gateway: 10.10.110.1/24}
  invariants:
    - no_route_target_leak
    - anycast_gateway_consistent
    - esi_multihoming_split_horizon
    - mtu_supports_vxlan
    - failure_paths_verified
```

Failure patterns

- Treating mac/ip advertisement as a vendor feature instead of an end-to-end system.
- Relying on intended configuration or controller state without proving applied and operational behavior.
- Ignoring reverse paths, external dependencies, identity, time, or partial failure.
- Changing several variables before preserving original evidence and stating a hypothesis.
- Allowing automation or AI to act on stale, ambiguous, or unauthorized data.
- Declaring success after one probe without negative tests, scale checks, rollback, and recurrence monitoring.

Validation and evidence

Method	Expected evidence
Examine	Requirements, topology, models, policy, configuration, ownership, and dependencies for mac/ip advertisement.
Observe	Control-plane or platform state, applied policy, forwarding state, telemetry, logs, and endpoint behavior.
Test	Expected traffic, prohibited traffic, dependency loss, partial failure, convergence, recovery, and rollback.
Measure	Availability, reachability, latency, loss, convergence, scale, resource use, change success, and user experience.
Reconcile	Intended state against observed platform, network, security, identity, application, and evidence records.

3.3 Inclusive multicast and replication

Inclusive multicast and replication must be treated as an engineering mechanism rather than a product checkbox. Use route type 3, ingress replication, underlay multicast, and BUM policy. The design should name the authoritative inputs, state transitions, dependencies, limits, ownership, telemetry, expected output, and conditions that make the result unsafe or inconclusive.

The guide traces this subject through the underlay, EVPN route, VNI, gateway, multihoming, service, and forwarding chain. Configuration, controller health, or a green dashboard is never sufficient proof by itself. The engineer must reconcile intended state with protocol or platform state, installed forwarding or policy, real transactions, failure behavior, and the experience of the affected user, device, service, or application.

Implementation begins with a minimal, known-good baseline and explicit invariants. Introduce one capability or dependency at a time, validate positive and negative cases, inject realistic failures, measure recovery, and preserve before-and-after evidence. Automation must be idempotent, bounded, observable, reversible, and able to stop safely when inputs are stale or outcomes diverge.

Troubleshooting should locate the first divergence from the expected transaction or state machine. Inspect both directions and all authority boundaries; account for caching, eventual consistency, tunnels, load sharing, policy, identity, offload, time, and partial failure. Closure requires causal evidence, restored service, rollback proof, residual-risk disclosure, and prevention or monitoring actions.

Engineering practices

- Define authority, ownership, scope, dependencies, and acceptance criteria for inclusive multicast and replication.
- Model the expected state and traffic path before implementation or troubleshooting.
- Validate intent, control state, applied policy or forwarding state, and end-to-end service independently.
- Test normal, denied, degraded, failed, recovery, upgrade, and rollback conditions.
- Retain topology, configuration, packet, telemetry, log, identity, timing, and service evidence.
- Automate through typed data, deterministic gates, canaries, bounded concurrency, and reversible changes.

Failure patterns

- Treating inclusive multicast and replication as a vendor feature instead of an end-to-end system.
- Relying on intended configuration or controller state without proving applied and operational behavior.

Ignoring reverse paths, external dependencies, identity, time, or partial failure.

Changing several variables before preserving original evidence and stating a hypothesis.

Allowing automation or AI to act on stale, ambiguous, or unauthorized data.

Declaring success after one probe without negative tests, scale checks, rollback, and recurrence monitoring.

Validation and evidence

Method	Expected evidence
Examine	Requirements, topology, models, policy, configuration, ownership, and dependencies for inclusive multicast and replication.
Observe	Control-plane or platform state, applied policy, forwarding state, telemetry, logs, and endpoint behavior.
Test	Expected traffic, prohibited traffic, dependency loss, partial failure, convergence, recovery, and rollback.
Measure	Availability, reachability, latency, loss, convergence, scale, resource use, change success, and user experience.
Reconcile	Intended state against observed platform, network, security, identity, application, and evidence records.

3.4 IP prefix routes

IP prefix routes must be treated as an engineering mechanism rather than a product checkbox. Use route type 5 for inter-subnet, external, and tenant-prefix distribution with correct next-hop and policy. The design should name the authoritative inputs, state transitions, dependencies, limits, ownership, telemetry, expected output, and conditions that make the result unsafe or inconclusive.

The guide traces this subject through the underlay, EVPN route, VNI, gateway, multihoming, service, and forwarding chain. Configuration, controller health, or a green dashboard is never sufficient proof by itself. The engineer must reconcile intended state with protocol or platform state, installed forwarding or policy, real transactions, failure behavior, and the experience of the affected user, device, service, or application.

Implementation begins with a minimal, known-good baseline and explicit invariants. Introduce one capability or dependency at a time, validate positive and negative cases, inject realistic failures, measure recovery, and preserve before-and-after evidence. Automation must be idempotent, bounded, observable, reversible, and able to stop safely when inputs are stale or outcomes diverge.

Troubleshooting should locate the first divergence from the expected transaction or state machine. Inspect both directions and all authority boundaries; account for caching, eventual consistency, tunnels, load sharing, policy, identity, offload, time, and partial failure. Closure requires causal evidence, restored service, rollback proof, residual-risk disclosure, and prevention or monitoring actions.

Engineering practices

Define authority, ownership, scope, dependencies, and acceptance criteria for ip prefix routes.

Model the expected state and traffic path before implementation or troubleshooting.

Validate intent, control state, applied policy or forwarding state, and end-to-end service independently.

Test normal, denied, degraded, failed, recovery, upgrade, and rollback conditions.

Retain topology, configuration, packet, telemetry, log, identity, timing, and service evidence.

Automate through typed data, deterministic gates, canaries, bounded concurrency, and reversible changes.

Failure patterns

Treating ip prefix routes as a vendor feature instead of an end-to-end system.

Relying on intended configuration or controller state without proving applied and operational behavior.

Ignoring reverse paths, external dependencies, identity, time, or partial failure.

Changing several variables before preserving original evidence and stating a hypothesis.

Allowing automation or AI to act on stale, ambiguous, or unauthorized data.

Declaring success after one probe without negative tests, scale checks, rollback, and recurrence monitoring.

Validation and evidence

Method	Expected evidence
Examine	Requirements, topology, models, policy, configuration, ownership, and dependencies for ip prefix routes.
Observe	Control-plane or platform state, applied policy, forwarding state, telemetry, logs, and endpoint behavior.
Test	Expected traffic, prohibited traffic, dependency loss, partial failure, convergence, recovery, and rollback.
Measure	Availability, reachability, latency, loss, convergence, scale, resource use, change success, and user experience.
Reconcile	Intended state against observed platform, network, security, identity, application, and evidence records.

Chapter 03 laboratory and review

Practical laboratory

Capture all primary EVPN route types during endpoint attachment, movement, multihoming, and prefix advertisement. Map each route to forwarding state.

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

Evaluate EVPN over SRv6, route-type evolution, controller-assisted policy, and cryptographic provenance.

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

VXLAN data plane and distributed gateways

Trace tenant frames and routed packets across virtual tunnel endpoints.

Chapter operating position

Trace tenant frames and routed packets across virtual tunnel endpoints.

4.1 VNIs and encapsulation

VNIs and encapsulation must be treated as an engineering mechanism rather than a product checkbox. Map VLANs or bridge domains to L2 VNIs, VRFs to L3 VNIs, UDP entropy, VTEPs, and outer routing. The design should name the authoritative inputs, state transitions, dependencies, limits, ownership, telemetry, expected output, and conditions that make the result unsafe or inconclusive.

The guide traces this subject through the underlay, EVPN route, VNI, gateway, multihoming, service, and forwarding chain. Configuration, controller health, or a green dashboard is never sufficient proof by itself. The engineer must reconcile intended state with protocol or platform state, installed forwarding or policy, real transactions, failure behavior, and the experience of the affected user, device, service, or application.

Implementation begins with a minimal, known-good baseline and explicit invariants. Introduce one capability or dependency at a time, validate positive and negative cases, inject realistic failures, measure recovery, and preserve before-and-after evidence. Automation must be idempotent, bounded, observable, reversible, and able to stop safely when inputs are stale or outcomes diverge.

Troubleshooting should locate the first divergence from the expected transaction or state machine. Inspect both directions and all authority boundaries; account for caching, eventual consistency, tunnels, load sharing, policy, identity, offload, time, and partial failure. Closure requires causal evidence, restored service, rollback proof, residual-risk disclosure, and prevention or monitoring actions.

Engineering practices

Define authority, ownership, scope, dependencies, and acceptance criteria for vnis and encapsulation.

Model the expected state and traffic path before implementation or troubleshooting.

Validate intent, control state, applied policy or forwarding state, and end-to-end service independently.

Test normal, denied, degraded, failed, recovery, upgrade, and rollback conditions.

Retain topology, configuration, packet, telemetry, log, identity, timing, and service evidence.

Automate through typed data, deterministic gates, canaries, bounded concurrency, and reversible changes.

Failure patterns

Treating vnis and encapsulation as a vendor feature instead of an end-to-end system.

Relying on intended configuration or controller state without proving applied and operational behavior.

Ignoring reverse paths, external dependencies, identity, time, or partial failure.

Changing several variables before preserving original evidence and stating a hypothesis.

Allowing automation or AI to act on stale, ambiguous, or unauthorized data.

Declaring success after one probe without negative tests, scale checks, rollback, and recurrence monitoring.

Validation and evidence

Method	Expected evidence
Examine	Requirements, topology, models, policy, configuration, ownership, and dependencies for vnis and encapsulation.
Observe	Control-plane or platform state, applied policy, forwarding state, telemetry, logs, and endpoint behavior.
Test	Expected traffic, prohibited traffic, dependency loss, partial failure, convergence, recovery, and rollback.
Measure	Availability, reachability, latency, loss, convergence, scale, resource use, change success, and user experience.
Reconcile	Intended state against observed platform, network, security, identity, application, and evidence records.

4.2 Symmetric and asymmetric routing

Symmetric and asymmetric routing must be treated as an engineering mechanism rather than a product checkbox. Compare gateway and VNI behavior, state, scale, troubleshooting, and mobility. The design should name the authoritative inputs, state transitions, dependencies, limits, ownership, telemetry, expected output, and conditions that make the result unsafe or inconclusive.

The guide traces this subject through the underlay, EVPN route, VNI, gateway, multihoming, service, and forwarding chain. Configuration, controller health, or a green dashboard is never sufficient proof by itself. The engineer must reconcile intended state with protocol or platform state, installed forwarding or policy, real transactions, failure behavior, and the experience of the affected user, device, service, or application.

Implementation begins with a minimal, known-good baseline and explicit invariants. Introduce one capability or dependency at a time, validate positive and negative cases, inject realistic failures, measure recovery, and preserve before-and-after evidence. Automation must be idempotent, bounded, observable, reversible, and able to stop safely when inputs are stale or outcomes diverge.

Troubleshooting should locate the first divergence from the expected transaction or state machine. Inspect both directions and all authority boundaries; account for caching, eventual consistency, tunnels, load sharing, policy, identity, offload, time, and partial failure. Closure requires causal evidence, restored service, rollback proof, residual-risk disclosure, and prevention or monitoring actions.

Engineering practices

Define authority, ownership, scope, dependencies, and acceptance criteria for symmetric and asymmetric routing.

Model the expected state and traffic path before implementation or troubleshooting.

Validate intent, control state, applied policy or forwarding state, and end-to-end service independently.

Test normal, denied, degraded, failed, recovery, upgrade, and rollback conditions.

Retain topology, configuration, packet, telemetry, log, identity, timing, and service evidence.

Automate through typed data, deterministic gates, canaries, bounded concurrency, and reversible changes.

Implementation sketch

```
fabric:
  underlay: ebgp
  overlay: evpn-vxlan
  tenants:
    - name: payments
      vrf: PAYMENTS
      l3_vni: 50100
      route_targets: ["65000:50100"]
      segments:
        - {vlan: 110, l2_vni: 10110, gateway: 10.10.110.1/24}
  invariants:
    - no_route_target_leak
    - anycast_gateway_consistent
    - esi_multihoming_split_horizon
    - mtu_supports_vxlan
    - failure_paths_verified
```

Failure patterns

- Treating symmetric and asymmetric routing as a vendor feature instead of an end-to-end system.
- Relying on intended configuration or controller state without proving applied and operational behavior.
- Ignoring reverse paths, external dependencies, identity, time, or partial failure.
- Changing several variables before preserving original evidence and stating a hypothesis.
- Allowing automation or AI to act on stale, ambiguous, or unauthorized data.
- Declaring success after one probe without negative tests, scale checks, rollback, and recurrence monitoring.

Validation and evidence

Method	Expected evidence
Examine	Requirements, topology, models, policy, configuration, ownership, and dependencies for symmetric and asymmetric routing.
Observe	Control-plane or platform state, applied policy, forwarding state, telemetry, logs, and endpoint behavior.
Test	Expected traffic, prohibited traffic, dependency loss, partial failure, convergence, recovery, and rollback.
Measure	Availability, reachability, latency, loss, convergence, scale, resource use, change success, and user experience.
Reconcile	Intended state against observed platform, network, security, identity, application, and evidence records.



4.3 Anycast gateway

Anycast gateway must be treated as an engineering mechanism rather than a product checkbox. Use consistent gateway identity, distributed routing, neighbor suppression, and host mobility. The design should name the authoritative inputs, state transitions, dependencies, limits, ownership, telemetry, expected output, and conditions that make the result unsafe or inconclusive.

The guide traces this subject through the underlay, EVPN route, VNI, gateway, multihoming, service, and forwarding chain. Configuration, controller health, or a green dashboard is never sufficient proof by itself. The engineer must reconcile intended state with protocol or platform state, installed forwarding or policy, real transactions, failure behavior, and the experience of the affected user, device, service, or application.

Implementation begins with a minimal, known-good baseline and explicit invariants. Introduce one capability or dependency at a time, validate positive and negative cases, inject realistic failures, measure recovery, and preserve before-and-after evidence. Automation must be idempotent, bounded, observable, reversible, and able to stop safely when inputs are stale or outcomes diverge.

Troubleshooting should locate the first divergence from the expected transaction or state machine. Inspect both directions and all authority boundaries; account for caching, eventual consistency, tunnels, load sharing, policy, identity, offload, time, and partial failure. Closure requires causal evidence, restored service, rollback proof, residual-risk disclosure, and prevention or monitoring actions.

Engineering practices

- Define authority, ownership, scope, dependencies, and acceptance criteria for anycast gateway.
- Model the expected state and traffic path before implementation or troubleshooting.
- Validate intent, control state, applied policy or forwarding state, and end-to-end service independently.
- Test normal, denied, degraded, failed, recovery, upgrade, and rollback conditions.
- Retain topology, configuration, packet, telemetry, log, identity, timing, and service evidence.
- Automate through typed data, deterministic gates, canaries, bounded concurrency, and reversible changes.

Failure patterns

- Treating anycast gateway as a vendor feature instead of an end-to-end system.
- Relying on intended configuration or controller state without proving applied and operational behavior.

Ignoring reverse paths, external dependencies, identity, time, or partial failure.

Changing several variables before preserving original evidence and stating a hypothesis.

Allowing automation or AI to act on stale, ambiguous, or unauthorized data.

Declaring success after one probe without negative tests, scale checks, rollback, and recurrence monitoring.

Validation and evidence

Method	Expected evidence
Examine	Requirements, topology, models, policy, configuration, ownership, and dependencies for anycast gateway.
Observe	Control-plane or platform state, applied policy, forwarding state, telemetry, logs, and endpoint behavior.
Test	Expected traffic, prohibited traffic, dependency loss, partial failure, convergence, recovery, and rollback.
Measure	Availability, reachability, latency, loss, convergence, scale, resource use, change success, and user experience.
Reconcile	Intended state against observed platform, network, security, identity, application, and evidence records.

4.4 BUM and unknown traffic

BUM and unknown traffic must be treated as an engineering mechanism rather than a product checkbox. Control flooding, replication, suppression, rate, and failure behavior. The design should name the authoritative inputs, state transitions, dependencies, limits, ownership, telemetry, expected output, and conditions that make the result unsafe or inconclusive.

The guide traces this subject through the underlay, EVPN route, VNI, gateway, multihoming, service, and forwarding chain. Configuration, controller health, or a green dashboard is never sufficient proof by itself. The engineer must reconcile intended state with protocol or platform state, installed forwarding or policy, real transactions, failure behavior, and the experience of the affected user, device, service, or application.

Implementation begins with a minimal, known-good baseline and explicit invariants. Introduce one capability or dependency at a time, validate positive and negative cases, inject realistic failures, measure recovery, and preserve before-and-after evidence. Automation must be idempotent, bounded, observable, reversible, and able to stop safely when inputs are stale or outcomes diverge.

Troubleshooting should locate the first divergence from the expected transaction or state machine. Inspect both directions and all authority boundaries; account for caching, eventual consistency, tunnels, load sharing, policy, identity, offload, time, and partial failure. Closure requires causal evidence, restored service, rollback proof, residual-risk disclosure, and prevention or monitoring actions.

Engineering practices

Define authority, ownership, scope, dependencies, and acceptance criteria for bum and unknown traffic.

Model the expected state and traffic path before implementation or troubleshooting.

Validate intent, control state, applied policy or forwarding state, and end-to-end service independently.

Test normal, denied, degraded, failed, recovery, upgrade, and rollback conditions.

Retain topology, configuration, packet, telemetry, log, identity, timing, and service evidence.

Automate through typed data, deterministic gates, canaries, bounded concurrency, and reversible changes.

Failure patterns

Treating bum and unknown traffic as a vendor feature instead of an end-to-end system.

Relying on intended configuration or controller state without proving applied and operational behavior.

Ignoring reverse paths, external dependencies, identity, time, or partial failure.

Changing several variables before preserving original evidence and stating a hypothesis.

Allowing automation or AI to act on stale, ambiguous, or unauthorized data.

Declaring success after one probe without negative tests, scale checks, rollback, and recurrence monitoring.

Validation and evidence

Method	Expected evidence
Examine	Requirements, topology, models, policy, configuration, ownership, and dependencies for bum and unknown traffic.
Observe	Control-plane or platform state, applied policy, forwarding state, telemetry, logs, and endpoint behavior.
Test	Expected traffic, prohibited traffic, dependency loss, partial failure, convergence, recovery, and rollback.
Measure	Availability, reachability, latency, loss, convergence, scale, resource use, change success, and user experience.
Reconcile	Intended state against observed platform, network, security, identity, application, and evidence records.

Chapter 04 laboratory and review

Practical laboratory

Trace same-subnet, inter-subnet, and external flows packet by packet through inner headers, VNIs, outer addresses, gateways, and return paths.

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

Extend to Geneve metadata, service insertion, programmable fabrics, and zero-trust workload identity.

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

Multihoming and endpoint attachment

Engineer resilient host, appliance, firewall, and legacy-domain connectivity.

Chapter operating position

Engineer resilient host, appliance, firewall, and legacy-domain connectivity.



5.1 All-active and single-active

All-active and single-active must be treated as an engineering mechanism rather than a product checkbox. Choose redundancy mode by endpoint behavior, hashing, state, and split-horizon requirements. The design should name the authoritative inputs, state transitions, dependencies, limits, ownership, telemetry, expected output, and conditions that make the result unsafe or inconclusive.

The guide traces this subject through the underlay, EVPN route, VNI, gateway, multihoming, service, and forwarding chain. Configuration, controller health, or a green dashboard is never sufficient proof by itself. The engineer must reconcile intended state with protocol or platform state, installed forwarding or policy, real transactions, failure behavior, and the experience of the affected user, device, service, or application.

Implementation begins with a minimal, known-good baseline and explicit invariants. Introduce one capability or dependency at a time, validate positive and negative cases, inject realistic failures, measure recovery, and preserve before-and-after evidence. Automation must be idempotent, bounded, observable, reversible, and able to stop safely when inputs are stale or outcomes diverge.

Troubleshooting should locate the first divergence from the expected transaction or state machine. Inspect both directions and all authority boundaries; account for caching, eventual consistency, tunnels, load sharing, policy, identity, offload, time, and partial failure. Closure requires causal evidence, restored service, rollback proof, residual-risk disclosure, and prevention or monitoring actions.

Engineering practices

- Define authority, ownership, scope, dependencies, and acceptance criteria for all-active and single-active.
- Model the expected state and traffic path before implementation or troubleshooting.
- Validate intent, control state, applied policy or forwarding state, and end-to-end service independently.
- Test normal, denied, degraded, failed, recovery, upgrade, and rollback conditions.
- Retain topology, configuration, packet, telemetry, log, identity, timing, and service evidence.
- Automate through typed data, deterministic gates, canaries, bounded concurrency, and reversible changes.

Failure patterns

- Treating all-active and single-active as a vendor feature instead of an end-to-end system.
- Relying on intended configuration or controller state without proving applied and operational behavior.
- Ignoring reverse paths, external dependencies, identity, time, or partial failure.
- Changing several variables before preserving original evidence and stating a hypothesis.
- Allowing automation or AI to act on stale, ambiguous, or unauthorized data.
- Declaring success after one probe without negative tests, scale checks, rollback, and recurrence monitoring.

Validation and evidence

Method	Expected evidence
Examine	Requirements, topology, models, policy, configuration, ownership, and dependencies for all-active and single-active.
Observe	Control-plane or platform state, applied policy, forwarding state, telemetry, logs, and endpoint behavior.
Test	Expected traffic, prohibited traffic, dependency loss, partial failure, convergence, recovery, and rollback.
Measure	Availability, reachability, latency, loss, convergence, scale, resource use, change success, and user experience.
Reconcile	Intended state against observed platform, network, security, identity, application, and evidence records.

5.2 ESI and designated forwarder

ESI and designated forwarder must be treated as an engineering mechanism rather than a product checkbox. Understand Ethernet segment identifiers, DF election, route advertisement, and failure recovery. The design should name the authoritative inputs, state transitions, dependencies, limits, ownership, telemetry, expected output, and conditions that make the result unsafe or inconclusive.

The guide traces this subject through the underlay, EVPN route, VNI, gateway, multihoming, service, and forwarding chain. Configuration, controller health, or a green dashboard is never sufficient proof by itself. The engineer must reconcile intended state with protocol or platform state, installed forwarding or policy, real transactions, failure behavior, and the experience of the affected user, device, service, or application.

Implementation begins with a minimal, known-good baseline and explicit invariants. Introduce one capability or dependency at a time, validate positive and negative cases, inject realistic failures, measure recovery, and preserve before-and-after evidence. Automation must be idempotent, bounded, observable, reversible, and able to stop safely when inputs are stale or outcomes diverge.

Troubleshooting should locate the first divergence from the expected transaction or state machine. Inspect both directions and all authority boundaries; account for caching, eventual consistency, tunnels, load sharing, policy, identity, offload, time, and partial failure. Closure requires causal evidence, restored service, rollback proof, residual-risk disclosure, and prevention or monitoring actions.

Engineering practices

Define authority, ownership, scope, dependencies, and acceptance criteria for esi and designated forwarder.

Model the expected state and traffic path before implementation or troubleshooting.

Validate intent, control state, applied policy or forwarding state, and end-to-end service independently.

Test normal, denied, degraded, failed, recovery, upgrade, and rollback conditions.

Retain topology, configuration, packet, telemetry, log, identity, timing, and service evidence.

Automate through typed data, deterministic gates, canaries, bounded concurrency, and reversible changes.

Implementation sketch

```
fabric:
  underlay: ebgp
  overlay: evpn-vxlan
  tenants:
    - name: payments
      vrf: PAYMENTS
      l3_vni: 50100
      route_targets: ["65000:50100"]
      segments:
        - {vlan: 110, l2_vni: 10110, gateway: 10.10.110.1/24}
  invariants:
    - no_route_target_leak
    - anycast_gateway_consistent
    - esi_multihoming_split_horizon
    - mtu_supports_vxlan
    - failure_paths_verified
```

Failure patterns

- Treating esi and designated forwarder as a vendor feature instead of an end-to-end system.
- Relying on intended configuration or controller state without proving applied and operational behavior.
- Ignoring reverse paths, external dependencies, identity, time, or partial failure.
- Changing several variables before preserving original evidence and stating a hypothesis.
- Allowing automation or AI to act on stale, ambiguous, or unauthorized data.
- Declaring success after one probe without negative tests, scale checks, rollback, and recurrence monitoring.

Validation and evidence

Method	Expected evidence
Examine	Requirements, topology, models, policy, configuration, ownership, and dependencies for esi and designated forwarder.
Observe	Control-plane or platform state, applied policy, forwarding state, telemetry, logs, and endpoint behavior.
Test	Expected traffic, prohibited traffic, dependency loss, partial failure, convergence, recovery, and rollback.
Measure	Availability, reachability, latency, loss, convergence, scale, resource use, change success, and user experience.
Reconcile	Intended state against observed platform, network, security, identity, application, and evidence records.

5.3 LACP and server attachment

LACP and server attachment must be treated as an engineering mechanism rather than a product checkbox. Coordinate host bonding, EVPN state, minimum links, orphan behavior, and failure evidence. The design should name the authoritative inputs, state transitions, dependencies, limits, ownership, telemetry, expected output, and conditions that make the result unsafe or inconclusive.

The guide traces this subject through the underlay, EVPN route, VNI, gateway, multihoming, service, and forwarding chain. Configuration, controller health, or a green dashboard is never sufficient proof by itself. The engineer must reconcile intended state with protocol or platform state, installed forwarding or policy, real transactions, failure behavior, and the experience of the affected user, device, service, or application.

Implementation begins with a minimal, known-good baseline and explicit invariants. Introduce one capability or dependency at a time, validate positive and negative cases, inject realistic failures, measure recovery, and preserve before-and-after evidence. Automation must be idempotent, bounded, observable, reversible, and able to stop safely when inputs are stale or outcomes diverge.

Troubleshooting should locate the first divergence from the expected transaction or state machine. Inspect both directions and all authority boundaries; account for caching, eventual consistency, tunnels, load sharing, policy, identity, offload, time, and partial failure. Closure requires causal evidence, restored service, rollback proof, residual-risk disclosure, and prevention or monitoring actions.

Engineering practices

- Define authority, ownership, scope, dependencies, and acceptance criteria for lacp and server attachment.
- Model the expected state and traffic path before implementation or troubleshooting.
- Validate intent, control state, applied policy or forwarding state, and end-to-end service independently.
- Test normal, denied, degraded, failed, recovery, upgrade, and rollback conditions.
- Retain topology, configuration, packet, telemetry, log, identity, timing, and service evidence.
- Automate through typed data, deterministic gates, canaries, bounded concurrency, and reversible changes.

Failure patterns

- Treating lacp and server attachment as a vendor feature instead of an end-to-end system.
- Relying on intended configuration or controller state without proving applied and operational behavior.

Ignoring reverse paths, external dependencies, identity, time, or partial failure.

Changing several variables before preserving original evidence and stating a hypothesis.

Allowing automation or AI to act on stale, ambiguous, or unauthorized data.

Declaring success after one probe without negative tests, scale checks, rollback, and recurrence monitoring.

Validation and evidence

Method	Expected evidence
Examine	Requirements, topology, models, policy, configuration, ownership, and dependencies for larp and server attachment.
Observe	Control-plane or platform state, applied policy, forwarding state, telemetry, logs, and endpoint behavior.
Test	Expected traffic, prohibited traffic, dependency loss, partial failure, convergence, recovery, and rollback.
Measure	Availability, reachability, latency, loss, convergence, scale, resource use, change success, and user experience.
Reconcile	Intended state against observed platform, network, security, identity, application, and evidence records.

5.4 Appliances and service nodes

Appliances and service nodes must be treated as an engineering mechanism rather than a product checkbox. Handle stateful firewalls, load balancers, clusters, asymmetric paths, and migration constraints. The design should name the authoritative inputs, state transitions, dependencies, limits, ownership, telemetry, expected output, and conditions that make the result unsafe or inconclusive.

The guide traces this subject through the underlay, EVPN route, VNI, gateway, multihoming, service, and forwarding chain. Configuration, controller health, or a green dashboard is never sufficient proof by itself. The engineer must reconcile intended state with protocol or platform state, installed forwarding or policy, real transactions, failure behavior, and the experience of the affected user, device, service, or application.

Implementation begins with a minimal, known-good baseline and explicit invariants. Introduce one capability or dependency at a time, validate positive and negative cases, inject realistic failures, measure recovery, and preserve before-and-after evidence. Automation must be idempotent, bounded, observable, reversible, and able to stop safely when inputs are stale or outcomes diverge.

Troubleshooting should locate the first divergence from the expected transaction or state machine. Inspect both directions and all authority boundaries; account for caching, eventual consistency, tunnels, load sharing, policy, identity, offload, time, and partial failure. Closure requires causal evidence, restored service, rollback proof, residual-risk disclosure, and prevention or monitoring actions.

Engineering practices

Define authority, ownership, scope, dependencies, and acceptance criteria for appliances and service nodes.

Model the expected state and traffic path before implementation or troubleshooting.

Validate intent, control state, applied policy or forwarding state, and end-to-end service independently.

Test normal, denied, degraded, failed, recovery, upgrade, and rollback conditions.

Retain topology, configuration, packet, telemetry, log, identity, timing, and service evidence.

Automate through typed data, deterministic gates, canaries, bounded concurrency, and reversible changes.

Failure patterns

Treating appliances and service nodes as a vendor feature instead of an end-to-end system.

Relying on intended configuration or controller state without proving applied and operational behavior.

Ignoring reverse paths, external dependencies, identity, time, or partial failure.

Changing several variables before preserving original evidence and stating a hypothesis.

Allowing automation or AI to act on stale, ambiguous, or unauthorized data.

Declaring success after one probe without negative tests, scale checks, rollback, and recurrence monitoring.

Validation and evidence

Method	Expected evidence
Examine	Requirements, topology, models, policy, configuration, ownership, and dependencies for appliances and service nodes.
Observe	Control-plane or platform state, applied policy, forwarding state, telemetry, logs, and endpoint behavior.
Test	Expected traffic, prohibited traffic, dependency loss, partial failure, convergence, recovery, and rollback.
Measure	Availability, reachability, latency, loss, convergence, scale, resource use, change success, and user experience.
Reconcile	Intended state against observed platform, network, security, identity, application, and evidence records.

Chapter 05 laboratory and review

Practical laboratory

Build all-active and single-active attachments, fail links and leafs, move endpoints, and validate split horizon, aliasing, and mass withdrawal.

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 smartNIC and DPU attachment, multi-domain Ethernet segments, and workload-attested admission.

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

Multitenancy, DCI, and cloud connectivity

Extend services across domains without losing isolation or creating fragile blast radius.

Chapter operating position

Extend services across domains without losing isolation or creating fragile blast radius.

6.1 Route targets and policy

Route targets and policy must be treated as an engineering mechanism rather than a product checkbox. Control import and export, shared services, route leaking, defaults, external routes, and governance. The design should name the authoritative inputs, state transitions, dependencies, limits, ownership, telemetry, expected output, and conditions that make the result unsafe or inconclusive.

The guide traces this subject through the underlay, EVPN route, VNI, gateway, multihoming, service, and forwarding chain. Configuration, controller health, or a green dashboard is never sufficient proof by itself. The engineer must reconcile intended state with protocol or platform state, installed forwarding or policy, real transactions, failure behavior, and the experience of the affected user, device, service, or application.

Implementation begins with a minimal, known-good baseline and explicit invariants. Introduce one capability or dependency at a time, validate positive and negative cases, inject realistic failures, measure recovery, and preserve before-and-after evidence. Automation must be idempotent, bounded, observable, reversible, and able to stop safely when inputs are stale or outcomes diverge.

Troubleshooting should locate the first divergence from the expected transaction or state machine. Inspect both directions and all authority boundaries; account for caching, eventual consistency, tunnels, load sharing, policy, identity, offload, time, and partial failure. Closure requires causal evidence, restored service, rollback proof, residual-risk disclosure, and prevention or monitoring actions.

Engineering practices

Define authority, ownership, scope, dependencies, and acceptance criteria for route targets and policy.

Model the expected state and traffic path before implementation or troubleshooting.

Validate intent, control state, applied policy or forwarding state, and end-to-end service independently.

Test normal, denied, degraded, failed, recovery, upgrade, and rollback conditions.

Retain topology, configuration, packet, telemetry, log, identity, timing, and service evidence.

Automate through typed data, deterministic gates, canaries, bounded concurrency, and reversible changes.

Failure patterns

Treating route targets and policy as a vendor feature instead of an end-to-end system.

Relying on intended configuration or controller state without proving applied and operational behavior.

Ignoring reverse paths, external dependencies, identity, time, or partial failure.

Changing several variables before preserving original evidence and stating a hypothesis.

Allowing automation or AI to act on stale, ambiguous, or unauthorized data.

Declaring success after one probe without negative tests, scale checks, rollback, and recurrence monitoring.

Validation and evidence

Method	Expected evidence
Examine	Requirements, topology, models, policy, configuration, ownership, and dependencies for route targets and policy.
Observe	Control-plane or platform state, applied policy, forwarding state, telemetry, logs, and endpoint behavior.
Test	Expected traffic, prohibited traffic, dependency loss, partial failure, convergence, recovery, and rollback.
Measure	Availability, reachability, latency, loss, convergence, scale, resource use, change success, and user experience.
Reconcile	Intended state against observed platform, network, security, identity, application, and evidence records.

6.2 Data-center interconnect

Data-center interconnect must be treated as an engineering mechanism rather than a product checkbox. Compare routed DCI, EVPN gateway, selective stretch, multi-site, latency, failure, and split-brain controls. The design should name the authoritative inputs, state transitions, dependencies, limits, ownership, telemetry, expected output, and conditions that make the result unsafe or inconclusive.

The guide traces this subject through the underlay, EVPN route, VNI, gateway, multihoming, service, and forwarding chain. Configuration, controller health, or a green dashboard is never sufficient proof by itself. The engineer must reconcile intended state with protocol or platform state, installed forwarding or policy, real transactions, failure behavior, and the experience of the affected user, device, service, or application.

Implementation begins with a minimal, known-good baseline and explicit invariants. Introduce one capability or dependency at a time, validate positive and negative cases, inject realistic failures, measure recovery, and preserve before-and-after evidence. Automation must be idempotent, bounded, observable, reversible, and able to stop safely when inputs are stale or outcomes diverge.

Troubleshooting should locate the first divergence from the expected transaction or state machine. Inspect both directions and all authority boundaries; account for caching, eventual consistency, tunnels, load sharing, policy, identity, offload, time, and partial failure. Closure requires causal evidence, restored service, rollback proof, residual-risk disclosure, and prevention or monitoring actions.

Engineering practices

Define authority, ownership, scope, dependencies, and acceptance criteria for data-center interconnect.

Model the expected state and traffic path before implementation or troubleshooting.

Validate intent, control state, applied policy or forwarding state, and end-to-end service independently.

Test normal, denied, degraded, failed, recovery, upgrade, and rollback conditions.

Retain topology, configuration, packet, telemetry, log, identity, timing, and service evidence.

Automate through typed data, deterministic gates, canaries, bounded concurrency, and reversible changes.

Implementation sketch

```
fabric:
  underlay: ebgp
  overlay: evpn-vxlan
  tenants:
    - name: payments
      vrf: PAYMENTS
      l3_vni: 50100
      route_targets: ["65000:50100"]
      segments:
        - {vlan: 110, l2_vni: 10110, gateway: 10.10.110.1/24}
  invariants:
    - no_route_target_leak
    - anycast_gateway_consistent
    - esi_multihoming_split_horizon
    - mtu_supports_vxlan
    - failure_paths_verified
```

Failure patterns

- Treating data-center interconnect as a vendor feature instead of an end-to-end system.
- Relying on intended configuration or controller state without proving applied and operational behavior.
- Ignoring reverse paths, external dependencies, identity, time, or partial failure.
- Changing several variables before preserving original evidence and stating a hypothesis.
- Allowing automation or AI to act on stale, ambiguous, or unauthorized data.
- Declaring success after one probe without negative tests, scale checks, rollback, and recurrence monitoring.

Validation and evidence

Method	Expected evidence
Examine	Requirements, topology, models, policy, configuration, ownership, and dependencies for data-center interconnect.
Observe	Control-plane or platform state, applied policy, forwarding state, telemetry, logs, and endpoint behavior.
Test	Expected traffic, prohibited traffic, dependency loss, partial failure, convergence, recovery, and rollback.
Measure	Availability, reachability, latency, loss, convergence, scale, resource use, change success, and user experience.
Reconcile	Intended state against observed platform, network, security, identity, application, and evidence records.

6.3 Cloud and edge integration

Cloud and edge integration must be treated as an engineering mechanism rather than a product checkbox. Connect VPCs, VNets, cloud routers, direct circuits, transit services, and overlapping address domains. The design should name the authoritative inputs, state transitions, dependencies, limits, ownership, telemetry, expected output, and conditions that make the result unsafe or inconclusive.

The guide traces this subject through the underlay, EVPN route, VNI, gateway, multihoming, service, and forwarding chain. Configuration, controller health, or a green dashboard is never sufficient proof by itself. The engineer must reconcile intended state with protocol or platform state, installed forwarding or policy, real transactions, failure behavior, and the experience of the affected user, device, service, or application.

Implementation begins with a minimal, known-good baseline and explicit invariants. Introduce one capability or dependency at a time, validate positive and negative cases, inject realistic failures, measure recovery, and preserve before-and-after evidence. Automation must be idempotent, bounded, observable, reversible, and able to stop safely when inputs are stale or outcomes diverge.

Troubleshooting should locate the first divergence from the expected transaction or state machine. Inspect both directions and all authority boundaries; account for caching, eventual consistency, tunnels, load sharing, policy, identity, offload, time, and partial failure. Closure requires causal evidence, restored service, rollback proof, residual-risk disclosure, and prevention or monitoring actions.

Engineering practices

- Define authority, ownership, scope, dependencies, and acceptance criteria for cloud and edge integration.
- Model the expected state and traffic path before implementation or troubleshooting.
- Validate intent, control state, applied policy or forwarding state, and end-to-end service independently.
- Test normal, denied, degraded, failed, recovery, upgrade, and rollback conditions.
- Retain topology, configuration, packet, telemetry, log, identity, timing, and service evidence.
- Automate through typed data, deterministic gates, canaries, bounded concurrency, and reversible changes.

Failure patterns

- Treating cloud and edge integration as a vendor feature instead of an end-to-end system.
- Relying on intended configuration or controller state without proving applied and operational behavior.

Ignoring reverse paths, external dependencies, identity, time, or partial failure.

Changing several variables before preserving original evidence and stating a hypothesis.

Allowing automation or AI to act on stale, ambiguous, or unauthorized data.

Declaring success after one probe without negative tests, scale checks, rollback, and recurrence monitoring.

Validation and evidence

Method	Expected evidence
Examine	Requirements, topology, models, policy, configuration, ownership, and dependencies for cloud and edge integration.
Observe	Control-plane or platform state, applied policy, forwarding state, telemetry, logs, and endpoint behavior.
Test	Expected traffic, prohibited traffic, dependency loss, partial failure, convergence, recovery, and rollback.
Measure	Availability, reachability, latency, loss, convergence, scale, resource use, change success, and user experience.
Reconcile	Intended state against observed platform, network, security, identity, application, and evidence records.

6.4 Security and service insertion

Security and service insertion must be treated as an engineering mechanism rather than a product checkbox. Integrate firewalls, policy, microsegmentation, encryption, inspection, and observability. The design should name the authoritative inputs, state transitions, dependencies, limits, ownership, telemetry, expected output, and conditions that make the result unsafe or inconclusive.

The guide traces this subject through the underlay, EVPN route, VNI, gateway, multihoming, service, and forwarding chain. Configuration, controller health, or a green dashboard is never sufficient proof by itself. The engineer must reconcile intended state with protocol or platform state, installed forwarding or policy, real transactions, failure behavior, and the experience of the affected user, device, service, or application.

Implementation begins with a minimal, known-good baseline and explicit invariants. Introduce one capability or dependency at a time, validate positive and negative cases, inject realistic failures, measure recovery, and preserve before-and-after evidence. Automation must be idempotent, bounded, observable, reversible, and able to stop safely when inputs are stale or outcomes diverge.

Troubleshooting should locate the first divergence from the expected transaction or state machine. Inspect both directions and all authority boundaries; account for caching, eventual consistency, tunnels, load sharing, policy, identity, offload, time, and partial failure. Closure requires causal evidence, restored service, rollback proof, residual-risk disclosure, and prevention or monitoring actions.

Engineering practices

Define authority, ownership, scope, dependencies, and acceptance criteria for security and service insertion.

Model the expected state and traffic path before implementation or troubleshooting.

Validate intent, control state, applied policy or forwarding state, and end-to-end service independently.

Test normal, denied, degraded, failed, recovery, upgrade, and rollback conditions.

Retain topology, configuration, packet, telemetry, log, identity, timing, and service evidence.

Automate through typed data, deterministic gates, canaries, bounded concurrency, and reversible changes.

Failure patterns

Treating security and service insertion as a vendor feature instead of an end-to-end system.

Relying on intended configuration or controller state without proving applied and operational behavior.

Ignoring reverse paths, external dependencies, identity, time, or partial failure.

Changing several variables before preserving original evidence and stating a hypothesis.

Allowing automation or AI to act on stale, ambiguous, or unauthorized data.

Declaring success after one probe without negative tests, scale checks, rollback, and recurrence monitoring.

Validation and evidence

Method	Expected evidence
Examine	Requirements, topology, models, policy, configuration, ownership, and dependencies for security and service insertion.
Observe	Control-plane or platform state, applied policy, forwarding state, telemetry, logs, and endpoint behavior.
Test	Expected traffic, prohibited traffic, dependency loss, partial failure, convergence, recovery, and rollback.
Measure	Availability, reachability, latency, loss, convergence, scale, resource use, change success, and user experience.
Reconcile	Intended state against observed platform, network, security, identity, application, and evidence records.

Chapter 06 laboratory and review

Practical laboratory

Design two sites and one cloud region with selective tenant extension and shared services. Test route leaks, site isolation, and DCI failure.

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 policy fabrics, sovereign multi-cloud, intent-aware DCI, and optical interconnect orchestration.

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

Automation and observability

Manage fabric state through models, APIs, continuous verification, and evidence.

Chapter operating position

Manage fabric state through models, APIs, continuous verification, and evidence.



7.1 Fabric source of truth

Fabric source of truth must be treated as an engineering mechanism rather than a product checkbox. Model racks, devices, links, loopbacks, ASNs, VNIs, VRFs, route targets, endpoint classes, and ownership. The design should name the authoritative inputs, state transitions, dependencies, limits, ownership, telemetry, expected output, and conditions that make the result unsafe or inconclusive.

The guide traces this subject through the underlay, EVPN route, VNI, gateway, multihoming, service, and forwarding chain. Configuration, controller health, or a green dashboard is never sufficient proof by itself. The engineer must reconcile intended state with protocol or platform state, installed forwarding or policy, real transactions, failure behavior, and the experience of the affected user, device, service, or application.

Implementation begins with a minimal, known-good baseline and explicit invariants. Introduce one capability or dependency at a time, validate positive and negative cases, inject realistic failures, measure recovery, and preserve before-and-after evidence. Automation must be idempotent, bounded, observable, reversible, and able to stop safely when inputs are stale or outcomes diverge.

Troubleshooting should locate the first divergence from the expected transaction or state machine. Inspect both directions and all authority boundaries; account for caching, eventual consistency, tunnels, load sharing, policy, identity, offload, time, and partial failure. Closure requires causal evidence, restored service, rollback proof, residual-risk disclosure, and prevention or monitoring actions.

Engineering practices

Define authority, ownership, scope, dependencies, and acceptance criteria for fabric source of truth.

Model the expected state and traffic path before implementation or troubleshooting.

Validate intent, control state, applied policy or forwarding state, and end-to-end service independently.

Test normal, denied, degraded, failed, recovery, upgrade, and rollback conditions.

Retain topology, configuration, packet, telemetry, log, identity, timing, and service evidence.

Automate through typed data, deterministic gates, canaries, bounded concurrency, and reversible changes.

Failure patterns

Treating fabric source of truth as a vendor feature instead of an end-to-end system.

Relying on intended configuration or controller state without proving applied and operational behavior.

Ignoring reverse paths, external dependencies, identity, time, or partial failure.

Changing several variables before preserving original evidence and stating a hypothesis.

Allowing automation or AI to act on stale, ambiguous, or unauthorized data.

Declaring success after one probe without negative tests, scale checks, rollback, and recurrence monitoring.

Validation and evidence

Method	Expected evidence
Examine	Requirements, topology, models, policy, configuration, ownership, and dependencies for fabric source of truth.
Observe	Control-plane or platform state, applied policy, forwarding state, telemetry, logs, and endpoint behavior.
Test	Expected traffic, prohibited traffic, dependency loss, partial failure, convergence, recovery, and rollback.
Measure	Availability, reachability, latency, loss, convergence, scale, resource use, change success, and user experience.
Reconcile	Intended state against observed platform, network, security, identity, application, and evidence records.

7.2 Configuration generation

Configuration generation must be treated as an engineering mechanism rather than a product checkbox. Use templates or data models, transactions, staged deployment, consistency checks, and rollback. The design should name the authoritative inputs, state transitions, dependencies, limits, ownership, telemetry, expected output, and conditions that make the result unsafe or inconclusive.

The guide traces this subject through the underlay, EVPN route, VNI, gateway, multihoming, service, and forwarding chain. Configuration, controller health, or a green dashboard is never sufficient proof by itself. The engineer must reconcile intended state with protocol or platform state, installed forwarding or policy, real transactions, failure behavior, and the experience of the affected user, device, service, or application.

Implementation begins with a minimal, known-good baseline and explicit invariants. Introduce one capability or dependency at a time, validate positive and negative cases, inject realistic failures, measure recovery, and preserve before-and-after evidence. Automation must be idempotent, bounded, observable, reversible, and able to stop safely when inputs are stale or outcomes diverge.

Troubleshooting should locate the first divergence from the expected transaction or state machine. Inspect both directions and all authority boundaries; account for caching, eventual consistency, tunnels, load sharing, policy, identity, offload, time, and partial failure. Closure requires causal evidence, restored service, rollback proof, residual-risk disclosure, and prevention or monitoring actions.

Engineering practices

Define authority, ownership, scope, dependencies, and acceptance criteria for configuration generation.

Model the expected state and traffic path before implementation or troubleshooting.

Validate intent, control state, applied policy or forwarding state, and end-to-end service independently.

Test normal, denied, degraded, failed, recovery, upgrade, and rollback conditions.

Retain topology, configuration, packet, telemetry, log, identity, timing, and service evidence.

Automate through typed data, deterministic gates, canaries, bounded concurrency, and reversible changes.

Implementation sketch

```
fabric:
  underlay: ebgp
  overlay: evpn-vxlan
  tenants:
    - name: payments
      vrf: PAYMENTS
      l3_vni: 50100
      route_targets: ["65000:50100"]
      segments:
        - {vlan: 110, l2_vni: 10110, gateway: 10.10.110.1/24}
  invariants:
    - no_route_target_leak
    - anycast_gateway_consistent
    - esi_multihoming_split_horizon
    - mtu_supports_vxlan
    - failure_paths_verified
```

Failure patterns

- Treating configuration generation as a vendor feature instead of an end-to-end system.
- Relying on intended configuration or controller state without proving applied and operational behavior.
- Ignoring reverse paths, external dependencies, identity, time, or partial failure.
- Changing several variables before preserving original evidence and stating a hypothesis.
- Allowing automation or AI to act on stale, ambiguous, or unauthorized data.
- Declaring success after one probe without negative tests, scale checks, rollback, and recurrence monitoring.

Validation and evidence

Method	Expected evidence
Examine	Requirements, topology, models, policy, configuration, ownership, and dependencies for configuration generation.
Observe	Control-plane or platform state, applied policy, forwarding state, telemetry, logs, and endpoint behavior.
Test	Expected traffic, prohibited traffic, dependency loss, partial failure, convergence, recovery, and rollback.
Measure	Availability, reachability, latency, loss, convergence, scale, resource use, change success, and user experience.
Reconcile	Intended state against observed platform, network, security, identity, application, and evidence records.

7.3 Telemetry and troubleshooting

Telemetry and troubleshooting must be treated as an engineering mechanism rather than a product checkbox. Collect BGP EVPN, VTEP, MAC/IP, interface, queue, buffer, route, host, and application-path data. The design should name the authoritative inputs, state transitions, dependencies, limits, ownership, telemetry, expected output, and conditions that make the result unsafe or inconclusive.

The guide traces this subject through the underlay, EVPN route, VNI, gateway, multihoming, service, and forwarding chain. Configuration, controller health, or a green dashboard is never sufficient proof by itself. The engineer must reconcile intended state with protocol or platform state, installed forwarding or policy, real transactions, failure behavior, and the experience of the affected user, device, service, or application.

Implementation begins with a minimal, known-good baseline and explicit invariants. Introduce one capability or dependency at a time, validate positive and negative cases, inject realistic failures, measure recovery, and preserve before-and-after evidence. Automation must be idempotent, bounded, observable, reversible, and able to stop safely when inputs are stale or outcomes diverge.

Troubleshooting should locate the first divergence from the expected transaction or state machine. Inspect both directions and all authority boundaries; account for caching, eventual consistency, tunnels, load sharing, policy, identity, offload, time, and partial failure. Closure requires causal evidence, restored service, rollback proof, residual-risk disclosure, and prevention or monitoring actions.

Engineering practices

- Define authority, ownership, scope, dependencies, and acceptance criteria for telemetry and troubleshooting.
- Model the expected state and traffic path before implementation or troubleshooting.
- Validate intent, control state, applied policy or forwarding state, and end-to-end service independently.
- Test normal, denied, degraded, failed, recovery, upgrade, and rollback conditions.
- Retain topology, configuration, packet, telemetry, log, identity, timing, and service evidence.
- Automate through typed data, deterministic gates, canaries, bounded concurrency, and reversible changes.

Failure patterns

- Treating telemetry and troubleshooting as a vendor feature instead of an end-to-end system.
- Relying on intended configuration or controller state without proving applied and operational behavior.

Ignoring reverse paths, external dependencies, identity, time, or partial failure.

Changing several variables before preserving original evidence and stating a hypothesis.

Allowing automation or AI to act on stale, ambiguous, or unauthorized data.

Declaring success after one probe without negative tests, scale checks, rollback, and recurrence monitoring.

Validation and evidence

Method	Expected evidence
Examine	Requirements, topology, models, policy, configuration, ownership, and dependencies for telemetry and troubleshooting.
Observe	Control-plane or platform state, applied policy, forwarding state, telemetry, logs, and endpoint behavior.
Test	Expected traffic, prohibited traffic, dependency loss, partial failure, convergence, recovery, and rollback.
Measure	Availability, reachability, latency, loss, convergence, scale, resource use, change success, and user experience.
Reconcile	Intended state against observed platform, network, security, identity, application, and evidence records.

7.4 Digital twin and reachability testing

Digital twin and reachability testing must be treated as an engineering mechanism rather than a product checkbox. Verify topology, policy, routes, forwarding, failure paths, and change differentials before release. The design should name the authoritative inputs, state transitions, dependencies, limits, ownership, telemetry, expected output, and conditions that make the result unsafe or inconclusive.

The guide traces this subject through the underlay, EVPN route, VNI, gateway, multihoming, service, and forwarding chain. Configuration, controller health, or a green dashboard is never sufficient proof by itself. The engineer must reconcile intended state with protocol or platform state, installed forwarding or policy, real transactions, failure behavior, and the experience of the affected user, device, service, or application.

Implementation begins with a minimal, known-good baseline and explicit invariants. Introduce one capability or dependency at a time, validate positive and negative cases, inject realistic failures, measure recovery, and preserve before-and-after evidence. Automation must be idempotent, bounded, observable, reversible, and able to stop safely when inputs are stale or outcomes diverge.

Troubleshooting should locate the first divergence from the expected transaction or state machine. Inspect both directions and all authority boundaries; account for caching, eventual consistency, tunnels, load sharing, policy, identity, offload, time, and partial failure. Closure requires causal evidence, restored service, rollback proof, residual-risk disclosure, and prevention or monitoring actions.

Engineering practices

Define authority, ownership, scope, dependencies, and acceptance criteria for digital twin and reachability testing.

Model the expected state and traffic path before implementation or troubleshooting.

Validate intent, control state, applied policy or forwarding state, and end-to-end service independently.

Test normal, denied, degraded, failed, recovery, upgrade, and rollback conditions.

Retain topology, configuration, packet, telemetry, log, identity, timing, and service evidence.

Automate through typed data, deterministic gates, canaries, bounded concurrency, and reversible changes.

Failure patterns

Treating digital twin and reachability testing as a vendor feature instead of an end-to-end system.

Relying on intended configuration or controller state without proving applied and operational behavior.

Ignoring reverse paths, external dependencies, identity, time, or partial failure.

Changing several variables before preserving original evidence and stating a hypothesis.

Allowing automation or AI to act on stale, ambiguous, or unauthorized data.

Declaring success after one probe without negative tests, scale checks, rollback, and recurrence monitoring.

Validation and evidence

Method	Expected evidence
Examine	Requirements, topology, models, policy, configuration, ownership, and dependencies for digital twin and reachability testing.
Observe	Control-plane or platform state, applied policy, forwarding state, telemetry, logs, and endpoint behavior.
Test	Expected traffic, prohibited traffic, dependency loss, partial failure, convergence, recovery, and rollback.
Measure	Availability, reachability, latency, loss, convergence, scale, resource use, change success, and user experience.
Reconcile	Intended state against observed platform, network, security, identity, application, and evidence records.

Chapter 07 laboratory and review

Practical laboratory

Generate a small fabric from structured data, validate route targets and reachability offline, deploy a canary leaf, and prove expected 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

Develop a self-verifying fabric with intent compilation, evidence bundles, anomaly reasoning, and bounded autonomous recovery.

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

Scale, failure, and lifecycle assurance

Prove the fabric remains correct under endpoint churn, failure, maintenance, and growth.

Chapter operating position

Prove the fabric remains correct under endpoint churn, failure, maintenance, and growth.



8.1 Control-plane scale

Control-plane scale must be treated as an engineering mechanism rather than a product checkbox. Measure BGP sessions, routes, MAC/IP state, VNIs, convergence, CPU, memory, and update churn. The design should name the authoritative inputs, state transitions, dependencies, limits, ownership, telemetry, expected output, and conditions that make the result unsafe or inconclusive.

The guide traces this subject through the underlay, EVPN route, VNI, gateway, multihoming, service, and forwarding chain. Configuration, controller health, or a green dashboard is never sufficient proof by itself. The engineer must reconcile intended state with protocol or platform state, installed forwarding or policy, real transactions, failure behavior, and the experience of the affected user, device, service, or application.

Implementation begins with a minimal, known-good baseline and explicit invariants. Introduce one capability or dependency at a time, validate positive and negative cases, inject realistic failures, measure recovery, and preserve before-and-after evidence. Automation must be idempotent, bounded, observable, reversible, and able to stop safely when inputs are stale or outcomes diverge.

Troubleshooting should locate the first divergence from the expected transaction or state machine. Inspect both directions and all authority boundaries; account for caching, eventual consistency, tunnels, load sharing, policy, identity, offload, time, and partial failure. Closure requires causal evidence, restored service, rollback proof, residual-risk disclosure, and prevention or monitoring actions.

Engineering practices

- Define authority, ownership, scope, dependencies, and acceptance criteria for control-plane scale.
- Model the expected state and traffic path before implementation or troubleshooting.
- Validate intent, control state, applied policy or forwarding state, and end-to-end service independently.
- Test normal, denied, degraded, failed, recovery, upgrade, and rollback conditions.
- Retain topology, configuration, packet, telemetry, log, identity, timing, and service evidence.
- Automate through typed data, deterministic gates, canaries, bounded concurrency, and reversible changes.

Failure patterns

- Treating control-plane scale as a vendor feature instead of an end-to-end system.
- Relying on intended configuration or controller state without proving applied and operational behavior.
- Ignoring reverse paths, external dependencies, identity, time, or partial failure.
- Changing several variables before preserving original evidence and stating a hypothesis.
- Allowing automation or AI to act on stale, ambiguous, or unauthorized data.
- Declaring success after one probe without negative tests, scale checks, rollback, and recurrence monitoring.

Validation and evidence

Method	Expected evidence
Examine	Requirements, topology, models, policy, configuration, ownership, and dependencies for control-plane scale.
Observe	Control-plane or platform state, applied policy, forwarding state, telemetry, logs, and endpoint behavior.
Test	Expected traffic, prohibited traffic, dependency loss, partial failure, convergence, recovery, and rollback.
Measure	Availability, reachability, latency, loss, convergence, scale, resource use, change success, and user experience.
Reconcile	Intended state against observed platform, network, security, identity, application, and evidence records.

8.2 Data-plane scale

Data-plane scale must be treated as an engineering mechanism rather than a product checkbox. Measure ECMP, hash quality, buffers, drops, latency, throughput, incast, and congestion behavior. The design should name the authoritative inputs, state transitions, dependencies, limits, ownership, telemetry, expected output, and conditions that make the result unsafe or inconclusive.

The guide traces this subject through the underlay, EVPN route, VNI, gateway, multihoming, service, and forwarding chain. Configuration, controller health, or a green dashboard is never sufficient proof by itself. The engineer must reconcile intended state with protocol or platform state, installed forwarding or policy, real transactions, failure behavior, and the experience of the affected user, device, service, or application.

Implementation begins with a minimal, known-good baseline and explicit invariants. Introduce one capability or dependency at a time, validate positive and negative cases, inject realistic failures, measure recovery, and preserve before-and-after evidence. Automation must be idempotent, bounded, observable, reversible, and able to stop safely when inputs are stale or outcomes diverge.

Troubleshooting should locate the first divergence from the expected transaction or state machine. Inspect both directions and all authority boundaries; account for caching, eventual consistency, tunnels, load sharing, policy, identity, offload, time, and partial failure. Closure requires causal evidence, restored service, rollback proof, residual-risk disclosure, and prevention or monitoring actions.

Engineering practices

- Define authority, ownership, scope, dependencies, and acceptance criteria for data-plane scale.
- Model the expected state and traffic path before implementation or troubleshooting.
- Validate intent, control state, applied policy or forwarding state, and end-to-end service independently.
- Test normal, denied, degraded, failed, recovery, upgrade, and rollback conditions.
- Retain topology, configuration, packet, telemetry, log, identity, timing, and service evidence.
- Automate through typed data, deterministic gates, canaries, bounded concurrency, and reversible changes.

Implementation sketch

```
fabric:
  underlay: ebgp
  overlay: evpn-vxlan
  tenants:
    - name: payments
      vrf: PAYMENTS
      l3_vni: 50100
      route_targets: ["65000:50100"]
      segments:
        - {vlan: 110, l2_vni: 10110, gateway: 10.10.110.1/24}
  invariants:
    - no_route_target_leak
    - anycast_gateway_consistent
    - esi_multihoming_split_horizon
    - mtu_supports_vxlan
    - failure_paths_verified
```

Failure patterns

- Treating data-plane scale as a vendor feature instead of an end-to-end system.
- Relying on intended configuration or controller state without proving applied and operational behavior.
- Ignoring reverse paths, external dependencies, identity, time, or partial failure.
- Changing several variables before preserving original evidence and stating a hypothesis.
- Allowing automation or AI to act on stale, ambiguous, or unauthorized data.
- Declaring success after one probe without negative tests, scale checks, rollback, and recurrence monitoring.

Validation and evidence

Method	Expected evidence
Examine	Requirements, topology, models, policy, configuration, ownership, and dependencies for data-plane scale.
Observe	Control-plane or platform state, applied policy, forwarding state, telemetry, logs, and endpoint behavior.
Test	Expected traffic, prohibited traffic, dependency loss, partial failure, convergence, recovery, and rollback.
Measure	Availability, reachability, latency, loss, convergence, scale, resource use, change success, and user experience.
Reconcile	Intended state against observed platform, network, security, identity, application, and evidence records.

8.3 Failure and upgrade testing

Failure and upgrade testing must be treated as an engineering mechanism rather than a product checkbox. Test spine, leaf, link, endpoint, route reflector, controller, DCI, and software failure. The design should name the authoritative inputs, state transitions, dependencies, limits, ownership, telemetry, expected output, and conditions that make the result unsafe or inconclusive.

The guide traces this subject through the underlay, EVPN route, VNI, gateway, multihoming, service, and forwarding chain. Configuration, controller health, or a green dashboard is never sufficient proof by itself. The engineer must reconcile intended state with protocol or platform state, installed forwarding or policy, real transactions, failure behavior, and the experience of the affected user, device, service, or application.

Implementation begins with a minimal, known-good baseline and explicit invariants. Introduce one capability or dependency at a time, validate positive and negative cases, inject realistic failures, measure recovery, and preserve before-and-after evidence. Automation must be idempotent, bounded, observable, reversible, and able to stop safely when inputs are stale or outcomes diverge.

Troubleshooting should locate the first divergence from the expected transaction or state machine. Inspect both directions and all authority boundaries; account for caching, eventual consistency, tunnels, load sharing, policy, identity, offload, time, and partial failure. Closure requires causal evidence, restored service, rollback proof, residual-risk disclosure, and prevention or monitoring actions.

Engineering practices

- Define authority, ownership, scope, dependencies, and acceptance criteria for failure and upgrade testing.
- Model the expected state and traffic path before implementation or troubleshooting.
- Validate intent, control state, applied policy or forwarding state, and end-to-end service independently.
- Test normal, denied, degraded, failed, recovery, upgrade, and rollback conditions.
- Retain topology, configuration, packet, telemetry, log, identity, timing, and service evidence.
- Automate through typed data, deterministic gates, canaries, bounded concurrency, and reversible changes.

Failure patterns

- Treating failure and upgrade testing as a vendor feature instead of an end-to-end system.
- Relying on intended configuration or controller state without proving applied and operational behavior.

Ignoring reverse paths, external dependencies, identity, time, or partial failure.

Changing several variables before preserving original evidence and stating a hypothesis.

Allowing automation or AI to act on stale, ambiguous, or unauthorized data.

Declaring success after one probe without negative tests, scale checks, rollback, and recurrence monitoring.

Validation and evidence

Method	Expected evidence
Examine	Requirements, topology, models, policy, configuration, ownership, and dependencies for failure and upgrade testing.
Observe	Control-plane or platform state, applied policy, forwarding state, telemetry, logs, and endpoint behavior.
Test	Expected traffic, prohibited traffic, dependency loss, partial failure, convergence, recovery, and rollback.
Measure	Availability, reachability, latency, loss, convergence, scale, resource use, change success, and user experience.
Reconcile	Intended state against observed platform, network, security, identity, application, and evidence records.

8.4 Migration and retirement

Migration and retirement must be treated as an engineering mechanism rather than a product checkbox. Move from VLAN or MLAG networks to EVPN, preserve service, maintain rollback, and remove obsolete state. The design should name the authoritative inputs, state transitions, dependencies, limits, ownership, telemetry, expected output, and conditions that make the result unsafe or inconclusive.

The guide traces this subject through the underlay, EVPN route, VNI, gateway, multihoming, service, and forwarding chain. Configuration, controller health, or a green dashboard is never sufficient proof by itself. The engineer must reconcile intended state with protocol or platform state, installed forwarding or policy, real transactions, failure behavior, and the experience of the affected user, device, service, or application.

Implementation begins with a minimal, known-good baseline and explicit invariants. Introduce one capability or dependency at a time, validate positive and negative cases, inject realistic failures, measure recovery, and preserve before-and-after evidence. Automation must be idempotent, bounded, observable, reversible, and able to stop safely when inputs are stale or outcomes diverge.

Troubleshooting should locate the first divergence from the expected transaction or state machine. Inspect both directions and all authority boundaries; account for caching, eventual consistency, tunnels, load sharing, policy, identity, offload, time, and partial failure. Closure requires causal evidence, restored service, rollback proof, residual-risk disclosure, and prevention or monitoring actions.

Engineering practices

Define authority, ownership, scope, dependencies, and acceptance criteria for migration and retirement.

Model the expected state and traffic path before implementation or troubleshooting.

Validate intent, control state, applied policy or forwarding state, and end-to-end service independently.

Test normal, denied, degraded, failed, recovery, upgrade, and rollback conditions.

Retain topology, configuration, packet, telemetry, log, identity, timing, and service evidence.

Automate through typed data, deterministic gates, canaries, bounded concurrency, and reversible changes.

Failure patterns

Treating migration and retirement as a vendor feature instead of an end-to-end system.

Relying on intended configuration or controller state without proving applied and operational behavior.

Ignoring reverse paths, external dependencies, identity, time, or partial failure.

Changing several variables before preserving original evidence and stating a hypothesis.

Allowing automation or AI to act on stale, ambiguous, or unauthorized data.

Declaring success after one probe without negative tests, scale checks, rollback, and recurrence monitoring.

Validation and evidence

Method	Expected evidence
Examine	Requirements, topology, models, policy, configuration, ownership, and dependencies for migration and retirement.
Observe	Control-plane or platform state, applied policy, forwarding state, telemetry, logs, and endpoint behavior.
Test	Expected traffic, prohibited traffic, dependency loss, partial failure, convergence, recovery, and rollback.
Measure	Availability, reachability, latency, loss, convergence, scale, resource use, change success, and user experience.
Reconcile	Intended state against observed platform, network, security, identity, application, and evidence records.

Chapter 08 laboratory and review

Practical laboratory

Execute a fabric acceptance plan with endpoint churn, leaf and spine loss, DCI partition, route-reflector loss, microbursts, and rolling upgrades.

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

Evaluate 800G and 1.6T fabrics, optical circuit switching, AI congestion control, and quantum-safe management planes.

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. IETF / RFC Editor - RFC 7432 - BGP MPLS-Based Ethernet VPN

Role: EVPN control-plane architecture.

Verified: 2026-07-26

Official source: <https://www.rfc-editor.org/info/rfc7432>

02. IETF / RFC Editor - RFC 8365 - EVPN as a Network Virtualization Overlay

Role: EVPN over VXLAN and other NVO encapsulations.

Verified: 2026-07-26

Official source: <https://www.rfc-editor.org/info/rfc8365>

03. IETF / RFC Editor - RFC 9136 - IP Prefix Advertisement in EVPN

Role: EVPN IP-prefix route and inter-subnet connectivity.

Verified: 2026-07-26

Official source: <https://www.rfc-editor.org/info/rfc9136>

04. IETF / RFC Editor - RFC 9746 - EVPN Multihoming Split-Horizon Extensions

Role: Current EVPN multihoming split-horizon behavior.

Verified: 2026-07-26

Official source: <https://www.rfc-editor.org/info/rfc9746>

05. IEEE Standards Association - IEEE 802.1Q-2022 - Bridges and Bridged Networks

Role: Bridging, VLAN, spanning-tree, and bridged-network authority.

Verified: 2026-07-26

Official source: https://standards.ieee.org/standard/802_1Q-2022.html

06. IETF / RFC Editor - RFC 8342 - Network Management Datastore Architecture

Role: Intended, applied, operational, and origin datastore model.

Verified: 2026-07-26

Official source: <https://www.rfc-editor.org/info/rfc8342>

07. OpenConfig - OpenConfig data models

Role: Vendor-neutral network configuration and operational-state models.

Verified: 2026-07-26

Official source: <https://www.openconfig.net/projects/models/>

08. OpenConfig - gNMI specification

Role: gRPC configuration retrieval and streaming telemetry protocol.

Verified: 2026-07-26

Official source: <https://www.openconfig.net/docs/gnmi/gnmi-specification/>

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-NET - Network Engineering & Architecture
Secondary domain	MYTHOS-CLD; MYTHOS-SEC; MYTHOS-DAT
Publication class	Field Guide / Canonical Living Overview Guide
Skill levels	L1 Foundational; L2 Practitioner; L3 Advanced; L4 Frontier
Tags	data center, EVPN, VXLAN, leaf spine, fabric, multihoming, anycast gateway, DCI, automation, telemetry
Canonical route	/library/field-guides/mythos-fg-net-0012/

Living publication

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