Velsanet Path Lifecycle White Paper

Network-Native Path Continuity, Mobility, and Transition Model

1. Purpose

This document defines the lifecycle management model for paths formed within the Velsanet architecture.

The purpose of this document is to specify how already formed paths are maintained, transitioned, duplicated, and recovered under mobility, topology change, and failure conditions without violating identity and constraint bindings.

2. Scope

This document covers:

- path state definitions
- path continuity requirements
- mobility handling across access and aggregation domains
- handover semantics
- redundant and overlapping path management
- failure recovery within admissible bounds
- termination semantics

This document does **not** define:

- identity provisioning
- initial path formation rules
- authentication mechanisms
- routing or matching algorithms

3. Design Principle

In Velsanet, formed paths are not recalculated under change.

Paths persist as identity-bound stateful entities.

All lifecycle operations preserve the original identity and constraint bindings.

No lifecycle operation may expand the admissible scope defined at path formation.

4. Path State Model

A path exists in one of the following states:

- **Active**
  The path is carrying traffic and satisfies all constraints.
- **Standby**
  The path is reserved and synchronized but not carrying traffic.
- **Overlapping**
  Two or more paths temporarily coexist to preserve continuity during transition.
- **Degraded**
  The path is operational but constraint compliance is partially violated.
- **Terminating**
  The path is being withdrawn and resources are being released.

State transitions are controlled exclusively by the network.

5. Continuity Requirement

For all lifecycle operations, the following invariants must be preserved:

- identity binding
- constraint profile
- hierarchy scope
- admissible topology domain

Violation of any invariant triggers path termination.

6. Mobility Handling

Mobility is defined as a change in the attachment point of the originating device.

Mobility handling includes:

- access-level movement
- RAN-level movement
- aggregation-level movement

Mobility does not trigger identity revalidation or path reformation.

7. Handover Semantics

Handover is executed as a state transition, not as a new path formation.

The default handover mode is **make-before-break**.

Break-before-make transitions are prohibited unless explicitly allowed by the constraint profile.

During handover:

- overlapping paths may coexist
- traffic migration is gradual
- continuity is preserved

8. Overlapping Path Rules

Overlapping paths are permitted only when:

- both paths satisfy the original constraint profile
- overlapping duration is bounded
- resource usage remains admissible

Overlapping paths must converge to a single active path.

Persistent overlap beyond allowed bounds is prohibited.

9. Redundant Path Management

Redundant paths may be provisioned as:

- hot standby
- synchronized dual paths

Redundant paths are identity-bound and constraint-aligned.

Activation of redundant paths does not alter the original path identity.

10. Failure Detection and Recovery

Failures may include:

- core failure
- plane failure
- link degradation

Recovery follows this order:

1. recovery within the same plane
2. recovery across admissible planes

If recovery violates constraints, the path enters the **Degraded** state or is terminated.

11. Constraint Preservation Under Change

The following elements are immutable:

- identity scope
- hierarchy level
- isolation requirements

The following elements may be adjusted within bounds:

- internal core allocation
- internal plane selection

Any adjustment outside permitted bounds requires path termination.

12. Reconfiguration Restrictions

Reconfiguration must not:

- re-evaluate identity
- expand admissible topology
- introduce new peers

Reconfiguration is limited to internal path representation.

13. Path Termination Semantics

A path is terminated when:

- the originating device disconnects
- mobility exceeds admissible bounds
- constraint violations persist
- recovery fails

Termination releases all associated resources.

14. Lifecycle Record

For each terminated path, the network records:

- identity reference
- lifecycle state transitions
- mobility events
- termination cause

Records are retained for audit and verification.

15. Summary

In Velsanet:

- paths persist as identity-bound entities
- mobility is handled as state transition
- continuity is preserved through overlap and redundancy
- lifecycle control resides exclusively in the network

Path lifecycle management completes the Velsanet connection model.