VELSA

Network AI Complete Design Specification

HC network topology design / O8 self-awareness / neighbor finding / network AI role / PAI, AAI, AsAI, E2E / 4 types of architecture reports

document number	VELSA-NET-AI-SPEC-001 v2.0
Workbook	Full integration of v1.3 (HC network topology) + v1.4 (architectural report)
Main contents	Overall Structure / WI / Self-Awareness / Neighborhood Search / Roles of Network AI Layers / PAI, AAI, AsAI / Four Types of Reports / Collection System
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1. Overall structural overview

Velsanet is a topology-first network consisting of five regular polyhedral layers (T4/H6/O8/D12/I20). The HC network begins at O8 (Q7), and T4 and H6 are autonomous nodes outside the HC network. Network AI is connected to the reference node (all bits 0) of each layer.

hierarchy	Q level	HC dimension	Base node	Number of neighbors	Structural role
T4	—	—	—	—	Edge. Outside the HC network. Belonging to H6.
H6	—	—	—	—	Autonomous node. Outside the HC network. Reporting connection to O8.
O8	Q7	7-bit	0000000	7	Local E2E domain. Connect to PAI/E2E Management Center.
D12	Q6	6-bit	000000	6	Regional Convergence. AAI/E2E Management Center Connection.
I20	Q5	5-bit	00000	5	National Sovereign. AsAI/E2E Management Center Connection

Three Core Principles

1 Structure first, address later: WI phase definition → self-recognition → face connection → neighbor verification, then address confirmation

2 Find neighbors = Create HC network = Minimum condition for parallel E2E: Neighbor unknown O8 does not participate in HC network

3 Base Nodes (0...0) = Network AI Connection. The rest = PAI/AAI/AsAI/E2E Management Center Connection.

2. WI (Work Instruction) — Phase Dictionary Definition

2.1 Role of WI

The WI is not simply an installation instruction, but a topology pre-definition document. Upon booting, the O8 first reads the WI to determine its location, connection structure, and the upper system to which it will be connected. Without the WI, self-identification cannot begin.

item	form	explanation
Sector code	A-01	City code + zone number
Equipment HC Address	A-01-0000000	Sector + Q7 7-bit coordinates
Q level	Q7 / Q6 / Q5	Layer identifier
Face connection definition	F0~F7 each	Connected / Unconnected / Scheduled
Neighboring nodes by axis	Axis 1~7	Neighboring equipment HC address for each axis
Core count planning	Allocation by Face	Total number of cores + allocation by purpose
Network AI connection	Y/N	Y if the reference node (0...0)
Type of connection equipment	PAI / AAI / AsAI / E2E	The parent system to be connected to the node
Sovereign Zone	City/Region/Country	Sovereign attribution of the node
Installation sequence	1~N	Specify the order of I20 → D12 → O8

2.2 Example of metropolitan sector division (Seoul)

The metropolitan area is divided into sectors, each with a Q7 network (128 nodes). Each sector forms an independent Q7 HC network, which converges to the D12 Q6 network.

Sector code	Administrative districts	Base node	D12 connection
A-01	Gangnam-gu	A-01-0000000	D12-Q6-KR01-000000
A-02	Seocho-gu	A-02-0000000	D12-Q6-KR01-000000
A-03	Songpa-gu	A-03-0000000	D12-Q6-KR01-000000
A-04	Mapo-gu	A-04-0000000	D12-Q6-KR01-000001
...	...	...	(Expands according to the number of sectors)

2.3 WI Verification — Physical State Verification

O8 compares the WI definition value with the actual physical connection status during self-recognition. WI is the reference (Ground Truth).

situation	verdict	treatment
WI "connection" + actual connection	normal	Continue to develop self-awareness
WI "Not Connected" + Actual Not Connected	normal	Recorded as scheduled disconnection
WI "connected" + actual unconnected	Installation error	WI reconfirmation alarm. Operator intervention required.
WI "Not connected" + actual connection	Security Warning	SECURITY_ALERT. Physical blocking
No WI	Boot interruption	No self-awareness without WI

3. O8 Self-Recognition — Level 4

O8 self-awareness is a top priority and must be completed before any other post-boot operation. Without self-awareness, HC network participation, E2E processing, and connected device activation are all impossible.

step	designation	Core actions	Completion conditions
1	Device name recognition	Check HC address + connection device type in WI	Structure address A-XX-XXXXXXXX confirmed
2	Obtaining cotton information	8 Faces connected/unconnected + optical core status	Complete the core state table by face
3	HC network configuration	Complete the Q7 network with Neighbor Finder + Pass	All 7 Axis confirmed
4	Initiate response	REGISTER transmission. Connected equipment activation signal.	Start parallel E2E wait

1 Self-Equipment Name Recognition — HC Address + Connected Equipment Type Detection in WI

- Read sector code + Q7 HC 7-bit coordinates from WI
- Check the type of connected equipment — Network AI (reference node) / PAI / AAI / E2E Management Center
- Confirm the structural address in the format A-XX-XXXXXXXX
- Booting halts when WI is missing or coordinates are unknown

example

```
"I am A-01-0000000. Q7 reference node. Network AI connection device."
"I am A-01-0000001. Q7 generic node. PAI connection device."
```

2 Obtain all connected face information — connected/unconnected per face + optical core status

- F0~F7 Connectivity of each face + WI contrast
- Connection Face: Collect neighbor node ID + optical core ACTIVE/STANDBY/FAULT
- Unconnected Face: Check if it matches the WI definition
- If there is a mismatch, an installation error or security warning is issued.

3 HC Network Configuration — Neighbor Finding + Automatic Completion of Q7 Network with Passes

- Sending neighbor confirmation messages in 7 Axis directions
- Confirm the corresponding Axis when neighbor responds + core-axis mapping
- Full phase detection beyond 2-hop using a pass mechanism
- 128-node Q7 network automatically completes without software

4 Initiate response — Send REGISTER + Activate connected equipment

- Send REGISTER to the 0000000 reference node (Network AI)
- Transmitting activation signal to connected equipment (PAI/AAI/AsAI/E2E management center)
- Start waiting for parallel E2E path requests
- Start real-time monitoring of neighbor status

4. HC Network Configuration - Neighbor Discovery and Pass

Key proposition

Neighbor search complete = HC network creation = Physical minimum conditions for parallel E2E

An O8 that has not completed neighbor discovery is considered non-existent in the HC network. Without the HC network, neither PAI nor E2E will work.

4.1 Finding Neighbors - 7 Axis Confirmation

In Q7, each node has exactly seven logical neighbors (nodes that differ by only one bit in the HC address). Each of the seven optical cores corresponds to Axis 1 through 7.

Axis	bit inversion	0000000's neighbors	Confirmation message
Axis 1	bit-0	0000001	Are you 0000001? I'm 0000000. Axis 1 confirmed.
Axis 2	bit-1	0000010	Are you 0000010? I am 0000000. Axis 2 confirmed.
Axis 3	bit-2	0000100	Are you 0000100? I'm 0000000. Axis 3 confirmed.
Axis 4	bit-3	0001000	Are you 0001000? I'm 0000000. Axis 4 confirmed.
Axis 5	bit-4	0010000	Are you 0010000? I'm 0000000. Axis 5 confirmed.
Axis 6	bit-5	0100000	Are you 0100000? I'm 0000000. Axis 6 confirmed.
Axis 7	bit-6	1000000	Are you 1000000? I'm 0000000. Axis 7 confirmed.

4.2 Pass — Self-expansion of the network

The topology of all 128 nodes in the Q7 network is automatically completed without software, as each neighbor passes (forwards) to its neighbor.

Bit-Fixing pass example: 0000000 → 1110000 (3 hops)

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0000000 →(Axis7)→ 1000000 →(Axis6)→ 1100000 →(Axis5)→ 1110000
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hop	Current node	Modification bit (Axis)	Next node
Hop 1	0000000	bit-6 (Axis 7)	1000000
Hop 2	1000000	bit-5 (Axis 6)	1100000
Hop 3	1100000	bit-4 (Axis 5)	1110000 arrival

※ Diversifying the bit modification order creates multiple parallel paths simultaneously. This is the structural basis of parallel E2E.

4.3 Neighborhood Status = Intelligence - Immediate Response to Axis Unit Failures

- Axis N neighbor non-response detection → Immediately recognizes "Axis N failure"
- Instantly calculate detour paths with remaining Axis combinations (Bit-Fixing)
- D12 can respond only to horizontal neighbors without vertical bypass

5. Network AI - Definition and Roles by Layer

5.1 Network AI Hierarchy

Network AI is an intelligent system connected to Belsanet equipment. It connects to the reference node (0...0) of each layer and is installed in three layers (O8/D12/I20) with different roles.

hierarchy	Q level	connection node	Key role	Reporting target
O8	Q7	A-XX-0000000	Local HC network recognition / self-recognition verification / generation of 4 types of reports	D12 Network AI
D12	Q6	A-XX-000000	Regional convergence management / inter-sector coordination / O8 report collection and analysis	I20 Network AI
I20	Q5	A-XX-00000	National Sovereign Policy / Overall HC Network Governance / D12 Report Collection	Top (As AI)

5.2 Roles and Reports by Hierarchy

Network AI	Key Features	Generate report	Reception report
O8 Network AI	Local HC network structure monitoring, real-time monitoring of neighbor status, self-awareness, and WI verification	Structural resilience, downward cluster convergence, sovereign policy implementation, and inter-sectoral boundary interference	None (lowest level constructor)
D12 Network AI	Collect and analyze regional O8 reports, coordinate inter-sector traffic, and optimize regional E2E routes.	Regional Convergence Comprehensive Report Regional Disability Analysis Report	Four O8 Reports (All Sectors)
I20 Network AI	Comprehensive Analysis of the D12 Report on the Downward Propagation of National Sovereignty Policy and the Entire HC Network Governance	National Network Status Report: Sovereign Policy Implementation Summary	D12 Report (All Regions)

※ Network AI calculates the error between the WI design value (reference) and the current physical state (actual state) and generates a report. This error calculation is the core of Belsanet's intelligence.

5.3 Network AI Vertical Connectivity Structure

Network AI connectivity between layers

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I20 Q5 00000 Network AI (for I20) ← D12 Report Collection
|
D12 Q6 000000 Network AI (for D12) ← O8 Report Collection
|
O8 Q7 0000000 Network AI (for O8) ← Report Generation (4 types)
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6. PAI / AAI / AsAI / E2E Management Center — Location and Role

6.1 Layer-by-layer connection locations

The base node (0…0) is connected to the Network AI. All other nodes are connected to PAI, AAI, AsAI, or E2E management centers. The connection type is predefined in WI.

hierarchy	Q level	Base node	remaining nodes	Connectable systems
O8	Q7	0000000 → Network AI	0000001~1111111 (127 numbers)	PAI (Personal AI) E2E Management Center
D12	Q6	000000 → Network AI	000001~111111 (63 numbers)	AAI (Area AI) E2E Management Center
I20	Q5	00000 → Network AI	00001~11111 (31 numbers)	AsAI (National AI) E2E Management Center

6.2 Role of each system

System	connection layer	Roles and Characteristics
PAI (Personal AI)	O8 General Node	Personal AI. Multimodal interaction. Local judgment. Service via O8 E2E routes.
AAI (Agent AI)	D12 General Node	Coordination of regional PAI clusters. Real-time resource allocation. Utilization of the D12 convergence path.
AsAI (Assistant AI)	I20 general node	National policy integration, forecasting, and multi-domain coordination. Utilizing the I20 Sovereign Path.
E2E Management Center	O8/D12/I20 general nodes	Parallel E2E path management. Traffic monitoring. SLA management. Hierarchical deployment.

※ PAI/AAI/AsAI are AI intelligence systems, while the E2E Management Center is an operating system that manages traffic and routes. Both systems can be connected to the same node.

7. Addressing System — Sector + HC Coordinate + Linking System

7.1 Address Composition Principles

Velsanet addresses are a result of the structure. The address is determined after the WI topology definition → self-identification → neighbor verification process is completed. The address is not assigned first.

address	sector	HC coordinates	connection system
A-01-0000000	A-01 Gangnam-gu	0000000	Network AI (for O8)
A-01-0000001	A-01 Gangnam-gu	0000001	PAI or E2E Management Center
A-01-1111111	A-01 Gangnam-gu	1111111	PAI or E2E Management Center
A-02-0000000	A-02 Seocho-gu	0000000	Network AI (for O8)
D12-KR01-000000	Region KR01	000000	Network AI (for D12)
D12-KR01-000001	Region KR01	000001	AAI or E2E Management Center
I20-KR-00000	Country KR	00000	Network AI (for I20)
I20-KR-00001	Country KR	00001	AsAI or E2E Management Center

7.2 Overall flow from WI to parallel E2E

	step	detail
①	WI phase definition	Predefined sector/HC address/Face connection/Neighbor ID/Connection device type
②	I20 boot	Activate Q5 reference node (00000). Connect to Network AI (for I20). Wait for REGISTER.
③	D12 boot	Activate Q6 reference node (000000). Connect to Network AI (for D12). Register with I20.
④	O8 Self-Awareness Level 1	Read WI to determine HC address + connected device type
⑤	O8 Self-Awareness Level 2	8 Face connected/unconnected + optical core status collection
⑥	O8 Self-Awareness Level 3	Finding Neighbors - 7 Axis Confirmed. Q7 Network Completed with Pass.
⑦	O8 Self-Awareness Level 4	REGISTER transmission. PAI/E2E management center activation signal.
⑧	H6 autonomous operation	Connected to O8. Push T4 status. No HC registration.
⑨	Parallel E2E operation	Automatic path formation with neighbor pass + bit-fixing
⑩	Generate report	O8 Network AI generates 4 types of reports → D12 → I20 collection

8. Four O8 Structure Reports

O8 Network AI calculates the error between the WI design values and the current physical state, generating four types of structural reports. All reports can only be generated if the self-identification process, "I am A-01-0000000 and have seven optical cores (Axis 1-7)," is complete.

report ①

Structural Resilience Report

Structural Resilience Report | Published by: A-01-0000000 Network AI

Status of Axis failure

Axis	Neighboring node address	Type of disability	Detection time
Axis 4	A-01-0001000	Optical core signal loss (FAULT)	2026-03-09 01:14:22
Axis 7	A-01-1000000	No response (TIMEOUT)	2026-03-09 01:14:35

Dimensionality reduction analysis

situation	Valid Axis	Residual parallel path	Bandwidth remaining
Normal (Q7)	7	Up to 7	100%
Axis 4,7 failure	5	Up to 5	About 71%
In case of additional failure	4 or less	3 or less	D12 Bypass Recommendation

Self-healing path — uses horizontal neighbors only (no D12 bypass)

channel	depart	Bypass Axis combination	arrive
Path-1	A-01-0000000	Axis 1 → Axis 2 → Axis 3	A-01-1001000
Path-2	A-01-0000000	Axis 2 → Axis 5 → Axis 3	A-01-1001000
Path-3	A-01-0000000	Axis 6 → Axis 1 → Axis 3	A-01-1001000
Path-4	A-01-0000000	Axis 5 → Axis 2 → Axis 1	A-01-1001000
Path-5	A-01-0000000	Axis 3 → Axis 6 → Axis 2	A-01-1001000

Transfer to D12 Network AI

Failed Axis: 4, 7 | Remaining Parallel Paths: 5 | Bandwidth Survival: 71% | Physical Recovery Urgency: Medium

report ②

Downward Cluster Convergence Report

Downward Convergence Report | Published by: A-01-0000000 Network AI

Traffic distribution by face

Face	Connection H6	Traffic proportion	Convergence delay	situation
F0	H6-C01	18%	0.3ms	normal
F1	H6-C02	22%	0.4ms	normal
F2	H6-C03	31%	2.1ms	bottleneck
F3	H6-C04	9%	0.2ms	normal
F4	H6-C05	11%	0.3ms	normal
F5	H6-C06	6%	0.2ms	normal
F6	D12 upward	3%	—	Convergence only

Transfer to D12 Network AI

Bottleneck: H6-C03 (F2) +56% exceeded | T4 address duplication error | Recommendation: H6 expansion or T4 relocation

report ③

Sovereign Policy Implementation Report

Sovereign Policy Compliance Report | Issue: A-01-0000000 Network AI

Isolation levels and consistency by axis

Axis	quarantine policy	Current isolation level	consistency
Axis 2	Sovereign exclusive	Complete isolation (Ch1 control only)	adjustment
Axis 3	Security Level A	Encryption Ch1 authentication applied	adjustment
Axis 5	Energy saving	Switching to sleep mode	adjustment
Axis 6	emergency reserve	STANDBY maintenance	adjustment

Transmitted to I20 Network AI

Policy Enforcement: Fully Conformant | Energy Savings: 68 W/hr (Axis 5,6 sleep) | Sovereign Packet Delay: Within Standard

report ④

Inter-sector boundary interference report

Inter-Sector Interference Report | Published by: A-01-0000000 Network AI

Boundary Load — Boundary node load

border node	Contact sector	Boundary Load	situation
A-01-0000111	A-01 ↔ A-02	43%	Warning — Threshold exceeded
A-01-0001111	A-01 ↔ A-03	28%	normal
A-01-1000000	A-01 ↔ B-01	12%	normal

Transfer to D12 Network AI

Warning: A-01-0000111 (A-01↔A-02) Boundary Load 43% | Recommendation: Realign sector boundaries or add optical cores.

9. Report Collection System — O8 → D12 → I20

Reports generated by O8 Network AI are collected by D12 Network AI, aggregated at the regional level, and finally consolidated at the country level by I20 Network AI. Urgent reports can be sent directly to I20, bypassing the tier.

Issuer	Report Type	Recipient	Issue cycle/trigger
O8 Network AI	Structural resilience	D12 Network AI	10 minutes / Axis failure immediately
O8 Network AI	Downward cluster convergence	D12 Network AI	30 minutes / Bottleneck threshold exceeded
O8 Network AI	Sovereign policy implementation	I20 Network AI	1 hour / Immediately upon policy violation
O8 Network AI	Inter-sector boundary interference	D12 Network AI	30 minutes / Boundary Load exceeded
D12 Network AI	Regional convergence synthesis	I20 Network AI	1 hour / local failure immediately
I20 Network AI	National Network Status	As AI / Sovereign Operator	6 hours / immediately after country

Report Flow Summary

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O8 Network AI → (4 types of reports) → D12 Network AI → (regional comprehensive) → I20 Network AI
Sovereign Policy Implementation Report is transmitted directly from O8 to I20 (no transit through D12).
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10. Additional Considerations

1. Overview of the overall structure and hierarchy

- 1.1 Definition of the five regular polyhedral hierarchies (T4/H6/O8/D12/I20)
- 1.2 Hypercube (HC) dimensions and roles by Q level

2. WI (phase pre-definition) and self-awareness

- 2.1 WI-based Ground Truth Setup
- 2.2 Four stages of self-awareness (identity → face recognition → core mapping → registration)
- 2.3 Address Resolution Mechanism (Result of WI + Physical Connection)

3. Hypercube (HC) network formation and neighbor finding

- 3.1 Physical mapping of the seven independent axes (Axis 1-7)
- 3.2 Global phase completion through the pass mechanism

4. [Reinforcement] Downward cluster convergence and physical acceptance

- 4.1 Principle of 100% acceptance of lower level nodes (H6) by upper level nodes (O8)
- 4.2 Face-based Sub-Address Recognition and Synchronization
- 4.3 Immediate mapping logic for 'Axis - Face' when requesting E2E

5. [New] Dynamic elasticity and autonomous bypass

- 5.1 H6 Autonomous Bypass Activation Conditions (when load exceeds 90%)
- 5.2 Creating a bypass route to another sector O8 through adjacent H6
- 5.3 Dimensionality reduction and horizontal link maintenance strategy during failure

6. Roles and Management by Network AI Layer

- 6.1 Network AI Management System Based on Reference Node (0...0)
- 6.2 Separate operation of PAI/AAI/AsAI service nodes

7. Four types of structural reports and automatic expansion

- 7.1 Structural Resilience / Downward Convergence (including a history of detours) / Sovereign Policy / Inter-Sector Interference Report
- 7.2 Vertical Bypass Detection-Based 'Horizontal Link Establishment Proposal' Mechanism
- 7.3 Automatically resetting the hypercube when adding new equipment (Self-Configuration)

8. Role of network AIs in each layer

- O8 Network AI
  → O8 HC network control → sector-internal parallel E2E procedure control → structure report generation
- D12 Network AI
  → Collects multiple O8 reports → Analyzes regional conditions → Apply regional policies
- I20 Network AI
  → National Report Synthesis → Sovereign Policy Management