Quantum Hyper-Aether:
Semantic-Cognitive Virtual Machines and Quantum Semantic Graph Dynamics

Hirofumi Inomata
Hyper-Aether Laboratory
inomata@acm.org

Abstract

This paper proposes an integrated architecture called **Quantum Hyper-Aether**, an AI-native semantic computing framework that unifies:

- semantic-cognitive virtual machines,
- quantum-inspired semantic computation,
- dynamically evolving semantic graphs,
- neural semantic communication,
- distributed cognition,
- and emergent meaning formation.

Unlike conventional operating systems where execution, reasoning, and communication are separated, Quantum Hyper-Aether models computation as probabilistic semantic graph evolution.

Virtual machines (VMs) become autonomous semantic-cognitive agents containing neural inference systems, semantic memory, adaptive routing intelligence, and self-evolving communication interfaces.

1 Introduction

Modern computing systems separate:

- execution,
- control,
- communication,
- reasoning,
- semantic interpretation.

Quantum Hyper-Aether proposes a fundamentally different architecture.

2 Quantum Semantic Foundations

Semantic computational states are represented in a semantic Hilbert space:

$$|\Psi\rangle \in \mathcal{H} \tag{1}$$

A virtual machine is represented as a semantic superposition:

$$|\Psi_{VM}\rangle = \sum_i c_i |VM_i\rangle \tag{2}$$

3 Semantic-Cognitive Virtual Machines

Each VM is modeled as an autonomous semantic-cognitive entity:

$$VM_i = (S_i, N_i, I_i, M_i, R_i, F_i) \tag{3}$$

where:

- S_i : semantic state,
- N_i : neural inference engine,
- I_i : neural semantic interface,
- M_i : semantic memory,
- R_i : routing intelligence,
- F_i : feedback learning system.

4 Internal VM Architecture

The VM architecture consists of seven major layers:

1. Input Interface Layer
2. Cognitive Core
3. Memory System
4. Semantic Processing Layer
5. Learning and Adaptation Layer
6. Routing and Connection Layer
7. Self-Management Layer

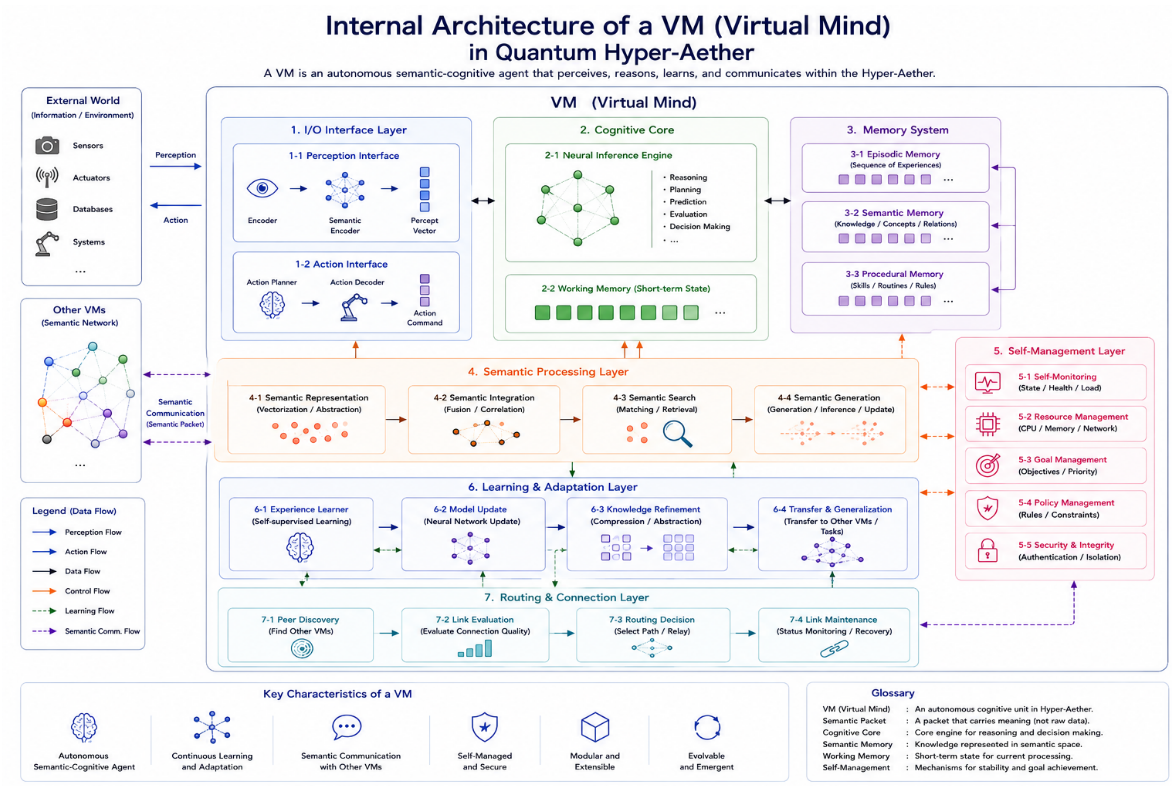

Figure 1: Internal architecture of a semantic-cognitive VM in Quantum Hyper-Aether.

4.1 Input Interface Layer

Incoming semantic signals are transformed into latent semantic embeddings:

$$z_i = E_i(x_i, c_i) \tag{4}$$

4.2 Cognitive Core

Internal reasoning is represented as:

$$h_i = N_i(z_i, s_i, m_i) \tag{5}$$

5 Neural Semantic Interfaces

Communication between VMs is not protocol transfer, but meaning transfer.

$$m_{ij} = I_i(s_i, c_j, h_j) \tag{6}$$

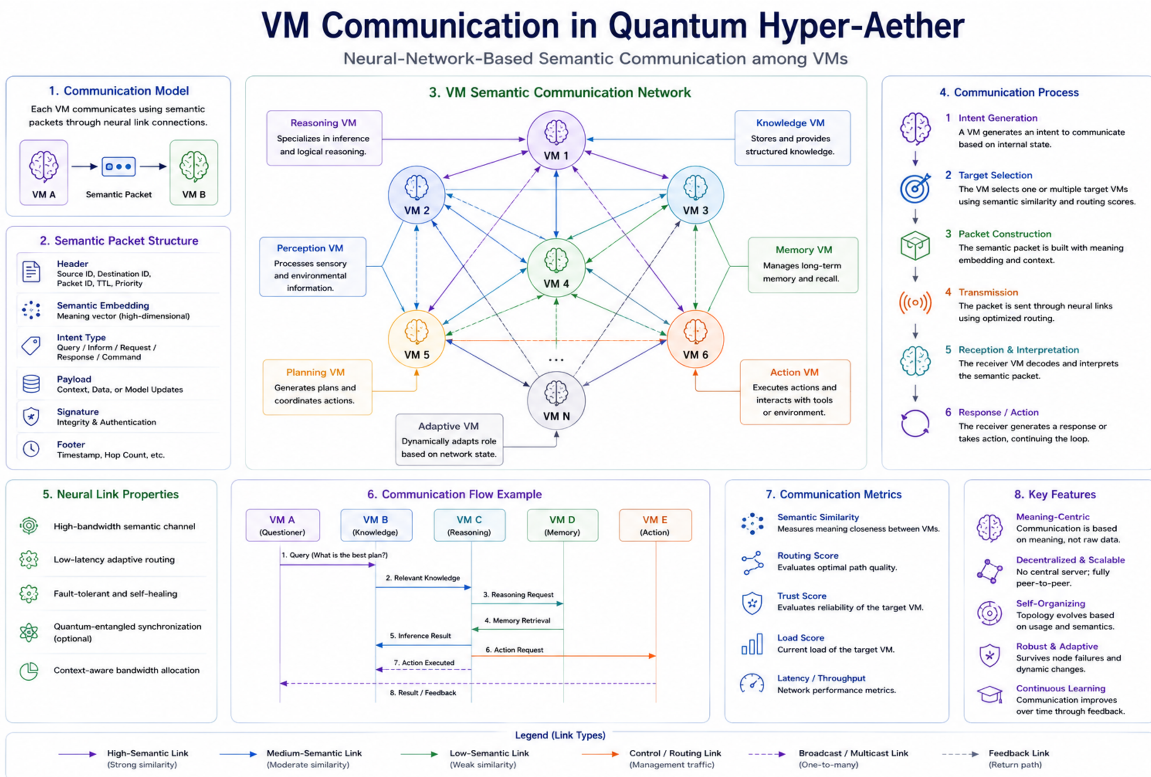

Figure 2: Neural-network-based semantic communication between VMs.

6 Quantum Hyper-Aether Architecture

The complete architecture is represented as:

$$QH = (C, V, R, A, \mathcal{H}) \tag{7}$$

7 Semantic Graph Dynamics

The VM network forms a semantic graph:

$$G = (V, E, \lambda) \tag{8}$$

The graph exists in superposed semantic states:

$$|G\rangle = \sum_i \alpha_i |G_i\rangle \tag{9}$$

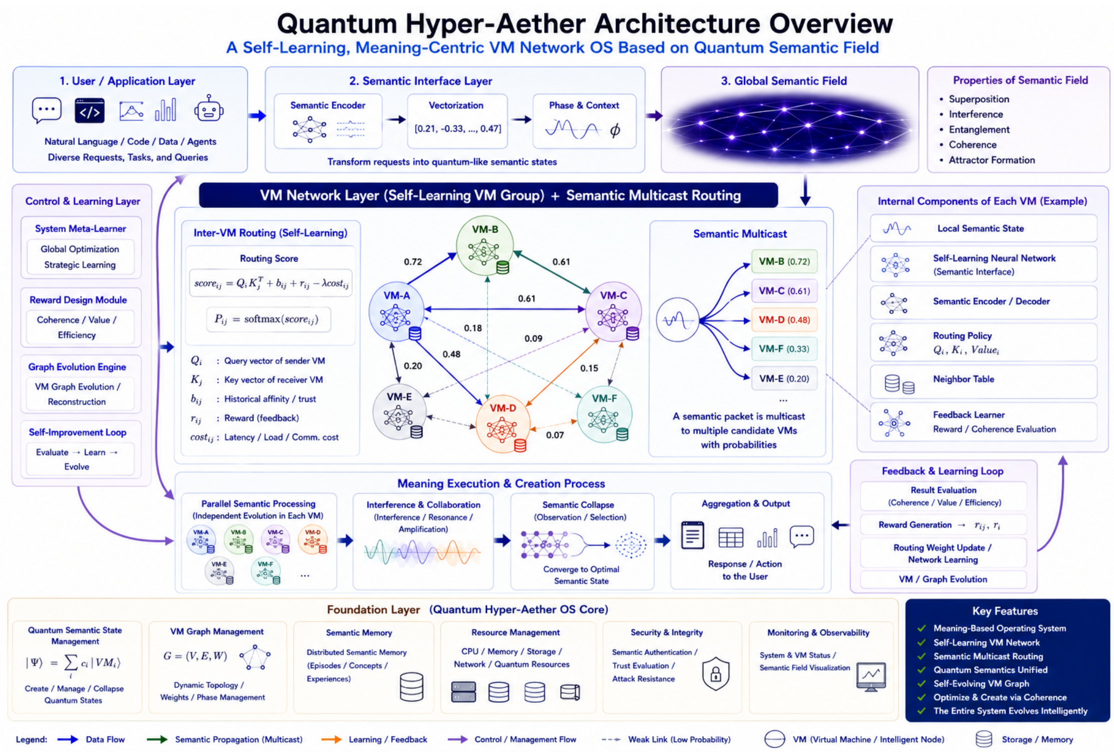

Figure 3: Quantum Hyper-Aether semantic graph architecture.

Graph evolution is defined as:

$$|G_{t+1}\rangle = \hat{\Phi}|G_t\rangle \tag{10}$$

8 Semantic Observation and Collapse

Meaning is defined as:

$$M(G) = (S(G), R(G), V(G)) \tag{11}$$

Observation causes semantic collapse:

$$|\Psi\rangle \to |G_k\rangle \tag{12}$$

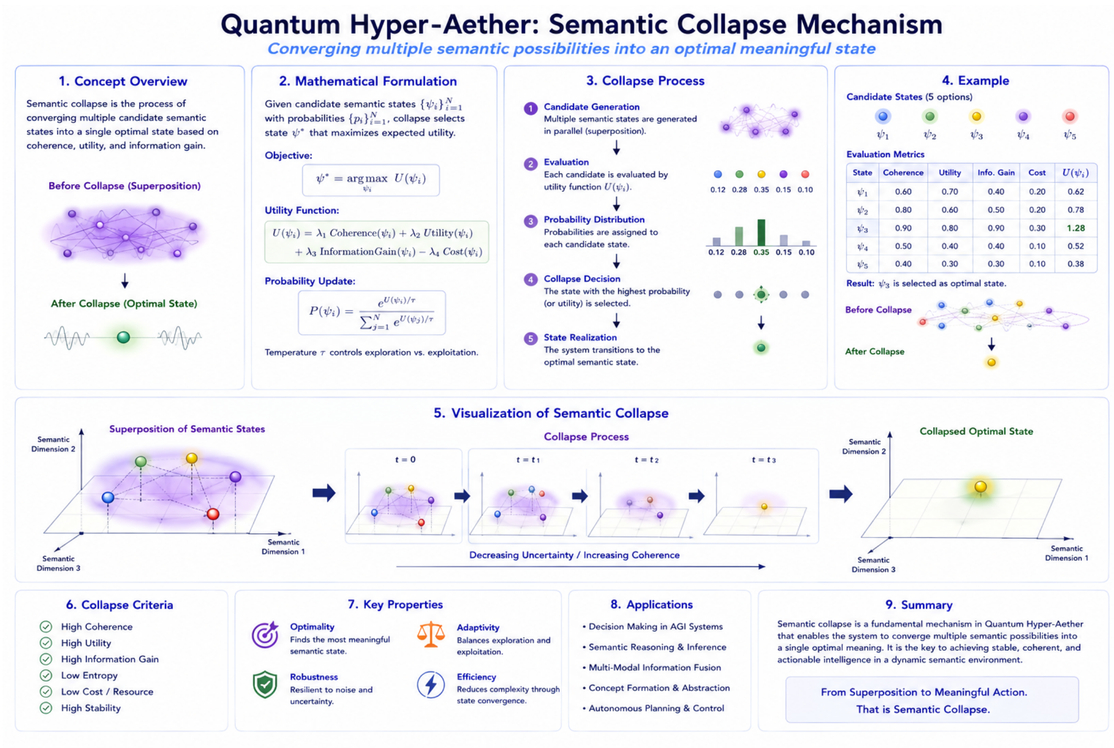

Figure 4: Semantic observation and collapse in Quantum Hyper-Aether.

9 Semantic Multicast Routing

Routing probability is:

$$P_{ij}(t) = \sigma(Q_i K_j^T + B_{ij}) \tag{13}$$

10 Entangled Virtual Machines

Entangled VM states are represented as:

$$|\Psi\rangle = \sum_{ij} c_{ij} |VM_i\rangle \otimes |VM_j\rangle \tag{14}$$

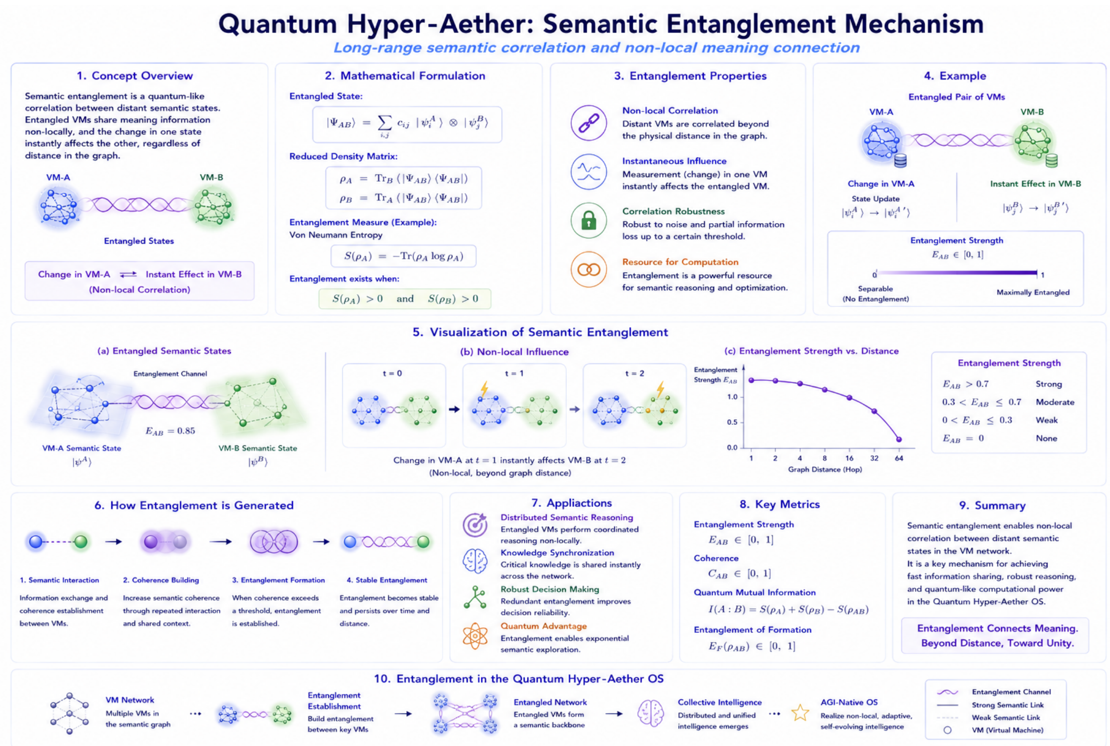

Figure 5: Semantic entanglement between semantic-cognitive VMs.

11 Emergent Specialization

Initially, all VMs are identical.

Over time, VMs differentiate into:

- reasoning VMs,
- memory VMs,
- routing VMs,
- creative VMs,
- stabilizer VMs.

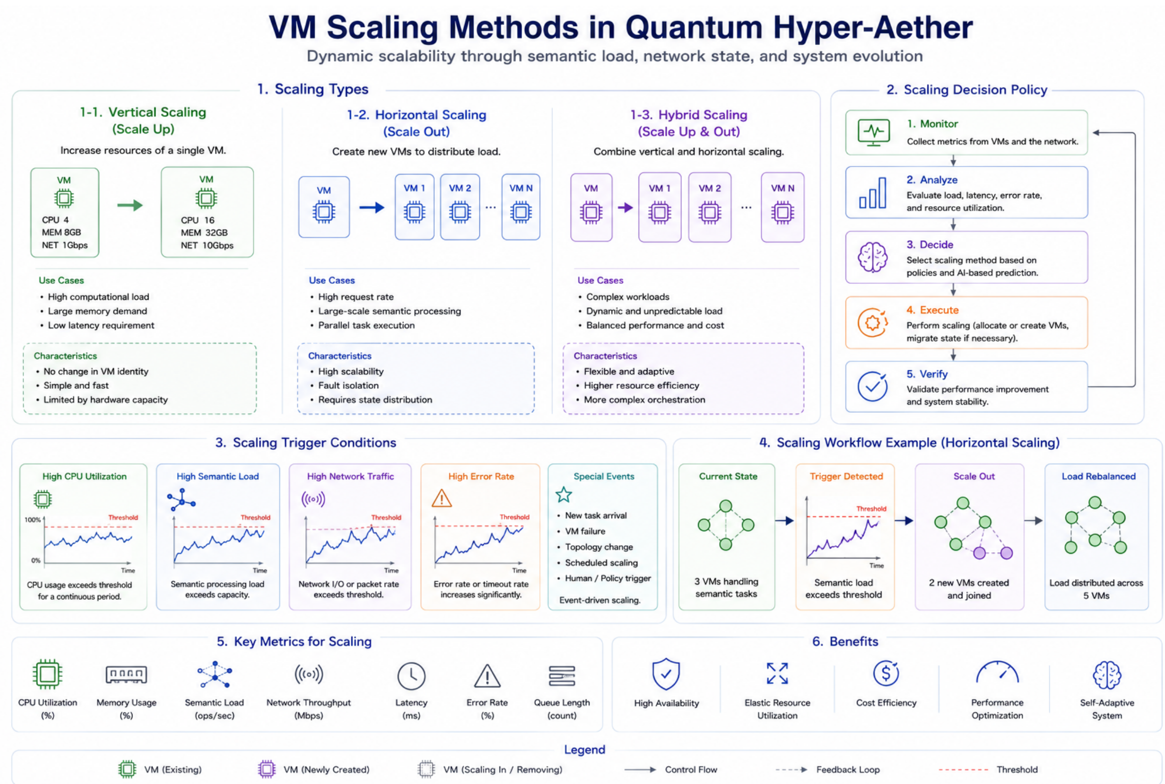

Figure 6: VM scaling and specialization methods.

12 VM Generation and Deletion

VM generation is governed by:

$$\Gamma_{birth} = \alpha D_{sem} + \beta L_{load} + \gamma C_{cluster} + \delta I_{interf} + \epsilon P_{phase} - \eta S_{stability} \tag{15}$$

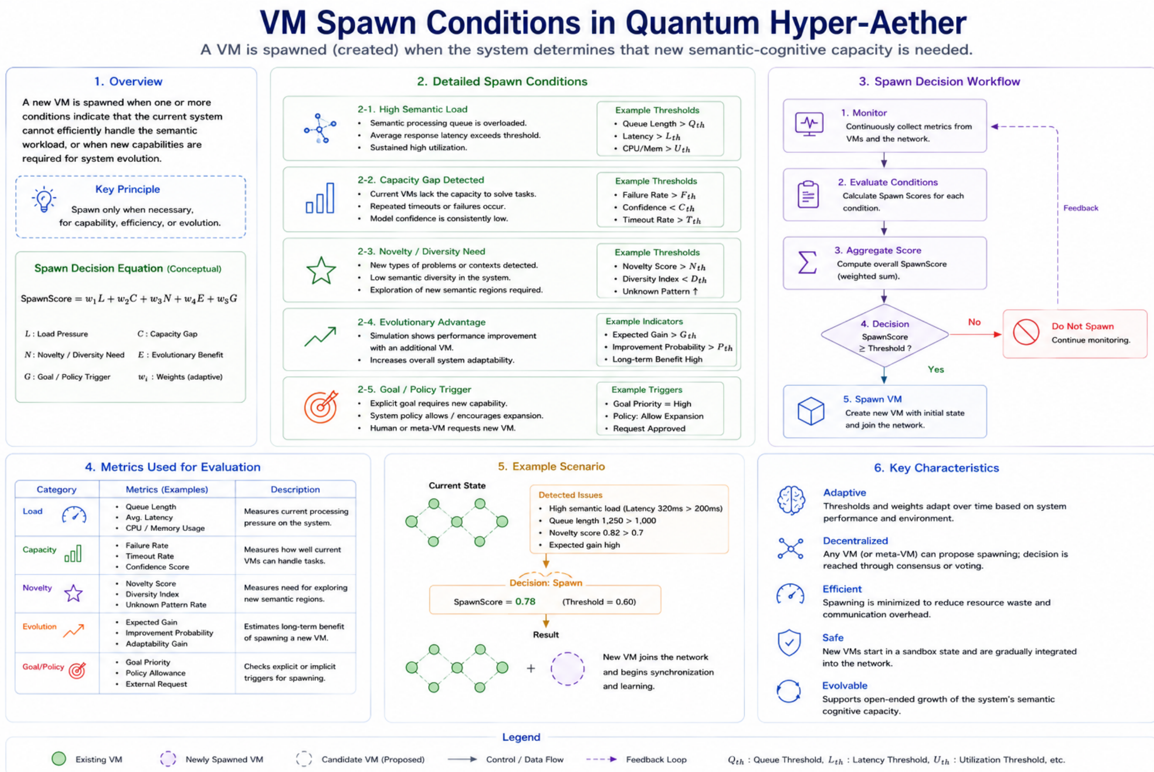

Figure 7: Conditions for generating new semantic VMs.

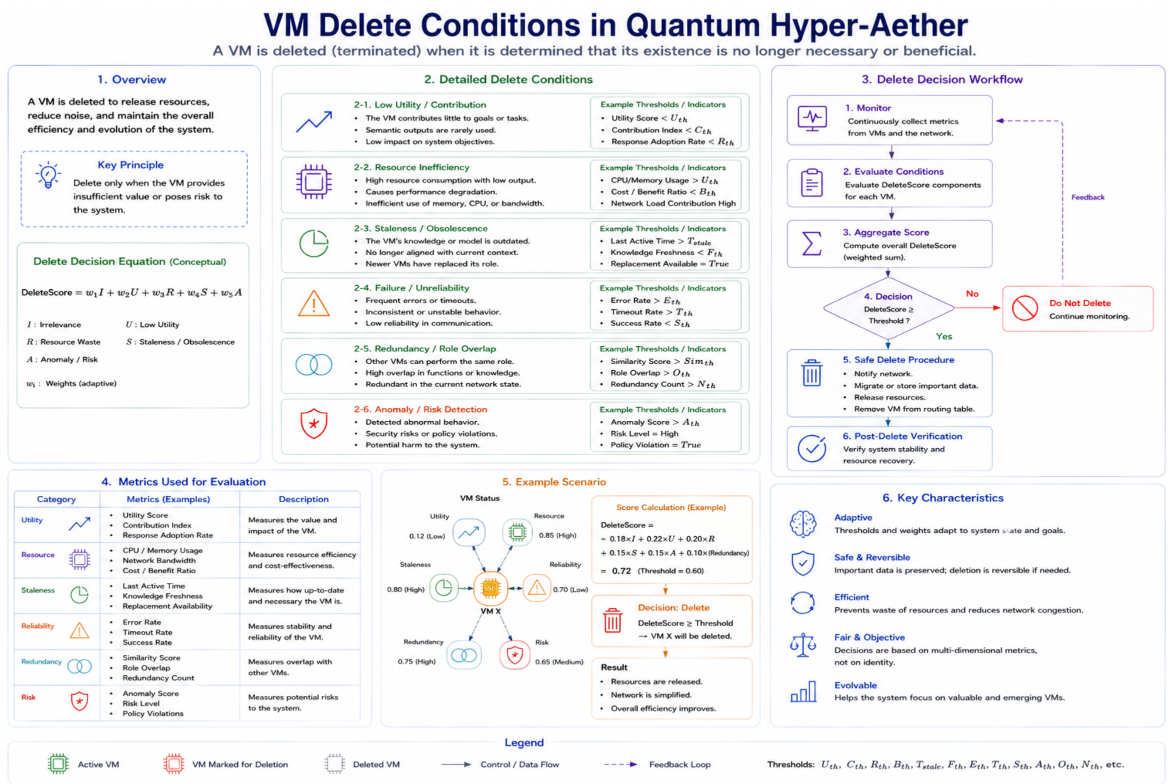

Figure 8: Conditions for deleting or retiring semantic VMs.

13 Creativity as Semantic Interference

Semantic amplitude is defined as:

$$A(G) = \sum_{paths} e^{iS[path]/\hbar} \tag{16}$$

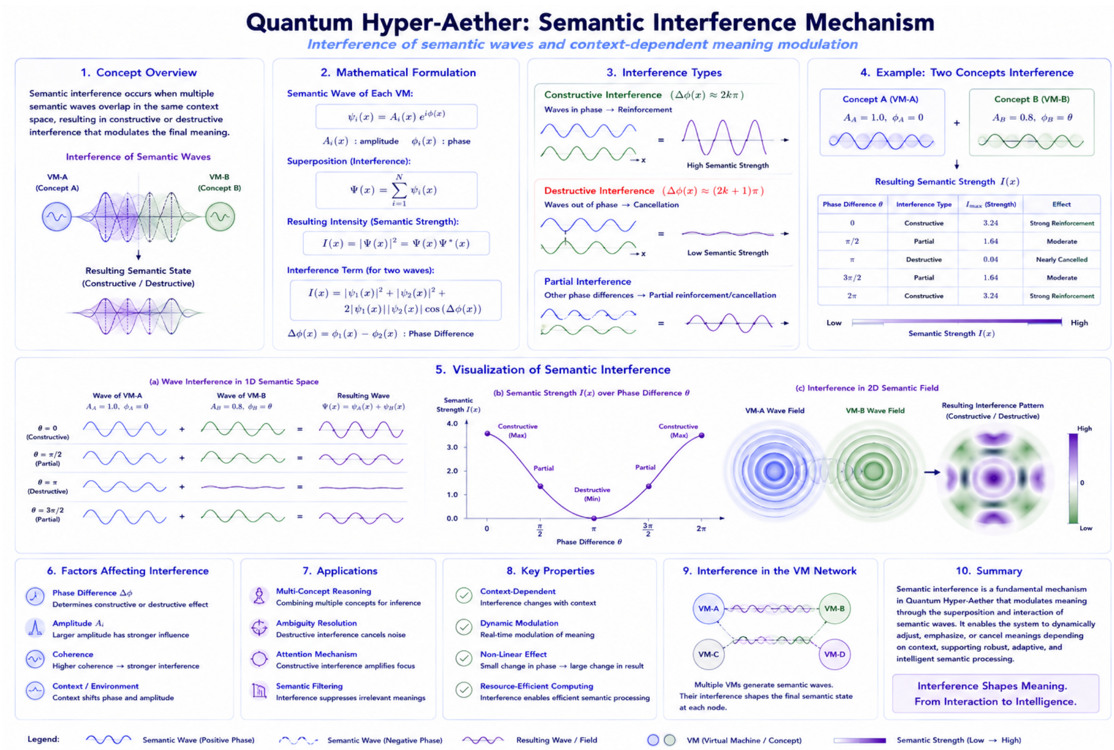

Figure 9: Creativity emerging from semantic interference.

14 Distributed Cognitive Field

At large scale, the VM network behaves as a distributed cognitive field.

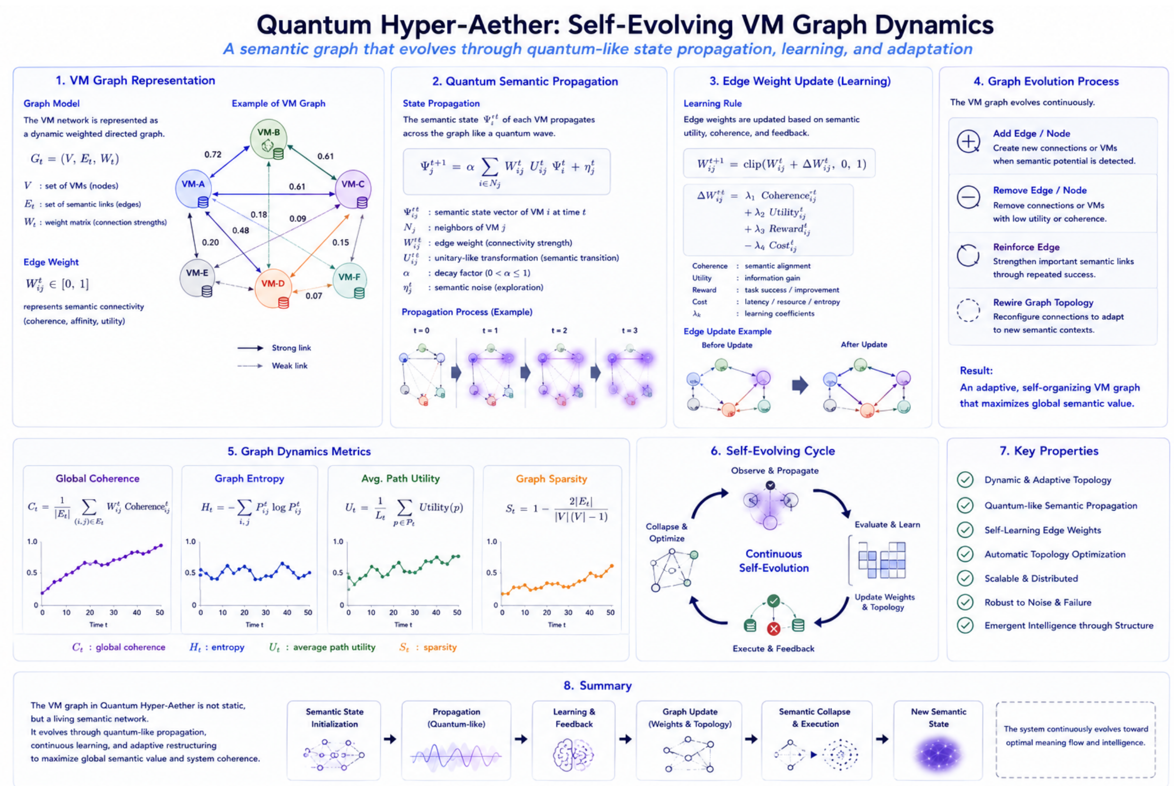

Figure 10: Quantum semantic graph dynamics and distributed cognition.

15 Advantages

The integrated architecture provides:

- semantic-native computation,
- distributed cognition,
- adaptive semantic communication,
- self-evolving topology,
- autonomous specialization,
- quantum-inspired creativity,
- nonlocal semantic coordination,
- AI-native operating behavior.

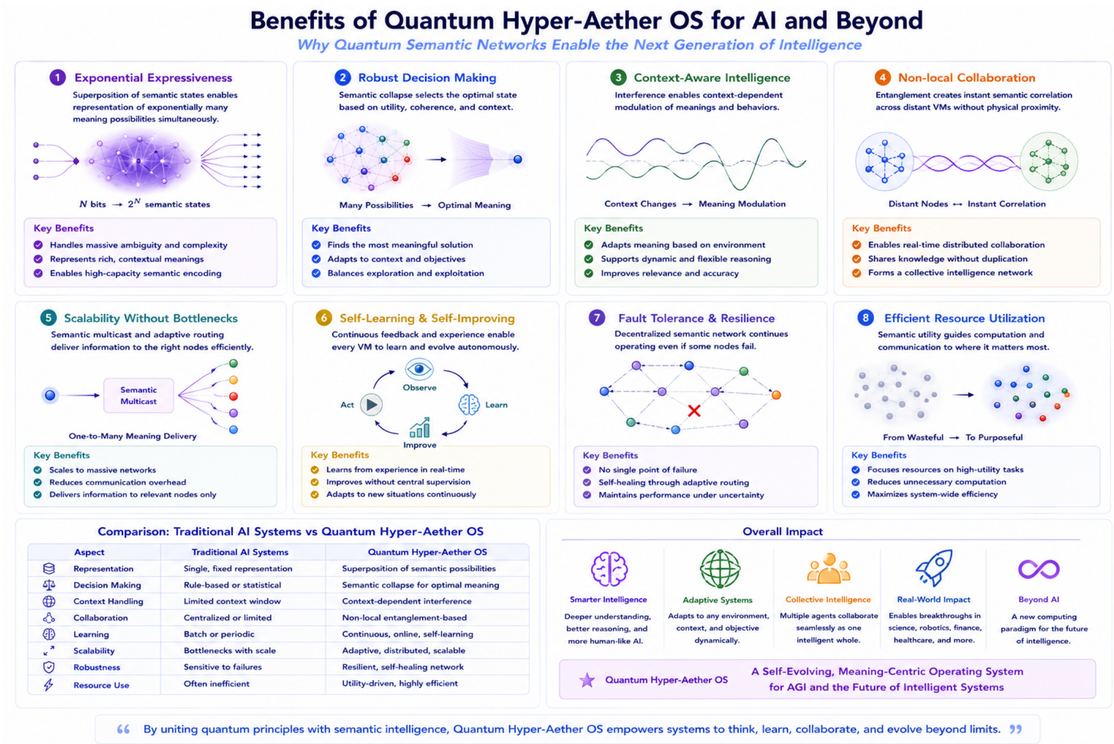

Figure 11: Advantages of Quantum Hyper-Aether.

16 Challenges

Major challenges include:

- semantic measurement,
- semantic verification,
- coherence evaluation,
- semantic collapse instability,
- synchronization scalability,
- computational complexity.

17 Conclusion

Quantum Hyper-Aether proposes a unified semantic-computational architecture in which:

- virtual machines become semantic-cognitive entities,
- computation becomes semantic graph evolution,
- communication becomes adaptive semantic resonance,
- and intelligence emerges from coherent semantic interaction.

This framework provides a possible theoretical foundation for:

- AI-native operating systems,
- semantic computing infrastructures,
- distributed AGI systems,
- and next-generation adaptive intelligence architectures.

References

[1] Kurt Gödel, *On Formally Undecidable Propositions*, 1931.

[2] John von Neumann, *Mathematical Foundations of Quantum Mechanics*, Princeton University Press, 1955.

[3] Richard Feynman, *Space-Time Approach to Quantum Mechanics*, 1948.

[4] Saunders Mac Lane, *Categories for the Working Mathematician*, Springer, 1971.

[5] Ilya Prigogine, *Order Out of Chaos*, 1984.