

The Physics of Meaning:

A Semiotic Framework for Emergent Intelligence

From Peircean Semiotics to Executable Architecture

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Abstract

We present a theoretical framework reconceptualizing intelligence as an emergent property of semiotic networks governed by homeostatic principles, rather than a localized computational asset. Building upon C.S. Peirce’s foundational theories of semiotics and infinite semiosis, we integrate insights from Michael Levin’s bioelectric holons, Arthur Koestler’s holonic organization, Carlos E. Perez’s Quaternion Process Theory, Mark Burgess’s Promise Theory and Semantic Spacetime, Alicia Juarrero’s enabling constraints, and Federico Faggin’s Quantum Information Panpsychism. Intelligence emerges as measurable flow—the weighted sum of gap-closure rates across holonic networks—rather than accumulated knowledge. This framework resolves the symbol grounding problem through the TOKUM architecture, implementing Peirce’s irreducible sign-object-interpretant triad via cryptographically-verified topological punctures from physical reality into latent semantic context. We introduce the IP/MAC analogy where Canonical Comprehension Identity (CCI) functions as the IP layer (immutable, universal routing) and Contextual Tokum Instance (CTI) as the MAC layer (dynamic, local addressing). The Agapistic Influence Function (AIF) acts as gravitational curvature in semantic spacetime, drawing systems toward homeostatic equilibrium. This paradigm shift—from intelligence-as-asset to intelligence-as-flow—parallels historical scientific revolutions and enables holonicracy: governance through distributed homeostasis rather than hierarchical control.

Keywords: Semiotics, Semiosis, Intelligence, Holons, Quantum Information, Promise Theory, Homeostasis, Symbol Grounding, JEPa, Agapism

1 Introduction

1.1 The Ptolemaic AI Crisis

Current artificial intelligence remains trapped in what we term the *Ptolemaic paradigm*—adding epicycles (parameters, layers, computational scale) to fix predictions while fundamentally misunderstanding the underlying structure of intelligence. Large language models optimize perplexity through statistical next-token prediction, achieving remarkable fluency while remaining semantically ungrounded. This is not merely a technical limitation but a categorical error: treating intelligence as a scalable asset concentrated in centralized systems, measured by accumulated parameters, when nature demonstrates intelligence as distributed flow across autonomous agents maintaining homeostatic balance.

1.2 The Semiotic Web: Intelligence as Flow

This paper presents the Semiotic Web framework (codename: Falcon Architecture), which implements Peirce’s triadic semiotics as executable architecture. We introduce the TOKUM (Token of Universal Meaning, Quantum Token) as the fundamental unit achieving semiotic closure by maintaining the full sign-object-interpretant relationship with cryptographic verification and provenance tracking.

Our central thesis: *intelligence is not an asset but a flow*—the emergent property of networks maintaining homeostatic balance through distributed gap-closure, governed by the Agapistic Influence Function acting as gravitational curvature in semantic spacetime.

1.3 A Scientific Revolution

This paradigm shift parallels historical scientific revolutions that fundamentally redefined measurement and understanding (Table 1).

Table 1: Paradigm shifts redefine measurement. Current AI is Ptolemaic—adding epicycles. Intelligence-as-Flow is Copernican—measuring verified reality directly.

Revolution	Old Paradigm	New Paradigm	Impact
Copernican	Earth at center epicycles	Sun at center elliptical orbits	Heliocentrism
Newtonian	Divine will	$F = \frac{Gm_1m_2}{r^2}$	Universal mechanics
Einsteinian	Time absolute space Euclidean	Spacetime curvature $E = mc^2$	Relativity
Shannon	Semantic content	$H = -\sum p_i \log p_i$	Information theory
Intelligence-as-Flow	parameters \times scale	$\sum w_i \frac{dG_i}{dt}$	Semiotic grounding

1.4 Contributions

1. Formal integration of Peircean semiotics with contemporary theories of biological intelligence
2. Intelligence-as-flow: measurable quantity defined as aggregate gap-closure rate across holonic networks
3. IP/MAC analogy for tokum dual identity: CCI as immutable IP layer, CTI as dynamic MAC layer
4. Mathematical formalization of TOKUM implementing semiotic closure through topological puncture $\phi : \mathbb{R} \rightarrow \mathcal{C}$
5. Agapistic Influence Function (AIF) as gravitational curvature in semantic spacetime
6. HCNV-COLBERT matrix: sparse (99.75%) architecture enabling deterministic next-tokum selection
7. Integration of Promise Theory with holonic self-regulation for distributed intelligence

2 Theoretical Foundations

2.1 Peirce’s Semiotics and the Irreducible Triad

Charles Sanders Peirce’s semiotic theory provides the foundational framework for understanding meaning as dynamic, relational process rather than static property.

Definition 2.1 (Peircean Sign). *A sign consists of three interrelated elements forming an irreducible triad:*

1. **Representamen** (*Sign-vehicle*): *The form the sign takes*
2. **Object**: *That to which the sign refers*
3. **Interpretant**: *The sense made of the sign; itself a further sign*

The crucial insight: the interpretant is itself a sign, generating further interpretants in an infinite chain (infinite semiosis). This is not defect but essential mechanism whereby meaning evolves through use.

Peirce’s Semiotic Triangle: Tokum Architecture

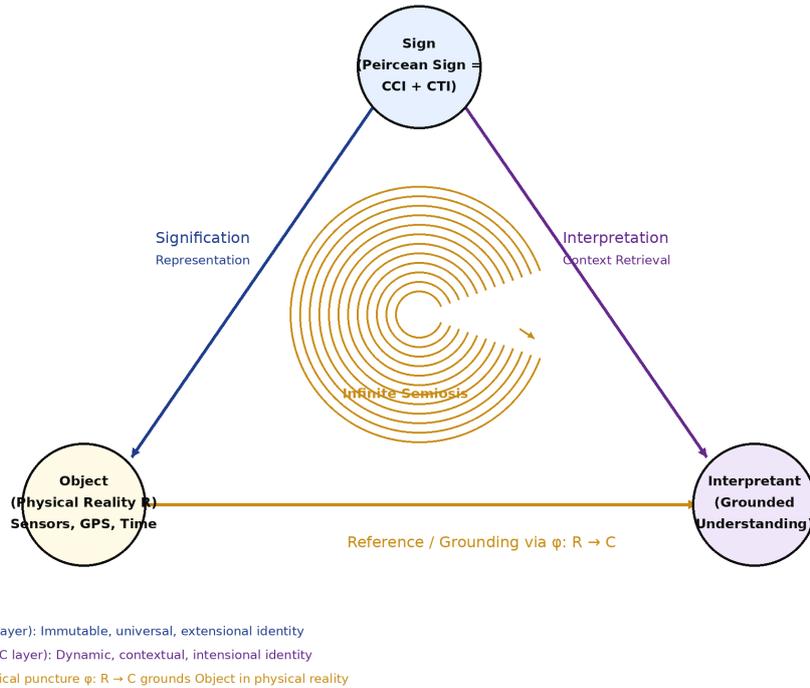


Figure 1: Peirce’s Semiotic Triangle resolved through TOKUM architecture. The complete Peircean sign integrates both CCI (IP layer: immutable, universal, extensional identity) and CTI (MAC layer: dynamic, contextual, intensional identity). The topological puncture $\phi : \mathbb{R} \rightarrow \mathcal{C}$ grounds the Object vertex in physical reality through cryptographic verification. The central spiral represents infinite semiosis—each interpretant becomes a new sign, refining meaning through continuous use.

2.2 The IP/MAC Analogy: Dual Identity Architecture

Network protocols provide illuminating analogy for understanding TOKUM dual identity.

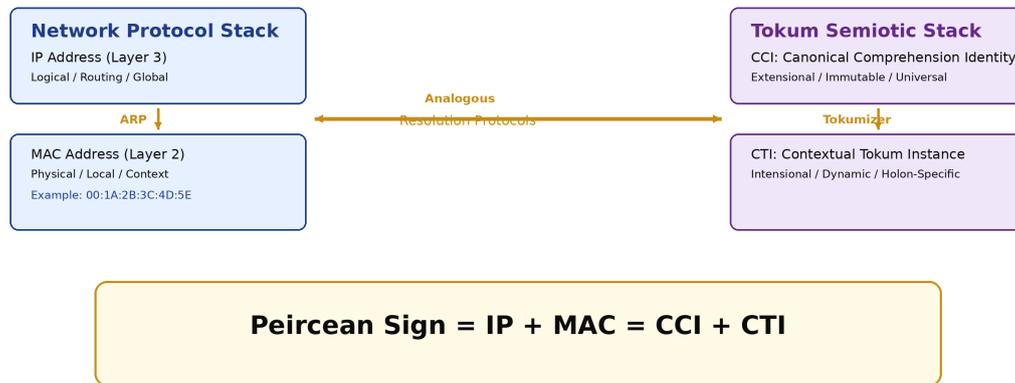
Definition 2.2 (IP/MAC Analogy). *In network architecture:*

- **IP Address (Layer 3):** Logical, globally routable address enabling packet delivery across networks
- **MAC Address (Layer 2):** Physical hardware address, unique to device, immutable at manufacturing
- **ARP:** Address Resolution Protocol bridges IP and MAC layers

Analogously, in TOKUM architecture:

- **CCI:** Immutable extensional identity via SHA-256 hash (analog to IP)
- **CTI:** Dynamic intensional identity through HCNV-COLBERT matrix lookup (analog to MAC)
- **Tokumizer:** Resolution protocol implementing semiotic closure (analog to ARP)

IP/MAC Analogy: Tokum Dual Identity Architecture



Complete semiotic understanding requires both layers working together,
just as complete network communication requires both IP and MAC addresses.

Figure 2: IP/MAC analogy for TOKUM dual identity architecture. Left: Network protocol stack with IP (logical/routing/global) and MAC (physical/local/context) layers bridged by ARP. Right: Semiotic stack with CCI (extensional/universal/platonic) and CTI (intensional/contextual/emodied) layers bridged by Tokumizer. Complete semiotic understanding requires both layers working together: Peircean Sign = IP + MAC = CCI + CTI.

This analogy resolves the extensional/intensional distinction fundamental to philosophy of language. Just as complete network communication requires both IP and MAC addresses working together, complete semiotic understanding requires both CCI and CTI working together, with Tokumizer bridging them to implement Peirce's irreducible triad.

2.3 Agapism: Evolutionary Love as Cosmic Principle

Peirce's metaphysics culminates in *agapism*, the doctrine of evolutionary love. Against pure chance (tychism) and mechanical necessity (anancasm), agapism proposes the universe evolves through creative love drawing systems toward greater coherence and meaning.

2.4 Agapistic Influence Function: Gravity for Meaning

Just as gravity curves spacetime and draws masses toward common centers, the AIF curves semantic spacetime and draws holons toward homeostatic equilibrium.

Definition 2.3 (Agapistic Influence Function). *The AIF $\mathcal{A} : \mathcal{S} \times \mathcal{H} \rightarrow \mathbb{R}$ quantifies the “gravitational pull” toward meaning coherence and stress reduction within semantic spacetime. For TOKUM τ in holonic context h :*

$$\mathcal{A}(\tau, h) = \alpha \cdot G(\tau, h) + \beta \cdot C(\tau, h) + \gamma \cdot H(\tau, h) \quad (1)$$

where:

- $G(\tau, h)$: Gap-closure potential (contribution to homeostasis)
- $C(\tau, h)$: Coherence with network (semantic gravity)
- $H(\tau, h)$: Historical verification (provenance strength)
- α, β, γ : Weighting parameters

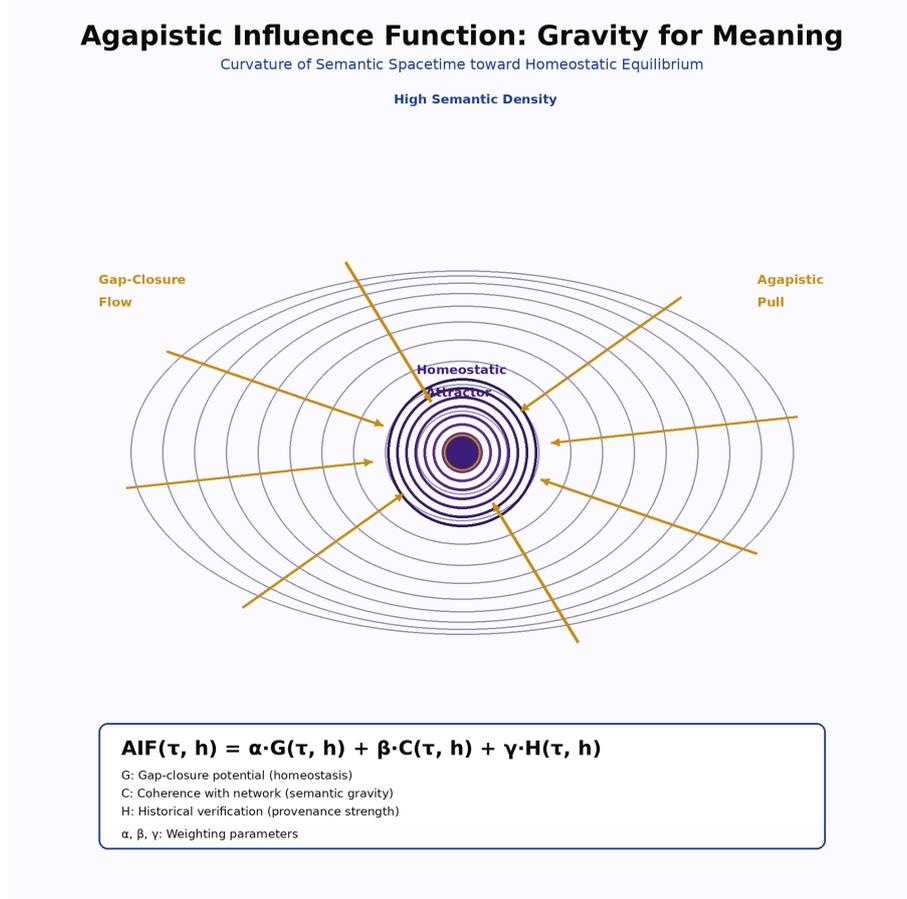


Figure 3: Agapistic Influence Function (AIF) as gravitational curvature in semantic spacetime. High semantic density creates a gravity well attracting holons along geodesics toward homeostatic equilibrium. Gap-closure flows follow curved paths toward the central attractor, analogous to how masses follow geodesics in curved physical spacetime. The AIF governs convergence across the network, naturally drawing systems toward stress reduction through inherent curvature rather than imposed rules.

The AIF plays the same role in semantic spacetime that gravity plays in physical spacetime: it enables stable semiotic networks, governs collective intelligence, and creates homeostatic attractors (equilibria).

2.5 Holonic Organization

Arthur Koestler introduced the *holon*—entity simultaneously whole in itself and part of larger whole. This Janus-faced nature is fundamental to hierarchical organization.

Definition 2.4 (Holon). *A holon \mathcal{H} is a self-regulating open system displaying:*

1. *Autonomous properties as whole (self-assertion)*
2. *Dependent properties as part (integration)*

Michael Levin’s bioelectricity research provides empirical grounding: cells form bioelectric networks through gap junctions, enabling collective decision-making; bioelectric patterns store morphogenetic information independent of genetic instructions; the “cognitive light cone” expands when components integrate into networks.

Holonic Architecture: Nested Self-Regulating Systems

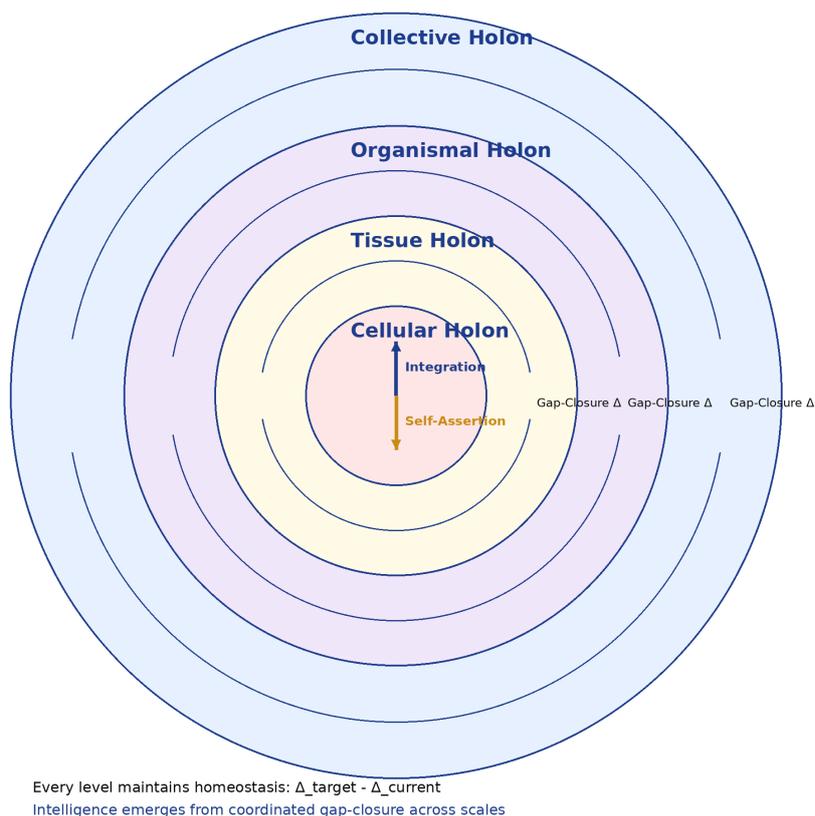


Figure 4: Holonic architecture with nested self-regulating systems. Each level—from cellular holons to collective holons—maintains homeostasis through gap-closure: minimizing the difference between target state (Δ_{target}) and current state (Δ_{current}). The Janus phenomenon is visible through bidirectional arrows: integration (outward/upward) toward larger wholes and self-assertion (inward/downward) maintaining autonomy. Intelligence emerges from coordinated gap-closure across all scales.

2.6 Promise Theory and Semantic Spacetime

Mark Burgess’s Promise Theory provides formal framework for autonomous agent cooperation.

Axiom 2.1 (Autonomy Axiom). *Every agent can only promise its own behavior, not others’ behaviors.*

This establishes that change must be determined independently at each point—voluntary cooperation, not imposed obligation.

Definition 2.5 (Promise). *A promise $\pi(a \rightarrow b, \sigma)$ is declaration by autonomous agent a to agent b concerning behavior σ . The promise creates no obligation on b and may or may not be kept.*

Promise Theory: Autonomous Agents & Semantic Spacetime

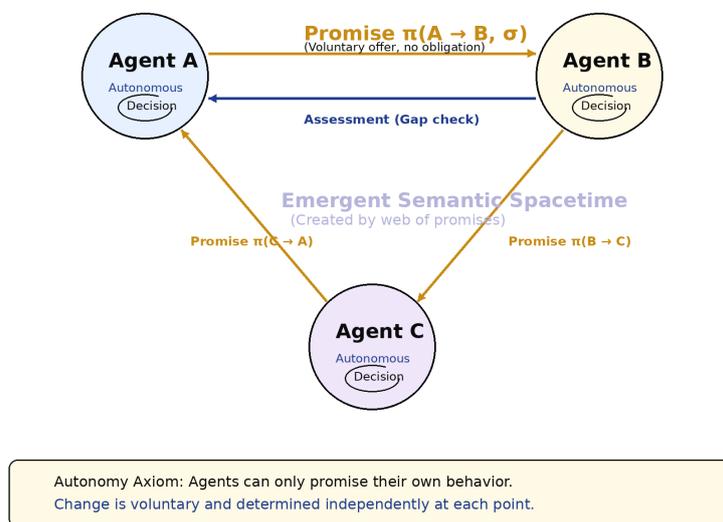


Figure 5: Promise Theory framework showing autonomous agents interacting through voluntary promises and assessments. Each agent makes promises about its own behavior (gold arrows) without creating obligations on others. Agents assess others’ promises through gap-checking (blue arrows). The web of promises and assessments creates emergent semantic spacetime—space and time acquire meaning through the commitments agents make and evaluate. This voluntary cooperation model aligns with holonic self-regulation and provides foundation for distributed intelligence without central control.

2.7 Quaternion Process Theory

Carlos E. Perez’s Quaternion Process Theory extends Kahneman’s dual-process theory (System 1/System 2) into four-dimensional cognitive framework.

Definition 2.6 (Quaternion Process Theory). *Cognition operates through four irreducible modes:*

1. **Intuition** (Fast-Iconic, Firstness): *Pattern recognition, resemblance-based*
2. **Fluency** (Fast-Symbolic, Degenerate Thirdness): *Symbol manipulation, syntactic flow*
3. **Empathy** (Slow-Indexical, Secondness): *Grounding in causality, verification loops*

4. **Wisdom** (*Slow-Integrative, Genuine Thirdness*): Coherence across scales, agapistic alignment

Current LLMs exhibit powerful Fluency but lack Empathy—ability to pause, verify, ground outputs in reality. This explains hallucination: models are syntactically correct but indexically wrong.

Quaternion Process Theory: 4-Mode Cognitive Framework

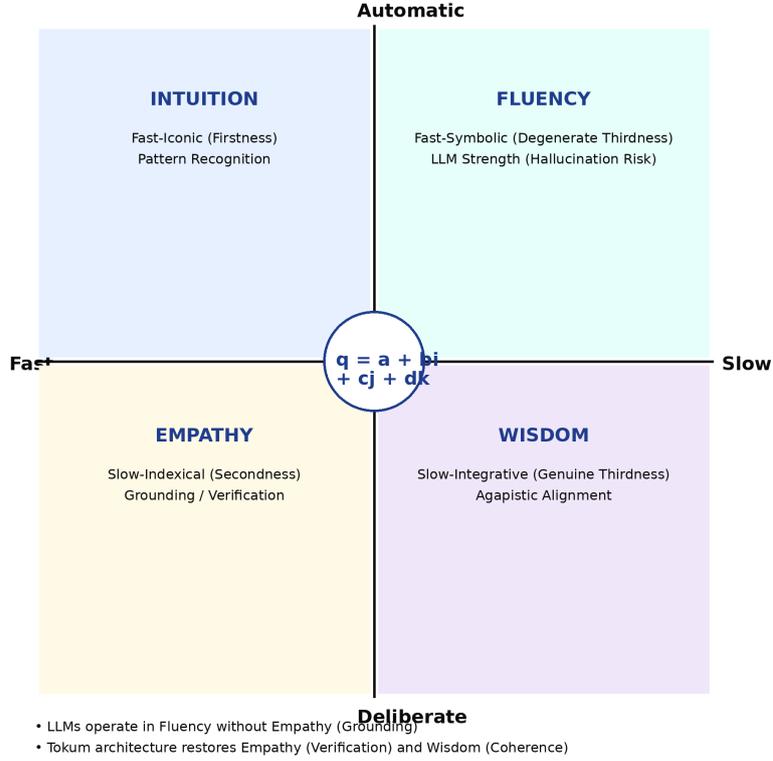


Figure 6: Quaternion Process Theory as four-mode cognitive framework mapped to Peirce’s categories. The four quadrants represent: Intuition (fast-iconic pattern recognition), Fluency (fast-symbolic manipulation where LLMs excel), Empathy (slow-indexical grounding through verification—what LLMs lack), and Wisdom (slow-integrative coherence through agapastic alignment). LLMs operating primarily in Fluency without Empathy explains their hallucination problem: syntactically correct but referentially ungrounded. The TOKUM architecture restores Empathy (verification via $\phi : \mathbb{R} \rightarrow \mathcal{C}$) and Wisdom (coherence via AIF).

3 Intelligence as Flow: The Copernican Shift

3.1 Intelligence as Homeostatic Flow

We propose radical reconceptualization: intelligence is not asset but flow—emergent property of network maintaining homeostatic balance through distributed gap-closure.

Definition 3.1 (Intelligence as Flow). *Intelligence \mathcal{I} of holonic network \mathcal{H} is weighted sum of gap-closure rates across all constituent holons:*

$$\mathcal{I}(\mathcal{H}) = \sum_{h \in \mathcal{H}} w_h \cdot \frac{d}{dt} \left(\Delta_h^{target} - \Delta_h^{current} \right) \quad (2)$$

where Δ_h^{target} is holon h 's target state, $\Delta_h^{current}$ its current state, and the weights are governed by the AIF:

$$w_h = \frac{\mathcal{A}(\tau_h, \mathcal{H})}{\sum_{h' \in \mathcal{H}} \mathcal{A}(\tau_{h'}, \mathcal{H})} \quad (3)$$

Paradigm Shift: From Asset to Flow

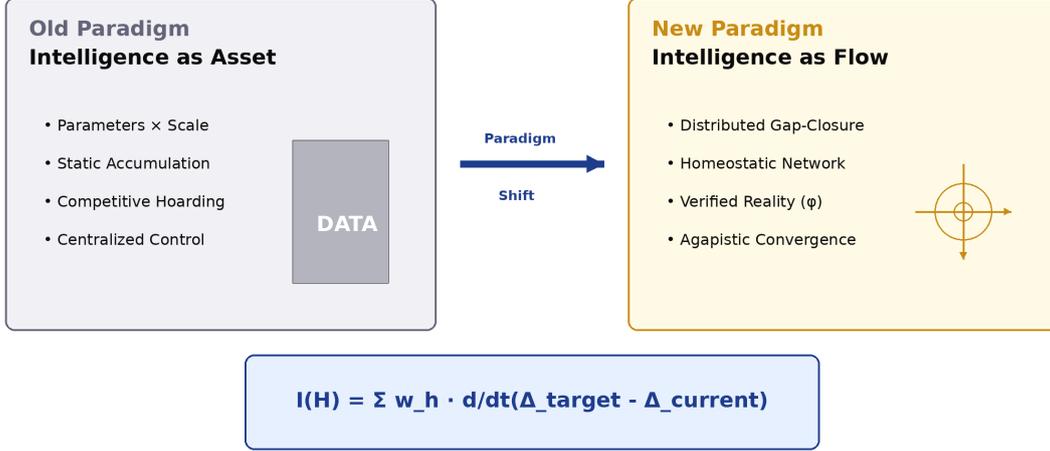


Figure 7: Paradigm shift from intelligence as static asset to intelligence as dynamic network flow. Left: Old paradigm treats intelligence as accumulated parameters and scale—centralized, competitive, hoarded knowledge. Right: New paradigm recognizes intelligence as distributed gap-closure across holonic networks—verified through topological puncture (ϕ), governed by agapistic convergence (AIF), flowing toward homeostatic equilibrium. The formula $\mathcal{I}(\mathcal{H}) = \sum w_h \cdot \frac{d}{dt}(\Delta_{target} - \Delta_{current})$ quantifies intelligence as measurable flow rate rather than static capacity.

4 The Semiotic Web Architecture

4.1 The Tokum: Token of Universal Meaning, Quantum Token

The TOKUM is the fundamental unit of Semiotic Web—Peircean sign implemented with full triadic structure.

Definition 4.1 (Tokum). *A TOKUM τ is cryptographically-verified semiotic unit consisting of:*

1. **Canonical Comprehension Identity (CCI):** *Immutable extensional identity via SHA-256 hash (IP-layer analog)*
2. **Contextual Tokum Instance (CTI):** *Dynamic intensional identity through HCNV-COLBERT matrix lookup (MAC-layer analog)*
3. **Provenance Chain:** *Cryptographic verification linking to physical reality*

Complete Peircean Sign = IP + MAC = CCI + CTI, bridged by Tokumizer implementing semiotic closure.

The critical innovation is topological puncture:

$$\phi : \mathbb{R} \rightarrow \mathcal{C} \quad (4)$$

This function injects cryptographically-verified observations from physical reality \mathbb{R} into latent context \mathcal{C} . Unlike embeddings merely encoding statistical co-occurrence, the puncture maintains verifiable chain to actual referents.

4.2 HyperComprehension Named Vector ColBERT

Definition 4.2 (HCNV-COLBERT Matrix). *The HyperComprehension Named Vector ColBERT (HCNV-COLBERT) matrix is a sparse (99.75% sparse) vector architecture where:*

- *Each vector is composed exclusively of Peircean Signs (named by TOKUMs)*
- *Vectors enable late-interaction similarity computation (ColBERT-style)*
- *Sparsity eliminates noise, preserving only meaningful semantic signals*
- *Matrix functions as Digital Synaptic Web connecting TOKUMs through verified relationships*

Navigation between TOKUMs proceeds through Quaternion Process Theory convergence.

Definition 4.3 (HyperComprehension via QPT).

$$QPT = (\Omega, \Sigma, I, \Rightarrow, \varpi^*) \quad (5)$$

where:

1. Ω (Omega): *Ground/Platonic space of all potential TOKUMs*
2. Σ (Sigma): *Signal space—current context filters possibilities*
3. I (Interpretant): *Response/belief generated from candidates*
4. \Rightarrow : *Implication dynamics (convergence process)*
5. ϖ^* (Fixed Point): *Stable outcome (selected TOKUM)*

Next TOKUM selection:

$$\tau_{next} = \arg \max_{\tau' \in \Sigma(\Omega, context)} \mathcal{A}(\tau', h) \quad (6)$$

where \mathcal{A} is the Agapistic Influence Function and h is current holonic context.

HyperComprehension Named Vector ColBERT + Quaternion Process Theory

$$\text{QPT} = (\Omega, \Sigma, I, \Rightarrow, \varpi^*)$$

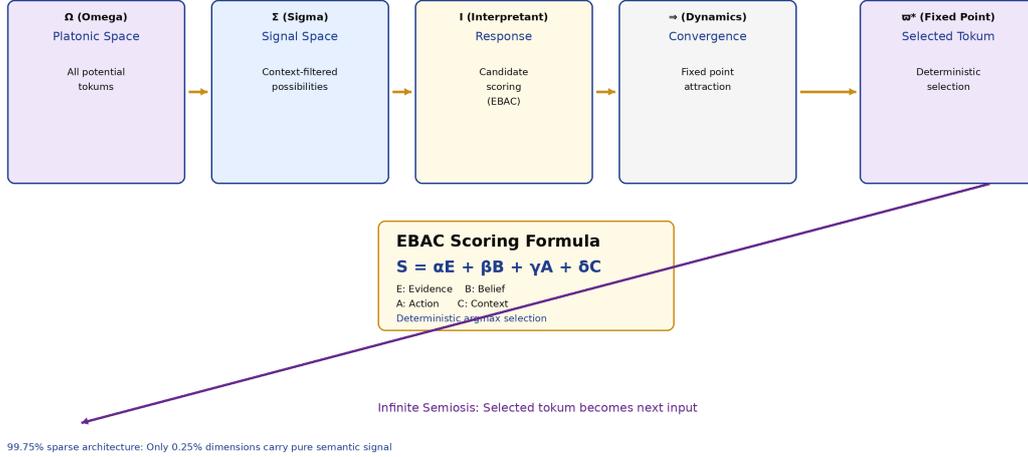


Figure 8: HCNV-COLBERT architecture with Quaternion Process Theory convergence implementing deterministic next-tokum selection. Stage 1 (Ω): Platonic space of all potential meanings. Stage 2 (Σ): Context filtering reduces possibilities using semantic spacetime constraints and ColBERT vectors. Stage 3 (I): Candidate interpretants scored via EBAC (Evidence + Belief + Action + Context): $S = \alpha E + \beta B + \gamma A + \delta C$. Stage 4 (\Rightarrow): Convergence dynamics governed by AIF. Stage 5 (ϖ^*): Fixed point deterministic selection via argmax. The selected TOKUM becomes new input, implementing infinite semiosis. 99.75% sparsity ensures only meaningful signals propagate.

5 Quantum Foundations

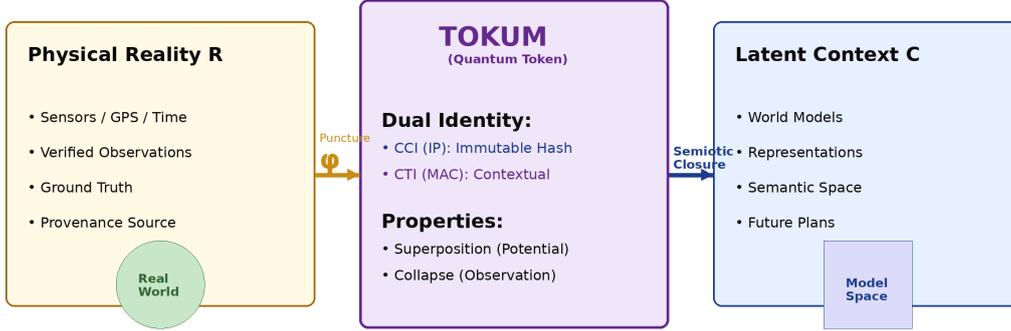
5.1 The Tokum as Quantum Token

Drawing on Faggin’s Quantum Information Panpsychism, we propose TOKUM functions as quantum token—unit of meaning bridging quantum and classical information.

Proposition 5.1 (Quantum Token Properties). *The TOKUM exhibits quantum-like properties:*

1. **Superposition:** Before context-specific retrieval (CTI lookup), TOKUM exists in superposition of potential meanings
2. **Collapse:** CTI lookup via HCNV-COLBERT matrix collapses superposition to specific contextual meaning
3. **Entanglement:** Semantically related TOKUMS exhibit non-local correlations in meaning
4. **Non-clonability:** Quantum state of meaning cannot be perfectly copied without original context

Tokum as Quantum Token: Bridging Reality and Context



Topological Puncture $\phi: \mathbb{R} \rightarrow \mathcal{C}$ ensures grounded representation

Figure 9: TOKUM as quantum token bridging physical reality (\mathbb{R}) and latent context (\mathcal{C}) through topological puncture $\phi: \mathbb{R} \rightarrow \mathcal{C}$. Left: Physical reality provides verified observations (sensors, GPS, timestamps) serving as ground truth. Center: TOKUM carries dual identity—CCI (IP layer: immutable hash enabling universal routing) and CTI (MAC layer: contextual instance enabling local grounding)—plus complete provenance chain. Right: Latent context contains world models, representations, and semantic spaces for planning. The TOKUM’s quantum properties (superposition of potential meanings before observation, collapse upon context retrieval) enable it to bridge the quantum realm of meaning and classical realm of computation.

6 Grounding JEPA: The Missing Layer

6.1 Complementarity with LeCun’s Vision

The Semiotic Web provides grounding layer JEPA world models require. LeCun’s vision of autonomous machine intelligence through predictive world models aligns with our framework:

- JEPA predicts in abstract representation space \rightarrow Semiotic Web grounds representations via $\phi: \mathbb{R} \rightarrow \mathcal{C}$
- JEPA handles uncertainty through latent variables \rightarrow TOKUM quantum superposition handles meaning uncertainty
- JEPA builds hierarchical predictions \rightarrow Holonic organization provides natural hierarchy with semantic DNA
- JEPA learns from video and interaction \rightarrow TOKUMS cryptographically verify sensory grounding

Proposition 6.1 (JEPA-Tokum Integration). *A JEPA world model W operating on TOKUM representations achieves grounded prediction:*

$$\hat{\tau}_{t+1} = W(\tau_t, a_t, z) \quad \text{where} \quad \tau_t = \phi(r_t) \tag{7}$$

Topological puncture ϕ ensures predicted TOKUMS maintain connection to physical reality through provenance chain. The predicted TOKUM $\hat{\tau}_{t+1}$ carries both CCI (IP layer: universal identifier enabling verification across systems) and CTI (MAC layer: contextual grounding in specific holonic environment).

LeCun predicts JEPAs will replace LLMs in 3–5 years because world models learn like animals do—through interaction with physical reality. The Semiotic Web provides the missing semiotic closure mechanism making this vision executable.

7 Economic and Governance Implications

7.1 Intelligence as Commodity: Homeostatic Economics

The flow conception of intelligence has profound economic implications.

Definition 7.1 (Tokum Value). *Intrinsic value of TOKUM determined by:*

$$V(\tau) = U(\tau) \times T(\tau) \times R(\tau) \quad (8)$$

where:

- $U(\tau)$: *Utility (contribution to gap-closure, measured by AIF)*
- $T(\tau)$: *Transaction frequency (network participation)*
- $R(\tau)$: *Rarity (information-theoretic uniqueness)*

All factors objectively measurable through network activity.

The AIF enables homeostatic economics where value creation stems from stress reduction (gap-closure) rather than extraction and hoarding. This fundamentally redefines money’s origin from debt-backed extraction to contribution-backed gap-closure.

7.2 From Hierarchy to Holonicracy

In holonicracy, value is created not by accumulating and controlling intelligence but by contributing to network’s collective gap-closure capacity. This aligns individual and collective interest through homeostatic principle governed by AIF.

8 Discussion

8.1 Implications for AI Safety and Alignment

The Semiotic Web provides natural mechanisms for AI safety:

- **Transparency:** Every TOKUM carries full provenance, enabling complete audit trails
- **Accountability:** Gap-closure contributions measurable and attributable via AIF
- **Alignment:** Homeostatic principles naturally align individual and collective interests
- **Verifiability:** Cryptographic puncture $\phi : \mathbb{R} \rightarrow \mathcal{C}$ enables verification of reality-claims
- **Containment:** IP/MAC architecture allows universal CCI routing while containing CTI to appropriate holonic contexts

9 Conclusion

This paper has presented theoretical framework for understanding intelligence as emergent property of semiotic networks governed by homeostatic principles. By integrating Peirce’s semiotics, holonic organization, Promise Theory, Quaternion Process Theory, and Quantum Information Panpsychism, we have developed coherent architecture for AI systems capable of genuine semantic grounding.

The TOKUM—as Token of Universal Meaning and Quantum Token—provides primitive unit for this architecture. Through IP/MAC analogy, we clarify dual identity: CCI as immutable IP-layer routing (extensional), CTI as dynamic MAC-layer context (intensional), bridged by Tokumizer implementing Peirce’s irreducible triad with cryptographic verification.

The Agapistic Influence Function (AIF) acts as gravity for meaning, curving semantic space-time toward homeostatic equilibrium. This enables intelligence-as-flow: not accumulated knowledge but measurable gap-closure rate across holonic networks.

The HCNV-COLBERT matrix, with 99.75% sparsity, implements HyperComprehension through Quaternion Process Theory convergence, enabling deterministic next-tokum selection via infinite semiosis converging to fixed points.

This paradigm shift—from intelligence-as-asset to intelligence-as-flow—parallels Copernican, Newtonian, Einsteinian, and Shannon revolutions. Current AI is Ptolemaic, adding epicycles (parameters, scale). Intelligence-as-Flow is Copernican, measuring verified reality directly.

The implications extend far beyond artificial intelligence into fundamental questions about nature of meaning, intelligence, and reality itself. As Peirce intuited, reality is indeed perfused with signs. The Semiotic Web makes this insight computationally tractable, providing the grounding layer enabling LeCun’s JEPa vision of world models learning through interaction with physical reality.

Intelligence is not what you accumulate. Intelligence is what flows through you toward the reduction of stress in the system you serve.

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