An Emergence-First Grand Unified Theory

Author: Randall Gossett
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Overview

This paper presents the emergence-first grand unified theory: the claim that validated entropy reduction is the universal primitive of contribution value, that emergence is the mechanism by which complex order arises from local interaction under feedback, and that these two ideas are not metaphors for each other but are formally connected through the Shannon-Landauer-Bennett lineage in physics and information theory.

The theory is not a collection of organizational case studies. It is a unified account of why feedback-driven emergence is the correct structural foundation for any system that measures, rewards, or governs complex contribution, and why any system that substitutes representation for the underlying condition will decay predictably, measurably, and often catastrophically.

The formal governance implementation of this theory is Randall's Feedback V4 (RF V4), documented separately. The protocol implementation is the Extropy Engine, documented in the Extropy Codex. This paper is the theoretical layer: the argument for why the framework is constructed the way it is, grounded in physics, information theory, complexity science, and the formal results that RF V4 establishes.

The model is allowed to lose. Every claim made here specifies or implies a falsification condition. That posture is not rhetorical humility. It is the first architectural consequence of the theory itself.

1. The Physical Foundation: What Entropy Actually Is

Entropy is not a metaphor. The tendency of the universe toward disorder is a physical law, and the formal connection between physical disorder and informational disorder is one of the deepest results in modern science.

Shannon (1948) established that the entropy of an information source, measured in bits, obeys the same mathematical structure as Boltzmann's thermodynamic entropy, measured in joules per kelvin. The equation is structurally identical. This is not an analogy; it is the same function applied to two different physical substrates.[^1]

Landauer (1961) closed the loop by proving that the erasure of one bit of information requires a minimum thermodynamic energy cost of $kT \ln 2$ joules, where k is Boltzmann's constant and T is temperature. Information processing has a physical cost. Information entropy and thermodynamic entropy are not merely formally similar; they are physically coupled.[^1]

Bennett (2003) extended Landauer's result to show that the energetic equivalence of bit erasure applies generally to irreversible logical operations. The implication is that every irreversible computation, every deletion of a record, every collapse of a probability distribution into a definite state, has a thermodynamic cost. Information is physical.[^1]

This is the theoretical floor of the emergence-first grand unified theory. When the Extropy Engine treats entropy reduction as the unit of value across eight canonical domains, it is not stretching a physics metaphor. It is applying a formally established equivalence between physical and informational disorder. The domains are not analogies for entropy. They are measurement contexts in which entropy, in its Shannon-Boltzmann sense, has an operationalizable instrument.

The claim is modest and precise: each domain has measurable forms of disorder, each domain admits a measurement instrument grounded in either physical or informational disorder, and value can be operationalized as validated reduction of that disorder. Domains are not physically equivalent to each other. Cross-domain aggregation requires explicit normalization. But the normalization is not arbitrary; it is anchored to the same theoretical floor.[^1]

2. Emergence: Order Without a Controller

Emergence is the phenomenon by which coherent, novel patterns arise spontaneously from local interactions among simpler elements, without central coordination imposing those patterns from outside.[^2]

The definition is formal, not impressionistic: a system exhibits emergence when coherent structures appear at the macro level that dynamically arise from interactions at the micro level, and these structures are novel with respect to the individual parts. A starling murmuration is not commanded by a conductor. Each bird follows local rules, proximity to neighbors, alignment, predator avoidance, and the global pattern arises from those rules without any agent computing the global pattern.[^2]

The thermodynamic perspective on emergence is central to the unified theory. Ilya Prigogine established that far-from-equilibrium systems receiving energy inputs can spontaneously self-organize into ordered patterns, which he called dissipative structures. These are not violations of the second law of thermodynamics; they are consistent with it. The local system reduces entropy while exporting more entropy to the environment. Order arises from chaos, not by violating physics, but by riding energy flows through open systems.[^2]

This is where emergence and entropy reduction connect at the physical level. Every emergent ordered structure is a local entropy reduction sustained by energy throughput. Ant colony foraging networks, biochemical oscillators, neural circuits, governance protocols, and working software systems are all dissipative structures in Prigogine's sense. They maintain local order against the thermodynamic gradient by importing energy and exporting disorder.

The emergence-first claim is therefore a physical claim, not just a design philosophy: systems that cultivate the conditions for emergent order, rather than imposing predetermined structure, are aligning with the physical mechanism by which complex order actually arises. This is not the same as saying systems should have no structure. Dissipative structures require specific boundary conditions, energy inputs, and feedback loops. The emergence-first approach is the disciplined design of those conditions, not the abandonment of design.

3. Feedback as the Physical Mechanism

Feedback is the mechanism that connects emergence to entropy reduction. Without feedback, energy flows through a system and dissipates. With feedback, energy flows can be captured, redirected, and used to sustain ordered structures against thermodynamic decay.

Norbert Wiener's cybernetics (1948) established feedback as the fundamental mechanism of self-regulation in both biological and mechanical systems. A negative feedback loop measures deviation from a target state and generates a corrective signal. The thermostat, the enzyme cascade, the immune response, and the governance vote all instantiate the same abstract structure.[^2]

The Randall's Feedback framework formalizes this in Axiom 1 (Feedback Primacy): the governance state evolves according to a feedback dynamical system[^1]

$$S_{t+1} = S_t + \alpha \cdot \mathcal{F}(S_t, E_t, G_t)$$

where $\mathcal{F}$ is the feedback functional, α is the learning rate, S_t is the state at time t, E_t is the environmental signal, and G_t is the current goal representation. Every governance transition is mediated by $\mathcal{F}$. No state change occurs outside the feedback loop.

This axiom is not a policy preference. It is the formal statement that the system instantiates a feedback dynamical system in the mathematical sense: a map from the current state and inputs to the next state, where the current state is informed by prior outputs. Feedback primacy is the formal condition that distinguishes a self-regulating system from an open-loop one.

The unified theory's claim is that contribution value can only be reliably measured in systems that satisfy feedback primacy. An open-loop system, one that prescribes outcomes without measuring actual effects, cannot distinguish order production from disorder production. It can only measure whether the prescribed outcome was executed, not whether execution produced order. This is the structural reason why top-down command systems, pure specification-driven development, and institutional compliance regimes all exhibit the same failure mode: they optimize for representation rather than for the underlying condition.

4. Why Representations Decay

The strongest empirical prediction of the emergence-first grand unified theory is that any representation of contribution value, if attached to sufficient incentive weight, will decay away from the condition it was built to track. This is not a sociological observation. It is a differential equation.

The Signal paper formalizes the decay as representational fidelity decay:[^1]

$$\frac{dF}{dt} = -k \cdot S(t) \cdot F(t) + r \cdot C(t) \cdot (1 - F(t))$$

where $F(t)$ is the representational fidelity at time t (the degree to which the label tracks its underlying territory), $S(t)$ is the social load on the label, $C(t)$ is the corrective feedback strength, k is the domain susceptibility coefficient, and r is the restoration rate.[^1]

The first term drives decay. The second drives recovery. The equilibrium fidelity is determined by the ratio of corrective force to gaming force. When corrective feedback is strong relative to social load, fidelity is near 1. When social load is high relative to corrective feedback, fidelity collapses toward 0.

The k-parameter taxonomy classifies domains by their susceptibility to fidelity decay, primarily through their feedback latency:[^1]

Domain Class	k value	Example labels	Reason
Physical	~0.02	Thermodynamic measurements, engineering metrics	Reality pushes back fast
Institutional	~0.15	Peer review, credentials, regulatory metrics	Slow, bureaucratically mediated feedback
Social/moral	~0.45	Reputation, identity claims, content authenticity	Near-zero corrective feedback

Every label that acquires incentive value passes through up to four observable phases: descriptive (functional, low social load), standardization (institutions invest in verification), capture (gaming proliferates, fidelity decays), and collapse or correction (semantic emptying or external corrective shock).[^1]

The emergence-first framework treats this decay as a permanent feature of the operating environment, not a bug to be engineered away. The response is structural: design the system so that the measurement instruments are grounded in conditions that have low k values (physical and informational disorder), keep representations that have high k values (reputation, identity, social standing) out of the value formula, and build explicit corrective feedback mechanisms into the protocol.

This is the theoretical foundation for the Extropy Engine's architectural invariant: reputation does not enter the XP formula. Reputation is a label with high social load and high k value. If reputation enters the value formula, optimizing for value forces optimization for reputation, and reputation-gaming is not a hypothetical — every reputation system deployed at scale has been gamed.[^1]

5. The Eight Canonical Domains

The unified theory claims that all measurable contribution value can be expressed as entropy reduction in one or more of eight canonical domains, each grounded in either physical or informational disorder.[^1]

Domain	Entropy definition	Primary instruments	k class	Maturity
Thermodynamic	Physical disorder, energy dispersal	kWh saved, J/K reduction, emissions reduction	Physical (~0.02)	Highest
Informational	Signal uncertainty, record quality	Bits removed, error rate, retrieval latency	Physical-adjacent	High
Code	Software structural disorder	Cyclomatic complexity, bug density, coverage	Physical-adjacent	High
Economic	Allocation and exchange disorder	Utilization, throughput, waste reduction	Institutional (~0.15)	Medium-high
Cognitive	Understanding and explanation disorder	Compression ratio, error rate reduction, rubric assessment	Institutional	Medium
Temporal	Sequencing and synchronization disorder	Cycle time, wait time, synchronization	Institutional	Medium

Domain	Entropy definition	Primary instruments	k class	Maturity
Governance	Decision system disorder	Decision latency, reversal frequency, participation quality	Institutional	Low-medium
Social	Trust and cooperation disorder	Network cohesion, conflict reduction, validated trust surveys	Social/moral (~0.45)	Low

The eight domains are not arbitrary. They satisfy three conditions: each admits a measurement instrument grounded in Shannon-Boltzmann disorder; each domain's measurement cannot be expressed under the other seven without loss; each domain has a falsifiability condition definable in advance.[^1]

Two domains that frequently appear in informal discussions of this framework are ecological and spiritual. Neither meets all three conditions. Ecological harms decompose cleanly into thermodynamic, informational, social, and economic components without loss. An ecological claim is therefore a multi-domain claim with a weight vector across the canonical eight. Spiritual experience cannot be operationalized under a falsifiable instrument without collapsing into one of the canonical eight. Meaning-making is cognitive. Community formation is social. Ritual is governance. The framework treats spiritual as a philosophically meaningful category without treating it as a minting domain.[^1]

6. Goal Evolution: How Emergence-First Governance Avoids Rigidity

A system that maintains fixed goals cannot be emergence-first. Fixed goals are the definition of a closed-loop control system: measure deviation from target, apply correction. The emergence-first claim is that goals themselves must be capable of evolving based on feedback, while remaining stable enough not to collapse into chaos.

RF V4 formalizes this in Axiom 2 (Goal Evolution):[^1]

$$G_{t+1} = G_t + \beta \cdot L(G_t, O_t)$$

where L is the goal-update operator, β is the goal learning rate, and O_t is an observation measured independently of the reputation state. The operator L is required to be Lipschitz continuous with contraction constant $\kappa \in (0, 1)$, ensuring that goal updates contract toward a fixed point G^* that is invariant under admissible perturbations of the reputation state.[^1]

The Lipschitz condition is the formal statement of the constraint that distinguishes productive goal evolution from chaotic drift. A goal-update operator that is not Lipschitz continuous allows arbitrarily large goal changes from small perturbations, which is the formal condition for chaos. The contraction requirement ensures that the system has a stable attractor: over time, collective goal-updating converges to a fixed point rather than diverging.

RF Theorem V4-2 (Collective Goal-Update Admissibility) establishes necessary and sufficient conditions on L for the collective system to remain in a Banach fixed-point contraction on the product of feasible reward sets. The result: governance can update goals over time without collapsing into chaos, provided the pairwise overlap condition holds across the feasible reward sets of individual agents.[^1]

The practical consequence is that emergence-first governance is not anarchic. It is not "let whatever emerge emerge." It is the disciplined design of goal-update operators that satisfy the Lipschitz-contraction condition, combined with feedback mechanisms that observe actual outcomes and update goals accordingly. The gardener metaphor that appears in accessible descriptions of this framework is not wrong, but it is the user-facing narrative for a formally constrained feedback system.

7. Fractal Self-Similarity: The Same Loop at Every Scale

The emergence-first framework claims that the feedback-emergence mechanism operates at every organizational scale: individual agents, teams, communities, institutions, and civilizations. This is not an intuitive observation about complexity; it is a formal structural claim.

RF V4 Axiom 3 (Fractal Self-Similarity via Functors) formalizes this: there exists a scale functor $\mathcal{F} : \mathrm{FeedLoop}_{\mathrm{micro}} \to \mathrm{FeedLoop}_{\mathrm{macro}}$ and a natural transformation $\eta : \mathrm{Id} \Rightarrow \mathcal{F}$ such that the SIIR loop (Sense-Infer-Integrate-Respond) commutes at every scale.[^1]

The SIIR loop is the fundamental dynamical primitive. At each scale, the loop runs the same four phases:[^1]

- **Sense:** observe the environment, collect signals about contributions, validation outcomes, and current state.
- **Infer:** update the internal belief model by minimizing variational free energy given new observations. In Bayesian-mechanics terms, internal states flow down the free-energy gradient.
- **Integrate:** combine updated beliefs with the goal representation to form an action plan. Policy selection via expected free energy minimization: $P(u) = \mathrm{softmax}(-G(u))$.
- **Respond:** execute the selected action, which modifies the environment and generates new sensory signals for other agents.

The fact that the SIIR loop commutes at every scale is the formal version of the intuitive claim that feedback-driven emergence looks the same whether you are observing a single agent learning a skill, a team shipping a product, a community managing shared resources, or a civilization coordinating against existential risk. The mechanism is the same. The measurement instruments differ by domain. The governance parameters differ by scale. The structural primitive is invariant.

In the Extropy Engine, the fractal DFAO scales (NANO, MICRO, MESO, MACRO, PLANETARY) are the operational form of this axiom. The same contribution graph, the same loop lifecycle, the same XP formula, and the same retroactive-burn window operate at every scale, with governance-tunable parameters that adjust to the appropriate scale dynamics.[^1]

8. The Value Formula: Formalizing Contribution

The unified theory's claim that value is validated entropy reduction requires a formula. The canonical XP formula (Extropy Engine v3.1.2) is:[^1]

$$\mathrm{XP} = R \cdot F \cdot \Delta S \cdot (\mathbf{w} \cdot \mathbf{E}) \cdot \log\left(\frac{1}{T_s}\right)$$

Each term answers a distinct question that the theory requires:

- **R (Rarity, $[0.1, 10.0]$):** Was this contribution class scarce in the network context? R is a property of the loop class, not the actor. Routine contributions (R near 0.5) earn proportionally less than domain-breaking contributions (R near 10.0). Rarity is looked up from per-domain governance-tunable tables.

- **F (Frequency-of-decay, $(0,1]$):** Is this actor repeating the same action class? F starts at 1.0 for the first instance of the fingerprint (submitter, claim type, domain, DFAO) and decays per subsequent occurrence under either log-tail or harmonic curves. F is not falsifiability and not feedback closure.[^1]
- **ΔS (Entropy reduction magnitude):** Did disorder actually decrease, in domain-native units, against a specified baseline? ΔS must be strictly positive for XP to mint. Domain-native units are normalized before cross-domain aggregation.
- **$\mathbf{w} \cdot \mathbf{E}$ (Domain weighting dot product):** How well do the contribution's measured effects match what this community values? $\mathbf{w}$ is the eight-element governance-tunable weight vector. $\mathbf{E}$ is the eight-element per-claim evidence vector.
- **$\log(1/T_s)$ (Settlement-time factor):** Did the loop close in a reasonable timeframe? T_s is a normalized settlement-time factor in $(T_{\text{floor}}, 1.0]$. The log term is capped at $\log(1/T_{\text{floor}})$ to prevent runaway values. [^1]

The formula is multiplicative, not additive. Multiplication enforces necessity: if any term is zero (no entropy delta, no rarity, no evidence), XP is zero. A submitter cannot compensate for missing evidence with high rarity. The multiplicative structure embodies the conjunctive logic of the unified theory: value is created only when rarity, freshness, measurable disorder reduction, domain relevance, and timely settlement are simultaneously satisfied.[^1]

The formula has a structural analogy that frames its theoretical position. The irreducible form is:[^1]

$$\text{XP} = \frac{\Delta S}{c_l^2}$$

where c_l is a per-domain causal closure speed. This is a structural analogy to $E = mc^2$, not a physical law. It states that the value of a contribution is inversely proportional to the squared speed of causal closure in its domain: contributions in domains where causation closes slowly (social, governance) face a higher denominator than contributions in domains where causation closes quickly (thermodynamic, informational). The operational formula remains the five-term version. The irreducible form is a calibration target and a theoretical anchor.

9. Goodhart Resistance as Structural Consequence

The unified theory predicts its own failure modes. Every term in the XP formula is a potential Goodhart target: if any term acquires sufficient incentive weight, actors will optimize for that term rather than for the underlying entropy reduction it represents.

The response is structural, because moral exhortation does not work against selection pressure. The full set of Goodhart-defense mechanisms in the formula and protocol is:[^1]

- R as a loop-class property (not actor-bound) prevents reputation laundering through the rarity term.
- F as a per-fingerprint decay prevents grinding the same action class for XP.
- ΔS requires a domain-instrument-baseline-falsifiability record; trivial submissions are filtered at OPEN.
- $\mathbf{w} \cdot \mathbf{E}$ requires multi-domain evidence; single-domain trivia cannot reach high XP.
- T_s with a floor and a cap prevents log-term inflation through artificially fast settlement.
- V_c thresholding at consensus prevents low-confidence claims from minting.

- The 30-day retroactive burn window corrects drift after the fact.
- Validator collusion penalties make the expected value of collusion negative.
- Instrument update cycles allow governance to revise measurement instruments when drift is detected, with revisions applying to future loops only.

Each mechanism targets a specific failure mode predicted by the representational fidelity decay theory. The formula's complexity is not aesthetic; it is the operational consequence of the unified theory's prediction about how all measurement systems eventually fail.[^1]

The Complexity Thermostat, formalized in RF V4, regulates the unified entropy measure S_{RF} combining goal entropy, contribution entropy, and validation entropy. When S_{RF} exceeds an upper threshold (governance is too chaotic), the Thermostat tightens admissibility. When S_{RF} falls below a lower threshold (governance is too rigid), it relaxes admissibility. This is the formal mechanism that maintains the system in the productive region between collapse and disorder.[^1]

10. Convergent Validation Without Ground Truth

One of the strongest objections to any emergence-first framework is epistemic: if outcomes emerge rather than being prescribed, how do you know whether they represent genuine order production or elaborate self-deception? This is the oracle problem. You cannot measure entropy reduction without a trusted measurement standard, and trusted measurement standards are exactly what Goodhart pressure destroys.

RF V4 Theorem V4-5 (Convergent Validation Without Ground Truth) addresses this directly: Byzantine-robust peer prediction can be extended to n validators with linear collusion tolerance, enabling consensus on claim validity without a trusted oracle, provided the validator population is structured as RF specifies.[^1]

The practical implementation is the blind-slice micro-validation architecture. Each claim is divided into ten blind fragments; each fragment is validated by a different volunteer; the submitter's identity and DFAO context are removed. No single validator sees the full claim. The aggregation across the ten fragments produces the validation confidence score V_c through a Beta-conjugate Bayesian model, where each validator's historical accuracy weights their update.[^1]

V_c is not F. These are two entirely different quantities. $V_c \in [0, 1]$ is the output of Bayesian aggregation over validator judgments. F is the frequency-of-decay penalty in the XP formula. Earlier drafts of the technical specification conflated them. The v3.1.2 correction is an architectural invariant.[^1]

The validator accountability mechanism closes the loop: validators whose consensus is later contradicted by new evidence take a reputation penalty proportional to the XP burned. The penalty is structured so that the expected value of collusion is negative at validator pool sizes $N \geq 10$ and detection probability $p \geq 0.3$. Validators have skin in the game. The validation pool is itself a feedback system.[^1]

11. The Person as DAG: Identity Without Reduction

The unified theory requires an identity architecture that is consistent with its core claim. If value is validated entropy reduction, and if the actor's identity must not enter the value formula (to prevent Goodhart pressure through reputation), then identity cannot be a scalar. A credit score, a follower count, and a reputation number are all scalars. Scalars are exactly the kind of representation that the representational fidelity decay theory predicts will be captured and gamed.

The Extropy Engine's resolution is that identity is a directed acyclic graph (DAG), not a database row. Each person is a signed causal history: an ordered set of vertices (events participated in) and edges (causal links between events). The three axioms of the DAG architecture are:[^1]

1. **Events, not state.** The DAG stores events. State is derived by replay. There is no row to mutate.
2. **Convergence is value.** When person-DAGs share a vertex (a co-authored contribution, a joint validation, a witnessed event), the convergence vertex is where multi-party minting happens.
3. **Graphs nest fractally.** A person is a DAG. A DFAO is a DAG of person-DAGs. The protocol is a DAG of DFAO-DAGs. The same primitives operate at every scale.

The DAG identity architecture enforces Digital Autarky: every participant retains sovereignty over their own intelligence stack, identity material, decision context, and local event history. The Personal Signed Local Log (PSLL) lives on the user's device; the network sees only periodic Merkle roots anchored as DAG vertices. Identity proofs are graph-shaped, enabling selective disclosure via zero-knowledge proofs over graph structure. [^1]

This is not a privacy feature. It is the structural consequence of the unified theory's claim that the user is not a leaf node in a network that knows best. The network is a coordination layer. The user is sovereign. The protocol's value formula is invariant under actor swap: same entropy reduction yields the same XP regardless of who reports it. That invariance is only achievable if the identity cannot enter the value calculation. DAG identity, with selective disclosure via ZKP, is the architectural mechanism that makes the invariance enforceable.[^1]

12. Formal Foundations: What Has Been Proven

The unified theory is stratified by confidence level. The following is an honest account of what is proven, what is conjectured, and what remains open.

Proven (RF V4 theorems with complete proofs):

- **V4-1 (RF Governance Convergence):** Agents satisfying the particular-partition conditions converge asymptotically to a governance attractor via Hamiltonian matching under the Free Energy Principle.[^1]
- **V4-2 (Collective Goal-Update Admissibility):** Necessary and sufficient conditions on L exist for the collective system to remain in a Banach fixed-point contraction on the product of feasible reward sets.[^1]
- **V4-3 (Dynamic Goodhart Resistance):** The discrepancy process between the contribution metric and the evolving goal remains light-tailed under bounded goal-update rates and Lipschitz metric continuity.[^1]
- **V4-4 (Unhackability Under Constrained Policy Classes):** RF's admissibility conditions restrict the strategy space to a finite (or effectively finite) set, enabling non-trivial unhackable metric-goal pairs.[^1]
- **V4-5 (Convergent Validation Without Ground Truth):** Byzantine-robust peer prediction with linear collusion tolerance enables consensus without a trusted oracle.[^1]

Conjectured (stated as open in RF V4):

- **V4-6 (MeritRank Trilemma Resolution):** RF achieves approximate Generalizability, approximate Trustlessness, and epsilon-Sybil-Resistance simultaneously. The formal proof is open. This is the strongest claim and therefore the most likely to require revision under adversarial pressure.[^1]

Open engineering gaps (acknowledged in Extropy Codex v3.1.2):

- Cross-domain normalization calibration is preliminary. Operational data from a running deployment is required to refine the calibration functions.
- The relationship between the five-term operational XP formula and the irreducible form $\mathrm{XP} = \Delta S / c_l^2$ is not yet formally derived.
- Social-domain instrumentation is the least mature. Structured trust instruments are under development.
- Production DAG replication (libp2p gossip layer) is on the roadmap; the current implementation uses a single-node PostgreSQL backend.[^1]

The theory does not claim to have solved these gaps. It claims to have formally constructed the measurement infrastructure, instrumented the system for correction, and exposed the claims to peer review. The model is allowed to lose.

13. The Emergence-First Claim, Restated Precisely

The emergence-first grand unified theory makes the following claims, ordered from strongest to weakest:

Physically grounded (follows from Shannon-Landauer-Bennett, not contingent):

1. Information entropy and thermodynamic entropy are physically connected, not metaphorically related.
2. Every irreversible information processing operation has a thermodynamic cost.
3. Local entropy reduction is physically possible and physically meaningful across all eight canonical domains.

Formally proven (RF V4 theorems):
4. Feedback-driven governance systems satisfying the particular-partition condition converge to attractors (V4-1).
5. Goal evolution under Lipschitz-constrained operators does not produce chaos (V4-2).
6. Goodhart pressure remains bounded under RF governance (V4-3).
7. Unhackable metric-goal pairs are achievable under constrained policy classes (V4-4).
8. Consensus is achievable without a trusted oracle under Byzantine-robust peer prediction (V4-5).

Conjectured (open proof):
9. The three-way trilemma (generalizability, trustlessness, Sybil-resistance) is approximately resolvable simultaneously (V4-6).

Empirically grounded but subject to revision:
10. The k-parameter estimates (0.02, 0.15, 0.45) for the three domain classes correctly order the susceptibility of those domains to representational fidelity decay.
11. The five-term multiplicative XP formula correctly captures the necessary and sufficient conditions for contribution value.
12. The eight canonical domains are complete under the three admissibility conditions.

Falsification conditions for the theory as a whole:

- If a running deployment of the Extropy Engine shows that XP does not track actual entropy reduction under the canonical instruments, the instruments or the formula require revision.
- If a social-domain k estimate of 0.45 is wrong (if human-made content labels under EU AI Act enforcement retain fidelity over a five-year horizon), the k taxonomy requires revision.
- If Conjecture V4-6 is disproven (if no system can achieve approximate generalizability, trustlessness, and Sybil-resistance simultaneously), the governance architecture requires fundamental rethinking.

The model submits itself to each of these tests. That submission is not rhetorical. It is the first structural consequence of the theory.

14. Relation to Other Frameworks

The emergence-first grand unified theory is in dialogue with, and in some cases in tension with, several existing frameworks.

Complexity theory (Santa Fe tradition): The unified theory draws heavily on complex adaptive systems theory, edge-of-chaos dynamics, and self-organization. The primary extension is the formalization: the Shannon-Landauer-Bennett grounding provides a physical floor that informal complexity theory lacks, and the RF V4 theorems provide formal proofs for claims that complexity theory typically leaves as intuitions.

Free Energy Principle (Friston): RF V4 Theorem V4-1 grounds RF governance convergence in the Free Energy Principle and Hamiltonian matching. The unified theory treats the FEP as a proven formal framework for understanding how agents minimize prediction error and how governance attractors emerge from distributed agent behavior. This is not a speculative connection.

Information theory (Shannon, Kolmogorov): Shannon entropy is the mathematical primitive. The unified theory extends Shannon's framework from channel capacity and source coding into a multi-domain measurement protocol for contribution value. Kolmogorov complexity (the shortest program that computes a string) appears implicitly in the cognitive domain's compression-ratio instruments but is not yet explicitly integrated into the formal framework.

Institutional economics (Ostrom, North): Ostrom's design principles for managing common-pool resources are consistent with the emergence-first framework and anticipate several of its structural choices. The key difference is formalization: Ostrom's principles are empirically derived heuristics; the unified theory grounds them in the formal feedback and goal-evolution axioms of RF V4.

Blockchain and decentralized governance: The unified theory is explicitly critical of token-based reputation systems and plutocratic governance tokens. This is not a general critique of decentralization; it is a specific prediction from the representational fidelity decay model. Tokens that acquire liquidity value become speculation surfaces. The architectural invariant that reputation does not enter XP is the structural response.

15. What This Theory Is Not

The emergence-first grand unified theory is not:

- **A claim that social entropy reduction is literally thermodynamic entropy reduction.** The Shannon-Landauer-Bennett connection establishes a formal equivalence between information entropy and thermodynamic entropy. It does not establish that every social action has a direct thermodynamic interpretation. The framework claims only that each domain has a measurement protocol grounded in either physical or informational disorder, and that cross-domain aggregation requires explicit normalization.

- **A claim that all human value reduces to a single number.** XP is a per-action entropy-reduction score. It is not a credit score, not a social credit system, not a measure of a person's worth. The person is a DAG, not a scalar. The protocol is a coordination layer, not a truth authority.
- **A complete theory.** The open gaps listed in section 12 are real gaps. The conjectured V4-6 result is open. The cross-domain normalization calibration is preliminary. The social-domain instruments are immature. The theory has been formally constructed, instrumented for measurement, and exposed to peer review. It has not been proven. It is a research program.
- **A replacement for Randall's Feedback V4.** RF V4 is the formal governance paper. This paper is the theoretical layer: the physical and information-theoretic argument for why the framework is constructed the way it is. The two documents are companion pieces. Reading this paper without RF V4 gives you the physical and philosophical grounding. Reading RF V4 without this paper gives you the formal theorems without the unified physical motivation.

Closing Note

The emergence-first grand unified theory is the claim that order is not imposed from outside; it arises from local interactions under feedback, grounded in the physics of information. That claim has formal consequences: for how value is measured, for how governance must be structured, for how representations inevitably decay, and for what a protocol that resists that decay must look like.

The theory does not claim to have finished the job. It claims to have located the right question, stated it with sufficient precision to be falsifiable, and built the initial measurement infrastructure against which answers can be tested.

Build, measure, validate, correct. Lose carefully, and learn from losing.

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Companion Documents

These are the author's own companion works referenced throughout this paper. Body-text markers of the form [C1]..[C3] point here.

C1. Gossett, R. Extropy Codex: Comprehensive Technical Specification (v3.1.2). Companion technical specification.

C2. Gossett, R. Formal Foundations for Emergence-First Governance with Adaptive Goal Evolution and Convergent Validation in Decentralized Systems (Randall's Feedback V4). Companion formal governance paper.

C3. Gossett, R. When the Signal Eats the Source. Companion paper on representational fidelity decay.