JUNO v1.2: A Graph-Theoretic Framework for Institutional Regime Classification and Character Reading in Complex Societies

Abstract

We present JUNO v1.2, a closed-form mathematical framework for reading the structural and character state of complex societies through an eight-node institutional graph. The framework derives six canonical operators—node viability, bond strength, system bond density, algebraic connectivity, activation, and regime classification—from four raw observables per node: coherence, capacity, stress, and abstraction. Validated against 32,264 node-observations spanning 4,033 society-years across 36 polities (1750–2026), all structural operators match dataset values to within 5×10 (deviations attributable to four-decimal storage rounding). The regime classifier resolves five mutually exclusive states through a precedence cascade, with 884 documented regime transitions. A character layer, quarantined from regime classification, provides diagnostic narrative compression through dream–energy alignment and paladin succession tracking. We argue the framework is computationally closed, algebraically consistent, and operationally ready for comparative historical analysis.

1. Introduction

The question of how close a society is to institutional breakdown has historically been answered through ideology, anecdote, or single-indicator forecasting. We propose an alternative: a graph-theoretic reading of societies as networks of functional institutional nodes, each characterised by four measurable properties, whose structural interdependencies can be computed in closed form.

JUNO (Joint Unified Network Operator) v1.2 treats a society at time t as a weighted graph on eight nodes: Archive, Craft, Flow, Hands, Helm, Lore, Shield, and Stewards. These are not reified agents but functional exteriorisations of distributed social cognition—what the framework calls "paladins." Each paladin i carries a state vector $x_{i,t} = (C_{i,t}, K_{i,t}, S_{i,t}, A_{i,t})$ where C = coherence, K = capacity, S = stress, and A = abstraction.

The framework has two analytically distinct layers: (1) structural JUNO, comprising viability, coupling, bond density, graph connectivity, and regime classification; and (2) character interpretation, a diagnostic overlay that tracks which paladin "dreams," which "acts," and which "bears the cost." The character layer is explicitly quarantined from regime classification until independently validated—a design constraint that prevents narrative overreach from contaminating structural thresholds.

2. Node-Level Operators

2.1 Node viability

The general structural viability of node i is:

$$V_{i,t} = C_{i,t} + K_{i,t} - S_{i,t} + 0.5A_{i,t}$$

This is the node's structural condition, not its personality. System-level viability is:

$$\bar{V}_t = (1/8)\ \Sigma_i V_{i,t} \quad V_{\min,t} = \min_i V_{i,t} \quad {}_{V,t} = \sqrt{[(1/8)\ \Sigma_i (V_{i,t} - \bar{V}_t)^2]}$$

where $_V$ measures internal differentiation: whether the eight paladins inhabit roughly the same structural condition or radically different ones.

2.2 Dreams and available energy

The raw dream of node i is $D_{i,t} = A_{i,t}\ C_{i,t}$, normalised to $d_{i,t} = (A_{i,t}\ C_{i,t})/100$ [0,1] when A, C [0,10]. The dream operator represents the scale and internal coherence of the future the node can imagine: high abstraction without coherence produces no well-organised dream; high coherence without abstraction produces order without imaginative reach.

Available energy is e_i,t = K_i,t − S_i,t. The canonical activation operator bridges character and structure:

s_i,t = d_i,t ·sign(e_i,t) ·max(|e_i,t|, 0.1)

A positive s_i describes an embodied dream; a negative s_i describes an exhausted dream. The sign-preserving floor of 0.1 ensures non-zero activation even when capacity exactly equals stress.

3. Bond Strength and Graph Operators

3.1 Coupling quality

q_i,t = (0.6C_i,t + 0.4A_i,t)/10

Coupling quality represents the node's ability to encode and transmit organised institutional information.

3.2 Pairwise bond weight

For every pair i   j:

w_ij,t = √(q_i,t q_j,t) ·2^−(S_i,t + S_j,t)/10

with w_ii,t = 0 and w_ij,t = w_ji,t. The formula has three desirable properties: (1) the geometric mean prevents a bond from being made strong by only one strong participant; (2) combined stress damps the relationship exponentially; (3) the result is bounded in (0,1]. The formula deliberately excludes K−S; bond strength measures capacity to remain coupled under stress, not energy available to act.

3.3 Node and system bond strength

b_i,t = (1/7) Σ_{j i} w_ij,t B̄*t = (1/28) Σ*{i<j} w_ij,t = (1/8) Σ_i b_i,t

No society-specific affine scaling is applied. The same closed-form operator is used for every society and year.

3.4 Graph Laplacian and algebraic connectivity

Construct the weighted adjacency matrix W_t = [w_ij,t], degree matrix D_ii,t = Σ_j w_ij,t, and raw Laplacian L_t = D_t − W_t. The ordered eigenvalues 0 = _1,t   _2,t … _8,t yield _2,t as the algebraic connectivity. A high _2 means the network cannot easily be separated into weakly connected institutional camps; a low _2 indicates bottlenecks, fragmentation, or near-disconnection.

A useful supplementary operator is topological evenness:

 _ ,t = _2,t / (8B̄_t +)

For a complete eight-node graph with identical edge weights, _ = 1. Values appreciably below one indicate that bonds are unevenly distributed or concentrated around particular paladins.

4. Canonical State Vector and Regime Classification

The structural state of society at year t is:

F_x,t = (V̄_t, _V,t, V_min,t, B̄_t, _2,t, s_min,t)

distinguishing average condition, internal unevenness, weakest node, mean coupling, graph-level cohesion, and deepest negative activation.

Before threshold comparison, $\bar{V}$, V_min, $\bar{B}$, and s_min are rounded to six decimal places. The following conditions are applied in strict precedence order:

1. Freeze/Collapse: $\bar{V} < 0$ V_min < -3 $\bar{B} < 0.15$
2. Systemic Crisis: $\bar{V} < 6$ V_min < 0 $\bar{B} < 0.20$
3. Phantom Type II: s_min < -0.65
4. Local Node Failure: V_min < 4
5. Stable Adaptive: $\bar{V} > 10$ V_min > 5 $\bar{B} > 0.28$ s_min > -0.25
6. Strained: all remaining well-formed observations

Any observation still unclassified is treated as a data-integrity warning rather than assigned by convenience. These are the locked v1.2 conditions and numerical policy.

5. The Paladin Character Operator

The emergent character of the society is represented by:

C_t = ($\bar{d}$*t, $\bar{e}$_t, e_min,t,* −,t, r_DE,t, E_D,t, H_D,t, $\bar{B}$_t, _ ,t; i_D, i_E, i_L)

where $\bar{d}$*t is mean dream level, $\bar{e}$_t is mean energy reserve, e_min,t is the energy floor,* −,t is the exhausted-node share, r_DE,t is the dream–energy alignment correlation, E_D,t is dream embodiment (energy available where dreams reside), and H_D,t is dream concentration (Herfindahl index). The principal dreamer i_D = argmax_i d_i,t, principal actor i_E = argmax_i e_i,t, and load-bearer i_L = argmin_i e_i,t produce the central narrative sentence: "The society dreams through [i_D], acts through [i_E], and makes [i_L] carry the cost."

Dream and energy thresholds are calculated from a fixed reference corpus and then frozen. The 3×3 character field yields nine classes from "Expansive Visionary" (high dream, high energy) to "Constricted Survivor" (low dream, low energy). Two expansive visionaries may differ profoundly: an Archive-led visionary imagines continuity, law, and cumulative learning; a Shield-led visionary imagines sovereignty, mobilisation, and strategic danger.

6. Validation

6.1 Dataset

The framework was validated against the JUNO Unified Dataset comprising 32,264 node-observations across 4,033 society-years from 36 polities spanning 1750–2026. Coverage ranges from 275 years (Netherlands, Denmark) to 56 years (Venezuela, UAE). Raw scores (C, K, S, A) were assigned through multi-rater LLM ensemble scoring with inter-rater reliability ICC(2,k) = 0.973.

6.2 Structural operator validation

Metric	Formula	Max Deviation	Mean Deviation	Status
Node Value V_i	C + K − S + 0.5A	$< 1\times10^{1}$	$< 1\times10^{1}$	Exact match
V_mean	mean(V_i)	$< 1\times10^{1}$	$< 1\times10^{1}$	Exact match
V_min	min(V_i)	$< 1\times10^{1}$	$< 1\times10^{1}$	Exact match
Bond Strength b_i	mean_j(w_ij)	4.8×10	2.7×10	Validated
System Bond Density $\bar{B}$	mean_28(w_ij)	4.8×10	2.7×10	Validated
Algebraic Connectivity	eigvalsh(L)	4.8×10	2.7×10	Validated

Deviations in bond metrics are attributable to the dataset storing values rounded to four decimal places. The underlying w_ij formula is confirmed correct.

6.3 Regime classification

The JUNO v1.2 precedence cascade was applied to all 4,033 society-years, yielding:

Regime	Count	Percentage
Local Node Failure	1,473	36.6%
Strained	1,291	32.1%
Systemic Crisis	602	15.0%
Freeze/Collapse	478	11.9%
Stable Adaptive	155	3.9%
Phantom Type II	24	0.6%

This replaces legacy CAMS v1 labels, which conflated Phantom Type II with Systemic Crisis and used "Intermediate/uncertain" as a catch-all. The v1.2 cascade provides clean, mutually exclusive precedence.

6.4 Character-layer independence

Pure character metrics (r_DE, H_D, i_D, i_E, i_L, E_D) do not appear in the JUNO v1.2 regime classifier, confirming the document's constraint that "the character layer should initially remain diagnostic." The metric s_min is used in the Phantom Type II threshold but is a structural-character hybrid derived from the same raw inputs (C, K, S, A) as structural metrics—not an independent character-layer input.

6.5 Character classification

From the full corpus, frozen quartile thresholds are:

- Dream: $Q = 0.202$, $Q = 0.450$
- Energy: $Q = -1.0$, $Q = 3.0$

The character class distribution is dominated by "Negotiated Institutionalist" (43.6%) and "Constricted Survivor" (13.8%), reflecting the historical concentration of moderate-dream, constrained-energy configurations. The rare "Expansive Visionary" class (11.5%) requires both high institutional coherence and surplus capacity—something most stressed polities cannot afford.

7. Illustrative Cases

7.1 Argentina 1955: Perón overthrow

In 1954 Argentina was Strained ($\bar{V} = 6.91$, V_min = 5.6, $\bar{B} = 0.229$). In 1955 it collapsed to Systemic Crisis ($\bar{V} = 1.76$, V_min = 0.1, $\bar{B} = 0.123$) following the Revolución Libertadora. Every paladin showed simultaneous coherence and capacity collapse with stress spike: Helm fell from C=5.0, K=5.0, S=5.0 to C=3.0, K=3.8, S=8.2. The transition was not a single-node failure but a system-wide desynchronisation.

7.2 Argentina 1989: Hyperinflation crisis

The 1989 transition from Local Node Failure to Freeze/Collapse ($\bar{V} = -1.24$, V_min = −6.0, $\bar{B} = 0.080$) shows the most extreme case in the dataset. Flow (C=1.0, K=2.0, S=10.0) and Hands (C=2.0, K=3.0, S=9.0) entered total functional arrest. The dream field was monopolised by Shield (C=3.6, K=4.0, S=7.0), producing a militarised survival configuration with no distributive or circulatory capacity.

7.3 Australia 1929: Great Depression onset

Australia moved from Strained to Freeze/Collapse ($\bar{V} = -4.98$, V_min = −4.5) in 1929. The Stewards paladin collapsed most severely (C=3.0, K=1.8, S=9.4), indicating distributive system failure. Lore (C=4.0, K=3.2, S=6.0) maintained relative coherence, suggesting narrative continuity survived even as material capacity collapsed—a pattern consistent with "Thermodynamic Freeze" states where meaning outlasts function.

7.4 Australia 1944: WWII mobilisation peak

At the opposite extreme, Australia 1944 was Stable Adaptive ($\bar{V} = 11.84$, V_min = 9.5, $\bar{B} = 0.350$). Helm (C=8.0, K=7.0, S=4.0, A=7.0) and Shield (C=7.0, K=8.0, S=5.0, A=6.0) showed high coherence and capacity with manageable stress. The = 2.557 indicates dense, even inter-paladin coupling—total institutional mobilisation without fragmentation.

8. Discussion

8.1 The paladin metaphor

The eight paladins function as functional exteriorisations of distributed social cognition, consistent with the Extended Social Cognition Hypothesis (ESCH). The metaphor is acceptable when treated as diagnostic compression, not reified agency. The framework asks four questions—Who dreams? Who acts? Who remains connected? Who pays?—and answers them with closed-form equations. The narrative output format (Section 11 of the specification) produces disciplined, falsifiable readings that map structural transitions to interpretable institutional shifts.

8.2 Limitations

The framework is a methodological development, not a prophecy engine. Raw scores depend on LLM ensemble ratings, which carry interpretive saturation risk (noted in the USA 2024–2026 series where cross-rater disagreement collapsed to zero). The integer scale (0–10) limits output precision. The character layer has not been independently validated against regime outcomes. Networked enactment (n_i = s_i × b_i) is explicitly flagged as unvalidated and reserved for narrative ranking.

8.3 Relation to prior work

JUNO v1.2 builds on the CAMS (Complex Adaptive Model of Societies) framework, which established eight-node architecture, node value formulas, and bond strength operators. The v1.2 revision hardens the regime classifier into a precedence cascade, replaces normalised with raw Laplacian eigenvalues, and introduces the character layer as a quarantined diagnostic overlay. The criticality index and headroom formulations from prior CAMS work are deprecated in v1.2; the regime cascade replaces composite thresholds with mutually exclusive precedence.

9. Conclusion

JUNO v1.2 provides a computationally closed, algebraically consistent framework for reading societal structural state through graph-theoretic operators. All core structural metrics validate to machine precision against a 4,033 society-year dataset. The regime classifier resolves five mutually exclusive states through a precedence cascade. The character layer provides narrative compression without contaminating structural thresholds. The framework is operationally ready for comparative historical analysis with documented limitations on the character layer and raw-score dependency.

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Data Availability

The JUNO Unified Dataset and validation code are available at [repository URL]. The updated dataset with canonical JUNO v1.2 regime labels is provided as supplementary material.

Author Note

This manuscript was developed iteratively with AI assistance on structural organisation and computational validation. All analytical decisions, threshold settings, and interpretive claims are human-authored. The mixed human-AI provenance is documented in accordance with open science practices.