Semantic Panarchy Towards a Rewrite Theory of Meaning in Complex Adaptive Systems

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Abstract

Organizations invest heavily in Common Lexicons, controlled vocabularies, and ontologies, on the assumption that shared meaning can be engineered by fixing definitions. Co-evolutionary Information Systems alignment research (Walraven et al., 2018–2023) has already shown that Business–IT alignment itself is not a designed end-state but a continuous co-evolutionary process. This paper asks what, exactly, is being co-evolved, and proposes an answer: meaning itself. Drawing on C. S. Holling's panarchy theory of nested adaptive cycles and on the universal rewrite system (URS) formalism developed by Peter Rowlands and Bernard Diaz for physics, the paper develops **Semantic Panarchy**: a framework in which a lexicon is understood not as a controlled vocabulary but as the temporarily stabilized semantic memory of an adaptive system, continuously regenerated through cycles of distinction (create) and stabilization (conserve) operating at different organizational and temporal scales. The paper is explicitly offered as a *theoretical working paper* rather than an empirical study: its claims are conceptual syntheses, not statistically tested hypotheses, and their value should be judged — in line with the ecological-rationality standard of Gigerenzer and the track-record standard of Taleb — by whether they generate robust, falsifiable predictions and survive contact with real organizational cases, not by whether they have yet cleared peer review. The paper closes by naming the specific empirical and formal work still required before Semantic Panarchy can be considered more than a promising heuristic.

Keywords: Common Lexicon, co-evolutionary IS alignment, panarchy, rewrite systems, semantic evolution, complex adaptive systems

1. Introduction

Most contemporary interoperability failures inside organizations are no longer caused by incompatible software. They are caused by incompatible interpretation. Different departments, professions, or institutions use the same word — "risk," "quality," "patient," "alignment" — while meaning different things by it, and this gap is often invisible until a decision fails.

The standard organizational response is the Common Lexicon: a shared glossary, taxonomy, or ontology that is supposed to fix the problem by fixing the definitions. Healthcare systems, government agencies, and universities all invest in such artifacts. The underlying assumption is simple: if everyone agrees on the words, everyone will communicate accurately.

In practice, lexicons decay. New technologies introduce new distinctions faster than governance processes can absorb them. Regulatory change redefines existing terms. Professional communities quietly drift apart in usage while continuing to use identical vocabulary. A Common Lexicon that is not actively maintained becomes, within a few years, a historical artifact rather than a working instrument.

This paper argues that this instability is not a governance failure to be corrected with better documentation discipline. It is evidence that meaning behaves as an adaptive system in its own

right, and that a Common Lexicon should be modeled accordingly — not as a static artifact to be designed and then maintained, but as an emergent structure that is continuously regenerated.

To make this argument, the paper draws on three literatures that are not normally brought into contact with one another: co-evolutionary Information Systems alignment research in the information-systems field, panarchy theory from ecological resilience research, and the universal rewrite system (URS) formalism developed within theoretical physics. The synthesis is offered as a conceptual framework — a *theoretical* rather than *empirical* contribution — intended to be tested, criticized, and refined rather than taken as established fact.

2. Background and Related Work

2.1 Co-evolutionary Information Systems Alignment

Business–IT alignment has traditionally been treated as a state that can be designed, achieved, and then governed into stability. Walraven's doctoral research directly challenges this assumption (Walraven, 2023). Working from a Complex Adaptive Systems perspective, Walraven and colleagues developed the concept of co-evolutionary IS alignment (COISA), defined as a continuously exercised organizational capability, "characterized by co-evolutionary interactions between heterogeneous IS stakeholders, in pursuit of a common interpretation and implementation of what it means to apply IT in an appropriate and timely way" (Walraven, van de Wetering, Caniëls, Versendaal, & Helms, 2021). Across a sequence of studies — a conceptual model built from Complex Adaptive Systems theory (Walraven, van de Wetering, Helms, Versendaal, & Caniëls, 2018), empirical work on Electronic Medical Record implementations in Dutch hospitals (Walraven, van de Wetering, Versendaal, & Caniëls, 2019; Walraven, van de Wetering, Helms, & Caniëls, 2020), a validated measurement scale (Walraven et al., 2021), and a combined necessary-condition/PLS-SEM analysis of alignment effects in healthcare (Walraven, van de Wetering, Caniëls, & Versendaal, 2022) — COISA is developed from concept to measurable construct. The dissertation that integrates this line of work explicitly reframes alignment as something that is never finished: it is repeatedly re-achieved through interaction between business and IT stakeholders inside a turbulent environment, not engineered once and then held in place (Walraven, 2023).

This is the departure point for the present paper. If alignment is co-evolutionary rather than designed, the natural next question is: what, concretely, is doing the co-evolving? Walraven's own later work on shared terminology across university stakeholders gestures toward an answer without formalizing it: the object that co-evolves alongside organizational structures and technologies is *meaning itself* — the interpretive content that stakeholders attach to shared terms.

2.2 Panarchy and Adaptive Cycles

Holling's panarchy theory was developed to explain how ecological and social-ecological systems evolve across multiple, simultaneously operating temporal and spatial scales (Holling, 2001). Each level of a panarchy moves through a four-phase adaptive cycle — exploitation, conservation, release, and reorganization — and levels are coupled: faster, smaller cycles generate innovation, while slower, larger cycles conserve accumulated structure and memory. Holling summarizes the resulting property directly: "each level is allowed to operate at its own pace, protected from above by slower, larger levels but invigorated from below by faster, smaller cycles of innovation. The whole panarchy is therefore both creative and conserving" (Holling, 2001).

Panarchy theory was built for ecosystems and later extended to social-ecological and institutional systems (Gunderson & Holling, 2002). It has not, to this author's knowledge, been applied to the

evolution of organizational vocabulary and shared meaning specifically. Section 4 argues that the same nested, nonlinear, nonetheless a formal one that has already been rigorously developed in an entirely different domain: theoretical physics.

2.3 The Universal Rewrite System

Rowlands and Diaz originally developed the universal rewrite system (URS) to derive the nilpotent form of the Dirac equation and, more broadly, to describe how physical structure can be generated recursively from an initial "zero" state rather than assumed to exist a priori (Rowlands, 2007; Diaz & Rowlands, 2005). The system operates through the repeated application of a rewrite rule to a starting alphabet that itself expands at every step, so that each application both creates a new symbol and conserves the internal consistency of everything already generated (Rowlands & Diaz, 2002; Diaz & Rowlands, 2005). Later work in this program extends the same rewrite logic beyond physics, proposing it as a candidate "meta-pattern" applicable across mathematics, physics, chemistry, and biology (Marcer & Rowlands, and related papers in this program).

This paper does not claim that Rowlands and Diaz's formalism is literally isomorphic to semantic change — that would require a rigor this paper does not attempt to supply. What is imported here is much narrower and more modest: the *structural idea* that a system can generate genuine novelty (create) while simultaneously preserving coherence with everything already established (conserve), and that this two-operation logic — rather than either pure invention or pure stability — is what allows a system's "alphabet" to keep expanding without collapsing into incoherence. That two-operation logic is a good candidate description of how professional and organizational vocabularies actually behave: new terms are continually created, but only some are conserved into durable use.

2.4 Information as Distinction

Bateson's foundational move in cybernetic epistemology — that information is "a difference which makes a difference" (Bateson, 1972) — supplies the missing first step that neither Walraven's nor Holling's nor Rowlands and Diaz's frameworks state explicitly: a semantic event begins with a *distinction*, not with a pre-existing object. This is the conceptual hinge that lets the paper connect physical rewrite systems to organizational meaning-making without claiming a literal identity between the two domains.

2.5 Positioning Relative to Adjacent Complexity Theories

The argument developed here is adjacent to, but distinct from, two other well-established complexity approaches to organizations. Stacey's theory of complex responsive processes treats organizational meaning as continuously enacted in local conversation, with no meaning existing independently of ongoing interaction — a position broadly compatible with the present framework's emphasis on interaction-generated meaning, though Stacey deliberately resists formal or cross-domain modeling. Snowden's Cynefin framework distinguishes decision contexts (simple, complicated, complex, chaotic) and is oriented toward practical sense-making and intervention rather than toward a generative account of how shared vocabulary itself evolves. Semantic Panarchy differs from both by attempting a specifically generative and multi-scale account — borrowing panarchy's nested-cycle structure and the URS's create/conserve logic — rather than a purely interactional (Stacey) or diagnostic (Snowden) one. This is a deliberate trade: more structure and more testable predictions, at the cost of the greater formal risk that comes with cross-domain borrowing.

3. The Problem With Static Lexicons

Three recurring failure patterns motivate the reframing proposed here.

First, **definitional lag**. By the time an organization has agreed on and published a formal definition of a term, the professional community using that term has often already moved on. Artificial intelligence terminology is a clear recent case: terms such as *prompt engineering*, *retrieval-augmented generation*, *hallucination*, and *AI agent* moved from informal technical usage to institutional vocabulary — and in some cases into legislative text — within a small number of years, faster than most organizational glossary-review cycles operate.

Second, **scale mismatch**. A single lexicon is typically maintained at one organizational level (e.g., an enterprise data-governance function), while the actual generation of new distinctions happens at many levels simultaneously — individual conversations, project teams, professional communities, regulators. A lexicon governed at only one scale cannot track change happening at faster, smaller scales, nor can it easily absorb change moving upward from those scales into durable institutional form.

Third, **false stability**. Publishing a definition creates the appearance that a term's meaning has been fixed, which can suppress the local renegotiation that would otherwise catch a drifting interpretation early. Ironically, a well-governed lexicon can sometimes *increase* the eventual size of a meaning gap, precisely because it discourages the small, frequent corrections that would otherwise occur.

Each of these three patterns has a direct counterpart in Holling's account of ecological panarchy: slow governance cycles unable to track fast innovation cycles; poor coupling between scales; and the trap of mistaking temporary stability for permanent stability (what Holling and colleagues describe as a "rigidity trap"). This structural parallel is the basis for the synthesis proposed in the next section.

4. Theory: Semantic Panarchy

4.1 Six Working Axioms

The following six axioms are offered as a first, deliberately minimal formalization — a starting point for critique and refinement rather than a finished theory.

1. **Distinction.** A semantic event originates with a distinction: some difference is marked as meaningful within a community of use (after Bateson, 1972).
2. **Rewrite.** Every new distinction perturbs the existing semantic state and forces local reorganization, analogous to the create-operation in a universal rewrite system (after Rowlands & Diaz, 2002).
3. **Conservation.** Not every distinction survives. A distinction is conserved into durable shared meaning only through repeated, socially reinforced use — analogous to the conserve-operation that keeps a rewrite system internally consistent as it expands.
4. **Lexicon.** A lexicon, at any given moment, is the set of currently conserved distinctions available to a community — a temporary stabilization, not a permanent structure.
5. **Panarchy.** Lexicons exist simultaneously at multiple nested organizational scales (team, department, profession, institution, sector), each operating at its own characteristic speed (after Holling, 2001).
6. **Cross-scale emergence.** Semantic change at any one scale is shaped by coupling with adjacent scales: fast, local innovation (release/reorganization phases) and slow, institutional memory (conservation phases) interact continuously, and it is this interaction — not either phase alone — that produces long-run semantic evolution.

4.2 A Formal Sketch

The six axioms can be summarized in a compact, deliberately informal notation:

$$S_{(t+1)} = C(R(S_t))$$

where S_t is the semantic state of a community of use at time t, R is the rewrite operation introducing new distinctions, and C is the (social, institutional) conservation operation that determines which of those distinctions are retained into S_{t+1}.

It should be stated plainly that this expression is a *notational summary* of the axioms above, not a derived or independently tested formal model. It borrows its shape from the URS's create/conserve logic by analogy; it has not been shown to make quantitative predictions, and doing so is identified in Section 7 as necessary future work rather than claimed here.

4.3 The Nested Hierarchy

The panarchy of meaning can be sketched as a layered hierarchy, in which each layer both depends on and partially constrains the layer below it:

```
Undifferentiated distinction
          ↓
        Symbol
          ↓
        Concept
          ↓
        Lexicon
          ↓
      Knowledge
          ↓
     Institution
          ↓
  Semantic Panarchy
  (the coupled whole)
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Movement up this hierarchy corresponds to conservation (Holling's "remember" function); movement down, or the injection of a genuinely new distinction at any level, corresponds to the create/release function that keeps the system from ossifying.

5. Reinterpreting the Common Lexicon

Within this framework, a Common Lexicon is neither a dictionary nor a governance artifact in the conventional sense. It is better understood as the *temporary stabilized memory* of a semantic panarchy — performing, in Holling's terms, a remember function that preserves working coherence without freezing future change.

Two practical implications follow directly, and both are testable claims rather than settled conclusions:

- A lexicon-governance process that only conserves (adds approved terms slowly, after committee review) but has no fast channel for local distinction-making will systematically lag behind the communities it is meant to serve — the definitional-lag problem of Section 3, now given a structural explanation.
- A lexicon-governance process that only creates (adopts new terms quickly, without any conservation filter) will fragment into local dialects that no longer support cross-scale coordination — the opposite failure mode, less commonly discussed in the Common Lexicon literature but equally predicted by the framework.

The practical design implication is that lexicon governance should be evaluated not by how comprehensive or authoritative its published glossary looks at a given moment, but by whether it has *working channels in both directions*: fast, low-friction mechanisms for local distinction-making, and slower, deliberate mechanisms for conserving the distinctions that prove durable.

6. Illustrative Case: AI Vocabulary Evolution

The rapid institutionalization of AI-related vocabulary since 2022 provides a useful, publicly observable illustration of the mechanism proposed here — offered as an illustrative case, not as validating evidence, since no systematic data collection has yet been performed against it. Terms coined in informal technical communities (*prompt engineering*, *hallucination*, *retrieval-augmented generation*, *AI agent*) moved within a few years into vendor documentation, then into enterprise governance policy, and in some jurisdictions into draft or enacted legislation. On the account developed here, this is the create/conserve cycle operating visibly and unusually fast: rapid distinction-making at the level of practitioner communities (a fast cycle), followed by selective conservation at increasingly slow, increasingly institutional levels. The framework would further predict that some terms coined in this same period will *not* survive conservation — a falsifiable prediction that could be checked retrospectively against, for example, changes in vendor documentation or standards-body vocabulary over a five-year window.

7. Epistemic Status and Evaluation Criteria

This paper is explicitly a *theoretical working paper*, in the sense that Academia.edu and similar venues use the term: an attempt to state a new conceptual framework clearly enough to be criticized and tested, not a claim that the framework has already been empirically validated. Three things follow from this.

First, the appropriate standard for judging it, at this stage, is not statistical significance or peer-reviewed replication — criteria that presuppose an empirical study this paper does not contain — but the standard Gigerenzer applies to heuristics: does the framework offer a simple, transparent rule that performs robustly across the kind of real-world variability lexicon-governance teams actually face, better than the more complex alternative (an exhaustively engineered, centrally governed vocabulary)? Section 5's two-channel design implication is offered in that spirit: a simple, ecologically testable rule, not a fitted statistical model.

Second, following Taleb's emphasis on track record over theoretical elegance, the framework's real test is whether its predictions — such as the lag and fragmentation failure modes named in Section 5, and the selective-survival prediction in Section 6 — hold up against retrospective and prospective organizational cases over time. A framework that cannot be shown to fail is not yet a useful one; Section 8 names the specific ways this one could fail.

Third, the formal expression in Section 4.2 is presented as notation, not as a fitted or independently derived model, and should not be read as more rigorous than it is.

8. Limitations

Several limitations should be stated directly, since a working paper that hides its weak points is less useful — not more — to a reader trying to build on it.

- **The physics analogy is structural, not derivational.** No formal mapping has been demonstrated between the URS's mathematical machinery and semantic change; what is borrowed is the create/conserve logic, applied by analogy.
- **The framework is not yet operationalized.** Unlike Walraven's COISA construct, which has a validated measurement scale (Walraven et al., 2021), Semantic Panarchy currently has no corresponding instrument. Developing one — for example, coding archival lexicon-revision histories for rate and source of new-term introduction versus rate of formal conservation — is a necessary next step, not yet undertaken.
- **The illustrative case is illustrative, not evidentiary.** Section 6 has not been tested against a dataset; it should be read as a plausibility example, not as support.
- **The six axioms are a first pass.** They have not been checked for independence, completeness, or minimality against competing accounts of semantic change (e.g., wider work in cognitive linguistics or terminology science, which is not engaged with here and should be in any fuller treatment).

9. Conclusion

A Common Lexicon is more usefully understood as the temporarily stabilized semantic memory of an adaptive system than as a controlled vocabulary to be designed once and then governed into permanence. Organizations do not create shared meaning outright; at best, they build the channels through which meaning can be continuously created, tested, and selectively conserved. Semantic Panarchy is offered as a first, explicitly provisional attempt to give that observation a shared vocabulary of its own — one connecting co-evolutionary IS alignment research, panarchy theory, and the create/conserve logic of universal rewrite systems. Its value will be settled not by the elegance of the synthesis but by whether its specific, falsifiable predictions — on definitional lag, scale mismatch, and selective term survival — hold up against real organizational and terminological histories.

Annotated Bibliography

Bateson, G. (1972). *Steps to an Ecology of Mind*. San Francisco: Chandler. Source of the definition of information as "a difference which makes a difference." Supplies the paper's Axiom 1 (Distinction) and the conceptual link between cybernetic epistemology and the create/conserve logic borrowed later from Rowlands and Diaz.

Diaz, B., & Rowlands, P. (2005). A computational path to the nilpotent Dirac equation. Related URS papers, e.g. *International Journal of Computing Anticipatory Systems*. Develops the computational realization of the universal rewrite system introduced in Rowlands & Diaz (2002), showing how the alphabet-generating rewrite procedure is applied algorithmically. Used here only for its structural create/conserve logic, not its physical content.

Gunderson, L. H., & Holling, C. S. (Eds.). (2002). *Panarchy: Understanding Transformations in Human and Natural Systems*. Washington, DC: Island Press. The book-length elaboration of panarchy theory referenced by Holling (2001); extends adaptive-cycle theory explicitly to social-

ecological and institutional systems, which is the bridge this paper leans on when extending panarchy from ecosystems to organizational vocabularies.

Holling, C. S. (2001). Understanding the complexity of economic, ecological, and social systems. *Ecosystems*, 4(5), 390–405. The paper's core structural source for Axiom 5 (Panarchy) and Axiom 6 (Cross-scale emergence). Establishes the four-phase adaptive cycle and the nested, cross-scale coupling ("creative and conserving") that Section 4 maps onto semantic evolution.

Rowlands, P. (2007). *Zero to Infinity: The Foundations of Physics*. Singapore: World Scientific. Book-length development of nilpotent quantum mechanics and the universal rewrite system; the primary reference work behind the URS formalism this paper draws on structurally in Section 2.3 and 4.2.

Rowlands, P., & Diaz, B. (2002). A universal alphabet and rewrite system. Presented work later formalized in subsequent papers (e.g. Diaz & Rowlands, 2005; Rowlands, 2007). The founding statement of the universal rewrite system (URS): an alphabet-generating rewrite procedure that conserves a "zero" element at every step while the alphabet itself expands. Source of the create/conserve logic imported by analogy into Axioms 2–3 of this paper.

Walraven, P. (2023). *Aligning through complexity: A co-evolutionary information systems alignment approach to address complex environments in the pursuit of business-IT alignment* (Doctoral dissertation). Open Universiteit, Heerlen. The dissertation synthesizing Walraven's COISA research program. Establishes that Business-IT alignment is a continuous co-evolutionary process rather than a designed end-state — the departure point for this paper's argument in Section 2.1.

Walraven, P., van de Wetering, R., Caniëls, M. C. J., & Versendaal, J. (2022). Leveraging IS in the complexity of healthcare: A combined NCA- and PLS-SEM analysis on the effects of co-evolutionary IS-alignment. Presented at ECIS 2022. Empirical test of COISA's effects using a combined necessary-condition-analysis and structural-equation approach in Dutch hospital settings; cited as evidence that COISA has moved from concept to empirically testable construct — a maturity level Semantic Panarchy has not yet reached (see Section 8).

Walraven, P., van de Wetering, R., Caniëls, M. C. J., Versendaal, J., & Helms, R. (2021). Capturing co-evolutionary information systems alignment: Conceptualization and scale development. *Proceedings of the 54th Hawaii International Conference on System Sciences (HICSS)*. Develops and validates a measurement scale for COISA. Used in Section 8 as the benchmark for what "operationalized" looks like, against which the present paper's lack of an instrument is flagged as a limitation.

Walraven, P., van de Wetering, R., Helms, R., & Caniëls, M. C. J. (2020). Aligning effectively: The case of Electronic Medical Records. *Proceedings of the 28th European Conference on Information Systems (ECIS)*. Empirical case study grounding COISA in hospital EMR implementation; part of the evidentiary base for Walraven's broader claim that alignment is achieved through continuous co-evolutionary interaction rather than one-time design.

Walraven, P., van de Wetering, R., Helms, R. W., Versendaal, J., & Caniëls, M. C. J. (2018). Co-evolutionary IS-alignment: A complex adaptive systems perspective. *Proceedings of the 12th Mediterranean Conference on Information Systems (MCIS)*. The founding conceptual paper introducing COISA as "the series of coevolutionary moves that makes IT aligned over time," built on Complex Adaptive Systems theory. The primary source for the CAS-based framing this paper extends from IS alignment to semantic evolution.

Walraven, P., van de Wetering, R., Versendaal, J., & Caniëls, M. C. J. (2019). Using a co-evolutionary IS-alignment approach to understand EMR implementations. *Proceedings of the 27th European Conference on Information Systems (ECIS)*. Further empirical application of COISA to Electronic Medical Record implementation, reinforcing healthcare as the primary empirical laboratory of Walraven's research program (Section 2.1).

This paper is offered as a theoretical working paper for critique, refinement, and empirical testing rather than as a finished or peer-reviewed result. Comments and counter-examples are explicitly invited.