Trust Architecture for Heterogeneous Cooperation

A Preliminary Discussion

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Abstract

Heterogeneous cooperation depends on arrangements whose participants may understand obligations differently, rely on different authorities, and possess unequal capacities to sustain or revise their involvement. This paper investigates the historical architecture connecting trust, interpretation, verification, maintenance, and reconfiguration. Its organizing problem is joint usability: supports that function separately can fail when combined, depend circularly on unavailable conditions, or become unusable during institutional change. The argument synthesizes earlier Generative Relational investigations of trust, formation, incomplete-trust cooperation, resources, and unequal revisability. It situates that synthesis within established research on international institutions, relational international theory, organizational trust, boundary objects, and polycentric governance. Trust remains differentiated from reliance, trustworthiness, legitimacy, and successful coordination. The philosophical analysis develops an account of accountable partial coordination without requiring comprehensive interpretive agreement. Several formal representations then isolate distinct aspects of the problem: history-bearing relational spacetimes; grounded support closure; local and joint compatibility; coherent operator families; and migration between architectures. A fixed-carrier connection field provides one restricted projection. A finite-group, rank-three field construction additionally permits combinatorial generation, with an explicit nonlinear interaction, coercive stabilization, gradient derivation, and homogeneous bifurcation analysis. These models establish conditional mathematical results rather than empirical social laws or ultimate ontology. Illustrative institutional configurations expose support dependence, transition burdens, and authority over revision. The contribution is a preliminary architectural synthesis and a set of inspectable analytical distinctions; its explanatory advantage over existing institutional approaches remains an open research question.

Keywords: trust architecture; heterogeneous cooperation; mediation; relational spacetime; group fields; operator algebra

Discussion Status

This paper is the sixth and final item in the present working-paper queue. It brings together questions clarified by five preceding discussions: near-critical trust relations; trust formation; cooperative reliability with incomplete trust; the resources required to maintain revisability; and unequal capacities for relational revisability. Those manuscripts remain separate working discussions. Their sequence supplies the problem organization of this paper, rather than independent evidence for its claims.

The phrase *trust architecture* is provisional. It names the historical organization of differentiated supports for cooperation, including their dependence on interpretation, maintenance, authority, and possible reconfiguration. It does not imply a single designer, complete visibility, a universally desirable increase in trust, or the discovery of a previously unrecognized institutional problem. Relevant antecedents already address distributed trust, mediation, institutional complexity, and the conditions of cooperation. The present contribution should be evaluated as a synthesis and focused formal investigation.

The manuscript is intended for public discussion and further knowledge development after author review. Definitions and propositions have different epistemic roles. Definitions specify this paper's analytical choices; mathematical propositions establish consequences inside stated models; philosophical arguments defend distinctions and interpretive commitments; institutional illustrations remain hypothetical. None of these should be read as empirical validation of GR as a whole.

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Notices

Status. This working draft is prepared for the author's review. It records an evolving research argument; definitions, section structure, and conclusions remain subject to revision. Completion of the draft does not imply publication, acceptance, or final author approval.

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Statement On The Use Of Language Models. The author selected the research problem, provisional working title, and paper queue and provided the exploratory discussion and corrections. OpenAI Codex assisted with source retrieval, conceptual analysis, formal reconstruction, drafting, computational examples, and technical checks. This completed working draft awaits the author's review; its new formulations and arguments have not yet received final author approval. Authorship credit remains with the human author. This disclosure should be reviewed before external circulation.

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1 Cooperative Architecture

This section establishes the paper's object and argumentative sequence. Its objective is to explain why cooperation supported by several apparently adequate arrangements can nevertheless become difficult to sustain or change. The method is conceptual: distinguish the functions involved, identify their relations of dependence, and specify the limits of the architectural perspective before formalizing any of them.

Participants rarely cooperate on the strength of a single judgment of another person's trustworthiness. A commitment may be intelligible because interpreters maintain a common vocabulary, actionable because an organization can allocate resources, credible because a record can be inspected, and tolerable because withdrawal remains possible. Each support has its own history. The record may depend on a technical platform; the platform on a supplier; the supplier on an authority whose decisions some participants contest. What appears to be a bilateral relation can therefore depend on relations that are neither bilateral nor equally accessible to the parties.

An architectural question begins when the arrangement of these supports matters to their practical operation. Several assurances can share one point of failure. An independent review procedure can depend financially on the institution it reviews. An interpretive compromise can remain usable while the parties disagree about its ultimate justification, yet cease to function when a registry changes its categories. The availability of a replacement institution does not establish that the old institution can be retired without interruption. These are problems of organization and transition, not simply of insufficient trust.

1.1 Architectural Organization

Definition 1.1 (Cooperative Architecture)**.** A cooperative architecture is a history-bearing organization of roles, practices, material supports, interpretive interfaces, and authorities through which differentiated participants can undertake, assess, maintain, contest, and revise cooperative activity.

Definition 1.1 is an analytical proposal. It collects no universal list of necessary institutions. A recurring informal practice may possess an architecture without a written constitution; an elaborate constitution may leave its operative dependencies unspecified. The term directs attention to relations among supports and to the ways those relations are reproduced. It does not confer legitimacy on an arrangement merely because the arrangement persists.

Its historical qualification is essential. An authority can acquire credibility through a sequence of restrained decisions; a formally identical authority installed by a coercive intervention can possess a different relational standing. Participants may carry commitments, injuries, accumulated competence, and memories of exclusion into an apparently new procedure. Architecture therefore concerns the organized continuation and transformation of histories, rather than only the simultaneous arrangement of components.

The primary question is whether an architecture supplies jointly usable possibilities for cooperation and correction. Joint usability is more demanding than the separate availability of its components. A complaint channel and a compensation fund do not together provide recourse if the channel's categories exclude every injury the fund is permitted to recognize. Conversely, cooperation can remain possible without agreement about all relevant meanings when a limited interface supports a sufficiently determinate undertaking. The unit of assessment must be appropriate to that undertaking, its affected participants, and its temporal requirements.

1.2 The Argumentative Commitments

The philosophical argument has three commitments. First, differentiated interpretation can be a durable condition of cooperation. A common world cannot simply be presupposed at the level at which the problem arises. Second, the conditions of continued participation require investigation alongside the reasons for initial agreement. An arrangement can satisfy a formation test while exhausting the resources

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needed to challenge its later operation. Third, the authority to revise supports belongs inside the object of analysis. Maintenance and modification are consequential social activities, not neutral services added after the substantive relationship has been settled.

These commitments do not demonstrate that every cooperation problem requires a GR treatment. Conventional institutional analysis may suffice when actors and shared criteria remain stable and enforcement is well specified. A GR reconstruction earns its additional complexity when the formation of actors, criteria, and relations of dependence is itself relevant to the failure being investigated. The appropriate comparison is explanatory and practical: which distinctions make otherwise obscured dependencies, transformations, or possibilities available for examination?

The argument proceeds from antecedent research and philosophical distinctions to conditional formal models. The models address support initiation, joint compatibility, coherent action, and institutional migration. A generative field representation then examines a nonlinear configuration problem while making its representational limits explicit. The final sections return to evidence, institutional examples, normative assessment, and objections. Mathematical tractability guides the selection of models; it does not determine the nature of the social objects they may eventually represent.

2 Antecedent Research

This section positions the architectural problem among established research programmes. Its purpose is to identify inherited insights and remaining analytical tasks. The review is organized by the problem each literature helps formulate; it does not treat terminological resemblance as agreement or attempt an exhaustive disciplinary history.

2.1 Organizational Trust Research

Accounts of trust differ over what is entrusted and what makes a trusting attitude distinctive. Jones emphasizes an affective orientation involving optimism about goodwill and competence; Hawley develops a commitment-based account that also distinguishes trust and distrust from their absence [24, 9]. These differences matter when an institution responds successfully to incentives while participants remain unwilling to credit its goodwill, or when a participant recognizes a commitment but disputes the motives supporting it. This paper does not resolve that disagreement by defining every dependable mechanism as trust.

Organizational research already makes trust consequential for the organization of activity. McEvily, Perrone, and Zaheer distinguish structuring and mobilizing pathways through which trust affects organizing and examine liabilities alongside benefits [29]. Lewicki, McAllister, and Bies develop a multidimensional treatment permitting trust and distrust to coexist [28]. These antecedents rule out a simple novelty claim for differentiated or organizationally effective trust. The architectural question concerns how such differentiation interacts with verification, interpretation, resource maintenance, and revision across connected arrangements.

O'Neill's account of intelligent accountability challenges an equation of increased information with increased trustworthiness or useful accountability [30]. Its relevance here is the demand for assessable evidence and the possibility that accountability procedures burden the work they are supposed to assess. An architectural analysis must therefore examine the production and usability of evidence rather than count reporting channels as independent improvements. This qualification applies especially when several channels reproduce the same unexamined classification.

2.2 Institutional Cooperation Research

International institutional research has long investigated cooperation without assuming general harmony or extensive prior trust. Keohane's functional account of regimes examines information and transaction costs. Axelrod and Keohane investigate cooperation within strategic and institutional contexts [25, 3].

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The present paper inherits the importance of arrangements that make cooperation possible under continuing conflict. It does not advance the discovery that institutions can support cooperation among parties who remain uncertain about one another.

The rational-design programme links institutional features to cooperation problems rather than treating those features as arbitrary decorations [26]. Fearon's analysis connects bargaining and enforcement, showing why favorable conditions for one aspect of cooperation need not simplify the other [8]. These approaches establish a demanding baseline: an architectural account should identify a dependence or transformation that matters beyond a general assertion that institutions are interconnected.

Compliance also admits competing explanations. Chayes and Chayes emphasize ambiguity, capacity, and temporal adjustment; Downs, Rocke, and Barsoom warn that high observed compliance can reflect limited cooperation and selection rather than effective enforcement of demanding commitments [5, 6]. Those positions are not interchangeable. Together they motivate distinguishing a supported undertaking from easy compliance, and a defective support from deliberate refusal. An architecture cannot be assessed from a single outcome indicator without reconstructing what was promised and what the arrangement made possible.

Centralization and independence provide established explanations of why states employ formal international organizations [1]. Reassurance and trustworthy signals have also been investigated in international relations [27]. Ruzicka and Wheeler's study of the Nuclear Non-Proliferation Treaty foregrounds trusting relationships within an institutional setting [33]. These contributions warrant neither a universal substitution thesis nor its reversal: institutional arrangements and interpersonal or interstate trust can condition one another, and the relevant relation must be established in each case.

2.3 Relational Political Theory

Constructivist and relational international theory challenge the assumption that the identities and interests entering cooperation can always be treated as externally fixed. Wendt examines their social constitution; Jackson and Nexon develop a process-relational approach; Qin places relations centrally in a relational theory of world politics [36, 23, 32]. Their projects differ in philosophical background and analytical ambition. GR should not absorb them into a common vocabulary at the cost of those differences. Their relevance is that the terms and participants of interaction can themselves require explanation.

Power likewise exceeds the direct imposition of one actor's preferred decision. Barnett and Duvall distinguish multiple forms of power in international politics [4]. Farrell and Newman investigate how positions in global networks can enable informational and exclusionary leverage [7]. An architectural account can use these insights to ask who controls indispensable supports, whose classifications structure access, and which apparent exit options retain dependence on the same infrastructure. Such questions do not establish that every dependency is domination. They specify where its possibility needs investigation.

2.4 Institutional Interface Research

Star and Griesemer examine boundary objects that support cooperation across social worlds. Such objects accommodate local uses while retaining sufficient shared identity for coordination [35]. This is a direct antecedent for partial interpretive interfaces. It also establishes a limit on the present claim: usable cooperation without comprehensive semantic agreement is an existing research problem with an established vocabulary. Here the additional question is whether several such interfaces remain compatible and revisable when combined.

Ostrom's polycentric analysis connects multiple scales of action, learning, and collective action while recognizing coordination difficulties [31]. Alter and Meunier examine how overlapping international regimes can generate political strategies and interaction effects; a map of overlap alone does not establish their causal importance [2]. These qualifications prevent a premature recommendation of decentralization or institutional multiplicity. Several centers can provide alternatives, but they can also impose incompatible requirements or draw on one constrained maintenance system. Star's infrastructure research directs attention to the work sustaining such arrangements [34].

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2.5 Prior GR Arguments

The author's earlier trust manuscript already investigates distributed trust, evidential narrowing, cross-scale mediation, and reconfiguration capacity [20]. The social-contract discussion develops partial interfaces and distinguishes formation, recognition, and coherence [19]. The diplomacy manuscript supplies a common-factor account of mediated coordination [13]. These are substantive antecedents, not vocabulary that can be relabeled as a new architecture. A common codomain by itself also does not show that any two local states express a common commitment: the selected states must satisfy the required matching condition.

The heterogeneous-dynamics and desire manuscripts supply the spacetime and field conventions used below [10, 22]. Related studies examine contextual constitution, potential, power, resources, temporality, and becoming [12, 16, 18, 14, 11, 15]. The recursive-power discussion further motivates investigation of the reproduction of support conditions [21]. These citations locate a programme of proposals. They do not imply that all those proposals possess the same evidential or formal standing.

The normative-relations manuscript warns that future objects and interpretive units can change, complicating recognition across histories [17]. The present synthesis carries that problem into architectural change. Its focused formal additions are a comparison of grounded and circular support, explicit joint-compatibility obstructions, a network formulation of coherent operators, and transition conditions separating safe endpoints from usable migration. The individual mathematical ingredients are elementary or standard within their selected representations. Their combination is offered for conceptual assessment, not as a demonstrated new mathematical theory or an established priority claim.

3 Historical Constitution

This section develops the historical meaning of architecture. It asks what is lost when actors, institutions, and their connections are represented only by their present observable attributes. The method compares histories that permit similar immediate actions while supporting different interpretations, obligations, and futures.

A participant is not exhausted by a current preference ordering or a position in an organizational chart. Past undertakings can remain operative after their initiating events disappear from view. Skills acquired through cooperation change what can subsequently be attempted. An injury can make an otherwise ordinary request difficult to accept. Institutions also carry histories: jurisdiction can be inherited, a category can preserve an earlier exclusion, and a routine can continue to function after its original justification has become obscure. These histories are constitutive when removing them changes the identity or practical significance of the relation being investigated.

The GR representation treats an object, where appropriate, as a history-bearing relational spacetime. This does not mean that every social description must contain a complete history or that a physical spacetime theory has been established. It means that temporal extension and relational constitution belong to the represented object, rather than appearing only as external parameters attached to a self-contained point. An organization can be investigated as a region of sustained activity whose boundary, participants, and powers are reproduced through interactions. A present organizational label is one projection of that history.

3.1 Relational Manifestation

The same manifestation can arise through materially different relations. Prompt compliance may express confidence, fear, exhaustion, strategic patience, or the absence of a usable alternative. An administrative record can describe each case as successful participation. The record is not necessarily false; it can accurately report a narrow event while failing to discriminate the histories that make the event significant. The architectural task is to identify which distinctions are necessary for the judgment being attempted.

Relational reality in this usage concerns the operative configuration of relations, dispositions, possibilities, and constraints through which manifestations become possible. Its invocation does not license

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access to an unobservable essence. Claims about it require evidence, reconstructive argument, and attention to alternative explanations. Where several histories fit the same record, uncertainty should remain visible. Increasing the quantity of records helps only if the additional observations discriminate relevant alternatives and arrive while action can still matter.

A support can accordingly remain visible after its efficacy has altered. A complaints office may retain its staff and formal mandate while losing access to the records required for a remedy. The office's continued existence is a manifestation; its capacity to connect recognition to action belongs to the larger configuration. The reverse is also possible: an informal practice can continue to provide meaningful recourse after its official description becomes inaccurate. Architecture directs inquiry toward those relations of practical connection.

3.2 Historical Continuity

Historical continuity does not require an unchanged list of components. A cooperative relation may persist through the replacement of a mediator, alteration of its vocabulary, and redistribution of maintenance work. Conversely, preserving the institution's name and personnel can accompany a substantial change in whose claims count. Identity judgments therefore depend on the feature whose continuity is at issue: legal succession, recognition by participants, preservation of obligations, or continuity of usable action.

The account should avoid two symmetrical mistakes. Treating every modification as the birth of an entirely new object prevents analysis of inherited responsibilities. Treating all modification as the evolution of a fixed object can conceal transformative exclusion. A disciplined reconstruction states what is being tracked and what would count as its failure to continue. Later migration models formalize particular preservation conditions without claiming to settle institutional identity in general.

Architecture also carries unrealized possibilities. A reserve interpreter, an unexercised right of appeal, and a maintained alternative supplier can affect conduct before they are used. Their practical existence depends on resources and recognition, not merely on their mention in a document. Some possibilities disappear quietly when skills atrophy or deadlines expire. The relevant history therefore includes the production and closure of actionable alternatives as well as the sequence of realized events.

4 Differentiated Trust

This section distinguishes the attitudes, capacities, and outcomes that an architectural analysis must keep separate. Its objective is to prevent an expanded vocabulary of support from collapsing into a single measure of trust. The distinctions remain compatible with disagreement among philosophical accounts of trust.

Reliance identifies a dependence of action on another event, practice, or participant. Trust adds an orientation toward another's conduct that is not exhausted by the prediction that the dependence will be satisfied. The precise additional element remains contested: goodwill, commitment, vulnerability, and normative expectation receive different emphases. Trustworthiness concerns whether the relevant trust is warranted; confidence can concern regularity without the same interpersonal or normative structure. Cooperation identifies activity with some coordination of contributions or purposes. None of these terms by itself establishes legitimacy.

An automated interlock can make a transaction reliable without becoming a trustee. Participants may trust the organization maintaining it, distrust its commercial operator's handling of personal information, and rely on a public authority to constrain that operator. Those attitudes can be differentiated by task, time, vulnerability, and beneficiary. A single scale would erase the question of what is entrusted and what remains deliberately restricted. The architecture should represent those distinctions before any aggregation is attempted.

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4.1 Appropriate Distrust

Distrust can be practically and ethically appropriate. A history of exploitation can justify narrow permissions, independent review, or a refusal to disclose. Those protections may support cooperation without requiring a favorable global judgment of the other participant. Treating them as transitional deficiencies on a universal path toward complete trust would prejudge the very relations being assessed.

Distrust does not automatically generate useful vigilance. It can reinforce its own expectations, narrow the interpretation of ambiguous events, or shift burdens onto already vulnerable participants. Earlier GR work examines such self-maintaining relational configurations; their existence is inherited background rather than the present paper's discovery. The architectural question is how a justified restriction can be maintained without rendering correction inaccessible. A restriction needs a domain, an evidential basis appropriate to that domain, and some account of who may contest its continued operation.

This argument does not require every participant to remain indefinitely available for repair. A party exposed to serious harm may have reason to withdraw. An architecture that preserves its own operation by making that withdrawal unintelligible or impossible can maintain cooperation in an administrative sense while undermining its normative justification. Continued participation is evidence of continued participation; its meaning depends on the available alternatives and their costs.

4.2 Support Substitution

Verification may substitute for a particular expectation about conduct. It also creates dependencies on measurement, record integrity, competent assessment, and enforceable response. The resulting configuration may require less trust in one actor while relying more heavily on others. This relocation is analytically different from the disappearance of trust. It is equally different from the assertion that all reliance ultimately reduces to trust.

Substitution is therefore a task-relative judgment. A deposit can reduce exposure to nonpayment while failing to address disclosure of sensitive knowledge. A second reviewer can improve independence if the reviewers do not share an undisclosed dependence that controls their judgments. A replacement must preserve the function relevant to the undertaking, and its own enabling conditions must be examined. Counting mechanisms without tracing those conditions can exaggerate redundancy.

The resulting philosophical position is modest. Cooperation does not require comprehensive trust, and arrangements that support it cannot be evaluated solely by their trust-producing effects. A defensible architecture may deliberately keep some vulnerabilities limited, some interpretations unsettled, and some relationships terminable. Its achievement consists in supporting appropriately bounded action and accountable revision, not maximizing a generalized trusting disposition.

5 Interpretive Interfaces

This section examines how participants can coordinate without a complete common interpretation. Its method separates partial matching from comprehensive translation and then asks what gives a partial interface practical authority. The objective is to preserve heterogeneity without treating every ambiguity as harmless.

An interface selects aspects of different practices that can be related for a particular undertaking. Two institutions may agree that a specified record counts as evidence of delivery while disagreeing about the wider obligations generated by the transaction. The interface does not reproduce either institution's entire normative world. It establishes a limited relation among expressions, procedures, and consequences. What is omitted remains significant when the undertaking extends beyond that limited relation.

Boundary-object research provides an important precedent for this account. GR adds no entitlement to replace its situated institutional analysis with a more abstract declaration of relationality. The value of a relational reconstruction would instead lie in showing how the interface is sustained, how its omissions matter during transformation, and whose activities maintain its usability. Translation is an achievement

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of practices and supports, not a property obtained by merely placing two descriptions in a common diagram.

5.1 Partial Agreement

Partial agreement differs from agreement about a vague totality. It can specify precisely what the parties undertake while leaving broader justifications open. Such precision can reduce pressure to assimilate participants to one authoritative worldview. It also permits disagreement to be located: a dispute about whether a record meets an agreed standard differs from a dispute about whether the standard still represents the relevant undertaking.

A common vocabulary does not itself establish matched interpretation. Two parties can use the same word while selecting different events as its instances. Even a shared formal codomain guarantees only that comparison can be expressed. The local states must satisfy the particular matching relation required for the action. This qualification is especially important when importing semiconjugacy or common-factor constructions from earlier GR work: the existence of maps into a shared object is insufficient to demonstrate agreement between arbitrary inputs.

An interface can also function without equal endorsement. A participant may accept its operational categories because refusal would forfeit access to essential services. The arrangement may produce coordinated behavior while leaving its authority contested. A successful translation test must therefore be distinguished from a legitimacy test. Questions about consent, necessity, representation, and distribution cannot be answered by the mathematical existence of a matching relation.

5.2 Interpretive Revision

Interpretive change creates an additional difficulty. A record that once carried a limited commitment can acquire a broader meaning when linked to a new database or regulatory category. Participants may continue using the record without recognizing the shift. The support now depends on an interpretive history extending beyond the immediate interaction. The architecture should disclose which mappings changed, who authorized the change, and which undertakings were affected.

Recognition can arrive after the practical possibility of correction has disappeared. Discovering that a category misrepresented a participant may not restore a lost opportunity or recover disclosed information. This temporal feature connects interpretive adequacy to the preservation of meaningful alternatives. More accurate retrospective description is valuable, but it cannot be assumed to repair every consequence of earlier misrecognition.

An accountable interface therefore requires some capacity to mark contested translations, preserve relevant records, and suspend consequential extension while revision remains possible. The necessary capacities vary with the stakes and reversibility of the undertaking. No universal right to indefinite delay follows. The next sections examine how these capacities depend on other supports and how their maintenance distributes burdens.

6 Support Dependencies

This section identifies what makes a collection of supports an architecture. Its objective is to distinguish the availability of each component from the conditions of their joint operation. The method reconstructs a support through the undertaking it enables and the further supports on which that enabling capacity depends.

A certification procedure can depend on access to records, competent interpretation, protected deliberation, and the authority to make a decision consequential. The certificate is the visible output of those dependencies. If the same administrative office controls the records and the interpretation, adding a second signature need not create independent assurance. An architecture can multiply visible confirmations while retaining a single effective point of control.

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Dependence is not always a defect. Specialization requires participants to rely on capacities they do not each possess. A common registry can reduce incompatible descriptions and unnecessary duplication. The question is whether the dependence is appropriate to the undertaking, sufficiently understood, and accompanied by workable responses to failure. Demanding universal independence would eliminate many useful cooperative arrangements while obscuring the narrower dependencies that deserve attention.

6.1 Circular Support

Some support relations are circular. An institution's records can sustain confidence in its authority, while that authority gives the records their recognized status. Such a cycle may be historically stable and practically useful. Circularity alone does not prove viciousness. The relevant question is which kind of sufficiency is being claimed: logical consistency, continued reproduction, initiation, or justification.

A mutually supporting arrangement can continue once established while lacking a route to establishment from currently available conditions. Two institutions might each require certification by the other before accepting responsibility. If neither can issue an initial certificate, their mutual willingness does not initiate cooperation. Historical bootstrapping, temporary guarantees, or bounded exposure may supply the missing route. Those mechanisms belong to the formation problem already investigated in the second paper of this sequence.

The distinction also matters epistemically. A system can reproduce its own endorsements without producing independent reason to believe its claims. Conversely, a practice can be well justified but materially unavailable. The finite support model below represents declared practical prerequisites. It must not be used to infer ultimate foundations for knowledge or to identify historical availability with normative warrant.

6.2 Joint Usability

Joint usability can fail even when every interface passes a local test. One agency may accept a community's naming practice, a second may accept the first agency's identifiers, and a third may require an identification rule that cannot be reconciled around the entire cycle. Each bilateral agreement can be meaningful in isolation. Their conjunction can leave no possible record that satisfies all three.

This failure is not resolved by increasing the goodwill of the parties. The constraints themselves require revision, or the scope of the undertaking must change. Nor does it prove that heterogeneity should be eliminated. The incompatible requirements may arise precisely because one interface imposes a uniformity that another protects participants against. The point of the analysis is to identify the obstruction and the authority needed to address it.

An architectural assessment should therefore distinguish redundancy, complementarity, and conflict. Redundancy requires sufficiently independent ways to sustain a function. Complementarity concerns supports that jointly enable what neither supplies alone. Conflict concerns combinations that exclude required actions or states. A single institutional component can participate in all three relations at different scales. Those relations cannot be read directly from a list of its formal responsibilities.

7 Formation Trajectories

This section connects architectural organization to the emergence of cooperation. Its objective is to show how support histories can change what participants are able to undertake without assuming a stock of trust that must already be sufficient. The argument develops formation as a sequence of bounded, revisable exposures whose significance depends on their interpretation and distribution.

At the beginning of a relationship, participants may lack shared history, established interpretive routines, and credible expectations about response to difficulty. A small cooperative undertaking can generate evidence and practical competence. It can also generate obligations and dependencies that make

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subsequent refusal more costly. Formation is therefore neither a simple accumulation of positive observations nor a harmless preliminary stage before the real relationship begins.

An initial arrangement can deliberately limit what is entrusted. Participants may use separate custody, short commitments, reversible actions, or a mediator recognized only for a narrow task. These provisions can make learning possible while keeping a mistaken expectation from determining the entire future of the relationship. Their value depends on whether the promised limitations actually bind the parties who can impose loss.

7.1 Historical Learning

Successful interaction supplies evidence under particular conditions. If cooperation succeeds because a mediator closely supervises every step, the episode does not by itself establish that the same conduct will occur without supervision. If a weak participant consistently fulfills commitments because refusal is prohibitively costly, compliance supplies limited evidence of freely sustained confidence. Learning requires identifying which configuration produced the result.

Interpretation also changes through participation. Actors can learn what another party treats as a promise, what counts as timely correction, and which apparently minor acts carry historical significance. This learning may revise the original categories used to describe the interaction. A formation model with fixed observation rules can represent one stage of that process, but it cannot silently stand for the whole process.

The architecture develops when provisional supports become linked to longer commitments. A mediator's temporary role may become indispensable because no participant develops the competence to replace it. A temporary registry can become the sole source of recognized history. These developments may be beneficial, but they change the conditions of exit and revision. Formation should therefore include periodic examination of dependencies created by the very measures that made initial cooperation safe.

7.2 Distributed Exposure

Bounded exposure is a relational property. A pilot arrangement that limits the sponsor's financial loss can leave another participant facing permanent disclosure, reputational damage, or unpaid maintenance work. The relevant bounds must be specified by bearer and type of consequence. An aggregate statement that an experiment is small can conceal a large exposure for a participant with fewer alternatives.

This observation connects initiation to the later architecture of authority. Participants who fund the initial support may acquire control over its categories, records, or continuation. The resulting dependence need not be illegitimate, but the initial contribution alone does not settle the scope of that control. A defensible formation trajectory makes the transition from temporary assistance to continuing authority available for examination.

The synthesis consequently treats trust formation as one architectural process among others. It can create capacities for cooperation, but it can also narrow alternatives and stabilize asymmetries. The appropriate evaluation asks what participants learn, what they become able to do, which dependencies they acquire, and whether the arrangement preserves a practical route to contesting its own continuation.

8 Distributed Governance

This section examines authority within architectures whose supports are distributed across institutions. Its aim is to separate useful plurality from an assumption that decentralization supplies accountability automatically. The method identifies decisions about standards, access, interpretation, maintenance, and revision that continue to require authorization even when no single center controls the whole arrangement.

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Distributed governance can make cooperation possible among participants who reject a common superior authority. Local institutions may retain different standards while recognizing a narrow class of each other's decisions. Multiple centers can provide opportunities for learning and recourse. They can also generate inconsistent demands, opportunities for selective forum use, or uncertainty about who must act when an undertaking fails. The existence of several centers describes an arrangement; it does not establish the quality of their relations.

A participant's ability to move between institutions depends on practical access. If every recognized route requires the same identity credential, funding source, or technical intermediary, formal plurality can coexist with concentrated control. Conversely, a centralized service can support meaningful autonomy when its authority is limited, reviewable, and accompanied by usable alternatives. Architecture is concerned with the organization of those dependencies, not with an unconditional preference for either centralization or dispersal.

8.1 Interface Authority

Control over an interface can matter more than control over an individual decision. An institution that defines admissible evidence shapes which claims can become decisions at all. An operator that changes a technical standard can impose adaptation costs on every connected participant. An authority that determines when a record has become obsolete can erase the practical value of another participant's accumulated history.

These powers may remain partially invisible because they appear as maintenance. Yet maintaining a system always involves choices about what it will continue to recognize. The relevant normative question is whether those choices are answerable to the participants and affected persons whose possibilities they alter. Answerability requires more than the publication of a change log if the affected persons cannot understand its consequences or obtain a timely response.

This does not imply that every local modification requires universal consent. Such a requirement could disable the arrangement and privilege those able to delay. It implies that the scope of unilateral authority should be related to the scope and reversibility of its effects. Routine changes with bounded consequences can be delegated; changes that redefine obligations, eligibility, or exit may demand a different procedure. The allocation must remain contestable rather than being justified solely by the fact that the current operator can implement it.

8.2 Affected Outsiders

An architecture can sustain mutual benefits among its participants while transferring costs to others. A verification arrangement may collect information about nonparticipants; a supply agreement may displace risks onto workers excluded from its governance; a stable institutional bargain may close options for future entrants. Internal compatibility cannot answer these objections. The boundary of formal membership and the boundary of relevant effects can differ.

The architectural perspective therefore requires a declared normative constituency. This paper adopts an orientation toward the agency of participants and materially affected persons, while recognizing that the specification of affectedness remains disputable. The orientation supports examining exclusions, burdens, and opportunities for recourse. It does not furnish a complete distributive theory or prove that every conflict can be settled through better institutional design.

Some conflicts concern incompatible ends rather than defective coordination. An architecture can make their terms clearer and preserve bounded ways to act, but it cannot promise reconciliation. The capacity to suspend or terminate cooperation may be part of its defensibility. An institution whose only permitted response to fundamental disagreement is intensified participation has already settled a substantive normative question through its architecture.

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9 Maintenance Burdens

This section examines the work required to keep supports available. Its purpose is to connect aggregate maintenance capacity with unequal burden incidence without turning every burden into a single scalar resource. The argument inherits the resource and unequal-revisability questions of the preceding two papers and asks how they constrain an integrated architecture.

Records must be preserved, procedures learned, disputes interpreted, interfaces updated, and alternatives maintained. Some of this work is visible in budgets; some appears as waiting, repeated explanation, emotional strain, or the opportunity cost of remaining available. A procedure can be formally open while imposing demands that only well-resourced participants can meet. Its actual accessibility depends on the relation between its requirements and the capacities of particular bearers.

The possibility of revision is especially dependent on maintenance. An appeal right may require preserved evidence, an available representative, a competent reviewer, and a decision before an irreversible event. Each element can disappear separately. Describing the right as intact because its legal text remains unchanged mistakes a nominal permission for a usable possibility.

9.1 Burden Transfer

An actor can preserve its own flexibility by requiring others to absorb uncertainty. A purchaser may reserve the right to alter specifications while suppliers maintain idle capacity. A governing body may defer a decision while applicants repeatedly update their records. A platform may preserve several technical options while small participants bear the cost of compatibility with all of them. Aggregate optionality can increase even as particular participants lose meaningful choices.

The relevant question is not whether flexibility has a cost in the abstract. It is which actor can require its preservation, which actor performs the necessary work, and which actor captures the benefit. These relations connect revisability to power. They also show why a universal instruction to keep all alternatives open can be normatively careless. Closure can reduce burdens and make an undertaking possible; its justification depends on how closure is decided and what it forecloses.

No single metric is assumed for these costs. Financial expense, time, exposure, and loss of standing may be only partially comparable. A formal resource vector can record selected demands without establishing a universal exchange rate among them. Where comparison is required for a decision, the procedure and its exclusions need justification. Numerical convenience is insufficient.

9.2 Sustainable Correction

A correction process can undermine its own supporting activity if its requirements consume the capacity needed to respond. Excessive reporting can displace service provision; repeated reassessment can prevent participants from developing a stable practice; maintaining unused alternatives can exhaust those expected to preserve them. These possibilities do not discredit accountability. They require an account of its material organization.

A sustainable architecture distinguishes ordinary maintenance, exceptional repair, and transformative revision. Their resource and authority requirements can differ. It should also identify who can declare an exception and whether temporary burdens become permanent without review. A procedure that repeatedly relies on unpaid emergency effort has incorporated that effort into its effective design, even if its official description omits it.

The synthesis therefore cannot conclude that more revision capacity is always better. Its defensible aim is proportionate, distributed, practically effective revisability. The relevant standards depend on the stakes of error, the reversibility of action, the availability of alternatives, and the burdens of preserving them. These judgments remain political and ethical even when parts of the resource problem can be formally represented.

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10 Temporal Reconfiguration

This section distinguishes the adequacy of an architecture from the adequacy of a transition between architectures. Its objective is to make temporal continuity an explicit object of assessment. The argument identifies recognition, authorization, implementation, and recovery as processes whose relative timing matters without presupposing a justified common clock for social interpretation.

A new arrangement can improve every assessed function once installed and still produce a harmful transition. Existing records may become unreadable before conversion is complete. The outgoing mediator may lose authority before the incoming institution is recognized. Participants can be required to comply with new categories before they understand which of their prior undertakings those categories alter. The endpoint comparison omits these intermediate conditions.

This gap is especially serious when the architecture being replaced supports the replacement itself. A registry may authorize the identities required to enter the successor registry. A review body may be needed to assess the transfer of its own jurisdiction. A maintenance team may have to sustain two systems while its budget is reduced in anticipation of savings. Reconfiguration depends on capacities that a plan can inadvertently remove before their transitional work is complete.

10.1 Timely Recognition

Recognition is timely when it can inform a relevant action while that action remains possible. This is a qualitative relation among processes, not a universal duration. A delayed interpretation may be adequate for a reversible classification and inadequate for an irreversible disclosure. The same period of deliberation can preserve judgment in one setting and exhaust another participant's options in another.

Earlier discussions of near-critical trust emphasize that relational transformation can outpace practical recognition. That possibility remains relevant here, but the title does not invoke criticality. Ordinary institutional change can produce the transition failures being analyzed. A stronger criticality claim would require an independently specified mechanism and evidence distinguishing it from rapid change, uncertainty, or crisis. The nonlinear model developed below supplies model-specific bifurcations; it does not supply that empirical identification.

Correction also has several temporal meanings. Revising a description, reversing a decision, restoring a capacity, and repairing an injury are distinct acts. Success in one does not entail success in the others. An architecture can acknowledge an error while leaving its consequences intact. The practical question is what remains alterable at the time of acknowledgment and which supports can connect acknowledgment to remedy.

10.2 Transitional Responsibility

Responsibility for migration cannot be assigned only to the actors who operate the completed replacement. Those who choose the sequence, withdraw resources, or redefine recognition can shape transitional exposure. The arrangement should identify who can halt a harmful transition, how outstanding commitments remain actionable, and which participants bear the cost of temporary duplication.

Preservation is nevertheless selective. Some inherited capacities should be discontinued, including capacities that enable exclusion or abuse. A requirement that every old operation survive would privilege the existing order. Migration analysis therefore begins by declaring what merits preservation and why. Formal intertwining conditions can then test that selected requirement; they cannot choose it on behalf of the participants.

The following models turn these distinctions into separate questions. Support closure investigates practical initiation. Constraint compatibility examines possible joint configurations. Operator families investigate coherent action across reversible interfaces. Migration examines preservation and intermediate reachability. Field models examine configuration dynamics and generative composition. Their separation is deliberate: solving one problem does not establish that the others have been solved.

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11 Relational Spacetime Representations

This section specifies the primitive representation inherited from earlier GR manuscripts. Its purpose is to keep the later models connected to history-bearing objects while preventing a change of incidence convention from silently changing their interpretation. The construction is representational; physical spacetime, quantum gravity, and a universal social ontology are not inferred.

A finite boundary is specified by a set P of elements, a set C of couplings, and an incidence map $\iota : C \to \mathcal{P}(P)$, where $\mathcal{P}(P)$ denotes the power set. Each coupling contains at least two elements; each element participates in at least one coupling. For the graph-representable sector, each element participates in at most two couplings. A boundary graph therefore represents couplings by vertices and elements by edges or half-edges. This is the convention of the earlier heterogeneous-dynamics manuscript [10]; reversing it would produce a different representation.

A history extends a boundary through a two-complex $F = (V, E, \Phi)$. Its vertices V represent events, edges E represent coupling histories, and faces Φ represent element histories. Incidence and attaching data specify how they meet. Labels can represent selected roles, records, obligations, or interpretive conditions. A partial occurrence order can be supplied when needed; it is additional data and must be acyclic if it is to represent the assumed precedence relation. Combinatorial incidence by itself is not a causal ordering.

11.1 History-Bearing Regions

A participant is ordinarily represented by an appropriate region $W_i(h)$ of a labelled history h, where i indexes the participant under investigation. Such a region can include many events and overlapping relations. It need not correspond to a single vertex, and its identity need not remain constant under every re-description. A public institution, for example, can involve intersecting histories of authorization, personnel, records, and service provision. Which region is relevant depends on the question.

Let $\mathfrak{H}$ denote a declared class of labelled histories and let $\mathcal{Q}$ denote a selected space of architectural descriptions. An observation or abstraction map is a function $q : \mathfrak{H} \to \mathcal{Q}$. Its fibres collect histories represented alike. Before using q to assess a property, one must ask whether that property is preserved by the identification. A graph of support dependencies can be an effective projection while discarding the history through which the dependencies became authoritative.

The interface graph used below belongs to $\mathcal{Q}$. Its vertices represent local interface descriptions, not the coupling vertices of the primitive boundary graph. Its edges represent selected matching relations, not automatically the coupling histories of F. Keeping these levels separate prevents a convenient network notation from replacing the GR object without acknowledgment. A projection should state what its vertices and edges mean and what historical distinctions it omits.

11.2 Historical Composition

Histories can be composed along compatible boundaries only after declaring a boundary identification that preserves the selected incidence and labels. Fresh identifiers away from the seam prevent unintended identification of unrelated elements. Composability therefore involves more than drawing two diagrams next to one another. An institutional translation between differently labelled boundaries requires additional data; it is not supplied by an incidence isomorphism alone.

Spin-foam instantiations may enrich an appropriate two-complex with group representations, intertwiners, amplitudes, and specified summation rules. These additions are optional. A general social history is not thereby a physical spin foam, and the existence of a two-complex representation does not establish the physical significance of its labels. The group-field model in Section 17 supplies one finite mathematical generator of stranded combinatorial structures, following the direction of earlier GR field proposals [22].

The gain from this primitive layer is disciplined scope. Later algebraic and dynamical objects can represent selected relations within or among historical regions. Their results apply to those representations

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under stated assumptions. Recovering a claim about actual participants requires a justified interpretation of the projection, evidence about its adequacy, and an account of distinctions that the projection leaves unresolved.

12 Grounded Support Closure

This section formalizes the difference between a support configuration that is internally self-maintaining and one that can be assembled from currently available supports. The model is finite and qualitative. It represents declared prerequisites, not degrees of trust or a foundational theory of justification.

Let D be a finite vocabulary of support capabilities. A member might denote an accessible record, a recognized review authority, or a funded translation function at the chosen level of description. Let $S_0 \subseteq D$ contain the capabilities treated as initially available. Let $\mathcal{K} \subseteq \mathcal{P}(D) \times D$ be a finite collection of clauses. A clause (A, b) says that the simultaneous availability of every member of A enables b, within the scope of the model. It says nothing about costs unless costs have already been incorporated into the meanings of these capabilities.

The closure operator is defined by the following iteration.

$$T(S) = S_0 \cup S \cup \{b : (A, b) \in \mathcal{K},\ A \subseteq S\}, \qquad S_{n+1} = T(S_n). \tag{1}$$

Equation (1) assumes that obtaining an additional support does not disable an existing one. This monotonicity is a substantial restriction. Rival resource use, expiry, and destructive actions require an extended state model.

Proposition 12.1 (Finite Grounded Closure)**.** *The iteration in Equation* (1) *stabilizes after at most* $|D|$ *strict inclusions. Its terminal set* S_* *is the least fixed point of* T*.*

Proof. If $S \subseteq S'$, every clause whose premises lie in S also has its premises in S', so $T(S) \subseteq T(S')$. The sequence is increasing because $S \subseteq T(S)$. Each strict inclusion adds at least one member of the finite set D, proving termination. Every fixed point Q contains S_0. If $S_n \subseteq Q$, monotonicity gives $S_{n+1} \subseteq T(Q) = Q$. Induction yields $S_* \subseteq Q$, proving leastness. □

Proposition 12.1 gives a precise meaning to grounded availability relative to declared starting conditions. It does not assert that S_0 is historically unconditioned. Its members can themselves have complex histories whose availability is taken as given for this particular analysis.

Consider $D = \{a, b\}$, with clauses $(\{a\}, b)$ and $(\{b\}, a)$. If S_0 is empty, the iteration remains empty, although $\{a, b\}$ is also a fixed point. If a is initially available, the iteration reaches $\{a, b\}$. The same mutually sustaining organization thus admits different initiation outcomes depending on its historical boundary conditions.

A circular institutional arrangement can consequently be coherent, reproducible once established, and unavailable from the present starting position. Describing it as an attractor-like configuration does not answer the formation question. Conversely, a temporary support can initiate a configuration without remaining part of its later reproduction. These are conceptual distinctions already motivated by trust-formation work; the closure construction makes their logical independence inspectable.

The model also exposes a danger of overly generous clauses. If an analyst writes that a procedure is available whenever an authority recognizes it, while omitting the staff and records required to operate it, closure can certify a nominal rather than usable support. The formal result remains correct for the written clauses. Its practical conclusion fails because the representation omitted a prerequisite. Validation must therefore examine the clauses and their provenance, not merely execute the iteration.

13 Joint Compatibility

This section investigates whether locally usable interfaces can be realized together. Its finite constraint representation isolates an obstruction that the support-closure model does not express. The purpose is diagnostic: expose the difference between passing bilateral tests and admitting a joint configuration.

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Let $\mathcal{G} = (J, \mathcal{E})$ be a finite undirected graph. Each vertex $j \in J$ has a finite nonempty set X_j of admissible local descriptions. An oriented version $e : u \to v$ of each edge carries a relation $R_e \subseteq X_u \times X_v$; reversing its orientation transposes the relation. A globally compatible tuple belongs to the following set.

$$\mathcal{C} = \left\{ (x_j)_{j \in J} \in \prod_{j \in J} X_j : (x_u, x_v) \in R_e \text{ for every } e : u \to v \right\}. \tag{2}$$

Equation (2) is an ordinary constraint representation. The sets might describe admissible record formats or declared versions of a procedure; they do not stand for complete social worlds.

An edge is arc-consistent in both directions when every value at either endpoint has at least one compatible value at the other. This is stronger than requiring R_e to be nonempty. It remains weaker than general joint compatibility on a graph containing cycles.

Proposition 13.1 (Tree Extension)**.** *If $\mathcal{G}$ is a finite tree and every edge is arc-consistent in both directions, every choice of value at a chosen root extends to an element of $\mathcal{C}$.*

Proof. Orient the tree away from the chosen root and assign its selected value. For each child, arc consistency supplies a value compatible with its already assigned parent. Continue by distance from the root. A child has only one parent, and a tree has no additional edges between assigned branches that could introduce another constraint. The procedure terminates and satisfies every edge relation. □

Proposition 13.1 depends on the absence of cycles and on unrestricted selection of the supplied compatible values. It does not apply when a shared resource couples choices that the graph omits.

A three-vertex cycle gives a minimal counterexample to extending this result without qualification. Let every $X_j = \{0, 1\}$. Require equality on edges 0–1 and 1–2, and inequality on 2–0. Every local value has a compatible neighbor on each edge. The first two constraints imply $x_0 = x_2$, contradicting the third. Thus $\mathcal{C}$ is empty despite bilateral arc consistency.

The example does not identify disagreement itself as pathological. A mismatch can reveal that a requirement should be revised rather than that participants should become alike. Nor does the example imply that trees are generally preferable institutional designs. Cycles can provide redundancy and mutual oversight. They require checking joint conditions that local tests alone cannot settle.

The philosophical implication is that negotiated interfaces acquire consequences through composition. A participant can accept each bilateral obligation without having a feasible way to satisfy their conjunction. Responsibility for the resulting failure cannot be allocated adequately by inspecting one relation at a time. An architecture should make the composite requirement visible and identify who can revise it.

The representation also suggests an empirical discipline. Investigators should document the actual admissible sets and matching rules rather than choose them merely to obtain an inconsistency. An empty $\mathcal{C}$ can indicate a real institutional obstruction, an overly restrictive model, or missing practices that enable exceptions. Distinguishing these possibilities requires inquiry into how participants actually resolve contested cases.

14 Coherent Operator Families

This section develops a reversible linear sector of interface compatibility and action. It distinguishes the existence of compatible state assignments from the existence of operations expressed coherently across interfaces. The algebraic model is one possible representation, not a claim that persons, meanings, or trust are quantum states.

Let $\mathcal{G}$ now be connected. Associate a complex Hilbert space $\mathcal{H}_j \cong \mathbb{C}^d$ with each vertex. For each oriented edge $e : u \to v$, let $U_e : \mathcal{H}_u \to \mathcal{H}_v$ be unitary, with $U_{\bar{e}} = U_e^\dagger$. Unitarity imposes reversible, norm-preserving translation in the selected representation. Real interfaces can be partial, lossy, or unequal in dimension; the present results do not cover them automatically.

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Choose a root r and a spanning tree. The ordered product along the tree path from r to j defines a unitary $P_j : \mathcal{H}_r \to \mathcal{H}_j$, with $P_r = I$. For each edge outside the tree, define its loop operator and the common fixed space.

$$H_e = P_v^\dagger U_e P_u, \qquad \mathcal{F} = \bigcap_{e \notin \text{tree}} \ker(H_e - I). \tag{3}$$

Equation (3) compares the two routes from the root to the endpoint v. The operator records their possible mismatch.

Proposition 14.1 (Compatible Sections)**.** *The assignments $f_j \in \mathcal{H}_j$ satisfying $f_v = U_e f_u$ on every edge are precisely the assignments $f_j = P_j x$ with $x \in \mathcal{F}$.*

Proof. Compatibility on tree edges determines every f_j uniquely from $x = f_r$ as $P_j x$. On an edge outside the tree, the remaining equation is $P_v x = U_e P_u x$. Multiplying by $P_v^\dagger$ makes it $x = H_e x$. These conditions are exactly membership in $\mathcal{F}$. Conversely, a member of $\mathcal{F}$ gives all the required equations by the same computation. □

Proposition 14.1 converts a network compatibility question into a common fixed-space question. It does not establish a shared interpretation of actual actors without a justified meaning for the vectors and transports.

14.1 The Coherent Algebra

An operator family consists of linear maps $A_j : \mathcal{H}_j \to \mathcal{H}_j$. Define coherence by compatibility of acting before or after transport.

$$A_v U_e = U_e A_u, \qquad \mathcal{A}_{\text{coh}} \cong \{A \in \text{End}(\mathcal{H}_r) : A H_e = H_e A \text{ for all } e\}. \tag{4}$$

The isomorphism asserted in Equation (4) is justified by the next proposition.

Proposition 14.2 (Loop Commutant)**.** *Coherent operator families form a unital finite-dimensional star algebra. Evaluation at the root identifies it with the commutant of the loop operators.*

Proof. Tree coherence forces $A_j = P_j A_r P_j^\dagger$. Substitution on a remaining edge gives $A_r H_e = H_e A_r$. Conversely, these commutation equations reconstruct a coherent family. The commutant is closed under sums, products, scalar multiples, and contains the identity. If A commutes with a unitary H, it also commutes with H^{-1}; taking adjoints of the latter identity shows that $A^\dagger$ commutes with H. Thus it is closed under adjoints. Finite dimensionality supplies norm closure. □

Proposition 14.2 concerns coherent expression, not executable authority. A participant's permitted operation set $\mathcal{O}_j$ may be a proper subset of $\text{End}(\mathcal{H}_j)$. It need not be closed under arbitrary linear combinations or adjoints. An algebraic operation that preserves coherence can still be institutionally forbidden, materially unavailable, or normatively objectionable.

Compatible states and coherent operations also differ. If a loop operator is $e^{i\theta} I$ with $\theta \notin 2\pi\mathbb{Z}$, its fixed space is zero while its commutant is the entire matrix algebra. Thus nontrivial coherent operations do not guarantee a nonzero compatible vector. The example blocks an inference from algebraic coherence to a common state or judgment.

14.2 Operator Coordinates

A change of orthonormal coordinates V_j replaces U_e by $V_v U_e V_u^\dagger$ and P_j by $V_j P_j V_r^\dagger$. The corresponding loop operator is $V_r H_e V_r^\dagger$. Common fixed-space dimension and commutant structure are therefore invariant under these coordinate changes. This is a mathematical covariance statement within the model. It does not prove that a socially consequential reinterpretation is a mere change of coordinates.

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The distinction is important for heterogeneous cooperation. A new description can preserve the selected algebra while changing which people are recognized or which harms become reportable. Such a change alters the interpretation of the representation and requires independent assessment. Algebraic invariance is informative only after the correspondence between old and new meanings has been justified.

15 Architectural Migration

This section examines preservation during a change of architecture. It separates a map relating completed representations from a feasible sequence of institutional operations. The first issue admits an intertwining condition; the second requires an explicit transition model.

Consider old and new reversible interface systems on the same graph, with spaces $\mathcal{H}_j, \mathcal{H}'_j$ and transports U_e, U'_e. Let $V_j : \mathcal{H}_j \to \mathcal{H}'_j$ be isometries, allowing the new local space to have a larger dimension. A migration respects transport when the following squares commute.

$$U'_e V_u = V_v U_e \qquad (e : u \to v). \tag{5}$$

Equation (5) states a preservation condition for the selected representation. It does not require all old institutional powers to survive.

Proposition 15.1 (Compatibility Preservation)**.** *A family satisfying Equation* (5) *sends every old compatible section to a new compatible section by $f'_j = V_j f_j$. Compositions of such migration families also preserve compatibility.*

Proof. If $f_v = U_e f_u$, then $U'_e f'_u = U'_e V_u f_u = V_v U_e f_u = V_v f_v = f'_v$. For a second migration W_j into a third system, substitution gives $U''_e W_u V_u = W_v U'_e V_u = W_v V_v U_e$. This is the same condition for the composite. □

Proposition 15.1 is a conditional preservation result. Preserving selected operations additionally requires $A'_j V_j = V_j A_j$, with explicit old and new admissibility conditions. Preserving observables or remedies may require further conditions. Earlier incomplete-trust work already employs capacity-preserving intertwiners; the present use extends that concern to an interconnected family.

15.1 Migration Paths

Safe endpoints can lack a safe transition. Consider two coupled offices whose versions are $x, y \in \{0, 1\}$. Suppose an interface works exactly when $x = y$, and an elementary update changes one office at a time. Both $(0, 0)$ and $(1, 1)$ are compatible. Every first step from $(0, 0)$ toward $(1, 1)$ enters either $(1, 0)$ or $(0, 1)$, which is incompatible. No sequence of individually permitted one-office updates remains compatible throughout.

This counterexample is elementary but decisive for the inference it addresses. An endpoint correspondence, including a perfectly valid migration map, does not establish an implementation path. A simultaneous update would alter the permitted transition set. A bridge version $*$ that communicates with both versions would alter the state space and compatibility relation. Either can provide a path, but each requires additional capacities and authority.

For example, if $*$ is compatible with 0, 1, and itself, the sequence $(0, 0)$, $(*, 0)$, $(*, 1)$, $(1, 1)$ maintains compatibility through one-office changes. The bridge must actually preserve the relevant records and procedures; its symbol alone guarantees nothing. Maintaining it can require duplicated staff, translation work, and a temporary allocation of responsibility.

15.2 Selective Continuity

Architectural migration raises a normative question before it raises a preservation problem: which continuities deserve protection? Existing rights of recourse, outstanding obligations, and the standing of

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affected participants can justify preservation. Existing exclusionary privileges may justify discontinuation. A formal map that preserves everything cannot substitute for this judgment.

The same issue applies to loss. A failed commuting square may reveal unacceptable discontinuity, or it may represent an intentional change to an objectionable requirement. The mathematical discrepancy identifies where preservation fails; its significance depends on the undertaking. An audit should therefore record the selected preservation claims, the excluded claims, and the reasons for both.

Changes of membership or incidence require a declared correspondence between graphs or between historical regions. The same-graph construction is deliberately limited. It provides a transparent preliminary case rather than concealing births, departures, mergers, or reinterpretations inside a fixed list of nodes. A fuller GR migration theory would need to connect such changes to the composition and refinement of history-bearing spacetimes.

16 Coupled Interface Fields

This section introduces a nonlinear field on a fixed interface graph. Its purpose is to connect compatibility to an explicit configuration dynamics while identifying what this projection cannot represent. Unlike the generative construction in the next section, it keeps the carrier and its transports fixed.

Use the Hilbert spaces and unitary transports of Section 14. Choose one orientation for each edge and positive weights w_e. A field is a tuple $f = (f_j)_{j\in J}$ in the direct sum of the local spaces. Define its covariant difference and connection Laplacian with the usual direct-sum inner products.

$$(d_U f)_e = \sqrt{w_e}(f_v - U_e f_u), \qquad L_U = d_U^\dagger d_U. \tag{6}$$

Equation (6) gives $\langle f, L_U f\rangle = \|d_U f\|^2 \geq 0$. Its kernel is precisely the compatible-section space. The weights specify this model's relative penalties; they are not measured degrees of trust.

Let $\beta > 0$ and $r > 0$. A quartic local response competes with the interface mismatch.

$$E(f) = \frac{1}{2}\|d_U f\|^2 + \frac{\beta}{4}\sum_{j\in J}(\|f_j\|^2 - r^2)^2. \tag{7}$$

Equation (7) rewards neither goodness nor legitimacy. It defines a mathematical potential favoring a selected nonzero local norm while penalizing mismatched transport.

Proposition 16.1 (Zero-Energy Compatibility)**.** *For a connected graph, E attains zero if and only if the common fixed space $\mathcal{F}$ in Equation* (3) *contains a nonzero vector.*

Proof. Zero energy requires both $d_U f = 0$ and every $\|f_j\| = r$. Proposition 14.1 then gives a nonzero root vector in $\mathcal{F}$. Conversely, rescale a nonzero member of $\mathcal{F}$ to norm r and transport it along the tree. Unitarity preserves its norm and compatibility makes every mismatch term vanish. □

Proposition 16.1 shows why locally preferred amplitudes need not form a jointly unstrained configuration. It does not establish that real cooperation minimizes such an energy.

Treat the complex field space as a real Hilbert space with inner product $\mathrm{Re}\langle\cdot,\cdot\rangle$. For a mobility $\kappa > 0$, its gradient law is the following optional dynamics.

$$\frac{df_j}{d\tau} = -\kappa\left[(L_U f)_j + \beta(\|f_j\|^2 - r^2)f_j\right], \qquad \frac{dE}{d\tau} = -\kappa\|\nabla E\|^2. \tag{8}$$

The derivation of Equation (8) is given in Appendix A. Finite dimensionality, smoothness, and coercivity give global forward solutions: the decreasing energy confines a solution to a compact sublevel, preventing finite-time escape. The parameter τ is model time. No identification with social time has been supplied.

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For a scalar complex field on an N-cycle, take unit weights and oriented transports $e^{i\theta/N}$, with indices $j = 0, \dots, N-1$ read modulo N. The Fourier mode $f_j = \rho e^{2\pi i k j/N}$ has Laplacian eigenvalue ℓ_k. Its nonzero stationary amplitude satisfies the following relations.

$$\ell_k = 2 - 2\cos\left(\frac{2\pi k - \theta}{N}\right), \qquad \rho^2 = r^2 - \frac{\ell_k}{\beta} > 0. \tag{9}$$

Equation (9) follows by substituting the mode into the difference operator and then the stationary gradient equation. It supplies exact stationary configurations, not a proof of their stability against every perturbation.

The fixed-carrier model isolates frustration among already selected interfaces. It cannot generate new participants, replace its graph, or explain how the translation operators become authoritative. It is useful precisely when those features can be held fixed for a limited question. The next construction provides a different representational level rather than presenting this projection as the main ontology of GR.

17 Generative Architecture Fields

This section specifies a finite group-field model whose interactions can organize combinatorial composition. Its objective is to provide a substantive field-theoretic investigation consistent with the earlier GR distinction between a field generator and a field placed on a completed network. The construction is regulated and conditional: its mathematical existence does not establish a social probability law.

Let G be a finite group of order n. Consider real fields on three group arguments that are invariant under a common right action. Define their space and normalized inner product.

$$\begin{aligned} \mathcal{V} &= \{f : G^3 \to \mathbb{R} : f(xa, ya, za) = f(x, y, z)\ \forall a \in G\}, \\ \langle f, h\rangle &= n^{-3} \sum_{x,y,z \in G} f(x, y, z) h(x, y, z). \end{aligned} \tag{10}$$

The action in Equation (10) is free, so its orbits have n elements and $\dim \mathcal{V} = n^2$. Four fields $\phi_c \in \mathcal{V}$, indexed by $c = 0, 1, 2, 3$, distinguish four interaction roles. These roles are colors in the combinatorial model, not four psychological types or four fixed actors.

A field argument is a formal relational label. A rank-three quantum can be interpreted combinatorially as a boundary building block with three incident strands. In the inherited incidence convention, the block represents a coupling and the strands represent elements at its boundary. This selected valence is a modeling restriction. It is not a claim that real institutions possess exactly three relations.

Define a tetrahedral contraction using six shared variables.

$$\begin{aligned} \mathcal{T}(\phi_0, \phi_1, \phi_2, \phi_3) = n^{-6} \sum_{g_1, \dots, g_6 \in G} & \phi_0(g_1, g_2, g_3)\phi_1(g_3, g_4, g_5) \\ & \cdot \phi_2(g_5, g_2, g_6)\phi_3(g_6, g_4, g_1). \end{aligned} \tag{11}$$

Every variable in Equation (11) appears twice. The pattern specifies the gluing of strands in an interaction. It can encode simultaneous composition that cannot be reduced to four independent local potentials. The amplitude itself carries no automatic institutional meaning.

17.1 A Stabilized Action

Let $K_c : \mathcal{V} \to \mathcal{V}$ be self-adjoint real operators, let $g \in \mathbb{R}$, and let $\lambda > 0$. Set $R^2 = \sum_c \|\phi_c\|^2$, and define the action.

$$\mathcal{S}(\phi) = \frac{1}{2}\sum_{c=0}^{3} \langle \phi_c, K_c \phi_c\rangle - g\mathcal{T}(\phi_0, \phi_1, \phi_2, \phi_3) + \frac{\lambda}{6} R^6. \tag{12}$$

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The sextic term in Equation (12) confines the finite-dimensional model even when the kinetic forms have negative directions. It is an explicit modeling choice. Its dependence on the total norm is not claimed to be a microscopically derived institutional interaction. In the integral below, $d\phi$ denotes Lebesgue measure in an orthonormal basis of the real space $\mathcal{V}^4$.

Proposition 17.1 (Finite Field Measure)**.** *The contraction obeys* $|\mathcal{T}| \leq \prod_c \|\phi_c\| \leq R^4/16$. *If* $k = \max_c \|K_c\|$*, then the action is coercive and has the lower bound below. Consequently, for every* $\varepsilon > 0$*, its finite-dimensional partition integral is positive and finite.*

$$\mathcal{S}(\phi) \geq -\frac{k}{2}R^2 - \frac{|g|}{16}R^4 + \frac{\lambda}{6}R^6, \qquad Z_\varepsilon = \int_{\mathcal{V}^4} e^{-\mathcal{S}(\phi)/\varepsilon}\, d\phi \in (0, \infty). \tag{13}$$

Proof. Contract the first two fields over g_3, and the last two over g_6. Cauchy–Schwarz first on each contracted index and then on the remaining four indices gives $|\mathcal{T}| \leq \prod_c \|\phi_c\|$, with the normalized sums preserved. Applying the arithmetic–geometric mean inequality to the four squared norms gives the second bound. Self-adjointness bounds each quadratic form below by $-k\|\phi_c\|^2$. The positive sixth-degree term dominates the negative lower-degree terms. Outside a sufficiently large ball the lower bound exceeds a positive multiple of R^6; inside it the continuous integrand is bounded. Finite-dimensional radial integration proves finiteness, and positivity is immediate. □

Proposition 17.1 and Equation (13) establish a regulated mathematical measure. The normalization does not justify interpreting ε as social noise or Z_ε as empirical evidence. The detailed contraction estimate appears in Appendix A.

17.2 Generated Relational Complexes

For a positive scalar Gaussian reference on $\mathcal{V}$, its inverse supplies covariance contractions. In the ambient space of functions on G^3, that covariance is the inverse scalar times the orthogonal projector onto invariant functions. The projector averages a common right translation, retaining three corresponding argument positions. These identifications supply the strands. The quartic interaction organizes stranded vertices, and contractions join their open strands. Coupling histories can then be represented by propagating lines and element histories by the resulting faces, while interaction vertices represent events. This supplies a route from field interactions to two-complex structures consistent with the selected GR convention.

Several qualifications are necessary. The full K_c in Equation (12) need not be positive or have the stated scalar form. It cannot always be used directly for these covariance contractions; an expansion about the selected positive reference must retain the difference as a further quadratic term. The sextic stabilizer is a product of norm terms and introduces additional, potentially disconnected interaction patterns. A formal expansion is not a proof of convergence or of a probability distribution over causal institutional histories. Causal order, admissible labels, connectedness requirements, and semantic extraction require further specifications.

A spin-foam instantiation would additionally choose representation-theoretic labels, intertwiners, and amplitudes for suitable generated complexes. The present finite model permits a mathematical investigation without making those choices or asserting a physical identification. Its function is to keep combinatorial generation explicit rather than hiding it behind a fixed social graph.

17.3 Field Equations

Define $\mathcal{C}_c \in \mathcal{V}$ by the Riesz representation of the partial variation of $\mathcal{T}$: for every $\eta_c \in \mathcal{V}$, the variation is $\langle \eta_c, \mathcal{C}_c \rangle$. For $c = 0$, the contraction has the following explicit form.

$$\mathcal{C}_0(g_1, g_2, g_3) = n^{-3} \sum_{g_4, g_5, g_6 \in G} \phi_1(g_3, g_4, g_5)\phi_2(g_5, g_2, g_6)\phi_3(g_6, g_4, g_1). \tag{14}$$

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The other $\mathcal{C}_c$ are obtained by varying their corresponding factors, with their argument positions retained. Reindexing the three summed variables by a common right multiplication proves that Equation (14) is invariant and hence belongs to $\mathcal{V}$.

For positive mobilities κ_c, the gradient and an optional dissipative model law are as follows.

$$\nabla_c \mathcal{S} = K_c \phi_c - g\mathcal{C}_c + \lambda R^4 \phi_c, \qquad \frac{d\phi_c}{d\tau} = -\kappa_c \nabla_c \mathcal{S}. \tag{15}$$

The chain rule gives the corresponding energy identity.

$$\frac{d\mathcal{S}}{d\tau} = -\sum_{c=0}^{3} \kappa_c \|\nabla_c \mathcal{S}\|^2 \leq 0. \tag{16}$$

Equations (15) and (16), together with coercivity, give global forward solutions in this finite-dimensional model. They neither prove convergence to the global minimum nor identify action reduction with social improvement.

The distinction between stationarity, stochastic weighting, and dissipative dynamics is substantive. The same action can be used to define three different mathematical questions; those uses do not establish a single empirical mechanism. A substantive application would have to explain the selected labels, couplings, kinetic operators, mobilities, and observable map. It would also have to explain how institutional interventions alter those data rather than treating the coefficients as self-explanatory.

18 Nonlinear Configuration Response

This section investigates an exactly tractable sector of the generative model. Its objective is to expose nonlinear coexistence and loss of stationary configurations without substituting a linear trust equation for the field theory. The homogeneous sector supplies conditional results whose extension to nonconstant fields remains open.

Assume $K_c = \mu I$ for all colors, with $\mu \in \mathbb{R}$, and take constant fields $\phi_c = a_c$. Since the group averages are normalized, constants have their ordinary absolute-value norm and the contraction is the product of the amplitudes. This subspace is invariant under the gradient equation. Its action is the following four-variable polynomial.

$$\mathcal{S}_{\mathrm{h}}(a_0, a_1, a_2, a_3) = \frac{\mu}{2} \sum_c a_c^2 - g a_0 a_1 a_2 a_3 + \frac{\lambda}{6} \left(\sum_c a_c^2 \right)^3. \tag{17}$$

Equation (17) is a restriction of the defined field action, not an independently postulated aggregate trust law.

On the equal-amplitude line $a_c = a$, its potential and stationary condition are as follows.

$$V(a) = 2\mu a^2 - g a^4 + \frac{32\lambda}{3} a^6, \qquad V'(a) = 4a(\mu - g a^2 + 16\lambda a^4). \tag{18}$$

The factors in Equation (18) result from four fields and $R^2 = 4a^2$. The induced equal-mobility flow on this line is $\dot{a} = -\kappa V'(a)/4$, rather than $-\kappa V'(a)$, because the line's induced metric has factor four.

Let $g > 0$. Writing $x = a^2$, the nonzero stationary branches satisfy the following formula, whenever its square root is real and the selected x is positive.

$$x_\pm = \frac{g \pm \sqrt{g^2 - 64\lambda\mu}}{32\lambda}, \qquad \mu_{\mathrm{sn}} = \frac{g^2}{64\lambda}. \tag{19}$$

Equation (19) displays a saddle-node value at which the two positive branches meet. For $0 < \mu < \mu_{\mathrm{sn}}$, the zero configuration and two nonzero positive-amplitude stationary configurations exist.

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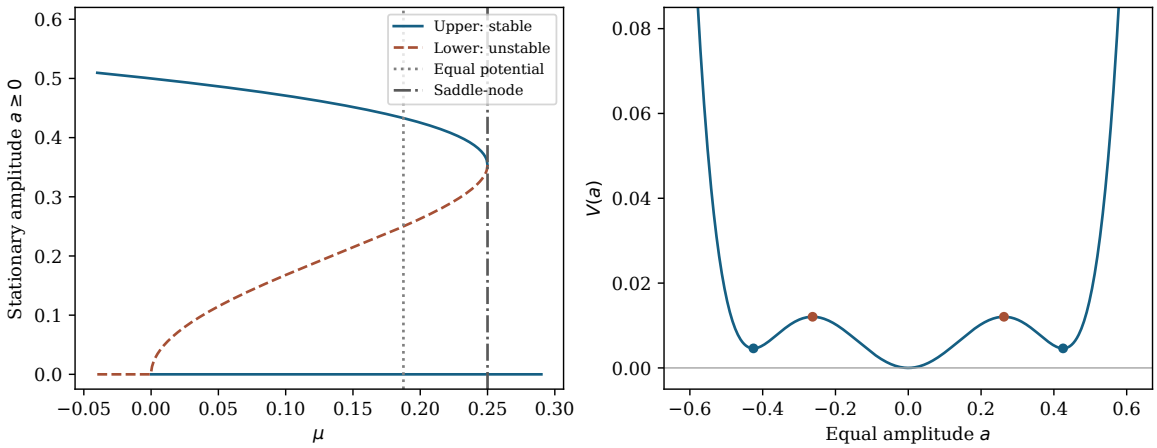

Figure 1: Illustrative homogeneous field response for $g = 4$ and $\lambda = 1$. Left: positive stationary amplitudes and their four-mode local stability; the zero branch is locally stable for $\mu > 0$. Right: the potential at $\mu = 0.2$, where both zero and a nonzero configuration are local minima. The parameters are uncalibrated.

Proposition 18.1 (Homogeneous Local Stability)**.** *For $g > 0$ and $0 < \mu < \mu_{\text{sn}}$, the zero configuration is a strict local minimum of the four-variable homogeneous action. The equal positive-amplitude configuration on x_+ is also a strict local minimum; the configuration on x_- has one unstable homogeneous direction.*

Proof. The Hessian at zero is μI_4. At a nonzero equal-amplitude stationary configuration, substitute $\mu = gx - 16\lambda x^2$ into the Hessian. Its diagonal entries become $gx + 16\lambda x^2$, and its off-diagonal entries become $-gx + 16\lambda x^2$. The equal-component eigenvector and its three-dimensional orthogonal complement consequently have the eigenvalues below.

$$h_{\parallel} = 2x(32\lambda x - g), \qquad h_{\perp} = 2gx \quad \text{with multiplicity 3.} \tag{20}$$

On x_+, both are positive; on x_-, the first is negative and the others positive. Positive mobilities preserve these stability signs under gradient flow. □

Proposition 18.1 and Equation (20) concern all four constant-field amplitudes. They do not establish stability against the remaining nonconstant field modes. At the saddle-node the radial eigenvalue vanishes, so the strict-minimum statement does not extend to that boundary.

The potential at a stationary nonzero configuration follows by substituting the same stationary relation into V.

$$V_{\text{stat}} = gx^2 - \frac{64\lambda}{3}x^3, \qquad x_{\text{co}} = \frac{3g}{64\lambda}, \qquad \mu_{\text{co}} = \frac{3g^2}{256\lambda}. \tag{21}$$

Equation (21) locates equality of the zero and selected nonzero homogeneous potentials. This value differs from loss of the nonzero stationary pair. Energetic preference, local stability, and branch existence are therefore distinct questions even inside this simple sector.

Figure 1 presents this exact sector. At $\mu = 0.2$, the upper amplitude is approximately 0.4253, and the intervening unstable amplitude is approximately 0.2629. Equal initial amplitudes on different sides of that barrier approach different stationary configurations under the illustrated gradient flow. Appendix B reports the reproducible numerical checks.

18.1 Field Interpretation

The four-field interaction provides a possible representation of mutually reinforcing components whose joint configuration has consequences not captured by independent local terms. Its nonlinear response

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illustrates how coordinated support can admit several persistent configurations and require finite reconfiguration to leave one of them. This is a heuristic interpretation, not an identification of amplitudes with trust, institutions, or welfare.

The model makes no empirical near-criticality claim. Its saddle-node and potential-equality values are exact properties of a chosen polynomial. A finite regulated partition integral does not acquire a thermodynamic singularity merely because a homogeneous stationary branch changes stability. A thermodynamic or continuum limit, a specified observable, and independent empirical interpretation would be required for stronger claims.

The example also leaves power and agency unresolved. Gradient descent describes a selected adjustment law, not deliberation, coercion, refusal, or authorized intervention. Changing g, K_c, or the allowed interaction pattern can represent an intervention only after explaining who can make that change and how. The field representation is useful when it opens such questions with explicit mathematical dependencies. It becomes decorative when its parameters are merely renamed social concepts without that work.

19 Evidential Access

This section asks what would make the architectural account answerable to evidence. Its objective is to prevent the formal representations from insulating their own assumptions. The method distinguishes evidence about components, evidence about their dependence, and evidence about transitions.

An investigator first needs to identify the undertaking and its relevant failures. A missed payment, an unrecognized claim, an unavailable remedy, and an interrupted service are different outcomes. Describing all of them as reduced trust would obscure the mechanisms the architecture is intended to reveal. Interviews, records, procedural observation, and historical reconstruction may supply different kinds of access; none is assumed to provide a complete view.

Evidence about a component includes its stated function, actual operating capacity, and conditions of access. Evidence about dependence concerns what happens when a supporting capacity changes or becomes unavailable. Evidence about architecture requires tracing the joint operation of those relations. A list of organizations and their mandates cannot establish that their procedures compose, that their assurances are independent, or that their replacement can be implemented safely.

19.1 Discriminating Histories

Let $m : \mathfrak{H} \to Y$ be a selected observation map and $b : \mathfrak{H} \to \{0, 1\}$ a property relevant to assessment. A decision based only on the observations can recover b exactly only if b is constant on every fibre of m. Indeed, if $m(h) = m(h')$ while $b(h) \neq b(h')$, any function of that shared observation must give the same answer for both histories. Conversely, constancy allows a well-defined function on the image of m. This elementary factorization criterion states a representational limitation; it is not a new theory of knowledge.

For example, an observation map recording completed transactions can identify voluntary continuation and coerced continuation alike. If the assessment concerns the availability of meaningful exit, transaction completion alone is insufficient. Adding a survey helps only if its design and conditions allow it to distinguish the relevant histories. A record of expressed satisfaction obtained under credible retaliation can reproduce the same ambiguity.

Dependence among evidence sources also matters. Three reports drawn from one registry can corroborate transcription while providing little independent support for the registry's categories. Architectural inquiry should trace source lineage and control, including who can correct an upstream record. This does not imply that only independent evidence is useful. It specifies which inference a particular combination supports.

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19.2 Architectural Explanation Tests

A useful study would compare explanations with different representational commitments. A conventional account might explain interruption through an unfunded mandate or enforcement failure. An architectural account might add that the replacement of one interface invalidated another institution's records, even though each institution remained adequately funded. The added account earns its place if the dependence improves explanation, supports discriminating predictions, or changes the available remedy.

Counterevidence should also be specified. If the proposed mismatch does not constrain actual practice because participants routinely use a recognized exception, the modeled obstruction may be irrelevant. If a claimed support cycle is bypassed by a stable external practice, the closure model has omitted a seed. If transitions succeed without the proposed bridge, either another path exists or the stated compatibility condition was too strong.

The same discipline applies to the generative model. Field parameters cannot be inferred merely from a suggestive curve. A substantive application would need observables, a measurement or coding procedure, alternative models, and a reason to associate the observed process with the selected interaction. Until then, the field results establish mathematical possibilities and distinctions. They do not provide calibrated predictions.

20 Institutional Configurations

This section develops three hypothetical configurations to show how the distinctions guide inquiry. They are analytical illustrations, not reports of documented cases. Each traces an undertaking through its supports and identifies a failure that cannot be assessed by the presence of those supports alone.

20.1 A Distributed Verification Arrangement

Suppose three public agencies coordinate certification for a shared environmental undertaking. Each retains its own jurisdiction and vocabulary. Agency A accepts community monitoring records; B accepts A's certification as evidence of a completed review; C accepts B's certification only when the underlying record uses a uniform identifier. A's accepted community records deliberately omit that identifier to protect participants.

Every bilateral arrangement can be intelligible. A's rule preserves privacy, B's rule delegates review, and C's rule supports traceability. Their combination may provide no admissible route for the protected community record. Calling this a shortage of trust would miss the institutional object of dispute. The issue is whether the architecture can preserve both the privacy commitment and the traceability function, or whether one requirement must change.

The finite compatibility model helps state the obstruction. It does not determine which value should prevail. A mediated identifier, restricted inspection, or a separate certification route might provide a bridge, but each changes access and authority. A proposal should specify who can link the records, who can challenge misuse, and whether the community can refuse the new relation without losing every route to recognition.

Several assurances may also depend on one technical registry. An outage would then reveal a common support dependency despite institutional plurality. The remedy could involve independent records or a controlled offline procedure, but duplication introduces maintenance burdens. The architectural assessment must compare the actual continuity gained with the resources and risks introduced.

20.2 A Shared Emergency Resource

Suppose neighboring communities establish access to a scarce emergency resource. They initially lack a shared history sufficient for broad commitments. A limited arrangement permits small transfers, re-

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tains local control over reserves, and uses an intermediary to record obligations. Successful exchanges generate a history that makes larger cooperation possible.

The initial support can become a bottleneck. If the intermediary controls the only recognized record, communities may be unable to dispute its account without losing eligibility for future transfers. Its original narrow role has become a source of continuing authority. Formation has produced both cooperative capacity and a dependency requiring separate justification.

A closure model can distinguish the conditions needed to initiate the arrangement from those needed to reproduce it. An operator or interface model can describe which transfers remain coherent across local accounting practices. Neither settles how scarce resources should be distributed during an emergency. That question requires an explicit normative argument, including the standing of persons not represented in the original agreement.

The architecture can preserve cooperation without complete trust in the intermediary by providing inspectable records, a limited mandate, and an independent route for contestation. Yet each protection must be materially supported. A nominal independent reviewer who depends entirely on the intermediary's discretionary funding may be unavailable when most needed. The example therefore connects differentiated trust, power, and maintenance without reducing one to another.

20.3 An Institutional Registry Transition

Suppose a regional programme replaces a registry used to establish eligibility and outstanding obligations. The new system better accommodates several languages and supplies more accessible correction procedures. Each feature can be beneficial at the endpoint. The transition nevertheless requires converting records, recognizing earlier decisions, training local staff, and preserving access during conversion.

If the old registry closes before the new one can recognize its records, participants can lose practical standing. A later correction may restore a record while failing to recover a missed deadline or interrupted benefit. The harm arises from the temporal relation between supports, not simply from a defective final design.

The two-version migration example identifies the structure of this problem. A bridge procedure can maintain recognition while individual offices convert. Its existence requires funding, authorized access to old records, an agreed dispute procedure, and a deadline that does not merely shift indefinite waiting onto participants. A mathematical commuting square captures selected preservation requirements; the transition graph captures whether those requirements survive the sequence of changes.

A further complication arises when some old classifications should be abolished. Preserving every old category would reproduce an injustice. The transition must instead preserve the claims and capacities judged defensible while providing a procedure for reassessing the categories through which they were expressed. This is where historical identity and normative judgment exceed a simple data-conversion task.

Across the three illustrations, the architectural contribution is a pattern of questions: what is jointly required, which dependencies are shared, how formation changes authority, and what must remain usable during change? The examples do not establish that the formal field model is necessary for every inquiry. They show where a richer model might become appropriate if interactions among configurations, rather than a single procedural defect, become explanatory.

21 Architectural Assessment

This section develops a provisional normative assessment. Its objective is to identify what counts in favor of an architecture without treating persistence, coherence, or action reduction as sufficient. The method derives assessment questions from the earlier account of cooperation among differentiated agents and affected persons.

The argument begins from a declared commitment: cooperation should be assessable in relation to the agency and legitimate claims of those who participate in or bear material consequences of it. This

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commitment is not a theorem of GR. It supplies a normative orientation that can be challenged and supplemented. Within that orientation, the ability to undertake an action matters together with the ability to understand, contest, and appropriately revise its conditions.

21.1 Practical Standing

A participant has practical standing when the architecture supplies usable means to make relevant claims consequential. Formal recognition is one component. Access to records, intelligible procedures, timely response, and protection against retaliation may also be required. Their necessity varies with the undertaking, but the distinction between nominal permission and usable action remains central.

Practical standing need not imply equal control over every decision. Roles can be differentiated by competence, responsibility, or exposure. Such differentiation requires reasons proportionate to its effects. An architecture becomes difficult to defend when those who bear its greatest unchosen burdens have no effective way to question the conditions producing them.

The argument also extends beyond existing membership. If the architecture's operation predictably constrains outsiders, its assessment should explain how their claims are considered. A closed agreement cannot establish its own legitimacy simply by obtaining the assent of those it already recognizes. Determining the relevant constituency remains a substantive political question.

21.2 Accountable Partiality

Partial interfaces can be defensible when they support a bounded undertaking and make their limits visible. They become problematic when a narrow agreement is silently treated as endorsement of a broader institutional order. Accountable partiality requires clarity about the selected domain, the consequences of matching, and the questions left unresolved.

This principle protects both cooperation and disagreement. It permits participants to act together without renouncing their wider commitments. It also prevents institutional success from being used as evidence that those commitments have become equivalent. The architecture should allow a party to distinguish failure to perform an accepted undertaking from refusal of an unaccepted extension.

Partiality does not mean that every incompatibility should remain unresolved. Some actions require a determinate decision. The question is how that decision is authorized and what forms of challenge remain appropriate. A final decision can close one dispute without erasing the historical or normative significance of dissent.

21.3 Proportionate Revisability

Revisability is defensible when it preserves meaningful correction at a cost and distribution appropriate to the risks. Maintaining every alternative indefinitely can exhaust collective capacity and impose unequal burdens. Closing alternatives too early can make acknowledgment of error practically empty. The architecture must therefore justify both what it keeps open and what it closes.

The justification should consider reversibility, timing, burden incidence, and the availability of substitutes. An irreversible disclosure may warrant stronger prior protection than a readily reversible classification. A transition that imposes concentrated costs may require compensation, shared maintenance, or altered sequencing. These are contextual judgments; the paper offers no universal scalar threshold.

The resulting assessment has four distinct objects: the undertaking's substantive justification, the joint usability of its supports, the distribution of maintenance and transition burdens, and the authority to revise their arrangement. A favorable result on one does not settle the others. A technically coherent architecture can remain unjust; a defensible objective can remain practically unsupported; a successful transition can preserve the wrong capacities.

This separation is a philosophical constraint on the formalism. Mathematical coherence and dynamical stability can inform assessment, but they cannot supply its entire normative content. Their role is to

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make dependencies and possibilities inspectable so that the relevant judgments can be made with greater precision.

22 Counterarguments

This section tests the scope and necessity of the proposed synthesis. Its objective is to identify objections that would limit or defeat its contribution. The responses defend a bounded research use, rather than insulating the architectural vocabulary from criticism.

22.1 Institutional Redescription

The strongest objection is that architecture redescribes problems already handled by institutional design, regime complexity, organizational theory, and infrastructure studies. Much of the paper supports that objection. Cooperation without complete trust, distributed authority, partial translation, and maintenance work are established concerns. A new overarching noun does not demonstrate a new contribution.

The provisional response is that a common analytical object can help examine dependencies across those concerns while keeping their differences explicit. The closure, compatibility, and migration models separate forms of adequacy that are easy to conflate. That contribution remains modest. If established frameworks identify the same distinctions with greater clarity or better evidence, the architectural vocabulary should be reduced or abandoned.

22.2 Representational Excess

A second objection concerns mathematical excess. Group fields and operator algebras can create an appearance of depth while leaving the empirical problem unchanged. The objection is justified wherever a parameter is merely named after a social concept or a theorem's assumptions are unconnected to the case.

The paper's response is to state separate representational contracts. Finite clauses express prerequisites; constraint relations express joint admissibility; unitary transports express reversible matching; the field action specifies a generative interaction and a selected dynamics. None is obligatory for every case. The generative model earns attention as a worked mathematical possibility, with explicit derivations and limits. Its empirical usefulness remains unproven.

This limitation does not make the formal investigation valueless. A complete derivation can reveal that apparently similar claims concern different mathematical objects, as the distinction between a nontrivial coherent algebra and a nonzero compatible state demonstrates. It can also expose the assumptions required for a proposed dynamical story. The value is conditional clarification, not borrowed authority from physics.

22.3 Architectural Functionalism

Architectural language can make participants appear to be components whose purpose is to sustain a system. Such a reading would conflict with the normative orientation developed here. Participants can challenge the undertaking, refuse assigned roles, or dissolve an arrangement. System continuation is not their presumed duty.

The gradient models are particularly vulnerable to this objection because their trajectories follow an assigned potential. They represent selected adjustment processes and cannot stand in for political agency. A richer account would need explicit intervention, contestation, and changes to the rules of composition. Until such an account is developed, the models should not be used to recommend that participants adapt to an existing architecture.

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22.4 Methodological Plurality

A synthesis can also create premature closure by giving every disagreement a place in one comprehensive framework. The present architecture is intentionally incomplete. It does not supply a universal ontology of institutions, a common metric of burdens, or a final theory of legitimacy. Some conflicts resist translation; some histories remain inaccessible; some undertakings should end.

Methodological pluralism requires more than declaring several models available. It requires allowing them to yield incompatible diagnoses and asking which assumptions generate the difference. A support graph can identify an available path while a historical account shows that its use would violate an outstanding commitment. A field model can exhibit stable configurations while a normative analysis rejects all of them. These disagreements are research results, not defects to be removed by definition.

22.5 Investigative Boundaries

Finally, tracing every support can produce an endless regress. No investigation can reconstruct the full history and all dependencies of a cooperative act. The response is a declared scope tied to the claim being evaluated. One can treat a support as available for a particular inquiry while documenting why that assumption is reasonable and what evidence would require reopening it.

This stopping rule is pragmatic and revisable. It differs from claiming that the omitted supports are irrelevant in principle. The architecture becomes useful when it identifies dependencies consequential to a specified undertaking at a manageable level of analysis. It becomes unhelpful when its demand for comprehensiveness prevents any discriminating judgment.

23 Research Limits

This section records what the paper establishes and what remains unresolved. Its purpose is to preserve the preliminary standing of the synthesis and make subsequent criticism actionable. The limits concern novelty, representation, evidence, and normative justification.

The philosophical argument identifies a history-bearing organization of cooperative supports as a useful candidate object. It distinguishes differentiated trust from general reliability, partial interpretive matching from comprehensive agreement, self-maintenance from initiation, and adequate endpoints from adequate transitions. It also places maintenance burdens and revision authority within the object rather than treating them as external administrative concerns.

The formal results establish consequences inside explicitly stated models. Finite monotone closure distinguishes grounded availability from circular fixed points. Tree extension and a cycle counterexample separate local from joint compatibility. A loop commutant characterizes coherent operator families in a reversible linear sector. Migration maps preserve compatible sections under commuting-square conditions, while the transition counterexample shows why endpoint preservation does not guarantee a usable path.

The field investigation has two levels. A connection field studies mismatch on a fixed carrier. A regulated rank-three model specifies nonlinear combinatorial interaction, proves finite-dimensional coercivity and integrability, derives a gradient law, and analyzes a homogeneous stationary sector. Its four-mode stability results do not establish full field stability. Its mathematical parameter thresholds do not demonstrate social criticality, and its formal diagrammatic interpretation does not yet supply a validated distribution of institutional histories.

The paper's contribution remains a synthesis and focused extension. Existing GR manuscripts already discuss trust ecologies, mediation, temporal transformation, resources, power, and reconfiguration. Established international and organizational research supplies substantial antecedents. The present organization should be retained only insofar as it sharpens a question, clarifies a failed inference, or supports an inquiry that those sources leave insufficiently explicit.

Several tasks remain before stronger claims are appropriate. Applications need documented interface rules, histories of support formation, and evidence about actual transition paths. Lossy and partial trans-

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lations require models beyond unitary transport. Changes of membership and incidence require a more general migration theory. The generative model needs an interpretation of labels and observables, investigation of nonconstant modes, and comparison with simpler explanations. Normative applications need an account of constituency, justified preservation, and distributive burdens appropriate to their setting.

Appendix C records the assumptions needed to move among representations. The next stage of inquiry should examine whether the architectural level adds explanatory value and whether its mathematical representations remain proportionate to the problems they are intended to illuminate. A successful application would clarify a consequential dependency or transformation while leaving disagreement, uncertainty, and the authority to revise the representation itself available for scrutiny.

A Field Derivations

This appendix supplies the steps used by the field models. It keeps the normalized group sums explicit, derives both gradients, and identifies the assumptions needed for the homogeneous stability calculation.

A.1 The Tetrahedral Bound

Write normalized averaging over a group variable as $\mathbb{E}_g = n^{-1} \sum_{g \in G}$. Define contractions X and Y on the four unsummed variables.

$$\begin{aligned} X(g_1, g_2, g_4, g_5) &= \mathbb{E}_{g_3} \phi_0(g_1, g_2, g_3) \phi_1(g_3, g_4, g_5), \\ Y(g_1, g_2, g_4, g_5) &= \mathbb{E}_{g_6} \phi_2(g_5, g_2, g_6) \phi_3(g_6, g_4, g_1). \end{aligned} \tag{22}$$

Equation (22) gives $\mathcal{T} = \mathbb{E}_{g_1, g_2, g_4, g_5} XY$. Pointwise Cauchy–Schwarz on the g_3 average, followed by the four remaining averages, yields the following bound.

$$\begin{aligned} \|X\|^2 &\le \mathbb{E}_{g_1, g_2, g_4, g_5} \left(\mathbb{E}_{g_3} \phi_0(g_1, g_2, g_3)^2 \right) \left(\mathbb{E}_{g_3} \phi_1(g_3, g_4, g_5)^2 \right) \\ &= \|\phi_0\|^2 \|\phi_1\|^2. \end{aligned} \tag{23}$$

In Equation (23), the repeated averaging symbols denote separate dummy sums inside the two factors. The remaining pairs of variables are disjoint, which gives the factorization. The same reasoning gives $\|Y\|^2 \le \|\phi_2\|^2 \|\phi_3\|^2$. Cauchy–Schwarz for $\mathbb{E}XY$ then proves the contraction bound used in Proposition 17.1.

For nonnegative $b_c = \|\phi_c\|^2$, the arithmetic–geometric mean inequality gives $\prod_c b_c \le (\sum_c b_c / 4)^4$. Taking square roots gives $\prod_c \|\phi_c\| \le R^4/16$. No statistical independence of fields is assumed. The factorization above concerns dummy indices in a finite sum.

A.2 Invariant Field Variations

Varying the first field in the tetrahedral contraction produces n^{-6} times the same sixfold sum with ϕ_0 replaced by η_0. Separating the three external sums from the three internal sums gives $n^{-3} \sum_{g_1, g_2, g_3} \eta_0 \mathcal{C}_0$, which is exactly the inner product specified in Equation (10). This proves the normalization in Equation (14).

To check invariance, replace each external argument g_i, $i = 1, 2, 3$, by $g_i a$. In the internal sums set $g_\ell = h_\ell a$ for $\ell = 4, 5, 6$. This is a bijective reindexing for every finite group. Each field then has all three arguments multiplied on the right by a, so its invariance removes that multiplication. The result is the original contraction.

Let $s = \sum_c \|\phi_c\|^2$. Varying this sum gives twice the sum of the inner products $\langle \phi_c, \eta_c \rangle$. The derivative of $\lambda s^3/6$ with respect to s is $\lambda s^2/2$. Multiplication cancels the factor two. Self-adjointness of K_c gives the variation of the quadratic term. Combining these contributions yields the full first variation.

$$D\mathcal{S}(\phi)[\eta] = \sum_c \left\langle K_c \phi_c - g \mathcal{C}_c + \lambda R^4 \phi_c, \eta_c \right\rangle. \tag{24}$$

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Equation (24) establishes the gradient in Equation (15). Substitution of the gradient law into the chain rule gives Equation (16). The vector field is polynomial and hence locally Lipschitz. A forward solution remains in its initial compact sublevel of the coercive action. The ordinary differential equation continuation criterion then excludes finite-time escape.

For the connection field, the variation of the mismatch term is $\mathrm{Re}\langle d_U f, d_U \eta\rangle = \mathrm{Re}\langle L_U f, \eta\rangle$. The local term has variation $\beta(\|f_j\|^2 - r^2)\,\mathrm{Re}\langle f_j, \eta_j\rangle$. Their sum proves Equation (8) with the real Hilbert metric. Its coercivity follows from the positive quartic terms and the finite number of vertices.

A.3 Homogeneous Hessian

For the four-amplitude action, let $s = \sum_c a_c^2$. Direct differentiation gives the Hessian entries below.

$$\begin{aligned} \frac{\partial^2 \mathcal{S}_{\mathrm{h}}}{\partial a_i^2} &= \mu + \lambda s^2 + 4\lambda s a_i^2, \\ \frac{\partial^2 \mathcal{S}_{\mathrm{h}}}{\partial a_i \partial a_j} &= -g \prod_{\ell \neq i,j} a_\ell + 4\lambda s a_i a_j \qquad (i \neq j). \end{aligned} \tag{25}$$

At equal amplitudes, Equation (25) has constant diagonal and off-diagonal entries. The vector $(1, 1, 1, 1)$ has eigenvalue equal to the diagonal plus three off-diagonal entries; each vector whose components sum to zero has eigenvalue equal to their difference. Substitution of $s = 4x$ and the stationary condition gives Equation (20).

For unequal positive mobilities, the linearized gradient operator is $-MH$, where M is the positive diagonal mobility matrix and H the real symmetric Hessian. It is similar to $-M^{1/2} H M^{1/2}$. Congruence by $M^{1/2}$ preserves the numbers of positive and negative Hessian directions, establishing the stability-sign claim in Proposition 18.1. Equal mobilities are needed to retain the equal-amplitude trajectory itself.

Finally, inserting $\mu = gx - 16\lambda x^2$ into V gives Equation (21). Setting that value to zero yields $x = 3g/(64\lambda)$, and resubstitution gives the stated μ_{co}. These calculations concern the selected homogeneous branches; they make no claim of global minimization over all nonconstant fields.

B Computational Examples

This appendix records reproducible checks of the finite examples and field calculations. The script `simulations/check_models.py` writes its results to `simulations/results/formal_checks.json`, stores illustrative trajectories separately, and generates Figure 1. It uses deterministic enumeration and the random seed 20261002. The checks supplement the analytic proofs; sampled calculations do not establish general theorems.

The closure test enumerates all 512 directed unary-dependency patterns on three supports, including self-dependencies, and all eight starting subsets. For each of the resulting 4096 cases, the computed closure is compared with every closed superset of the starting set. This verifies the implementation of the least-closure procedure in that finite class. The manuscript's proof covers general finite premise sets beyond this enumeration.

The compatibility test enumerates all binary relations on two-element sets for each edge of a three-vertex path. All 49 pairs that satisfy two-sided arc consistency extend both possible root values. Exhaustive enumeration separately confirms that the equality–equality–inequality triangle has no joint tuple. The migration test searches the finite transition graph and confirms that the two binary endpoints are disconnected within the compatible states. Adding a bridge state supplies a path of three elementary changes.

The operator checks use two-dimensional unitary matrices and verify the coordinate covariance of loop operators. A scalar nontrivial phase has zero fixed-space dimension and a four-dimensional complex commutant, confirming the distinction between compatible vectors and coherent operators. Isometric

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Representation	Selected Object	Additional Obligation
Relational spacetime	Labelled histories, incidence, and history-bearing regions	Justify labels, boundaries, occurrence order, and abstraction.
Support closure	Declared capabilities and enabling clauses	Establish initial availability, omitted costs, and monotonicity.
Constraint system	Local descriptions and matching relations	Verify that the admissible sets represent actual practices.
Operator family	Reversible translations and coherent operations	Justify linearity and distinguish coherence from permission.
Migration system	Preservation maps and allowed transitions	Specify protected capacities, intermediate support, and authority.
Connection field	Nonlinear response on a fixed carrier	Justify weights, potential, and the fixed-carrier approximation.
Generative field	Invariant boundary fields and interaction patterns	Supply semantic extraction, admissibility, and evidence for dynamics.

Table 1: Representation Scope

embeddings into three-dimensional local spaces satisfy the selected migration squares. These examples check the formulas; they do not validate unitary translation as an empirical institutional assumption.

The connection-field test compares the three-cycle spectrum with Equation (9) and checks the gradient through a centered directional difference. For the generative model, right-invariant fields are sampled on the cyclic groups of orders two and three. If u is an array on G^2, the field $f(a, b, c) = u(a - c, b - c)$, with indices taken modulo the group order, is right-invariant. Sixty samples check the contraction estimate, invariance of partial contractions, the action's lower bound, and the full directional gradient.

For the saved run, the largest contraction-to-norm-product ratio was approximately 0.6013, below the proved bound of one. The largest relative directional-gradient discrepancy was below 2×10^{-9}. These values describe a finite numerical diagnostic and its floating-point accuracy; neither is an empirical confidence level.

The homogeneous checks verify both stationary amplitudes at $g = 4$, $\lambda = 1$, and $\mu = 0.2$, compare the four Hessian eigenvalues with Equation (20), and verify potential equality at $\mu = 0.1875$. Two equal-amplitude initial conditions, 0.05 and 0.6, are integrated by fourth-order Runge–Kutta with step 0.01 to model time 100. The first approaches zero and the second approaches 0.4253254. The sampled action is nonincreasing within the declared numerical tolerance.

The trajectory computation investigates the invariant homogeneous sector only. It does not test robustness to nonconstant field perturbations, estimate a social parameter, or establish a physical phase transition. Its purpose is to make the manuscript's nonlinear example reproducible and expose coefficient or differentiation errors that a qualitative analogy would conceal.

C Representation Interfaces

This appendix records the relation among the paper's models. Its objective is to prevent a result at one representational level from being silently promoted to a result at another. Table 1 summarizes the selected objects and their principal omissions.

A history projection can produce a support vocabulary by selecting capabilities relevant to an undertaking. It can produce a constraint representation by selecting admissible descriptions and their matching conditions. These are different maps; neither is assumed to determine the other. A closure model may certify that several interfaces are available while a constraint model finds their requirements incompatible.

A unitary system is a special algebraic representation of reversible matching. It does not follow from an arbitrary relation R_e. To pass from a finite relation to unitary transport, one would need a justified

encoding, equal-dimensional local spaces, reversibility, and norm preservation. Many institutional interfaces fail those assumptions. Partial maps, correspondences, or other operator classes might be more appropriate, but their theorems would need separate derivation.

A connection field retains an already specified carrier and assigns amplitudes to it. A generative group field instead supplies boundary building blocks and interaction patterns from which combinatorial structures can be assembled. Recovering a fixed-carrier field from such a generator would require a selected complex, suitable observables or conditioning, and a derivation of effective couplings. This paper does not claim to have established that reduction.

Likewise, a partition measure and a gradient law are distinct uses of an action. Their relation would require an additional stochastic process and its invariant-measure analysis. No such equivalence is assumed. The finite positive integral proves mathematical normalizability under the chosen regulator, while the gradient law proves dissipation for the chosen deterministic dynamics.

Finally, normative assessment does not arise as a projection of an action minimum. It supplies reasons for selecting protected capacities, relevant persons, and acceptable burdens before a preservation test can be interpreted. A formal result can constrain the feasibility of a proposal or reveal an omitted dependency. It cannot remove the need to justify what the architecture is meant to sustain.

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