A Cause-Effect Model for Emergent Time and Distance

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1 One-Sentence Summary

A single stable Node with incomputable internal structure yields emergent time from cause-effect ordering and distance from causal step counts.

2 Abstract

We present a framework in which reality emerges from a single, stable Node possessing an incomputable internal structure. This Node is fundamentally unchanging in total energy, yet contains subnodes capable of creating cause-effect relationships. These relationships define a partial order of "before" and "after"—which we interpret as *time*. Distance likewise emerges by counting the number of causal steps required for a subnode i to affect a subnode j. When access to j is indirect or nonexistent, a round-trip chain of cause and effect within the same subnode can serve to define both a clock and a notion of distance. Despite its minimal assumptions, this scheme remains consistent with the idea that space, time, and measurement originate from interactions internal to a stable underlying structure.

3 Keywords

cause-effect, emergent time, emergent distance, subnodes, partial order, stable Node

4 Introduction

Conventional physics often begins by assuming a background space and a global time parameter. In contrast, we start with a single, indivisible Node, denoted by N, that is *by definition* changeless in its overall property (e.g., total energy).

Within N, however, exists a richly layered, incomputable arrangement of *subnodes* that interact, producing cause-effect chains.

Key idea

> *"Time" emerges as the observed ordering of cause and effect among subnodes. Distance emerges by counting how many cause-effect steps occur between two subnodes (or within repeated interactions of the same subnode).*

5 Stable Node and Internal Structure

5.1 Definition of the Node

Let us call this entire structure **N**:

$$\mathbf{N} = \{n_i \mid i \in I\}$$

where each n_i is a subnode. The Node as a whole is stable: there is no net change in total energy or other overall properties. Internally, however, the subnodes can be arranged so that *local* causes produce *local* effects elsewhere.

5.2 Cause-Effect Relation

We formalize a cause-effect relation among the subnodes. If subnode n_i can trigger a change in subnode n_j, we write:

$$n_i \succ n_j$$

meaning "n_i is the cause, n_j is the effect." This relation is partial: not all pairs of subnodes need to be causally related. It is also not necessarily symmetric; if n_i affects n_j, it does not automatically mean n_j affects n_i.

5.3 Emergent Time as Ordering

From the partial order $\succ$, we interpret $n_i \succ n_j$ as "n_i occurs *before* n_j" in the emergent sense. A chain

$$n_i \succ n_a \succ n_b \succ n_j$$

implies a sequence of cause-effect steps linking n_i to n_j. Thus, even without referencing an external clock, we can consistently define an ordering akin to time.

6 Constructing a Clock

6.1 Local Clock from Self-Interaction

A single subnode n_i can be used to build a rudimentary "clock" by the following repeated loop:

1. **Cause in n_i:** n_i emits a perturbation or signal.
2. **Propagation:** The perturbation travels through a chain of subnodes (possibly including n_i itself multiple times).
3. **Return to n_i:** Eventually the effect reappears in n_i, closing the loop.

We then count the discrete causal steps (or observe a repeated pattern of changes in n_i) to define a repeatable unit. This cyclical process *is* the "tick" of the clock.

6.2 Cause-Effect Duration

If subnode n_i directly affects subnode n_j, we define a one-step cause-effect delay (one "unit"). If a signal must travel a longer chain:

$$n_i \succ n_a \succ n_b \succ \cdots \succ n_j$$

then the chain length can be counted, giving more units. In practice, each step might be weighted by a factor (e.g., different subnode couplings), but the essential notion is that *time* emerges from counting these intervals.

7 Emergent Distance

7.1 Definition of Distance

Distance between two subnodes n_i and n_j can be defined as the causal step count for n_i to affect n_j. If the minimal chain from n_i to n_j has length L_{ij}, then

$$d(n_i, n_j) \propto L_{ij}$$

Here, L_{ij} might be 1 if they are "adjacent" in causal terms or larger if the signal must traverse many intermediate subnodes.

7.2 Local vs. Non-Local Interactions

- **Local:** If n_i can directly trigger n_j with minimal intermediaries, $d(n_i, n_j)$ is small.
- **Non-Local:** If there is no straightforward path from n_i to n_j, then the distance is undefined or effectively infinite.

Sometimes we lack direct access to n_j. Then we measure distance via a round-trip within n_i itself:

$$n_i \succ \cdots \succ n_i$$

Count the steps in the loop. A subnode can gauge an apparent distance to something else by noticing changes in its own state after some chain of events.

8 Reflections and Chains

Signals or perturbations may:

- Travel directly from n_i to n_j if they are adjacent in the cause-effect diagram.
- Pass through multiple intermediaries $(n_a, n_b, \dots)$.
- Reflect back to the original subnode n_i, closing a loop used for timing.

Regardless of path complexity, each segment corresponds to a well-defined cause-effect step. Summing or concatenating these steps yields a measure of duration and thus a notion of distance.

9 Discussion

9.1 Why the Node is Still "Stable"

Although we speak of cause-effect steps and subnode interactions, the Node N as a whole remains changeless in its global property (energy, etc.). The cause-effect network represents internal rearrangements of that fixed total. Nothing external changes; the entire structure is like a static tapestry of possible cause-effect pathways, but locally perceived as sequences of transformations.

9.2 Consistency with Physical Theories

- **General Physical Compatibility:** By not specifying the exact subnode coupling, emergent geometry or fields can arise. Standard concepts (mass, charge, etc.) may be grafted onto these cause-effect relationships.
- **Signal-Based Metric:** Physics often uses light signals or wave propagation to define time and distance operationally. This model generalizes that idea to any cause-effect path in the abstract Node.

10 Conclusion

We have outlined a model in which:

1. A single, stable Node houses an incomputable internal structure of subnodes.

2. Subnodes interact via cause-effect relationships, establishing a partial order.
3. *Time* emerges from the local ordering of cause and effect.
4. *Distance* emerges by counting how many steps are required for a subnode i to affect another subnode j (or itself again in a loop).

This framework reproduces the key operational features of measurement: we build clocks from repeated cause-effect loops, and we measure distances by the causal chains needed to propagate signals. Hence, familiar constructs of time and space follow naturally from the stable Node's internal logic of cause and effect.

11 About Author(s)

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12 References

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