Unified Framework for Fundamental Interaction and Communication (FIL) — Part I: Local Language Constructors and the Nibbler Algorithm

Abstract

This first installment of the FIL research program introduces the core architectural constructs underlying the Fundamental Interaction and Communication (FIL) framework. The emphasis is on Local Language Constructors (LLC), minimal and correctness-preserving semantic bridges between distinct knowledge domains, and the Nibbler Algorithm, a method for differential discovery and path compression in semantic graphs. Recent refinements integrate temperature-weighted Voronoi tessellation concepts, extending LLC bridging efficiency into thermodynamically-informed contexts. Bridge efficiency is defined as the ratio of preserved semantic fidelity to traversal cost, while comprehension distance quantifies the minimal path length in transformed semantic space between source and target domains. We also introduce prime-encoded path signatures, enabling high-resolution analogy tracking across graph structures. An illustrative appendix demonstrates analogy construction through prime factor mapping, providing a deterministic and verifiable basis for analogy validation. Part I establishes the groundwork for subsequent releases, which will explore finite knowledge bounds, semantic shadow reconstruction, and the thermodynamic limits of language transformation.

Keywords: Fundamental Interaction Language; Local Language Constructors; Nibbler Algorithm; Semantic Physics; Voronoi Tessellation; Prime Encoding; Bekenstein Bound; Discovery–Invention Interface

1. Introduction

The FIL framework seeks to unify structural, semantic, and temporal similarity measures within a single operational kernel. Local Language Constructors act as high-fidelity semantic mappers, enabling controlled traversal between otherwise isolated domains.

2. The Nibbler Algorithm

The Nibbler Algorithm implements an incremental, differential search through semantic graph space. It identifies minimal change sets needed to bridge knowledge nodes, compressing traversal cost while preserving semantic integrity. Recent updates introduce weighting functions derived from thermodynamic parameters, improving prioritization under energy constraints.

3. Temperature-Weighted Voronoi Boundaries

By mapping semantic domains into Voronoi regions and applying a temperature gradient, LLC performance can be optimized according to environmental or contextual constraints. This transforms the LLC selection process into a heat-diffusion problem.

4. Prime-Encoded Path Signatures

Each semantic traversal is encoded as a composite of prime identifiers. Analogical relationships are detected via factorization, allowing for deterministic matching between structurally similar paths even when surface representations diverge.

5. Conclusion and Outlook

Part I defines the foundational tools for the FIL program. Future work will integrate these with finite knowledge bound theory, semantic shadow reconstruction, and dynamic masking for drift detection in human and machine cognition.

Appendix

Appendix A: Example Prime-Encoded Analogy Mapping Source Path: Node A → Node B → Node C Prime Encoding: $2 \times 5 \times 11 = 110$ Target Path: Node X → Node Y → Node Z Prime Encoding: $2 \times 5 \times 17 = 170$ Common Factors: 2×5 (shared semantic base) Distinct Factors: 11 vs 17 (differentiating semantic elements) Interpretation: Shared foundational meaning with domain-specific extensions.