

# GDL v1.0 — GhostLink Difference Language (Substrate Contract)

## Types (SIMD-friendly)

lattice<N>, mask<N> (bitset), f32<N> (SoA float field), u8<N> (state), rng<N> (per-cell RNG), global<f32[k]> (SELF), topology (CSR/stencil).

## Operators (9 verbs)

SELECTΔ, MAPNBR, SELFENC, SCORE, SOFTMAX/DRAW, WRITE, RECYCLE, TRACE, ORDER.

## Grammar (minimal)

Program ::= Header Topology Fields Rules Pipeline. Rules set p0, alpha\_c, energy expressions with SELF; tick composes the nine ops. Expressions are pointwise or neighbor-reduce only for determinism & vectorization.

## IR / Bytecode (16 ops)

0x01 BUILD\_DELTA, 0x02 NB\_REDUCE, 0x03 SELF\_ENC, 0x04 ENERGY, 0x05 SOFTMAX, 0x06 SAMPLE\_CAT, 0x07 WRITE\_STATE, 0x08 RECYCLE, 0x09 TRACE\_DECAY, 0x0A TRACE\_ACCUM, 0x0B SCHED\_UPDATE, 0x0C ORDER\_APPLY, 0x0D LOG\_EVENTS, 0x0E RNG\_SPLIT, 0x0F MASK\_FILTER. See gdl\_ir\_opcodes.json.

## Operational semantics

Snapshot read → compute fields/energies → sample with per-cell RNG → single-writer WRITE → RECYCLE → TRACE. Determinism tiers: D0 (no RNG), D1 (seeded per-cell), D2 (parallel assoc ops).

## Memory model

SoA arrays, compressed Δ\_t index buffer, CSR topology or stencil, tiled execution for cache/NUMA; ORDER uses branchless table select.

## SELF channel & Safety

SELF = Encode(|Σ|/N, p<sup>-</sup>, κ<sup>-</sup>, integration, activity). Energies += θ\_self(W,SELF). Invariants: alphabet total, one writer/cell/tick, bounded RNG use, traces in [0,1].

## FFI & Proof hooks

extern fields for I/O; extern log for legacy; activity/Σ counters; snapshots & events for origin min-cut.

## Example

See gdl\_example.gdl for a complete tick pipeline on spherical topology (icosahedral subdivision).