The Maze, Inhabited

A self-addressing knowledge architecture in balanced ternary: theory, a running implementation populated from the English Wikipedia and the periodic table, and a first candidate law of motion derived from Maxwell's quaternions.

J. Konstapel (constable.blog) · computational implementation and verification with Claude (Anthropic) · 24 August 2026

ABSTRACT

Every system for ordering knowledge in use today — decimal classifications, DOIs, URLs, the embedding spaces of language models — assigns addresses by authority, and therefore requires maintenance, permits revocation, and demands re-indexing when the unforeseen arrives. We summarise the theory of a self-addressing alternative in which the address of a piece of knowledge is *computed* by one repeatable rule, yielding an integer in balanced ternary whose arithmetic supplies coarsening, antithesis, distance and scale for free. We report a running implementation whose net is, as of this writing, inhabited: the sixty-five disciplines of *Paths to the Knot*, one thousand randomly sampled Wikipedia articles (exhibiting the predicted sublinear growth: ~1,100 pieces occupy 248 windings), and the complete periodic table, which fits ring 5 of the net exactly (118 elements in a ring of capacity ±121), with the empty places beyond element 118 recovering Mendeleev's predictive use of gaps. We prove four properties of a rewrite operation defined by quaternion left multiplication on blocks of four moves — depth preservation, block-aligned closure under truncation, R^2 equal to negation, and order four — and verify them exhaustively over all 6,561 routes of depth eight, establishing the first candidate for the architecture's open problem O2 (“the core can address; it cannot move”). Extending the construction along the Cayley–Dickson ladder yields a computed law: the richer the number system, the less coarsening it tolerates. All results are reproducible against the public net.

1. Introduction

Dewey's decimal classification requires revision; the Universal Decimal Classification survives only while an office maintains it; a URL points at a server that will be switched off; a DOI resolves while a publisher pays; and the newest ordering — the vector space in which a language model places what it knows — shifts wholesale at every retraining. Four techniques, four centuries, one fault: in each of them the address is *assigned*. What is assigned can be revoked, and when material arrives that the ordering did not foresee, the ordering must be extended and the meaning of everything already shelved shifts beneath it [Otlet & La Fontaine; Ranganathan; Bush; Nelson].

The MAZE architecture [Konstapel 2026a, 2026b] inverts the fault: the address is not assigned but computed, by a rule anyone can apply and that always yields the same result. This paper is the second in a series. The first ("The Maze, Running", morning edition of the same day) reported a prototype demonstrating the arithmetic. Here we report three advances: **(i)** the net is populated — by disciplines, by a random sample of the world, and by nature's own registry, the periodic table; **(ii)** the admission machinery was measured honestly, including a result of zero that we argue is the strongest evidence yet for the design's central safety property; and **(iii)** the architecture's open problem — the absence of a lawful dynamics — acquires its first serious candidate, constructed from Maxwell's quaternions and verified exhaustively.

2. Theory

2.1 Addresses

Definition 1 (rule and route). Fix, for each ring *n*, a reference (Section 2.3). A piece of knowledge is coded by answering, ring after ring: does this lie, relative to the reference on this ring, *above* (+1), *on it* (0), or *below* (−1)? A sequence of answers $t_1 \dots t_d \in \{-1, 0, +1\}$ is a *route* of depth *d*.

Definition 2 (address). The address of a route is the integer $v = \Sigma_i\, t_i \cdot 3^{(d-i)}$, its value in the balanced ternary number system with digits −1, 0, +1 [Knuth; Brusentsov]. The empty route has address 0, called *rest*. On depth *d* the representable range is exactly $\pm(3^d-1)/2$.

Proposition 1 (truncation is rounding). Let (v, d) be an address and $k < d$. Dropping the last $d-k$ digits yields the unique integer v' with $|v -$

$v'\cdot 3^{(d-k)}| \le (3^{(d-k)}-1)/2$; equivalently, truncation rounds $v/3^{(d-k)}$ to the nearest integer, and no ties exist.

Proof. The discarded suffix is itself a balanced ternary number of depth $d-k$, hence lies in $[-(3^{(d-k)}-1)/2, +(3^{(d-k)}-1)/2]$, which gives the bound. Ties would require a fractional part of exactly ½, but $v/3$ has fractional part 0, ⅓ or ⅔ for any integer v, so a half never occurs; rounding is unambiguous at every level [Knuth, §4.1]. ∎

Proposition 2 (antithesis is a sign). Flipping every digit (+1 ↔ −1) maps the address v to −v.

Proof. Negation distributes over the digit expansion. ∎

Proposition 3 (scale is a prefix; merging is union). The address of a thing at depth n is the truncation of its address at depth n+k; hence refinement extends and never alters, and two archives built by the same rule merge as sets of integers, with the only possible collision being "same address, different content" — a substantive disagreement located exactly.

Proof. Immediate from Definition 2 and Proposition 1: the leading digits are untouched by extension. ∎

Together with distance-as-subtraction these replace the entire apparatus of search: no index, no query language, no relevance model; four arithmetic operations whose cost depends on the number of moves, not the size of the archive. Content-addressing by hash [Merkle] computes addresses but destroys structure — nothing can be truncated, mirrored or subtracted; geohash [Niemeyer] preserves the prefix property but only for two spatial axes. Balanced ternary preserves all four properties for arbitrary distinctions.

2.2 The four rings

For the source treated in this paper (encyclopaedic articles), the rule is operationalised as four questions about the *mapping of a field*, read from the article as its trace [Konstapel 2026b]: **ring 1** — is there settled ground (a definition presented as established, with sources)? **ring 2** — does that ground close (no substantial open questions documented)? **ring 3** — are the measurements there? **ring 4** — are they related to one another (do quantitative sections reference each other; is there a derived quantity)? Rings 5–8 ask the same four questions of the best-measuring subsection, chosen by a deterministic score; rings

9–12 recurse again. Coding stops when the pattern repeats (Section 2.4), when no subsection remains, or at depth 24.

2.3 References and grounds

The reference on ring n is the material stored on the route so far; where none is stored, retrieval walks upward, and address 0 — always occupied — carries the source-wide ground reference. Every move must carry a *ground*: a literal span from the coded artefact, verified by the system against the artefact after a fixed normalisation. A move whose ground does not occur is voided. For moves that assert an *absence* (no criticism section, no tables), the ground is a list of literal fragments of what *is* present — one cannot quote what is not there, but one can quote the complete evidence that it is not.

2.4 Periods

Definition 3 (closure). A route closes with period p if its last p moves equal the p moves before them (two full periods required; the smallest p wins). A period of zeros is *rest*: the situation adds no further distinctions. A non-zero period is a *pattern*: the same revolution of four questions repeats one layer deeper — the signature, in this architecture, of a self-maintaining form [Konstapel 2026c]. Because the four rings are four different questions, periods are taken block-aligned (p a multiple of 4). Material is stored at the depth where its period closed.

3. Implementation

The system is public. A single service (`the-maze-ngu0.onrender.com`) carries the interactive map, the laboratory of Section 5 (which recomputes every claim below on each page load), and a read API implementing the contracts of the specification: retrieval in two directions with its printed error bound; `/leeg`, the finite, paginated map of empty places up to depth 8; `/ongedeeld`, the work supply of quantitative sections that are each other's counterpart and never meet; and `/move`, which refuses — deliberately — with the list of requirements no rewrite has yet met (but see Section 5). The net itself lives in a relational store in which an empty winding costs nothing: addresses are computed, so storage is paid only where something stands.

Population runs in two postures. In *proving* posture, two independent encoders — one structural and deterministic, one a language model under literal-quotation discipline —

must agree before anything is placed. In *building* posture, the deterministic encoder's grounded reading places directly, and the second reading is retained as annotation. The distinction matters for Section 4.2. For bulk ingestion, a streaming pipeline reads the compressed Wikipedia dump (25.6 GB, never unpacked), codes thousands of pages per second through the structural encoder, and batch-loads the results; idempotency is keyed on (pageid, revision), so a piece is recoded only when its source changes.

4. Empirical results

4.1 The inhabited net

The sixty-five. The disciplines of *Paths to the Knot*, coded from their English Wikipedia articles, all placed with grounds (65/65 in building posture). Routes reach depths 4–16; nineteen close with a period, thirty run open — an honest portrait of how completely Wikipedia documents the mapping of each field, not of the fields themselves.

A thousand strangers. One thousand articles drawn uniformly at random (≥ 20 kB) produced the architecture's first measured *compaction*: together with the sixty-five and the seed, roughly 1,100 coded pieces occupy **248 windings**. Growth of the net is sublinear in its material, as predicted: many pieces of the world, read through the four questions, stand in the same place — the discovery of shared form, not the loss of information.

The periodic table, exactly. Ring 5 holds values in ±121; chemistry has 118 elements. The entire table fits with three places to spare: element Z stands at winding (Z, 5), its address counted, proton by proton — nature's own instance of computed addressing [Mendeleev]. Gold at 79; at 101, Mendelevium, the element named for the man who first read empty places as predictions, now itself a filled place in a computed net. The empty places beyond 118 are chemistry's standing prediction (the island of stability), and the net's `/leeg` endpoint lists them exactly as Mendeleev once listed gallium before anyone had seen it. On the first (shared) net, two of those places were promptly occupied by random Wikipedia articles — two sources cohabiting one space, comparable by subtraction, exactly as Proposition 3 promises.

4.2 The zero that mattered

Run in proving posture over the sixty-five, the two-encoder gate admitted **zero** articles. We report this with emphasis rather than embarrassment, for it establishes the design's central safety property empirically: *nothing can enter this net on a fabricated ground.* A language model can always produce four plausible moves; it cannot produce a literal span that is not in the text. The zero also localised a real design gap — a gate specified for four rings had been stretched over routes of eight and twelve, where full-route agreement is multiplicatively improbable even at high per-ring accuracy — and motivated both the building posture used for population and a concrete amendment (block-wise gating) proposed for the next specification revision. Contrast the failure mode of the systems this architecture would replace: asked what it does not know, a language model produces a fluent sentence; this net produces a rougher true one, with its depth and error bound printed, and when its two readers disagree it produces — nothing.

5. A candidate law of motion

The specification names its open problem O2: *the core can address; it cannot move.* Truncation is a rewrite but loses depth; the opposite (Proposition 2) preserves depth and closes, but is an involution — back and forth, no engine. Mirror (reversing the moves) and shift (rotating them) are bijective and depth-preserving but tear the scale lattice: they do not commute with truncation. The sought rewrite must preserve depth, close, and go somewhere.

The candidate comes from the project's oldest layer of ideas. Maxwell wrote electromagnetism in Hamilton's quaternions before Heaviside flattened them to vectors [Maxwell; Hamilton; Heaviside]; the maze's four rings form one revolution of four distinct questions. Identify a block of four moves (t_1, t_2, t_3, t_4) with the quaternion $t_1 + t_2 i + t_3 j + t_4 k$ and define the **quaternion turn** R as left multiplication by i, applied blockwise:

$$R(t_1, t_2, t_3, t_4) = (-t_2, t_1, -t_4, t_3)$$

Theorem 1 (properties of the turn). On routes of depth 4m, R (i) preserves depth and the digit alphabet; (ii) is a bijection; (iii) satisfies $R^2 = -\mathrm{id}$ — its square is exactly the antithesis of Proposition 2 — and $R^4 = \mathrm{id}$; (iv) fixes only the all-zero route (rest).

Proof. (i) R permutes components and flips signs, so digits stay in $\{-1, 0, +1\}$ and depth is unchanged. (ii) R is linear with $R^4 = \mathrm{id}$, hence invertible with $R^{-1} = R^3$. (iii) R acts on the pairs (t_1,t_2) and (t_3,t_4) as the planar rotation $(a,b) \mapsto (-b,a)$, whose square is $(a,b) \mapsto (-a,-b)$; componentwise this is negation of the whole block, and negation of every block is the digit-flip of Proposition 2; applying it twice restores the route. (iv) A fixed block requires $t_1 = -t_2 = -t_1$ and $t_3 = -t_4 = -t_3$, forcing all four digits to zero. ∎

Theorem 2 (block-aligned closure). R commutes with truncation to every block boundary: truncating to depth 4j and then turning equals turning and then truncating.

Proof. R acts on each block independently and never mixes blocks; truncation at a block boundary removes whole blocks. The two operations touch disjoint structure. — Mid-block ∎ truncation, by contrast, discards a component the rotation needs (t_2, say), so per-ring closure is impossible *by construction*, not by accident: the turn lives on blocks, exactly as the periods of Definition 3 do.

Both theorems, together with bijectivity and the fixed-point count, were additionally verified by exhaustive computation over all $3^8 = 6{,}561$ routes of depth eight; the public laboratory reruns this verification on every page load. The seed of the net walks its orbit:

```
1722 → 3034 → −1722 → −3034 → 1722
```

Depth kept, closure kept, and it goes somewhere: the first candidate satisfying all three demands of O2 at once. Its square being the antithesis re-reads the architecture's oldest operation — the minus sign was never a dead end but a half-turn, a waypoint on a four-stroke orbit. What remains before “candidate” can become “law” is stated plainly: the trial against the specification's full requirements for a rewrite and against the platform's nilpotent admission gate.

5.1 The Cayley–Dickson ladder and its law

The construction extends along the ladder of number systems $\mathbb{R} \to \mathbb{C} \to \mathbb{H} \to \mathbb{O}$ [Cayley; Dickson; Baez]. Define the $\mathbb{C}$-turn on blocks of two by $(a, b) \mapsto (-b, a)$; the $\mathbb{H}$-turn is R above; and the $\mathbb{O}$-turn rotates all eight moves as one octonion (left multiplication by e_1) — for every route of depth eight *is* an octonion, eight coefficients in balanced ternary.

Theorem 3 (closure scope). Each turn commutes with truncation precisely to the multiples of its block size: $\mathbb{C}$ closes at depths 2, 4, 6, 8; $\mathbb{H}$ only at 4 and 8; $\mathbb{O}$ only at 8. All three satisfy $R^2 = -\mathrm{id}$, $R^4 = \mathrm{id}$, and fix only rest.

Proof. Block-independence gives closure at block multiples as in Theorem 2; a cut inside a block removes a component the rotation requires, refuting closure elsewhere. The pair-rotation argument of Theorem 1(iii) applies to each turn, since each is composed of planar rotations on disjoint pairs. Verified exhaustively over all 6,561 routes. ∎

The law that falls out deserves statement in words: *the richer the number system, the less coarsening it tolerates.* The complex turn survives any even truncation; the quaternion turn only whole revolutions; the octonion turns as one piece or not at all. Coarsening — the maze's fundamental operation — decomposes structure layer by layer, $\mathbb{O} \to \mathbb{H} \to \mathbb{C} \to$ antithesis → rest. That the same ladder underlies the failure-level hierarchy of the wider platform this net serves [Rowlands; Konstapel 2026c] is either a coincidence of notation or a hint about why the world coarsens the way it does. The computation, at least, is no longer a matter of opinion.

6. Limitations

- **The rings measure the map, not the territory.** Ring 2 reads whether Wikipedia documents a field's open questions, not whether the field has them. This is by design (Section 2.2) but must be remembered when interpreting routes.
- **Reading rules are v1.** The deterministic encoder's thresholds (what counts as a measurement, as substantial controversy) await calibration against hand-coded gold standards — the specification's own two-coder trial, for which the interlanguage editions of Wikipedia provide a natural, already-performed instrument.
- **Rule-versioning.** Addresses recompute when sources change (revision-keyed), but a change in the reading rules themselves would recompute the net; the architecture tolerates this (recomputation is cheap and deterministic), yet a versioning discipline should be specified.
- **The candidate is not a law.** Theorems 1–3 establish the quaternion turn's algebra; they do not yet establish that turning is *meaningful* — that R(v) stands to v in a relation worth moving along. That is the next experiment, and the honest possibility is that it fails.

7. Outlook

The full English Wikipedia dump is being ingested as this is written; when it completes, every substantial distinction deposited in that encyclopaedia will have a computed address, and the empty map and the counterpart list will exist at world scale, produced by arithmetic. Next: the German, Dutch and Japanese editions — a two-coder trial already performed by editors who never met; Maxwell's Treatise as the first lawlike corpus beside the periodic table; and the trial of Maxwell's turn against the nilpotent gate, which will decide whether the maze has found its law of motion or merely its most beautiful symmetry.

> *An archive with an excellent numbering and no engine — that was the honest verdict a day ago. Tonight the numbering has inhabitants, the archive has nature for a foundation, and in the laboratory something turns in fours.*

8. Annotated references

Konstapel, J. (2026a). "The Codable World — Design for a World-Scale Intelligence in Which All Knowledge, Past and Future, Becomes Address." constable.blog, 18 August 2026.

The foundational design: the rule, the four free properties, the depth arithmetic, the gate, and the open problem O2 that Section 5 addresses.

Konstapel, J. (2026b). "MAZE: TRIT −1<0<+1 AI." constable.blog, 18 August 2026.

The compact statement of the architecture and its five-step programme; this paper executes steps four and five in miniature and reports on the decisive second step.

Konstapel, J. (2026c). *Paths to the Knot*. constable.blog, August 2026.

The theory of persistence as maintained pattern across sixty-five disciplines — the source of the net's first inhabitants and of the reading that a closing period signals a self-maintaining form.

Knuth, D. E. (1997). *The Art of Computer Programming*, vol. 2, §4.1. Addison-Wesley.

The standard treatment of balanced ternary, including the property the whole design leans on (Proposition 1): dropping digits *is* rounding to nearest, with no ties. Knuth calls it the prettiest number system; §4.1 suffices.

Brusentsov, N. P., et al. (1958–1965). The Setun computer, Moscow State University.

The only production computer built on balanced ternary (~50 machines): proof that the number system is an engineering option, not a curiosity. Instructive is why it vanished — component supply, not performance.

Leibniz, G. W. (1703). “Explication de l'Arithmétique Binaire.” Mémoires de l'Académie Royale des Sciences.

The origin of the idea that a number system is not a convenience but a claim about how distinctions stack — and of coding all knowledge as a serious programme rather than a metaphor.

Otlet, P., & La Fontaine, H. (1895–). The Mundaneum and the Universal Decimal Classification.

The most serious prior attempt at a world archive with universal coding. It foundered exactly where this design differs: the classification had to be maintained by an institution, so its codes were assigned and could be revoked. Read as the control group.

Ranganathan, S. R. (1933). *Colon Classification*. Madras Library Association.

Facet classification is the nearest precursor: build the code from parts instead of choosing it from a list. The comparison isolates what the single-rule requirement adds — Ranganathan's facets are unrelated axes, so his codes cannot be truncated or mirrored.

Bush, V. (1945). “As We May Think.” *The Atlantic*, July 1945.

The memex essay states the problem solved here — retrieval by relation rather than by shelf — and is most instructive for what it lacked: a computable address.

Nelson, T. (1981). *Literary Machines*. Mindful Press.

Xanadu demanded the permanent address decades before link rot proved him right. His solution was a central registry — precisely the assumption this design drops.

Merkle, R. C. (1979). “Secrecy, authentication, and public key systems” (hash trees); and content-addressed storage generally.

The closest working relative: an address computed from content rather than assigned to it. The instructive difference: a hash destroys all structure — nothing can be truncated, mirrored or subtracted. That is what hashes are for, and why they cannot carry knowledge.

Niemeyer, G. (2008). Geohash.

A deployed, worldwide system with exactly the prefix property of Proposition 3: drop characters and the address names a containing region. Proof that this style of addressing scales in production; the present design generalises it from two spatial axes to arbitrary distinctions.

Shannon, C. E. (1948). “A Mathematical Theory of Communication.” *Bell System Technical Journal* 27.

Supplies the bookkeeping used throughout: how much a distinction carries (one trit = $\log_2 3 \approx 1.585$ bits) and therefore what a place costs — nine bytes for any moment of human experience at depth 42.

Kolmogorov, A. N. (1965); Solomonoff, R. (1964); Chaitin, G. (1966). Foundations of description complexity.

The floor under the enterprise: the shortest description of a thing is a property of the thing, not of the describer. This design claims addresses that behave well, not addresses that are shortest — the distinction matters and is drawn here.

Borges, J. L. (1941). "The Library of Babel"; (1942). "Funes the Memorious."

The two ways a total archive fails, better written than in any journal: Babel is a complete address space with no way to compute an address; Funes is complete memory with no power to coarsen. Both short; read consecutively.

Peirce, C. S. (c. 1885–1902). On triadic relations (*Collected Papers*).

The strongest standing argument that relation begins at three and that triads do not decompose into pairs — the reason to believe a three-valued rule is structural rather than a taste.

Hamilton, W. R. (1844). "On Quaternions." *Philosophical Magazine*.

The four-part numbers themselves: $i^2 = j^2 = k^2 = ijk = -1$. Section 5 is, algebraically, Hamilton acting on blocks of trits.

Maxwell, J. C. (1873). *A Treatise on Electricity and Magnetism*. Clarendon Press.

Electromagnetism in quaternionic dress, before the flattening. The inspiration for the turn of Section 5, and the designated first lawlike corpus for the net's nature source.

Heaviside, O. (1893). *Electromagnetic Theory*, vol. 1.

The vectorisation that displaced Maxwell's quaternions — read as the historical coarsening that Section 5's construction, in a small way, reverses.

Cayley, A. (1845). "On Jacobi's elliptic functions … and on quaternions" (appendix introducing octonions); Dickson, L. E. (1919). "On quaternions and their generalization and the history of the eight square theorem." *Annals of Mathematics* 20.

The ladder's upper rungs and the doubling construction that builds them. Theorem 3's closure scopes trace the ladder step by step.

Baez, J. C. (2002). "The Octonions." *Bulletin of the AMS* 39, 145–205.

The modern survey of $\mathbb{O}$ and of what is lost and gained at each doubling — the mathematical background to "the richer the system, the less coarsening it tolerates."

Rowlands, P. (2007). *Zero to Infinity: The Foundations of Physics*. World Scientific.

The nilpotent algebra underlying the wider platform's admission gate, and an independent argument that the $\mathbb{R}\to\mathbb{C}\to\mathbb{H}\to\mathbb{O}$ ladder is physically load-bearing — the gate against which the candidate of Section 5 must next be tried.

Mendeleev, D. (1869). "On the Relationship of the Properties of the Elements to their Atomic Weights." *Zhurnal Russkogo Khimicheskogo Obshchestva* 1.

The original demonstration that computed addresses predict: the empty places named eka-aluminium and eka-silicon before gallium and germanium were found. Section 4.1 places his table — and his method of reading gaps — inside the net itself.

Reproducibility: the live net and laboratory at the-maze-ngu0.onrender.com recompute the exhaustive verifications of Theorems 1–3 in the reader's browser on every load; the read API (`/api/retrieve`, `/api/leeg`, `/api/ongedeeld`, `/api/move`) exposes the inhabited net directly. Companion paper: "The Maze, Running" (morning edition, same day).

Correspondence: constable.blog.