The Materialization of Archetypal Patterns in Information Science and Quantum Computing (2025)

Abstract

This article presents an academic, rigorous, and transdisciplinary version of an interpretive thesis on the convergence of **modular quantum computing**, **distributed informational infrastructures** (e.g., blockchain), and **additive manufacturing** (3D printing). We analyze recent technical developments — especially IBM's roadmap for **quantum-centric supercomputing** and Microsoft's announcement of the **Majorana 1** (topological QPU) — as technoscientific evidence that lends plausibility to a theoretical framework based on three principles: (i) the **triadic structure** (physical–informational–quantum); (ii) **verifiable modularity**; (iii) **distributed informational encapsulation**. From a methodology of **archetypal synthesis** (abduction structured through cross-domain analogies), we propose testable propositions concerning (A) reality as a distributed informational system, (B) consciousness as a consensus process with analogies to informational redundancy (quantum Darwinism), and (C) evolution as the progressive "printing" of complexity. We discuss limitations, risks of extrapolation, and empirical agendas for falsification/collaboration.

Keywords: modular quantum computing; topological qubits; distributed consensus; blockchain; additive manufacturing; quantum Darwinism; philosophy of information.

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1. Introduction

Recent years have seen a concrete inflection toward **large-scale quantum–classical integration**. On February 19, 2025, Microsoft announced the **Majorana 1**, described as the first **quantum processing unit (QPU) with topological qubits** based on a "**topological superconductor**" and a **Topological Core architecture**, with the explicit ambition of shortening the horizon for **fault tolerance** "from decades to years." On June 10, 2025, IBM outlined its plan to build the **world's first large-scale fault-tolerant quantum computer** at a new dedicated data center, articulating this effort with its vision of **quantum-centric supercomputing**: a fabric that **weaves QPUs, CPUs, and GPUs** into a coherent computational mesh.

Taken as **sentinel cases**, these initiatives reinforce the hypothesis that certain **archetypal patterns** — modularity, encapsulation, and distributed verification — traverse distinct ontological levels and **recur** in next-generation technologies.

2. Recent technical-scientific foundations

2.1. Quantum-centric supercomputing (IBM)

Since 2022, IBM has formalized the concept of **quantum-centric supercomputing**, i.e., architectures that **couple** QPUs to **HPC systems** through dedicated software, interconnections, and schedulers. This vision was updated in 2025 with goals for **modular scaling**, error-correcting codes (e.g., *bivariate bicycle*), and a trajectory toward **useful logical machines**, culminating in the **Starling system** projected for 2029 (capable of executing ~**100 million gates** on ~**200 logical qubits**). The company also announced a **quantum data center** and a path toward **large-scale fault-tolerant quantum computers**.

2.2. Topological qubits and the Majorana 1 (Microsoft)

Microsoft presented the **Majorana 1** as a QPU in which **processing and memory** are integrated into a **topological core** built on a **topological superconductor**, leveraging **Majorana modes** for **intrinsic noise protection**. The company links this advance to an acceleration of **fault tolerance** and an **engineering ramp** (e.g., via DARPA consortia) to expand qubit density and fidelity. Academic evidence of relevant *building blocks* (interferometry, *parity readout*, and InAs-Al heterostructures) was reported in *Nature* in 2025, reinforcing the physical plausibility of scalable topological devices.

3. Theoretical framework: three archetypal principles

(P1) Triadic structure (physical–informational–quantum).

- **Physical: Additive manufacturing** materializes forms by **discrete layers**, as per ISO/ASTM 52900 standards and consolidated literature.
- **Informational: Blockchains** organize data into **chained blocks** with **distributed consensus**, ensuring conditional immutability and broad verifiability.
- **Quantum:** the **substrate** of states and entanglement provides degrees of freedom for computation and metrology, but requires **protection/error-correction** modularity.

(P2) Principle of verifiable modularity. Modern engineering favors **self-certifying modules**: **logical qubits** composed of many physical ones; **shards/sub-ledgers** that are auditable; **manufactured parts** validated by testing. IBM and Microsoft's roadmaps explicitly point toward **quantum modules** with **standardized interfaces** and **parallel composition** (running subroutines and "stitching" results), aligned with proposals for **distributed quantum computing** via interconnections and entanglement.

(P3) Distributed informational encapsulation. The redundancy/replication of **informational records** confers **operational objectivity**: at the microphysical limit, **quantum Darwinism** conceptualizes how **environments** proliferate **redundant copies** (*environment as a witness*), enabling agreement among observers on **pointer states**.

4. Methodology: archetypal synthesis (structured abduction)

We employ an **abductive strategy** in three steps: (i) mapping **isomorphisms of structure** (layers/blocks/logical qubits); (ii) **triangulation** with recent technical-scientific sources (roadmaps, white papers, peer-reviewed articles); (iii) formulation of **refutable propositions**. The approach is **theoretical-constructive** (not empirical) but oriented toward **observables** that can support validation/falsification.

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5. Propositions and dialogue with the literature

5.1. Reality as a distributed informational system

Thesis: the empirical regularity of mechanisms of **encapsulation + consensus + redundancy** across scales suggests an informational ontology compatible with **Wheeler's** (*it from bit*) and **Floridi's Philosophy of Information**. **Implication:** laws and causality may be interpreted as **consistency rules** over distributed records (ledger analogy). **Caution:** this is a **heuristic metaphor**, not a literal identification (*cosmic blockchain*).

5.2. Consciousness as consensus (informational analogy)

Hypothesis: conscious processes could exploit **redundancies** and **internal consensus** among neural modules, analogous to **quantum Darwinism** (environmental redundancy of records). **Counterpoint:** classical critiques (e.g., **Tegmark**, 2000) estimate **brain decoherence times** as too short for macroscopic coherent quantum computation; proposals such as **Orch-OR** remain controversial. Thus, the analogy here is **informational-structural**, not a claim of **strong quantum cognition**.

5.3. Evolution as progressive "printing" of complexity

Programmatic hypothesis: biological evolution may be read as the **layer-by-layer accretion** of **functional structures**, with **distributed verification** through environments and ecologies (analogous to incremental printing). This proposition seeks dialogue with **systems biology** and **materials informatics**; its testability depends on **metrics of redundancy/consensus** in biophysical networks. (Not a claim that "DNA is literally a blockchain.")

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6. Technological implications (scenarios)

1. **Modular informational medicine (2025–2027). Immediate and plausible use:** quantum–classical simulations (**quantum-centric**) for **drug chemistry/optimization**, with **validation** via standardized pipelines and **auditable trails** (DAGs, scientific ledgers). Recent technical evidence (IBM) provides **backing** for high-performance hybrid

workflows.

2. **Adaptive materials (2027–2030).** Integration of **materials discovery** via information/consensus models (autonomous labs) with **additive manufacturing** to **iterate geometries and microstructures** rapidly, combining measurement, feedback, and layered production.

3. **Programmable reality (2030–2035).** Speculative (high risk): quantum–classical stacks with **interoperable modules** and **protective codes** could enable **local control** of **effective dynamics** (e.g., engineered Hamiltonians), but **not** manipulation of **fundamental constants**; this remains a **hypothetical perspective** dependent on matured **topological error-correction logics**.

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7. Limitations, risks, and criteria for refutation

- **Evolving technical evidence:** the 2025 announcements (IBM/Microsoft) outline **roadmaps and prototypes**, not ready-made commodities. The claim of "years, not decades" for **FTQC** is an **engineering wager**; objective milestones include **logical qubits with sustained fidelity/lifetime** and **deep circuits** of practical use.
- **Analogy ≠ identity:** "blockchain," "3D printing," and "quantum consensus" are **structural metaphors**. They must be operationalized into **predictions**: e.g., (i) demonstrations of **linked quantum modules** via **entanglement swapping** with total *error rates* below thresholds; (ii) **redundancy metrics** à la **quantum Darwinism** in **physical systems** (not mental) that explain intersubjective objectivity; (iii) **auditable workflows** of scientific data/models with **reproducible provenance**.
- **Consciousness:** any "strong quantum" links to the brain remain **controversial**; critiques of **fast decoherence** remain substantive.

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8. Conclusion

The **modular quantum–classical convergence** (e.g., IBM) and the advance in **topological qubits** (e.g., Microsoft Majorana 1) provide **empirical substance** to an archetypal reading in which **modularity**, **encapsulation**, and **consensus/validation** recur across multiple layers of organization. This framework **does not imply** reducing the world to a literal blockchain; rather, it proposes **structural heuristics** that may **guide research**, **standardization**, and **science policy**. The suggested program is **refutable**: either we will see **interoperable and useful quantum modules** with functional **error correction** and **end-to-end verifiable workflows**, or the archetypal thesis will lose explanatory power. For now, the milestones of 2025 legitimize **serious attention** to the hypothesis.

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Appendix A — Priority empirical claims (research agenda)

1. **Standardized quantum interconnections** between modules (entanglement rates, end-to-end fidelity, throughput).
2. **Public demonstrations of logical qubits** with **topological codes** (e.g., *bicycle*) executing **deep circuits** with *logical error rate < physical threshold*.
3. **Auditable scientific–industrial workflows** via ledgers (data, models, and parameters with **reproducible provenance**).

*Scope note: where we use terms such as "quantum consensus" and "cosmic blockchain," they are **analogical models** to **guide hypotheses** and **metrics** (redundancy, verifiability, modularity), maintaining a clear separation between **metaphorical language** and **empirical claims**.*