

Cryptographic Drift Observatory: Runtime Integrity Monitoring using AI and Quantum-Inspired Behavioral Models

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Abstract

This paper introduces the **Cryptographic Drift Observatory (CDO)**, a telemetry-driven runtime integrity monitoring framework for cryptographic and distributed systems. The core argument is that conventional cybersecurity predominantly validates outputs, such as successful signatures, consensus completion, or protocol correctness, but does not directly observe the internal behavioral physics of deployed secure systems. The proposed framework addresses this gap by continuously monitoring symmetry drift, parity instability, temporal inconsistency, behavioral deformation, structural drift, entropy instability, and runtime degradation. The paper develops the concept of symmetry drift as gradual deviation in structural, temporal, statistical, and behavioral regularity, arguing that such drift may precede visible compromise even when the system still appears correct. To operationalize this idea, the framework combines telemetry collection, temporal integrity monitoring, AI-based anomaly detection, and quantum-inspired behavioral modeling based on high-dimensional state representations and probabilistic system evolution, without requiring a quantum computer. A continuous trust-evolution perspective is proposed in which trust changes with runtime evidence rather than binary pass/fail validation. A cloud-native architecture using FastAPI, Firestore, BigQuery, and AI inference services is presented, together with a conceptual evaluation path and application scenarios including post-quantum cryptography monitoring, blockchain integrity analysis, zero-day anomaly detection, AI agent misuse detection, and critical infrastructure observability. The paper argues that behavioral observability should become a foundational complement to traditional security validation because behavioral physics do not lie.

Scenario	Expected Drift Signal
Side-channel stress	Temporal incoherence
Entropy poisoning	Entropy instability
Blockchain desync	Structural asymmetry
AI-agent misuse	Behavioral deformation

Keywords

Runtime integrity monitoring, cryptographic drift observatory, symmetry drift, temporal coherence, AI anomaly detection, quantum-inspired models, post quantum cryptography, distributed systems observability, trust evolution.