Trust Slope Entanglement: Cryptographic Lineage for Semantic Agents

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Introduction

In cognition-native systems, agents are not authenticated by usernames, certificates, or persistent cryptographic keys. Instead, each semantic agent carries an identity derived from its internal state and its verified history of transformation.

Trust slope entanglement ensures that every authorized mutation of an agent is cryptographically bound to both the agent's prior state and the device-local unpredictability that enabled the mutation. Identity is therefore inseparable from lineage: an agent is trusted only if its path to the present can be verified.

1. Dynamic Agent Hashes

Each semantic agent maintains a Dynamic Agent Hash (DAH) representing its current semantic state, including intent, scope, memory commitments, and mutation parameters. Any structural change to these fields deterministically produces a successor DAH.

DAHs are not credentials. They are non-reusable, non-exportable state commitments that enable peers or validators to assess whether an agent's current presentation is a valid continuation of a previously trusted state.

2. Cryptographic Entanglement with Device Identity

When an agent mutates, the mutation event is cryptographically entangled with the Dynamic Device Hash (DDH) of the host device that executed the mutation. This binds semantic evolution to a concrete execution context without turning the device into a principal identity.

Device-local unpredictability may be derived from non-exportable local entropy sources, sealed device anchors, volatility-tuned state vectors processed by strong extractors, or combinations thereof. The essential property is that valid successors cannot be synthesized off-device from observed identifiers alone.

The resulting entangled mutation record includes the semantic delta, a reference to the prior DAH, the current DDH, and policy metadata governing admissibility. This record is appended to the agent's lineage and cannot be altered retroactively.

Critically, lineage events are not merely logged after the fact. The record is produced only when the proposed mutation has been admitted under the applicable signed policy and meta-policy constraints prior to mutation execution, ensuring that identity continuity reflects governed evolution rather than ungated state change.

3. Identity as Verifiable Lineage

Agent identity is evaluated by validating the trust slope: the ordered sequence of entangled DAH transitions. Validators verify that each step satisfies continuity rules, policy constraints, and device entanglement requirements.

If lineage is incomplete, inconsistent, or violates policy, the agent can be deterministically rejected, sandboxed, or subjected to additional verification. No centralized registry or key authority is required.

4. Security and Integrity Properties

Trust slope entanglement provides strong resistance to impersonation, replay, and unauthorized mutation. An attacker cannot synthesize valid future states without access to both the agent's

prior state and the host's non-exportable local unpredictability.

Because authentication does not rely on long-lived private keypairs, there is no persistent key material to exfiltrate, rotate, or manage at fleet scale. Compromise of a single state does not enable forward impersonation under continuity validation, and policy can deterministically quarantine or downgrade trust when suspicious lineage is detected.

Security properties described here reflect structural guarantees of lineage validation under defined policy and entropy assumptions. They do not assert immunity to all attack classes, implementation flaws, or future cryptographic advances.

5. Deployment in Autonomous and Defense Systems

This model is well suited for autonomous agents, distributed AI systems, and defense or intelligence environments where centralized identity services are unavailable or undesirable.

Trust slope entanglement supports stateless operation, delayed validation, and recovery through policy-bounded checkpoints—while maintaining auditability and cryptographic integrity across disconnected or adversarial environments.

References to autonomous, defense, or intelligence environments are illustrative of structural applicability rather than claims of authorization, adoption, or readiness for use in regulated or classified systems.

Conclusion

Trust slope entanglement reframes agent identity as a provable history rather than a static secret. By requiring every governed semantic transformation to leave a cryptographically verifiable trace, this architecture defines conditions under which integrity, accountability, and resilience can be computed in cognition-native systems, without asserting deployment readiness or outcome guarantees.

An agent's identity is not where it came from—but how it became what it is.