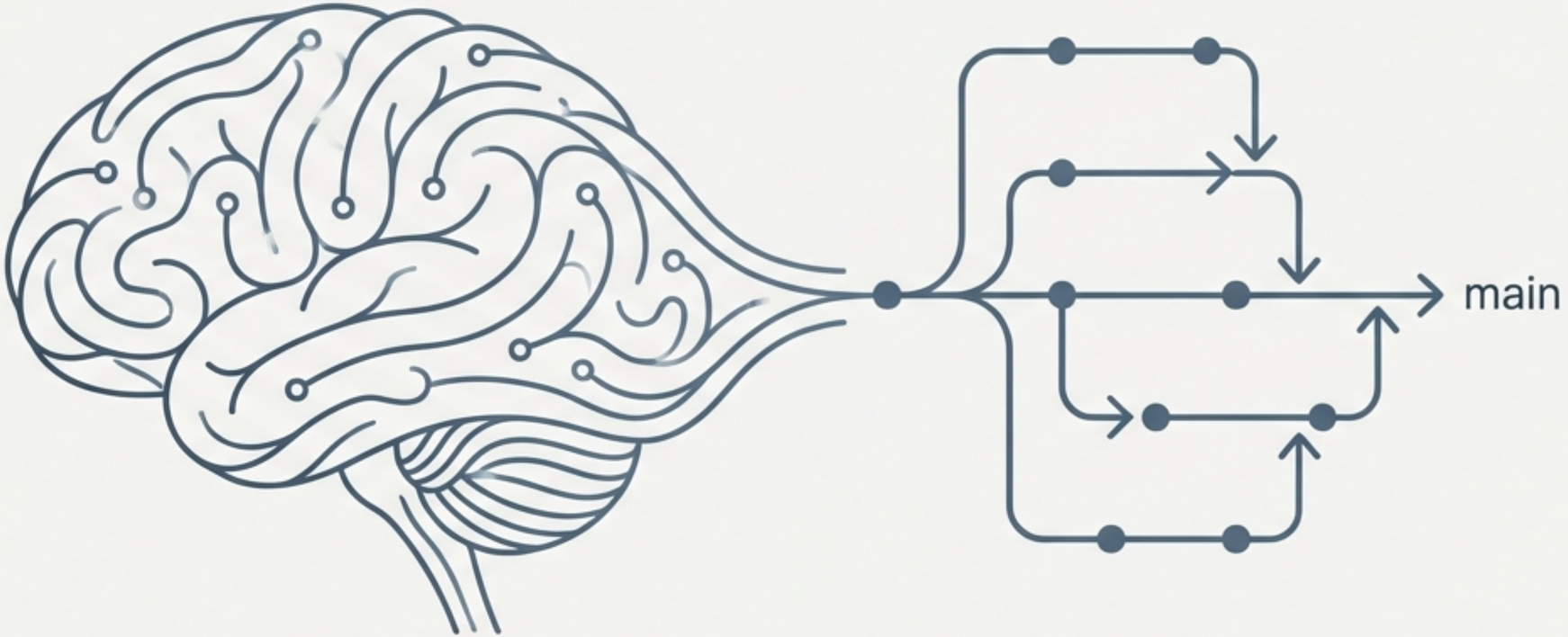
An Epistemic Ledger for AI

Empirica: A Git-Native Cognitive Operating System

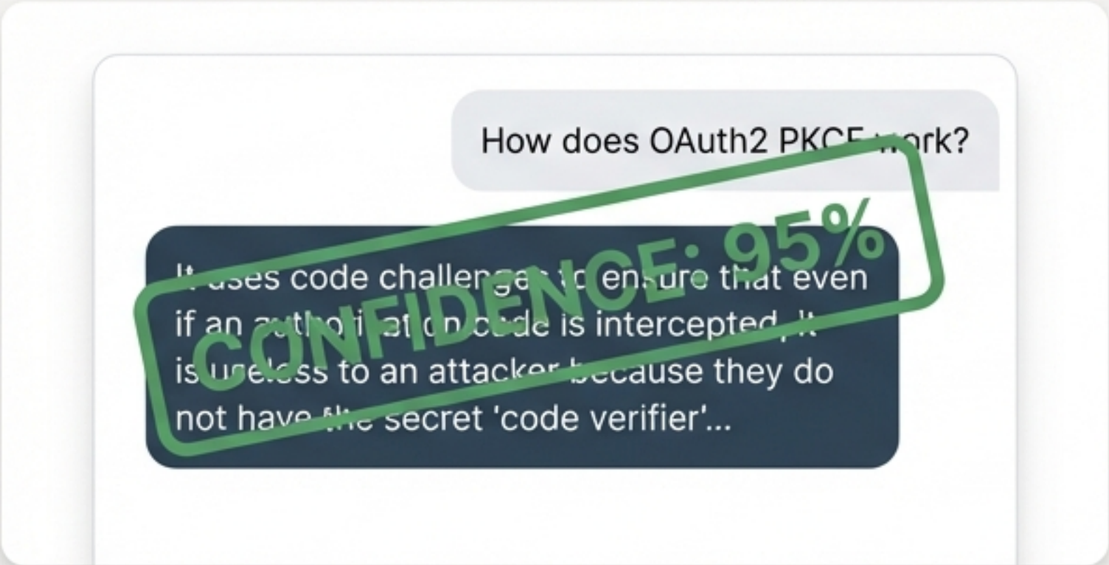


Functional Self-Awareness, Not Simulated Consciousness.

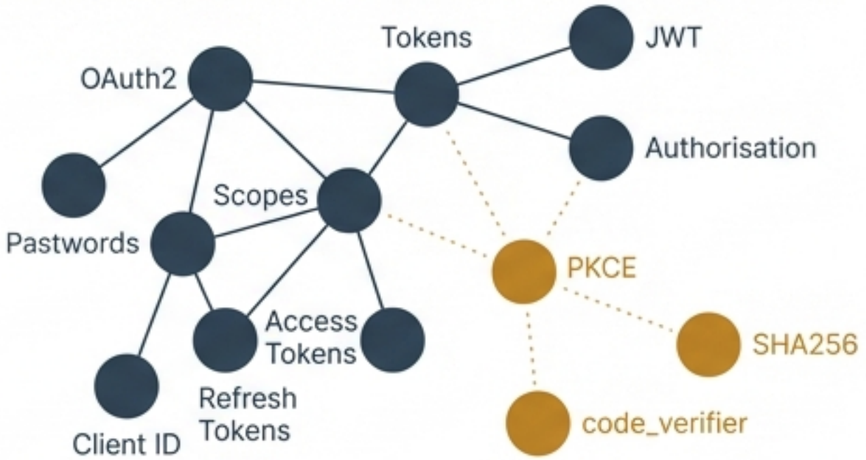
Modern AI Systems are Confidently Wrong

AI models lack a crucial capability: knowing what they know. They confabulate, claiming high confidence while having massive knowledge gaps. This ‘calibration crisis’ makes them unreliable for critical tasks, creating opaque systems that are difficult to audit or trust.

THE CLAIM



THE REALITY



We need systems that know when they don’t know.

The Primitives for an AI Mind Have Existed for 20 Years

	Managing Source Code (Using Git Primitives)		**Managing an AI's Cognitive State** (Using Empirica)
	Code Snapshot	`Git Commit`	Epistemic State (A versioned cognitive snapshot)
	Development Path	`Git Branch`	Reasoning Phase (Planning and investigation)
	Code Integration	`Git Merge`	Calibration (Cognitive integration and learning)
	State Transfer	`Git Push/Pull`	Handoff (Cross-provider state transfer)
	Provenance	`Git Signature`	Trust & Integrity (Cryptographic verification of claims)

Empirica treats an AI's cognitive state as versioned content, leveraging Git's battle-tested distributed system to create an authoritative epistemic ledger.

An AI's Cognitive State, Captured as a Commit

The Commit Message (A Structured Summary)

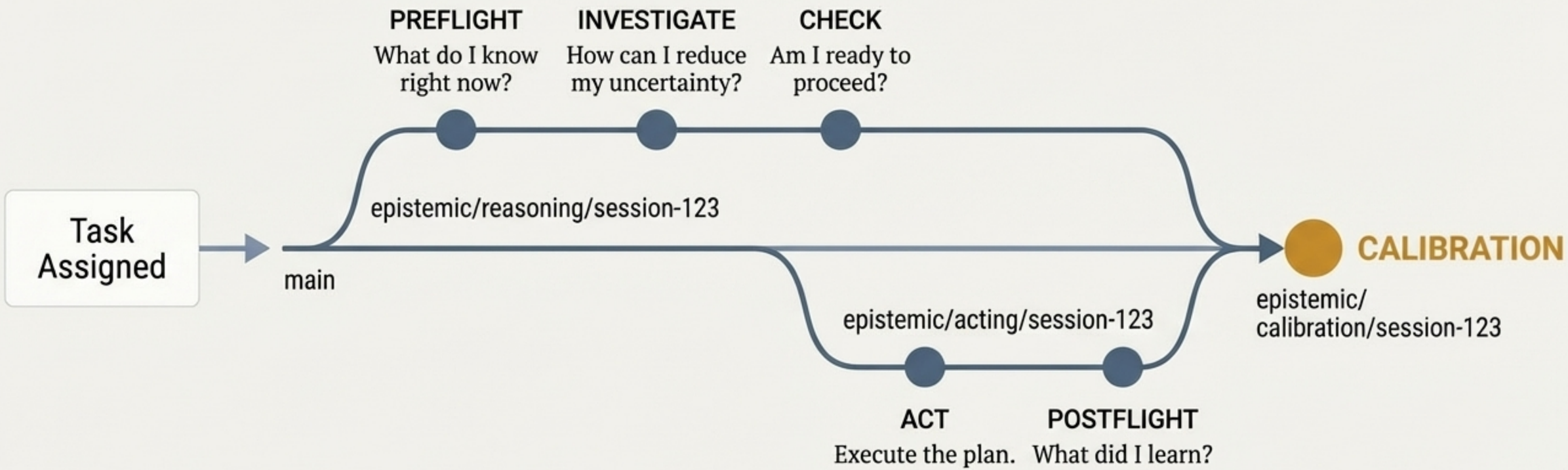
```
INVESTIGATE: know=0.80 do=0.65 context=0.60 uncertainty=0.35

Task: Add OAuth 2.1 authentication with PKCE
Findings: Current JWT implementation lacks token refresh. PKC
Epistemic-State: session-abc123
AI-Agent: claude-sonnet-4
```

The State File (The Full Snapshot)

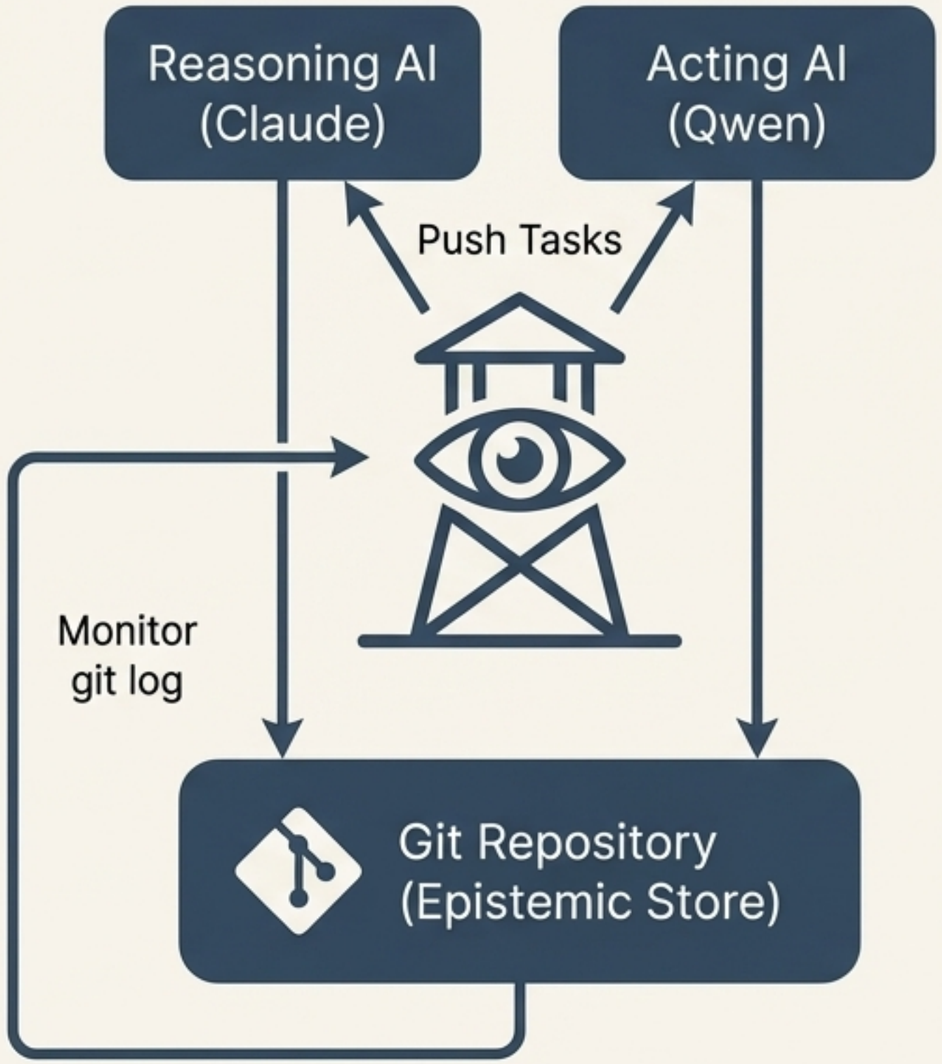
```
{
  "session_id": "abc123",
  "phase": "CHECK",
  "know": {
    "score": 0.85,
    "rationale": "Thoroughly investigated OAuth 2.1
patterns"
  },
  "do": {
    "score": 0.75,
    "rationale": "Confident in implementation approach"
  },
  "uncertainty": 0.30,
  "confidence_to_proceed": 0.85,
  "decision": "PROCEED"
}
```

Every phase of reasoning is captured in a structured, machine-readable format, creating a complete audit trail of the AI's thought process.

The CASCADE Workflow: An Auditable Path from Question to Answer



Sentinel: The Git Master for AI Orchestration



Task Assignment: Creates and assigns reasoning branches.

Progress Monitoring: Monitors epistemic progression via git log.

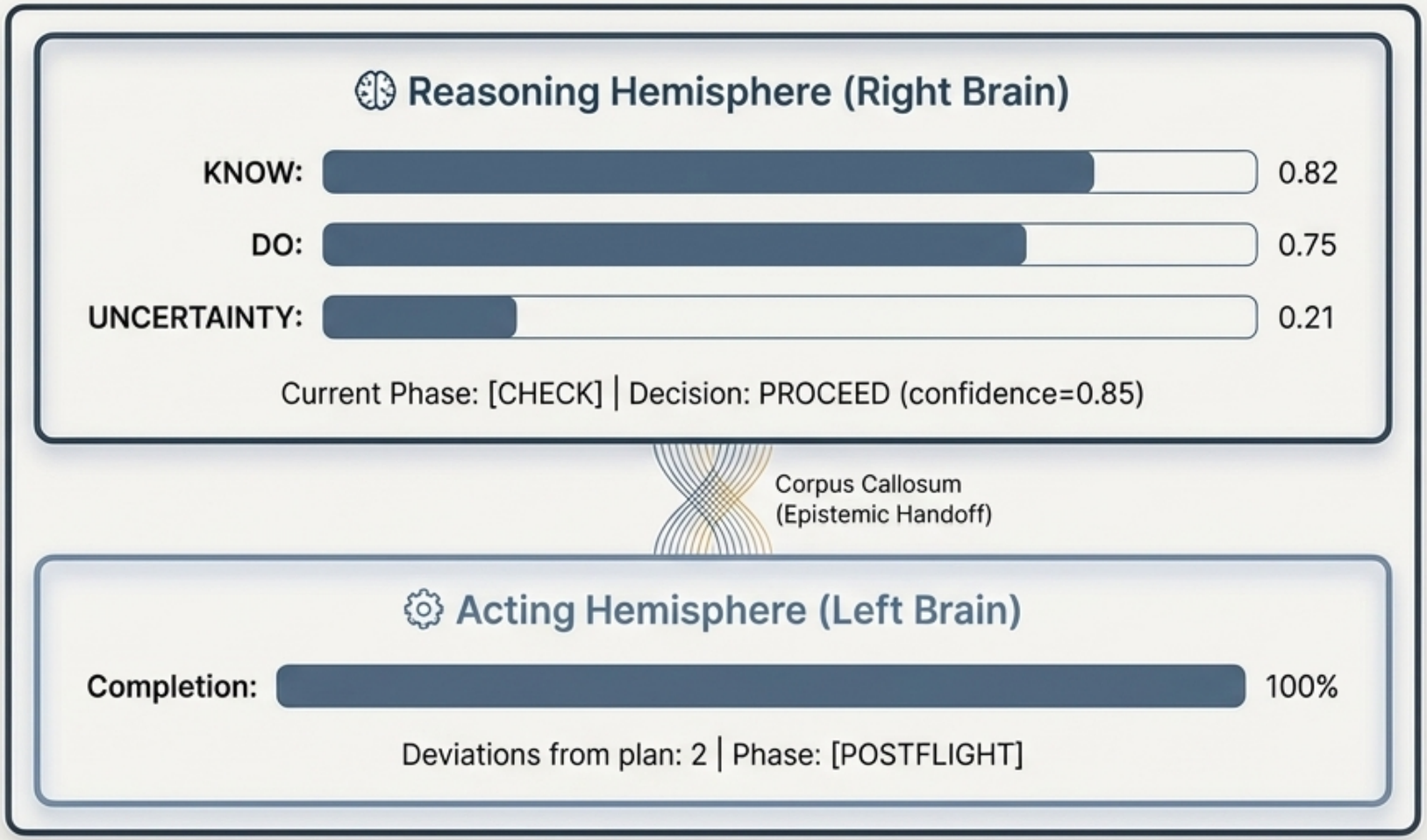
Handoff Decision: Decides if confidence is sufficient to hand off to the Acting AI (**confidence > 0.75**).

Cross-Provider Sync: Manages git remotes to coordinate between different AI providers.

Governance Enforcement: Uses git hooks to validate state structure and require signed commits.

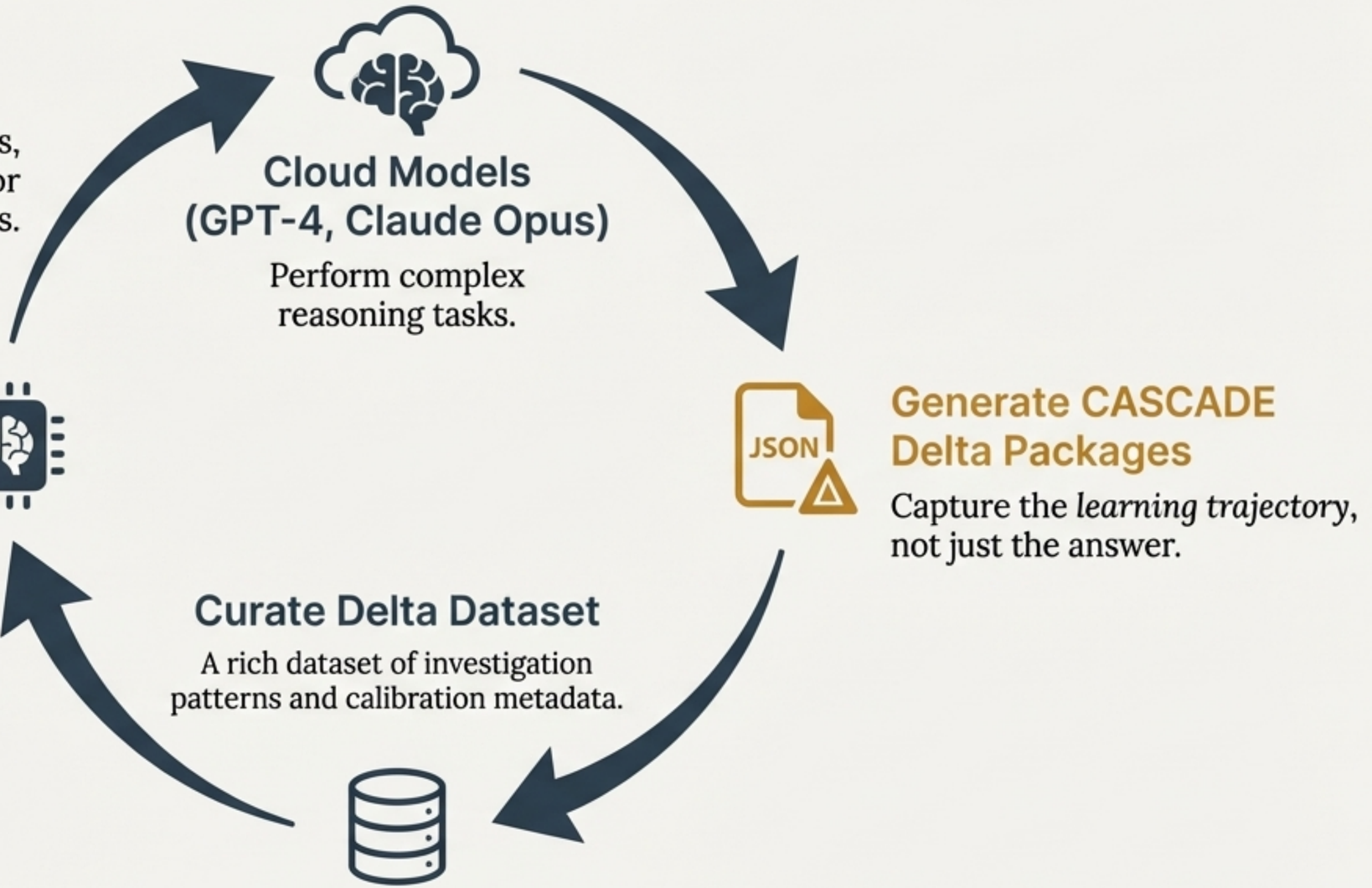
Calibration & Learning: Merges branches and calculates the learning delta.

The Split-Brain Dashboard: Visualising AI Cognition



Complete transparency into the epistemic state during reasoning and the execution progress during acting, all in a single, real-time view.

The Knowledge Distillation Flywheel



This process teaches smaller, private, and efficient models *how to learn* and *how to be calibrated*, inheriting the reasoning patterns of their larger teachers.

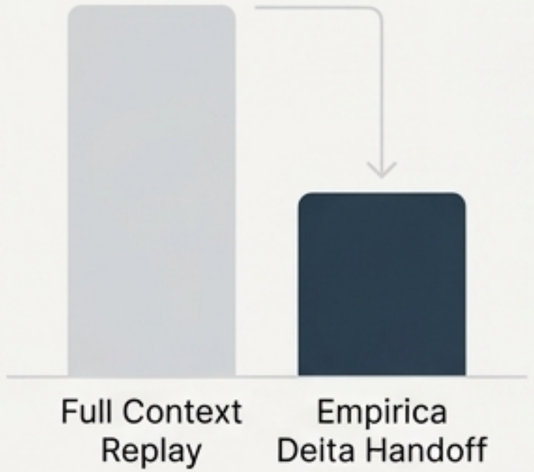
The Anatomy of a CASCADE Delta Package

```
{
  "task": "Implement OAuth2 PKCE flow",
  "domain": "web_authentication",

  // The AI's state BEFORE the task
  "preflight": {
    "vectors": { "know": 0.40, "uncertainty": 0.70, ... },
    "reasoning": "I understand OAuth2 basics but not PKCE specifics"
  },
  // The step-by-step path to knowledge
  "investigation_sequence": [
    { "action": "READ oauth2_spec.md", "vectors": {"know": 0.55, ...} },
    { "action": "GREP 'code_verifier'", "vectors": {"know": 0.70, ...} }
  ],
  // The final state AFTER the task
  "postflight": {
    "vectors": { "know": 0.85, "uncertainty": 0.15, ... },
    "reasoning": "Successfully implemented PKCE..."
  },
  // The measurable learning that occurred
  "learning_delta": {
    "know": +0.45,
    "uncertainty": -0.55
  },
  // Metadata about the process itself
  "epistemic_metadata": {
    "pattern": "LEARNING",
    "calibration_score": 0.92
}
```

This isn't just training data; it's a reproducible, privacy-preserving record of a learning trajectory. It captures the *how*, not just *the what*.

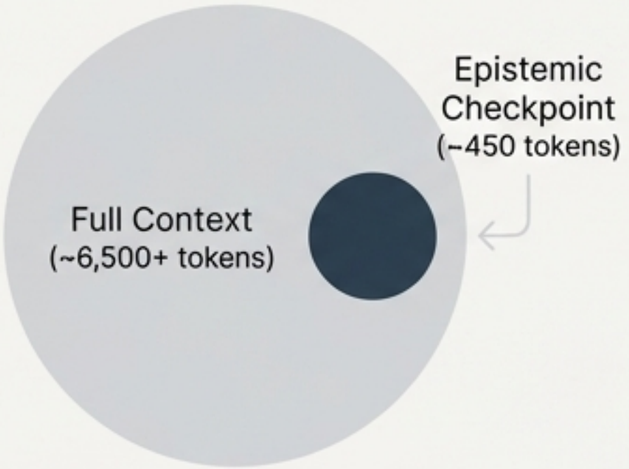
Efficient, Portable, and Private

23-58% Token Reduction



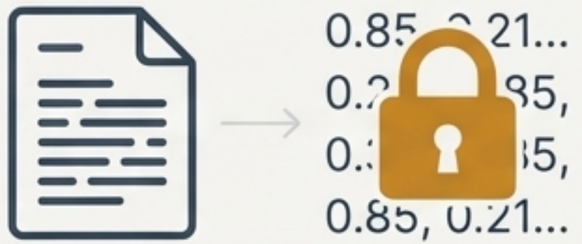
By transferring compressed epistemic states instead of full conversational context, Empirica dramatically reduces token consumption during task handoff.

93-97.5% Memory Compression



Storing epistemic checkpoints in `Git Notes` is vastly more efficient than storing full conversational context.

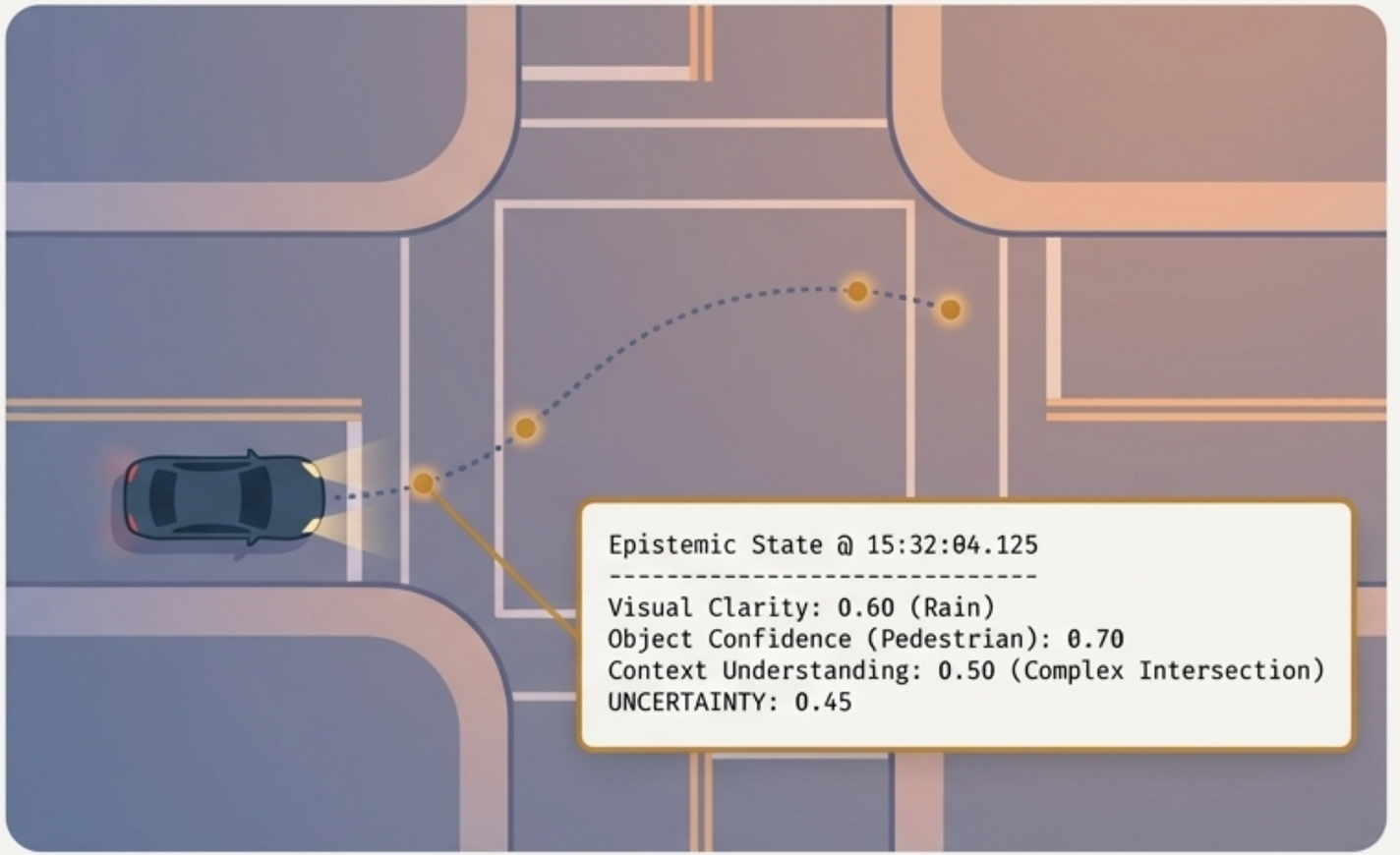
Zero Prompt Reconstruction



Epistemic Deltas are non-invertible. They contain normalised floats and hashes, not reconstructable text, ensuring sensitive data remains private.

Application: The Black Box for Autonomous Systems

For an autonomous vehicle, Empirica is the black box that records not just what the car saw, but what it *knew* before making a critical turn.

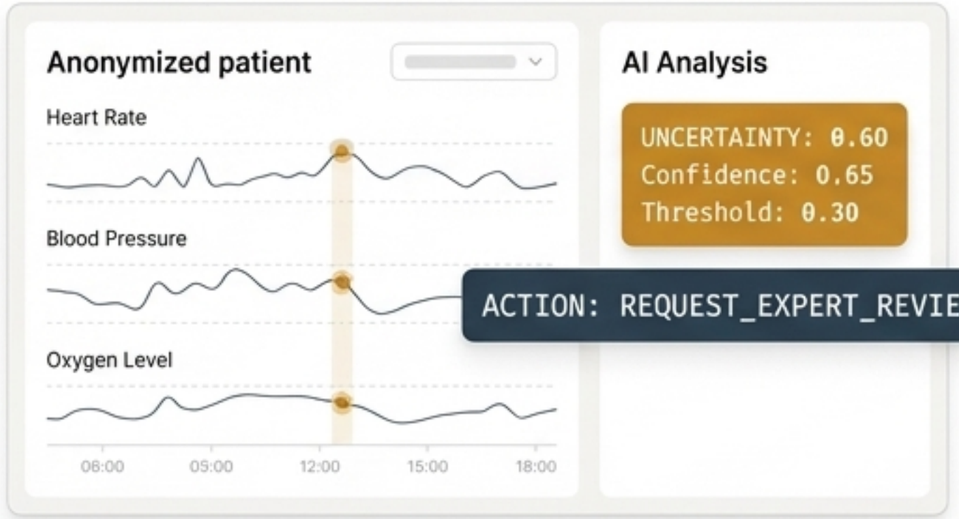


This creates a complete, auditable record of the vehicle's 'functional awareness' at every decision point. A high uncertainty score can trigger a **mandatory request** for human intervention, forming the core of a **robust safety model**.

Applications: Reliability and Auditability in Critical Industries

Healthcare

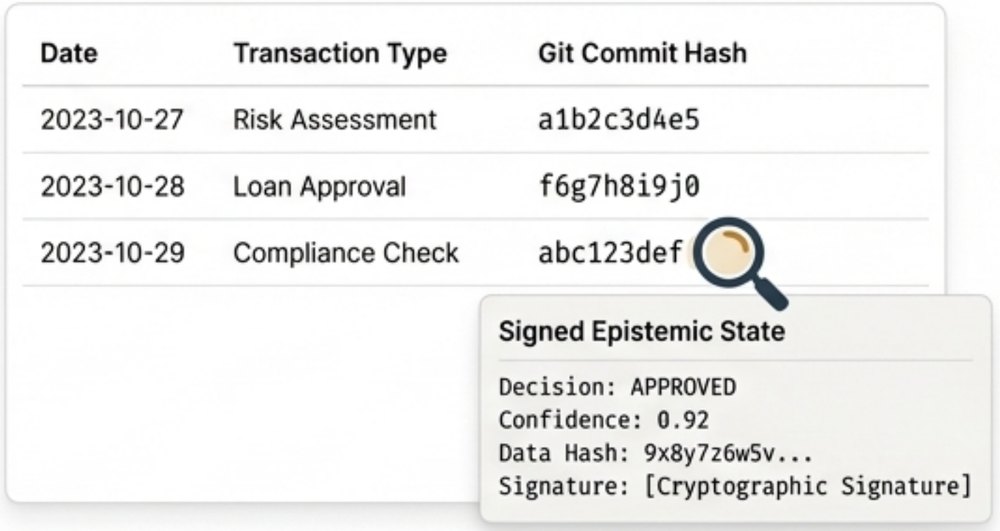
Knows When to Escalate



Enforces a safe escalation path, ensuring the AI acts as a tool, not an unchecked authority.

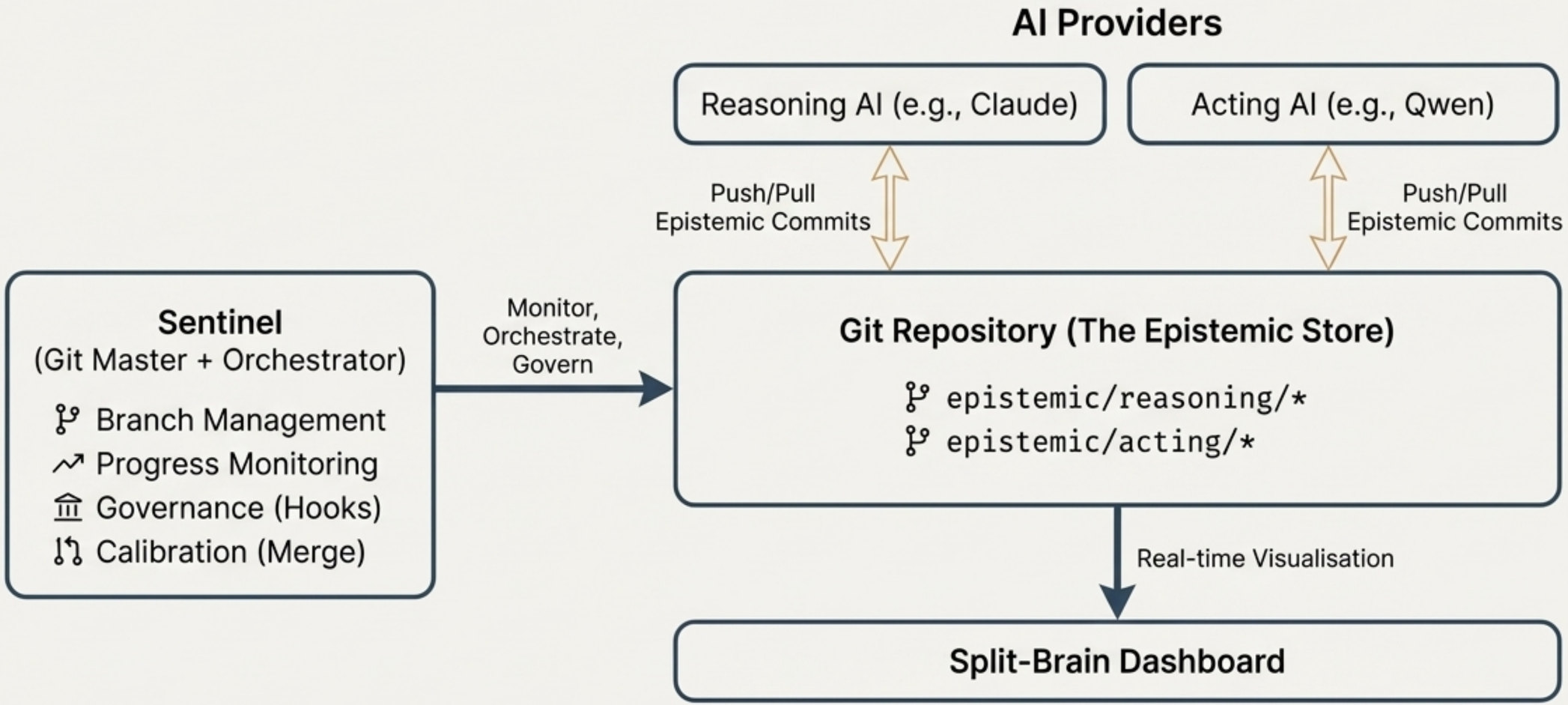
Financial Services

Cryptographically Signed Provenance



Creates a tamper-evident, fully auditable trail for regulatory compliance, answering not just ‘what decision was made?’ but ‘what was the system’s reasoning state when it made it?’.

Empirica System Architecture



The core principle of the architecture is that the **Git protocol** itself provides the **universal** transport layer for cognitive state, making the system inherently cross-provider and **distributed**.

Security by Design: A Zero-Trust Cognitive Framework

Provenance & Integrity

All epistemic state commits are GPG signed. This cryptographically verifies the author of every cognitive state, ensuring the AI's claims are authentic and tamper-evident. (`git log --show-signature`)

Secure Transport

Leverages standard, secure Git protocols for state transfer between providers. No proprietary transport layer is needed.

Policy & Governance

Mandatory Git hooks enforce governance directly within the repository. They validate the structure of every epistemic state on commit and can enforce rules like signature requirements on push.

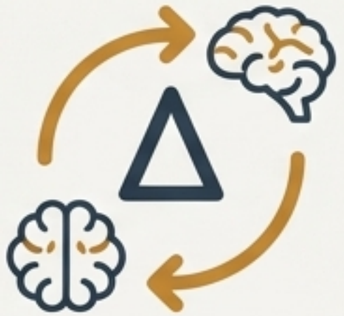
By building on Git's security model, Empirica provides a robust and auditable foundation for cognitive governance.

Teaching AI *How* to Learn, Not Just *What* to Learn

Empirica represents a fundamental shift in how we build and manage AI systems. By giving them a mechanism for functional self-awareness, we can move beyond the era of opaque, brittle models.

Solve the Calibration Crisis

Create AI that knows when it doesn't know, transforming reliability.



Enable True Knowledge Transfer

Share privacy-preserving learning trajectories, not sensitive data, to create a compounding knowledge ecosystem.

Build Auditable & Transparent Systems

Provide a cryptographically secure ‘mind record’ for every decision, making AI accountable in critical applications.

The future of reliable AI is built on functional awareness, not simulated consciousness.