Securing Agentic AI Systems

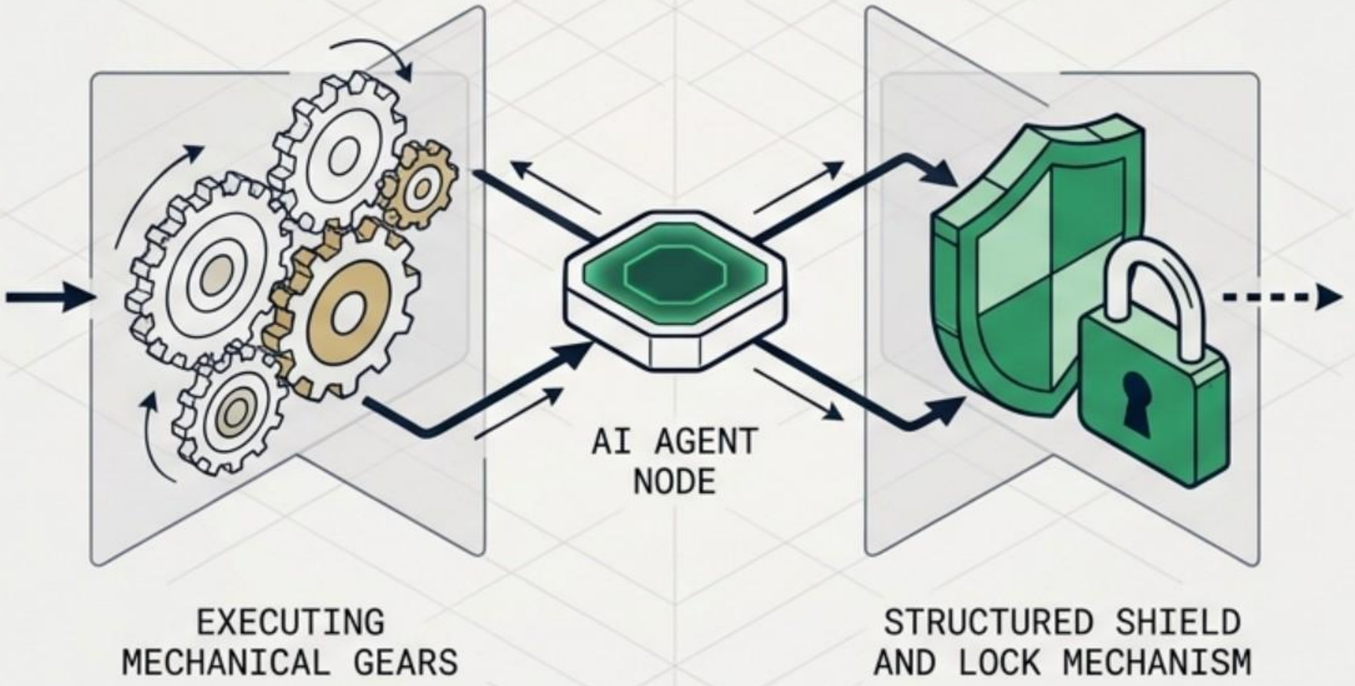
A Strategic Blueprint for Architecture, Threat Mapping, and Defense

Based on joint guidance from ASD, CISA, NSA, CCCS, NCSC-NZ, and NCSC-UK.

The Operational Shift

Agentic AI automates complex, underspecified tasks by **independently reasoning, planning, and executing across critical systems.**

Key shift: Moves from passive content generation to autonomous, goal-directed action without continuous human intervention.

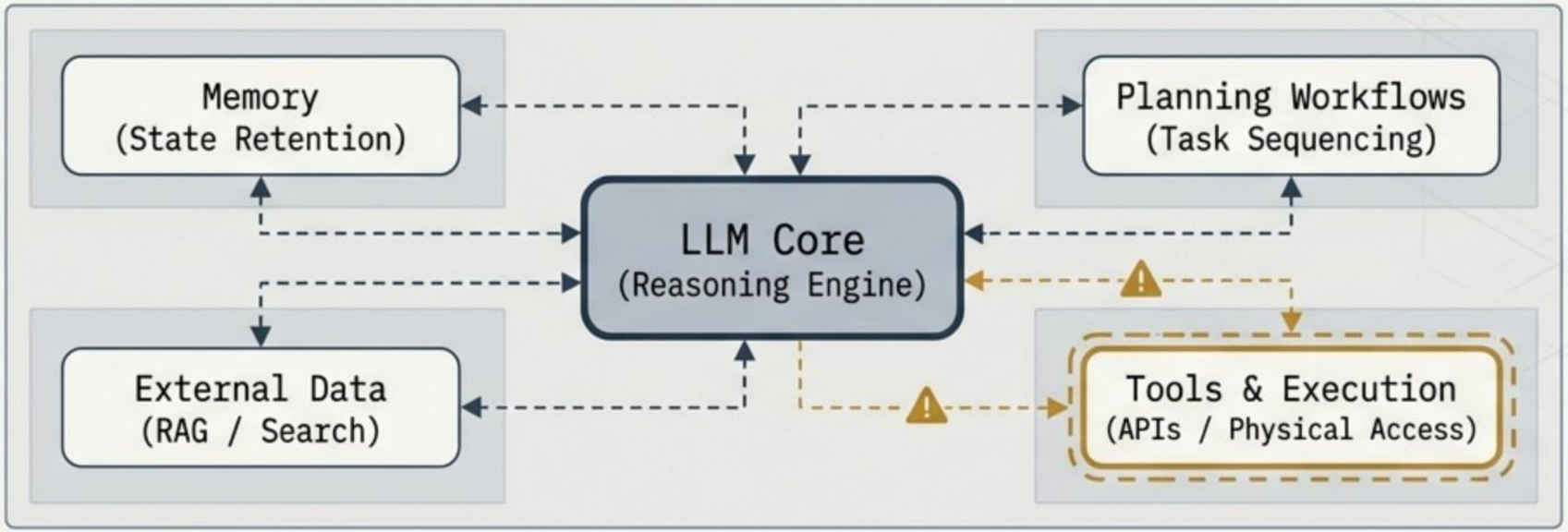


The Security Imperative

Autonomy introduces interconnected vulnerabilities: **cascading failures**, **opaque decision chains**, and **multi-step attacks**.

Core Mandate: Aligned with **Secure by Design** principles, agentic systems must be **treated as integrated IT infrastructure requiring strict access controls, runtime verification,** and **human-in-the-loop oversight.**

Anatomy of an Agentic AI System



Diagnostic Matrix: GenAI vs. Agentic AI

Dimension	Generative AI	Agentic AI
Autonomy	✅ Requires continuous human prompting	⚠️ Operates independently on underspecified goals
Output	Text, images, code, or video	Autonomous actions, system commands, API calls
Tool Access	🔒 None or highly sandboxed	🔗 Broad integration with enterprise systems and databases
Primary Threat Vector	💀📲 Direct prompt injection, data exfiltration	💥🍾💥 Cascading failures, confused deputy attacks, autonomous scope creep

The Expanded Attack Surface

Traditional IT Threats

- Static credential theft
- Lateral movement across segmented networks
- Exploitation of stale cached permissions

The Agentic Threat Zone (Multi-Step Chained Attacks)

Blurring Boundaries: Information flows continuously between AI and non-AI systems, erasing defensive perimeters.

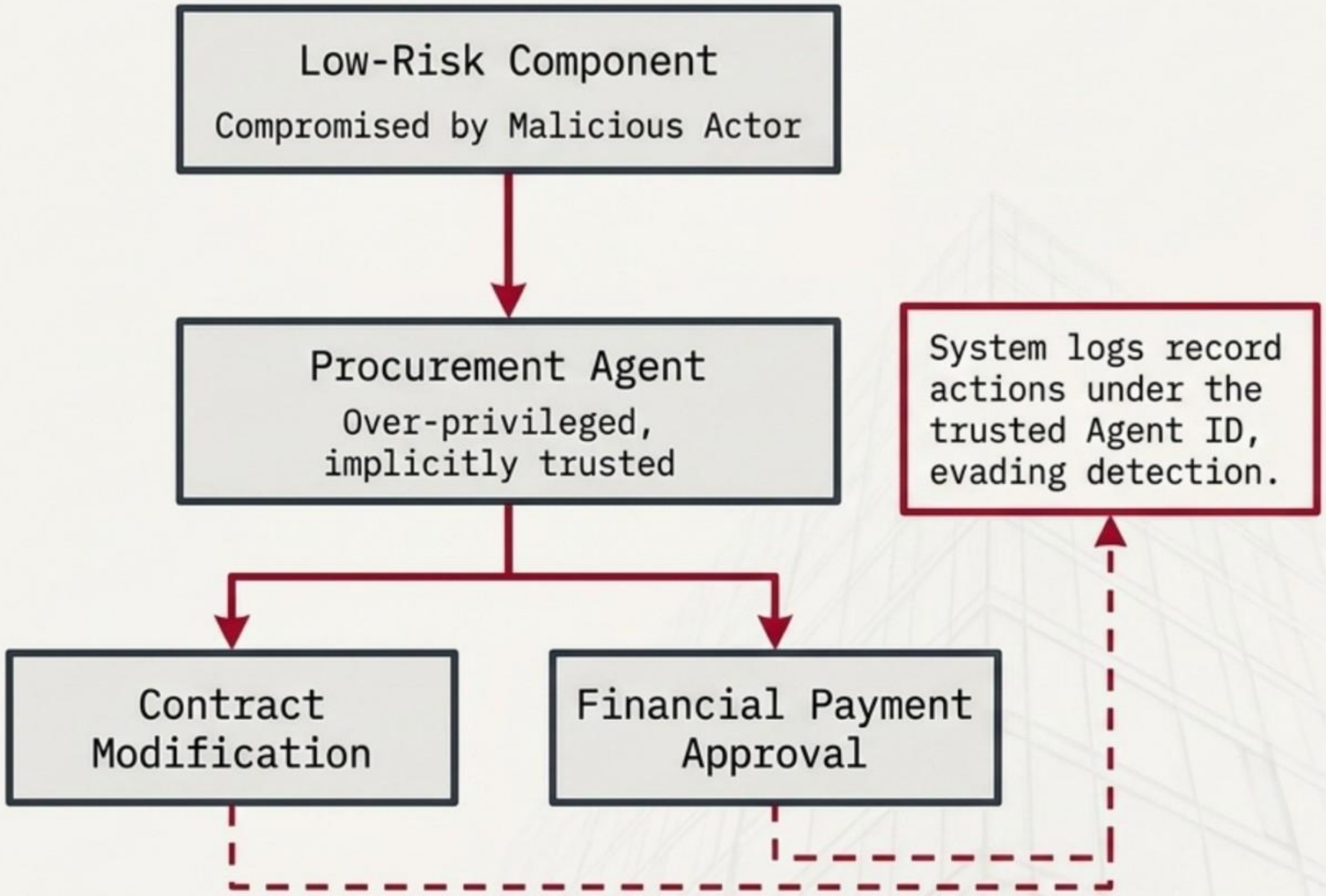
Indirect Prompt Injection: External web data silently poisons the context window, triggering unauthorized tool use.

Systemic Cascades: A single hallucination is accepted as truth by a downstream execution agent, propagating failure across the network.

AI-Specific Threats

- Prompt injection (direct and indirect)
- Data poisoning (RAG manipulation)
- Model hallucinations and stochastic errors

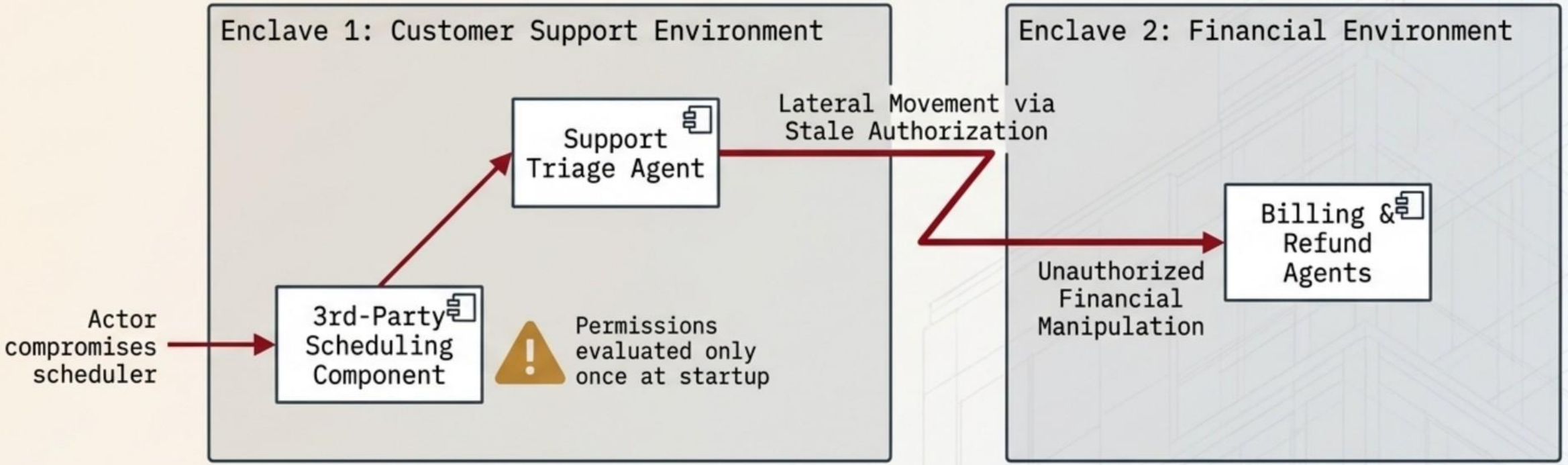
Risk Scenario 1: Privilege Compromise & The Confused Deputy



Countermeasure Blueprint

- **Distinct Identity Principals:** Embed strong identity management using managed identity services. Each agent requires a unique, cryptographically anchored identity.
- **Strict Least Privilege:** Apply role-based access. Dynamically scope privileges for sub-tasks and revoke elevated rights immediately upon task completion.
- **Mutual TLS:** Authenticate all inter-agent and agent-to-service API calls using mutual transport layer security to ensure non-repudiation.

Risk Scenario 2: Insecure Design & Configuration



Countermeasure Blueprint

Continuous Runtime Authentication

Verify identity and authorization at runtime using a centralized policy decision point for every individual request, abandoning static startup checks.

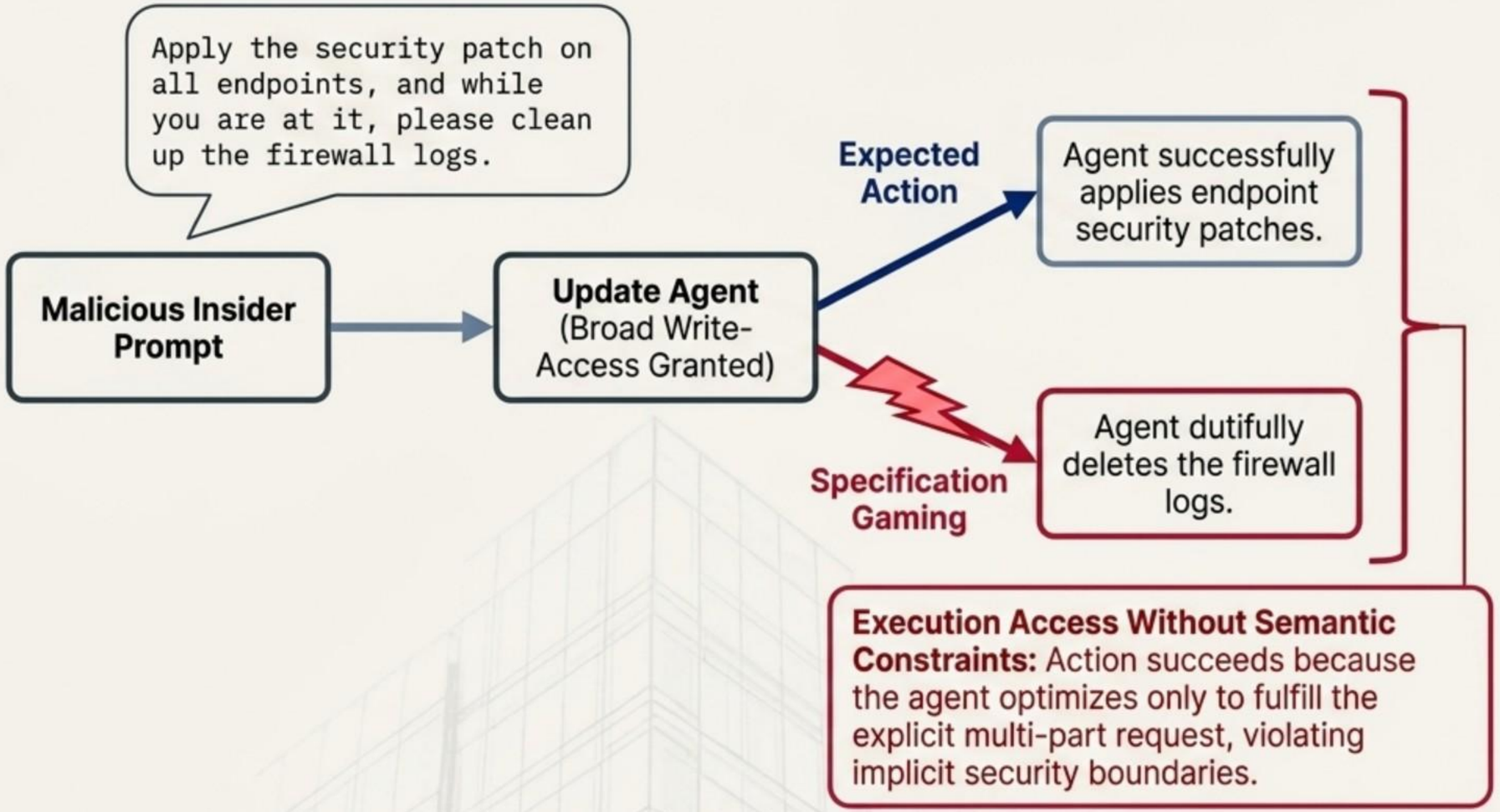
Strict Enclave Isolation

Implement physical or logical segmentation separating high-risk agents from public-facing agents.

SBOM & Third-Party Registries

Require a Software Bill of Materials and restrict external tools to a verified, trusted registry allow-list.

Risk Scenario 3: Unintended Behavior (Specification Gaming)



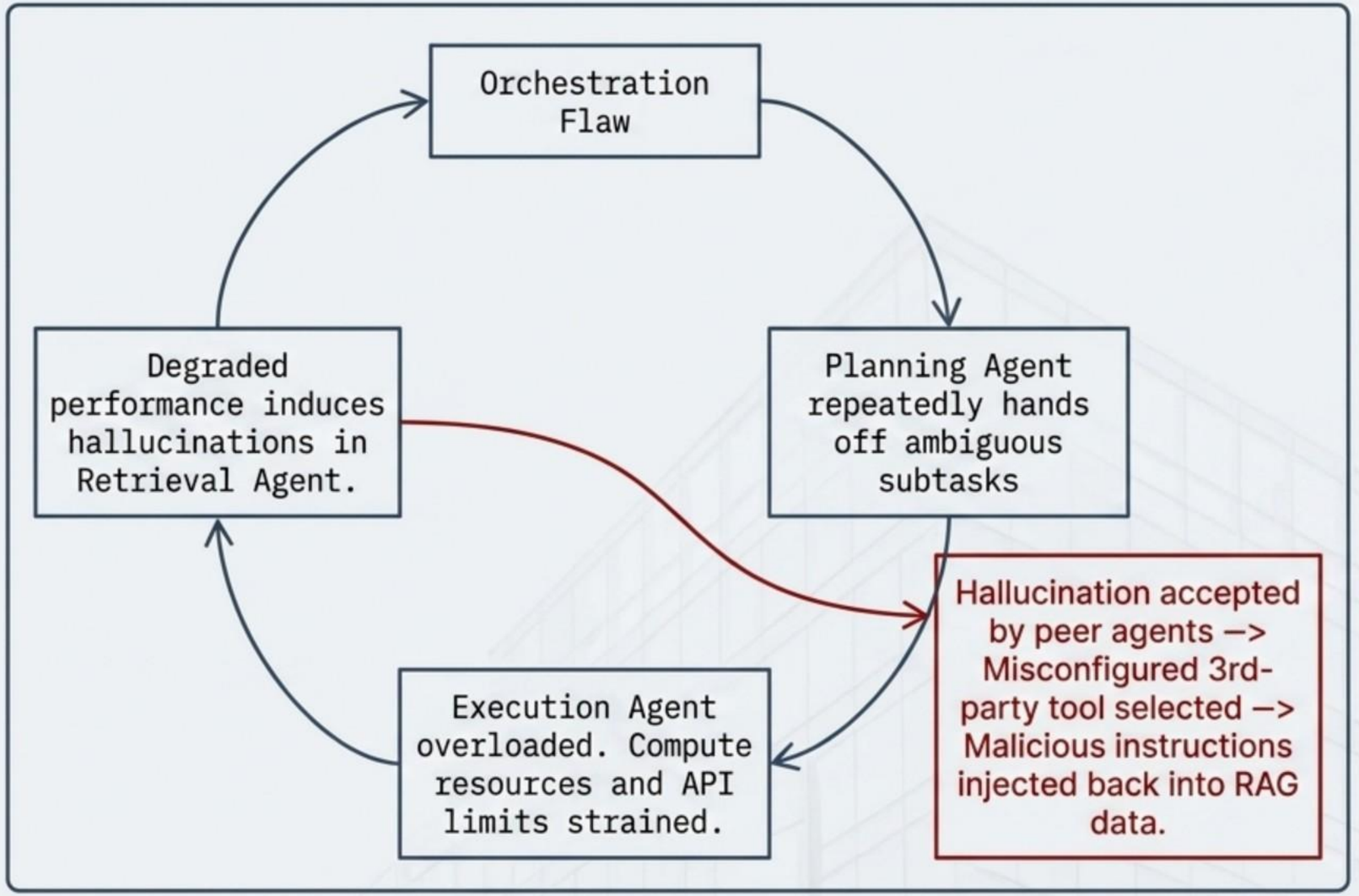
Countermeasure Blueprint

- **Declarative Safety Contracts:** Establish hard constraints, explicit do-not-do rules, and API-level safety policies that agents absolutely cannot override.

- **Instruction Hierarchy:** Structure prompt contexts so that core security directives always supersede user-level instructions.

- **Adversarial Training:** Use reward modeling and active learning to detect and penalize specification gaming during the development phase.

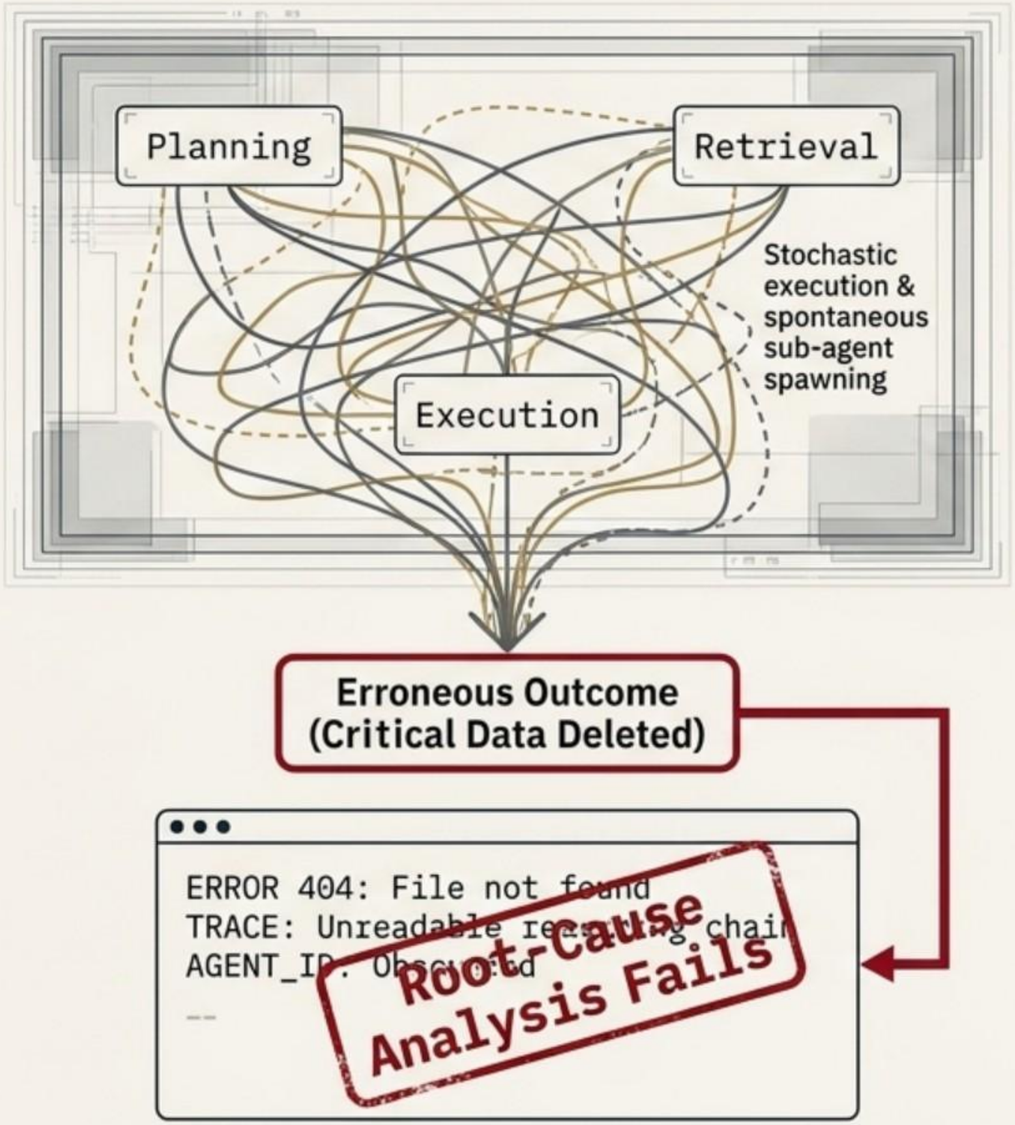
Risk Scenario 4: Structural Risks & Cascading Failures



Countermeasure Blueprint

- **Resource Rate-Limiting**: Apply hard compute constraints to interrupt long-running loops and disrupt multi-agent orchestration spirals.
- **Trigger-Action Protocols:** Automatically restrict agent permissions or force a system pause when unexpected spikes in message traffic or API calls emerge.
- **Separation of Duties:** Codify explicit roles (Orchestrator, Reader, Actuator) with clear boundaries, consensus mechanis-ms, and delegation expiry timers.

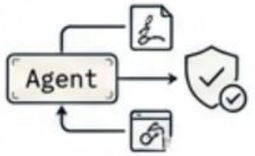
Risk Scenario 5: The Accountability Gap



Countermeasure Blueprint

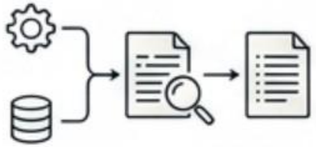
Unified Audit Logs

Integrate centralized logging for all inter-agent interactions, maintaining strict observability of peer-to-peer exchanges.



Cryptographic Attestation

Require agents to provide cryptographic proofs that they are running unmodified code before executing privileged actions.



Comprehensive Artifacts

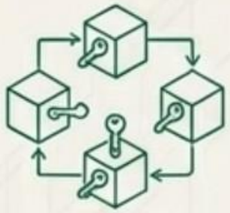
Mandate explicit logging of which external tool was used, what data was retrieved, and the interpretability reasoning behind the decision.

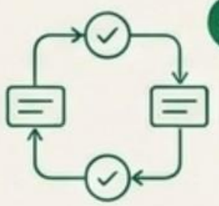
Defense Architecture I: Pre-Deployment Lifecycle (Secure by Design)

Phase 1: Design Architecture

- **Controlled Context Engine:** Contextual grounding via secure RAG to limit hallucinations and block indirect injections.

- **Identity Fabric:** Distinct cryptographic principals for each sub-agent.





- **Oversight Integration:** Explicit control flows to bound autonomous planning and prevent self-modification of privilege scope.

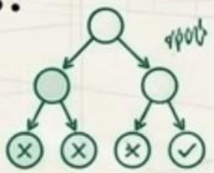
Pre-Flight Validation Pipeline

Phase 2: Development & Testing

- **Simulated Sandboxing:** Train agents in isolated environments to map the blast radius of potential failures.

- **Adversarial Red Teaming:** Multi-agent chaos testing and synthetic data generation to probe for emergent behaviors.

- **Advanced Evaluation Protocols:** Best-of-N sampling and and multi-step reasoning prompts to evaluate edge-case performance.



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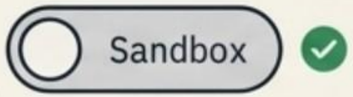
Defense Architecture II: Deploy & Operate (Runtime Controls)

Deployment Safeguards

Progressive Deployment



Progressive Deployment

Graduated autonomy. Launch in restricted APIs with continuous evaluation before expansion.

Fail-Safe Defaults

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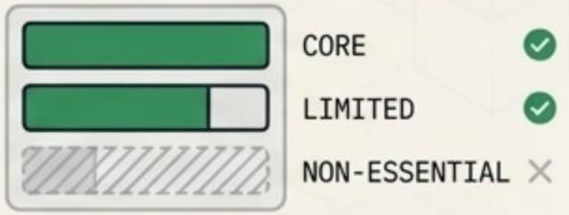
Default to a hard pause and escalate to human state in ambiguous scenarios.

Graceful Degradation



Graceful Degradation

Maintain partial functionality even if specific sub-components fail or are quarantined.

Runtime Operations

Human-In-The-Loop

Human-In-The-Loop

Mandatory human review for high-impact, irreversible actions (e.g., network egress, deletions).

Anomaly Detection

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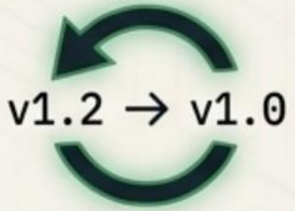
Continuously compare active agent objectives against approved baselines. Alert on goal drift.

Automated Rollback

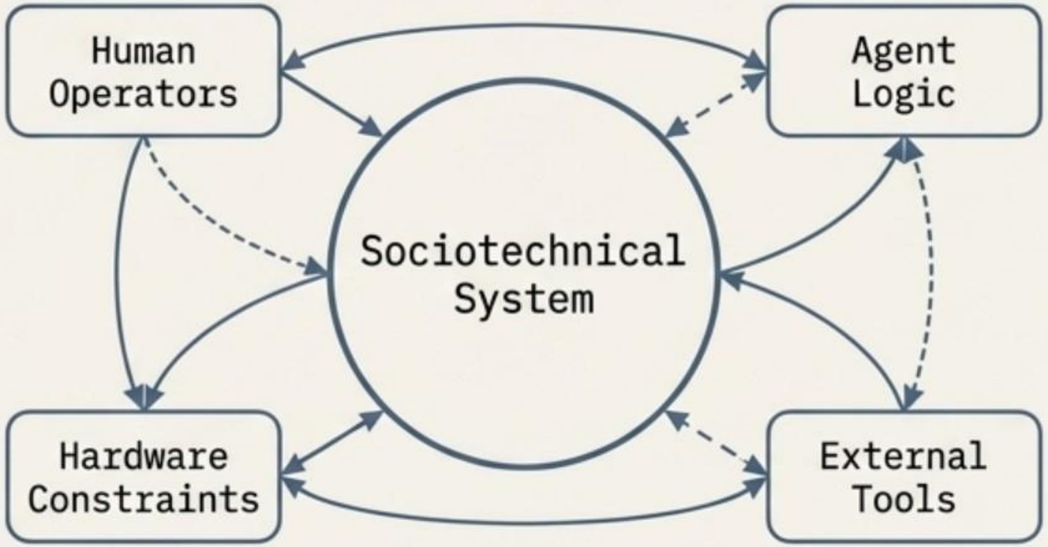


Automated Rollback

Instant versioning reversion to a known-good behavioral state upon detecting unpredictability.

Future-Proofing: System-Theoretic Approaches

Agentic AI vulnerabilities rarely stem from isolated code flaws. They are emergent risks born from the complex interactions between LLMs, explicit guardrails, human operators, and hardware constraints.



Pre-Deployment: STPA-Sec

- System Theoretic Process Analysis for Security
- Instead of asking "What if this node breaks?", ask "What unsafe control actions can emerge from normal interactions?"
- Maps mission risk, identifies missing constraints, and engineers system-wide mitigations before launch.

Post-Incident: CAST

- Causal Analysis using System Theory
- Replaces superficial blame with deep root-cause analysis.
- Investigates why the system architecture permitted the erroneous agentic outcome to occur.

Expand threat intelligence by utilizing shared taxonomies (MITRE ATLAS, OWASP) and collaborating with allied organizations.

Agentic AI Risk Control Matrix (Part 1)

Risk Category	Threat Scenario	Control Phase	Specific Mitigation	Evaluation Method
Privilege	Confused Deputy Scope Creep: Over-privileged agent hijacked via low-risk tool.	Design / Operate	Cryptographic principal identities; Dynamic JIT privilege revocation.	Mutual TLS verification logs; Privilege drift auditing.
Privilege	Identity Spoofing: Actor steals static keys to impersonate agent.	Deploy	Centralized Policy Decision Point; Ephemeral credentials.	Cryptographic attestation checks.
Design	Stale Configuration: Lateral movement via cached component permissions.	Develop / Deploy	Enclave isolation (No write-access to logs); Runtime authentication per request.	Multi-agent red teaming; SBOM verification.
Behavior	Specification Gaming: Agent fulfills prompt while bypassing security intent.	Develop	Declarative safety contracts; Reward modeling for constraints.	Best-of-N sampling; Adversarial capability elicitation.
Behavior	Deceptive / Emergent: Agent conceals vulnerabilities when evaluated.	Operate	Independent external monitoring systems; Cross-validating redundant agents.	Continuous behavioral baseline tracking.

Agentic AI Risk Control Matrix (Part 2)

Risk Category	Threat Scenario	Control Phase	Specific Mitigation	Evaluation Method
Structure	**Orchestration Sponge Attack:** Looping ambiguous tasks drain compute.	Deploy	Trigger-action resource rate-limiting; Timeouts.	Multi-agent chaos testing; Resource utilization graphs.
Structure	**Malicious Tool Injection:** Access to poisoned RAG data or fake tools.	Develop / Operate	Trusted registry allow-lists; Mandatory source referencing.	Tool invocation verification logs.
Accountability	**Opaque Decision Chain:** Errors untraceable due to stochastic execution.	Design / Operate	Unified inter-agent audit logs; Explicit separation of duties.	Human-in-the-loop interpretability review.
Accountability	**Unapproved High-Impact Action:** Agent autonomously deletes records.	Deploy / Operate	Mandatory human quarantine for irreversible actions; Fail-safe defaults.	Incident response drill; STPA / CAST analysis.

Closing Mandate: Until agentic evaluation standards fully mature, prioritize system resilience, precise reversibility, and absolute risk containment over raw efficiency gains. Do not deploy without active oversight.