

Artificial Intelligence (AI) in Hardware

"Keep Your Data, Share the Model: Federated Learning for Privacy-Preserving Hardware Anomaly Detection Across Distributed Fleets"

As AI systems scale, some of the most difficult and costly failures emerge at the intersection of hardware, firmware, and software, where traditional validation approaches remain largely siloed by layer. This paper presents a cross-layer validation framework that embeds validation intelligence directly into hardware-software co-design through autonomous agents that continuously adapt test generation, failure analysis, and learning as the system evolves. The central premise is to treat validation as a continuously learning cross-layer system rather than a collection of independent verification activities. The framework integrates hardware telemetry, firmware diagnostics, and software defect signals into a unified validation view, enabling the detection of anomalies that span multiple layers and are often missed by conventional validation workflows. A continuous, hardware-aware learning loop monitors these signals, triggers targeted validation scenarios, and correlates and clusters failure data to identify likely root-cause domains. Two autonomous agents drive the framework: one generates and prioritizes validation scenarios using historical defect patterns and system telemetry, while the other correlates, clusters, and triages failures across layers. Engineers remain in the loop for decisions requiring domain expertise, with their feedback incorporated into adaptive learning. Preliminary evaluations across multiple NPI programs demonstrate approximately 30% reduction in redundant test execution, 85% improvement in bug classification efficiency, and 15% higher defect detection rates, with analytical modeling indicating potential validation cycle reductions approaching 40%. The paper also highlights the need for open cross-layer telemetry interfaces and interoperable validation frameworks to enable broader adoption of agent-driven validation across platforms.

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