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An AI Agent Framework with Elasticsearch for Scalable Post-Silicon Debug Automation

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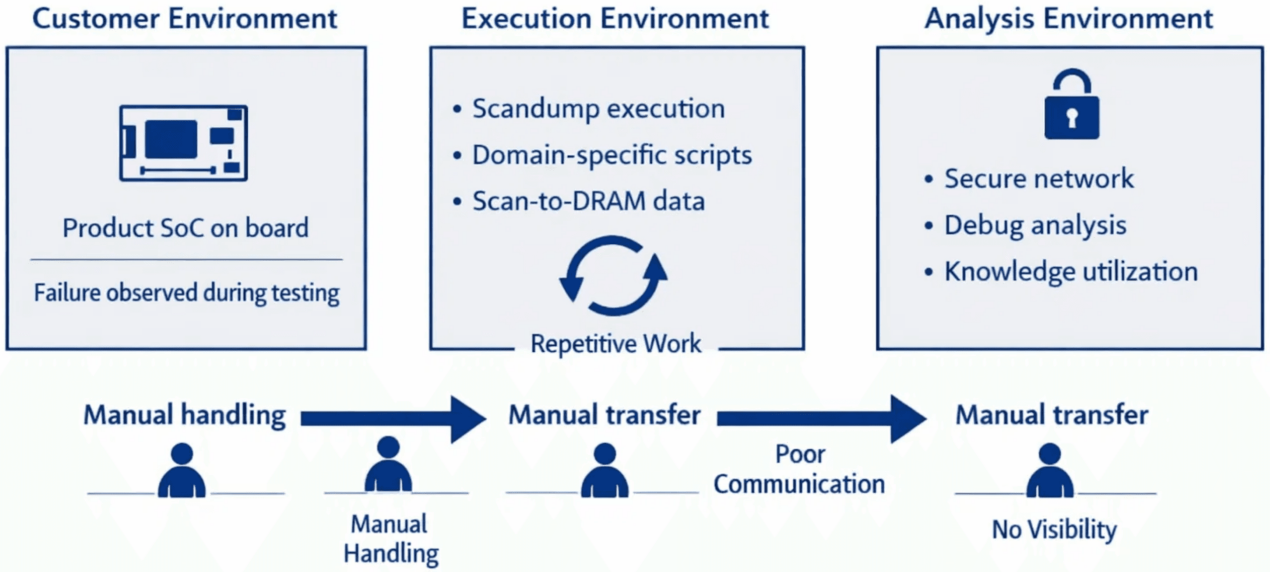
SAMSUNG

Post-Silicon Debug: real-world constraint



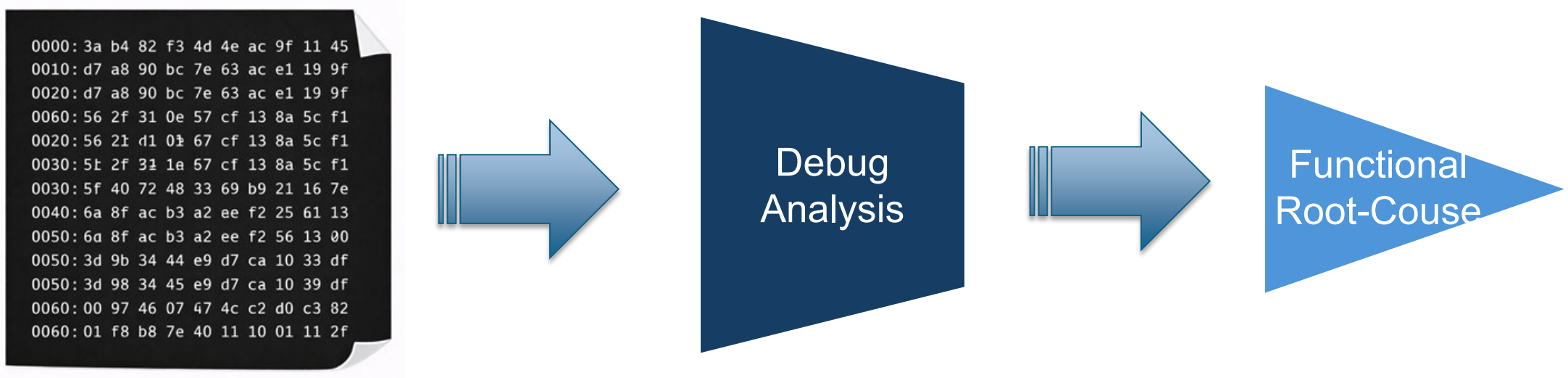
Isolated Domains
Three strictly separated networks prevent seamless data flow.

Manual Bottlenecks
Human-in-the-loop operations required for every transfer.

Execution-Analysis Gap
Physical disconnect between data generation and analysis.

Security Constraints
Strict customer protocols limit standard tool access.

Scan dumps: Critical Path for Root-Cause Analysis

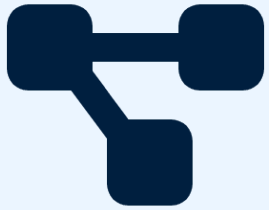


Why Existing Automation Does not Scale

Local Silos

- Fragmented, IP-specific scripts
- Artifacts siloed on local machines
- Non-standardized data formats
- Zero organizational knowledge reuse

Unified Framework



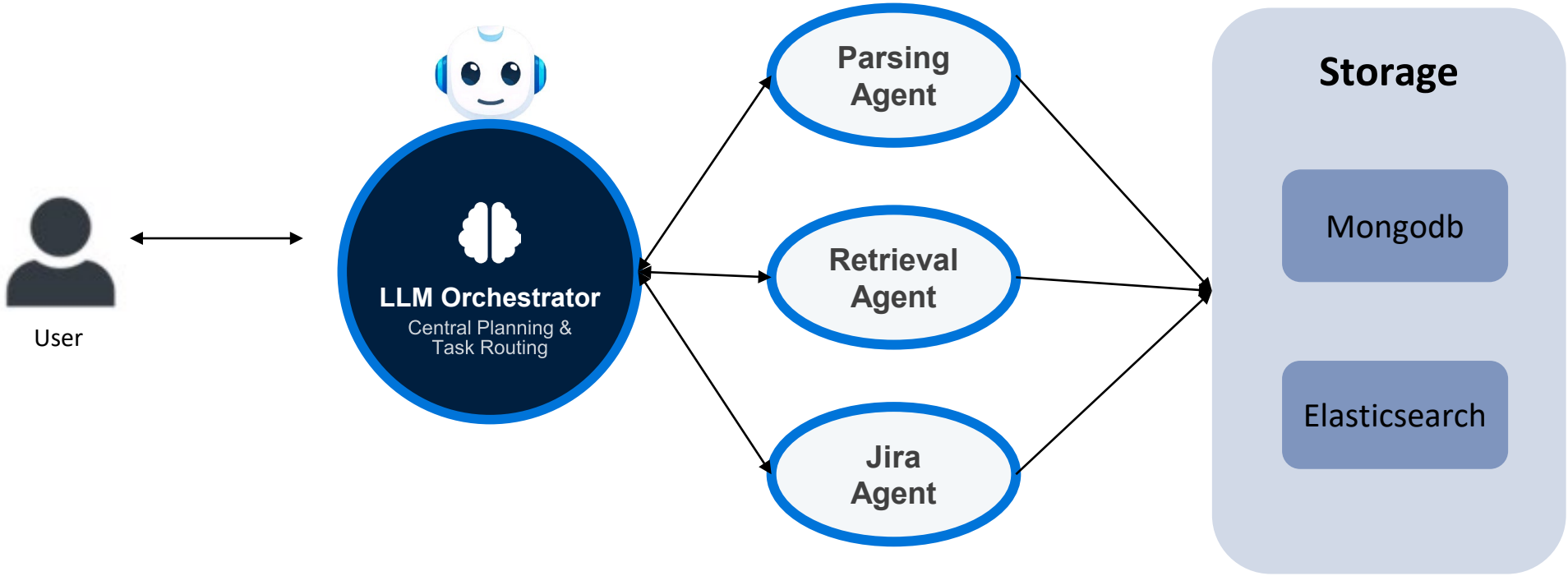
- Centralized, systemic automation
- Global visibility of debug artifacts
- Standardized, machine-searchable data
- Scalable company-level memory

Reframing the Problem

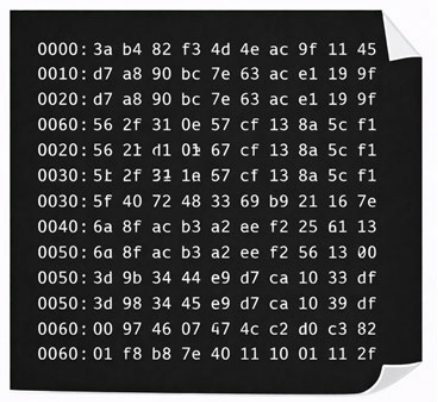
Automated and Reusable Workflow is the Key

Shifting from local script execution to systemic organizational memory

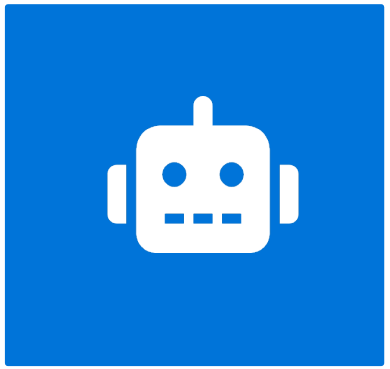
Proposed Agent-Based Framework Overview



Scandump Parsing Agent



Raw Scandump



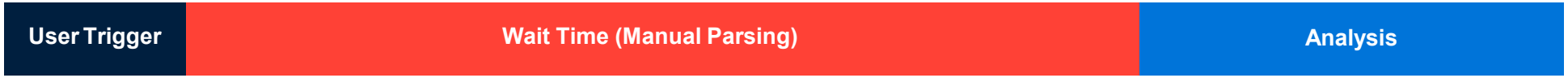
Parsing Agent

Structured Text

- **Intelligent wrapper** around existing domain-specific scripts
- **Normalizes** heterogeneous outputs into structured text
- Critical infrastructure for **LLM readability**

Proactive vs Reactive Mode: Eliminating Latency

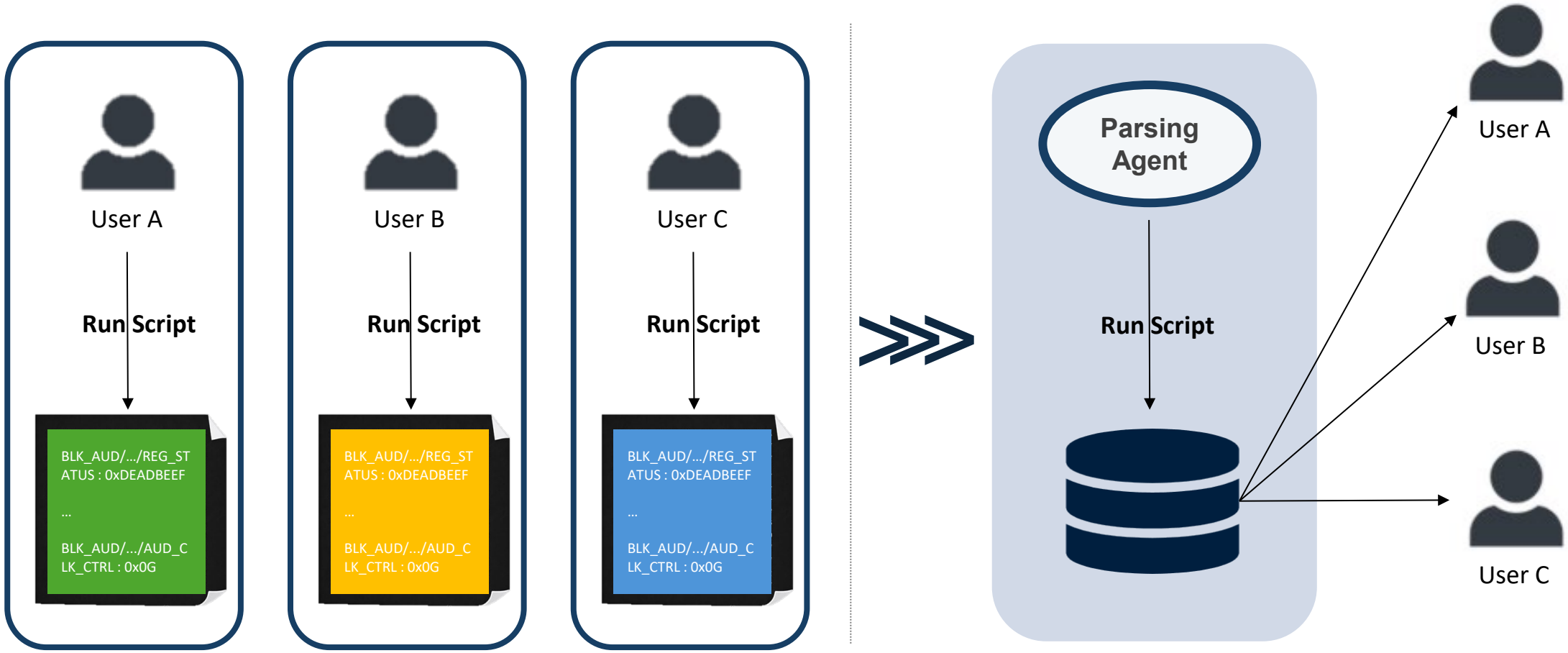
⏳ Reactive Mode (Traditional)



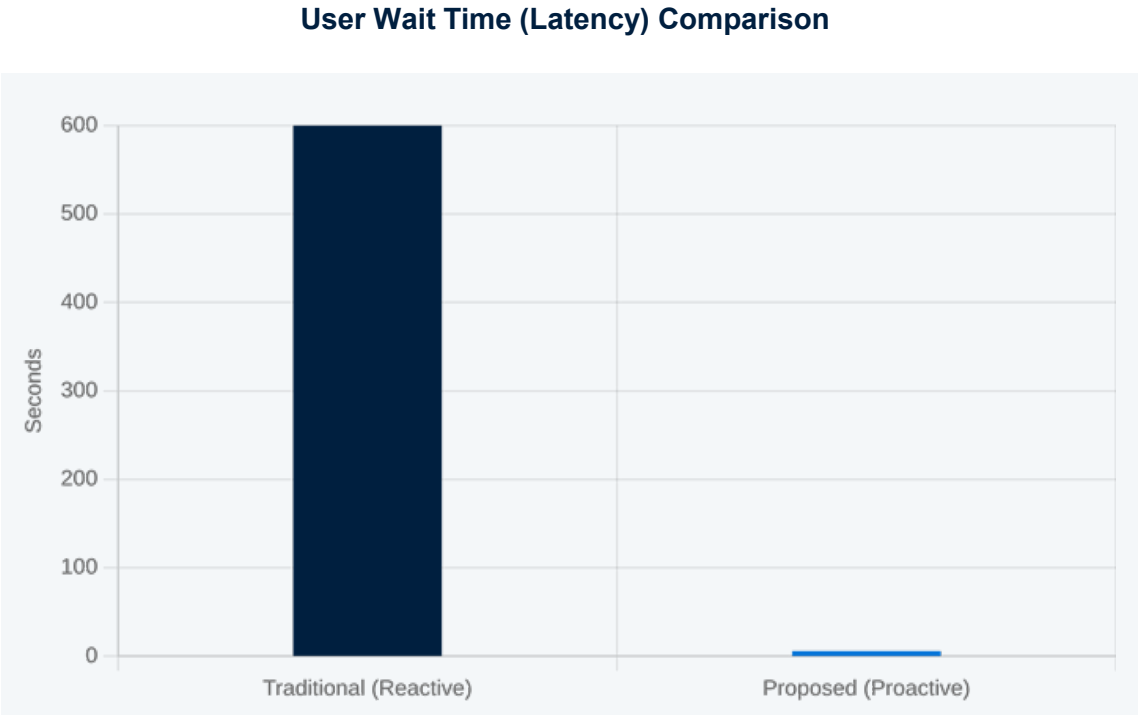
⚡ Proactive Mode (Proposed)

Event-driven pipeline (Parse-on-Upload) eliminates manual data-preparation bottlenecks, allowing engineers to focus on active analysis immediately.

Centralizing Knowledge



Experimental Results



Metric	Traditional Workflow (On-Demand)	Proposed Framework (Proactive)
Parsing Model	Synchronous/Manual	Asynchronous/Automated
Compute Time	~10 min	~10 min
User Wait Time	**~10 min**	**<5 sec**
Redundancy	30 min	10 min

99.2% Reduction

In perceived debug latency via proactive, event-driven parsing.

66% Saving

In redundant compute resources across engineering teams.

What do We do with Centralized Data?

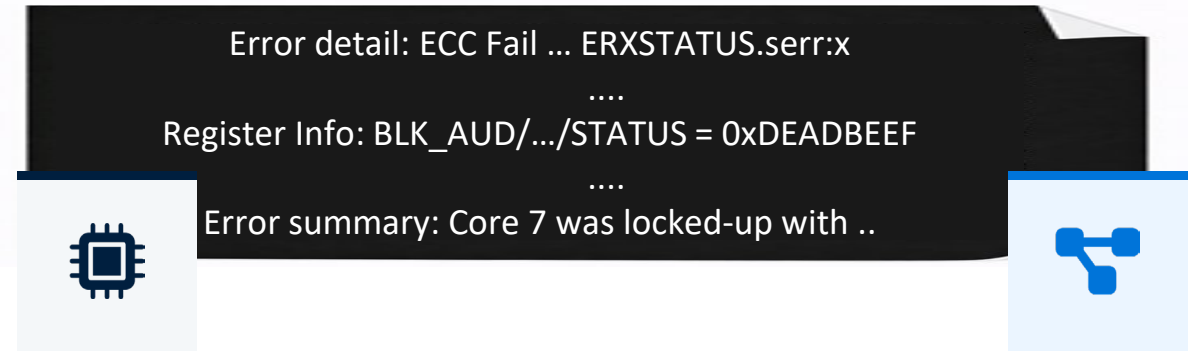
From Passive Storage to Active Utilization

Centralized Repository

Actionable Insights

Retrieval Agent: From Storage to Active Utilization

The Challenge: Dual Nature of Debug Data



Keyword Search

Surgical precision for exact hardware identifiers and register addresses.

Target Artifacts

- Register: 0x4000_1234
- Error Code: ERR_TIMEOUT_01
- IP Block: PCIE_GEN4_CTRL

Semantic Search

Conceptual flexibility for failure symptoms and vague descriptions.

Target Artifacts

- "Link training failure after reset"
- "Intermittent hang during DMA"
- "Clock domain crossing issues"

Why Elasticsearch?

Hybrid Capability

Native support for blending BM25 keyword search and kNN vector search, essential for hardware debug queries.

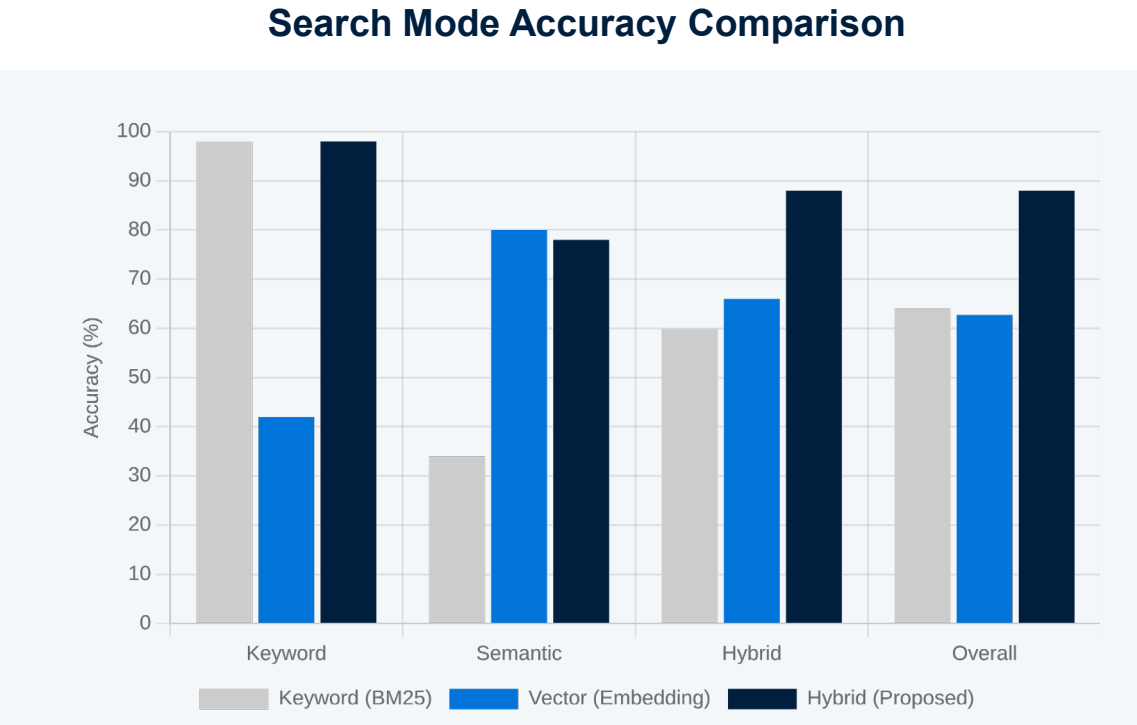
Internal Experience

Leverages existing organizational expertise and established infrastructure for rapid deployment and maintenance.

Scalability

Proven performance in handling large-scale, distributed datasets with high availability and low-latency retrieval.

Experimental Results



Hybrid search maintains robust performance across all query types.

Category	Keyword Search(BM25)	Vector Search(Embedding)	Hybrid Search(Proposed)
Keyword	98%	42%	98%
Semantic	34%	80%	78%
Hybrid	60%	66%	88%
Average	64%	62.7%	88%

88% Accuracy

Hybrid search significantly outperforms single-mode retrieval by blending architectural precision with semantic flexibility..

* Recall@5 metric used for evaluation across 300+ debug queries.

Jira Agent: Closing the Debug Loop

Automated Analysis

Provides on-demand automated analysis comments directly within Jira tickets, reducing manual reporting effort.

Data Leverage

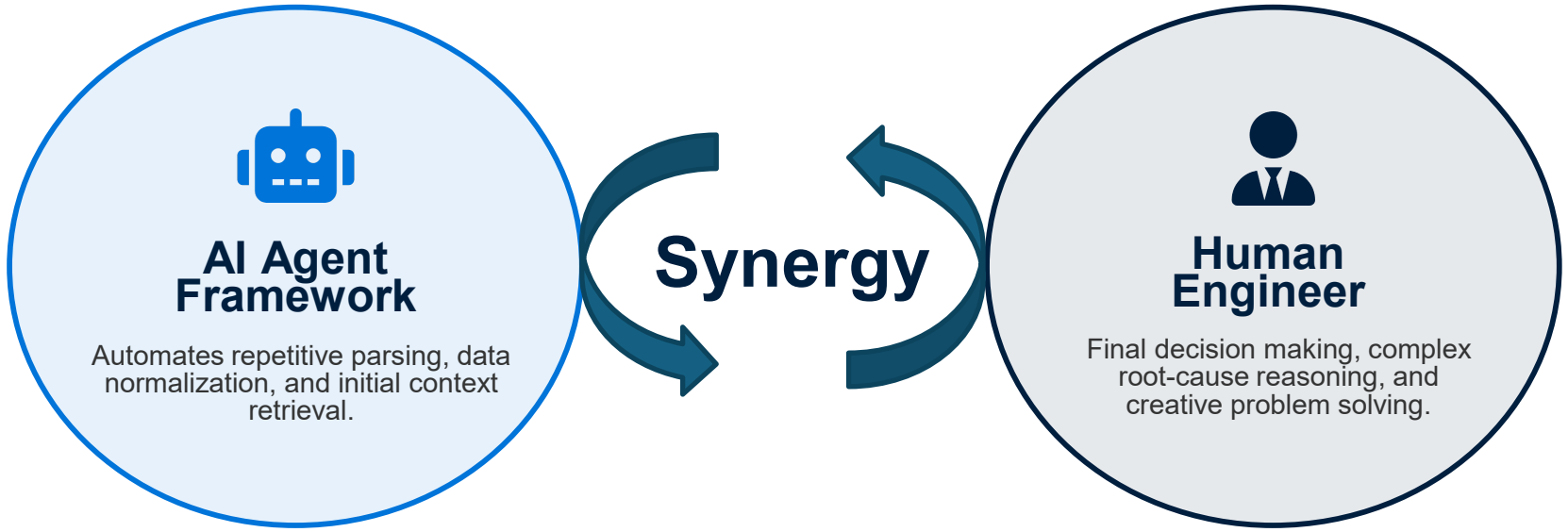
Utilizes existing Jira issue data, historical comments, and linked artifacts to provide extended, context-aware analysis.

JIRA-456

A similar lock-up issue occurred previously in the project1 task. Please refer to it for reference.
JIRA: JIRA-123

- On-demand automated analysis comments in Jira.
- Leverages Jira issue data for extended analysis

Limitation & Challenges



Support, Not Replacement

The framework is designed to augment engineering capabilities by handling the "heavy lifting" of data preparation, not to replace expert judgment.

Technical Challenges

Maintaining model accuracy across diverse IP blocks and handling highly non-deterministic hardware behaviors remain ongoing areas of refinement.

Conclusion: Scaling Debug Expertise through Automation

Operational Efficiency

99.2%

Latency Reduction

Perceived debug latency eliminated via proactive, event-driven parsing pipelines.

66%

Resource Saving

Reduced redundant compute cycles across engineering teams through centralized data reuse.

Retrieval Quality

88%

Search Accuracy

Hybrid search outperforms naive keyword or vector search by blending precision with flexibility.

Robust

Performance

High accuracy maintained across all query categories, from exact registers to vague symptoms.

Systemic automation and hybrid search provide a scalable path to managing increasing SoC complexity.

QnA