Bs"d

Real-Time Monitoring & ML for Enhanced Storage Device Testing

Eyal Hamo
Technologist & Reliability System Architect, SanDisk

"We no longer wait for bugs to surface — we detect and understand them as they happen."

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SANDISK™

FMS the Future of Memory and Storage

Agenda

- Introduction to Reliability Intelligence
- Real-Time Monitoring
- Automatic Failure Analysis System

What is Reliability Intelligence?

📘 Definition

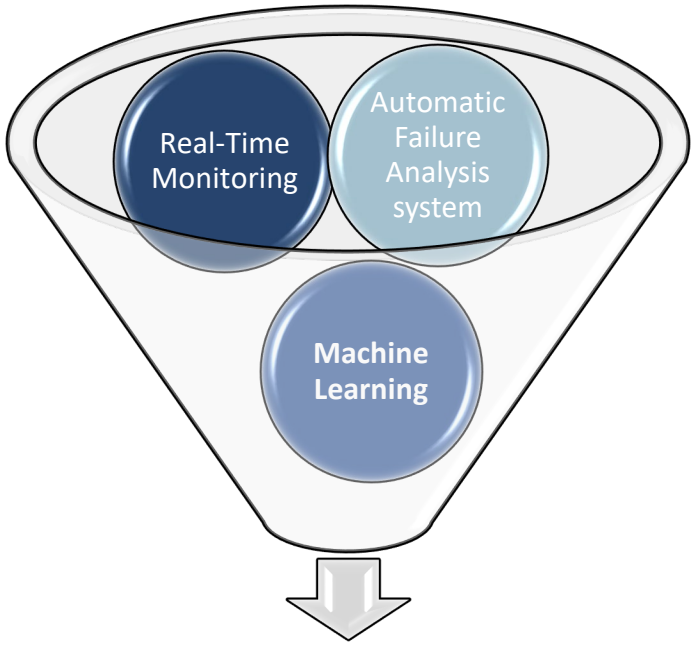
- **A data-driven approach** using **real-time monitoring**, automated detection tools — called **Checkers** — and machine learning to identify issues early, reduce Failure Analysis time, and improve test coverage.

❓ Why you need it

- Massive amounts of complex test data are generated during testing
- Manual analysis is slow, and prone to error
- Debug time is wasted on unclear failures

✅ Benefits

- ✓ Faster issue detection
- ✓ Better product quality
- ✓ Smarter validation decisions



Reliability Intelligence

Real-Time Monitoring : Data Sources & Use Cases

📥 **Environment Sensors :** Temperature, voltage, and power logs from the test setup.

📜 **Host/Device**

- **Logs & Events**
  Capture system logs and debug events from the host **during** test execution (e.g., FW events)
- **Protocol I/O**
  Track command timing, status flags, and responses exchanged between host ↔ device
- **Device Reports**
  Collect device health and metrics retrieved by the host (e.g., wear level, error counters)

✅ **Uses**

Provides a real-time view of device behavior, live anomaly detection, and checker results for use in ML systems.

Real-Time Monitoring

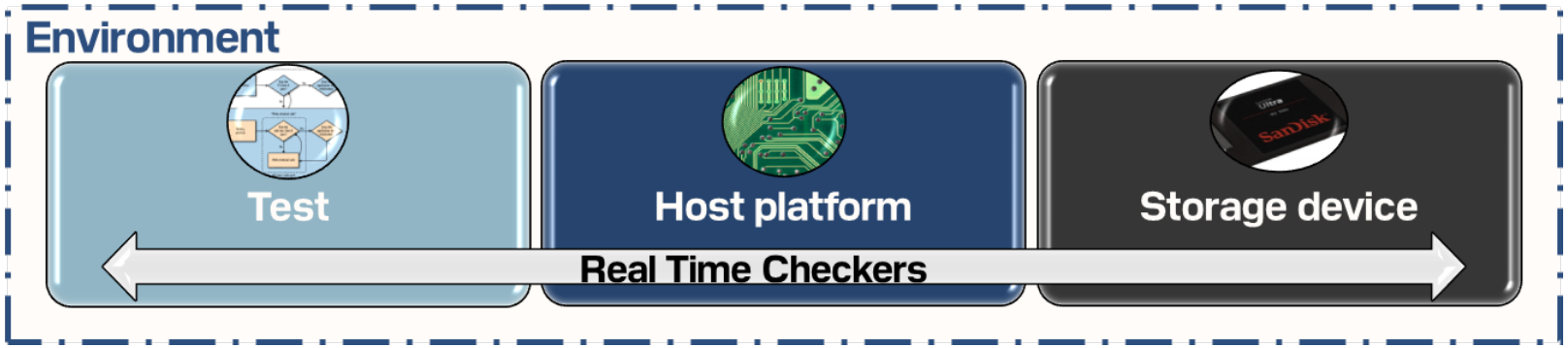
📘 Definition

Monitor Provide visibility into system behavior

Checker Detects what's wrong — validating system behavior in real time, beyond the main test flow.

🎯 Purpose

Capture and identify unexpected conditions, enforce test assumptions, and improve reliability across layers.



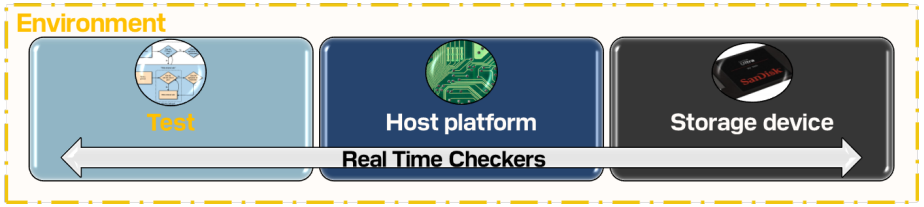
Real-Time Monitoring

Checker Types & Logic

Type	Checker Logic	Example
🔍 **Static Checkers**	Fixed rule or threshold	Flagging blocks exceeding a Prog/Erase count > wear level
🧠 **Context-Aware Checkers**	Rule adapts to test context (conditions, sequence, timing)	Triggered only if high temperature occurs during heavy I/O
🤖 **AI-Based Checkers**	Learns from data, new anomalies	Learns performance patterns per test phase, flags unexpected deviations

Real-Time Monitoring

Environment & Test



💡 Any checker type (Static/Context/AI) can apply to any monitor category.

Monitoring Category	Checker Logic & Examples
🔧 Platform & Configuration	Validates: FW, setup, and DUT settings **Static**: Wrong FW version **Context**: Buffers sizes during heavy write operations **AI**: Learns typical setups and identifies outliers
📄 Test Output Verifier	Verifies logs are generated live, confirms events align with test phases, and flags unusual patterns
🌡️ Temperature Monitor	Monitors chamber temperatures for stability and flags out-of-range conditions
⚡ Voltage Stability Checker	Detects voltage fluctuations and tracks power supplier delivery stability
⏱️ Duration Checker	Learns average duration by test type, dynamically flags abnormal overruns or early exits

[REL Err] Device current temperature 75 is not in the required range [85,

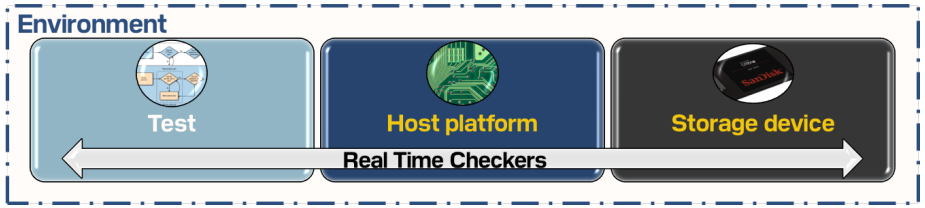
Error 1: Rel error - The test is writing to hybrid!

The cold temperature in the chamber stuck for more than: 350.0(minutes),

Device Spec version (0x410) is different

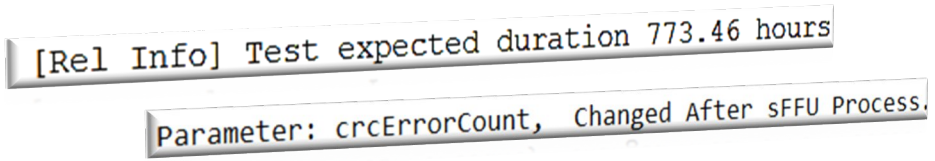
Real-Time Monitoring

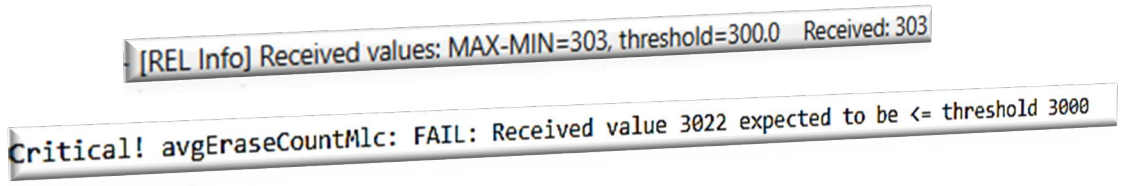
Host & Device



💡 Any checker type (static/context/AI) can apply to any monitor category.

Monitoring Category	Checker Logic & Examples
🕒 System Events Clock Drift	Ensures consistent internal timestamping for reliable log synchronization
📈 Duration & Performance	Compare actual test runtime and performance against predefined expected thresholds , patterns or anomalies
⏪ Regression test results	Detected by comparing results against historical baselines or prior test passes
🔥 Throttle, Spike & Power Budget	Detects throttling, power spikes, and compares NAND power usage vs. expected design limits
🔌 Live Data Link Verifier	Monitors real-time host-device communication using tools like 'Internal Eye' and link error counters
🩺 Device Health Log	Periodically collects logs to detect 'silent error' issues and monitor changes between FW versions





Automatic Failure Analysis System

Failure Detection Categories and How Checkers Contribute

📌 **Signature** — Static Checkers

Known combination of errors or events that reliably indicates failure e.g., 'Fatal', 'Assert'

🔁 **Pattern** — Context-Aware Checkers

Repeating trends or event sequences that suggest early failure signs

🧩 **Context-Based** — Context-Aware Checkers

Failures triggered only under specific conditions or combinations (e.g., reset + temperature + aging)

⚠️ **Rare Event** — AI-Based Checkers

Unexpected one-time issues flagged by anomaly detection until classified

Automatic Failure Analysis System - Workflow

Failure Detection by Real-Time Monitoring & Diagnostic Systems

Automatic FA System

Collect Data

Organize Information

Apply Machine Learning

Generate Reports

Match Known Signature / Pattern / Context?

No or "Rare Failure"

Yes

Update/Open Ticket

Cluster and Anomaly Detection

Suggest Similar Historical Issues

Create New Ticket

FA for Labeling & Coverage Detection

Update ML Model with new Signature

Automatic Failure Analysis System

⚙️ What It Does

- Classifies and detects known failure types
- Uses ML to predict and link new issues with historical cases
- Auto-generates structured tickets (e.g., JIRA) with relevant context
- Highlights key data near failure point

❓ Why It Matters

- **Before:** Manual log digging, slow, inconsistent
- **After:** Fast, automated, and consistent analysis
- Saves significant time and effort across teams

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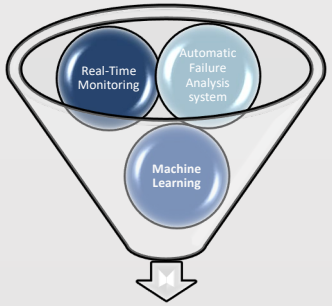

Reliability Intelligence

Thank you

Q&A

Eyal.Hamo@sandisk.com

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