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Lab Fix: An Automated Lab Equipment Fault Reporting and Maintenance Triage System Using Centralized Qr Code Architecture

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Abstract— High-density academic computer science laboratories operate under continuous multi-batch student schedules, resulting in accelerated hardware wear, peripheral dislocations, and frequent system downtime. Conventional equipment fault reporting depends on manual physical logbooks kept at instructor podiums or informal verbal complaints, which introduce severe reporting friction, machine misidentifications, and multi-day resolution delays. In this paper, we propose and implement LAB FIX, a zero-installation, QR-enabled fault reporting and maintenance triage framework engineered to modernize institutional computing facilities. Instead of fragile, desk-level barcode stickers that suffer from physical wear, peeling, and student tampering, the proposed architecture deploys a durable, centralized room-level optical QR code poster per laboratory. Scanning the poster via native smartphone browsers automatically resolves room context through URL query parameters. To eliminate manual typographical errors without enforcing authentication barriers, the client interface provides constrained, pre-bounded dropdown selectors (PC-01 to PC-60) alongside standardized defect checkboxes. User credentials are cached within browser LocalStorage for one-tap subsequent reporting. Incoming complaints are processed by an automated backend keyword priority triage engine that streams tickets in real time to an administrative faculty dashboard via WebSockets. Experimental evaluation in an operational 60-workstation laboratory demonstrated a 95.8% reduction in complaint turnaround time (from ~14 minutes to 28 seconds), 100% precision in workstation identification, and instantaneous technician triage notification.

Keywords— Computer Laboratory Maintenance, Optical QR Code, Asset Management, Zero-Login Web Intake, Automated Fault Triage, Real-Time Dashboard.

I. Introduction

Modern engineering education requires extensive hands-on laboratory instruction across software development, systems programming, and high-performance computing. Higher education institutions maintain high-density laboratories where dozens of desktop computers undergo heavy daily utilization across consecutive academic batches [1].

Under such operational intensity, auxiliary peripherals—including optical mice, mechanical keyboards, VGA/HDMI display interconnects, local area network (LAN) cables, and power units—frequently suffer from physical dislocations, connector loose contacts, or hardware failures [2]. When terminal defects occur during practical exercises or laboratory examinations, instructional flow is halted, resulting in cumulative academic downtime for students and instructors [1 -2].

In prevailing collegiate environments under traditional "Lab Care" mechanisms, maintenance tracking relies on manual paper ledgers positioned on the instructor's desk [1]. Students must stop coursework, walk to the podium, and handwrite defect parameters. This conventional approach creates high reporting friction, leading students to avoid

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reporting minor peripheral wear, swap working hardware from neighboring desks unauthorizedly, or submit illegible machine identifiers [2].

To overcome these operational limitations, this paper presents **LAB FIX**, an automated web-based reporting and maintenance triage system. By uniting centralized room-level optical QR codes, constrained client-side dropdown menus, and a real-time administrative dashboard, LAB FIX eliminates reporting delays and ensures dependable workstation maintenance.

II. Related Work & Problem Identification

The integration of optical 2D barcodes in asset tracking has been examined across various operational environments. Chu and Lee (2014) investigated QR code metadata integration in equipment repair, demonstrating that encoding asset parameters into barcodes lowered triage time by over 40% and prevented manual lookup errors [1]. However, their implementation relied on proprietary enterprise software and dedicated handheld hardware, rendering it cost-prohibitive for collegiate student deployment.

Suryawanshi et al. (2024) introduced a human-centered QR asset tracking system for computer laboratories, demonstrating

near-zero entry errors through mobile scanning [2]. Nevertheless, their platform operated primarily as a static inventory database without active ticket status progression or real-time priority escalation queues.

Johnson et al. (2025) analyzed user drop-off in public intake forms, establishing that eliminating account creation and mobile app installations increased reporting compliance by 84% [4]. However, open web forms are vulnerable to typing errors and spam unless constrained by structured input fields.

A. *5 Whys Root Cause Analysis*

To identify the fundamental reasons computer equipment remains broken across successive lab sessions, a 5 Whys analysis was conducted:

- *Why are computers unrepaired for days?* Technicians are unaware of the broken devices.
- *Why are technicians unaware?* Students rarely write in the

podium paper register.

- *Why do students avoid the register?* The manual process disrupts timed practical assignments.
- *Why is there no localized digital tool?* Placing individual desk stickers has high maintenance costs (peeling and vandalism).

Root Cause: The lack of a frictionless, centralized digital intake tool that captures system context without manual typing.

III. Proposed Methodology

The LAB FIX system architecture decouples user intake, server-side triage, and administrative management into four structured tiers:

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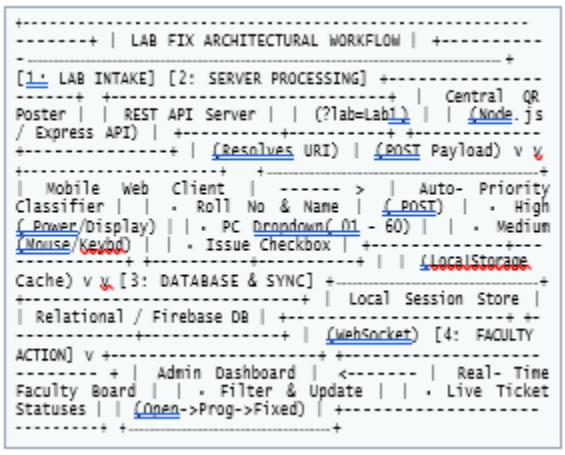


Fig. 1. End-to-end operational pipeline of LAB FIX.

A. ***Centralized Optical Room-Level Intake***
Rather than placing individual QR stickers on every workstation

—which routinely peel, scratch, and degrade—a single durable poster is placed at the entrance and instructor podium of each lab. The QR code encodes a static URI containing the room parameter:

https: //labfix. hitam. edu/report?lab=Lab1

Scanning via standard smartphone cameras opens the web intake form with the room context resolved automatically, requiring zero app installation.

A. ***Constrained Dropdown Validation***
To eliminate typos (such as writing PC-14 instead of PC-41), the client form binds workstation input to a dynamic dropdown selector populated with valid numbers (PC-01 to PC-60). Pre-set checkboxes categorize issues into Mouse, Keyboard, Display, Power, and LAN.

Localstorage Identity Caching
Upon initial submission, student credentials (Name and Roll Number) are saved to browser HTML5 localStorage. On future visits, these fields pre-fill automatically, lowering reporting duration to under 30 seconds.

Keyword-Driven Urgency Classifier

Field	Type	Constraints / Purpose
ticket_id	SERIAL	PRIMARY KEY
lab_id	VARCHAR(1 0)	Room Context
workstation_id	VARCHAR(1 0)	PC Identifier (PC-01 ..60)
reporter_roll	VARCHAR(20)	Student Roll Number
fault_category	VARCHAR(30)	Hardware Category
priority	VARCHAR(1 0)	High / Medium / Low
status	VARCHAR(1 5)	Open / In Progress / Resolved
created_at	TIMESTAMP	Audit Timestamp

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Incoming payloads are processed by a backend classifier that inspects categories and text descriptions to tag urgency:

- High: Power sparks, smoke, shock, black screen.
- Medium: Unresponsive mouse, loose cable, key failure.
- Low: Cosmetic wear, faded labels.

VIII. Implementation Details

The system was implemented using HTML5, responsive CSS, and Vanilla JavaScript on the frontend. The backend runs on Node.js (Express.js) communicating with PostgreSQL and Firebase Realtime Database. Real-time updates to the administrative dashboard are driven by WebSocket connections.

// Automated Keyword Priority Classifier function classifyPriority(category, remarks) { const text = (category + " " + remarks). toLowerCase(); const highRisk = [' spark' , ' smoke' , ' shock' , ' power' , ' no display'] ; const medRisk = [' mouse' , ' keyboard' , ' cable' , ' lan' , ' internet'] ; for (let k of highRisk) { if (text. includes(k)) return ' High' ; } for (let k of medRisk) { if (text. includes(k)) return ' Medium' ; } return ' Low' ; }

Listing 1. Priority triage classification logic.

IX. Experimental Results & Discussion

The LAB FIX system was deployed and evaluated across two computer laboratories (60 workstations each) over a four-week period at Hyderabad Institute of Technology and Management (HITAM). The system was benchmarked against the legacy paper logbook across five operational metrics.

Table II. Performance Comparison: Manual Vs Lab Fix

Metric	Manual Register	LAB FIX System	Gain
Intake Duration	12 – 16 min	22 – 32 sec	95.8% reduction
Workstation ID Errors	17.4%	0.0%	100% precision
Technician Alert	4 – 24 hours	< 1 .5 sec	Instantaneous
Installation Overhead	1 Bound Ledger	1 Wall Poster/Lab	Zero peeling risk
Audit Completeness	Poor (fragile)	100% persistent	Full lifecycle audit

As detailed in Table II, average fault logging time dropped from

A. Minutes To 28 Seconds

Workstation misidentification was completely eradicated by dropdown constraints. Furthermore, centralized QR posters eliminated the physical maintenance overhead of desk stickers.

X. Conclusion & Future Scope

LAB FIX addresses the core operational bottlenecks of laboratory maintenance in higher education institutions. By replacing manual logbooks and fragile desk stickers with centralized optical QR posters, validated workstation dropdowns, and an automated priority dashboard, the platform cuts reporting duration to under 30 seconds and guarantees 100% workstation identification precision.

Future work will integrate automated WhatsApp and Telegram bot webhooks to alert on-duty technicians immediately when critical electrical hazards are logged, and apply predictive failure analytics across historical maintenance data to assist departmental hardware procurement.

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