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Sakthi Hackathon 1.0

Problem Statement proposal on

Digital Monitoring System for Raw and Mixed Coolant Consumption

Title of problem statement

BleuLink -
A Digital Monitoring System for Raw and Mixed Coolant Consumption

College name

KPR Institute of Engineering and Technology

Student team Details

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Project Proposal

1. **Major Area**
    - Industry 4.0
    - Smart Utilities Monitoring
    - Sustainability

2. **Problem Statement**

“Digital Monitoring System for Raw and Mixed Coolant Consumption”

3. Problem Statement Summary (1500 words Max)

1. Need of Coolant in Machines:

Coolants are vital fluids used in industrial machines—especially CNC machines and metal-cutting operations—to **control temperature, reduce friction, and extend tool life**. When machines operate continuously at high speeds, they generate intense heat that can cause wear, deformation, or even complete failure of components. A well-maintained coolant system ensures **smooth operation, accurate machining, and prevents thermal damage**, directly impacting **product quality and machine longevity**.

2. Why Monitor Raw and Mixed Coolant Consumption?

While coolant is critical, **its consumption is often overlooked**—leading to excessive operational costs and avoidable breakdowns. Plants typically use **raw coolant concentrate**, which is diluted to form **mixed coolant** for actual use. Without a monitoring system, factories risk **improper mixing**, **unaccounted losses**, and **refill inefficiencies**. According to industry estimates, coolant-related waste can account for **up to 15-20% of total consumable costs** in some machining plants. Overuse leads to cost spikes; underuse affects machine performance. Hence, **measuring both raw and mixed coolant accurately** is essential for balancing cost, performance, and sustainability.

A 2024 report by the Indian Machine Tool Manufacturers' Association (IMTMA) estimates **coolant-related waste accounts for 15-20**% of consumable costs in Indian machining plants, with some facilities losing up to **₹40 lakh annually** due to overuse or mismanagement (IMTMA, 2024). For instance, a Pune-based auto parts manufacturer faced 12 hours of unplanned downtime in 2023 due to improper coolant ratios damaging a CNC machine, costing **₹10 lakh in repairs and lost production**.

3. Problems Faced without a Monitoring System

- No visibility into **daily coolant usage** per machine, shift, or operator
- **Improper mix ratios** go undetected, risking equipment damage
- **No alerts** for overuse or low coolant conditions
- **Manual logging** is error-prone and time-consuming
- Lack of **real-time dashboards** with predictive alerts (e.g., "coolant will run out in 6 hours")
- No **trend analysis** or cost impact visualization
- Refills are irregular, with **no auto-flagging of too frequent or rare top-ups**
- No **QR-based machine logs**, centralized refill tracking, or anomaly detection
- **Access control is weak**, and there's no cloud backup or offline detection support

Without a smart way to track coolant usage, factories often face a chain of problems—coolant gets wasted, mixing isn't done right, and maintenance is always one step too late. Since coolants play a key role in keeping machines healthy and running smoothly, ignoring their management can lead to downtime, faster wear and tear, and unnecessary expenses. What's needed is a simple yet intelligent system that keeps an eye on how much raw and mixed coolant is being used, sends timely alerts, and helps plan maintenance before issues arise. With such a system, manufacturers can move away from guesswork and manual logs, and instead run their operations smarter, faster, and more efficiently—saving both time and money in the long run. This results in **wasted coolant, suboptimal machine performance, and increased costs**. A smart monitoring system is needed to track raw and mixed coolant usage, provide real-time alerts, and enable predictive maintenance. Such a system eliminates guesswork, reduces downtime, and enhances efficiency, aligning with **India's Industry 4.0 initiatives like SAMARTH** and **sustainability goals** by minimizing waste.

4. Proposed solution with methodology

We propose a three part solution – Data Collection, Data Analysis and Data Representation.

1. **Data Collection – Retrofitting Existing Machines with Smart Sensors :**

To ensure affordability for Indian manufacturers, **we retrofit existing machines with non-invasive IoT sensors** (e.g., YF-S201 flow meters and ultrasonic level sensors) on coolant lines and tanks, measuring daily usage (liters/day) for raw and mixed coolant. Installation **uses clamp-on flow meters** and tank-mounted level sensors, requiring minimal downtime (1-2 hours per machine) to suit busy Indian plants, such as those in Chennai's industrial belt. Each machine is assigned a unique identifier, and shift data is tagged via keypad or manual entry. ESP32 microcontrollers capture sensor data, calculate mix ratios (e.g., flagging deviations ±10% from the standard 1:10 concentrate-to-water ratio), and support manual refill inputs for semi-automated setups. The system scales to support up to 100 machines per plant, with data aggregated across multiple plants (e.g., Gujarat and Tamil Nadu) via a **centralized cloud.**

2. **Data Analysis - Intelligent Processing and Cloud Integration**

Data collected by each ESP32 unit is transmitted via **Wi-Fi using MQTT or HTTP protocols** to a centralized **cloud backend** (Node.js or Python Flask server). The backend processes data in real-time, aggregates it, and stores it securely in **Firebase or MongoDB Atlas**.

This backend performs:

- **Daily total calculations** per machine and operator
- **Mix ratio analysis** to flag improper dilution
- **Deviation tracking** for refill amounts
- **Anomaly detection** based on refill frequency or usage spikes
- **Predictive estimations** (e.g., "At current usage, this machine will run out in 6 hours")

Maintenance checklists, refill logs, and calendar views are also generated here, enabling **predictive maintenance planning**.

3. **Data Representation – Dashboard, Alerts and Admin Panel**

A **React.js-based frontend**, communicating via **REST APIs**, provides a responsive interface:

- **Color-coded gauges** (Green: >50% tank level, Yellow: 20-50%, Red: <20%) for coolant status.
- **Live refill notifications** via **WhatsApp** (popular in India for operator communication).
- **Predictive alerts** (e.g., "Refill needed in 6 hours").

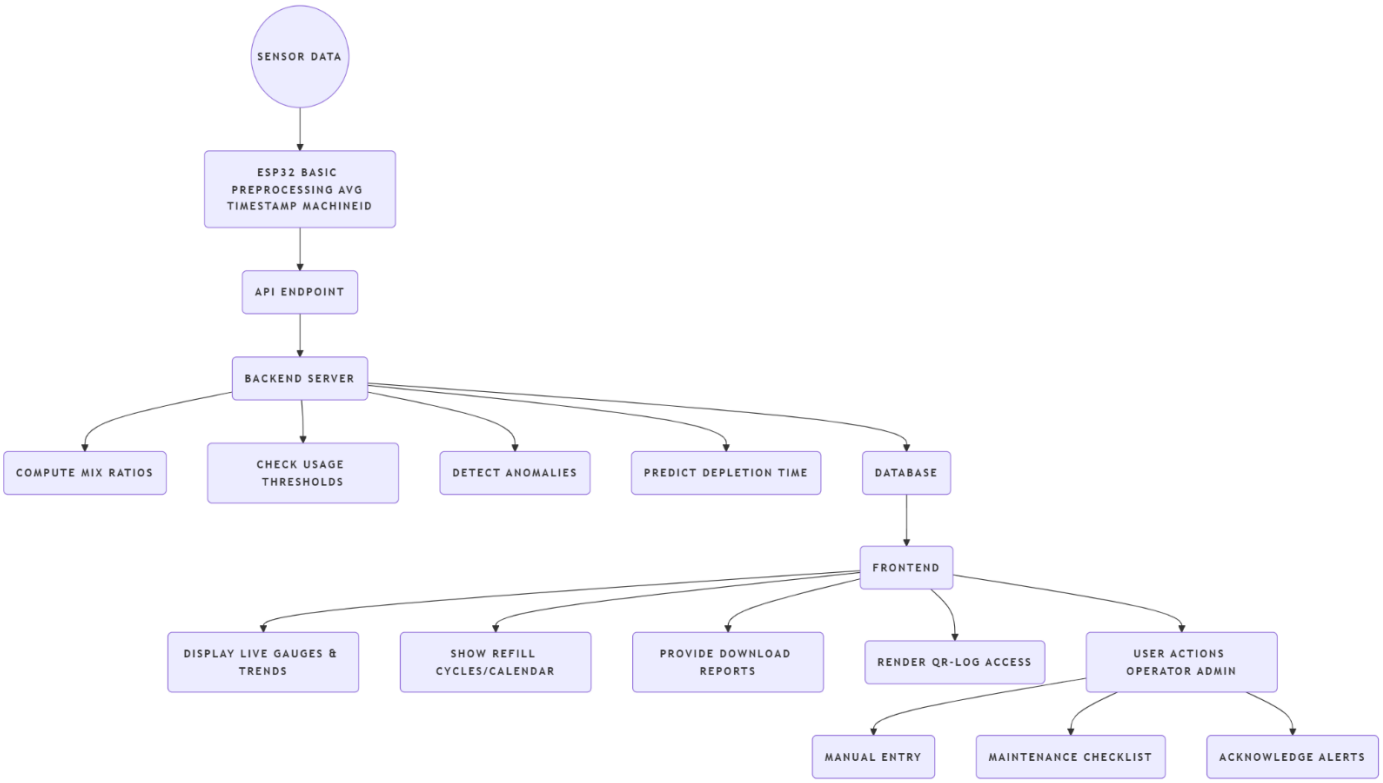
- **Interactive charts** (via Chart.js) for usage trends, mix ratios, and operator performance.
- Calendar view of refill cycles across plants.
- Downloadable CSV/PDF reports for cost analysis.
- **QR code scanning** for machine-specific logs, accessible on **low-cost smartphones**. The **Admin Panel** includes **role-based access** (Operator, Supervisor, Manager), audit logs, and **cloud backups (AWS S3)**. The interface is designed for **minimal training**, with **Hindi/English options** to suit Indian operators. **Offline sync** ensures usability in poor network conditions.

The **Admin Panel** offers:

- **Role-based access** (Operator, Supervisor, Manager)
- **Audit logs** for traceability
- **Offline detection and sync**
- **Cloud backup options** for data reliability

This representation layer closes the loop by offering **actionable insights** and **smart alerting**, transforming manual, reactive coolant management into a **digital-first, proactive system**.

Data Flow Diagram:



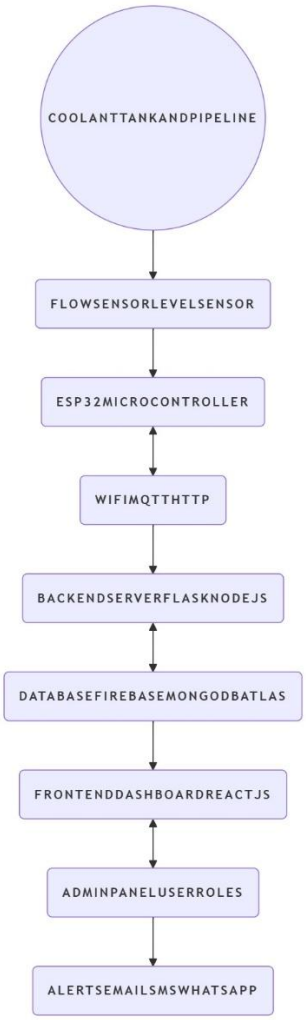
5. Technical Approach

Category	Technology / Component	Purpose / Use Case
Programming Languages	C++ (Arduino)	Programming the ESP32 for sensor control and data transmission
	JavaScript (Node.js)	Backend API handling, cloud communication, and data processing
	JavaScript (React.js)	Building the interactive, real-time dashboard

		HTML/CSS	Structuring and styling the frontend
Frontend		React.js	Responsive dashboard with user roles and live charts
		Chart.js / Recharts	Visualizing coolant trends, mix ratios, and refill cycles
Backend & Database		Node.js / Flask	Backend API logic and integration with ESP32 and frontend
		Firebase Realtime DB	Cloud-based storage for sensor data and user logs (real-time updates)
		JWT Authentication	Secure role-based login (Operator, Supervisor, Manager)
APIs & Integrations		Twilio / WhatsApp Cloud API	Sending real-time SMS/WhatsApp alerts to maintenance heads
		Google Drive / AWS S3	Secure cloud backup of logs and reports
Hardware		ESP32 Microcontroller	Wi-Fi-enabled microcontroller for IoT data collection and transmission
		Flow Sensor (YF-S201 / Paddle Wheel)	Measures coolant flow rate and daily consumption
		Ultrasonic Level Sensor / Float Switch	Tracks tank level to calculate available coolant
		Keypad (Optional)	Manual input of refill data if needed
Communication Protocols		MQTT	Lightweight protocol for real-time data

		push from ESP32 to backend
	HTTP / REST API	Standard communication between backend and frontend
	Wi-Fi	Wireless data transmission from devices to cloud

System Architecture Diagram:



6. Impact and Benefits

This coolant monitoring system brings a smart, affordable upgrade to traditional manufacturing environments. By **tracking coolant usage in real-time**, it helps ensure that machines always receive the right mix, preventing both wastage and damage due to improper dilution. It offers **machine-wise, shift-wise, and operator-specific data**, improving **transparency, accountability, and operational discipline**. The system generates **alerts for overuse, underuse, and refilling needs**, enabling **predictive maintenance** and significantly reducing the risk of unplanned downtime. With features like **trend analysis, cost impact reports, and refill cycle tracking**, managers can make **data-driven decisions** that optimize both performance and expenses. Designed to be **retrofitted onto existing setups using low-cost hardware**, it aligns perfectly with **Industry 4.0 goals**, making smart manufacturing accessible even to small and medium industries. Overall, the system enhances **efficiency, reliability, and cost-effectiveness**, transforming coolant management from a manual task into a fully digital, intelligent process.

P.S.

While AI tools, including ChatGPT, were used to refine the structure, language, and clarity of this proposal, the core idea, solution approach, and innovation are entirely my own. These tools served as creative collaborators, not originators.