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IoT Driven Battery Health Monitoring Framework for ICE Two Wheelers with WhatsApp Based User Interaction

Moubani Mukherjee*
Department of Management, IQ City United World School of Business, Kolkata, India

***Abstract*: India's two-wheeler ecosystem remains heavily dependent on Internal Combustion Engine (ICE) vehicles. Unlike electric vehicles, ICE batteries operate without intelligent monitoring systems, leaving users unaware of battery condition until failure occurs. This research presents a conceptual Internet of Things (IoT) framework designed to introduce real-time battery health visibility to ICE two-wheelers using affordable electronic components and cloud connectivity. The proposed system measures voltage, current, and temperature parameters through sensors connected to an ESP32 microcontroller. Battery data is transmitted to cloud servers and communicated to riders through WhatsApp Business API in the form of alerts and maintenance reminders. In addition to the technical framework, this study introduces an integrated business model that focuses on delivery riders, motorcycle enthusiasts, and garage mechanics. Primary insights were obtained through field interactions with mechanics and battery retailers in West Bengal. The framework demonstrates how low-cost IoT infrastructure can reduce unexpected battery failures while strengthening relationships between riders, service providers, and manufacturers. This study offers a practical approach for modernizing conventional ICE battery systems in emerging mobility markets.**

***Keywords*: IoT-based Battery Monitoring, ICE Two-Wheelers, Predictive Maintenance, WhatsApp Business API, Smart Mobility Systems, Battery Health Diagnostics, Applied Industry Research.**

1. Introduction

Two-wheelers form the backbone of personal and commercial mobility in India. From daily commuting to gig economy deliveries, millions of riders depend on their vehicles for income and essential travel. Despite this dependence, battery maintenance in Internal Combustion Engine (ICE) two-wheelers remains largely reactive. Riders typically become aware of battery problems only after their vehicle fails to start.

Electric vehicles benefit from advanced Battery Management Systems that continuously monitor battery performance. In contrast, ICE vehicles rely on basic lead-acid batteries with no diagnostic intelligence. This absence creates uncertainty regarding battery lifespan and leads to frequent breakdowns, especially among delivery riders who require uninterrupted mobility.

Battery failures often result in lost working hours, emergency replacement costs, and dissatisfaction with service providers. Mechanics also face challenges due to delayed warranty resolutions and limited technical support from manufacturers.

This research proposes a connected battery monitoring framework that introduces real-time visibility into battery condition. By combining low-cost IoT hardware with cloud platforms and WhatsApp-based notifications, the system aims to shift battery care from reactive replacement to preventive management.

Beyond technology, this study explores how such a system can be embedded within a niche business ecosystem that includes mechanic loyalty programs, sustainability initiatives, and user engagement strategies.

2. Problem Statement

Battery-related issues are among the most common causes of two-wheeler downtime in India. However, current ICE battery systems provide no mechanism for riders to assess battery health during everyday use. This lack of transparency leads to unexpected vehicle immobilization and replacement anxiety.

Field discussions with local mechanics and retailers revealed recurring challenges:

- Customers approach service centres only after complete battery failure.
- Delays in warranty replacement processes.
- Lack of communication between battery brands and end users.
- Mechanics receiving minimal after-sales support.
- Riders unaware of battery degradation until breakdown occurs.

Delivery riders expressed particular concern, as battery failure directly impacts their income. Mechanics reported frustration with existing brand ecosystems that prioritize sales volumes over service relationships.

These issues indicate the need for a system that enables continuous battery monitoring, early warning alerts, and structured engagement between riders, mechanics, and manufacturers.

*Corresponding author: rayamukherjee10@gmail.com

3. Market Context and Opportunity

India sells over 20 million ICE two-wheelers annually, while electric two-wheelers still represent a small fraction of total registrations. Budget lead-acid batteries dominate the replacement market, typically priced between ₹1,000 and ₹1,500.

Despite the scale of this market, predictive battery monitoring remains absent. Most battery brands operate purely as product suppliers, with limited digital engagement after purchase.

This gap presents a strong opportunity to introduce affordable IoT-based diagnostics to ICE vehicles, allowing brands to move from transactional sales models to service-driven relationships.

Regional insights from West Bengal suggest strong acceptance potential, particularly among gig economy riders and neighbourhood garages seeking better diagnostic tools.

4. Methodology

This study follows a conceptual design methodology supported by field observations conducted over four months during the author's internship at Exide Industries Ltd.

A. Field Observations

Primary qualitative insights were gathered through informal interviews and discussions with:

- Five independent garage mechanics
- Three battery retailers
- One long-standing dealer

These interactions were conducted in Kalyani and nearby areas of South-East Bengal, including Kolkata. Conversations focused on battery failure patterns, customer behaviour, service delays, and brand responsiveness.

Common observations included customer dissatisfaction due to delayed replacements, lack of battery health awareness, and limited manufacturer engagement with mechanics.

B. Conceptual System Design

Based on field inputs, a conceptual IoT monitoring framework was developed. The system uses:

- ESP32 microcontroller
- Voltage and current sensors
- Temperature sensors
- GSM or Wi-Fi connectivity
- Cloud platforms for data storage

No physical deployment was conducted. Instead, architecture design, workflow mapping, and cost modeling were carried out at proof-of-concept level to demonstrate feasibility.

5. Proposed System Architecture

The framework operates through four sequential stages.

Stage 1: Data Acquisition

Sensors connected to an ESP32 development board capture electrical and thermal parameters from the battery. These inputs are used to estimate:

- State of Charge (SoC)
- State of Health (SoH)
- Cranking voltage

This stage provides continuous visibility into battery performance.

Stage 2: Cloud Transmission

Collected data is transmitted to cloud servers using GSM or Wi-Fi modules. The cloud platform stores historical records and supports basic analytics, enabling trend analysis over time.

Stage 3: User Communication

Processed information is delivered to riders through WhatsApp Business API. Notifications include:

- Low battery warnings
- Health degradation alerts
- Warranty expiry reminders
- Preventive maintenance tips

WhatsApp is chosen due to its widespread usage in India and low learning barrier.

Stage 4: Experience Layer

Additional features include:

- Nearest service center navigation
- Live service tracking
- Transaction confirmations
- Personalized reminders

This stage creates a continuous feedback loop between rider, mechanic, and system.

6. Cost Analysis

Estimated component costs:

- ESP32 Development Board: ₹230–₹491
- Current Sensor Module: ₹79–₹260
- GSM Module: ₹280–₹450
- Cloud Services: Free tier or minimal
- WhatsApp Messaging: ₹0.115–₹0.75 per message

Total hardware cost remains below ₹2,000 per unit, enabling affordability for budget battery segments.

Operational costs scale with message volume and cloud usage, making the model suitable for phased deployment.

7. Business Integration Framework: ShieldPlus

Technology adoption depends on ecosystem alignment. To ensure real-world viability, the monitoring framework is embedded within ShieldPlus, a niche battery brand concept.

A. Target Segments

- Urban delivery riders who prioritize uptime.
- Motorcycle enthusiasts seeking performance and identity.
- Mechanics who influence purchasing decisions.

B. Value Propositions

- Real-time battery diagnostics.
- Mechanic loyalty programs offering commissions and training.
- Skill development for underprivileged youth.
- Environmental contribution through tree plantation per battery sold.

Distribution follows a direct-to-garage model, positioning mechanics as sales partners. Marketing includes rider camps, digital storytelling, and localized garage branding.

Revenue is generated through tiered battery pricing, service packages, and ecosystem partnerships.

8. Results and Discussion

Although full-scale deployment was not conducted, field observations indicate strong demand for transparent battery diagnostics, especially among delivery riders.

Mechanics expressed interest in structured incentive programs and diagnostic tools. The WhatsApp-based communication model was perceived as accessible and practical due to user familiarity.

The combined technical and business framework demonstrates potential to improve battery reliability while creating economic value for local garages and service providers.

By integrating sustainability and skill development, the model also supports long-term community engagement.

9. Limitations

This study is limited by its conceptual nature and absence of quantitative validation. Long-term sensor accuracy, system durability, and user behavior impacts were not measured.

Future research may involve pilot deployments and empirical evaluation across larger vehicle populations.

10. Conclusion

This research presents a conceptual IoT-based battery monitoring framework for ICE two-wheelers that enables real-time diagnostics and user communication through accessible digital platforms. By integrating affordable hardware with cloud services and WhatsApp messaging, the system provides early warnings and maintenance guidance to riders.

When combined with an impact-oriented business model involving mechanics and sustainability initiatives, the framework evolves into a service-driven mobility ecosystem. The study demonstrates how traditional battery markets can adopt data-enabled practices without requiring electric vehicle infrastructure, offering a scalable pathway toward predictive maintenance in emerging economies.

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