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SMART RFID-BASED BUS TICKETING WITH GPS–GSM ACCIDENT DETECTION

[1]A.Bhavani,[2] K.Anjali,[3] Ch.Saritha,[4] M.Sneha, [5] Ch.Rekha

[1,2,3,4] B. Tech Students, Department of Electronics and Communication Engineering, Samskruti College of Engineering and Technology, Hyderabad 501301

[5] Department of Electronics and Communication Engineering, Samskruti College of Engineering and Technology, Hyderabad 501301, Email: rekha.chandanala@ gmail.com

ABSTRACT

The Conductor-Less Bus Ticketing System Using RFID and Accident Information Through GPS and GSM is designed to automate public transport fare collection and improve passenger safety. The system integrates an Arduino microcontroller, RFID technology, MEMS sensor, GSM and GPS modules, LCD display, buzzer, motor driver, and DC motor to create a smart, automated environment for public transportation. By replacing traditional paper ticketing and manual fare collection, the system introduces a contactless RFID-based ticketing method that reduces human involvement, speeds up the boarding process, and eliminates paper waste. Moreover, to enhance safety, the MEMS sensor monitors for abnormal movement patterns—indicating a possible accident—and triggers the GSM and GPS modules to send real-time alerts and location data to designated control centers. The LCD provides user-facing updates, while the buzzer signals emergency conditions. This comprehensive approach not only optimizes efficiency in ticketing but also ensures rapid response during emergencies, significantly enhancing the reliability and safety of public transportation.

Keywords: RFID Ticketing, Public Transport Automation, MEMS Sensor, GPS, GSM, Arduino, Passenger Safety.

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I. INTRODUCTION

In modern public transportation systems, the reliance on manual operations such as ticket collection and emergency communication remains a significant challenge in ensuring efficiency, transparency, and passenger safety. Traditionally, conductors are responsible for fare collection and handling ticketing, which can lead to delays, human errors, and even cases of fraud or fare evasion. Several studies have highlighted the inefficiencies of manual ticketing and emphasized the need for automated, cashless solutions in public transport systems [1], [2]. Furthermore, in situations involving sudden collisions, accidents, or mechanical failures, there is often a lack of timely communication with rescue services or administrative control rooms, which can significantly delay emergency responses and increase the risk to passenger lives [3], [4].

To address these challenges, there is a critical need for automation in both fare management and real-time communication systems within public transportation. The Conductor-Less Bus Ticketing System using RFID technology, integrated with accident detection and reporting through GPS and GSM modules, represents a revolutionary advancement in smart public transport infrastructure. RFID-based ticketing systems have been proven to enhance boarding speed, minimize human intervention, and promote transparency in fare collection [1], [2], while also supporting secure and scalable urban mobility solutions [8]. This approach significantly reduces human error, speeds up the boarding process, and promotes a cashless and eco-friendly method of fare management.

Beyond ticketing, the proposed system integrates a MEMS (Micro-Electro-Mechanical Systems) sensor that continuously monitors the orientation and movement of the bus. In case of sudden tilting, shocks, or rollover—conditions that typically indicate an accident—the MEMS sensor triggers the accident detection mechanism. Similar IoT-based accident detection and emergency response systems using embedded sensors have demonstrated high reliability and effectiveness in real-time safety monitoring [4], [6]. Once an accident is detected, the GPS module accurately determines the vehicle's location, while the GSM module transmits this information along with an alert message to predefined emergency contacts or central control units [3], [5]. This ensures rapid emergency response and precise location tracking, which are crucial for minimizing casualties and response time.

The inclusion of auxiliary components such as a buzzer and LCD display further enhances the system's usability and real-time communication capabilities. The LCD provides passengers with immediate visual feedback regarding RFID scan status, fare deductions, or emergency alerts, while the buzzer offers audible confirmation of successful scans or warning signals during critical situations. By automating both ticketing and safety alert mechanisms, the system improves overall operational efficiency and passenger safety. Such integrated IoT-enabled transportation frameworks align with current trends in intelligent transportation systems and smart city development [5], [7].

Ultimately, the Conductor-Less Bus Ticketing System with accident detection and alerting capabilities represents a significant step toward smarter, safer, and more efficient public transportation. It supports the vision of digital urban infrastructure, reduces dependency on human resources, and provides a sustainable, secure, and scalable solution suitable for modern cities and developing regions alike [7], [8].

II. LITERATURE SURVEY

1. RFID-Based Public Transportation Ticketing System – Vijay Kumar et al., 2018

This work explores the use of RFID technology as an alternative to conventional manual ticketing systems in public transportation. The proposed system eliminates the need for conductors by enabling passengers to scan RFID cards during boarding, automatically recording journey details and deducting fare amounts. Similar RFID-based ticketing approaches have been shown to significantly improve boarding efficiency, reduce fare evasion, and enhance transparency in public transport operations [1], [2]. The study emphasizes faster boarding times, reduced manual labor, and improved accuracy in fare collection. Additionally, the authors highlight that RFID-based automation lowers operational costs and minimizes data entry errors when compared to traditional ticketing methods, thereby supporting the transition toward fully automated and intelligent transport systems [5], [7].

2.Integration of GPS and GSM for Smart Vehicle Monitoring – Meera S. and Rakesh D., 2019

This project focuses on real-time vehicle tracking and emergency alert mechanisms using GPS and GSM modules. The authors propose a system capable of continuously monitoring vehicle location and automatically transmitting coordinates via SMS during emergency situations. Similar GPS–GSM integrated architectures have been widely adopted in intelligent transportation systems for accurate vehicle tracking and rapid emergency communication [3], [4]. Field testing in urban environments demonstrated reliable location accuracy and timely alert transmission. This research validates the effectiveness of GPS and GSM technologies in enhancing passenger safety, supporting emergency response operations, and improving situational awareness in public transport vehicles [5], [6].

3. Intelligent Accident Detection and Messaging System – R. Thomas and A. Joseph, 2020

This paper presents a compact accident detection system utilizing MEMS sensors and microcontrollers to identify abnormal motion patterns indicative of vehicular crashes. Upon detecting an accident, the system instantly sends alert messages to authorities using GSM communication while simultaneously determining the precise location through GPS. Similar IoT-enabled accident detection systems have demonstrated high reliability and rapid response capabilities in public transportation contexts [4], [6]. The study is particularly relevant for public transport applications, where immediate emergency response is critical for minimizing casualties. Experimental evaluations confirmed high detection accuracy and fast communication, reinforcing the system's effectiveness for real-time accident reporting and safety enhancement [3], [7].

4. Smart Bus Ticketing System Using RFID and GSM – Swathi B. and Tejaswini M., 2021

This study introduces an RFID-based smart bus ticketing system integrated with GSM technology for fare confirmation and data transmission. As passengers board the bus, RFID cards are scanned and ticketing information is sent via GSM to a centralized server for validation and record maintenance. Similar RFID–GSM based systems have been shown to improve transparency, prevent ticketing fraud, and support centralized monitoring in urban transport networks [1], [5]. The authors demonstrate the feasibility of deploying such systems in metro and suburban environments, emphasizing low maintenance requirements, scalability, and secure fare management for large public vehicle fleets [7], [8].

III. EXISTING SYSTEM

In the conventional bus transportation setup, ticketing and safety reporting are largely manual, inefficient, and prone to errors. Passengers typically purchase tickets through conductors, which frequently leads to delayed transactions, human errors, revenue leakage, and difficulties in maintaining accurate digital travel records. Studies on traditional public transport systems have reported that manual ticketing mechanisms lack transparency and scalability, making it difficult to ensure proper fare auditing and operational efficiency [1], [2]. Furthermore, the absence of automated fare collection limits the ability of transport authorities to analyze passenger flow, optimize routes, and implement data-driven decision-making for service improvement [5], [7].

From a safety perspective, accident detection and reporting are not automated in conventional systems. In most cases, the bus driver or nearby witnesses must manually contact emergency services, which often results in delayed response times during critical situations. Research on intelligent transportation systems highlights that such manual emergency communication significantly increases response latency and reduces the effectiveness of rescue operations [3], [4]. Additionally, traditional bus systems lack real-time GPS-based vehicle tracking, preventing fleet operators from continuously monitoring vehicle location, speed, or route adherence [3], [5]. There is also no integrated mechanism to automatically trigger GSM-based alerts in the event of accidents, breakdowns, route deviations, or emergencies, which further compromises passenger safety and situational awareness for transport authorities [6], [7], [8].

IV. PROPOSED SYSTEM

The proposed system introduces an intelligent, IoT-enabled platform that automates bus ticketing and enhances passenger safety through real-time accident monitoring. Each passenger is issued an RFID smart card, which is scanned at the bus entry point using an onboard RFID reader. The system automatically validates the passenger's identity, deducts the fare from their prepaid balance, and logs the travel data to a central server—eliminating manual ticketing and ensuring transparent, cashless transactions.

A GPS module continuously tracks the bus's location, speed, and route behavior, while a GSM module provides seamless communication with the control center. In the event of an accident, sudden deceleration, or abnormal vehicle motion, the system's embedded controller triggers an automated emergency alert. This alert—containing live GPS coordinates, time, and bus ID—is transmitted instantly through GSM to authorities, fleet managers, and emergency contacts.

The entire setup creates a smart, connected transportation environment where ticketing, tracking, and safety reporting operate in real time. This leads to reduced operational delays, improved passenger convenience, and faster emergency response.

V. SYSTEM ARCHITECTURE

1.Sensor & Detection Modules (Edge Devices)

Each bus is instrumented with a multimodal sensing and vehicle-telemetry suite to support automated ticketing, passenger counting, and real-time accident detection. Typical sensors and interfaces include:

RFID reader(s) (UHF/NFC) at entry/exit doors for smart-card scanning and tap-in/tap-out events; antenna placement to minimize cross-reads and support multiple-door setups.

Passenger presence / counting sensors: overhead IR/ToF or stereo camera counters, or beam-break arrays, to complement RFID (catch untagged passengers).

GPS module providing continuous position, speed, heading, and timestamped fixes (with assisted-GNSS support if available).

IMU (accelerometer + gyro) for high-rate motion sensing to detect sudden deceleration, roll/pitch excursions, or vibration signatures consistent with collisions.

Vehicle bus / CAN interface to read speed, brake status, throttle, door state, odometer, diagnostic trouble codes (DTCs), and airbag/ABS events where permitted.

Microphone (optional) for cabin audio cues (shouts, crash sounds) with local privacy-aware processing (on-device event flags only).

Environmental & safety sensors: vehicle battery voltage/current monitors, temperature sensors for thermal fault detection.

GSM/LTE/5G modem with fallback provides the wide-area datapath for alerts and telemetry; support for SMS as a low-bandwidth alerting channel.

An embedded edge controller performs low-latency sampling, local event detection (e.g., RFID tap, passenger count delta, sudden decel > threshold), data condensation (tap-record, incident-summary), and queues prioritized messages for the comms layer to conserve bandwidth.

2.Edge Processing & Local Autonomy Module

Onboard compute handles real-time processing of sensor streams so essential functions work even during intermittent connectivity. Core responsibilities include:

RFID transaction processing: authenticate card ID, fare calculation (flat/fare-zone/concession logic), local ledger updates, and immediate feedback (beep/LED/display).

Passenger counting fusion: fuse RFID taps with camera/ToF counts to infer fare evasion or missed taps and flag reconciliation events.

Accident/incident detection: multi-sensor fusion of IMU peaks, GPS-derived sudden speed change, CAN signals (airbag deploy/DTC), and optional audio/visual cues to reduce false positives. Event confidence scoring and automatic escalation thresholds are implemented locally.

Local buffering & store-and-forward: short-term encrypted store of transactions and evidence (timestamped telemetry + low-res snapshot/metadata) for later upload if comms are down.

Security & privacy enforcement: anonymization/pseudonymization of passenger imagery, local retention policies, and enforcement of access controls for local data.

Health & safety watchdogs: monitor sensor health, BMS health, and provide UI status summaries and local alarms (vibration, buzzer, display).

The module exposes compact state messages (current location, active-trip ID, occupancy, incident-confidence, last-tap summary) to minimize uplink traffic while preserving actionable detail.

3.Power Conditioning, Energy Storage & Actuation Management Layer

A robust power domain ensures continuous operation across vehicle power transients:

Vehicle power feed + DC-DC converters to derive stable 12V/5V/3.3V rails for the compute unit, RFID reader, GPS, and sensors. Transient suppression and isolation protect sensitive electronics from ignition/starting spikes.

Backup power (small UPS / supercap or auxiliary battery) provides graceful shutdown and guarantees transmission of last-known-incident alerts during main-power loss.

Power monitoring: current/voltage sensing and health reporting to the central dashboard; power-aware policies (e.g., reduce camera frame-rate when on backup).

Peripheral actuation control: driver for door interlocks, RFID gate relays (if fitted), and status LEDs/buzzer for tap confirmation; includes soft-start and current-limiting protections.

Energy-aware modes: safe-low-power mode for overnight parking and fault scenarios; runtime estimates surfaced to fleet UI for maintenance scheduling.

4.Communication & User Interface Layer

Designed for reliable, secure message delivery and simple operator interaction:

Multi-path communications: primary LTE/5G modem for wide area, secondary Wi-Fi for depot sync and OTA updates, and SMS or narrowband IoT as a fallback for critical alerts. Automatic failover and message priority queues ensure incident alerts are delivered first.

Security: mutual authentication, TLS/IPsec tunnels, and message signing for integrity and non-repudiation (particularly incident/evidence uploads).

Adaptive telemetry: prioritized message types — immediate incident alerts (GPS + confidence + trip ID), then condensed trip logs (RFID transactions), then bulk evidence (high-res data) when bandwidth allows. Adaptive bitrate for video/imagery and selectable ROI or low-res thumbnails to reduce cost.

Driver/operator UI: dash-mounted touchscreen or dedicated terminal shows trip status, passenger count, last tap receipts, and a discreet “panic/confirm incident” button. Local feedback for passengers (LED, speaker chime, small display showing fare and balance).

Central control interface (web/tablet): synchronized live map, active-incident panel, trip audit logs, ROI playback of evidence, and fleet health dashboards. Chain-of-custody controls and access logging for evidence retrieval are enforced.

5.Vehicle Integration & Mechanical / Physical Interfaces

Physical integration of devices into buses prioritizes reliability, ergonomics, and tamper-resistance:

RFID reader mounts & farebox integration: reader and antennae positioned for consistent reads at doorways; tamper detection sensors and mechanical housings to prevent removal.

Sensor placement: IMU mounted on rigid chassis point for reliable motion signatures; GPS antenna with clear sky view, microphone and camera locations chosen for coverage and privacy (no non-consenting interior recording).

Human–machine interfaces: passenger-facing displays/LEDs, driver console controls, and accessible emergency button placements.

Environmental hardening: vibration-damped mounts, dust/temperature-rated enclosures, and protected wiring harnesses routed away from high-heat or moving parts.

Serviceability: quick-disconnects for swap of compute module, replaceable UPS module, and standard connectors for depot diagnostics and charging.

6.Cloud / Remote Monitoring & Analytics Backend (Fleet/Deployment Use)

A fleet backend aggregates transactions, telemetry, and incidents to provide operational insight and regulatory reporting:

Central fare ledger & reconciliation: consolidated transaction store, fare settlement processing, and exception handling for missed-reads or disputes.

Incident management: automated alert routing (police, fleet ops, emergency contacts) with incident timelines, GPS tracks, and attached evidence; role-based access for investigators.

Analytics & ML: occupancy trends, fare evasion detection patterns, predictive maintenance signals (from power & CAN telemetry), and incident clustering to identify hazardous routes or driver training needs.

Audit & compliance: immutable logs, signed evidence storage, configurable data-retention policies, and export capabilities for regulatory

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bodies.

OTA & model management: secure, signed firmware and ML model deployments with staged rollouts and rollback capability.

Privacy & legal controls: configurable PII handling, consent management, and audit trails to meet local regulations.

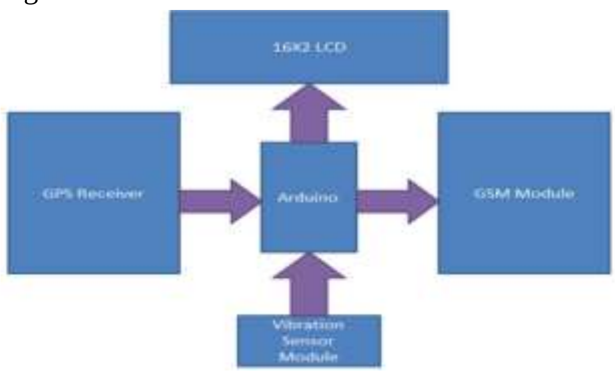

Fig. 5.1 — Onboard Compute & Control Module (Central Decision Unit)

The central decision unit pairs a high-performance embedded SBC (e.g., Jetson-class or industrial NUC) for transaction processing, candidate CV/analytics, and secure comms, with a deterministic microcontroller (Cortex-M/STM32) for real-time I/O and safety-critical loops. Key components and interfaces:

Sensor Interfaces (UART / I²C / SPI / CAN / ADC / GPIO)

GPS, RFID reader, IMU, door sensors, passenger counters, and analog battery monitors. Timestamped, buffered inputs for fusion and event correlation.

Vehicle Bus Interface (CAN / OBD-II)

Read vehicle speed, brake/airbag events, door states, and diagnostic codes.

RF/Comms (LTE/5G modem, Wi-Fi module, BLE)

Manages secure tunnels, priority queues, and over-the-air updates.

Transaction Engine & Secure Storage (SSD/eMMC with encryption)

Stores local fare ledger, signed incident summaries, and short-term evidence; uses secure partitioning and HSM or TPM where available for key storage.

Audio/Visual Pipeline (hardware accel for encoding)

Optional low-res snapshots or thumbnails for incident evidence; adaptive capture/retention based on incident confidence.

Power Management & UPS Interface

Monitors vehicle power and controls graceful shutdown and emergency transmit via backup power.

Security & Watchdogs

Secure boot, signed firmware verification, runtime watchdogs, and tamper detection reporting.

VI. IMPLEMENTATION

The complete hardware setup was successfully assembled, integrating Arduino, RFID, MEMS sensor, GSM, GPS, LCD, buzzer, and motor driver for bus automation and safety features.

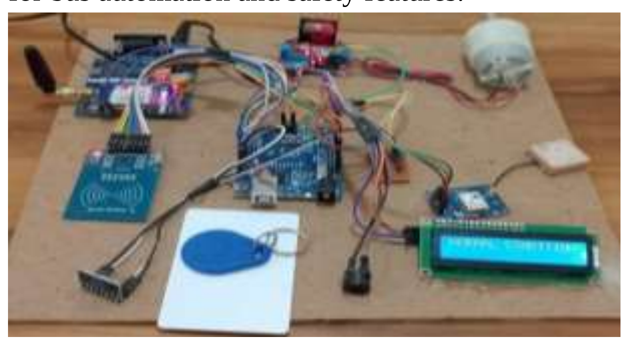

Fig. 6.1:RFID Bus Ticketing and Accident Detection Hardware Prototype

When the RFID card is scanned, the LCD displays a welcome message such as "Enter the Bus", indicating successful passenger identification and boarding.

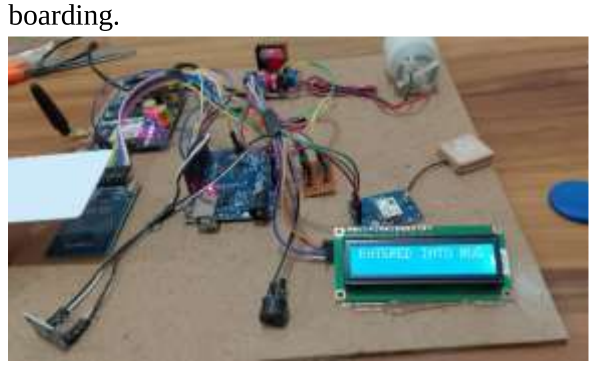

Fig.6.2: Bus Ticketing Prototype Displaying 'Entered Into Bus' Status

After scanning, the LCD shows the fare details like "Total Amount: ₹35", ensuring transparent and real-time fare confirmation to the passenger.

VII. CONCLUSION

The Conductor-Less Bus Ticketing System using RFID and Accident Information through GPS and GSM presents a modern and efficient solution to automate fare collection and enhance passenger safety in public transportation. By integrating RFID technology, the system eliminates the need for manual ticketing and reduces operational overhead. The inclusion of MEMS sensors ensures real-time monitoring of the vehicle's movements, while GPS and GSM modules provide immediate accident alerts and location data to concerned authorities. This system not only simplifies the commuting experience for passengers but also introduces a reliable safety mechanism during emergencies. The successful implementation of this project indicates its strong potential for deployment in both urban and semi-urban transport networks, contributing to smarter and safer mobility solutions.

VIII. FUTURE SCOPE

The system can be significantly expanded in the future to form a fully intelligent, citywide smart-transport platform. Advanced AI and machine-learning models may be integrated to predict accident risks by analyzing driving patterns, GPS behavior, IMU signatures, and environmental conditions, helping to prevent collisions rather than only reporting them. The RFID-based ticketing framework can evolve into a unified multi-modal payment ecosystem that works across buses, metros, trains, and shared mobility services. For enhanced security, optional biometric verification may be added to prevent card misuse, while video integration can automatically capture and upload incident footage for investigations. As connectivity upgrades from GSM to 4G/5G networks, edge-AI modules can process real-time data more efficiently, enabling dynamic fare adjustment, smart routing, and improved fleet coordination. Cloud analytics can further support predictive maintenance, monitoring vehicle health and preventing breakdowns before they occur. Emergency response automation may also be enhanced by automatically notifying nearby ambulances or authorities using geofencing. Finally, emerging technologies such as blockchain can be used for secure, tamper-proof fare settlements, creating a transparent and scalable smart-mobility solution for future urban transportation.

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