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Full Length Article

Intelligent Ticketing With Safety Surveillance Based On Real-Time Tracking

Ms. S Manjula[1], Janumpally Soni[2], Koluthala Vyshnavi[3], Kurva Saraswathi[4]
[1]Associate Professor; Department Of Electronics And Communication Engineering Bhoj Reddy Engineering College For Women Hyderabad India.
[2,3,4]B.Tech Students; Department Of Electronics And Communication Engineering Bhoj Reddy Engineering College For Women Hyderabad India.
Mail Id; vyshnavikoluthala@gmail.com[3]
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Abstract
Rapid urbanization has significantly increased the demand for reliable, secure, and efficient public transportation systems. Conventional manual ticketing methods often lead to delays, fare leakage, human errors, and poor passenger experience. In addition, many transport systems lack continuous monitoring, live tracking, and emergency response mechanisms. This paper presents an intelligent transportation framework that integrates automated ticketing, passenger counting, safety surveillance, and real-time vehicle tracking into a unified embedded platform. The proposed prototype uses Arduino Uno as the central controller, RFID for contactless fare collection, GPS for location acquisition, GSM for communication, infrared sensors for occupancy counting, and vibration/tilt sensors for accident detection. The system automatically validates passenger cards, calculates fares, updates occupancy, and transmits live location data to a monitoring center. During emergency events, alert messages containing coordinates are sent instantly to predefined contacts. Experimental observations indicate improved boarding efficiency, transparent fare management, faster emergency notification, and better route visibility. The proposed design is economical, scalable, and suitable for smart city mobility applications.

Keywords: *RFID, Smart Ticketing, GPS Tracking, GSM Alerts, Arduino, Public Transport, IoT*

Introduction

Public transportation plays a vital role in sustainable urban development by reducing traffic congestion, fuel consumption, and environmental pollution. Buses remain one of the most affordable transport modes for students, workers, and daily commuters. However, traditional bus operations in many regions still depend on paper tickets and manual fare collection. These practices consume time, create queues, reduce transparency, and increase operational inefficiency.

In rapidly growing cities, transportation authorities are under pressure to improve service quality while controlling operational cost. Passengers expect punctual services, simple payment methods, route visibility, and safe travel conditions. Conventional systems struggle to satisfy these expectations because they depend heavily on manual processes and fragmented monitoring mechanisms.

Modern commuters also expect accurate arrival information, digital payment convenience, and enhanced safety. The absence of live vehicle tracking often creates uncertainty and dissatisfaction among passengers. Similarly, delayed emergency response during accidents may increase risk.

Advances in embedded systems, wireless communication, and low-cost sensors enable practical solutions to these problems. By combining RFID, GPS, GSM, and IoT technologies, transportation systems can become faster, safer, and data-driven.

Smart ticketing reduces cash handling, improves accounting transparency, and accelerates boarding time. Real-time tracking helps passengers plan travel efficiently and enables fleet managers to observe route adherence. Safety surveillance systems further strengthen public confidence by reducing emergency response delays.

This paper proposes an integrated intelligent ticketing platform with surveillance and real-time tracking capabilities for buses and fleet vehicles. The architecture is intentionally designed with affordable components so that it can be adopted in schools, universities, industries, municipalities, and semi-urban transport services.

The remainder of the paper explains the design methodology, hardware implementation, experimental observations, benefits, limitations, and future development opportunities.

Literature Review

Smart transportation has attracted growing research interest over the last decade because of rapid urban growth and increasing passenger expectations. Researchers have explored automation in fare collection, route optimization, fleet monitoring, passenger information systems, and safety management.

RFID-based fare systems reduce ticketing delays and support cashless travel. In these systems, passengers use rechargeable smart cards that are authenticated through radio frequency readers. Such models decrease dependency on paper tickets and minimize accounting discrepancies. They also improve boarding speed during peak hours.

GPS-based fleet management improves route transparency and scheduling. Vehicle location data can be transmitted to centralized dashboards where transport authorities monitor delays, stoppage duration, route deviation, and estimated arrival time. These systems are especially useful in metropolitan transport services where punctuality is critical.

IoT-enabled systems combine sensors, communication networks, and cloud dashboards for data-driven operations. Passenger counters, environmental sensors, engine monitoring devices, and surveillance cameras may all be connected to a unified analytics platform. This helps administrators make evidence-based operational decisions.

Several studies also discuss biometric authentication, mobile ticketing applications, QR-code travel passes, and AI-based demand forecasting. However, many reported systems focus on a single feature such as ticketing, tracking, or security. Fewer practical implementations integrate fare automation, occupancy monitoring, emergency alerts, and real-time tracking in one embedded prototype.

This research contributes a compact multi-feature embedded architecture suitable for cost-sensitive deployments such as educational campuses, municipal bus services, and semi-urban transport networks.

Embedded Systems

Embedded systems form one of the most important domains in modern engineering because they combine hardware and software to perform dedicated real-world functions. Unlike desktop computers or laptops that are designed for multiple purposes, embedded systems are created to execute specific tasks efficiently, reliably, and continuously. These systems are widely deployed in automobiles, medical devices, industrial machines, consumer electronics, communication devices, and intelligent transportation solutions.

A typical embedded system consists of a microcontroller or microprocessor, memory units, input/output interfaces, sensors, actuators, and communication modules. The controller serves as the decision-making unit that executes programmed instructions. Sensors collect physical information such as motion, temperature, distance, or location, while actuators perform required actions such as opening gates, activating alarms, or controlling motors. Through this close integration, embedded systems can sense, process, and respond to environmental conditions in real time.

One of the defining characteristics of embedded technology is deterministic or real-time performance. Many applications require immediate response within fixed time limits. For example, in transportation systems, ticket verification, passenger counting, accident detection, and live location updates must happen without delay. Therefore, embedded platforms are optimized for speed, reliability, and continuous operation.

Another important feature of the embedded domain is resource efficiency. Since these systems often run on limited memory, low processing power, and battery-based energy sources, engineers must optimize both circuit design and software logic. This includes low-power architectures, lightweight code, and cost-effective hardware selection.

Embedded systems also serve as the foundation of the Internet of Things (IoT). By enabling communication among devices, they support automation, remote monitoring, predictive maintenance, and intelligent decision-making. As a result, embedded technology has become essential in smart cities, connected healthcare, industrial automation, and intelligent transportation systems.

Existing System

The existing transportation ticketing system mainly depends on a combination of manual practices and partially digitized tools. In many public transport services, Electronic Ticketing Machines (ETMs) are used by conductors to issue tickets and calculate fares. These handheld systems improve speed compared to paper ticketing, but still require manual operation. Some transport networks also use GPS devices to monitor vehicle movement and estimate arrival schedules.

Passenger counting in older systems is often managed through infrared sensors or pressure-based counters placed near doors. Although these provide approximate occupancy values, their accuracy may decrease in crowded conditions. In selected urban networks, RFID smart cards are used for cashless fare collection. However, such systems often require expensive infrastructure and user compliance.

Safety surveillance in many existing systems is limited to CCTV cameras installed inside buses or stations. These cameras record footage, but real-time incident analysis and automated alerts are not always available. As a result, existing systems offer only partial automation and limited intelligence.

Conventional Manual Ticketing System

The conventional manual ticketing system is one of the oldest fare collection methods used in public transportation. In this model, passengers board the bus and inform the conductor of their destination. Based on the travel stage or route distance, the conductor manually calculates the fare and issues a paper ticket. Payment is usually collected in cash, and the conductor is responsible for maintaining revenue records.

This approach is simple and does not require sophisticated technology, making it suitable for rural or low-resource regions. However, it has several disadvantages. The process becomes slow during peak hours, leading to queues and delays. Human errors may occur during fare calculation or ticket issuance. In addition, cash handling and weak record management may cause revenue leakage and reduced transparency.

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Proposed System

The proposed Intelligent Ticketing System with Safety Surveillance based on Real-Time Tracking is designed to overcome the limitations of existing systems by combining automation, connectivity, and embedded intelligence into a single platform.

Passengers use RFID cards, QR codes, or mobile-based passes while entering and exiting the bus. The system automatically verifies the passenger identity and calculates the fare according to travel distance or route stage. This eliminates the need for manual fare collection and reduces boarding time.

Passenger counting sensors installed at entry and exit points continuously update occupancy levels. Safety surveillance modules such as cameras, vibration sensors, smoke detectors, and emergency buttons monitor the internal environment of the vehicle. If an accident or abnormal event is detected, alerts are transmitted immediately through GSM or IoT communication channels.

GPS modules continuously provide live location data, allowing passengers to track the bus and transport authorities to monitor routes. Automated gate mechanisms regulate orderly entry and exit while preventing unauthorized movement.

Overall, the proposed system creates a fully integrated transportation model that improves efficiency, safety, transparency, and passenger convenience.

Block Diagram of Proposed System

The block diagram of the proposed system represents a connected architecture in which all modules communicate with a central embedded controller. Input devices include RFID readers, QR scanners, entry and exit sensors, safety sensors, and GPS modules.

The central controller processes fare data, validates passengers, updates occupancy count, and controls gate mechanisms. Communication modules such as GSM or IoT units transmit information to the cloud or control room. Output devices include LCD displays, alarms, automated gates, and monitoring dashboards.

This integrated design enables seamless data flow and coordinated system operation.

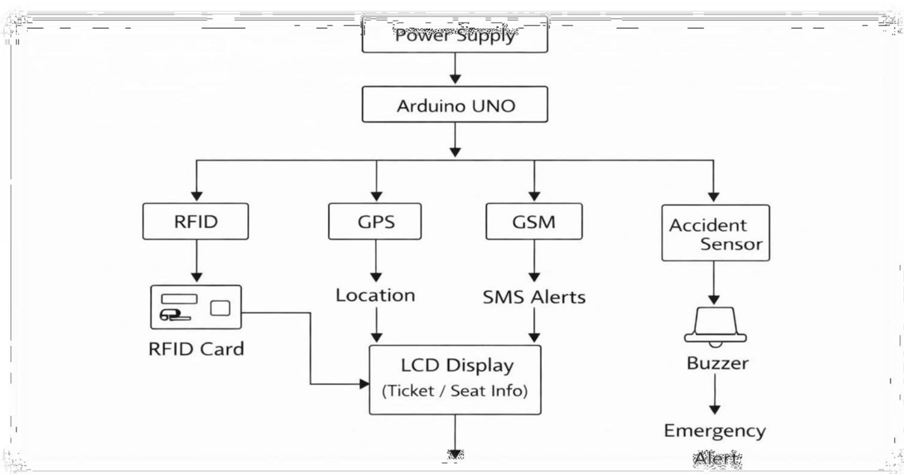

Fig 1; Block Diagram of Proposed System

Bus Start and Stop Control Module

The Bus Start and Stop Control Module ensures that vehicle movement occurs only under safe operating conditions. The embedded controller continuously monitors inputs from door sensors, passenger motion sensors, and occupancy systems.

Before the bus starts, the system verifies that all doors are properly closed and no passenger is in the boarding area. If movement is detected near the entrance or if doors remain open, the controller prevents the bus from moving. This reduces the risk of accidents during boarding and alighting.

The same mechanism can be used at bus stops to ensure that the vehicle halts correctly for safe passenger movement. This module improves operational discipline and passenger safety.

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Implementation of ITSS Based on Real-Time Tracking

The hardware implementation of the Intelligent Ticketing System with Safety Surveillance (ITSS) based on Real-Time Tracking forms the technological foundation of the entire transportation management model. These hardware components are responsible for sensing passenger activity, processing ticketing data, transmitting live information, and controlling safety mechanisms. A carefully designed hardware platform ensures reliable operation, accurate data collection, and efficient automation.

At the center of the system architecture is a microcontroller platform such as the Arduino Uno, which serves as the main control unit. It interfaces with multiple input devices including RFID readers, GPS modules, accident sensors, passenger counting sensors, and communication modules. Data collected from these devices is processed by the controller to perform ticket validation, occupancy updates, location monitoring, and emergency management.

Communication hardware such as GSM modules enables the transmission of alerts, location coordinates, and system updates to remote control centers. Output devices such as LCD displays, buzzers, relays, and servo motors improve user interaction and automate mechanical operations like gate opening, alarm activation, and notification display.

A regulated power supply unit is also essential to provide uninterrupted voltage to all connected modules. Since transportation systems require continuous operation, stable power management increases durability and performance consistency. Together, these components create an integrated embedded solution capable of modernizing public transportation through automation and intelligence.

Circuit Diagram

The circuit diagram of the Intelligent Ticketing with Safety Surveillance System is designed around the Arduino Uno, which acts as the central controller connecting all peripheral modules. Each device is interfaced through suitable communication pins and protocols to ensure synchronized system performance.

The RFID module is connected through SPI communication pins of the Arduino to read passenger smart cards. When a card is scanned, the module sends identification data to the controller for verification and fare processing.

The GPS module is connected using serial communication pins and continuously provides latitude and longitude coordinates. These coordinates are used for real-time bus tracking and route monitoring. Similarly, the GSM module is interfaced through serial pins to send SMS alerts, status messages, and tracking information over the mobile communication network.

The 16×2 LCD display, often connected through I2C communication lines, shows fare details, card balance, passenger count, system messages, and emergency notifications. This improves interaction between passengers and the system.

Accident detection sensors such as vibration, tilt, or impact sensors are connected to digital input pins. When abnormal motion is detected, the controller immediately processes the signal and activates emergency response mechanisms.

Servo motors are connected to PWM output pins and are used for automated gate opening and closing. Relay modules are connected to digital control pins and operate higher-power devices such as warning lights, alarms, or door actuators.

A regulated power supply provides 5V DC to the Arduino, display unit, sensors, and servo motors. Since GSM modules often require higher current, a separate stabilized supply may be used. All devices share a common ground reference for proper circuit operation.

Working Methodology

The working methodology of the Intelligent Ticketing System with Safety Surveillance based on Real-Time Tracking involves coordinated operation of multiple hardware modules. Once the power supply is switched on, the controller initializes all connected devices including the RFID reader, GPS module, GSM module, LCD display, sensors, and gate control mechanisms.

When a passenger enters the bus, the RFID card is scanned near the reader. The controller verifies the card identity and checks available balance. If authentication is successful, the system deducts the required fare and records the transaction. A confirmation message is shown on the LCD display, and the automated gate opens using the servo motor.

Passenger counting sensors positioned near the entrance and exit detect movement and continuously update occupancy values. This information helps determine available capacity and prevents overcrowding.

During vehicle movement, the GPS module continuously acquires location coordinates and sends them to the controller. Through the GSM module, these coordinates are transmitted periodically to a remote monitoring center for route tracking and fleet management.

The system also monitors safety conditions in real time. If vibration or tilt sensors detect a possible accident, the controller immediately activates alarms and sends an emergency message containing the live vehicle location. A manual emergency push button can also be used by staff or passengers to trigger alerts.

Thus, the entire system functions as an intelligent automated transport platform combining ticketing, monitoring, and safety management.

Results and Discussion

The results obtained from the implementation of the Intelligent Ticketing System indicate that the model performs successfully and satisfies the intended project objectives. All major hardware components were integrated correctly, and the system responded accurately to real-time inputs.

The RFID-based ticketing system produced highly reliable outcomes during repeated trials. Passenger cards were scanned quickly, and the system verified user identity within a short time. Automatic fare deduction was completed accurately, reducing ticket processing time when compared with manual methods.

The passenger counting module showed satisfactory performance. Entry and exit sensors updated occupancy values in real time and maintained count accuracy under regular traffic conditions. During crowded boarding situations, slight variations were observed due to overlapping movements, which suggests the need for future sensor refinement.

The GPS module continuously tracked the vehicle position and generated stable coordinate updates. These coordinates were transmitted through the GSM module to the monitoring system successfully. In emergency simulations such as accident detection or manual distress activation, alert messages were sent immediately.

The LCD display clearly showed passenger information, fare status, available seats, and warning messages. Servo motors used for gate control operated smoothly, enabling automatic opening and closing mechanisms.

These results demonstrate that the system is capable of handling multiple transport functions simultaneously with acceptable speed and reliability.

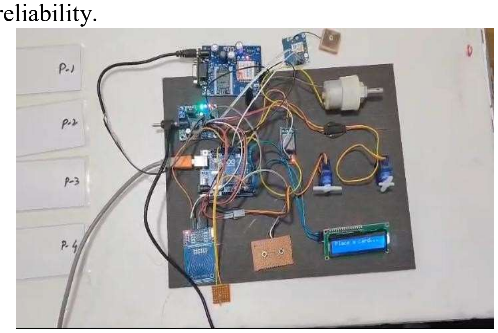

Figure 2; Hardware Setup of Intelligent Ticketing and Crowd Management System

The hardware prototype consists of Arduino Uno as the central controller connected with RFID reader, LCD display, sensors, and motor units. Servo motors and DC gear motors were used for gate and door control functions. The arrangement demonstrates successful integration of all embedded modules.

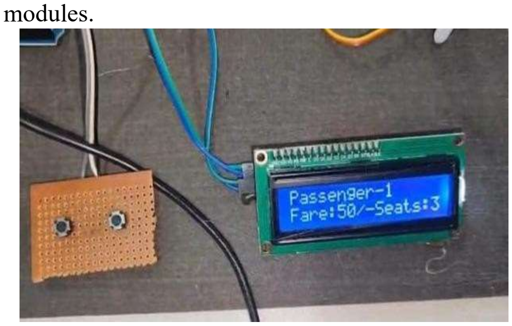

Figure 3; LCD Output Display Showing Passenger Ticket and Seat Information

The LCD display presented passenger number, fare amount, and available seats in real time. Push buttons were used during testing to simulate passenger entry and exit operations. This setup confirmed smooth communication between input devices and display modules.

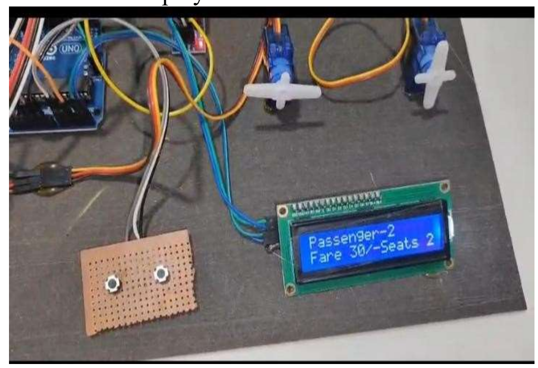

Figure 4; LCD Output Showing Fare Reduction

The display successfully updated passenger details after ticket validation and showed reduced balance or processed fare amount. Passenger count was updated dynamically based on system inputs.

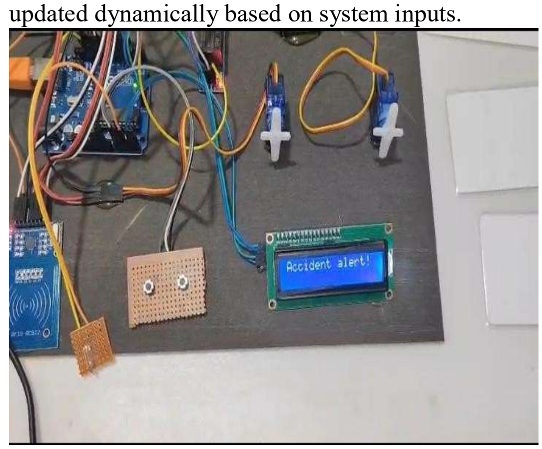

Figure 5; LCD Output Showing Accident Alert

During emergency simulation, the LCD displayed the message "Accident Alert!" indicating that the safety detection module functioned correctly. The alert response was immediate and demonstrated the effectiveness of the emergency monitoring system.

Discussion

The overall discussion of results indicates that embedded systems combined with communication technologies can successfully modernize public transportation operations. The integration of RFID, GPS, GSM, and sensor modules creates a coordinated platform capable of delivering multiple services simultaneously.

The most notable strengths of the system are reduced manual effort, improved operational transparency, better passenger convenience, and stronger safety mechanisms. Real-time data availability enables informed decisions regarding route planning and occupancy management.

Although some limitations remain, such as sensor accuracy under crowd conditions and communication dependency on mobile networks, these issues can be addressed through future enhancements.

The prototype confirms that low-cost embedded platforms like Arduino can be effectively used to implement intelligent transportation solutions.

Conclusion

The Intelligent Ticketing System with Safety Surveillance based on Real-Time Tracking presents a complete and innovative solution to modern transportation challenges. The project successfully integrates Arduino Uno, RFID modules, GPS tracking, GSM communication, sensors, LCD displays, and motor control mechanisms into one unified system.

Automated ticketing reduces manual effort, minimizes fare errors, and improves passenger convenience through contactless travel. Passenger counting supports better occupancy management and route planning. Real-time GPS tracking improves vehicle monitoring and service reliability. Safety surveillance is one of the strongest features of the system. Accident detection sensors and emergency alerts allow immediate communication during critical situations, improving passenger protection and reducing response time.

Automatic gate control improves passenger flow and reduces congestion. The LCD interface provides clear and useful real-time information. Together, these modules form a smart transportation platform that is efficient, reliable, scalable, and suitable for modern cities.

Future Scope

The Intelligent Ticketing System offers many opportunities for future development and expansion. A dedicated mobile application can allow passengers to book tickets, check bus schedules, receive live tracking updates, and manage digital payments.

RFID cards can be complemented or replaced with QR-code ticketing so passengers can travel using smartphones without physical cards. Cloud computing platforms can be integrated for secure storage of passenger and operational data with real-time analytics.

Artificial Intelligence and Machine Learning techniques can be introduced to predict passenger demand, optimize routes, reduce waiting times, and improve scheduling efficiency. AI-based surveillance systems using facial recognition or behavior detection can further enhance onboard security.

IoT connectivity can improve remote monitoring of devices and predictive maintenance of system hardware. Renewable energy solutions such as solar-powered modules can reduce operational costs and improve sustainability.

The system can also be integrated with smart city infrastructure and multimodal transportation services such as buses, metro rail, taxis, and intercity transport. This would create a unified and seamless mobility ecosystem for future urban transportation.

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