"IOT-Based Smart Toll Booth System Using Arduino"

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Abstract

This project introduces an IoT-based smart toll collection system that aims to automate toll collection processes to improve traffic management and reduce congestion. By integrating Radio Frequency Identification (RFID) technology with microcontroller-based systems and wireless communication modules, the system enables seamless vehicle identification and toll collection. An Arduino Uno microcontroller acts as the central processing unit, communicating with various components such as RFID readers, Wi-Fi modules, LCD displays, and motor controllers. The system facilitates real-time data transmission to a central server, enabling efficient monitoring and management of toll collection operations.

1. Introduction

With the rapid urbanization and emergence of smart cities, there is an urgent need to upgrade the transportation infrastructure. Traditional toll collection methods are often burdened with long queues, manual errors and cash handling issues. This project aims to address these issues by implementing an IoT-based smart toll collection system. To overcome these issues, this project presents the design and implementation of an IoT-based smart toll collection system that uses modern embedded technology and wireless communication to automate the toll collection process. The system is designed to enable fast, secure and contactless toll payment.

The system uses RFID technology to identify vehicles and collect tolls automatically. An Arduino Uno microcontroller serves as the brain of the system, communicating with RFID readers, a Wi-Fi module (ESP8266) for internet connectivity, an LCD display for user feedback and a motor mechanism to control the toll gate.

For a long time, manual operations have been the conventional way of collecting tolls. In this setting, the toll booth operator collects payments from the drivers, issues receipts, and controls the traffic flow. This method has many demerits that have been in use for decades. The processes are so manual that there are very long queues at the toll plazas in most cases during peak hours. The vehicles must stop completely; hence, there is time delay fuel wastage and increased emissions because of engine idling.

In addition, manual toll collection is prone to human error—such as incorrect toll calculations, misidentification of vehicle categories, and issues with issuing or tracking receipts. Furthermore, handling physical currency increases the risk of theft and fraud. With the advent of the Internet of Things (IoT), there is a unique opportunity to overcome these limitations and bring about a significant transformation in toll collection systems. IoT enables devices to communicate and operate intelligently without human intervention. By integrating technologies such as RFID, wireless communication modules, cloud connectivity, and microcontrollers, toll collection can be automated, accurate, and contactless.

2. Methodology/Procedure adopted:

- The project initiated with a literature review to establish the research gap, scope, objectives, and project title.

The proposed system architecture comprises the following components:

Table 1: List of Components

Component	Description	Key Features	Role In the Project
1.Arduino Uno 	The Arduino Uno is an open-source microcontroller board based on the **ATmega328P** microchip	14 digital I/O pins (6 PWM outputs) 6 analog inputs 16 MHz clock speed USB connection for programming and serial communication	Acts as the **brain of the system**. It controls all peripherals—reads data from the RFID reader, drives the motor using L293D, controls the LCD and buzzer, and communicates with the Wi-Fi module.
2. RFID Reader (EM-18) 	The EM-18 is a low-cost RFID reader module that operates at **125 kHz** frequency. It reads RFID tags (passive) and sends the ID serially to the microcontroller.	Operating voltage: 5V Communication: UART (serial) Read range: 2–5 cm Compatible with 12-digit RFID cards	Acts as the **brain of the system**. It controls all peripherals—reads data from the RFID reader, drives the motor using L293D, controls the LCD and buzzer, and communicates with the Wi-Fi module.
3.ESP8266 Wi-Fi Module 	The ESP8266 is a compact and cost-effective Wi-Fi module that enables microcontrollers to connect to a Wi-Fi network and send/receive data.	802.11 b/g/n Wi-Fi protocol support Built-in TCP/IP stack Operates at 3.3V Can function as both **client and server**	Provides **internet connectivity** to the Arduino. Used for **sending toll transaction data** to a server or cloud for logging, analytics, and account updates.
4. 16x2 LCD Display 	A **Liquid Crystal Display** with 16 columns and 2 rows. It is commonly used to display information in embedded systems.	Displays 32 characters (16x2) Controlled via parallel or I2C interface Operates at 5V	Gives **real-time feedback** to the user.
5. DC Gear Motor with L293D Motor Driver 	**DC Gear Motor Description:**A geared DC motor reduces speed and increases torque, making it suitable for mechanical applications like opening gates. **L293D Motor Driver Description:** A dual H-bridge driver IC that allows you to control the speed and direction of two DC motors using logic signals	Dual motor control Operates at 5V logic with motor voltage up to 36V Provides up to 600 mA current per channel	The motor physically **opens and closes the toll gate**. The Arduino sends signals to the L293D, which drives the motor accordingly.
6.ESP8266 Wi-Fi Module 	A piezoelectric buzzer is a small speaker that produces sound when voltage is applied. Used for simple sound alerts.	Operates at 3V–12V Compact size Loud enough for alerts	Acts as an **alert mechanism**. The buzzer sounds in situations such as: Unauthorized vehicle detected RFID error System failure notification

3. Operational Flow

a) **Vehicle Detection and RFID Tag Scanning:** As a vehicle approaches a toll booth, it enters the detection zone of the RFID reader (EM-18). Each vehicle is equipped with a unique RFID tag that acts as its digital ID. The reader scans this tag from a short distance (usually 2-5 cm) and sends the tag ID to the Arduino Uno microcontroller for further processing.

b) **Tag Verification and Balance Check**: Once the tag ID is received, the Arduino checks the following:

- Whether the tag is registered in the database (validity check)
- Whether the associated account has sufficient balance to pay the toll
- The database can be stored locally (on an SD card or EEPROM) or accessed via the cloud/server using an ESP8266 Wi-Fi module. This ensures that only authorized vehicles with active accounts can proceed.

c) Toll Deduction and Gate Operation

If the RFID tag is verified successfully:

- The predefined toll amount is deducted from the vehicle's account (simulated or real, depending on implementation).
- A signal is sent to the L293D motor driver, which activates the DC gear motor to lift the toll gate barrier, allowing the vehicle to pass.
- Simultaneously, transaction details such as vehicle ID, date/time, and deducted amount are transmitted to a remote server or cloud database via the ESP8266 module for logging and analysis.

d) User Feedback via LCD Display

During this process, the 16x2 LCD display provides real-time feedback to the vehicle driver. Example messages include:

- "RFID Detected – Toll ₹50 Deducted"
- "Gate Opening – Please Proceed"
- "Transaction Successful"
- "Thank You – Have a Safe Journey"

After the vehicle passes, the Arduino closes the gate by reversing the motor direction. **e)**

Unauthorized Access Alert

If the system encounters any of the following conditions:

- Unregistered or fake RFID tag
- Insufficient balance • Communication error

It:

- Denies access to the vehicle (the gate remains closed)
- Triggers the buzzer to emit an alert sound
- Displays an appropriate warning on the LCD such as:

o "Access Denied – Invalid Tag" o

"Insufficient Balance – Recharge Required"

This helps in preventing toll evasion and notifies the vehicle owner of the issue instantly.

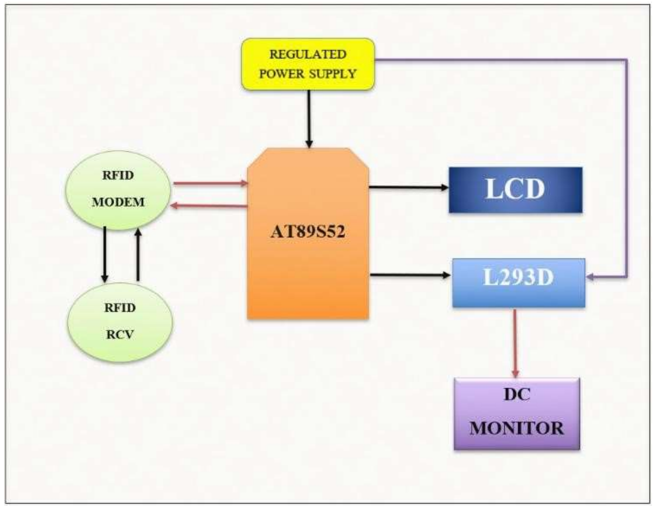

Figure 1:Illustrative Image

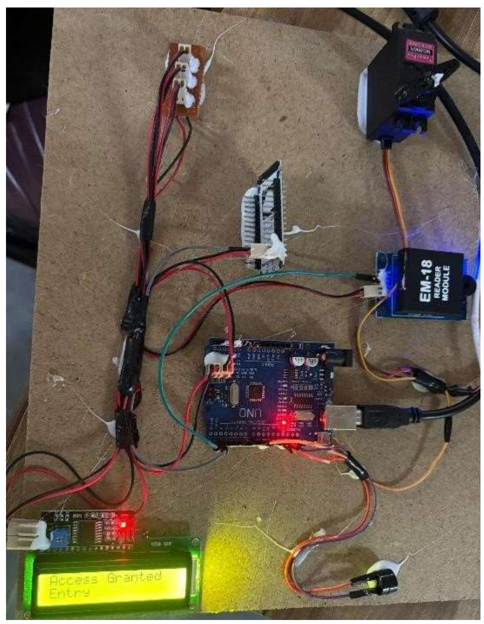

Figure 2:Working Model

4. Conclusions

From the experimental results it was observed that the Compressive strength, Split Tensile strength, Flexural strength of Foam concrete increases as Fiber content and density increases. The following conclusions can be obtained:

a) Efficiency: The proposed system automates the RFID identification and payment process, allowing vehicles to pass through toll booths without stopping. This reduces waiting times, improves traffic flow, and reduces congestion at toll booths, especially on expressways and highways.

b) Accuracy: Human errors in toll collection were minimized. This has been achieved by automating the toll deduction process through RFID together with Arduino-controlled logic which greatly minimizes the risks. The system exactly makes verification and deduction for every transaction hence reliable and consistent operation with minimal to zero error rates.

c) Transparency: Real-time transaction records available to authorities and users. All transactions are automatically recorded, using the ESP8266 Wi-Fi module able to send in real-time to a centralized server. This enables:

- Live monitoring by toll authorities
- Digital transaction history accessible to users and administrators
- Easily generated reports and audit trails.

This kind of transparency doesn't just improve operational accountability; it also enhances public trust in the system.

d) Security: Enhanced monitoring to prevent toll evasion and unauthorized access. The use of unique RFID tags for each vehicle ensures secure validation of access. Unauthorized vehicles or unregistered tags trigger an alert (via buzzer) and the gate remains closed. This reduces the likelihood of:

- Toll evasion
- False entries
- Data manipulation

In addition, all vehicle entries and transactions are digitally recorded, making the system tamper-proof and traceable

e) Scalability: System can be expanded to multiple toll booths and integrated with central databases. One of the most promising outcomes is the scalability of the system. The modular nature of the hardware and software allows deployment across multiple toll booths or highways, integration with a central or cloud-based database and expansion to include additional features such as mobile app connectivity, GPS tracking, or real-time vehicle analytics.

This makes the system future-ready and adaptable to broader smart city infrastructure frameworks.

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