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IoT Based Smart and Secured Mobile ChargingStation in Public Place

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Abstract
Mobile phones have become an integral part of daily life due to technological advancements. While many developed countries offer public charging facilities, they often lack security measures, particularly in developing nations. This paper proposes a smart and secure mobile phone charging station that can be easily installed anywhere and is compatible with all mobile phone types. The system is centered around an Arduino microcontroller, which interfaces with a coin recognition module to validate inserted coins. Based on the coin value, the system determines the charging duration for the mobile phone. To enhance security, a solenoid door locker controlled by RFID cards is employed, allowing only authorized users to access the charging station. Additionally, features are implemented to facilitate coin collection by system administrators to prevent overloading. The functionality of the system has been verified through prototype testing.

Keywords
Cellphone charging, microcontroller, IoT, ESP8266, Blynk.

1. INTRODUCTION

Everyone in the modern digital era relies heavily on their mobile phones. These devices have become an essential part of daily life, simplifying various tasks and serving as a lifeline in emergencies. Whether it's for communication, navigation, or accessing vital information, mobile phones play a crucial role in ensuring connectivity and facilitating convenience.
The increasing demand for mobile phones stems from their multifaceted utility and widespread adoption across both urban and rural areas. As more people integrate mobile technology into their daily routines, the mobile phone industry continues to expand its reach, catering to diverse consumer needs and preferences.
However, despite the convenience they offer, mobile phones are susceptible to battery depletion, especially during critical moments when access to a conventional charger is unavailable. While some public spaces provide USB charging ports for convenience, these ports can pose security risks. Hackers have exploited these connections to gain unauthorized access to users' devices, compromising sensitive data such as browsing history and passwords—a phenomenon known as "Juice Jacking."

To address these security concerns and ensure safe charging practices, users should exercise caution when using public charging ports and consider alternative solutions, such as portable power banks, to avoid potential security breaches. Additionally, staying informed about emerging threats and implementing cybersecurity best practices can help mitigate risks associated with mobile device usage in public spaces. In recent years, incidents of personal information theft and mobile phone theft have become increasingly common. Hackers exploit vulnerabilities in public charging ports to gain unauthorized access to users' devices, while thieves seize opportunities to steal phones when users are distracted.

Motivated by the growing security concerns surrounding mobile phone charging, researchers have explored various solutions to address these issues. One approach involves implementing a coin-operated mobile battery charging system, allowing users to conveniently charge their devices on the go. Given the indispensability of mobile phones in modern communication, such systems offer a practical solution for individuals who may forget to carry their chargers or find themselves on extended journeys without access to power outlets.

Several research studies have proposed different charging systems utilizing coin detection sensors and microcontrollers to regulate charging processes. Some systems automatically cut off power after a set duration to prevent overcharging, while others incorporate solar power sources for sustainability and employ alarms to deter counterfeit coin usage.

The system presented in this paper offers enhancements over previous works by leveraging the Arduino Uno microcontroller to streamline operations and ensure reliability. By consolidating all necessary peripherals, this system minimizes setup time and offers automated functionality. A comparative analysis of this research with prior studies is provided in Table I.

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2. DEVELOPMENT OF THE SYSTE

The methodology of developing the system is discussed in this section.

TABLE I COMPARISON WITH PREVIOUS WORK

Features	Previous Work					This Work
	PW-1 [1]	PW-2 [2]	PW-3 [3]	PW-4 [4]	PW-5 [5]	
Total Balance Check	No	No	No	No	No	Yes
Locker System	No	No	No	No	No	Yes
Sending Notification to System provider	No	No	No	No	No	Yes
Coin Acceptor	Yes	Yes	Yes	Yes	Yes	Yes
RFID Reader Sending	No	No	No	Yes	No	Yes

A. Block Diagram of the System

The block diagram of the system is depicted in Fig. 1. Input devices include the coin acceptor, IR sensor, and RFID reader, while output devices consist of the LCD display, relay, servo motor, and door lock. The Wemos D1 serves as both an input and output device.

Components of the system include:

- Arduino UNO: The core component featuring an ATmega328P microcontroller with built-in I2C and SPI communication protocols.
- LCD I2C (16×2) Display: Used to show specific messages to the user.
- Coin Acceptor: Detects valid coins.
- Door Lock: Utilized for security purposes, along with a solenoid door lock and door lock driver.
- RFID Reader and Tag: Ensures security by automatically releasing an RFID tag when a cellphone is placed inside the device.
- IR Interface: Detects the presence of a cellphone between the transmitter and receiver.
- Relay: Controls the power switch.
- Wemos D1: Functions as an IoT device to update the status of earned coins.
- Servo Motor: Moves the card to allow the user to retrieve it from the slot.

B. Methodology

The system begins by awaiting a valid coin (BDT 5). Upon detecting a valid coin, the user is permitted to place a cellphone inside the box for charging. A

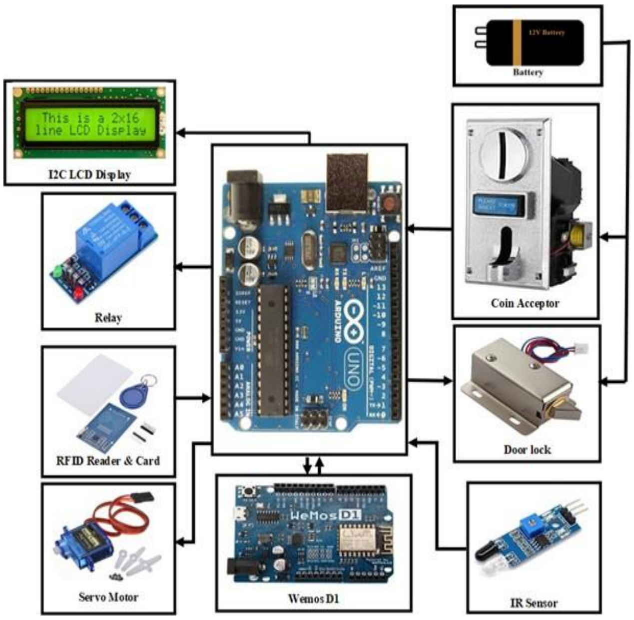

Fig. 1. Block Diagram of the System.

The coin acceptor utilized in this system is programmable and capable of detecting three different types of coins based on their thickness, diameter, and fall time. It is programmed to identify two types of BDT 5 coins. The coin acceptor has four pins: Vcc, GND, Out, and Count. The 'Out' pin is connected to the interrupt pin (I/O pin 3 of ARDUINO UNO) of the microcontroller. When a BDT 5 coin is inserted, the 'Out' pin sends five pulses to the microcontroller. The microcontroller counts these pulses using an interrupt subroutine to determine if a valid coin has been inserted. If five pulses are received, indicating a valid coin, the microcontroller sets the solenoid door lock driver's switching pin to a logic HIGH state, unlocking the door so the user can place their cellphone inside.

Within the slot, there is an infrared-ray (IR) sensor pair consisting of an IR transmitter and an IR receiver. Under normal conditions, IR can pass from the transmitter to the receiver, resulting in a low logic state of the sensor output. However, when a cellphone is placed in the slot, IR cannot transmit from the transmitter to the receiver, causing the sensor output to become HIGH. The microcontroller reads the output state of the IR sensor using an input pin (D6) and connects the charger port to the power supply through a relay when the sensor output is HIGH. Additionally, the microcontroller activates a servo motor to push and remove the RFID tag from its slot. The user must retrieve and retain this tag to unlock the box and retrieve their cellphone.

Once the cellphone is placed inside, the system locks the solenoid door lock and begins counting time. The system will automatically
The system allows charging for a duration of thirty minutes upon insertion of a BDT 5 coin. An RFID reader is integrated into the system, and communication between the microcontroller and RFID reader occurs via the serial peripheral interface (SPI). The SPI pins (CLK, MOSI, and MISO) of the microcontroller are connected to the corresponding pins of the RFID reader. When an RFID tag is placed in the slot, the microcontroller reads the tag's address through the RFID reader. If the tag address matches the one provided by the system during cellphone placement, the door unlocks, allowing the user to retrieve their device.

An LCD display connected to the I2C (SCL and SDA) bus of the microcontroller provides necessary messages and instructions to the user. Coins inserted into the coin acceptor are collected in a small box, with the microcontroller keeping track of the number of coins received. Additionally, an ESP8266 WiFi module is interfaced with the microcontroller, enabling the microcontroller to transmit the number of received coins to a server via ESP8266.
Furthermore, a simple Android app has been developed for this system. The device owner can access information about the number of received coins from the server using this app. The simplified circuit diagram of the system is depicted in Fig. 2.

C. Programming

The system incorporates two programmable devices: the Atmega328P microcontroller (Arduino Uno development board) and the ESP8266 (WeMos D1 R1 development board). Programs for these devices are developed using the ARDUINO IDE software. The program structure consists of two fundamental functions: void setup() and void loop().

The void setup() function includes instructions to define I/O pins and interrupt functions, initialize the serial port, I2C bus, and SPI bus. These instructions are executed by the microcontroller only once. On the other hand, the void loop() function serves as an infinite loop where instructions are executed repeatedly.

Instructions related to reading the coin acceptor, displaying messages on the LCD, reading the IR sensor, reading the RFID tag, controlling the solenoid door lock, sending the number of coins to the server, and switching the power supply of the cellphone charger are written within the void loop() function.

A crucial task of the microcontroller is to accurately and promptly read data from the coin acceptor, as it is unpredictable when a user places a coin in the acceptor. To address this, the microcontroller employs hardware interrupt features. The 'Out' pin of the coin acceptor is connected to the interrupt pin of the microcontroller. Consequently, when pulses are received at this pin, the microcontroller interrupts its current execution and immediately jumps to a specific subroutine to count the pulses from the coin acceptor. This ensures that the microcontroller can promptly respond to coin insertion events without missing any data from the coin acceptor, preventing any loss of service to the user.

The prototype of the proposed system has been successfully implemented, and all functions described in the system design section have been thoroughly tested and validated. The comprehensive overview of the system is depicted in Fig. 3 and Fig. 4. In this section, the system objectives are justified with accompanying images.

Upon powering on the device, it displays a message 'Insert Coin' on the LCD, as illustrated in Fig. 5. When a valid BDT 5 coin is inserted through the coin acceptor, it is stored in the coin box, and a notification is displayed on the LCD, as depicted in Fig. 6. Simultaneously, the solenoid door lock is unlocked, and a servo motor rotates to push out the RFID tag, allowing the user to collect it.

Users then place their cellphones in the designated slot, connecting them to the charging port, as shown in Fig. 7. The

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charger remains disconnected from the power supply until a cellphone is placed in the slot. Upon cellphone insertion, the microcontroller promptly switches a relay to connect the charger to the power supply, initiating charging. The user can then lock the door, which can only be unlocked using the RFID tag.

During the charging period, the microcontroller tracks the charging time and displays it on the LCD. The system does not accept additional charging requests during this time, as indicated by a message on the LCD (Fig. 8). Once the allocated charging time is reached, charging ceases, and the LCD displays the message 'Time Up' (Fig. 9).

The system also prevents new charging requests until the current user retrieves their cellphone by opening the box with the RFID tag. After retrieval, the system becomes ready to accept new coins for charging requests. Additionally, the system uploads the number of received coins to a server, allowing the system owner to monitor this information via a mobile application, as shown in Fig. 10.

The total cost of the prototype is calculated in Table II. While development boards were used for the prototype, transitioning to integrated circuits (ICs) or application-specific integrated circuits (ASICs) could significantly reduce manufacturing costs.

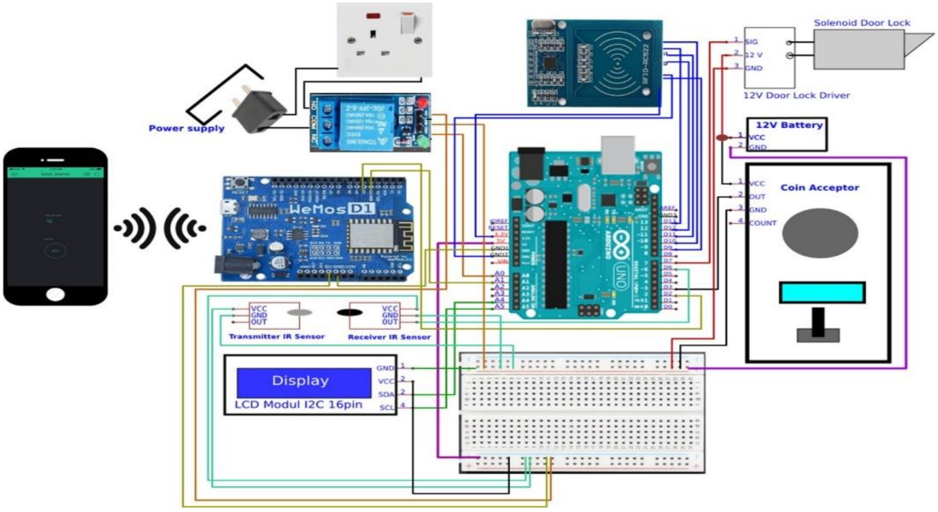

Fig. 2. Simplified circuit diagram of the System.

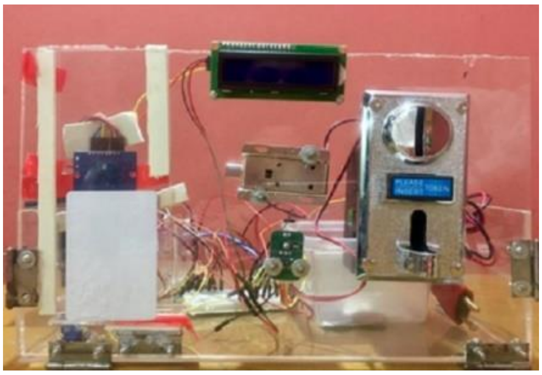

Fig. 3. Complete overview of the prototype (Font View)

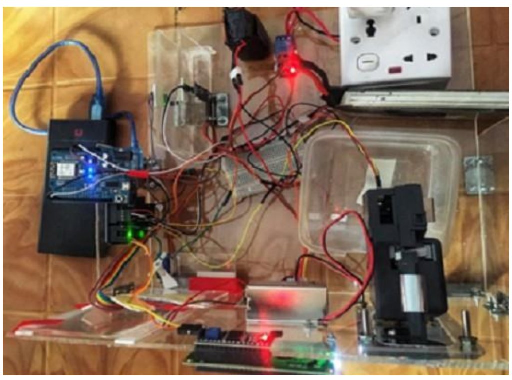

Fig. 4. Complete overview of the prototype (Top View)

Fig. 5. Message in idle state (Door Locked)

Fig. 6. Message after Coin insertion (door unlocked).

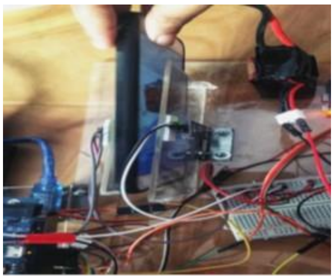

Fig. 7. Cell phone is placing in the slot

Fig. 8. Message and Time shown in LCD when mobile is charging.

Fig. 9. Message on LCD when time goes up

Fig. 10. Device owner can know the coin received by device through thisapplication

TABLE II COST OF PROTOTYPE

No	Item	Cost
1	Microcontroller (ARDUINO UNO)	389
2	Coin Acceptor	1560
3	Solenoid Electric Door Lock	965
4	WeMos D1	400
5	RFID Reader	199
6	LCD Display	120
7	IR Sensor Pair	196
8	I2C interface LCD module	75
9	Relay	70
10	Servo Motor	119
11	12V Battery	500
12	Others	200
	Total Cost	4793

3. CONCLUSION

The proposed system holds significant relevance in today's context, considering the widespread use of mobile phones among individuals. In instances where individuals embark on long journeys, they may inadvertently forget to carry their chargers. This project aims to address such situations by providing a coin-based secured charging station, offering a convenient solution for users.

The system is designed to be user-friendly and cost-effective. It offers a straightforward process whereby users can charge their mobile phones by simply inserting a coin. This simplicity makes it suitable for deployment in public settings, such as shopping malls, bus or railway stations, universities, and other high-traffic areas.

By offering the ability to charge a low or dead mobile phone with the use of a coin, this charging system enhances convenience and accessibility for users on the go. Its installation in public places can cater to the needs of individuals who require a quick and reliable charging solution while out and about.

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