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Design and Implementation of a Secure Electronic Voting System Using Fingerprint Identification and Real-Time SMS Notifications

P. **Bhargavi[1], Anam Pavan Kumar[2], Kanchi Chaitanya[2], Ingilela Keerthanrao[2], Bathala Rajesh[2]**

[1]AssistantProfessor, Department of ECE, Geethanjali Institute of Science and Technology, Nellore, Andhra Pradesh, India

[2]UG Scholar, Department of ECE, Geethanjali Institute of Science and Technology, Nellore, Andhra Pradesh, India

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Abstract

This project presents the design and implementation of an electronic voting system that enhances security, efficiency, and reliability through the integration of several key technologies. The system incorporates an LCD display for user interaction, a fingerprint module for secure voter identification, and a GSM module for sending real-time SMS notifications. The primary objectives are to ensure that only registered voters can cast their votes, prevent multiple voting by the same individual, and provide timely updates on voting results. The hardware setup includes an Arduino microcontroller connected to an LCD display, a fingerprint module, a GSM module, buttons for voter input, a buzzer for feedback, and a shifter for controlling the GSM module's power state. The software is designed to manage the enrolment of voter fingerprints, validate RFID cards, identify voters, and record votes. Votes can be cast for one of three parties, with the system maintaining and displaying vote counts. Additionally, the system sends periodic updates of the vote counts via SMS. This project achieves significant milestones in securing the voting process through fingerprint recognition, providing user-friendly interaction via the LCD, and ensuring transparency with real-time SMS updates. The system effectively prevents voting fraud by ensuring each voter can vote only once. Future enhancements could include scaling the system to accommodate more voters and candidates, improving error handling, refining the user interface, and integrating with broader voting systems. This electronic voting system demonstrates the practical application of embedded systems and communication technologies to improve election integrity and management.

Keywords: Electronic Voting System**,** Fingerprint Identification**,** Arduino Microcontroller, GSM Module**,** Real-Time SMS Notifications.

1. Introduction

The Election Commission of India developed the country's EVMs in partnership with two government-owned companies, the Electronics Corporation of India (ECIL) and Bharat Electronics Limited (BEL). Though these companies are owned by the Indian government, they are not under the administrative control of the Election Commission. They are profit-seeking vendors that are attempting to market EVMs globally [7]. The first Indian EVMs were developed in the early 1980s by ECIL. They were used in certain parts of the country, but were never adopted nationwide. They introduced the style of system used to this day, including the separate control and ballot units and the layout of both components. These first-generation EVMs were based on Hitachi 6305 microcontrollers and used firmware stored in external UVerasable PROMs along with 64kb EEPROMs for storing votes. Second-generation models were introduced in 2000 by both ECIL and BEL. These machines moved the firmware into the CPU and upgraded other components. They were gradually deployed in greater numbers and used nationwide beginning in 2004 [3]. In 2006, the manufacturers adopted a third-generation design incorporating additional changes suggested by the Election Commission. According to Election Commission statistics, there were 1,378,352 EVMs in use in July 2009. Of these, 448,000 were third-generation machines manufactured from 2006 to 2009, with 253,400 from BEL and 194,600 from ECIL. The remaining 930,352 were the second-generation models manufactured from 2000 to 2005, with 440,146 from BEL and 490,206 from ECIL [4]. (The first-generation machines are deemed too risky to use in national elections because their 15-year service life has expired [5], though they are apparently still used in certain state and local contests.) In the 2009 parliamentary election, there were 417,156,494 votes cast, for an average of 302 votes per machine [6].

In the recent years, voting equipment which were widely adopted may be divided into five types [7].

1) Paper-based voting: The voter gets a blank ballot and use a pen or a marker to indicate he want to vote for which candidate. Hand counted ballots is a time and labor consuming process, but it is easy to manufacture paper ballots and the ballots can be retained for verifying, this type is still the most common way to vote.

2) Lever voting machine: Lever machine is peculiar equipment, and each lever is assigned for a corresponding candidate. The voter pulls the lever to poll for his favorite candidate. This kind of voting machine can count up the ballots automatically. Because its interface is not user-friendly enough, giving some training to voters is necessary.

3) Direct recording electronic voting machine: This type, which is abbreviated to DRE, integrates with keyboard, touchscreen, or buttons for the voter press to poll. Some of them lay in voting records and counting the votes is very quickly. But the other DRE without keep voting records are doubted about its accuracy.

4) Punch card: The voter uses metallic hole-punch to punch a hole on the blank ballot. It can count votes automatically, but if the voter's perforation is incomplete, the result is probably determined wrongfully.

5) Optical voting machine: After each voter fills a circle correspond to their favorite candidate on the blank ballot, this machine selects the darkest mark on each ballot for the vote then computes the total result. This kind of machine counts up ballots rapidly. However, if the voter fills over the circle, it will lead to the error result of optical scan.

2. Existing system

In traditional voting systems, paper-based ballots and manual vote counting have been the norm. Voters physically visit polling stations, mark their choices on paper ballots, which are then collected and

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manually counted by election officials. However, this approach has several limitations. Firstly, it is prone to human error, both in the marking of ballots and in the counting process, leading to inaccuracies and disputes over results. Additionally, traditional systems are vulnerable to various forms of fraud, such as ballot stuffing, tampering with ballot boxes, or miscounting by officials. Moreover, the manual nature of the process makes it time-consuming and resource-intensive, often resulting in delays in announcing election outcomes. Furthermore, traditional systems may disenfranchise certain groups of voters, such as those with mobility issues or those living in remote areas, due to limited access to polling stations. Overall, the limitations of traditional voting systems highlight the need for modernization and the adoption of more secure, efficient, and inclusive voting methods.

3. Proposed methodology

The proposed electronic voting system integrates multiple components to ensure a secure, efficient, and reliable voting process. The primary components include an LCD display for user interaction, a fingerprint module for voter identification, and a GSM module for sending SMS notifications. The system is designed to ensure that only registered voters can cast their votes, prevent multiple voting by the same individual, and provide real-time updates on voting results. The workflow involves enrolling voters' fingerprints, which are then stored for later identification. During the voting process, voters are identified via their fingerprints. Once identified, they can cast their vote for one of three parties. The system maintains and displays vote counts on the LCD and sends periodic updates via SMS.

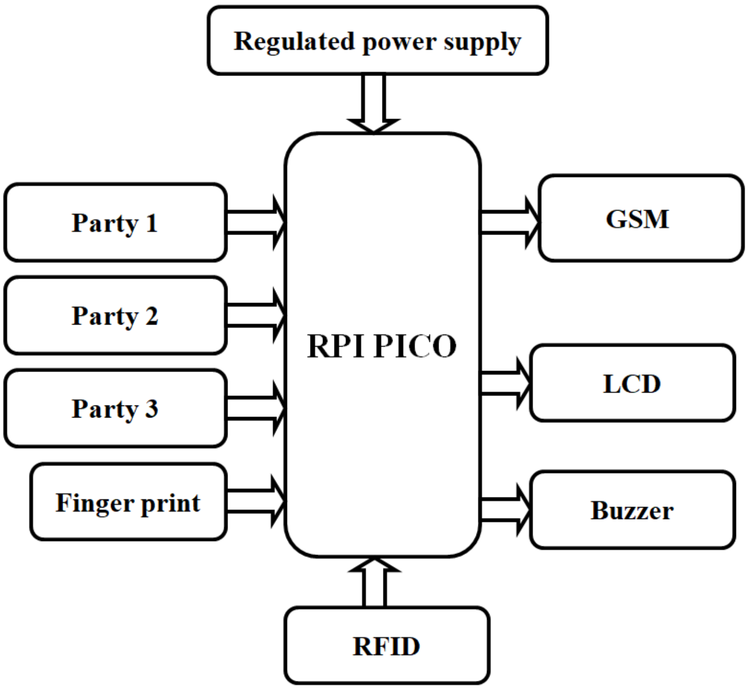

Figure 1: Block diagram of proposed system.

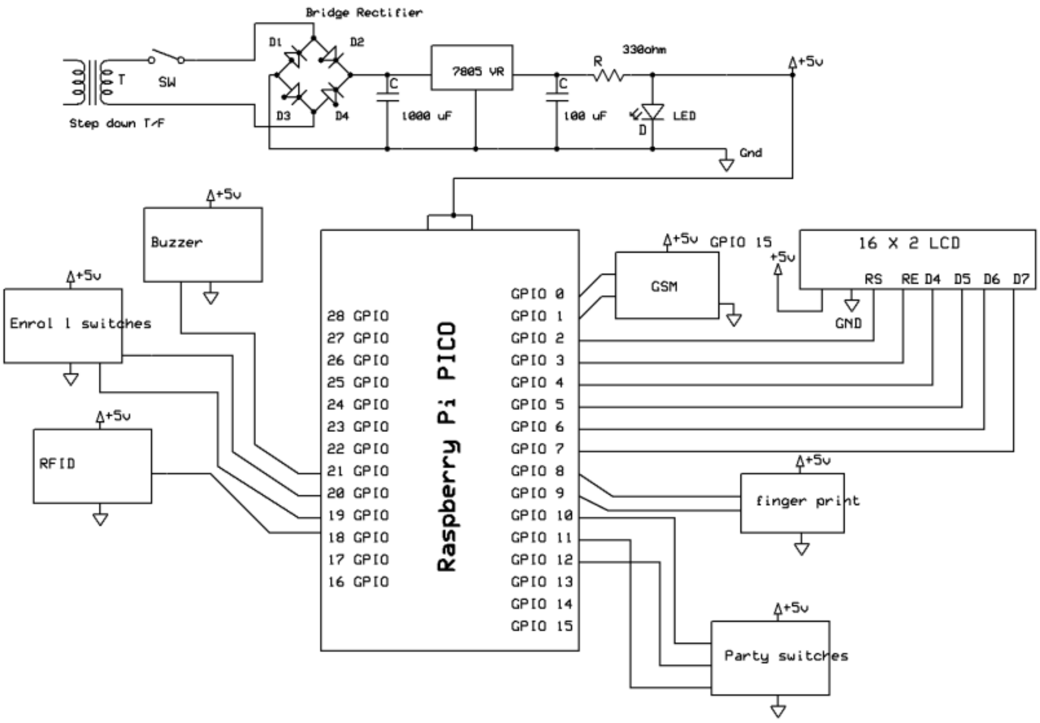

Figure 2: Schematic diagram of proposed system.

3.1 Workflow

In terms of hardware, the system includes an LCD display connected to the Arduino to provide feedback and instructions to the user. The fingerprint module, crucial for both enrolment and identification, is connected to Serial1. The GSM module, which sends SMS updates, is connected to Serial2. Buttons are used for enrolment and voting, while a buzzer provides auditory feedback for actions such as successful identification or errors. A shifter is used to control the GSM module's power state.

The software workflow starts with the setup phase, where all components are initialized, including the LCD, fingerprint module, and GSM module. Pin modes and initial states are set. In the main loop, the system first checks for the enrolment button press. If pressed, it enrols a new fingerprint and assigns an ID. The system then reads RFID card data to check for validity. Upon a valid card, it initiates fingerprint identification. Successful identification allows the voter to cast their vote by pressing one of the buttons corresponding to a party. Vote counts are maintained for each party and results are periodically sent via SMS. Helper functions manage fingerprint enrolment and search, GSM initialization, SMS sending, and vote handling, including preventing multiple votes by the same individual and updating vote counts.

4. Results and discussion

Figure 3 illustrates the hardware setup of the project. The kit is powered ON by providing a regulated power supply of 12V, which is then converted to a 5V DC current. The LED serves as an indicator for the presence of 5V current; thus, if there is a 5V current, the LED automatically glows. The generated 5V DC current is distributed to every hardware component in the circuit.

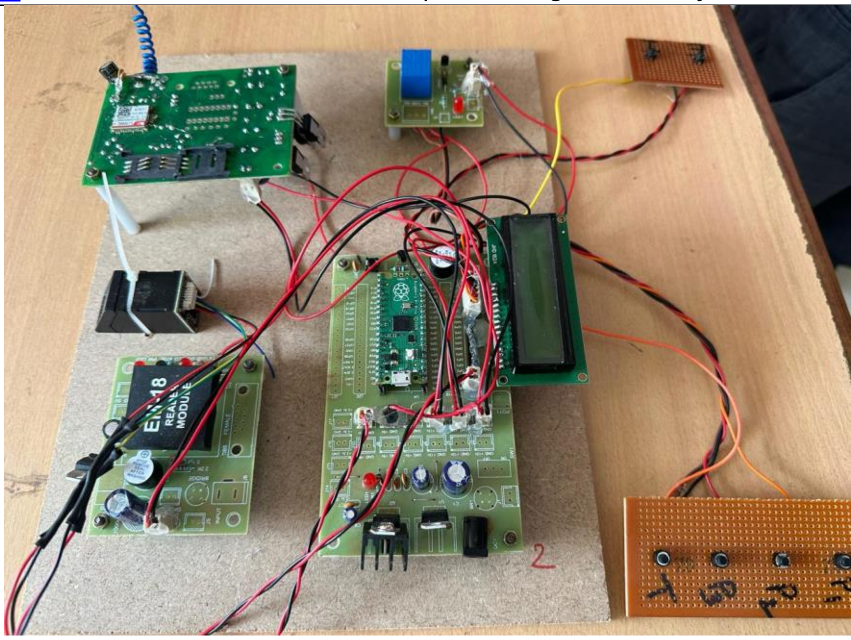

Figure 3: Hardware setup of the proposed system.

In Figure 3, the input sections include the RFID reader module, fingerprint sensor, polling switches, and enrolling switches. Initially, the SIM IC must be correctly placed into the GSM module, followed by checking the signal strength, which is then displayed on the LCD display. Next, a mobile number must be stored to receive SMS alerts from the polling section.

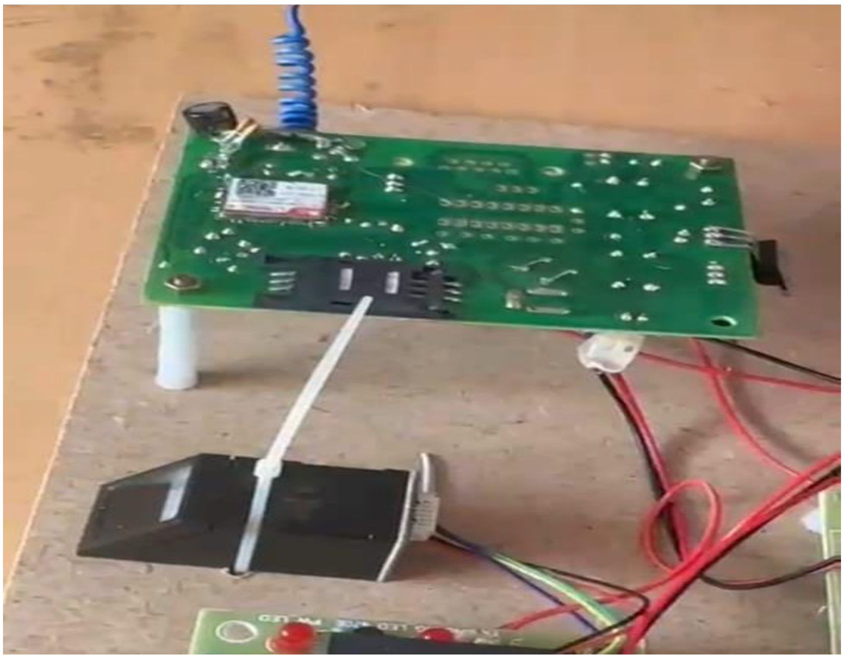

Figure 4: GSM module and finger print module.

Following this, smartcards and biometric access registered for voting, as depicted in Figure 5, are accessed. Once confirmed, the voter becomes eligible for the voting process. During polling, both the smartcard and fingerprint must be accessed; if applicable, the vote is placed. If not, the LCD display indicates "Invalid user," and an SMS alert is sent.

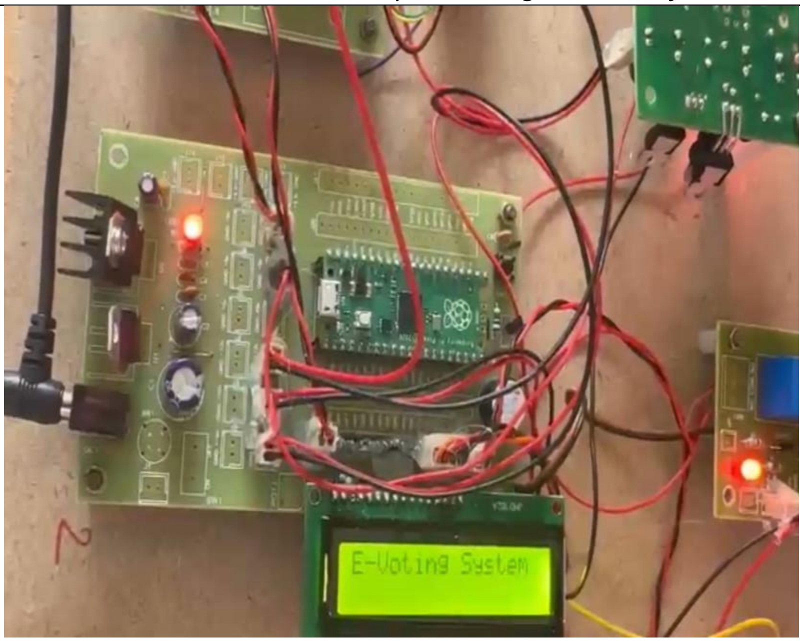

Figure 5: Displaying e-voting system on LCD.

If a voter attempts a second vote, their details are accessed, and the buzzer is triggered to alert of a second-time voter. The smartcard is then used to evaluate polling results, displaying the entire polling vote results. This system ensures accurate voter identification and efficient vote counting.

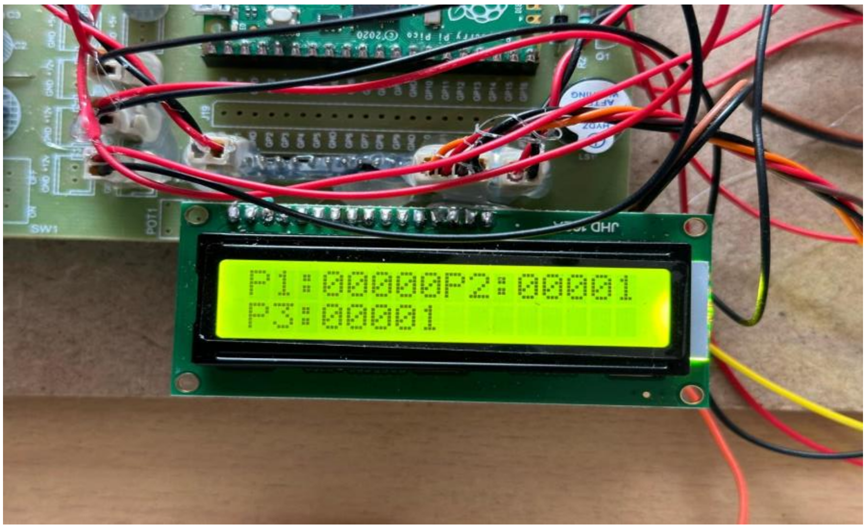

Figure 6: Displaying the vote count on LCD.

5. Conclusion

The electronic voting system effectively integrates hardware and software to provide a secure, reliable, and user-friendly voting process. By using fingerprint recognition, it ensures that only registered voters can cast votes, significantly reducing the possibility of fraud. The LCD display provides clear instructions and feedback, enhancing user interaction. Real-time SMS updates on vote counts enhance transparency and trust in the voting process. The system also includes mechanisms to prevent multiple votes from the same individual by checking fingerprint IDs against previously cast votes. Key achievements of the system include enhanced security through fingerprint recognition, user-friendly interaction via the LCD display, and real-time updates through the GSM module. These features contribute to the overall reliability and transparency of the voting process. Future improvements could focus on scalability to handle more voters and candidates, improved error handling and recovery mechanisms, a more intuitive user interface, and broader integration with other systems for applications such as national elections or organizational voting systems. Overall, this electronic voting system demonstrates a practical application of embedded systems and communication technologies to address real-world challenges in election management.

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