

A Proposed Framework for Biometric Electronic Voting System

Md. Mahboob Karim¹, Nabila Shahnaz Khan², Ashratuz Zavin³, Shusmoy Kundu⁴, Asibul Islam, Brazab Nayak
Department of Computer Science and Engineering, Military Institute of Science and Technology, Dhaka-1216, Bangladesh

¹mahboob4146@yahoo.com, {²nabilakhan1024, ³ashzavin, ⁴kshusmoy14}@gmail.com

Abstract— In this modern age of digitization, Bangladesh Election Commission (EC) still uses manual system during election for vote casting. Recently, it is considering to introduce Electronic Voting Machine (EVM) in parliamentary elections though EVM is not entirely automated and has many limitations. In this work, we have designed an automated biometric voting system with a convenient user interface and integrated database system containing all voters' information. Casted votes will be counted automatically at the end of the voting process and result will be generated centrally with less time. Therefore, the proposed system will improve the voting management of Bangladesh by ceasing fraudulent activities, corruptions, ensuring security, transparency, fairness, accuracy and keeping backup trails of voting process.

Index Terms—Automated result calculation, Biometric authentication, Central integrated database, Electronic Voting Machine (EVM).

I. INTRODUCTION

Bangladesh is a democratic country where election of the government is a part and parcel of this democracy. Being a citizen of Bangladesh voting is the fundamental right. It expresses the choice of the people and that is why voting process needs to be fair, transparent and legal. Under many circumstances the voting system has become a debatable issue. At current time manual voting process using ballot papers is followed in the electoral system of Bangladesh. In the manual ballot system, people need to cast their votes on the paper provided by the Election Commission, no bio-metric identification of the voter is required. As a result transparency of the voting process is always in question [1]. Also the votes are preserved and counted manually which is a long time consuming process.

Bangladesh EC is looking forward to make the voting process digitized for which they are considering about using EVM [2]. At Chittagong and Narayanganj city corporation election EVM was used in the voting process [3]. It has mainly two units: Control Unit and Ballot Unit. The Control Unit is the main unit which stores all data and controls the functioning of EVM. In the EVM, people need to cast vote by pressing a button against the candidate in the Ballot Unit. EVM then automatically update the number of votes against the candidate in the Control Unit which is supervised by a presiding officer [4]. But the problem is that the system is vulnerable to corruption and security issues. No integrated database and biometric authentication are integrated to this

method, hence EVM is considered to be unsuitable for general election [5].

Both the ballot paper voting system and EVM system failed to achieve proper security and authenticity as false vote casting is very easy in these systems by threatening people. Sometimes by creating terror, antisocial intruders force genuine voters to cast illegal votes. Considering these problems and to overcome the consequences, we have proposed an automated biometric voting model keeping in mind the electoral rules and regulations of this country. Biometrics are distinct and measurable characteristics of human beings used to identify each individual separately [6]. At present different biometric identification methods like fingerprint identification, hand geometry, palm vein authentication, retina scan, iris scan, digital signature, voice analysis etc are commonly in use [7]. For our model we have used the most commonly used and verified fingerprint identification biometric method.

In this paper, we have focused on designing a biometric electronic voting machine (BEVM) along with fingerprint authentication and centralized database. Based on total number of voters, several BEVM will be installed in each polling station for different elections in Bangladesh which will help to deploy the fingerprint matching task accurately within less time. Furthermore, the system is applicable to use anywhere in the world with some adjustment according to their election process.

We organize the rest of the paper as follows. Background study of related work is discussed in Section II. In Section III, we present the system model and architecture. System implementation steps are stated in Section IV. Section V states the result analysis while Section VI focuses on the limitations and future plans. Finally Section VII concludes the paper.

II. RELATED WORKS

Recently biometric EVM has gained the attention of many researchers. In this section, the related works on electronic voting system with biometric authentication are discussed briefly.

In a study [8], a model of electronic voting machine was discussed where user verification was done using Near Field Communication (NFC) ID card and biometric technologies. In this process, multiple vote casting was restricted by marking this NFC card after the user had casted his vote once. Use of different biometric identification in e-voting and their security aspects were analyzed in another study conducted by Hof [9].

He discussed some of the weaknesses of biometric systems such as spoofing, false accept and reject rate etc and therefore, suggested to implement biometric in e-voting with precautions. In a study [10], an abstract model of voting system with fingerprint authentication and details matching process in fingerprint minutiae were introduced.

A study conducted by Sarkar et al. [4] provided a brief overview on existing e-voting systems and their framework and protocols. They discussed the recent developments of EVM in context of Bangladesh and suggested some strategies to improve the security, accuracy of the existing design. In another study, Sarker et al. [11] proposed a conceptual design of electronic voting machine with fingerprint authentication that helped to eradicate defrauding of the manual voting systems and prior versions of electronic voting. They used four layer network system with three application server and a client to send data from client to database.

In [12], Chakraborty et al. introduced a biometric voting system (BVS) with fingerprint recognition in context of India. In their designed model, voter's information was stored in Adhar card- government ID card database and the data was accessed from this card during voting process. Adhar card contains biometric information such as fingerprint and iris of every citizens of India. Some other studies [13]–[15] also introduced Adhar card such as in study [13], [15], a conceptual design to link up the biometric data of Adhar card with e-voting machine was proposed. Stephen et al. [14] designed an IOT based e-voting system with Adhar card database model.

A study conducted by Khasawneh et al. [16] proposed an idea of multifaceted online e-voting system with combined biometric authentication like fingerprint, facial recognition, iris scanning etc. In this model, electronic ballot paper with multiple scope was introduced and computer simulations were run to test the robustness and accuracy.

Reddy mentioned several existing problems in EVM of India in this case study [17] and those problems are- unauthorized vote casting, rigging, network threats and poor software support. He proposed to use biometric authentication with this EVM. Yinyeh [18] provided an overview of electronic voting system in Ghana using biometric authentication which was implemented at each polling station over a LAN (local area network).

In another study [19], the authors proposed a voting system where voter could give vote in two ways - online and offline. In online voting system, voters could give vote through internet with only a password verification, therefore hackers may apply brute-force attack and get succeed. In offline method, voters could give vote by using a voting matching appearing in the booth where iris recognition technology and finger print sensor were used. A study conducted by Baig [20] discussed an e-voting system where user can give vote using smart phone application with QR code verification and this application uses the user information stored in Adhar card.

In sum, each of the research work introduces different ways for the authentication of electronic voting system. Though some studies show the implementation of BEVM, each of

them has pros and cons in their own use of context. Such as NFC or Adhar card needs to use in some proposed system which introduces the issues of losing or stealing IDs. Some of the designed model did not ensure convenient user interface and integrated database, biometric authentication etc like EVM that was tested in some countries- Bangladesh, India [21]. Therefore, our contribution in this paper is to introduce a conceptual design and development of BEVM which is unique, secured and convenient to solve the raised problems.

III. OUR PROPOSED SYSTEM

A. Proposed System Model

The proposed system is a biometric e-voting system which has two main sections- 1) voter registration & 2) voting control and result calculation. Each user needs to register first as a voter through the system with biometric (fingerprint) verification. The information of the voter will be saved in a central database. Then during the election, digital ballot paper will be used instead of paper ballot paper and it will contain the list of candidates and their respective logos. A registered voter can cast only one vote by verifying his finger print. The registration and voting process of the proposed system is explained below:

1) *Registration Process*: As shown in Figure 1, at the beginning of the registration process system will store detailed information of voters along with their NID numbers. Then the fingerprints of the voters will be collected under complete supervision of the registration officers using their NID numbers. If the fingerprints are valid, the system will generate templates for respective fingerprints which will be stored in the database alongside the voters' other information. To check the authentication of a voter during registration process following cases will be considered:

- (I) Case A: If the NID number provided by the user isn't valid then the system will show '*Invalid ID*' and terminate the process. If fingerprint has already been taken for that NID number then system will show '*Voter already registered*'. At the same time the buzzer will beep and an SMS will be send to the authority in charge to notify them about false registration attempt.
- (II) Case B: If the given NID number is valid but match is found for the given fingerprint then system will display a message that '*Fingerprint Already Exists*' and generate the ID number with which the fingerprint match was found. Then after beeping buzzer and sending SMS to the authority in charge the process will terminate.
- (III) Case C: If no match is found then system will save the template for that specific NID in the database and will display a message saying '*Registration Complete*'.

2) *Voting Process*: As shown in Figure 2, the system will ask for the voter's fingerprint until properly scanned. Then it will try to find a match with templates existing in the database. During voting process following cases will be considered:

- (I) Case A: If the match is not found then system will display a message saying '*Voter Not Registered*' and send SMS to the control.

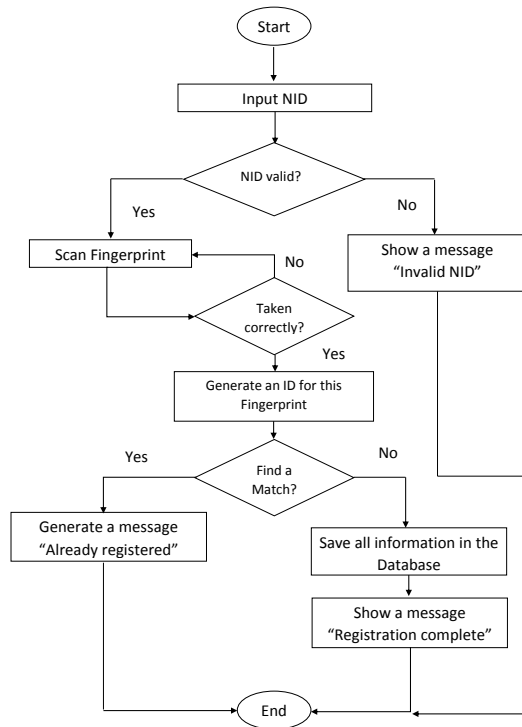


Fig. 1: The Work Flow Diagram of Registration Process

- (II) Case B: If the match is found then system will check if vote has been already given or not against that fingerprint.
- If vote is already given against that fingerprint then system will display a message '*Your vote is already given*' and notify authority with SMS.
 - If vote is not given against that fingerprint then system will ask to vote displaying a message '*Choose your candidate*'. The voter will be able to see the candidate list on the display. Then the system will initialize time with 0 second and will wait for a certain time for the the voter to give his vote.
 - If the button is pressed then system will add the vote against the candidate, display a message that '*Vote is granted*' and an SMS will be sent to the voter to avoid any kind of miscommunication.
 - If the button is not pressed then system will wait for 30 second for the button to be pressed. If time exceeds 30 second, the process will terminate.

The voting process will be held in each polling station by comparing a fingerprint with the voters of that specific station for faster operation. At the end of the election, the result of each polling station will be calculated automatically and will be integrated to the central database for overall result.

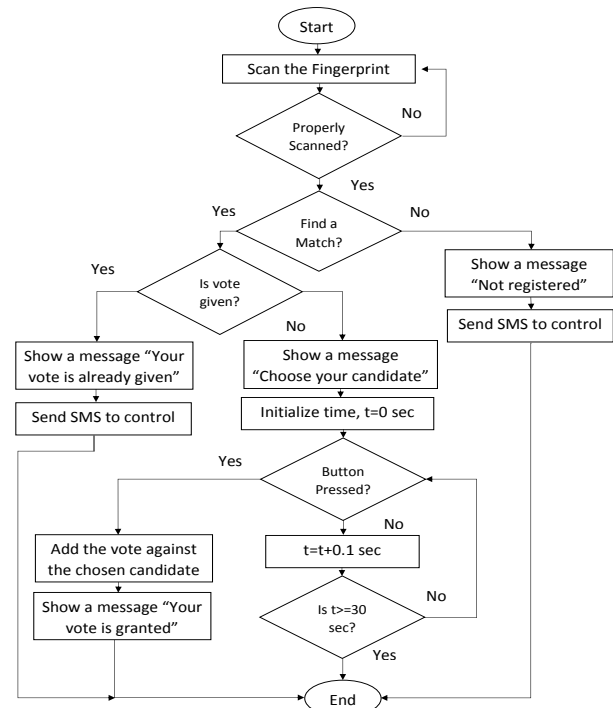


Fig. 2: The Work Flow Diagram of Voting Process

B. System Architecture

The overall conceptual architecture of the system has been highlighted in Figure 3. A fingerprint sensor will be used for the biometric identification process of the proposed system. LCD display will be used to show candidate list, their logos and which button to press to vote for a specific candidate. There will be another small LCD display to show the users various instructions like which button to press for selecting which option during the registration and voting process. A keypad will be used which will take user input for various

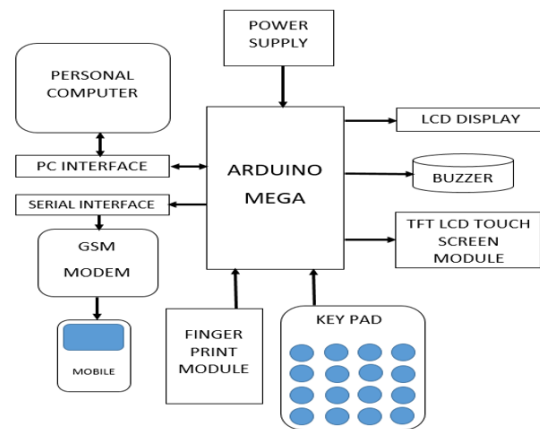


Fig. 3: Conceptual Architecture of the System

options. A GSM Modem will be used to send SMS to the central authority for any kind of complication during the voting process and also to the voters after they have successfully cast votes. Buzzers will be used to generate different types of alert sounds at different situations.

IV. SYSTEM IMPLEMENTATION

Different hardware which have been interfaced together for implementing a prototype of the system as shown in Figure 4 are given below:

- 1) Arduino Mega R3 2560
- 2) Finger Print Module FPM 10A
- 3) GSM modem
- 4) 16x2 LCD Display
- 5) Ethernet Shield
- 6) TFT LCD Touch Screen Module
- 7) 4*4 flexible keypad
- 8) Adapter 12v 2amp
- 9) Buzzer
- 10) Jumper wire
- 11) TP link Router



Fig. 4: Implemented System Prototype

According to the system architecture, a model of the system is developed by integrating Arduino Mega with 16x2 LCD, 4x4 keypad, finger print module, Ethernet Shield, TFT LCD Touch Screen, GSM, Buzzer etc. A database is designed on MYSQL server which is used to store the fingerprint templates generated through the fingerprint module, voter's detailed information, list of candidates for specific election and other necessary information. A wired connection using ethernet shield and router is established for the database connection with Arduino. A user interface is designed using HTML, CSS, PHP, JavaScript and JQuery to access the data stored in the database and also to provide an integrated platform to the election controllers for the central control. The implemented features are:

A. Procedural Instructions and Option Selection

During the whole process, the LCD display shows the user all kind of necessary instructions and displays different kinds of messages to make the system easier to understand and use.

For different types of operations like giving user id, voting for a candidate, the user has to press different buttons in the keypad.

B. Registration

Only users, whose information are already stored in database, are eligible for the registration process. For checking process user has to input his id at first. If eligible, user will be asked for the same fingerprint twice for better accuracy. If the same fingerprint already exists in the system, the system will notify about that and user won't be registered. Otherwise the user will be registered successfully.

C. Voting

In the voting process, the user will have to give his fingerprint first. If the fingerprint exists in the database and the id holding that fingerprint has not voted yet, then the user will be granted the permission to vote any candidate.

D. Candidate List

The candidate list along with their serial number for the voting process is displayed on the TFT monitor which tells the user which button to press to vote for a specific candidate.

E. Generating SMS and Buzzer Alarm

When a voter has voted successfully, the system will generate a message to the voter's number to notify him. For any kind of disturbance sms will be sent to authority. In case of any kind of false attempt like - trying to register with invalid id or same id, trying to register twice with same fingerprint, non-voter trying to vote or voter trying to vote twice, the system will generate an alarm using the buzzer.

F. Voter Profile

Voter's all information can be viewed by the control officer from the central website. So, during the registration process registration officer can easily see voter's detailed information and his picture to verify if he is actually the person he is claiming to be and only then take his fingerprint for registration.

G. Stored Voting Information

During the voting process the exact date and time of giving vote along with the name of candidate who has been voted will be stored in the database. But for security purpose, the name of the candidate will be stored in an encrypted format.

V. RESULT AND DISCUSSION

The implemented prototype of the system was tested for various constraints and loopholes but the result was quite satisfying. There is no way a user can register or vote falsely. All information regarding the voting process (voter, voting date, time) is stored in the database but the user name is encrypted using algorithm. Message from GSM and data from server are sent in an encrypted form using SHA-1 algorithm which is then decrypted in the receiver end to protect data from eavesdropping, spoofing or any kind of network breach.

In order to test accuracy of the system fingerprints of around 65 people were collected. Later on, while conducting voting process, among 70 people (5 not registered) fingerprints of 63 people were recognized correctly by the system. So, the value of True Positive (TP) and False Negative (FN) was calculated to be 63 and 2 respectively with a sensitivity of 97%. The system was found to be quite user friendly and easy-to-understand so that general people (both literate and illiterate) can easily get used to it.

VI. LIMITATION AND FUTURE IMPLEMENTATION

Few limitations of the prototype are given below which we plan to work on in future to make the system foolproof to a great extent.

A. Huge Volume of Fingerprints

The matching of fingerprints may take some more time than expectation when the matching has to be done with a huge volume of fingerprints existing in the database.

B. Better Interface

At present the voters have to press buttons in the keypad to vote for specific candidate which might be difficult for people with less educational knowledge. We plan to solve this problem by using different fingerprint sensors for each candidate, the voter will only need to put his finger in the fingerprint sensor appointed for the specific candidate he is willing to vote for.

C. Multi-biometric System

Result of fingerprint matching may not always be correct so depending only on fingerprints will increase the risk of error. Again, people with no hands won't be able to cast votes following this procedure. So in future we plan to extend our biometric identification system to a multi-biometric system by integrating facial recognition, retinal scan and iris scan system to our model.

VII. CONCLUSION

Being a democratic country, Bangladesh needs a fair and transparent election. Use of a biometric EVM is one of the most secured ways of conducting a fair election. Using biometric identification process, no one will be able to cast someone else's vote or vote multiple times. BEVM helps to overcome the drawbacks of the current EVM system recollecting the voting information (audit trails) which will provide evidence of the EVM's integrity and accuracy. Therefore we can say that implementation of BEVM can provide transparent, fair, secure and accurate election process which is the main desire of every democratic country like Bangladesh and thus hold democracy upright in our country.

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