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Electoral Process using Biometric Fingerprint Scanner that Suits the Bhutanese Election

Younten Tshering[1], Karchung[2], Deo Raj Biswa[3], Thinley Wangmo[4]
Jigme Namgyel Engineering College, Royal University of Bhutan
[1]Associate Lecturer, Department of Information Technology
[2]Associate Lecturer, Department of Electrical Engineering
[3]Associate Lecturer, Department of Electronic and Communication Engineering
[4]Assistant Lecturer, Department of Humanities & Management

Abstract: Democracy is a gift from the golden throne; from 2008, Bhutanese people started to choose their leader by casting a vote. The right to vote and more importantly the exercise of franchise by the eligible citizens is the heart of every democracy [1]. Through this exercise of their right to vote have the ultimate power to shape the destiny of country by electing representatives who run the government and make decisions for the growth, development, and benefit of all the citizens. However, the voter turnout seems to be decreasing at an alarming rate based on the Election Commission of Bhutan [5]. This paper proposes an electoral process aiming at better voter turnout. It replaces whole electoral system using Biometric Fingerprint scanner for the voter authentication and a display unit connected to a central database which helps a voter to cast their vote from nearest polling station instead of having to go to his/her polling station to cast vote. It is a hybrid of internet voting and a traditional electronic voting method where the system uses electronic equipment at the nearest polling station to cast vote instead of using a personal laptop or mobile phone to cast vote using an app. The hybrid system is adopted with the major findings shown in "Internet Voting in Estonia" [13] which is a small country and suitable to adopt internet voting.
Keywords: Biometric, democracy, electoral process, fingerprint, voting.

I. INTRODUCTION

A. Background

As Bhutan celebrated its 100 glorious years of Monarchy in 2008 under the golden reign of the Wangchuck Dynasty, the country transited to a Democratic Constitutional Monarchy. This was with the Royal command of the 4th King of Bhutan; His Majesty Jigme Singye Wangchuck in the view of decentralizing the power to the people where every citizen can participate in decision making by electing the people whom they can trust and approach for the grass-hood developmental activities as their government. The democratic transition was marched by the conduct of first-ever Parliamentary Election for the National Council (NC) and National Assembly (NA) which are the highest decision-making body. The very first elections saw a voter turnout of 53.05% in the National Council Election and 79.38% at the National Assembly Election in 2008 [5] that instituted the first democratically elected government in the History of Bhutan. Second Parliamentary Election was held in 2013 after the completion of the term for the first Government and the voter turnout reduced to 45.15% and 66.13% respectively for NC and NA, which showed an alarming decrease in voter turnout although it is not alarming as compared to other countries. For instance, the voter turnout in the US was 58.2% in 2008, 54.9% in 2013 and 55% in 2016 according to the Centre for the Study of the American Electorate. Similarly, in Canada, the voter turnout was 58.8% in 2008, 61.1% in 2011 and 61.5% in 2015 according to Elections Canada. Bhutan's Election does not conduct just NC and NA but series of the election almost yearly such as series of Local Government (LG) Elections and by-elections for the Gewog Tshogdes and Dzongkhag Thromdes for vacant Local Government Demkhongs.

B. Purpose of this Study

This study seeks to provide relevant and appropriate technology considering the current situations in Bhutan. Currently, voter turnout is low for instance 53.05% and 79.38% respectively for NC and NA election in 2008, 45.15% and 66.13% in the 2013 election, which is not a satisfactory one. The research team found out that the low voter turnout is because of the two main reasons listed below:

1) Bhutan by locating on young Himalayan Mountain having life-risking roads frequently encountering roadblocks due to landslides and getting news of life lost due to narrow road causing vehicle veering off the road. This discourages voters travelling their constituency passing narrow and steep valleys.

2) The cost incurred is huge as it takes days while making a round trip back from their constituency to the workplace. This discourages low-income family to turn out for voting although they are eligible and interested.

This study proposes to make an electronic electoral system communicating using ICT and making it possible for everyone to vote for their candidate from their nearest polling station without having to go all the way to their constituency. This system enables free, safe, fair, and costless voting with improved voter turnout.

C. Problem Statement

The election process in Bhutan is mostly viewed with possession of risk factors. Most voters are residing and working far from their constituency, and it takes a minimum of seven days or two weeks to resume for the work, which perhaps hampers their work performance and incurs huge expenses [9]. In addition, the risky roads which are prone to landslides especially in summer are life-threatening and discouraging people to travel to the constituency. Another reason is the spread of fake news in various medium in society. The growth of online news prompted a new set of concerns, among them that excess diversity of viewpoints that would make it easier for like-minded citizens to form "echo chambers" or "filter bubbles" where they would be insulated from contrary perspectives [10]. According to Silverman 2016 [10], fake news is more widely shared on Facebook than the most popular mainstream news stories. Because of this, people lose hope to vote as they think their energy in going all the way to vote long way will be a wastage. The other reason is the rejection of postal Ballot. For instance, in [6], 741 Postal ballots rejected out of 3416 ballot applicants. Moreover, the voter turnout keeps on decreasing because everyone must carry Voter Photo Identity Card (VPIC) and due to lost cases of VPIC [9] and [9] points out that the youngsters of age 18-24 do not turn out to vote, as the traditional system does not give charm in voting. By looking at the decreasing trend of voter turnout in National Assembly Election 2003 & 2013, National Council Election 2008 & 2013 and two rounds of Local Governmental Elections, there is a need to follow up the strategic plan to control declining voter turnout trend in the election process. The best and easiest strategy is by making voting possible from the nearest polling station from their residence without having to go to their constituency and without having to procure VPIC all time for just one-time voting.

D. Research Objective

As mentioned in the problem statement, the key objective of this study is to improve the current electoral system aiming to improve voter turnout in Bhutan.

E. Definition of Terms

For this study, two terms have identified, for which general definitions have not used, rather the terms have given a specific meaning for purposes of this study. These terms are "Voter Turnout" and "Over vote".

1) *Voter Turnout:* the percentage of eligible voters who cast a vote in an election. Eligibility varies by country. For Bhutan, age and citizenship status are criteria used to determine eligibility, while in some countries further restrict eligibility based on sex, race, and/or religion.

2) *Over Vote:* An overvote occurs when one vote for more than the maximum number of selections allowed in a contest. The result is a spoiled vote which is not included in the final tally. One example of an overvote would be voting for two candidates in a single race with the instruction "Vote for not more than one."

F. Assumptions

In this study, assumptions have been minimized as much as possible, however, the methods selected for data collection, notably the use of a data for voter and candidate details, necessitated those certain assumptions be made:

1) It was assumed that the Election Commission of Bhutan does not have the record of all details listed in our projects such as ID Number, Name, Sex, Date of Birth, Village, Dzongkhag, House Number, Polling Station, Dzongkhag, Constituency, and voter photo. Therefore, in the first step itself, the systems ask whether to register as voter, candidate or cast vote. However, this is visible only to the administrator not to the voters or candidates.

2) The research team limited the personal details of both candidate and the voter to the details listed in point 1 with the assumption that ECB maintains these details only.

G. Significance of the Study

Globally, electoral system-related research has been an area of significant academic, national, and international importance. As this research aims in improving electoral processes in Bhutan, this research will greatly help voters as individuals, Election Commission of Bhutan (ECB) in particular and nation at large.

1) A Benefit to Voter

a) A voter does not have to spend much time verifying the documents step by step or wait in queue as everything will be conducted electronically.

b) Voters need not worry about the voter identity card as the identification is made by biometric which is secure, safe, and precise.

c) S/he can get enough time to look at the name or photo of the candidate to whom s/he is going to vote as there is no one around thus reducing voters to be anxious or nervous.

d) Voters satisfaction as s/he gets to vote for the right candidate.

2) To ECB

a) Voter turnout will be increased.

b) High cost will be reduced as the number of officials in each polling station will be reduced.

c) The problem of human resource will be reduced as the polling officials will be replaced by the computer system.

3) To Nation

a) Best government officials elected with better voter turnout takes nation in the right direction.

b) The national economy will be retained, and that budget can be used for some other developmental activities.

II. LITERATURE REVIEW

A. Voting System in Estonia

Estonia was the first country in the world to introduce Internet Voting pan-nationally in binding elections in 2005 [13]. Although Internet Voting is only one of the ways to vote in Estonia, the voter-turnout has increased exponentially because Estonia is a small country with just 1.35 million inhabitants dispersed over 45,227 km2, with the positive experiences of e-services and the implementation of the idea of remote voting in the uncontrolled environment using ID cards. According to the paper, Estonia has had electronic voting since 2005 and in 2007 was the first country in the world to allow online voting. In the 2015 parliamentary election, 30.5% of all votes were made though the nation's I-voting system [13]. The bases of this system were the national ID card that all Estonian citizens are given. These cards contain encrypted files that identify the owner and allows the owner to carry out several online and electronic activities including online banking services, digitally signing documents, access their information on government databases and i-voting [17].

To vote, the voter must enter their card into a card reader and then access the voting website on the connected computer. Then enter their PIN and check is made to see if they are eligible to vote. Once confirmed, they can cast/change their vote until four days before election day. The voter may also use a mobile phone to identify themselves for I-voting if they do not have a card reader for their computer. However, this process requires a specialized SIM card for the phone [13].

When a voter submits their vote, the vote is passed through the publicly accessible vote forwarding server to the vote storage server where it is encrypted and stored until the online voting period is over. Then the vote has all identifying information cleaned from it and is transferred by DVD to a vote counting server which is disconnected from all networks. This server decrypts and counts the votes and then outputs the results. Each stage of this process is logged and audited.

During the 2013 Local Election, researchers observed and studied the I-voting process and highlighted several potential security risks with the system. One such risk is the possibility of malware on the client-side machine that monitors the user placing their vote and then later changing their vote to a different candidate. Another possible risk is for an attacker to directly infect the servers though malware being placed on the DVDs used to set up the servers and transfer the votes [16].

In [16], analysis of the security of the Estonian I-voting system based on a combination of in-person election observation, code review, and adversarial testing was conducted. Adopting a threat model that considers the advanced threats faced by a national election system—including dishonest insiders and state-sponsored attacks and the paper found out that the I-voting system has serious architectural limitations and procedural gaps that potentially jeopardize the integrity of elections. In experimental attacks on a reproduction of the system, authors demonstrated how such attackers could target the election servers or voters' clients to alter election results or undermine the legitimacy of the system. Their findings illustrated the practical obstacles to Internet voting in the modern world, and they carry lessons for Estonia, for other countries considering adopting such systems, and for the security research community.

Authors have also used their reproduction of the I-voting system to experiment with a range of attacks. The I-voting system places significant trust in client and server components, making these highly attractive targets for an attacker. While certain server operations are protected by cryptography (e.g., cast votes cannot be decrypted on the front-end web server, since it lacks the requisite private key), in other instances the servers are completely trusted to perform honestly and correctly when handling votes. Similarly, while the smartphone verification app gives voters some ability to check that the client software is behaving honestly, there are major limitations to this safeguard that can be exploited to hide malicious client behaviour. Authors have experimentally verified that these trusted components are vulnerable by conducting two sets of demonstration attacks against them in their mock election setting. The first type is attacks on the client that are within reach of a financially capable attacker, in which an attacker can change votes in a retail manner for large numbers of individual voters. The second kind is server-side attacks within the reach of a well-resourced state-level attacker or dishonest insider, in which an attacker could change the wholesale results of the entire election by compromising the vote-counting server.

One core strength of the I-voting system pointed out by the authors is Estonia's national ID card infrastructure and the cryptographic facilities it provides. While the ID cards cannot prevent every important attack, they do make some kinds of attacks significantly harder. The cards also provide an elegant solution for remote voter authentication, something few countries do well. Authors pointed out that since its inception in 2005, the system has undergone significant changes i.e., from the switch to a standalone client to the deployment of the log server that enhances forensic and monitoring capabilities, to the addition of the verification app, the I-voting system has not stood still.

With this modified system, the client-side attack named by [16] as "Ghost Click Attack" can be eliminated as our system does not require an ID card to log in to the system. Moreover, this system tries to eliminate "Bad Verify Attack" where the system will be set up on the touchscreen and which is an independent system without having to connect it to PCs time and again. This system does not use DVDs to transfer data from client to server, rather the data gets transferred online which minimizes the server-side attacks.

B. Digital Voting with the use of Blockchain Technology

The authors in "Digital Voting with the use of Blockchain Technology" [2] aims in solving the issues of digital voting by using blockchain technology. The report starts by introducing the problems with current voting practices especially portraying the issues pointed out in 2.2, it then goes into a brief explanation of what blockchain technology is and how it is currently used.

The first aspect of their design is the registration process which makes verifying a voter essential in establishing security within the system. Making sure that someone's identity is not being misused for fraudulent purposes is important, especially when voting is considered, where every vote matters. To allow users to register to vote our proposed service utilizes both postal based forms as well as web forms requiring the same information to ensure they cater for those without a direct internet connection. This information includes their national identity number, postal address, optional email address and a password. All this information then forms a transaction for the user agreeing with the government that they are asking to vote; this transaction is then created on the voter blockchain which is distinctly different from the voting blockchain.

The local tier contains all the digital polling stations across the country, each of which is associated with a constituency node. A local node is a setup to only communicate with the other local nodes under the associated constituency node and the constituency node itself.

The constituency tier contains all the nodes that are deemed to be at a constituency level. These nodes would be directly connected and to a subset of polling stations depending on location. The national tier is a collection of nodes that are not tied to location, their pure purpose is to mine transactions and add blocks to the voting blockchain, all constituency nodes communicate to a national node and national nodes can communicate with each other.

When it is time to vote, authentication of a user requires three distinct pieces of evidence; their identification number, the password supplied on registration, their ballot card which contains a QR code. As there are two methods of voting (web browser, physical polling station) the way the user will input the authentication details shall differ; however, to vote they are required to provide all three pieces of information. It is also important to note that each user will have been registered at a certain constituency so they will only be able to vote at a local polling station within that constituency or via the internet at the URL provided on the ballot card.

One risk is, if a voter were to forget their ID, password, or polling card on the day of voting, the voter will be unable to cast their vote as they cannot enter the system. Possible risk mitigations include the voter returning later that day with the correct information or the implementation of a backup authentication service such as by phone. Alternatively, a forgotten password system could be added to the voter registration website; this could work in much the same way as recovering a password works on other websites. However, this increases the risk of a hacker attempting to change a voter's password without their knowing.

The author admits a 51% attack is a potential threat to their proposed design. The basis of the attack being that someone could theoretically control a majority of the digital voting mining hash-rate, leading to them being able to manipulate the public ledger. The chances of this type of attack occurring are slim due to the immense cost needed to purchase hardware capable of this scale of processing. The online aspect of the voting within the system is the largest attack vector for hackers as they could potentially exploit voters through their own devices in a host of ways. To combat this software could be developed that could be downloaded onto the client's device to establish a secure connection to the polling station.

Our system supersedes the first risk portrayed in this literature i.e., the risk of forgetting the voter ID, password or polling card as this risk is being eliminated by substituting with the biometric system.

III. RESEARCH DESIGN AND METHODOLOGY

The research design according to Mouton (2001) provides the framework for how the rest of our study will be performed and as such needs to be considered early in the research process.

The choice of research design is generally influenced by the research objectives and the nature of the research problems to be solved. Some of the research questions framed are:

1) What are the possibilities of designing an electoral system incorporation of information technology to enhance the electoral process?
2) How will this system enhance the electoral process?
3) Will the new design support in improving voter turnover in the current electoral system?

Following the example of researchers who had previously studied and researched on Electoral System, the most appropriate research design for this study was found to be one which allowed for the online voting system, which is proved to be easy and handy for all as nowadays everyone is familiar with using mobile phone. However, our design approach slightly deviates from this exploring the pros and cons to the semi-online method of voting without providing full encryption to the voter. As technical research mostly comes under the mixed mode, we have followed mixed mode.

One of the flexibilities for the voter is they do not have to carry an ID card or VPIC when they come for voting. The voter need not produce VPIC to cast vote of his/her choice within the polling hour. The voter just needs to register his/her fingerprint once before polling day and that will provide identification through and through unless his/her detail is removed from the database.

The voter will be allowed to get his/her finger verified by the Biometric Fingerprint scanner which is connected to display unit/touch screen which again is connected to the central database. The voter is notified with the status of the fingerprint verification and if successful will display his/her details on the screen. Upon agreeing, will be taken to a voting page where the candidates' list with name and coloured photo to recognize and button to select and vote for a candidate will be displayed. After voting, the system will notify the status of the vote (success/failure).

The central database system will be controlled by election commission head office and the client-server will be at respective polling stations. Every change will be notified to the central server but vote count or the status of the vote will not be accessible to anyone until the voting time ends. As soon as the voting is closed from the central server, all the votes will be collected, and the Result button becomes accessible to view the results. The votes for each constituency irrespective from where it is voted will be displayed in its respective constituency.
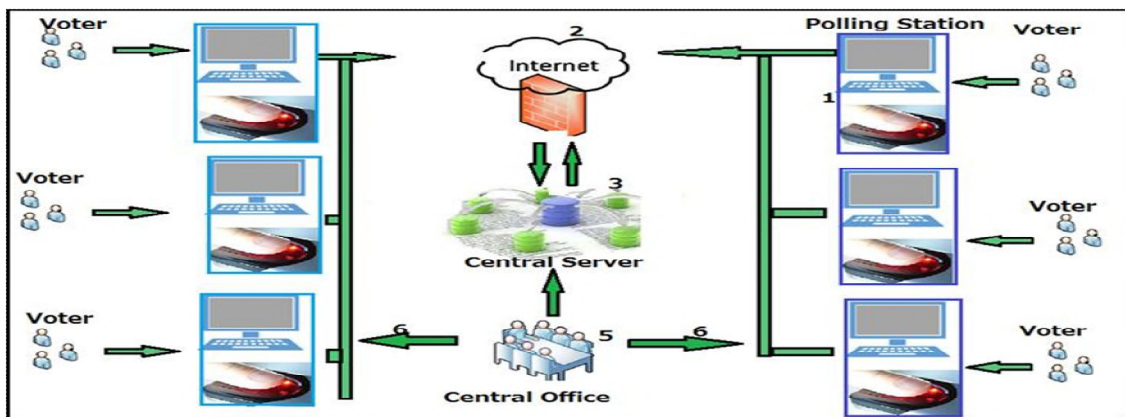

Figure 1. Skeleton of Proposed Electoral System

Necessary comparisons and checking can be done with the contents collected in the database for instance to see voter turnout based on age limit and male and female turnout. For the design purpose, we are using simple DigitalPersoniaTM 4500 Fingerprint Scanner which provides 100% security as it can be used only when the serial Number, Registration Code and Activation code is provided.

Figure 2. DigitalPersoniaTM Fingerprint Scanner

The Fingerprint scanner is compatible with Visual Studio; therefore, this system was developed using Visual Studio with .net framework to build a voting platform.

A. Research Instruments

Research instruments are the tools used to gather data for purposes of further research according to Hofstee (2006: 115).

For purposes of this study, the design uses the following tools:

c) Mobile table/laptop, Touch Screen: This is basically to provide the interface between the voter and the database. A voter can vote from the button displayed on this screen.

d) Biometric Fingerprint Scanner: This is used for the identification purposes where voter details will be verified and approve the voting status of a voter.

e) MySQL database: MySQL is a relational database management system based on SQL – Structured Query Language. This provides the platform to store data on the web and allow the local server to interact with the central server for various purposes.

f) Visual Studio 2017 with C# programming software platform is used to create the database and make the linkage with the MySQL database and biometric fingerprint scanner.

B. Data Sources

As indicated in the previous section, to adequately address the research questions posed in this study a combination of primary and secondary data was needed. The primary data source in this study is the Election Commission of Bhutan. Majority of the study used their press release. Since it is a model, we are not concerned about the ethical issue. The secondary data sources included the conference papers, journals, books chapters and other related sources online.

C. Data Collection

As per the existing electoral system in Bhutan, we used the same information to design our system. The voter details required to register as per Election Commission of Bhutan is listed below with the pseudo details:

1) National Identity Card Number/VPIC Number: 11502001089

2) Full Name: Karma Dorji Dukpa

3) Sex/Gender: Male/Female/unspecified

4) Date of Birth: 05-07-1999

5) House Number: Ka-3-308

6) Village: Kalamazoo

7) Gewog: Gomdar

8) Polling Station: Changshing

9) Gewog: Nanong

10) Dzongkhag: Pemagatsel

11) Constituency: Nanong-Shumar

12) Voter Photo: 032.jpg

13) Fingerprint: 000000101010101

This much information is enough to verify the voter and avoid the forging and duplication of a voter. As the candidate is the registered voter by nature should have his/her details registered in the database but only the following will be displayed on the screen with the button to cast and submit vote.

a) National Identity Card Number/VPIC Number: 11502001089
b) Full Name: Karma Dorji Dukpa
c) Village: Pemathang
d) Photo
e) Constituency (subheading)

D. Data Analysis

The design is tested with randomly selected people. The personal details required in the system fields are inserted and the fingerprint is registered for the selected group of people.

The mock election was conducted with few candidates selected randomly and voted. We then tried with the unregistered voter and with the same voter for the second time.

IV. RESULT

Five main interfaces are created on the Visual Studio such as index page, voter registration form, candidate registration form, voter verification interface and voting interface. The vote count and result interfaces are built separately from the voting section to provide better security as the result cannot be viewed or vote cannot be forged. Each interface will be discussed separately:

A. Sign in Interface

The first and foremost thing to get access to the system must get the first line of security check. This is achieved by using the login page. This login page gives two different types of user rights to access the database as either Administrator or the Member. The administrator has greater user rights than the Member.

Figure 3. Login Form

Figure 4 shows the homepage for the administrator. As explained in an earlier section, the administrator has higher jurisdiction than the member does because he/she is the responsible person for the whole system. For instance, the Result and Setting are two major sections, which should be handled by the administrator only. It can have many members which include Presiding and Polling Officers in Polling Stations but only one Administrator.

B. Index Page

The index page is the page which appears as soon as the user login as administrator. Index page allows you to do different tasks. Either register or update voter, register, or update candidate or view the result. The index page will be handled by Returning Officers for registration of the voters and candidates and the Polling Officers to open voting on the polling day.

Figure 4. Index page

The Voter Registration, Update Voter, Candidate Registration, Update Candidate buttons are to be used before the polling day to make sure accurate data is being inserted into the database and Results button to view or declare the result during the polling day.

C. Voter Registration form

The voter registration form is the most important page which contains every detail of the voter as listed in Figure 5. Even the candidate details will be present in voter detail because the candidate is an eligible voter. Therefore, the candidates do not need to go and register themselves with the election board as this can be done by people working in the election office once candidature is approved.
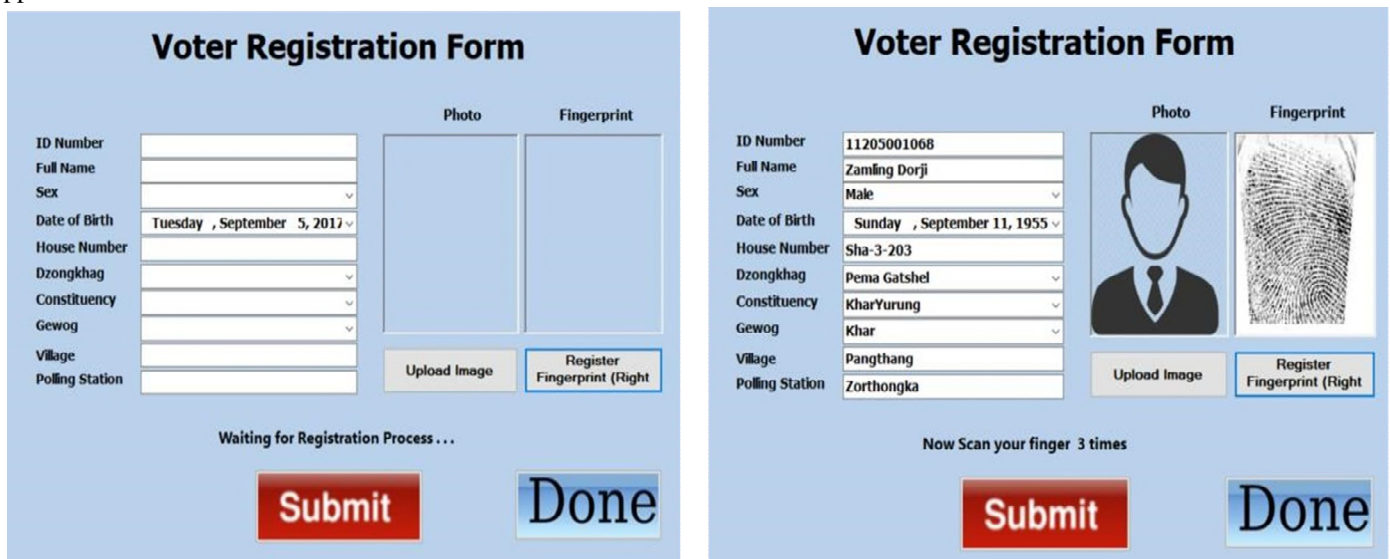
Figure 5. Voter registration form

D. Candidate Registration form

Candidate registration is created mainly to pop up automatically when a voter enters into the voting line. As this system is a dynamic one, the name and photo of the candidate will not be pasted on the voting machine instead the candidate with details listed in Figure 6 will appear on the screen when a voter is successfully verified. The candidate is then eligible voter; details can be pulled from the database by just typing the ID number of a candidate as shown in the right figure in Figure 6.
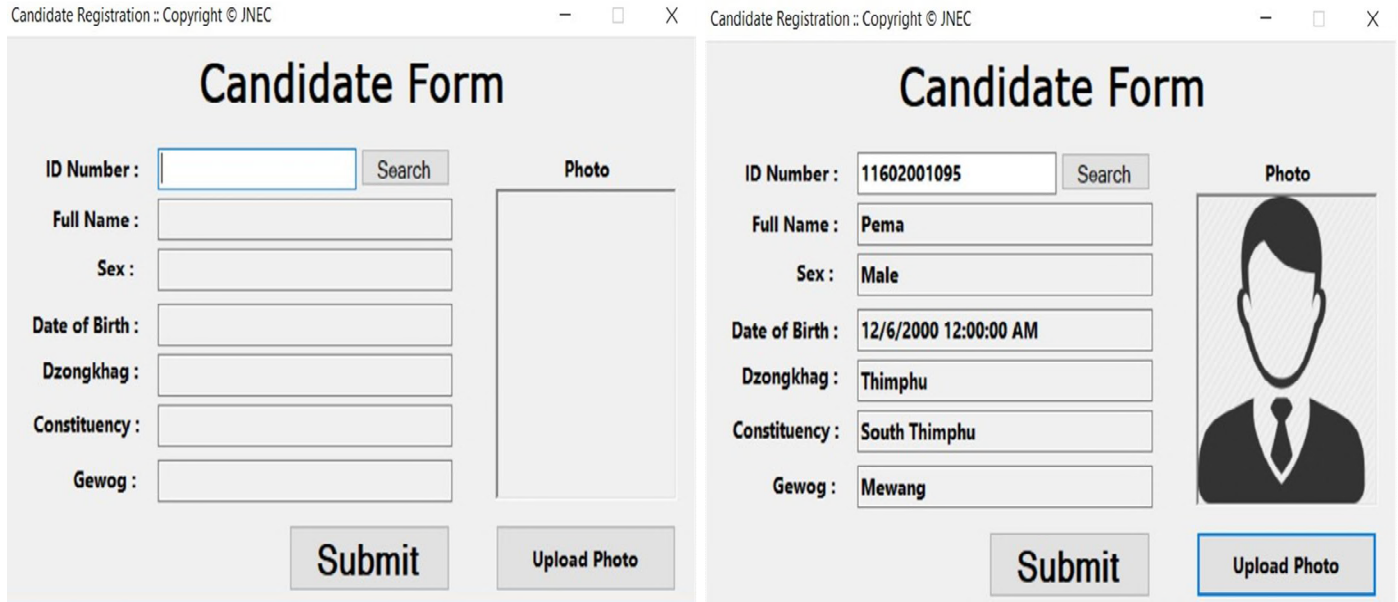
Figure 6. Candidate registration form

E. Verify Fingerprint

This section is created to check and make sure correct fingerprint data is being stored in the database. If the fingerprint matches with the database fingerprint, the verification page will appear.
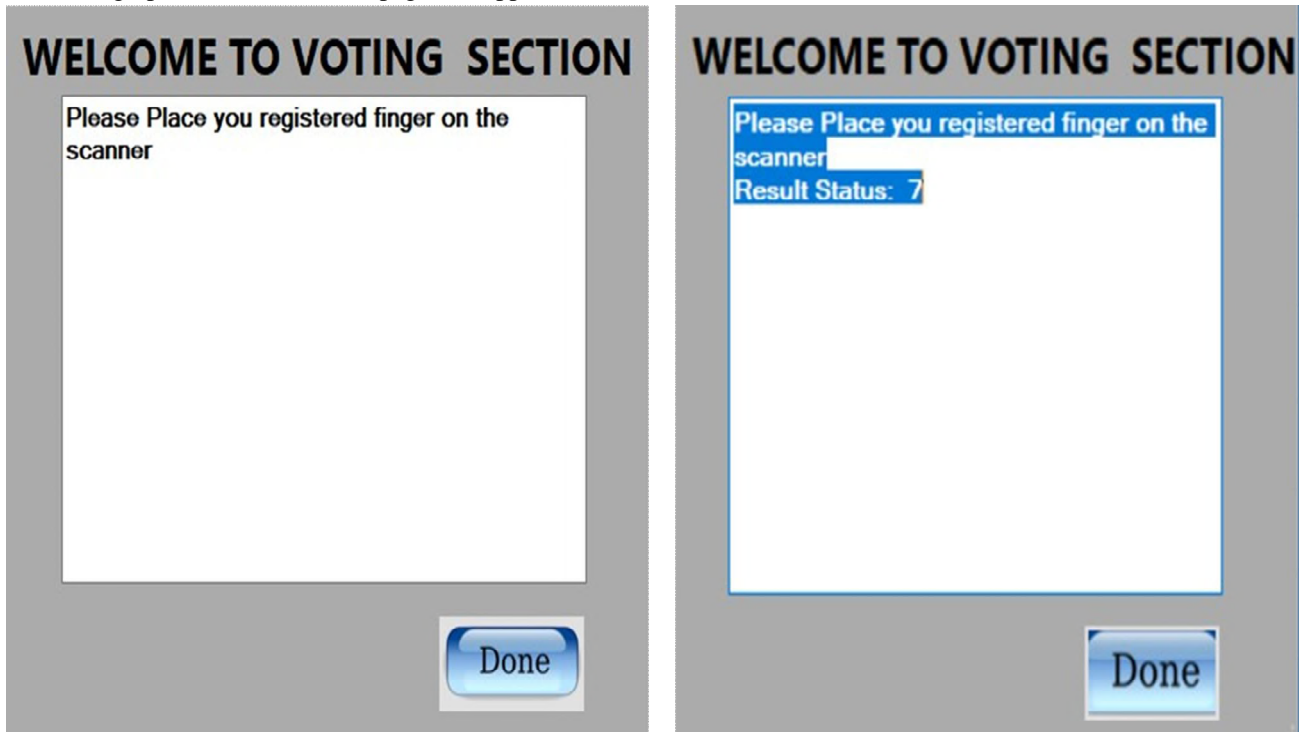
Figure 7. Fingerprint Scan Platform

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F. Verification Interface

This interface is developed to give assurance for voter themselves that they are the actual voter because voter may even doubt of their own identity as there is no visual verification system while using the computer system.

This interface is also the voting page as the voting procedure starts from this page. The voter just has to scan his/her registered finger and thus the details are being displayed on the space provided for each. After the fingerprint is scanned successfully and the details are displayed, the voter has to click on the right-side button which says, "Click here after Finger Scan". Then the voter is directed to a voting interface.
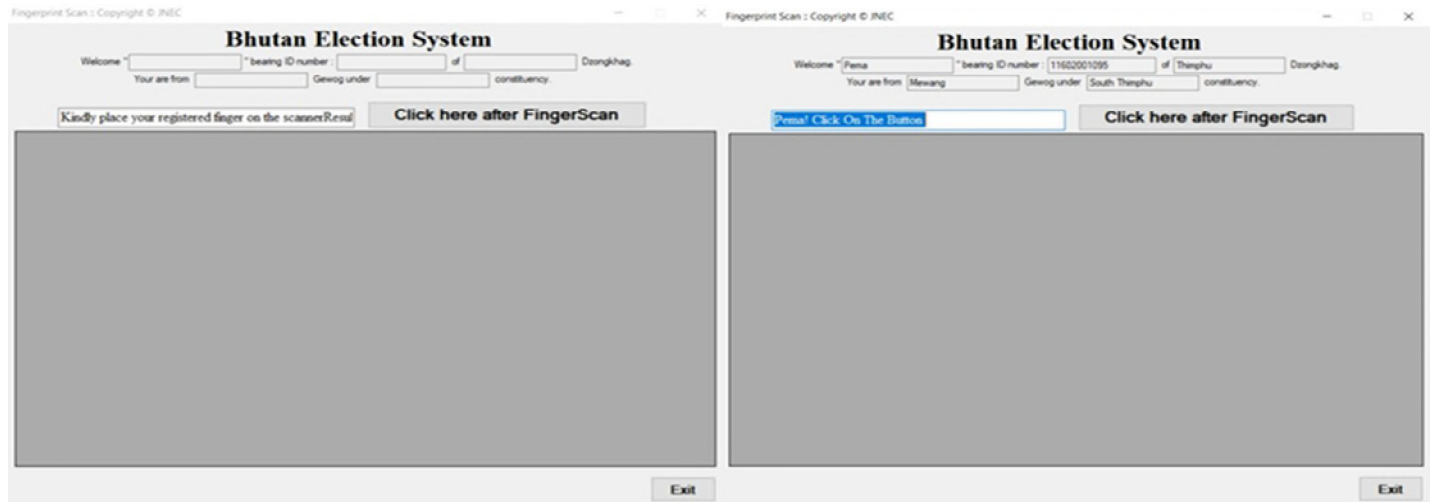
Figure 8. Voter verification interface

Figure 9. Voting Interface

A voter can choose the right candidate from the list appearing against their constituency as shown in Figure 9 and the status page will display confirming the vote being counted or registered in the database. Trying to vote for the second time will be restricted automatically.

The vote once is updated into the database must be displayed back by using a certain protocol as we cannot access a database directly given the risk factor.

G. Result Page

As the result page is more important, at the end of the poll day, the declaration of the result can be done by logging in as Administrator. Then select the result options under an action menu to see the result. The page as shown in Figure 10 will be displayed.
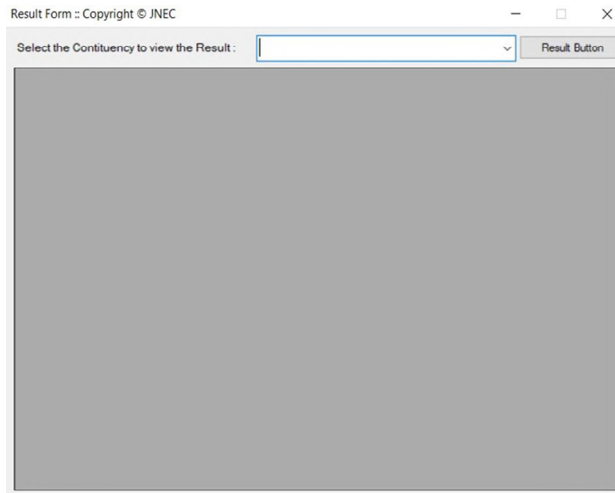

Figure 10. Constituency Selection

We are choosing a constituency-wise result declaration method as it will be complicated to the eye if all results are displayed together at a time. For instance, in example shown in Figure 11, a candidate belonging to a selected constituency only is displayed. This method is best suitable both for the election body and the viewers and for the media people to show to the public.

Figure 11. Constituency wise Result Sheet

V. DISCUSSIONS

The prototype is developed with the fingerprint scanner and laptop computer. The development of the system is created in Visual Studio and are interfaced to the server using MySQL web server and programming is done in C# language. The MySQL database contains two tables which contain the voter details and the other contains the candidate details. In the voter, details include voter ID number, name, sex, date of birth, village, house No., Gewog, Polling Station, Dzongkhag, Constituency, voter photo and voter fingerprint are included. Similarly, the candidate details include ID number, Name, age, photo, constituency, and the empty field to store the votes.

The central database could not be created as the detailed voter information is required. For the testing and demonstration purpose, few people are chosen and tested. This system still can be modified based on the ECBs requirement and improve the security at the server end.

VI. CONCLUSION

A. Future Research

While this study provides several important insights into the hybrid system of the election system, there are several aspects to be done still. The voting system can be made with a permanent structure similar to ATM for the banks or the cashier at the shopping malls with touch panel instead of Personal Computer. The voter and candidate's details can be made available in both local and central servers because the polling stations will be connected to central server timely based on the Election officials' requirement and they have full authority to connect anytime mainly to share data to a central server. When it is not connected, all votes should be stored to a local server. This is the most distinctive feature this system can adapt to make it more secure and reliable. There is a need to focus on security issues and adopt the measures in this system.

B. Ethical Consideration

While undertaking this research, we did not encounter any ethical issues and we hope it will not as this is purely a design and developmental based project without duplication of others work. The proposed research was carried out keeping the Royal University of Bhutan's research policies, guidelines, and procedures.

VII. ACKNOWLEDGMENT

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