BK Web-Based E-Voting System: Ensuring Confidence with Votes and Results Verification

Ben Beklisi Kwame Ayawli¹, Albert Cosmos Gershon², George Asante³

¹Dept. of Computer Science, ²Dept. of Commercial Studies, ³Dept. of Information Technology

¹Sunyani Polytechnic, P. O. Box 206, Sunyani, Ghana
²Sunyani Polytechnic, P. O. Box 206, Sunyani, Ghana
³University of Education, Wenneba-Kumasi Campus, Kumasi, Ghana

bbkayawli@yahoo.com, ²cossey2003@yahoo.com, ³geosante@yahoo.com

Abstract

The purpose of this study was to design an e-voting system to improve verification and auditing of votes and election results to aid build confidence in the use of e-voting. A top-down design approach was adopted in the design and development of the e-voting system. BK Web-based e-voting system after design was implemented in ten different elections in 2012, 2013 and 2014. It was very helpful in ensuring voter’s confidence in e-voting since they were able to verify their votes through Short Message Service, reports generated from the system and the provision of ‘strong room’ facility. The verification procedures demonstrated in this study when applied in e-voting systems would help build voter’s confidence in e-voting systems.

Keywords:
E-Voting; Web-Based; PHP; Mysql; Election; SMS; Voter Verification Code; CSS; Xampp; Voter Confidence; Results Verification

Introduction

Elections allow the populace to choose their representatives and express their preferences for how they will be governed [6]. How confident are we that our vote counts? Would society benefit if improvements were made to the current voting systems? The arguments made in favor of paper ballots versus electronic ballots persist. Yet which one is more beneficial to use? And does this outweigh its costs? [1]. Many researchers suggested e-voting as a solution to the problems of paper ballots electoral process [14][15][16][17][18][19][20].

Neumann as cited by Jegede, et al. [5] suggested that a voting system should be so hard to tamper with and so resistant to failure. They stressed that, no commercial system is likely to meet the requirements and developing a suitable custom system would be extremely difficult and prohibitively expensive. Rebecca Mercuri invented the Mercuri method for electronic voting. Her philosophy and that of Neumann were very similar. A critical component of this method is also very similar to the Caltech/MIT proposal: a voting machine must produce human-readable hardcopy paper results, which can be verified by the voter after the vote is cast and manually recounted later if necessary [7]. Dr. Michael Shamos of Central Michigan University however provided a sharp counterpoint to Neumann and Mercuri’s views. While his six commandments summary of requirement for a voting system is very similar to others requirements, he is less afraid of the catastrophic failures and sweeping fraud made possible by imperfections in electronic voting machines actually occurring in real elections. Shamos is much less impressed with paper ballots than are Neumann and Mercuri. He places a great deal of faith in decentralization to make fraud difficult to commit and easy to detect. He stressed that elections must be auditable to allow verification of accuracy of election results[8].

Chaum[9] presented a very interesting scheme, whereby voters could get receipts for their votes. This receipt would allow them to know if their votes were included in the final tally or not, to prove that they voted without revealing any information about how they voted. Wei-Chi et al.[10] also described an e-voting scheme to improve the resistance to bribery and coercion to ensure confidence in e-voting. Cohen and Fischer [11] also proposed a
robust and verifiable cryptographically secure election scheme to improve e-voting security. Civitas was described as the first electronic voting system that is coercion-resistant that allow for voter verification, and also suitable for remote voting [12].

According to a policy paper by INTERNATIONAL IDEA [4], Electronic voting is often seen as a tool for making the electoral process more efficient and for increasing trust in its management. If properly implemented, e-voting solutions can increase the security of the ballot, speed up the processing of results and make voting easier. If not carefully planned and designed, e-voting can undermine the confidence in the whole electoral process. Esteve, et al. [3] in their research to determine new challenges and potential problems of electronic voting machines identified lack of confidence and the problem of auditing of results when election results are challenged among other challenges as potential problems of e-voting.

The Council of Europe requires that the correctness of the results produced by an e-voting system should be verifiable and that the system should be auditable [2]. Gritzalis[13] suggested in his paper that an e-voting should be considered only as a complementary means to the traditional election processes due to the inherent distrust in the e-voting procedure in addition to the inadequacy of existing technology to meet certain requirements.

It is believed that, electronic voting systems pose a number of risks leading to irregularities in the election process including lack of recount ability, human error, and security vulnerability, complexity of the voting system, faulty programming codes and inability to verify votes cast by a voter [5]. Therefore, to ensure confidence in the use of e-voting, these problems should be addressed. This study considered the design of an e-voting system to improve the verification of votes and election results to ensure confidence in the use of e-voting.

**Objectives of the Study**

The purpose of this study was to design an e-voting system that would improve verification and auditing of votes and election results to build confidence in the use of e-voting. The proposed system is to help a voter verify his/her choice of votes through Short Message Service while ensuring secrecy of votes. ‘Strong room’ facility that allows agents of candidates to be in a secured and an enclosed location until the end of the election with a giant screen showing the status of election results from the start of the election till the end was considered. Election reports are also to be provided to aid auditing of election results.

**Methods and Tools**

A top-down design approach was adopted for this system. Data flow diagrams were used at the logical design stage to illustrate the detail and the relationship between the different subsystems of BK Web-based E-voting system.

The hardware tool used was a computer with Intel ® CORE™ i5 processor (2.67 GHz (4CPUS) speed, 4 GB of RAM and 750GB hard disk) installed with Windows 7 operating system. Adobe Dreamweaver, MySQL database and a browser were used for the development, testing and implementation of the system. Hypertext Markup Languages (HTML), Cascading Style Sheet (CSS) and PHP scripts accompanied with SQL commands were used in the development of the system. Xampp which comprises Apache web server and MySQL database server was used at the server side for testing and implementing the system. Firefox, Internet Explorer, Google Chrome and Opera web browsers in addition to desktop computers and cell phones were used at the client side for the testing and implementation of the system.

The minimum hardware requirements for the implementation of the system include Pentium 3, 450 MHZ processor computer. Computers of other processors of similar capacity, Smart phones and Tablets could also be used. It is Operating system platform independent and it runs on Android, Linux, Windows and any operating system that allow access to the internet. Web browsers including Mozilla Firefox, Opera, Safari, Internet Explorer, Google chrome and any other web browser are the software required at the client side in using the BK Web-based E-voting system. MySQL is required at the database server level while Apache web server is required at the web server level.

The Logical Design of BK Web-Based E-Voting System

Data flow diagrams were used to illustrate the logical design of the BK Web-based E-voting system.

**Context Data Flow Diagram**

![Context Data Flow Diagram](image1)

**Level 0 Data Flow Diagram**

![Level 0 Data Flow Diagram](image2)

**Data Flow Diagram for Subsystems**

BK Web-based E-voting system is basically made up of four subsystems including:

- User management
- Voter registration management
- Voting management
- Election results management

**User Management Subsystem**

The purpose of the user management subsystem is to keep records of users of the election system including the Polling station officers and the executive electoral officers including the Electoral Commissioner, the system administrator and all the top officials of the Electoral Commission. This subsystem is to aid in the management and monitoring the activities of users in relation to the use of e-voting system.
Voter Registration Management

The Voter registration management system is used to keep an electronic voter register of voters. For a voter to be allowed to vote using BK Web-based system, the voter have to be registered in this system.

Voting Management Subsystem

The voting management subsystem keeps records of votes during the election period. This system is used in managing the generation of pin codes and votes of voters.
Election Results Management Subsystem

Election results management subsystem helped in the management of election results. It is used during the time of election results declaration and generation of election results reports. Members of the strong room also view results from this subsystem.

Functional Overview of BK Web-based e-voting system

BK e-voting system provides the following functions:

- Compilation of voter register by EC officials before voting day
- Keeping records of EC officials that would use the system in compiling the voter register, generation of PIN codes for voters and the officials with the authority to view and declare election results.
- Ability to electronically display the status of ballot box to electorate at the polling site on a wide projected screen before election starts.
- Registration of candidates
A voter is allowed to vote only after a successful login using Voters ID number generated during the time of voter register compilation and PIN code to be generated on the day of voting by designated EC officials after they have gone through the appropriate authentication procedures as laid down by the EC. The system keeps record of the EC officials that generate PIN codes for each voter. A PIN code just as a scratch card codes of mobile communication networks becomes useless after it is used by a voter. This therefore prevents ballot box stuffing.

A Voter Verification Code (VCode) of not more than three digits is generated at random for each candidate including the chosen candidate by the voter in the election during voting by a voter. The VCode for the chosen candidate of a voter is sent through SMS to the voter’s phone through the phone number provided during registration for verification purposes. This is to assure the voter that the vote went to his/her chosen candidate and also ensuring privacy of votes cast since the codes are generated at random during the time of voting. The name or identification number of the candidate could be sent through SMS to the voter but this would expose and infringe on the secrecy of votes and it would encourage vote buying. This was therefore not considered.

The voting system supports complex election involving multiple contested positions with multiple candidates and, a voter is given the opportunity to escape voting for a particular position of his/her choice and this is recorded.

During the voting process, the voter first selects the candidate of choice among the number of candidates vying for the given position. Secondly he/she confirms his/her choice and the candidates for the next position are displayed for the voter to go through the same procedure till he/she votes for all the positions. After confirming the vote or escaping the vote for the last position, a congratulatory message and the list of all the candidates the voter voted for in addition to the random generated Voter Verification Code (VCode) is displayed to the voter for verification. SMS containing the verification codes generated for each chosen candidates is sent to the voter based on the phone number provided during the time of registration. The voter is logged out after a given period in seconds based on the automatic logout configuration.

During voting, in case of power outage or any unforeseen circumstances that prevents a voter to complete casting his/her vote and the system goes off, the system allows the voter to continue from the position where he/she ended before the problem occurred. The voter is requested to login again either on the same computer or on a different computer used for the voting process. The system keeps records of the number of times a voter logged into the system.

An interface offering the opportunity for real time view of election results (To be refreshed every 60 seconds) where the creation of “Strong Room” is necessary. With the strong room system, candidates in an election appoints trusted agents to a given secured and enclosed location monitored by security officers and designated EC officials where the status of votes casts is displayed on a big screen and it is refreshed every 60 seconds (The refresh time period can be adjusted based on the agreement of the candidates and the EC officials). Members allowed in the “Strong room” are not allowed to go out until the election process is over. After polls are closed, generated reports of the outcome of the election are signed by these agents before the declaration of election results to the public. The purpose of this process is to build confidence and trust for the results of the e-voting system.

No vote cast is allowed when the voting process is closed by the designated EC official in the system. Also, not until the designated EC official “opens” the voting process, no one can cast a vote. This measure is provided to prevent ballot box stuffing.

Displaying and declaration of election results by the designated EC official after a successful authenticated login on a giant projected screen to the full glare of the public including the media.

Privacy of votes is ensured in the system

Security measures are provided in the system to prevent fraud and hacking. Measures are put in place to prevent SQL injection from hackers.
• Reports of election results including details of election results for each position, elected candidates and losers of the elections can be generated and printed

• A report can be generated and printed from the system after voting to determine the login and logout time of a voter including the time (minutes and seconds) used by a voter to complete voting

• A report can be generated and printed from the system after voting indicating votes for each candidate that can be counted manually where necessary.

**Voting Using BK Web-Based E-Voting System**

A voter goes through the following steps to choose and cast vote for his/her candidates.

1) **Step 1: Verification and Generation of PIN Code**

The voter has to identify himself to the EC officials with a valid ID card and go through the necessary physical verification processes. Using the Voter ID number and the random generated five-digits codes sent to the voter through SMS during the time of voter registration, a PIN code that goes with the ID number of the ID card and the random generated code sent to the voter through SMS during voter registration would then be generated for the voter after a successful verification. If a user cannot provide the code sent through SMS, it can be resent to the voter by clicking a command button. It is resent to the phone number provided by the voter during the time of voter registration.

![Sample Generated PIN Code](image)

2) **Step 2: Voter Login**

The voter goes to the poll and could login into the voting system using the Voter’s ID Number and the PIN code.

![Voter Login Page](image)

3) **Step 3: Selecting a Candidate to Vote for**

The candidates for the first position in the election (if it involves multiple positions in the election) is displayed with a random generated Voter Verification code (VCode) which would be sent to the voter through SMS for verification purposes. The voter at this stage selects a candidate to vote for. In case of multiple candidates for a given position, the voter can click the Picture of the candidate, the Name, the Click Here link under the VOTE heading of the candidate of choice or the Voter verification code (VCode) of the candidate of choice. The voter can however decline to vote for a position and move to the next position in the election. This is demonstrated in Figure 9. When it involves a single candidate for a position, the system allows the voter to vote YES or NO for the candidate. In this case, the voter selects either YES or NO.

![List of Candidates](image)
4) Step 4: Confirmation of Selected Candidate

After selecting a candidate to vote for, the next thing is to confirm and accept the vote for the candidate of choice. At this stage, the voter can go back and choose another candidate instead of his/her current choice. To accept a vote for a candidate, the voter clicks (touches if using touch screen) the Picture of the candidate or the Name of the candidate or the check mark below the VOTE heading or the ACCEPT AND CONTINUE command button. This is shown in Figure 10

After accepting a vote for a candidate, the list of candidates for the next position in the election appears as shown in Figure 9. The voter goes through Step 9 and Step 10 until all the positions are voted for.

![CONFIRM AND ACCEPT VOTE FOR A CHOSEN CANDIDATE](image1)

5) Step 5: Vote Verification Report

After confirming the vote or escaping the vote for the last position, a congratulatory message and the list of all the candidates the voter voted for in addition to the random generated Voter Verification Code (VCode) would be displayed to the voter for verification. Figure 11 demonstrates a list of eleven candidates for eleven different positions voted for by a voter. SMS containing the verification codes generated for each chosen candidates is sent to the voter based on the phone number provided during the time of registration. This is shown in Figure 12. The voter is logged out after a given number of seconds based on the automatic logout configuration by the EC officials.

![LIST OF CANDIDATES THE VOTED FOR BY A VOTER FOR VERIFICATION](image2)
6) Step 6: Declaration of Election Results and Generating of Reports

After the voting process is closed and the agents of each candidate in the ‘strong room’ signed to confirm the votes and indicating comments where necessary, the next thing is the declaration of election results. The Chairman of the electoral commission or his/her representative declares the election results. Generated reports are given to each candidate after the declaring of election results.

Figure 13 demonstrates the voter login and logout report indicating the PIN codes used by each voter and the user who generated the PIN code. In addition, it shows the time a voter login into the voting system to vote, the time he/she finished voting, the number of minutes and seconds used to finish voting, the number of times the voter attempted login into the voting system and a remark column indicating whether the voter completed voting for all the positions before leaving the polls.

Figure 14 shows the voting details that allow manual counting of votes for each candidate for auditing purposes. Each candidate is represented by an Identification Number (ID) known to them during the registration of candidates. The arrangements of records in this report does not follow the order voter’s voted. It was ordered randomly in order to ensure privacy of votes by voters. To check the number of votes for a particular candidate, the ID’s under the position column is counted.
While voting is in progress, agents of candidates are allowed to be in a secure and enclosed location where they can monitor the status of election results from the beginning of the election till the end of the election. These agents are not allowed to go out till the end of the election after they have signed the provisional election results with comments where necessary. Washroom is therefore necessary to be available at the chosen location. Figure 15 shows a sample status of election results in a ‘strong room’.

FIGURE 15 STATUS OF ELECTION RESULTS IN A ‘STRONG ROOM’
Conclusion and Recommendations

The purpose of this system was to ensure election results verification auditing and confidence in e-voting system. After the development and implementation of BK Web-based e-voting system in ten elections, updates were done based on the challenges faced during the implementation of this system until this final system was developed. This system was very helpful in ensuring confidence of voters in e-voting since the voters could verify their votes through SMS as per the random code that was generated for each candidate during the time they voted. It also ensured voter privacy and did not give room for vote buying since the code sent to the voter through SMS was known and understood by the voter alone because it was randomly generated. Confidence of voters were also ensured with respect to the provision of ‘strong room’ and final reports that was generated by the EC officials that allow manual counting of votes. The provision of voter registration number and a random generated code sent to the voter during registration before a PinCode could be generated for a voter to vote aided in preventing voter impersonation and ballot box stuffing. SHA1 encryption mechanism used in encrypting user Passwords, Pin Codes and Voter registration number in the Votes table in the database was meant to ensure security and privacy of voters and users.

We recommend the implementation of these verification methods in e-voting systems to help build voters confidence in e-voting systems. Biometric verification could also be implemented to login a voter instead of the generation of Pin Codes. We recommend future research into the development and implementation of e-voting system to ensure high security while ensuring user friendliness.

REFERENCES


