Design and Implementation of an Electronic Voting System with Contactless IC Cards

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Abstract

In the past, people go to polling place and take the blank ballots, then punch a hole or append the seal. If the seal is not clear enough, or the vote is damaged by soiling, it may bring some debate on the result. In order to resolve these situations, the technology of electronic voting (e-voting) comes into existence. By using information technology, E-voting system can cast and count votes with higher convenience and efficiency, even make the electoral procedures simple and reduce the mistake rate of ballot examination. Due to construct an E-voting system with practical utility, at first, we compare foreign E-voting system by literature review to clarify the existing problem. Furthermore, we design and implement an E-voting system with contactless IC card. Our system can not only make sure voter's identity but also ensure the validity of IC card.

Keyword: Electronic voting, contactless IC card, information security

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1. Introduction

In a true democracy, elections are the basis for the nation functions healthy. As the elections are hold frequently, the costs of voting are increasing geometrically. In order to save human resource and time, the current trend is using information technology on elections.

Recent years the issues of combining voting with information technology have developed into two directions. The former one is electronic voting (E-voting), which is voting on the particular machine in the fixed position; the latter is internet voting (I-voting), which is voting on the internet without limiting people in the polling station but needs higher level of security. Over the years, the scholars are addressed their concept of e-voting, they integrated information technology to satisfy the characteristic of election such as uniqueness, accuracy, completeness, verifiability, auditibility, privacy, and uncoercibility. But most of these researches focused on designing encryption algorithm, a usable and applicable implementation is rarely.

In our research, we design and implement a feasible system with contactless IC card for identification. Because of contactless IC card can be recycled, we can use this feature for the effective long term cost reduction. With information technology, we can simplify the traditional electoral procedures and saving the cost of human resource and time. In addition, we use the touchscreen panel to be the input interface with accessibility, and it can decrease the learning difficulty when the voters are instructed in how to use the new system.

2. Literature Review

David Chaum [2] addressed the concepts of untraceable electronic mail and digital pseudonyms, which can apply for electronic voting for anonymity. In order to reduce the cost of human and material, moreover, to enhance the convenience in the task of polling, E-voting has taken the place of traditional

voting in a considerable number of countries over the past few years. In this section, we aim to review literature we consider relevant to E-voting.

2.1 Evaluation of Voting Equipment

In the recent years, voting equipments which were widely adopted may be divided into five types [10]:

(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.

2.2 Effectiveness of E-voting Among Different Countries

Recent years, a considerable number of countries has adopted E-voting for their official elections. In this section, four empirical examples are enumerated as following.

(1) America: Government of the United States hold election collaterally in several ways, in other words, each state can choose the suitable way to hold elections independently. Because there are some debates about E-voting, such as some vote casts were not counted, or election system crashed during the Election Day. Secretary of State Kevin Shelley established an "Ad Hoc Touch Screen Task Force" to research the debates on DRE in February 2003 [1]. Shelly advanced that DRE should include voter verifiable paper audit trails (VVPAT) to solve electoral debates.

(2) Japan: Japan adopted E-voting for local election in 2002, such as mayor and councilor election of Niimi city in Okayama

prefecture in June 23, 2002; mayor election of Hiroshima city in February 02, 2003; and mayor election of Kyoto city in February 08, 2004. Take mayor and councilor election of Niimi city for example, electoral center surveyed the voters' reliability when the election finished. There are 83% of voters considered that E-voting system is trusted. 56% of them considered that the results of E-voting and paper-based voting are the same therefore E-voting is sufficient for reliable. The reasons why voters can't trust the E-voting system are voters worried about the abuses in E-voting system, and they can not make sure their ballot are recorded correctly.

(3) Belgium: Election for the Federal Parliament is held in May 18, 2003. In order to assist voters in being familiar with E-voting system, electoral center held short-term training. Counting efficiency in the election with E-voting system was faster then convention. Belgium's compulsory voting system and E-voting complement each other, voters' satisfaction and attending willingness of join voting are improved obviously.

(4) Brazil: Brazil used E-voting in 1998. When the voter reaches the polling place, he shows his identity card for authenticating; if he is an eligible voter, he can get the ballot for E-voting. Brazil's E-voting system transmits votes to electoral center immediately, so that the count of votes can announce rapidly while the voting finished.

2.3 Comparison of E-voting System

Besides many vendors to develop and sell commercial electronic election machines, there are various open source E-voting systems. We cite some examples as following [4,8]:

(1) AccuVote-TS: AccuVote-TS's vendor is Diebold Election Systems. This system includes touchscreen, card reader, keyboard, headphone, and paper tape printer. The voter selects his favorite candidate on touchscreen, and the vote will be printed on the paper tape. Its design balances the policy, electoral procedure and technology. But all the electoral information (including identity authentication, audit, or counting of votes) are stored in Microsoft Access database without setting password so there are high risks of attack.

(2) iVotronic: The vendor of iVotronic is Election Systems and Software (ES&S). iVotronic provides multi-language, and uses flash memory to save voting records. Electoral workers use PEB (Personal Electronic Ballot, a device which is similar to disk) to start polling machine up. When the election is finished, the workers use PEB to access voting records in the polling machine, then delivers PEB to electoral center or transmits data from network. Because the PEB's password is only three characters, the risk of password breaking exists. This system have made mistake in the past elections, such as the number of voters is not corresponding between master server and backup server, the candidate selected on the ballot is not the voter's

selection, and so forth.

(3) eSlate 3000: Hart InterCivic invented eSlate 3000. The voter gets a personal identity number (PIN) as four digits from electoral workers, then goes to the booth to input the PIN into polling machine to login. He can rotate selector wheel to select the candidate whom he want to poll for. Each terminal connects to the server which is named JBC (Judges Booth Controller). Counting of votes will send to JBC from every terminal by network, then save it in MBB (Mobile Ballot Box). This system doesn't encrypt voting data, so there are some risks of data security. Furthermore, the electoral functions are not protected with password, anyone, even the voter, can finish the election.

(4) AVC Edge: AVC Edge is a multi-language polling machine which is manufactured from Sequoia Voting Systems. This machine includes touchscreen and flash memory for saving voting recorded, and its electoral procedure is similar to a foregoing E-voting machine, Accu Vote-TS. There were some stumbles when this machine operated in the elections. For example, the E-voting system crashes when the user chose language; the counting of votes is not correct; and the ballot became blank because of the system breakdown.

(5) SAVIOC: SAVIOC is an open source E-voting system and all the source code and software can download from its official website [5,6]. This system is written in C language, and it can be saved in disk with FreeDOS. This system operates from disk, so hard disk is not necessary and the discarded computer is enough. This system is not connected to any networks and most of keys on the keyboard are disabled, attackers can't find the way to invade. SAVIOC's advantages are its simple disposition and low cost, but on the other hand, there are short of GUI and ease of use on SAVIOC.

2.4 Contactless IC card

We can distinguish IC card into contact card and contactless card [11]. Contact card has to contact with card reader for transmitting data, but contactless card can transmit data from remote retrieval by coil. There are 16 sectors in the contactless IC card, and there are 4 blocks in every sector. Each sector is individual. We can find the application of contactless card in daily life, such as Easy Card, entrance guard card, and so forth. Because of Mifare card's low cost and applicability, our research choose Mifare card for storage.

2.5 The Security Issues of E-voting

Foreign experience [9] revealed that they are often confronted by security issues while the electronic voting system is running. The origin of the security issues happened was due to not only outsider (such as voters and attackers) but also insider (such as system developers and administrators), even just because the inheritance of some objects in the source code are unsuitable. These errors caused the voting system crashed.

The proposed solutions were correspondingly outlined to hold back these attacks [5]. For example,
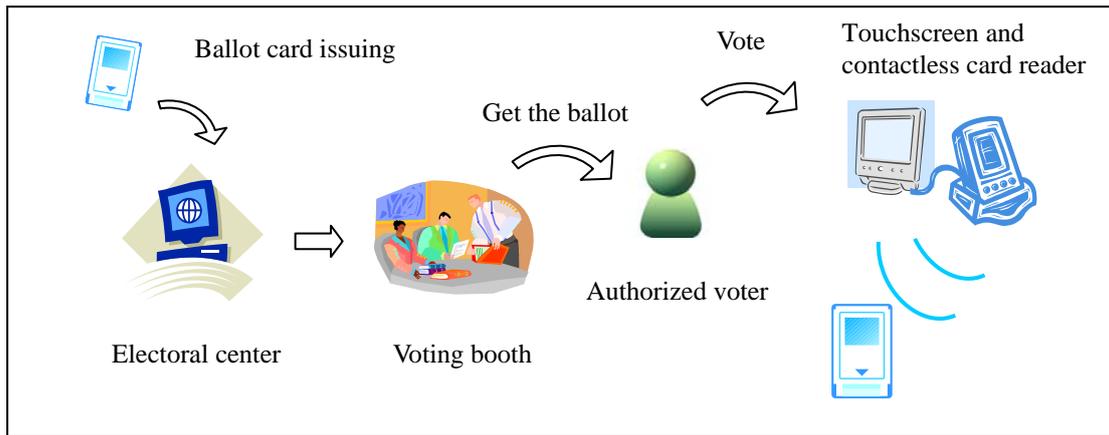
Figure 1. System Architecture

to avoid hacker making incursion into the voting system via network, we can design our system to transmit data without network. Another example is to limit voter to input particular data, so that preventing the command injection from running.

3. System Architecture

Our implementation uses Borland C++ Builder 6 for user interface and accesses contactless IC card with contactless IC card reader. Furthermore, we utilize touchscreen for user to use this system by touch. The E-voting system can divide into three parts: ballot card issuing machine, polling machine, and counting machine. Ballot card issuing machine writes specific voting information into Mifare card, so that polling machine can verify that each Mifare card is the ballot card for this election or not.

If the Mifare card is issued from our ballot card issuing, polling machine will check the ballot card is voted or not. For the criterion of uniqueness, the voted ballot card can't poll again. Therefore, the polling machine will reject the voted card. In another situation, polling machine will reject the Mifare card which is not issued from ballot card issuing machine; it is possible that the voter uses his own card. In order

to avoid the ballot being from counting twice, the ballot card verifying will execute when counting machine counts the votes. The complete system architecture is shown as Figure 1.

3.1 Ballot Card Issuing

The ballot card issuing machine (shown as Figure 2) sets ballot cards with specific voting information to ensure theirs integrity. The specific voting information includes electoral district code, verification of polling machine, and so forth. To protect privacy, it is noteworthy that the voter's personal identification isn't written to the ballot card.

Figure 2. Card issuing center

3.2 Electoral Procedures

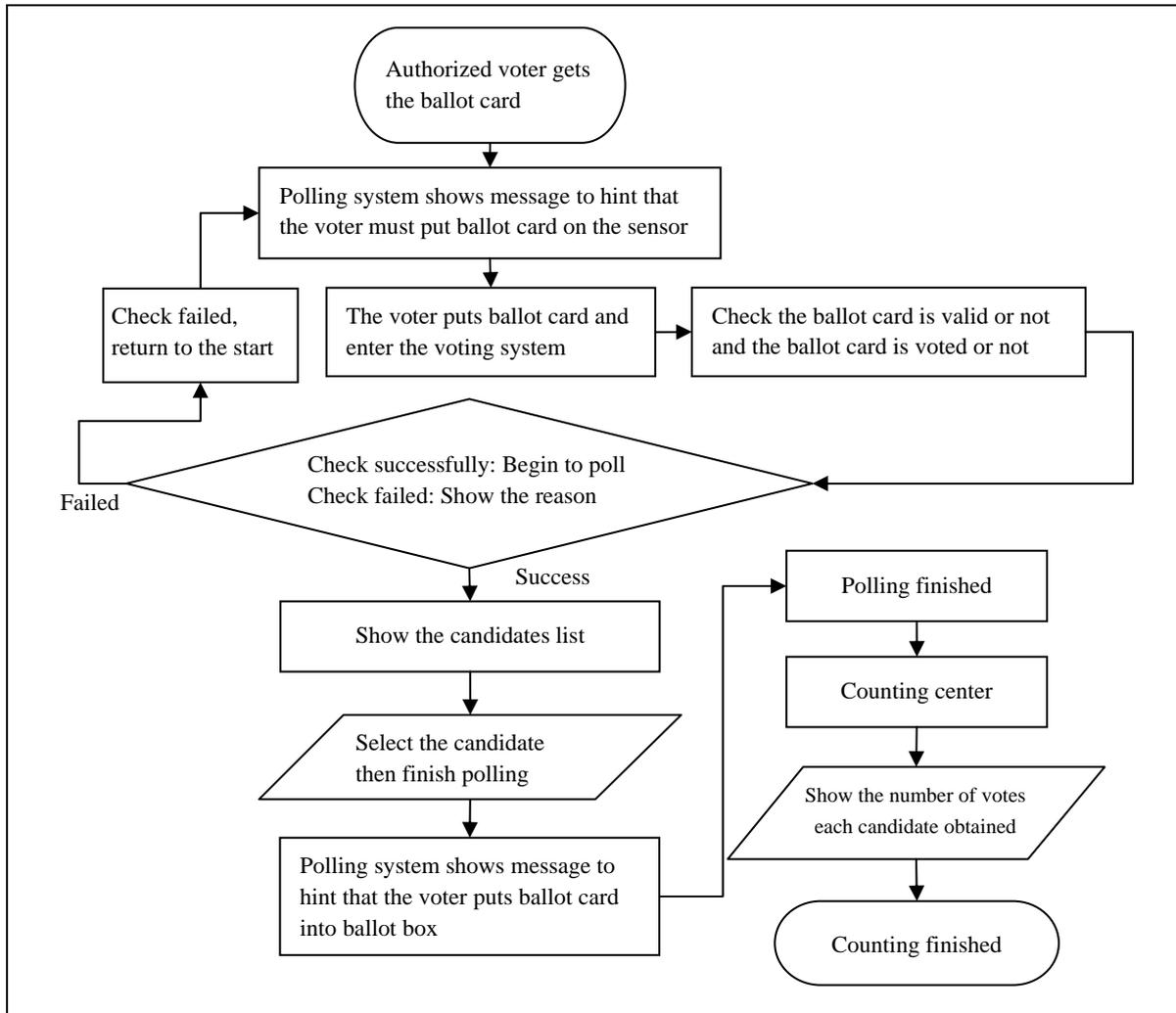The electoral procedures (shown as Figure 3) can represent as follows:

Figure 3. Process flow diagram

(1) Before to login polling system, the polling machine verifies the ballot card is legal or not. If the ballot card is not issued from ballot card issuing machine or it is voted, the polling system will show a pop-up warning window. When the ballot card is verified successfully, the voted tag will be written in the ballot card. The screenshot is shown as Figure 4.

Figure 4. Start of polling system

(2) After the voter login, the polling system shows the list of elections in this electoral district. The voter must complete each election on the election list, and the "OK" button for exit will be visible. The screenshot is shown as Figure 5.
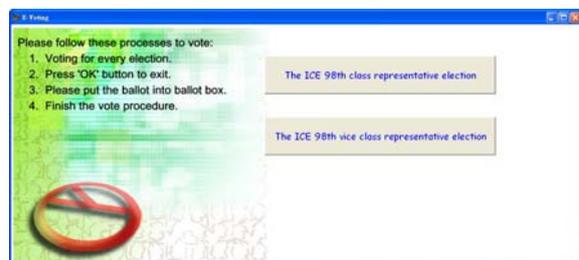

Figure 5. Main menu of elections

(3) The following serves as an example: the voter press "the ICE 98th class representative

election" button to show the candidate list (shown as Figure 6). After selected the favorite candidate, the voter should press "Check" button to go to next step; or press "Back" button to back to Step (2).

Figure 6. Candidates list

(4) In this step, the polling system shows the candidate who is selected in previous step for checking (shown as **Figure 7**). Once the voter press "Submit" button, he can't modify his choice. If he wants to change his selection, he can press "Cancel" to back to Step (3).
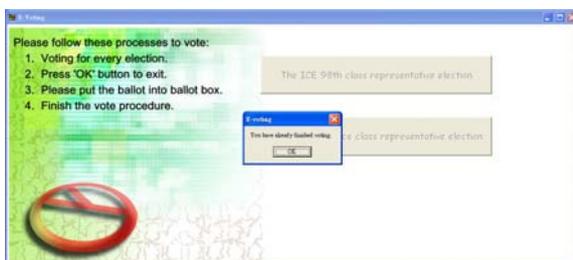

Figure 7. The voter's selection

Figure 8. Exit polling system

(5) After Step (4) completes, the polling system is back to the main menu of election as Figure 8 shows. The button of the election which is voted will be disabled, and the voter can't poll for the same election twice. If all items of election are finished, the

"OK" button for exit will be visible. After press "OK" to exit and return to the start, the screenshots are shown as Figure 9.

Figure 9. Verifying the ballot card which has voted

3.3 Counting of Votes

When the polls close, the ballot boxes are delivered to electoral center for counting up (shown as Figure 10). Before counting of votes, in order to assure the result is fairness and accuracy, the system eliminate invalid card, included improper card, blank ballot card, and ballot card which has counted already. Using electronic voting system can avoid the errors while calling out the name selected in ballots.
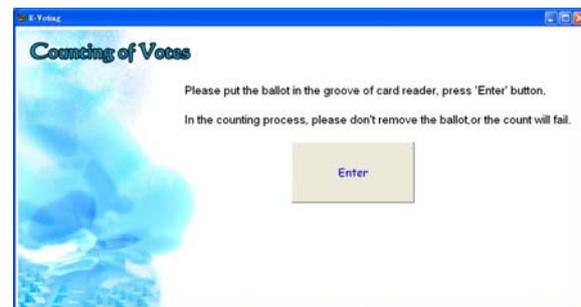

Figure 10. Counting of votes

4. Conclusions

To sum up the discussion above, this paper clarifies the requirements and key elements of E-voting system, and our implementation provides the following features. To begin with, the accuracy of voter's identity and ballot card are ensured with this voting system. Next, voter's identities are not written

in the ballot card to protect voter's privacy and confidentiality. This system will validate whether the ballot card is authorized or not, to make sure only legal user can vote, and voter's authorities are limited in order to prevent his violation. Furthermore, our system fits in with the parts of principles proposed by IPI [7], including secrecy, non-coercibility, integrity, and uniqueness.

But because of the limitation of incomplete laws and regulations, absentee voting can't be held. It still needs to be discussed in legislative systems. In the future, to eliminate maladministration and human destruction, setting up a strongly secure E-voting system is necessary. It can speed up the electoral procedures, make ballot counting efficaciously, and use resource effectively.

Acknowledgement

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