Research Journal of Information Technology 3(2): 91-98, 2011
ISSN: 2041-3114

Submitted: July 22, 2011 Accepted: August 27, 2011 Published: September 30, 2011

The Design of an Electronic Voting System

G.O. Ofori-Dwumfuo and E. Paatey
Methodist University College, Ghana

Abstract: The aim of this study is to design an electronic voting system based upon the electoral process adopted in Ghana. In recent years, information technology has greatly affected all aspects of life, and to a large extent, this includes politics. In order to choose people to various positions different methods have been set up, with researchers continually trying to find improvement to the existing methods. The most recent method to be devised is electronic voting (e-voting). It is meant to phase out outdated paper ballot, punched cards and other mechanical voting systems with paperless electronic or online voting systems. E-voting systems endeavour to make elections simple while reducing the total cost of the election. Designing an air-tight and reliable e-voting system is therefore a great task, in that, the system that must be developed must protect the privacy of the voter, be easily understood and used by the entire voting populace - no matter who they are or where they come from. Based on this, OVIS, an On-line Voting System, has been developed. It came about as a result of the findings of a study of the electoral process of the Electoral Commission of Ghana.

Key words: Electronic voting systems, Ghana electoral system, manual voting systems, voting system design

INTRODUCTION

One basic feature of democracy that cuts across all divides of people is the act of election. Democracy thus encourages individual freedom according to the rule of law, so that people may behave and express themselves as they choose. This not only gives people a chance to choose their leaders, but also to freely express their views on issues. In response to the 1948 Universal Declaration of Human Rights which puts import on the necessity of free elections, nations aim at new and improved voting procedures which are of relevance to elections in the 21st century (Salomonsen, 2005). With the passage of time, voting, which was mainly manual, has been influenced by Information Technology, with debates arising about the relevance or not, of computerized/online voting (Shamos, 2004; Cranor, 2011). Nevertheless, it is impossible to completely rule out the need for technology and electronic voting, with the growing number of eligible voters and manual ballot papers involved (Hunter, 2001). Smith and Clark (2005) indicate that electronic voting is the next logical step in applying online information-gathering and retrieval technologies to e-government. The project for this paper evolved based on this theory. The project is to develop an Online Voting System (OVIS) based on current voting procedures in Ghana.

Types of voting systems: Voting is a method by which groups of people make decisions. These decisions could be political, social or public. Voting can also be used to choose between difficult plans of actions or to decide who is best eligible to be awarded a prize. Voting can thus be defined as a process that allows a group of individuals to choose between a number of options. Most voting systems are based on the concept of majority rule or plurality. For example, in an election, a candidate with a plurality receives more votes than any other candidate, but does not necessarily receive the majority of the total votes cast.

Five different types of voting systems may be identified. These are:

- Paper-Based Voting Systems
- Direct-Recording Electronic (DRE) Voting Systems
- Public Network DRE Voting Systems
- Precinct Count Voting Systems
- Central Count Voting Systems

Paper-based Voting Systems (PVS): record, count, and produce a tabulation of the vote count from votes that are cast on paper cards or sheets. Some PVSs may allow voters to make selections by means of electronic input devices. Voter selections are, however, not independently recorded, stored or tabulated by such input devices.

Direct-recording Electronic (DRE) voting systems: record votes by means of a ballot display provided with mechanical or electronic optical components which could be activated by the voter. Such systems record voting data and ballot images in computer memory components. Also, data processing is achieved by the use of computer programs.

Corresponding Author: G.O. Ofori-Dwumfuo, Methodist University College, Ghana

Public network DRE voting systems (PNDRE): Make use of electronic ballots and transmit vote data from the polling stations to other locations over a public network. The votes may be transmitted as individual ballots as they are cast, or periodically as batches of ballots, or as one single batch, at the end of voting.

Precinct count voting systems (PCVS): put the ballots in a tabular form at a particular place, say, a polling station. They provide mechanisms that store vote count electronically and transmit the results to a central location over public telecommunication networks.

Central count voting systems (CCVS): Tabulate ballots from multiple precincts at a central location. Voted ballots are safely stored temporarily at the polling station. These ballots are then transported or transmitted to a central counting location. CCVSs may, in some cases, produce printed reports on the vote count.

Characteristics of a voting system: Voting systems must be transparent and comprehensible enough that voters and candidates can readily accept the results (Kohno *et al*., 2004). This means that the veracity of a voting system is necessary for the acceptance of the results of that election. Shamos (2004) gives a comprehensive assessment of paper versus electronic voting systems. For a voting system to be considered transparent and comprehensible, some important criteria must be met, otherwise it may lead to indecisive or inaccurate election results.

First of all, the anonymity of a voter's ballot must be preserved, in order to ensure that the voter is safe when voting against a candidate, and also to guarantee that voters have no evidence that proves which particular candidates received their votes. It is believed that the existence of such evidence could allow votes to be bought (Kohno *et al*., 2004). Secondly, the voting system must be tamper-proof in order to prevent a wide range of attacks, including ballot stuffing by voters and incorrect tallying by insiders (poll officials). Thirdly, it should be user-friendly. This means that it should be easily comprehensible and usable by the entire voting population.

Current day voting systems: With the development of information technology, nations all over the world are replacing archaic punch cards and mechanical voting systems with electronic voting systems (e-voting) aimed at increasing voter participation and speeding up the release of election results (Kelly, 2003). Cranor (2011) gives an extensive list on references relating to electronic voting (including internet-based voting). Brazil and India are examples of countries that use e-voting for both general and state elections (Mira, 2004; Gadekar *et al*., 2011). Statistics show that the use of Electronic Voting Mechanisms (EVMs) - an e-voting system in India - has eliminated the occurrence of invalid votes during elections. Prior to their use, the number of invalid votes that were recorded in India was always more than the winning margin between the candidates. Aside from eliminating invalid votes, EVMs ensured that the total number of votes cast was tallied within two to three hours as against thirty to forty hours when the conventional means were used. In considering voting mechanisms, Kitcat (2004) examines the process of setting technical communication standards for e-voting. Awad and Ernst (2011) also analyze various attempts at e-voting and discuss their benefits and vulnerabilities.

St. Albans, UK, in May 2007, implemented a fully electronic election with no paper-based voting allowed. People were to use a number of channels to vote, the Internet, kiosks, Interactive Voice Recognition (IVR) via telephones or mobile phones, and also by post. Within six minutes, the system had counted all the ballots - recording the fastest ever vote count. Furthermore, no invalid vote was recorded, and all attempts to subvert the system by means of worms, viruses and Denial-of-Service proved futile (Kelly, 2003).

Newer and more improved trends in voting are showing that a greater number of developed nations are beginning to choose e-voting systems over manual voting systems due to their convenience and the ease which they offer voters and election officials (Gefen *et al*., 2005; Awad and Ernst, 2011). It is important to note that even though e-voting systems appear to be the best alternative to paper-based and other mechanical systems, they must be used with caution because experts believe that some of such systems could have challenges ranging from software engineering, auditing pitfalls, to insider threats, thereby undermining their integrity (Rubin, 2002; Lebre *et al.*, 2004).

In his review on electronic voting security criteria, i.e., confidentiality, integrity, availability, reliability and assurance, Neumann (1993) concluded that a lot of such criteria are by nature very difficult to satisfy. Evers (2004) wrote on the US online voting system and the challenges it faces, Pescatore and Baum (2004) clearly pointed out critical security requirements for online voting and Evangelia *et al.* (2007) discuss e-voting privacy protection. Despite all the success stories recorded on the use of electronic voting systems, it is believed that further studies must be carried out to improve upon them (Morse, 2002).

Traditional manual voting systems - Ghana: For a properly operational online voting system to be developed, it was necessary for us to place the spotlight on elections that are conducted locally and overseen by the Electoral Commission (EC) of Ghana (which is believed to be a good example of a manual voting

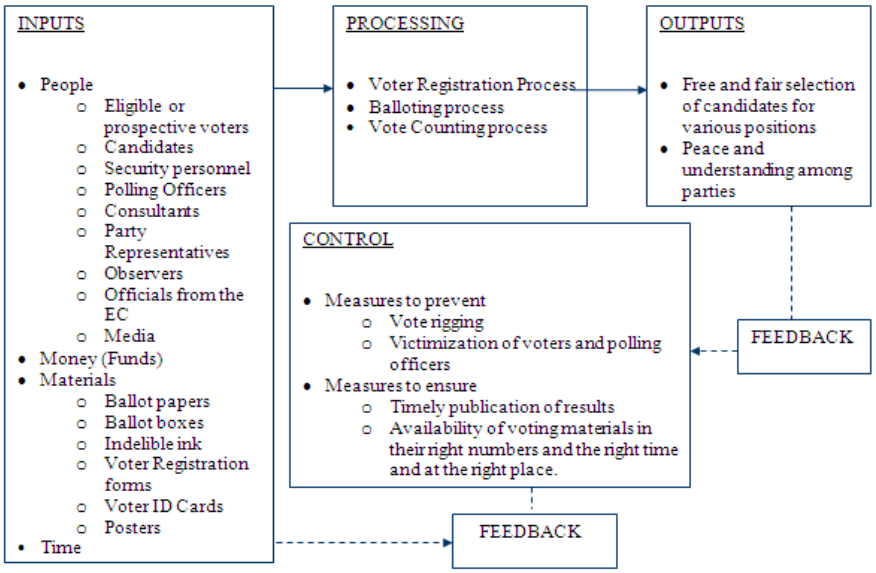

Fig. 1: Manual voting system - (Ghana)

system). The EC, in its perspective, can describe the Ghana electoral process as the means by which the legitimacy of a governing body is recognized and established in Ghana. The process gives a platform for such a mandate to be expressed, and it gives legal certification to the authority of a governing body with regards to the laws of the land (Spannaus, 2004).

At this juncture, it is necessary to point out the difference between the words *election* and *voting* as used by the Ghana Electoral Commission. Whereas voting refers to the actual process of casting ballots (on the assigned day of voting), election refers to the whole process that contributes to selecting a candidate for a particular position. Elections involve the undertaking of some activities; pin-pointing eligible persons as candidates to contest various positions, registering people who are eligible voters, voting, counting of ballots and publishing the results. A systemic view of a manual voting system is shown in Fig. 1.

The Ghana EC electoral process: In Ghana, elections take place every four years to vote into power a President and Members of Parliament. The electoral procedure involves many processes. The processes discussed here are voter Registration, Voter Register Exhibition, Voting, Vote Counting, Collation and Publication of Results.

Registration of voters: This is the process of enabling an eligible voter to have his/her name enrered into a document (Voter Register) with the aim of offering the person the opportunity to exercise his/her franchise on the appointed day of voting. Ghana laws peg an eligible voter as one who is 18 years of age or above, a national and resident in the country. Materials used by the EC to register eligible voters include scanable forms, pencils, photographs (or thumbprints) of the voter and indelible ink.

The Voter Register is considered provisional so that changes may be made, until such time when it has been pushed to the Voter Register Exhibition stage. Various security measures are put in place to ensure the validity of the register. These include:

- Barcodes on the voter registration form to enable the validity of the forms to be easily ascertained. Forged registration forms are easily detected by the system responsible for data processing on eligible voters.
- Use of indelible ink. This guard against double registration. The left thumbs of registered people are marked with indelible ink.
- Unique voter registration number. Every registrant has a number that is unique to him/her; no two voters have the same registration number.

Exhibition of the voter register: The provisional Voter Register is exhibited at each polling station once the registration is over, for the public to come and check that there are no discrepancies. The public checks for the accuracy of their personal information. To a large extent, the success of an election is determined by how accurate the Voter Register is.

Voting (manual): Voting is the actual process of casting ballots. An eligible voter goes to the polling station where his name is registered and shows his voter identification card to the polling official for inspection. Based on the

(unique) voter registration number on the card, the official looks up the name of the voter. When it is ensured that no vote has been cast by that voter, he is issued a ballot paper and his left thumb marked with indelible ink as having cast his vote. In an enclosed space, he selects a candidate of choice on the given ballot paper and thumbprints in a space allotted for that candidate. The voter then carefully folds the ballot paper (to avoid the fingerprint soiling other parts of it) and deposits it into the ballot box provided. He is then expected to leave the polling centre.

Vote counting and publication of results: Ballot counting is done manually, with results collated through a bottom-up process. This means that counting is first done at the lowest level (i.e., the polling station level) and the results collated from that level up to the constituency level and then to the national level. At the highest level, the overall votes of various candidates are ascertained. After this, the EC publishes the final results.

Manual voting-associated problems: A number of problems associated with each phase of the electoral process are discussed below:

Invalid votes: A vote is considered to be invalid if the thumbprint has not been placed at the right spot. Also, a ballot paper which is improperly folded can be the cause of an invalid vote. (The EC has published that an average of 2 to 2.5% of invalid votes are recorded during every election.)

Long voting process: The manual voting exercise involves a number of steps that result in long queues. This is because each voter takes a considerable amount of time to vote.

Delays in result publication: It has been gathered that it takes the EC about three days to eventually publish a presidential election result.

High cost of election organizing: The procurement of materials that ensure the validity of the voters registration, as well as the complete success of the electoral process make election costs very high. Indelible ink, ballot boxes and papers as well as other logistics, despite being expensive, are indispensable in a manual voting system.

The case for online voting: Efforts may be geared towards the minimization, if not the total elimination, of the problems associated with manual elections. A number of mechanisms can be introduced to ensure that time and other resources are efficiently used. The most effective and desirable of these options is online voting. Sergei *et al*. (2011) developed an efficient electronic voting platform that would offer distinct advantages over traditional paper ballot voting and the available electronic voting systems.

Computerizing the voting system: Computerizing voting procedures imply the use of computer technology in undertaking such activities as Voter Registration Exercises, Voting and Vote Counting. Although the initial cost of developing computerized voting systems would be high, the long run effects would be that election costs would drastically reduce. Computerized voting systems would make obsolete the need for ballot boxes and papers, because the system would simulate these. This would mean that printing costs would be reduced by a considerable amount. Computerizing the verification process by using the computerized voting systems would help to enforce relevant controls in order to verify whether or not a person has already cast a vote, leaving no need for indelible ink.

Computerized voting systems usually tally results as and when votes are cast. This also means that vote counting, which wastes time when done manually, would be eliminated. At the click of a button, results of an election would be known. In the event of a run-off, there would be no need to print a different batch of ballot papers or purchase indelible ink. The computerized system would be reset to reflect the candidates who would contest. A number of electronic voting systems have so far been developed (Joaquim, 2005; Eliasson *et al*., 2006; Sergei *et al*., 2011). Our online voting system (named OVIS) has been developed taking the Ghana voting procedures into consideration (Amankona and Paatey, 2009).

The online voting system - OVIS: OVIS is a Direct Recording Electronic Voting System which provides a platform for simplifying the electoral process for all institutions that employ voting in decision-making. OVIS has several security requirements like access control, as well as user authentication incorporated into its design structure, making it not only secure and reliable, but also resilient. OVIS also provides for user-friendly graphical interfaces and tools which make voting easy and enjoyable, because it equipped with security measures that range from the application design to implementation, management and monitoring.

Goals of OVIS: The main goal of OVIS is to use advanced computer technology or information technology to simplify the electoral process as practiced by the EC of Ghana. Also OVIS seeks to:

- Ensure proper management of the personal data of voters
- Reduce election costs
- Prevent double voting

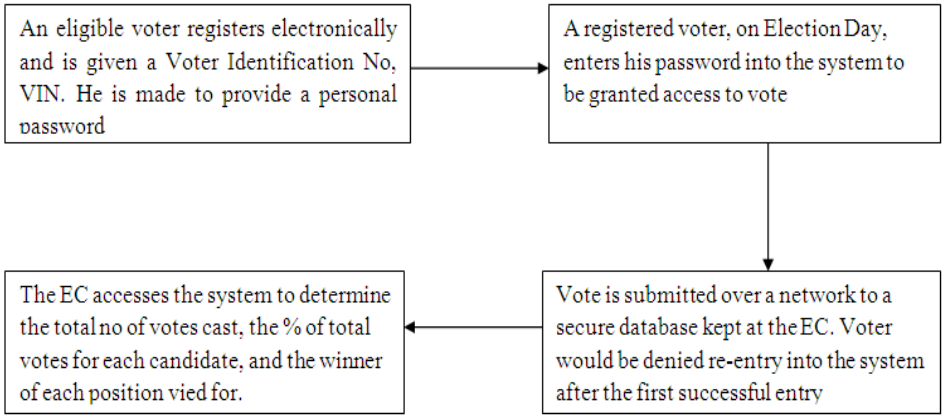

Fig 2: The framework of OVIS

- Ensure that invalid votes are not issued
- Ensure quick, effective and efficient processing of votes cast during elections
- Speed up the release of election results

Functions of OVIS:

Installation of a database management system (DBMS): A DBMS called the OVIS Database Manager (ODM) would be installed to manage system data. ODM would allow for voters' data to be retrieved, added, updated, deleted, sorted and traversed easily and quickly. ODM would also store data with regard to the election results and other information relevant to the system.

Facilities to allow for online voter registration, online balloting and accessing of election results: A Graphical User Interface (GUI) application has been developed to allow prospective voters to register and vote online. The application would also enable a functionality that allows only election administrators to have access to election results as and when they require it.

Implementation of controls to avoid double voting: User identification and access control functionalities are built into the system so as to guard against double voting and vote riggings. Also, these features would help to prevent anyone without the proper authorization to gain access into the system. This means that a voter who attempts to vote a second time will be denied access and prompted by the system.

Implementation of controls to eliminate invalid votes: The design architecture of the system does not easily allow a voter to cast an invalid vote; for example, trying to vote for two contestants on the same e-ballot paper would not be allowed. The result of this is that the issue of invalid votes would be eradicated.

Generation of reports: The system would allow the preparation and printing of various reports, ranging from Voter Registration details to Election Results.

Provision of personalized portal to all registered voters: Each registered voter would be able to interact with the system as if it were made personally for him, upon log in. This function is designed to make the system interactive as well as user friendly. For example, a registered voter, John Smith, upon logging in would meet a welcome screen with the greeting message "Welcome John".

Voting (online - OVIS): A prospective voter would need to register at a designated centre, where the system, OVIS, would provide him with a unique Voting Identification Number (VIN). The person would then be expected to provide a password known only to him during registration. The VIN and password would then be entered into the system on Election Day to give access to the voter into the system so as to vote. The system would grant access once only to a user to use his or her VIN and password.

On Election Day, a registered voter would enter an e-voting kiosk where OVIS has been installed. He would then be required to log onto the system with his VIN and password. If any of the data is wrong, the voter would be denied access. Registered voters who forget their VIN or passwords may contact the Voting Supervisor or Official at the voting centre, who would use the name search function to retrieve the VIN and password of the voter (after other personal identification checks).

Once a voter has access to the system, the person may vote for his chosen candidate. After the candidates for the various positions have been selected (e.g., parliamentarians), the system brings up a summary screen

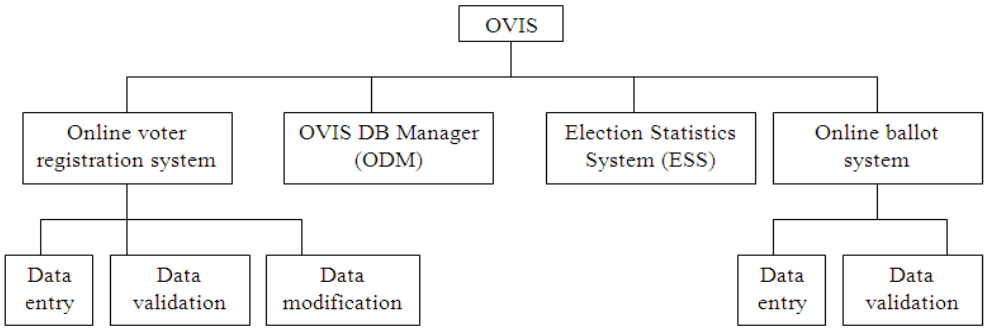

Fig. 3: Top-down design of OVIS

that shows the candidates for whom the voter cast his ballot. The voter, at this stage, may make changes to his votes before finally submitting it to the system. After this, increments are made to the votes of candidates who were voted for, and other internal statistical computations made. Once a vote is submitted to the system, the voter would not be granted access into the system again. This is to guard against multiple voting.

Whenever votes are cast, necessary increments are made to the votes for whom the votes are cast, and the appropriate administrator can access the results of the elections so far. When voting finally ends, all relevant statistics and reports are generated. Figure 2 provides a summary of how the OVIS system works.

Design specification of OVIS: We now discuss the technicalities of the OVIS design architecture, including the top-down structure and database environment.

Top-down structure: OVIS is made of four major subsystems which interact with users by means of GUI screens, namely, Online Voter Registration System (OVRS), Online Ballot System (OBS), Election Statistics System (ESS) and OVIS Database Manager (ODM).

Online Voter Registration System (OVRS): OVRS is the subsystem responsible for managing the voter registration process. It provides interfaces where voters can enter their records as well as update their records. OVRS works in conjunction with ODM to generate a Voter Identification Number (VIN) for each voter.

Online Ballot System (OBS): OBS manages all online balloting activities. It provides interactive interfaces for registered voters to cast their votes. OBS works alongside ODM to deny people who have already cast their vote's re-entry into the system.

Election Statistics System (ESS): ESS is the subsystem responsible for automatically tallying votes and performing various statistical computations. Alongside OBS and ODM, ESS provides a user-friendly interface where election results are displayed. Also, it provides facilities for the printing of hard copies of results.

OVIS Database Manager (ODM): ODM has an important role to play in the operation of OVIS, in that, it is the part that stores information such as voter registration details, votes of candidates, voters who have already voted, etc. All other subsystems depend largely on ODM to function as expected. Figure 3 is a pictorial representation of the top-down design of OVIS.

OVIS database environment:

OVIS entities: OVIS database comprises four major entities, namely, Voter_Registration, Voter_Log_Book, Presidential_Ballot and Parliamentary_Ballot. The Voter_Registration entity or table gives information about registered voters. It contains fields or attributes like the voter's Voter Identification Number (VIN), Name, Address and others. The Voter_Log_Book keeps records on the date and time the registered voter logs into the OBS to vote. It has attributes as VIN, Date, Time and Vote Status. The Presidential_Ballot and Parliamentary_Ballot entities contain information about candidates who are contesting the election. (In Ghana, both Presidential and Parliamentary elections are held together). The entities contain attributes such as Election_Id, Date, Votes_for_Candidate and Total_Vote.

Queries: In a database environment, a query is the object which facilitates retrieval, insertion, update and deletion of records. ODM makes use of various queries in order to maintain system data. Some of these include Retrieve_Voter_Record (which retrieves the details of a registered voter from the Voter_Registration table), Update_Voter_Record (which updates the records of a voter), Voters_from_a_Region (which displays the details of all registered voters from a given region in the country), Presidential_Votes (which displays the votes of each of the presidential candidates) and

Vote_Status_of_Voters (which displays the list of voters who have already cast their ballots along with the date and time they voted).

Entity-relationship diagram: The relationship between the various entities that make up a system is an important aspect of any database design. This relationship could be of three kinds; one-to-one, one-to-many and many-to-many. The entity-relationship diagram on OVIS ODM is shown in Fig. 4.

OVIS on trial: OVIS was implemented using Microsoft Visual Basic. The software components of the GUI screens serve as the front-end. The database was implemented using Microsoft Access. The system was tested on elections of the Students Representative Council (SRC) of the Wisconsin International University College, Ghana. The voting system at the University follows the same pattern as that of national elections. The system was customized to have each candidate for the positions that were being vied for, i.e., SRC President, Secretary and Treasurer. Each voter was interviewed after he/she had voted to find out their opinion on online voting in general and OVIS in particular. Interview questions asked ranged from the ease of use, the feeling of anonymity, security and interface design. Information gathered was highly satisfactory (Amankona and Paatey, 2009).

CONCLUSION

Online voting offers convenience to the voter and considerable ease to election administrators as they can get election results out more quickly than conventional methods of manual voting. Even though computerized voting systems have a number of advantages over manual ones, there a few challenges that must be overcome in order that their benefits may be fully realized. First of all, there is the high initial cost of implementing such a system, as is typical of all computerized systems. (This is often prohibitive to developing countries like Ghana). Secondly, there is the challenge of voter education. The electorate needs to be educated adequately on the use of online voting. (In developing countries like Ghana, not all voters may be able to enter their voter identification numbers and passwords!).

A third concern is the voting system security at national level; how the system could be attacked by hackers and fraudsters, including system administrators (who may be in favour of some particular candidates (Smith and Rupp, 2002). Finally, electronic voting systems should be allowed to be scrutinized by experts in systems analysis and design, computer programming and computer system security. This would be the only way to ensure public confidence in such systems.

In this study, we have presented OVIS, our online voting system, which offers a number of advantages over the conventional manual paper-based voting system employed in Ghana.

REFERENCES

Amankona, E. and E. Paatey, 2009. Online Voting Systems. Graduation Project, Wisconsin International University College, Ghana.

Awad, M.L. and L. Ernst, 2011. Internet voting in the USA: Analysis and commentary. Transforming Government: People, Process Policy, 5(1): 45-55.

Cranor, L., 2011. Electronic Voting Hot List. Retrieved from: http://lorrie.cranor.org/voting/hotlist.html (Accessed on: 15 May, 2011).

Eliasson, Charlott, Zúquete and André, 2006. An electronic voting system supporting vote weights. Int. Res., 16(5): 507-518.

Evangelia K., G. Stefanos and C. Kalloniatis, 2007. Protecting privacy in system design: The electronic voting case. Transforming Government: People, Process Policy, 1(4): 307-332.

Evers, J., 2004. Experts Challenge US Online Voting System. Retrieved from: http://www.infoworld.com/article/04/01/21/HNonlinevoting_1.html (Accessed on: 15 May, 2011).

Gadekar, R.R. T. Kiran and A.P. Hwa, 2011. Websites for E-Electioneering in Maharashtra and Gujarat, India. Int. Res., 21(4).

Gefen, D., G.M., Rose, M. Warkentin and P.A. Pavlou, 2005. Cultural diversity and trust in IT adoption: A comparison of potential e-voters in the USA and South Africa. J . Global Inf. Manage., 13(1): 54-78.

Hunter, G.E., 2001. The role of technology in the exercise of voting rights. Law Technol., 34(4): 1-14.

Joaquim, R., 2005. A fault tolerant voting system for the internet. M.S. Thesis, IST/UTL, Lisboa.

Kelly, A.D., 2003. Secure Oracle 91AS Gets Their E-Vote. Oracle Magazine, January-February, 45-50.

Kitcat, J., 2004. Government and ICT standards: An electronic voting case study. J. Inf. Commun. Ethics Soc., 2(3): 143-158.

Kohno, T., A. Stubblefield, A.D. Rubin and D.S. Wallach, 2004. An Analysis of an Electronic Voting System. McGraw Hill, New York.

Lebre, R., R. Joaquim, A. Zúquete and P. Ferreira, 2004. Internet voting: Improving resistance to malicious servers. Paper presented at the IADIS International Conference Applied Computing 2004, Lisboan.

Mira, L.M., 2004. For Brazil Voters, Machines Rule. Wired News, Jan, 24.

Morse, R., 2002. Electronic voting: progress over setbacks. Law Technol., 35(4): 1-6.

Neumann, P.G., 1993. Security Criteria for Electronic Voting. 16th National Computer Security Conference, Baltimore, Maryland, September. Retrieved from: http://www.csl.sri.com/users/neumann/ncs93.html, (Accessed on: 15 May, 2011).

Pescatore, J. and C.H. Baum, 2004. Online Voting can't be Trusted on Standard PCs. Retrieved from: http://news.zdnet.co.uk/security/0,1000000189,39148110,00.htm (Accessed on: 15 May, 2011).

Rubin, A., 2002. Security considerations for remote electronic voting over the internet, Communications of the ACM, 45(12): 39-43

Salomonsen, G.. 2005. Voting for Online Democracy. Retrieved from: http://www.physorg.com/news4011.html, (Accessed on: 15 May, 2011).

Sergei A, K. Nikolai, L. Denis and L.Vitaly, 2011. The Guarantor: A web-centric system for organization and remote monitoring of election events, Transforming Government: People, Process Policy, 5(1): 56-67.

Shamos, M.I., 2004. Paper v. Electronic Voting Records-An Assessment. Retrieved from: http://euro.ecom.cmu.edu/people/faculty/mshamos/paper.htm, (Accessed on: 15 May, 2011).

Smith, A.D. and W.T. Rupp, 2002. Issues in cyber-security: Understanding the potential risks associated with hackers/crackers. Infor. Manag. Comp. Sec., 10(4): 178-183.

Smith, A.D. and J.S. Clark, 2005. Revolutionizing the voting process through online strategies. Online Infor. Rev., 29(5): 513-530.

Spannaus, E., 2004. Electronic Voting is Threat to the Constitution. Executive Intelligence Review.