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Towards Remote Electronic Voting Systems

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Abstract

During the last few years, a lot of research has been done to create voting protocols and election systems that facilitate voting via private computer networks, the Internet or remote mobile terminals. The interest in e-voting on one hand is founded in problems such as violence, intimidation, ballot stuffing, underage and multiple voting, complicity of security agencies, absence or late arrival of election materials etc which often characterise conventional voting systems. On the other hand, it is based upon interest and attention devoted to e-government, e-democracy, e-governance, etc.

In this paper, a critical appraisal of e-voting variants; the benefits and risks associated with the various electronic voting methods and electronic voting systems were presented and exhaustively discussed.

Keywords: E-voting, Democracy, Election, Ballot, Punched card system, Optical scan voting system, Direct recording electronic systems and Remote e-voting.

1. Introduction

"While democracy must be more than elections, it is also true it cannot be less" former Secretary General Kofi Annan once said (Annan, 2000). Democracy is a government by the people exercised either directly or through elected representative. Election on the other hand, is a process in which voters choose their representatives and express their preferences for the way that they will be governed (Kohno et al., 2003) and (Malkawi et al., 2009). Naturally, the integrity of the election process is fundamental to the integrity of democracy itself.

Democracy and elections have more than 2500 years of tradition. However, technology has always influenced and shaped the ways elections are held (Held, 2006). In times past, different voting systems that are based on traditional paper ballots and mechanical devices were developed for elections (Malkawi et al., 2009). In traditional paper ballots, voters choose or mark their favourite choices on ballots and place them in boxes, which are sealed and officially opened under special conditions to warrant transparency. The ballots are then counted manually, which is a tedious process that is subject to human error. With voting via mechanical systems, voters make their choices by pulling down on mechanical levers that correspond to their favourite choice of candidates. Each lever has a mechanical counter that reports the number of votes for that position. These machines are no longer manufactured (NSF, 2001).

In Africa, most elections are conducted using paper ballots. However, there have been countless reported cases of eligible voters being unable or prevented from exercising their right to vote as stated in the Universal Declaration of Human Rights of the United Nations, sometimes due to violence, intimidation, ballot stuffing, under-age and multiple voting, counting error, complicity of the security agencies and the absence or late arrival of election materials etc (Boniface, 2008).

ISSN 2222-1719 (Paper) ISSN 2222-2863 (Online)

Vol 2, No.4, 2011

Recent elections worldwide have seen a gradual decline in the overall percentage of the electorate exercising their right to vote (Qadah, 2005). This is worrying from a democratic point of view in that, if the reasons of the decline are left unchecked, the mandate of those elected to hold the positions might eventually be questionable (Qadah, 2005). Moreover, it is interesting to note here that traditional/manual voting systems are slow, complex, inaccurate and inefficient. To counter these drawbacks, Governments have proposed a number of possible methods for re-engaging the electorate in the voting process. One of these methods is the modernization of the way in which the elections are being conducted. These methods include the use of electronic voting (e-voting) as a new and modernized way to carry out the election process (Qadah, 2005).

The term e-voting is being used from casting the vote by electronic means to asking the internet community for an opinion on a political issue, as well as from tabulating the votes by electronic means to integrated electronic systems from voters' and candidates' registration to the publication of election results (Buchsbaum, 2004). The term is used, in variety of different ways mainly and it encompasses all voting techniques involving electronic voting equipment, including voting over the internet, using booths in polling stations and sometimes even counting of paper ballots (Magi, 2007).

In addition to overcoming commonly encountered election pitfalls, electoral vote counts are done in real time that by the end of elections day, the results are automatically out (Mercuri, 2000) and (Rubin, 2002). The election process can be easily enhanced with various features based on the demand and requirements of different countries around the world. E-voting is an interdisciplinary subject and should be studied together with the experts of different domains, such as software engineering, cryptography, politics, law, economics and social sciences. Although many people have worked on this subject, mostly e-voting is known as a challenging topic in cryptography because of the need to achieve voter anonymity, and therefore, to ensure his/her privacy (Cetinkaya and Cetinkaya, 2007).

2. Electronic voting

E-voting is any voting method whereby at least the voter's intention is expressed or collected by electronic means (Magi, 2007). It is a term encompassing several different types of voting, embracing both electronic means of casting a vote and electronic means of counting votes. In general, two main types of e-voting can be identified (Buchsbaum, 2004):

a) E-voting supervised by the physical presence of representatives of governmental or independent electoral authorities. This may include the following voting technologies:

   (i) Document based ballot voting systems (punched cards and optical scan voting systems)

   (ii) Direct-recording electronic voting systems (DREs).

This is usually referred to as kiosk voting.

ISSN 2222-1719 (Paper) ISSN 2222-2863 (Online)

Vol 2, No.4, 2011

b) E-voting within the voter's sole influence, not physically supervised by representatives of governmental authorities, e.g. voting from one's own or another person's computer via the internet, by mobile phones (including Short Message Service, SMS), or via digital television (Buchsbaum, 2004). This is usually referred to as remote e-voting.

2.1 Kiosk voting

Kiosk voting in most cases involves the use of dedicated voting machines in polling stations or other controlled locations (Magi, 2007). Voters mark their choice electronically (perhaps on touch sensitive screen) rather than on paper ballot. The votes are counted on individual machines, known as Direct Recording Electronic (DRE) machines, and the votes cast are transferred to the central tallying point by unspecified means. A ballot paper can be printed and retained in confidence in a ballot box as an additional check. Variants of kiosk voting include the following:

2.1.1 Document based ballot voting systems

Document based ballot voting system includes the following technologies:

a) **Punched card system**: Punched card systems employ a card (or cards) and a small clipboard-sized device for recording votes (Jones, 2001). Voters punch holes in the cards (with a supplied punch device) opposite their candidate or ballot issue choice. After voting, the voter may place the ballot in a ballot box, or the ballot may be fed into a computer vote tabulating device at the precinct (ward). The idea of voting by punching holes on paper or cards originated in the 1890s and inventors continued to explore this in the years that followed. The first major success for punched-card voting came in 1965, with Joseph P. Harris 'development of the Votomatic punched-card system. This was based on IBM's Port-A-Punch technology (Jones, 2001).

b) **Optical scan voting system:** An optical scan voting system is an electronic voting system that uses an optical scanner to read marked paper ballots and tally the results. Types of optical scan systems include (Jones, 2001):

   i. **Marksense systems:** One technology used is the optical mark recognition scanners where voters mark their choice in a voting response location, usually filling a rectangle, circle or oval, or by completing an arrow. Various mark-sense voting systems have used a variety of different approaches to determining what marks are counted as votes.

      Early systems, such as the Votronic, introduced in 1965, had a single photo-sensor per column of marks on the ballot. Most such tabulators used analog comparators that counted all marks darker than a fixed threshold as being votes. The use of digital imaging technology to view the ballot does not necessarily imply more sophisticated mark recognition. The ballot can be immediately tabulated at polling stations allowing for voters to be notified by the voting system of voting errors such as an over-vote and can

ISSN 2222-1719 (Paper) ISSN 2222-2863 (Online)

Vol 2, No.4, 2011

prevent residual votes. One such method can display a digital image of the ballot being submitted and allows the voter to review how their ballots are being read. This is known as a precinct count voting system. Alternately the ballots can be collected in the polling station and tabulated later at a central facility, known as central count voting system (Jones, 2001).

ii. **Electronic ballot marker:** An electronic ballot marker (EBM) or ballot marking device (BMD) is an electronic device that can aid a disabled voter in marking a paper ballot. This device can allow for audio interfaces and still provide paper ballots (Jones, 2001).

iii. **Digital pen voting systems:** Digital pen voting systems use ballots on digital paper which is recognized by a small camera in the pen while it is marked by the voter. The ballots are collected in a ballot box and the digital pen is returned to an election official for tabulation. This technology was expected to be used in the 2008 Hamburg state elections, but eventually was decided against due to controversy surrounding the accuracy of voting tallies. The technology was first used in Scotland in 2006 for a local community council election (Jones, 2001).

2.1.2 Direct recording electronic systems

DREs (direct recording electronic systems) are the first completely computerized voting systems. They were introduced in the 1970s. DREs are somewhat analogous to (although more sophisticated than) lever machines. The voter chooses candidates from a posted ballot. Depending on the equipment used, the ballot may be printed and posted on the DREs, as it is with a lever machine, or it may be displayed on a computer screen. Voters make their choices by pushing buttons, touching the screen, or using other devices. The voter submits the choices made before leaving the booth, for example by pushing a "vote" button and the votes are then recorded electronically (Fischer, 2003). There is considerable variability in the design of DREs, but they can be classified into three basic types. The oldest design essentially mimics the interface of a lever machine. The entire posted ballot is visible at once. Instead of moving levers to make choices, the voter pushes a button next to a candidate's name, or pushes on the name itself, triggering an underlying electronic micro-switch and turning on a small light next to the choice. With the second type, a ballot page is displayed on a computer screen, and the voter uses mechanical devices such as arrow keys and buttons to make choices on a page and to change ballot pages. The third type is similar to the second except that it has a touch-screen display, where the voter makes a choice by touching the name of the candidate on the computer screen and casts the ballot by pressing a separate button after all choices have been made. In all kinds of DREs, when a ballot is cast, the votes are directly stored in a computer memory device such as a removable memory card or non-volatile memory circuit (Fischer, 2003).

As with lever machines, there is no document ballot, although with a DREs each cast ballot may also be separately recorded. Touch-screen and other DREs using computer-style displays are

ISSN 2222-1719 (Paper) ISSN 2222-2863 (Online)

Vol 2, No.4, 2011

arguably the most versatile and user-friendly of any current voting system. Each machine can easily be programmed to display ballots in different languages and for different offices, depending on voters' needs. It can also be programmed to display a voter's ballot choices on a single page for review before casting the vote. It can be made fully accessible for persons with disabilities, including visual impairment. Like lever machines, it can prevent over votes and ambiguous choices or spoilage of the ballot from extraneous marks, since there is no document ballot; but it can also notify voters of under-votes. No other kind of voting system possesses all of these features (Fischer, 2003).

2.1.3 Public network DRE voting system

A public network DRE voting system is an election system that uses electronic ballots and transmits vote data from the polling place to another location over a public network. Vote data may be transmitted as individual ballots as they are cast, periodically as batches of ballots throughout the Election Day, or as one batch at the close of voting (Fischer, 2003). This includes Internet voting as well as telephone voting. Public network DRE voting system can utilize either precinct count or central count method. The central count method tabulates ballots from multiple precincts at a central location (Fischer, 2003).

2.2 Remote e-voting

The advancement of information and telecommunications technologies allow for a fully automated, online computerized election process (Malkawi et al., 2009). This type of election process is referred to as remote electronic voting (e-voting). Remote electronic voting is the preferred term for voting that takes place by electronic means from any location (Magi, 2007). This could include the use of the Internet, text message, interactive digital TV or touch tone telephone. Internet voting (i-voting) is a specific case of remote electronic voting, whereby the vote takes place over the Internet such as via a web site or voting applet. Sometimes also used synonymously with remote electronic voting. Remote e-voting links the possibility of quick and reliable counting to that of voting outside of polling stations and traditional polling times as well as to the possibility of voting from abroad irrespective of locations of diplomatic and consular missions as well as unreliable postal services (Buchsbaum, 2004).

3. Benefits of e-voting

A number of countries, worldwide, has started or considered starting, thinking and experimenting as well as implementing e-voting (Goodman, 2010). In Europe, a variety of e-voting schemes is developed, tested and piloted across the continent. Outside of Europe, e-voting at poll sites is practiced in some states of the USA and Brazil progressively followed by Mexico and considered by other Central and Latin American countries, in some countries of the former Soviet Union and in India (Goodman, 2010). The reasons for the growing interest in e-voting may not be identical in all cases but the following reasons are identified (Buchsbaum, 2004).

ISSN 2222-1719 (Paper) ISSN 2222-2863 (Online)

Vol 2, No.4, 2011

i. Enabling voters to cast their vote from a place other than the poll site in their voting district.

ii. Facilitating the casting of the vote by the voter.

iii. Facilitating the participation in elections and referendums of all those who are entitled to vote, and particularly of citizens residing or staying abroad;

iv. Widening access to the voting process for voters with disabilities or those having other difficulties in being physically present at a poll site and using the devices available there.

v. Increasing voter turnout by providing additional voting channels.

vi. Bringing voting in line with new developments in society and the increasing use of new technologies as a medium for communication and civic engagement in pursuit of democracy.

vii. Reducing, over time, the overall cost to the electoral authorities of conducting an election or referendum.

viii. Delivering voting results reliably and more quickly and

ix. Providing the electorate with a better service in pursuit of democracy, by offering a variety of voting channels.

4. Risks of e-voting

Those opposed to, or skeptical of, electronic voting point to several drawbacks and perceived risks that are associated with the underlying technologies of this voting system. The most prominently cited risk relates to security (Goodman, 2010). Threats of computer viruses or hacker-orchestrated 'denial of service' attacks are most commonly mentioned as problems that could compromise an election and public confidence in electronic voting. This concern is most prevalent with regard to the security of personal computers. In the light of this, the maintenance of ballot secrecy is presented as an issue when using computers that are unprotected, located in public places, or which may be susceptible to virus attacks. Other potential technical problems or issues include power outages or malfunctions in Internet connectivity as well as the possibility of servers shutting down or crashing. The reliable recording and storage of votes is also an important consideration (Goodman, 2010).

Secondly, problems with access are raised. There is a digital divide between those who have home computers with Internet connections and those who do not. Also, there may be a digital divide between those who have faster access and those who have slower connections and hence lower quality access. People with higher incomes are more likely to be able to afford access. Furthermore, access is often less expensive and of higher quality in urban areas. Those with

ISSN 2222-1719 (Paper) ISSN 2222-2863 (Online)

Vol 2, No.4, 2011

lower incomes and who live in rural areas are at a disadvantage. Therefore, the extension of remote e-voting has the potential to create divides with respect to many socio-economic variables, namely income, education, gender, geography and race and ethnicity. These potential divides could be problematic for participation and representation (Goodman, 2010).

Thirdly, it is said that remote e-voting present greater opportunity for fraud and coercion or vote-buying. Fraud occurs when someone votes on another's behalf without their permission, whereas coercion or vote-buying takes place when a voter is pressured by others to vote in a way that he or she would not have otherwise (Goodman, 2010). Both present problems for ballot integrity since it is important that every vote cast be tallied as the voter intended. There is additional opportunity for fraud in electronic voting systems if voter notification cards, which contain unique passwords required to cast a ballot, are intercepted. In the case of ballots not cast in person it is more challenging to verify a voter's identity. Remote voter authentication can be a problem since it may be difficult to confirm that the person voting is actually who he or she claims to be. While digital signatures and passwords can help, they are not foolproof and could potentially be shared.

The issue of voter education is cited as a concern. A lot of time and money must be invested to ensure that the public is aware that electronic voting is an option and that voters are able to understand and use the on-line system to cast a ballot. Without correct marketing and advertising, it will be difficult to engage electors (Goodman, 2010).

Privatization is a concern when electoral administrators cede control to a hired firm. Contracting elections out to private companies to run the electronic operations has negative implications for some people, and hence has the potential to negatively impact public confidence and trust in government and elections (Goodman, 2010) and (Putnam, 2000).

Besides the aforementioned limitations, there is a dire need for international standards to govern the technology, the software reliability and accuracy, the processes and algorithms deployed within the technology, and the verification of all hardware, software and protocols involved. Such standards will eventually allow elections to proceed in any part of the world without the need for monitoring bodies (Malkawi et al., 2009)

5. Conclusion

Elections allow the populace to choose their representatives and express their preferences for how they will be governed. Naturally, the integrity of the election process is fundamental to the integrity of democracy itself. The election system must be sufficiently robust to withstand a variety of fraudulent behaviors and must be sufficiently transparent and comprehensible that voters and candidates can accept the results of an election. However, this cannot be said for conventional voting systems. Unsurprisingly, history is littered with examples of elections being manipulated in order to influence their outcome. Allegations of violence, intimidation, ballot stuffing, under-age and multiple voting, counting error, complicity of the security agencies and

ISSN 2222-1719 (Paper) ISSN 2222-2863 (Online)

Vol 2, No.4, 2011

the absence or late arrival of election materials etc often trail elections conducted using these systems of voting.

Electronic voting is emerging as significant alternative to these conventional systems in the delivery of reliable and trusted elections. The emergence of e-voting will undoubtedly enabled voters to cast their vote from a place other than the poll site in their voting district, facilitate the casting of the vote by the voter, facilitate more participation in elections by those who are entitled to vote, widen access to the voting process for voters with disabilities or those having other difficulties in being physically present at a poll site, increased voters turnout by providing additional voting channels, reduced overall cost to the electoral authorities of conducting an election, deliver voting results reliably and more quickly amongst many other benefits.

However, technological threats to the security of an electronic voting system still constitute some basic challenges in our electoral process. Some of the threats include viruses that can easily cause denial of service to the system, modifications to and deletion of the ballots data. Hackers can also take advantage of vulnerabilities that exist with the internet. Database and systems administrators who are in charge of the election hardware constituting the elections can also be security threat.

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Vol 2, No.4, 2011

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