

# Applicability of an Electronic Voting System in Sri Lankan Context

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**Abstract-** Elections are plays a vital role in modern democracy. It is the form of transferring power of citizen in to their representatives. Sri Lanka, being the oldest democracy in South Asia, is still using old traditional paper-based election system. But the modern technology is improved to provide faster, better, cheaper vote counting, and have stimulated great interest in managing the election process through the use of electronic voting systems. In nowadays, many democracies have adopted electronic systems, and the number of deployed systems is rising. Although the electronic voting process has gained popularity and users, it is a great challenge to provide a reliable system. The time is come for Sri Lanka to replace the current paper-based election system from paperless e-Voting systems. Electronic voting system have many advantages over traditional hand-counted paper ballots, therefore it will be a needful replacement for the future of Sri Lankan democracy.

**Index Terms-** DRE , e-Voting, Elections, Paperless

## I. INTRODUCTION

Electronic voting or someone calls e-Voting is a computerized Electronic voting machine which use paperless electronic ballots (see figure 1). These machines also referred as Direct Recording Machines (DREs). These e-Voting systems consist of three types. Those are, 1) touchscreen, 2) wheel machines and 3) punch-key machines. Touchscreen machines are letting voters cast votes by touching an electronic ballot on an LCD screen. Wheel machine are using a wheel and punch-key machines using a keypad for making selections on an electronic ballot.

According to the election officials' opinion, electronic voting machines save printing cost, easy to produce ballots in multiple languages and ballots also can update at last minute. The usability of the machine is also high, because past literature says that the machine allow most disabled voters to cast ballots without assistance as well. Summarizing past election results, it says that the machines produce faster and more accurate results than other types of voting machines [1].

But the electronic voting machines also have some problems too. One major problem is if the machine is badly programmed, then it may give wrong results. Another one is, these machines are proprietary and the trust and faithfulness of those manufactures may also cause some problems. Some articles stated that without a paper backup trail or some other means to verify votes, there is no meaningful way to determine the integrity of the machines or an election [1]. Also the hardware problems may also cause some problems for the machine functionality.

In Sri Lanka, hand-counted paper-based election method is the only method using for all type of elections. But compare to paperless electronic voting machines, it is far more behind. But still it is in the action. As everyone knows, Sri Lanka is a democratic country, people have their freedom to choose preferred candidates for the country's administration. The election is the only way of selecting those candidates. Therefore, it is vital to transfer current system in to new technological system and make things easy in election process in Sri Lanka. This paper is talked much about how to do this change; the background of these electronic voting method to use in future elections.

Initially this review paper is being gone to talk about election background of Sri Lanka. Then current election procedure and the available voting methods are being gone to talk. After those detailed descriptions, there is some small descriptions of paperless and e-Voting systems. Next sections are being talked about security and usability of electronic voting systems. Then the paper included a section, which describe the challenges of designing an e-Voting systems. Finally there is a discussion and conclusion which talk much about the Sri Lankan future with e-Voting and the compressed summery of this paper.



Fig. 1. Cast a vote in an Electronic Voting System

## II. REVIEWING LITERATURE

Being the oldest democracy in South Asia, Sri Lanka is a democratic, socialist republic and a unitary state which is presidential system and a parliamentary system [2]. In 1931, with the introduction of universal franchise a new political enthusiasm was generated in Sri Lankan society. Therefore, in 1931, people of Sri Lanka had their first opportunity to participate for an election and elect their members to the State Council. The first Parliamentary General Election was conducted in 1947, under Ceylon (Constitution) Order in Council of 1946 and it was held on multiparty system. After 25 years, the first Republican Constitution was introduced in 1972 with the President as the Head of the State who was to be nominated by the Prime Minister. Later in 1978 the Second Republican Constitution was introduced, which promulgated the establishment of an Executive Presidency and a Parliamentary legislative [3].

Every person who qualifies to be an elector is eligible to vote at any elections held in Sri Lanka. Mainly, there are five different elections. Those are, 1) Presidential Election, 2) Parliamentary General Election, 3) Provincial Councils Elections, 4) Local Authorities Elections, and 5) Referendum [3]. Electors can vote for preferred member or members and number of votes are decided the qualified members of each election. Therefore the process of voting should be accurate, robust and non-vulnerable to elect most preferred and qualified members through the elections.

In Sri Lanka, current election is conducted by using paper based materials as main voting source and computerized publication channel to transfer results in to general public. It is a process of lot of paper works and manual vote counting, which should need hard work of several responsible parties. Therefore, it is seasonable to take an idea of the current election process, before enter in to main topic.

### A. Existent Election System

The election is started after the official announcement of the Commissioner of Elections. Then candidates register with the election under their parties. Next, paper based ballot is prepared for that election and paper based ballot card also printed to each individual elector as an identification mechanism. Those card are distributed through post mails for relevant electors to use as an election identity to present on that day. Before the Election Day, all the ballots and ballot boxes are distributed to the regional areas under the guidance of Department of Elections.

On the Election Day, electors goes to polling-booth and authenticate themselves with the use of ballot card and national identity card<sup>1</sup>. Then if the authentication success, ballot card is destroyed and gives a ballot to mark the elector's vote. The polling-booth provide a secret place to mark elector's vote and he should put ballot in to the ballot box after he completed. End of the day, ballot boxes are sealed and transferred in to counting centers placed in several specific areas.

Then the counting process is started. The process of counting of votes can be classified into three stages. 1) Counting of the number of ballot papers in each box and transferring them to the trough, 2) Sorting and counting the ballot papers according to the

valid votes received and the preparation of the statement of votes received by each party and group in the electoral district, and 3) Recording the preferences received by each candidate in the Tally Sheet and transferring them through a series of Summary Sheets into a District List for a party or a group, which gives the total of preferences received by each candidate in the electoral district [3].

By following above stages, final result is created and published to general public through media. Finally, the Commissioner of Elections presents the overall final result and stated the end of that election. In Sri Lanka hand-counted paper ballots, which is described above is the only voting method presently used. But in the world, there are few more than this. Next sub-section is going to talk about various types of voting methods used in world nowadays.

### B. Types of Voting Method

Voting methods are varying from country to country and within in a country as well. In literature also, there are several categorizations of voting methods. David C. Kimball [4] in his analysis, he introduced nine types of voting methods. That categorization includes; 1) Punch Card-Votomatic, 2) Punch Card Datavote, 3) Lever Machine, 4) Paper Ballot, 5) Older DRE (full face), 6) Newer DRE (touch-screen), 7) Optical Scan-Central Count, 8) Optical Scan-Precinct Count and 9) Mixed. But in the paper of Daniel P. Tokaji [5], "The Paperless Chase: Electronic Voting and Democratic Values", says that David's nine types can put under five main voting methods. Those are, 1) hand-counted paper ballots, 2) mechanical lever machines, 3) punch card ballots, 4) optical scan or "Marksense" ballots, and 5) direct record electronic or "DRE" machines. Daniel further telling that, Michael Alvarez z, et al. [6], in their analysis, "Counting Ballots and the 2000 Election: What Went Wrong?" is also categorized main voting methods under these five types. Therefore, in this paper is also followed Daniel and Michel and stated the categorization under five main types.

According to the literature, these types of methods vary considerably in their operation and there susceptibility to error. These are also differ from capacity to prevent inadvertent "overvotes"<sup>2</sup>. Perhaps most important, there are significant differences in the capacity of different technologies to provide feedback to voters, by notifying them of mistakes and providing an opportunity to correct such mistakes [5]. But these differences only exist within some of these categories. Therefore, now it is time to go through these categories one by one in details to find out differences of those categories, which is ultimately entering us in to the main topic of this paper.

1) *Hand-Counted Paper Ballots*: Paper ballots<sup>3</sup> constitute the oldest voting system still in use [7]. But it is one of least commonly used type of voting equipment [5]. In paper ballots, candidates' names are printed next to boxes, which voters mark. Paper ballots are hand counted, therefore those remain in use mostly in small counties with few contested offices [7]. Paper ballots used pencil as the input medium and if there is any

<sup>2</sup> Voting for more than the allowed number of candidates.

<sup>3</sup> The term "paper ballots" is referring systems in which voters mark their choices on pieces of paper that are then counted by hand.

<sup>1</sup> Any other accepted certificate behalf of the national identity card also considered here.

necessity of audit trail, again the original ballots are counted manually. The main problem with hand-marked and hand-counted paper ballots is the time required to count them. As ballots become more complicated with multiple offices and propositions in a single election, humans find it more difficult to reliably and quickly count hand-marked paper ballots [8]. Therefore, manual counting can take as a disadvantage of this paper ballots method, because it influences to the efficiency of the process.

2) *Mechanical Lever Machines*: On mechanical lever machines (see figure 2), each candidate's name is assigned to a lever on a rectangular array of levers on the face of the machines. The voter pulls down selected levers to indicate choices. Levers are connected to a counting wheel, which at the close of the polls indicates the number of votes cast on the lever that drives it. Further interlocks are arranged to prevent "overvoting" within the machine as well [7].



Fig. 2. Mechanical Lever Machines

Daniel P. Tokaji, in his analysis [5], he founded that the problems with mechanical lever machines can occur if the machines are improperly configured, or if the counters fail to register voters' choices. The age of these machines, and the difficulty in obtaining replacement parts, can also lead to problems with this system. Therefore he further stated that many

jurisdictions have abandoned to use these Mechanical Lever Machines nowadays.

3) *Punch Card Ballots*: Punch card systems as shows in figure 3, employ one or more cards and a clipboard sized device for recording votes. Information about the ballot choices is provided in a booklet attached to a mechanical holder and centered over the punch card, which is inserted by the voter [7].

There are two types of punch card ballots available. Those are, votomatic and datavote. In the votomatic system, the punch card contains many rows of holes that correspond to particular choices. The voter inserts the card into a slot in the punch card holder, which contains several pages indicating the actual issues. In the datavote system, the voter receives one or more punch cards with the choices printed on the card itself. The votomatic system sacrifices voter verifiability for reduced cost. Although a voter can examine the punch card and attempt to determine if her vote is correctly recorded, it is difficult to do so. The holes on the card do not have labels that identify candidates directly; to verify the punch card, the voter must map the card holes back to the ballot. With the datavote system, voters can more easily verify their choices because the candidate names are printed on the punch card [8].



Fig. 3. Punch Card Machine

Punch cards gained prominence in the late 1960s and it was cheap and fast [9]. But the problem of this punch card system is, this needs printing custom punch cards for each election and a typical election requires more than one punch card per voter. Therefore, this leads to logistical difficulties and new possibilities for error as well [8]. Furthermore, according to David and Nathanael analysis of e-voting [8] says that the problems occur after the state of Florida's 2000 US Presidential election, voters have lost faith in them, which makes them unacceptable. Further they stated that, this incident ultimately destroy voter confidence in punch card systems, regardless of whether punch cards can record votes accurately.

4) *Optical Scan Ballots*: Optical scanning systems are widely used in standardized testing and other functions besides voting. Optical scanning began to be used in voting at about the same time as punch card systems, although its use spread more slowly until the 1980s. These systems use large ballots similar to those of paper ballot systems, so that information about candidates can be printed directly on the ballot. The ballots are counted by a



machine that uses light or infra-red as a sensor to discern which oval or rectangle the voter marked from a set of choices [7]. In optical scanning, instead of making a physical hole in the paper as in a punch card type system, voters indicate their choice by filling in an oval or completing an arrow [8]. Then the scanning machine can scan the votes and human should trust the scanning machine to correctly interpret the ballot. But here human also can count the ballots by using manual counting mechanism.

5) *Direct Record Electronic (DRE) Machines*: DRE introduced in mid 1970s. These systems are similar to lever machines, and different from other systems, in the absence of any physical ballot, and no possibility of “overvotes” if the equipment is programmed correctly. Voter choices directly enter electronic storage, using touch screens, push buttons, or keyboards [7]. Many of the reasons for the increased adoption of DRE machines include accessibility and prevention of voter mistakes. DRE machines can use audio interfaces to let the visually impaired vote without assistance. We can program DRE machines to prevent “overvotes” and to warn voters about “undervotes”. Furthermore, DRE machines save precincts the costs associated with producing and securing paper ballots [8]. The more about this DREs are talked in future sections of this paper. Table I shows some brief summary of the methods talked above, which was actually derived from Rebecca Mercuri’s “A Better Ballot Box” [10].

Table 1: Summary of Voting Methods

Medium	Input	Counting Method	Audit Trail
Paper Ballot	Pencil	Manual	Original Ballots
Mechanical Lever Machine	Switches	Running tally by machine	Subtotals remain on machine
Punch Card Machine	Metal punch	Cards sorted and tallied by computer	Original Cards
Optical Scan Ballot	Circle darkened or arrow drawn by voter	Optically scanned	Original ballots
DRE	Push-button, touchscreen, or keypad	Running tally by machine	Tallies collected on disk

C. Paperless Voting

When we consider above methods, then three out of five are considered as paper based voting mechanisms. The DRE and Mechanical Lever Machine are considered as paperless. With paperless technologies, trust becomes more centralized. Therefore some problems like no physical record of votes is kept, more opportunity exists for votes to be lost, altered, or inserted without detection are existed as well [8].

Paperless voting contains many advantages over paper based voting mechanism. Some advantages of paperless voting are, 1) Cost savings, 2) Increased participation rates, 3) Better informed voters, 4) Reduced administration, 5) Create and deploy ballot quickly and with ease, 6) Integrity of the vote, 7) Instant runoffs, 8) Last minute changes to the ballot, 9) Elimination of human error in the vote counting and 10) No need for recounts [11].

Since DRE and Mechanical Lever Machine both are concerned as paperless voting mechanisms, in literature, DRE is concerned as a better mechanism over Mechanical Lever Machines. The problem with Mechanical Lever Machines is that there is no any physical record of voter’s intent exist, after the voter leaves the booth. If the voting machine worked correctly, then the actual intent is counting and votes of the relevant parties are increased. Otherwise, there is no way to perform a manual recount. In practice, Mechanical Voting Machines have been notoriously inaccurate [8]. Since Mechanical Lever Machines had some problems over past, it is not consider as better option to use in Sri Lanka as well. Therefore, four out of five mentioned here are not suitable for suggest for Sri Lankan election system. But DRE is a method which can consider for Sri Lanka. Therefore, next section, more about DRE is going to talk.

D. E-Voting Systems

With a paper-based system, the electronic component is usually a tabulation device. It means, votes are counted on an electronic system. Actually, it is much faster than a manual count. Some ballot printing systems are more similar to the DRE systems. Voters use a touchscreen or similar electronic device to make their choices. In here, there is a printer attached to the device and when the voter submits his vote, then the printer produces a physical paper ballot. Next responsible officer collect all the paper ballots produced to a centralized location after the polls are closed. Then there is a separate electronic device, which can optically scan these ballots and tabulates the results [12].

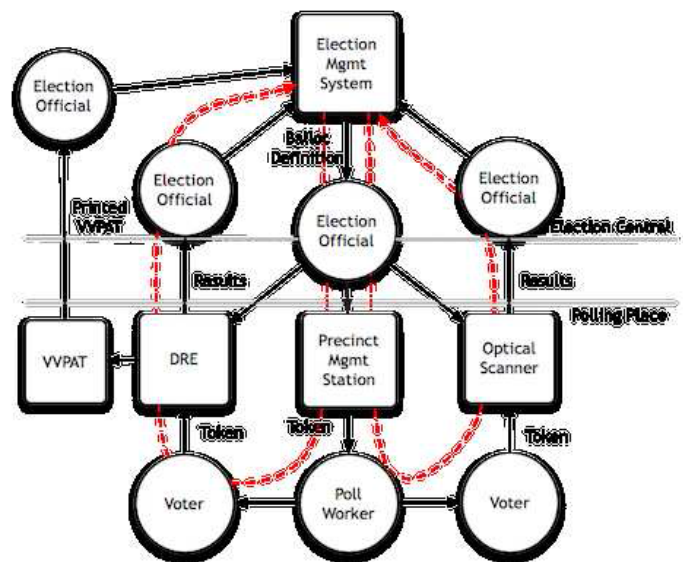


Fig. 4. A Physical Structure of an e-Voting Poll

One of the advantages of a paper-based system is that the ballot is physically represented by a piece of paper. That mean tangibility is there. This tangibility reassures voters that their

choices are being counted. But there is no mechanism to verify that a vote will be correctly counted. Many factors can contribute to a misapplied vote. Holes in punch cards may not be properly aligned or fully punched, resulting in a “hanging chad”, made infamous in the 2000 election in Florida. On optical scan cards, stray marks or incomplete markings may be misinterpreted when tabulation process conducted. Another problem of optical scan card is incomplete or unreadable cards. With the use of some printers that mark optical scan cards which run low on toner, resulting in cards with incomplete or unreadable marks. It may also be possible for a voter to vote for two or more candidates for a single position, means “overvoting”; these selections are not counted by tabulation devices [12].

As anyone know, physical ballots can be lost or destroyed before tabulation. But it is very less compare to intangible paperless records. But with the use of correct electronic recording mechanisms, paperless will more effective and efficient. As talked above, DRE is a type of electronic recording systems, which record votes solely on just such an intangible record [12], which have capabilities to contribute effectively and efficiently for an election system.



Fig. 5. A Modern DRE Machine

A DRE System is essentially a computer. When voter come in-front of this DRE, then he can view the ballots on a screen and make choices using an input device such as a bank of buttons or a touchscreen. In some cases, DRE asked some electronic card for the authentication purposes. After the voter successfully follow the authentication process, then the machines will be activated. Then voter can cast their vote and votes will be recorded to a memory card, compact disc or other memory device. Then like paper-based ballots, election officials transport these memory devices to a centralized location for tabulation. Some machines have the capability to broadcast results over a network, but due to concerns about data security, these results are normally keep in secure until they can be verified by tabulating the results stored on the memory devices. Many DRE devices also have the capacity to print a paper record of ballots cast. Some, however, have no corresponding paper trail [12].

A DRE system as shown in figure 5, actually an e-voting system, can have major advantages over paper-based systems, assuming it is secure and reliable. Because in e-voting systems, ballots are displayed electronically, there are no limitations on a ballot's appearance. Since the ballots displayed through programs, programmers can create ballots in any language. Also programmers can design large print layouts for voters with poor eyesight or even record and incorporate audio files for blind

voters. This e-voting will be keep things easy for election officials as well. They do not need to estimate how many ballots to order for each possibility; any particular format could be called up as situations arise. Since votes are recorded on a memory device, tabulation takes less time. There are no paper ballots to scan, so there is some less risk of mechanical error. In an e-voting systems, tabulation is instantaneous with no need for recounts as well [12]. Therefore, technologically and timely, e-voting is in far ahead than traditional paper based election system which still exists in Sri Lanka.

Since e-voting is technically and timely solution, human error is still a factor in here as well. Therefore, it should always concern about software bugs. So as bugs, security and usability is also strong factors which can measure the success of any voting system. The reason for that is, an election's integrity depends on the recorded votes accurately reflecting the voter's intent. This could be compromised either by tampering with the recording of voter intent or by interfaces that increase the probability that the recorded votes will not accurately reflect the voter's intent [8]. Therefore, next two subsections of this paper is going to talk about security and usability of e-voting systems, to find out whether it is a valid mechanism for Sri Lankan elections.

#### *E. Security in e-Voting*

Security is a must thing to consider in an election system. Because, some vulnerabilities may affect for the actual intent of voters. Therefore, DRE machines also raise serious security concerns. They make the election process less verifiable and greatly expand the aspects of an election for which voters must rely solely on trust. Not like mechanical-lever machine which has no physical record of a voter's intent exists, however, the mechanism for recording a vote in DRE is hidden in the code for the machine, which vendors keep secret [8].

In a DRE or an e-voting system, there are some areas, which may become impacts at the end. Those are, 1) Malicious Payload, 2) Delivery Mechanism, 3) Communication and 4) Social Engineering. Therefore next the paper is being gone to talk about these areas in details.

*1) Malicious Payload:* According to the literature, there can be hundreds of attack programs. When one malicious payload reaches a host, there is practically no limit to the damage it can do. In today's context, with existing hardware and software architectures, these kind of a malicious payload on a voting host can actually change a voters vote without the voter or anyone else noticing, without concerning the encryption or voter authentication in place. The main reason for this is, malicious code can do its damage before the encryption and authentication is applied to the data. Then this module can erase itself, without keeping any evidence of fraud to correct or even to detect. These types of codes were designed to be especially difficult to detect and it is also difficult to detect even while it is running [13].

There are software packages which can view and control every aspect of that machine as though the person were sitting at the console. Back Orifice 2000 (BO2K<sup>4</sup>) is only a one example for that kind of a software package [13]. By installing these kinds of

<sup>4</sup> BO2K is software packaged and distributed as a legitimate network administration toolkit. See [www.bo2k.de](http://www.bo2k.de) for more details.

software packages, administrators can handle these malicious payloads to protect voter's intent without dissatisfying them.

2) *Delivery Mechanism*: When someone run a malicious code, they should install it first in the election system. They can use two methods. One is physical installation. Other one is, if the election is carried out through network, then they can deliver that malicious code remotely. But few people keep their computers in a carefully controlled, locked environment. Then it may become difficult to an attacker to install code in the machine. But the election responsible persons should use correct mechanisms to protect machines from physical installation of malicious codes. Actually, malicious code can be delivered that triggers particular actions at a later date, enables future access (as in the case of BO2K), or disrupts normal operation at a particular time [13]. Therefore, responsible parties should take care of these election machines for a fair election.

While the physical delivery of malicious code is a serious problem, it is not nearly as effective as remote automated delivery. There are ways to install codes remotely. Typically, these cause temporary disruption in service and perform some annoying action. In most cases, the attacks spread wider and faster than even their creators imagined. One thing they all share is the ability to install some code on the computers being infected [13].

3) *Communication*: When we talk about the network communication, there are two end points. One is user host and other one is the election server. The one before the above paragraph, paper talked about how to protect the host. While in no way trivial, the technology exists to provide reasonable protection on servers as well. Concerning communication between the two endpoints, cryptography can be used to protect the communication between a user's side and an election server. The technology is mature and can be relied on to ensure the integrity and confidentiality of network traffic. The remote delivery happened when the remote election voting over the Internet. Then the classic security properties of the communications infrastructure which is available on the Internet service is also there to protect voter's vote [13].

4) *Social Engineering*: This is the term used to describe attacks that involve fooling people into unwittingly compromising their own security [5]. According to Aviel D. Rubin's [13] discussion with election officials, discovers that an issue they grapple with is the inability of many people to follow simple directions. He further stated an example by telling that, it is surprising to learn that when instructed to circle a candidate's name, many people underline it. Therefore, if the user interface is not easy to handle, then if the voter is unfamiliar with the computer, someone can use him to vote against the voter intent. Therefore, the user interfaces also should simplify the process, without creating a confusion to the user.

Another problem here is, when the election is carried out over the Internet, then fake interfaces for the elections can implement and distribute. Then unfamiliar voter won't recognize this and he may make his vote for that. Then ultimately he won't give his vote in to valid election server. But the system to be secure, there must be a way for voters to know that they are communicating with the legitimate election server. To carry out that, there are infrastructures available which can verify that their browsers are communicating with a valid election server. The SSL protocol

and server-side certificates can be used for this. Even if we assume the process is flawless, despite its risks and pitfalls, it is still unreasonable to assume that average Internet users who want to vote on their computers will understand the concept of a server certificate, verify its authenticity, and check the active cipher suites to ensure strong encryption is being used. Most users would probably not distinguish between a page from an SSL connection to the legitimate server and a non-SSL page from a malicious server with the exact same look as the real page [13].

#### F. Usability of e-Voting Systems

The unusual requirements of voting systems bring special concerns related to support of all citizens in their access and trust of voting machines. Interface also played an important role here and it won't create any confusion in voters mind. In addition, there are further concerns relating to the possible bias of anonymity of voters, and validity of the recorded vote. Therefore, according to Benjamin B. Bederson et al., here also this paper talked about the usability factor under four sub topics, namely, 1) Accessibility, 2) Age and Technical Experience, 3) Bias and 4) Accountability and Verifiability.

1) *Accessibility*: One of the largest issues related to DRE voting systems is accessibility. But National Organization on Disability says that compare to lever, punch-card, optical scan, and hand-count systems, DRE balloting systems are the most accessible technology. In real application development scenario, accessibility is the easiest design factor to ignore by computer program designers. Many classes of voters can easily be disenfranchised by a voting system that accommodates only "normal" users [14]. Figure 6 shows a DRE machine build for both disable and normal people<sup>5</sup>.



Fig. 6. The Venezuelan Electronic Voting System

2) *Age and Technical Experience*: When we come for an e-Voting stage, age is also a matter to consider. According to general practice, the issue of "computer disability" can cause

<sup>5</sup> <http://digitalvote.wordpress.com/2011/08/02/disabled-people-vote-withcomfort-in-venezuela/>



problems in DRE elections. Literature shows that older adults consistently perform more poorly than younger adults in performing computer-based tasks. This is actually a matter of time required to perform the task and as well as the number of errors made. This is likely due in part to a perception on the part of older adults that they might inadvertently damage the computer, or general complexity in using the technology. By the side of user training also, literature identified that older adults have less mastery of the training content than younger adults. Therefore, they require more time to cover the training material than young adults [14] [15].

Literature stated that, any individuals with movement disorders are unable to make efficient use of graphical computer interfaces. Furthermore it may also be that a decrease in manual dexterity and in eye-hand coordination accounts for greater difficulty in operating such systems. As a general thing, age was positively correlated with difficulty in performing tasks with a computer mouse. But now modern most popular DRE systems do not use a computer mouse and they used touch screen facilities behalf of it. Then also the similar issues are present. Viewing a computer screen is also a difficult task for older adults and correct conceptualization of the relationship between screen or button manipulation and program activity may be a problem as well [14] [16].

3) *Bias*: Aside from accessibility, the issue of bias presents both a logistical and a legal problem for elections. When designing a ballot, the location of the ballot also may matter. Actual most of candidates believe that their location on the ballot changes the likelihood that a voter will select them. For example, candidates listed first on a ballot are generally favored. For this reason, before design the ballot, the responsible parties wants to order the list. Most of the times, candidates are listed by party in a specified configuration, by lottery, or alphabetically [14].



Fig. 7. An example of an e-Voting Ballot

This is not a unique problem for e-Voting systems. This problem still exist for paper-based voting systems as well. Therefore, all most all the countries used any of above mentioned mechanism to list the candidates. Computers, of course, can randomize the presentation of names, but this creates difficulty again [14]. Because some of users who have pre-planned their voting may

become confuse there or they may vote for another one. With this standardized ballot display, another problem also arises. As general practice, using the same place for many times on a touch screen may create some hardware failures. In DRE, most of time they used touch screens and therefore, some problems may arise for the most popular candidate due to some hardware malfunctions. Avoid such cases, consistent hardware maintenance is needed in this technology. Otherwise, problems can develop with localized sensitivity. This means that, if the equipment is not properly maintained and replaced, it could physically become more difficult to vote for a popular candidate than to vote for an unpopular one [14]. Therefore with electronic voting, the election officers should consider about the quality of equipment used to avoid bias for certain users.

4) *Accountability and Verifiability*: With traditional method, votes were cast on paper and counted by hand. Other than the e-Voting systems like DRE, voters marked their vote by their hands. Then the confidence goes high. But in DRE kind of machines, voter marks his vote in computer interface, but they actually don't know what happen behind the screen. They may get some doubt like whether they voted for the correct candidate. Therefore DRE systems raise the question: how can one know that when a voter chooses a particular candidate on the screen, a vote for that candidate is recorded? And it is also fair to raise this kind of problem, because most of the times systems are provided by private companies, and the government usually has no oversight into the production of the systems beyond choosing whether or not to use them [14].

Think a scenario that one careless programmer sets up a situation like, Candidate A is appear on the display, but when one voted for him, the vote is tabulated under Candidate B. Then, the whole result of the election may get wrong due to this careless programmer. Then if the Candidate A questioned about his votes, there is no any records to review the result. Therefore, literature understood that there is a problem of verification in e-Voting systems. But literature also too have a solution to this critical problem as well. It is to provide the user with a printed record of the votes electronically recorded, which actually a copy of the displayed screen. Then by looking at that printed paper he may get satisfied and before leaving the polling place, he would be required to certify the contents of the paper record and place it into a ballot box. Then if any problem occur, the printed records could then be manually counted. This approach, however, has not been implemented in any commercial systems according to Benjamin B. Bederson et al., but this is the correct way to make elections more accurately reflect the voter's intent [14].

#### G. Challenges in Designing an e-Voting System

When one country is moving from traditional voting method in to e-Voting, then they have to face few challenges as well. This section is going to talk about those challenges and the action should take to overcome from those as well. Here the challenges are talked under seven subtopics. Those are, 1) Privacy, 2) Lack of Evidence, 3) Fraud-Resistance, 4) Ease-of- Use, 5) Scalable, 6) Speed and 7) Low Cost.

1) *Privacy*: The system should design to count only the vote. It won't collect any of other information about the voter. It is not acceptable to record the used language of the voter as well. This is made difficult by the abundance of sidebands available to

transmit information. But some poorly design e-Voting systems contain sidebands<sup>6</sup>. This sidebands can be used to determine how a person voted without breaking the security assumptions of the system [17]. Therefore, the e-Voting system must design to protect the privacy of the voter.

Actually in traditional ballots, the privacy is not concern as a major factor. Because those ballots are creating in separate formats. As general thing, when some people want ballots written in their primary language or people with weak or no vision might need large print, recorded, or Braille ballots, then they should need specific ballot. But then the voter may identified through the ballot design and it may harm for it privacy. In e-Voting, it may not be a problem, because technology exists to overcome from such an issues.

2) *Lack of Evidence*: The voting system should not collect any evidence of how the voter place his vote. This is also a matter of privacy, but recording the steps followed by the voter may arise some issues in later. In modern DRE systems provide no evidence of votes apart from the internal storage and possibly a paper record, neither of which can be retrieved by the voter [17]. Therefore, when designing an e-Voting system, it is advisable to check this thing as well.

3) *Fraud-Resistance*: The system should be designed to give authorities to vote only for qualified users and that user also can vote one time. No other persons cannot vote behalf of him and the system must verify the identity of each potential voter and determine their status, but must not allow this information to become associated with their vote [17]. There should be mechanisms to avoid duplicate votes and forged/modified votes as well.

4) *Ease-of-Use*: Elections must server for entire general public. This includes people with various levels of technological familiarity, various languages, and various physical capabilities like vision, hearing, etc... Any systemic bias in the error rates between these groups could unfairly alter the election results [17]. Therefore, system must design to represent all most all variety of people of that country.

5) *Scalable*: Some large elections have millions of voters to vote. Then the machines should have capabilities to handle all of these users to provide a successful elections. Scalability is also a challenge when designing an e-Voting system.

6) *Speed*: In DRE, the ballots are counted through machines. But in traditional method, it is by hands. Then comparing these two, DRE is very much speed and have facilities to publish results very quickly. As all know, after finishing an election, all the parties and general public are waiting for the election results. If it get late, it may not create a good image on anybody. Therefore, designers of these systems must care about the speed and the time it takes to complete an election. Because any voting system that requires lengthy counting time will not be acceptable.

7) *Low Cost*: Cost is a major factor concern by countries when selecting a voting system. When designing a system, designers should think about the cost of it as well. Because if a system can't be implement cheaply, then it isn't useful for anyone.

As talked above subsections, privacy, lack of evidence, and fraud resistance affect the security of the system. Those factors should

consider to ensure the security of the system other than the factors talked in section II.E. Ease-of-use affects the fairness of the system. Scalability, speed, and cost affect the practicality of the e-Voting system and providing those perfectly are identified challenges as well.

### III. DISCUSSION

In Sri Lanka, the paper-based election system is still exists. It has so many disadvantages. Main disadvantages are time and the number of human resource needed to complete an election. As general thing, Sri Lankan elections take much time compare to other large population country's elections. By understanding the efficient and effectiveness of paperless, this paper is talking to transfer Sri Lankan election system from paper-based in to paperless system.

In here, there are five types of voting methods. Three out of these five are paper-based and other two are paperless. But as talked above, the problem with Mechanical Lever Machines is that there is no any physical record of voters' intent exist, after the voter leaves the booth. Therefore, paper suggested that, according to the literature, e-Voting is the timely and technologically advanced option for Sri Lanka. One such a system is the DRE. Let's look here, how and why e-Voting is suited for Sri Lanka nowadays.

When talking about e-Voting, it also can divide in to two. One is offline e-Voting system, which use memory drive to store voters' intent and transfer memory drive in to a counting center. Then by using that memory drive, election officers can tabulate the votes.

Other one is remote e-Voting system, which is connected through Internet and runs on centralized election server. With the remote e-Voting system, Internet and networking infrastructure is essential. But still Sri Lanka don't have those well-defined infrastructures to move to a remote e-Voting system. On the other side, security also high in offline compare to remote e-Voting system. Because attacker must attack each machine individually to attack a district. But with the remote e-Voting, he can attack from the middle and do the damage for the election. Then to protect the system against those attacks, it should come under careful scrutiny, and the system may be held to a higher standard. The cost of such a machine may goes high. Therefore, by considering factors like lack of infrastructure and cost, then offline e-Voting system is more recommended for Sri Lanka.

The e-Voting systems are saving lot the e-Voting systems are saving lot of money used to print paper-based ballots and it make the election process easier. Also the time for the tabulation process gets decrease and then election officials can publish results very quickly. Then Sri Lankan government can decrease the amount of money they put in to elections every year. Security and usability should consider here to provide better election system. As talked in section II, updated security features, locked environments, protections in physical environments and verification of votes are highly needed to consider to provide better security at the end.

When talking about the usability of e-Voting systems, we identified that old adult gets difficulty in accessing computer. By the way, Sri Lanka is not having very much high computer literacy too. Therefore, it is not good for Sri Lanka to convert all generations at once in to this new election system. It is advisable to transfer generation by generation and keep the traditional

<sup>6</sup> A sideband is a channel of communication internal or external to the system not explicitly designed to convey information.



voting method for few generations as well. Then people who can use e-Voting system may use it and others may use the traditional way. Then the introduction of new system may not harm for the active votes in elections and society also transferring slowly in to new system. In Sri Lanka currently have a standard way of creating a ballot. Here Department of Election used alphabetical order to list candidates. This e-Voting system also can use that mechanism to list the candidates. Then any bias may not occur for few candidates. But to avoid hardware issues as talked in section II, election officials have to maintain the systems properly.

In Sri Lanka, the verifiability of the votes is really important factor. As general factor, there are occasions that the recounting have to proceed due to some challenges. With the traditional system also, candidates have doubt about the votes and they asked to review as well. But if Sri Lanka used available DRE technology machines for the elections, then surely the same questions talked in section II raise here as well. Therefore, if Sri Lanka using this e-Voting, then government should use the attached printing machine, which can produce physical evidence of voter's intent. Then separate ballot box can collect those; if any reviewing case occurred, then those physical ballots should use to maintain the voter's trust with e-Voting system.

#### IV. CONCLUSION

Traditional paper-based election system is now outdated and only few small countries used. There are new technologies available, which can produce efficient and effective election system. DRE is such a type of advanced paperless election system, which used many countries all over the world. DRE is an e-Voting system and it has many advantages over traditional paper-based election system. Some of them are, cost savings, increased participation rates, reduced administration, create and deploy ballot quickly and with ease, integrity of the vote, elimination of human error in the vote counting, etc...

Security and usability are main factors to measure the success of any election system. In e-Voting system, there are standard securities to protect from unauthorized attackers. Also there are some third party software which can track malicious attacks as well. Therefore, with the available security features, e-Voting is considered as secure voting system. Usability is also a factor to consider, because the election system means all most all the citizen in a country may use it. Therefore, when designing a ballot, disable people, old people, non-educated people and non-technical people have to be considered. Other than the accessibility, there are few more to consider as well. One specific thing is, the system should not bias for any candidate. Therefore, standard accepted mechanism should use to design the list of candidates as well. In an e-Voting system, hardware maintenance is also important. Otherwise, voter may get uncomfortable if the machine didn't function properly.

Another specific factor to consider in e-Voting system is the manufacture. The government or organization should hand over the project in to quality software building organization. Because as we talked in this paper, one careless programmer can do a big damage in to nations democracy. Verifiability is also a considerable factor, because it may increase the confidence of the voter. Another important factor identified in this paper is recounting of votes. Any election system should ready for

recount votes at any time to keep the confidence of the voters. But the current e-Voting system called DRE doesn't support for this functionality.

E-Voting is timely technique that Sri Lanka can use to replace the current election system. It carries many advantages over currently used traditional voting method. But there are things to consider, when Sri Lanka moving to e-Voting system. Some of main factors are, proper security standards, usability testing and the manufacture of the system. Also according to Sri Lankan computer literacy rate, both methods should carry some time for few elections until people get used to it.

#### V. FUTURE WORKS

The e-Voting system with post-verification is still only a theory. There isn't any practical machine that function in both ways. Therefore, researchers can do some work in this area and suggest a better architecture for that kind of a system. Then the demand of this e-Voting may go high as well. The reason is, without providing voter-verifiable paper audit trails, with today's technology and testing procedures, e-Voting method pose an unacceptable risk for the potential benefits they provide. Therefore, post-verification process is essential in practical scenario. Also researches in e-Voting security and usability is also good areas, because more findings are creating more secure and more useful election system.

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