The Roadmap to the Electronic Voting System Development: A Literature Review

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Abstract*—Since the start of the use of the electronic voting system, it has gone through numerous updates and upgrades. These upgrades and updates include changes from paper-ballot to a paperless, manual to technology, mechanical to electronic, offline to online, polling based stations to remote places and so on. In this paper, we briefly investigate the above issues of the electronic voting system as well as the development of its revolution and legalization, guidelines and recommendations, vulnerabilities and hacking, security and protection, and the alike in course of time.*

Keywords— Voting Technology, Lever Machine, Legalization, Hacking.

I. INTRODUCTION

The purpose of Electronic voting technology is to provide a plain, simple and secret voting process, speed up the counting of ballots, reduce the cost of paying staff to count votes manually and can provide improved accessibility for disabled voters [Douglas, 2003]. However, there has been contention, especially in the United States, that electronic voting, especially DRE voting, could facilitate electoral fraud and may not be fully auditable. In addition, electronic voting has been criticized as unnecessary and expensive to introduce. Several countries have cancelled e-voting systems or decided against a large-scale rollout, notably the Netherlands, Germany and the United Kingdom. Yet electronic voting system has been practicing widely for last two decades. But historically it is seen that it has been using more than last 150 years. The first concept of electronic voting ideas comes from de Brettes. He develops an electronic decision-making telegraph in 1849. But first electronic vote recorder was invented by Thomas Edison in 1869 [Thomas A, 2008]. In this system, a signal to a central recorder, listed the names of the members in two columns of metal type headed 'Yes' and 'No.' [Vote Recorder, 2008], and was introduced first automated voting system in 1886.

In the following sections, "Road Map to Electronic Voting System Development" is categorized into seven phases :

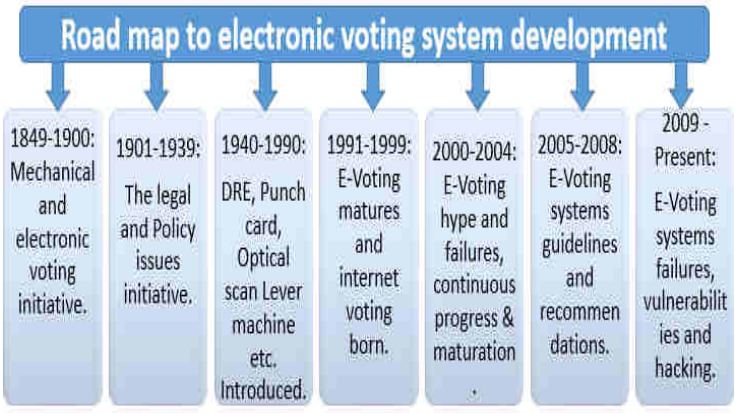

Fig.1: Road Map to Electronic Voting System Development

II. E-VOTING DEVELOPMENT PHASES

2.1 Mechanical and electronic voting initiative: 1849–1900

In 1856, The Australian state of Victoria becomes the first place to use uniform official ballots. This style of paper ballot, lists the names of all candidates and issues in a fixed order, and is counted by hand [Mary, 2000]. In 1888, Massachusetts becomes the first US state to adopt the Australian ballot system on a statewide basis. In January 1989, Herman Hollerith patents a method of using punched cards to compile data for the US Census. Later in November, Jacob H. Myers of Rochester, New York patents the first mechanical lever voting machine, called the Myers Automatic Booth, prevents over votes, speeds up the vote counting process, and significantly reduces the chance of dishonest vote counting because the votes are counted by machine [Jacob, 1889]. This machine was first used in 1892 in Lockport, New York.

Table -1: Mechanical and electronic voting initiative: 1849–1900

Year	Description
1849	De Brettes develops an electronic decision-making telegraph.
1856	Victoria, Australia first place to use uniform official ballots [Mary, 2000].
1859	"Werner von Siemens" develops this idea further with its first application.
1865	The first automated decision-making (Yes/No decisions) method used.

1869	An electro-mechanical device is developed and patented by Thomas Edison.
1888	Massachusetts adopts Australian secret ballot.
1889	Punch Card System Patented [Herman, Jan. 8]. Mechanical Lever Machine Patented [Jacob, Nov. 19].
1892	Lever Machine first used in Lockport, New York [Douglas, 2003].
1895	The first e-Voting company was founded - based on Jacob H. Meyr's invention.
1900	Japan started first secret ballot voting. On Dec. 14, 1900, the U.S. standard voting machine company was formed.

2.2 The legal and Policy issues initiative: 1901-1939

The legal framework for e-Voting technologies should ensure adequate protection of human rights. In particular, special consideration should be given within the legal framework of the impact of e-Voting technologies on the rights to vote by secret ballot, to be elected, and to participate in public affairs. The legal framework should determine the legal relationship between electronic and paper voting records as well as procedures to be followed in cases of discrepancy between them. It should include a clear calendar for the elections, including those aspects related to e-Voting.

Table 2: The legal and Policy issues initiative: 1901-1939

Year	Description
1901	State electoral laws, including the secret ballot, applied for the first election of the Australian Parliament. Denmark in connection with the shift of government [Danish: Systemskiftet].
1913-14	Allan Walsh of New Jersey introduced an electrical and mechanical system of vot e casting.
1915-16	Installed electrical voting system in the Wisconsin legislature, by Representative William Howard of Georgia.
1930	Used Lever Machines in almost Every Major US City [Mary, 2000].
1939	The reorganization act enacted April 3, 1939. [Wikipedia.]

2.3 DRE, Punch card, Optical scan lever machine etc. introduced: 1940-1990

Direct-recording electronic (DRE) voting system was originally introduced in 1986 (later in 1974). Modern DREs are physically hardened machines, preventing access to the typical PC connectors, e.g., USB ports [Weldemariam, 2010]. Punch Card Voting/Tabulation System was first used in Georgia, United States in 1962 (later in 1964). An optical scan voting system uses an optical scanner to read marked paper ballots and tally the results [VoterAction, 2008], was developed in the 1950's (also developed in 1962). Lever Voting Machines were first introduced in 1892 in New York [Douglas, 2003].

Table 3: DER, Punch card, Optical scan lever machine etc. introduced: 1940-1990

Year	Description
1940-1950	Don A. Allen, member of the California State Assembly and of the Los Angeles City Council in the 1940s and 1950s, urged adoption of voting machines for Los Angeles.
1955	"Erich Fromm" presents the idea of communicating and decision-making via interconnected technical devices.
1960	The first computers for tabulating votes have been developed. The first punch card machines have been developed and implemented.
1962	First Optical Scan Ballots used in Kern City, California [Douglas, 2003].
1965	Votomatic Punch Card Voting System Patented [Joseph, 1965].
1969	The first worldwide network, ARPANET Founding.
1970	"Murry Turoff" developed a computer supported Delphi panel.
1974	Direct Recording Electronic (DRE) Voting Machine Patented [Richard, 1974].
1977	Precinct-Based Optical Scan System Patented.
1982	Nebraska First to Officially Use American Information Systems (AIS) Central-Count Ballot Tabulator [Douglas].
1987	Shouptronic Electronic Voting Machine Patented [FKA, 1987].
1988	Report Warns of Problems with Pre-Scored Punch Cards [Roy, 1988].
1990	Touch screen or keyboard interfaces and online technology are developed. Federal Election Commission (FEC) Releases First Standards for Computer-Based Voting [FEC, 1998]. First Governmental Election Conducted over the Internet [Lorrie, 2003].

2.4 E-Voting matures and internet voting is born: 1991–1999

Today the keyword most often associated with Internet in Europe is e-Government. Internationally, many states are currently working on electronic voting (e-voting) solutions. This expression covers a broad range of ballot systems, from electronic ballot reading devices, to electronic ballot boxes installed in polling stations,

activated by buttons or touch screens, or to mobile phone voting systems. Only the United Kingdom and Switzerland have reached the step of developing an Internet voting application. However Estonia, the first country in the world, fully covered Internet voting including mobile voting. At present, several American states and the U.S. government are exploring REVS (remote electronic voting systems) via the secure electronic registration and voting experiment (SERVE) [Jefferson et al., 2004].

Table-4: E-Voting matures and internet voting is born: 1991–1999

Year	Description.
1991	Belgium, the first countries in the world, used Electronic Voting (Waarschot in Flanders and Verlaine in Wallonia) for the parliamentary and provincial elections. (The New Belgian E-voting System Carlos Vegas González)
1995	Belgium introduces e-Voting using a magnetic card inserted in a computer.
1996	First Governmental Election Conducted over the Internet [Lorrie, 2003]. Brazil introduces e-Voting for its Parliament elections. First Internet Voting at the candidate selection of the Reform Party (US). Finland tests electronic voting in polling stations.
1997	The city of Cologne, Germany, trials Electronic Voting Machine.
1998	First Internet Voting trial in Germany.
1999	Seven French cities test Internet Voting during the European Parliament Elections.

2.5 E-Voting hype and failures, continuous progress and maturation: 2000-2004

Faculty from the California Institute of Technology and the Massachusetts Institute of Technology create the Voting Technology Project in the wake of the 2000 election to provide "strong academic guidance in this intersection of technology with democracy." They offer several recommendations to improve election administration for the future in their July, 2001 report (What Is and What Could Be) [Caltech/MIT, 2001]. In May, 2002, The FEC releases an updated version of the standards for electronic voting systems. In July 2004, Nevada becomes the first state to mandate that all electronic voting machines used for federal elections be equipped with printers that produce a voter-verified paper audit trail [Dean, 2004].

Table 5: E-Voting hype and failures, continuous progress and maturation: 2000-2004

Year	Description.
2000	The university of Osnabruck develops and implements an Internet Voting System. The ICANN elects its five directors via the Internet.
2001	Voting Technology Project Publishes Voting: What Is and What Could Be [Caltech/MIT, 2001] .
2002 Oct. 29	The first e-Voting election in Japan at Niimi city of Okayama prefecture. This election ended successfully. Georgia First to Use Direct Recording Electronic (DRE) Voting Machines Statewide [Cathy, 2002]. India, the biggest democracy in the world has successfully used electronic voting machines (EVMs) throughout the entire country.
2003 Dec. 9	Election Systems Companies Form Information Technology Association of America (ITAA) "[ETC, 2003].
2004	Nevada Mandates Voter-Verified Paper Audit (VVPA) [Dean, 2004].

2.6 E-Voting systems guidelines and recommendations: 2005-2008

In Sept. 2005, The Commission on Federal Election Reform, chaired by President Jimmy Carter and former U.S. Secretary of State James Baker, releases a report. Building Confidence in U.S. Elections makes several recommendations for improving confidence in elections and modernizing election administration, including a recommendation that all DREs include voter-verified paper audit trails [Carter-Bake, 2005]. In 2006, HAVA requires that voting systems notify voters of over votes and permit them to review their ballots and correct errors before casting their votes. Also recommended that each polling place used in a federal election have at least one voting machine that is fully accessible for persons with disabilities" [CRS, 2003]. Florida Fair Elections Center Reports over 100,000 Florida Votes Not Counted in Nov. 2006 [FFEC, 2008].

Table 6: E-Voting systems guidelines and recommendations: 2005-2008

Year	Description
2005 Dec.	First legally binding internet voting channel available at the local elections in Estonia. Commission on Federal Election Reform Releases Report with Recommendations [Carter-Bake, 2005].

	Election Assistance Committee Adopts Voluntary Voting System Guidelines [EAC, US 2005].
2006 Jan. May. Sep. Sep. Nov.	HAVA Implements Over vote and Accessibility Requirements. [CRS, 2003]. Black Box Voting Demonstrates Electronic Voting Machines' "Backdoors" [BBV, Harri, 2006]. Computer Security Expert Installs Malware on Diebold Electronic Voting Machine in Less than a Minute [Edward]. Maryland's Governor Urges Voters to Use Absentee Ballots over Electronic Voting Machines [Robert, 2013]. HAVA Funds and Changes Increased Use of DREs [EDS, 2006].
2007 Jan. Dec.	EAC Denies CIBER, Inc. Accreditation [Christopher, 2007]. EVEREST Report Finds DREs Do Not Meet Computer Industry Security Standards [EverestReport, 2007].
2008 Jan. Nov.	Florida Fair Elections Center Reports over 100,000 Florida Votes Not Counted in Nov. 2006 [FFEC, 2008]. Presidential Election Runs Relatively Smoothly.
2009 June 5 Sep. 3	Sequoia Voting Systems Allows Access to Technical Information about DREs [Tim, 2009]. Diebold, Inc. Sells Election-Systems Business to Election Systems & Software, Inc. for $5 Million [Veronica, 2009].
2010	In Bangladesh, e-Voting with electronic voting machine (EVM) introduced.
2010 Sep. 13	Brennan Center Report Calls for Publicly Available National Database of Voting System Malfunctions [Brennan, 2010].
2010	The Philippines: Precinct Count Optical Scan (PCOS) -based e-Voting was introduced throughout the country.
2011	Security Experts Hack Voting Machines by Remote Control [Brad]
2012 Nov. 6	Long Lines Due to Voting Machine Malfunctions in 2012 Presidential Election.
2013	New York City Returns to Lever Machines for Primary Election and Runoffs [Thomas, 2013].
2015	In Estonia, 25% of the voters cast their vote over the Internet/online. Norway introduces Internet voting at the municipal elections for predefined communities. Swiss living abroad has the ability to cast their vote over the Internet.
Today 2016	HARVEY WASSERMAN upcoming book is The Strip & Flip Selection of 2016: Five Jim Crows & Electronic Election Theft**.**

2.7 E-Voting systems failures, vulnerabilities and hacking: 2009 – Present

In December 2005, Black Box Voting, Inc. sets up a demonstration in Leon County, Florida in which computer security experts Harri Hursti and Herbert Thompson are able to hack into the central vote tabulator of an electronic voting system and change the outcome of a mock election without leaving any trace of their actions. This exercise is considered to demonstrate that the software running electronic voting systems is vulnerable to tampering [Herbert, 2006]. In Sept. 2010, Brennan Center for Justice at NY, issues a report calling for a publicly available national database (2MB) containing information on voting system failures and vulnerabilities. The report finds that the same malfunctions occur frequently with the same machines in different jurisdictions. Election officials are often not aware of vulnerabilities because vendors are under no legal obligation to notify election officials of past system problems [Brennan, 2010].

*Table 7: E-Voting systems **failures, vulnerabilities** and hacking: 2009 – Present*

Year	Description
2009	Internet voting is used as an additional voting channel at the elections for the Austrian Student Federation in Austria

III. FURTHER WORKS

Further works need to be done in designing and incorporating extra protocols into the existing one to cater for elections where voters need to vote for multiple candidates at various levels of the government (for example a voter needs to vote for candidate X for presidency, Y for senate and Z for governor of a state etc.) at a go without having to vote individually for every candidate at separate times. The day is not far when e-voting will be the norm and people can exercise their franchise via the internet from own house rather than going voting zone without any corruption. But voters must have a substantive reason for trusting that their intentions have been correctly interpreted and recorded, and that their votes have been counted correctly. Future intention regarding electronic voting should be improve our capability and increase our knowledge in all the areas of cyber security [EV, 2013]. The new technology should be improved in such way – that anyone can ensure that the intent of the voters is reflected in the official tally of the vote, that they are credible when margins of victory may be as small as a fraction of a percent. Thus the future

electronic voting environment would satisfy the needs of voters and election officials, thus new rules and reliable, trustworthy voting systems would win over voters and would be known as the solution that overcome the constraints and save the democracy [Lewis, 2007].

IV. CONCLUSION

Here we have carerefuly examined the existing literature on electronic voting system as well as the pilot experiences of many jurisdictions. All these suggest that both the extremely optimistic and pessimistic positions about the effects of voting systems are overstated. We have also discussed the security requirements of electronic voting and highlighted the contradiction in some of these requirements. Finally we discussed limitations and suggested further works that should be done to address them. However, practical testing and pilot projects are the only ways of knowing what will work and what will not. Trials of particular methods will give the best insight into understanding what requirements must be met for modern voting to work well as well as the actual pros and cons of electoral systems. The modern electronic voting will not act as a panacea for the social causes responsible for electoral disengagement, nor will it remedy negative attitudes toward political entities. It will, however, increase voting opportunities for electors and make casting a vote more accessible. On the other side, electronic voting will not erode democracy or result in vote buying and election fraud any more than does the existing system.

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