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Voting Systems in the United States: An Examination of Histories, Degree of Use and Performance Characterisitics

CAPSTONE REPORT

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Abstract for

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Elections in the United States are conducted with widely varied voting systems. The purpose of this study is to better understand each system and to suggest potential changes. A review and content analysis of selected literature published between March 1982 and April 2002 identifies eleven specific voting methods and examines their history, degree of use and performance characteristics. An annotated taxonomy of systems is presented for use by election officials and the general voting public.

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CHAPTER I

Brief Purpose

The purpose of this study is to identify and examine voting systems used or currently proposed for use in presidential elections in the United States. Specific focus is placed on the history, performance characteristics and current applications of each method (Roth, 1998 and Nilsson, 2001). Literature review methodology (Leedy, 1997) is used to identify the most commonly used voting systems. Literature is collected from a comprehensive review of government and private industry research published between March 1982 and April 2002. Once identified, literature about each system is subjected to content analysis (Weber, 1990) in order to determine its history, performance characteristics and current applications. The results of this content analysis are presented as a taxonomy of voting systems for use by election officials and the general voting public.

Full Purpose

The National Clearinghouse on Election Administration contends that selection of voting equipment is one of the most important and long lasting decisions that election officials make (1982). The appropriate choice of system depends on variables such as usability for the demographic group, cost, accessibility, security and reporting accuracy (United States House of Representatives, 2001). Casting an individual vote for elected officials is a fundamental piece of the American democracy (Baltimore, 2000) and a critical examination of methods used to calculate those votes can aid voters' understanding of how elections are conducted in other districts around the country.

The purpose of this study is to identify and examine voting systems used or currently proposed for use in presidential elections in the United States. Public voting for the President of the United States is one of the fundamental pillars of democracy and yet there is no uniform balloting procedure in place today (Baltimore et al, 2000, p. 2). Recent Presidential elections raised questions about the state of current voting technologies and the possible need for change (Fischer, 2001). Because no Federal agency has ever been assigned ultimate responsibility for developing and maintaining standards for election equipment (United States House of Representatives, 2001, p. 4), the assumption underlying this study is that it is up to the public to remain informed about existing and emerging voting systems.

Voting is defined by Cambridge Dictionary Online as "to express your choice or opinion, especially by officially marking a paper or by raising your hand or speaking in a meeting" (2002). A voting system is "a combination of mechanical, electromechanical or electronic equipment-including the software and firmware required to program and to control the equipment-that is used to cast and count votes" (Federal Election Commission, 1990). Voting systems are grouped into the following categories: paper ballots, punchcards, electronic machines, computer-based and remote voting (Fischer, 2001, summary section). For the purposes of this study the terms voting systems and voting methods are used interchangeably.

The time frame for this study is focused on voting methods that were used during the 1996 and 2000 Presidential election and methods currently under development for possible use in the next presidential election. A history of each method is identified through content analysis performed on Congressional Research documents and independent reviews conducted by Computer Professionals for Social Responsibility. These histories are presented along with comprehensive descriptions of performance characteristics and current applications. In addition,

usability studies conducted by Susan King Roth (1998) and reports issued by the Election Reform Information Project (2001) and Computer Professionals for Social Responsibility (2001) provide the framework for identification of the strengths and weaknesses of each voting method.

The following voting systems are examined:

- Direct Recording Electronic
- Traditional paper ballots
- Hart Intercivic e-slate
- Internet
- Mechanical Lever
- Optical scan (Marksense)
- Punchcards (Datavote and Votomatic)
- Safevote Delta
- Vote by mail
- Election Systems and Software iVotronic

The new systems selected for review are Internet, Hart Intercivic e-slate, Safevote Delta and Election Systems and Software iVotronic. The Internet method of voting is selected because of the vast array of studies conducted on the feasibility of its implementation. Internet voting has recently captured the interest of election officials and citizens as an alternative to voting in person at polls or by mail (Alexander and Jefferson, 2000). This method has both benefits and potential dangers that are being carefully studied. Hart Intercivic e-slate is chosen because of its innovative, user-friendly PDA-style design and departure from all other methods in use today. Safevote Delta recently concluded its first real-time test in Sweden and therefore the information on its use is timely and pertinent. The Safevote Delta method is a new iteration of Direct Recording Electronic technology and as a result is appropriate for this study. The Election Systems and Software iVotronic is chosen because, like the Hart Intercivic, the interface is a PDA-style device. The iVotronic is ADA compliant, portable and has safeguards to stop overvotes and notify the voter about undervotes.

U.S. Presidential elections are conducted by states and local governments through approximately 10,000 jurisdictions and currently there are no universal mandatory standards in place for voting methodology (Fischer, 2001). In 1990 the United States Congress authorized the Federal Election Commission to develop national standards for voting machines. But those standards were voluntary and today 18 states have not adopted these standards (United States House of Representatives, 2001). More than ever before, state and local election officials are confronted by complexities in methods available to gather, record and tabulate votes. These officials are tasked equally with retaining the integrity of the democratic voting process while identifying new voting methods and examining existing ones (Fischer, 2001).

The method chosen to study the above voting methods and gather information about each one is literature review (Leedy, 1997). Documents gathered are limited to those written between March 1982 and April 2002. Keywords are used in searches of the World Wide Web, academic journals and United States government publications to gather related literature. Bibliographies of gathered literature are also consulted for additional sources. Each document is subjected to content analysis (Weber, 1990), which assists in breaking down the related literature into categories discussing the history of each voting method, performance characteristics, usability/reliability/performance and new methods.. These categories are then assembled into a taxonomy of voting methods and comprise the data presentation of this study.

The taxonomy resulting from this study is intended to assist officials, as well as the voting public, in understanding the performance characteristics of each method under review and to inform them of emerging methods being proposed for use in future elections. This information could be applied to discussions surrounding review of technologies in place now and those

proposed for use in future elections. A critical examination of each voting system is the right of every voter to make informed choices about how they cast votes.

Limitations:

Voting for elected officials has been an integral part of the United States democracy since its inception. Methods that citizens have used to cast votes have changed much through time, often reflecting current innovations in technology and machinery. Because of the high number of voting systems that have been implemented through the years, it would be difficult to assess those that are no longer in use or used sporadically. Therefore this study focuses solely on voting systems that were used in the United States in the 1996 and 2000 Presidential election and systems proposed for use in the next election. The intent is that this scope will further the purpose of this paper to provide voting citizens with relevant information on voting systems currently in use and those under development.

This study is limited to a review of literature located in government publications, academic journals and Internet articles published from March 1982-April 2002. March 1982 is the established beginning date for the collection of literature used in this study because on this date the Federal Election Commission published its second review of voting systems available on the market and this publication has not been re-published since that date (NCEA, 1982, introduction section). The Federal Election Commission review incorporated many of the voting systems still in use today. Its purpose was to provide elections officials with detailed, unbiased information on voting equipment products that were in the market. The report also provided explanations about performance characteristics of each product.

Due to the controversial nature of the 2000 presidential election, many editorial-style books and articles were published discussing the specifics of the problems that occurred and

calling for extensive change. Because most of these articles were written from political standpoints, it is impossible to extract unbiased reviews. Therefore the choice was made to use these articles solely to frame the context of the problem.

Government agency reports and academic journal articles are used to supply the information regarding voting systems in use during the 1996 and 2000 Presidential elections. These sources provide comprehensive statistical information collected after each election and provide unbiased surveys on their history, usability for the voter, and reporting reliability.

Three of the new methods (Hart Intercivic e-slate, Saftevote Delta and Election Systems and Software iVotronic) are examined solely through product information available on the vendor's website. Because they have never been used in a presidential election, there is no data on their real-time use in this context and these systems have not been examined by researchers for their usability or reporting reliability. The decision to include these methods in the examination despite lack of real-time use is supported by this study's overarching purpose to provide election officials and voters information about voting methods currently in use and those being proposed for use in future elections.

Vote-by-mail and the Internet have been used in elections and therefore the real-time use of these methods is examined along with data from research that has been conducted on their usability and reporting reliability.

The voting methods chosen for review are examined solely for their use in United States elections. Many of these same methods are also used for elections in other countries but for the purposes of this paper no foreign applications of these methods will be considered.

This study does not make conclusions about the validity of voting systems or recommendations on their use in future elections. Instead, the goal of this study is to provide

informational reviews of voting methods to voters in terms of selected categories including paper ballots, punchcards, electronic machines, computer-based and remote voting. The study is based on content analysis of articles selected according to the goals and limitations presented and is not intended to be an inclusive review of all literature on this topic.

Problem area/significance

Concerns surrounding voting methods used in United States elections have existed for many years and several times in the past, problems that have occurred during elections have spawned animated discussions about the need for change (Drinkard, 2001). During the 1970's there was an unexplained increase in vendors creating new "voting machines" and many states were eager to buy them and test them out in elections (Hunter, 2001, p. 3). This resulted in many different companies producing numerous different machines, none of which were being tested for meeting certain standards (NCEA, 1982). Election outcomes were often inaccurate and flawed. These sketchy results prompted many citizen furors and resulted in a government-funded study in 1975 regarding the declined integrity of the voting process (Hunter, 2001).

The first action taken by the government in response to these problems was in February 1975 (Hunter, 2001). At that time the General Accounting Office's Office of Federal Elections (now known as the Federal Election Commission or FEC) worked in tandem with the National Bureau of Standards to discuss guidelines for election administration. The purpose was to ensure the accuracy and security of the vote-tallying process (Hunter, 2001, p. 4). The resulting report, "Effective Use of Computing Technology in Vote-Tallying" (1975) concluded that the integrity of the voting process was being impeded by a lack of technical skills among state and local election administrators (Hunter, 2001). Additionally, the report concluded that the creation of "a National Election Systems Standards Laboratory would serve a valuable function...if established

to set national minimum standards for Federal election procedures assuring accuracy and security, and similar standards for election equipment and systems performance" (Saltman, 1993).

This report prompted Congress to direct the FEC and the National Bureau of Standards to conduct a study on the feasibility of implementing voluntary engineering and operational standards for voting systems (Hunter, 2001, p. 4). In 1982 this effort produced Voting System Standards: A Report on the Feasibility of Developing Voluntary Standards for Voting Equipment (FEC, 2002). Following the release of this feasibility study, Congress appropriated funds to allow the FEC to begin the development of voluntary national standards of voting systems (FEC, 2002). In 1990 the commission published the first national performance and test standards for three specific voting systems, punchcard, marksense and direct recording electronic systems (FEC, 1990).

From 1990 to 2001, 37 states adopted the proposed standards in part or in whole (United States House of Representatives, 2001). Many states, however, exempted equipment that was in use before 1990 from meeting the standards (United States House of Representatives, 2001). Interestingly, popular systems such as mechanical lever machines, punchcards and marksense were in use as early as 1892, 1964 and 1980 respectively (Fischer, 2001).

Changes to established voting methods are expensive and time consuming to implement, with most of the money coming out of state and local budgets (Alexander, 2000). Therefore, because money is always in short supply, these systems continued to be used heavily despite warnings from researchers such as Roy Saltman (Drinkard, 2001). Saltman identified flaws in the voting process as early as 1988, when he wrote that the Votomatic punchcard machines "were hard to use and vulnerable to error and should be banned" (Drinkard, 2001). The

Presidential election of 2000 brought their performance and the performance of all voting systems under increased scrutiny (Election Reform Information Project, 2001).

In November 2000, the United States witnessed an unprecedented presidential election, the results of which continue to be questioned today. In the months that have followed, citizens and legislators alike have brought forth discussions about differing voting methodologies, the design of the ballots used and the time delay in reporting final results. The controversial election illustrated to voters the significant flaws and limitations in the voting systems in use throughout the United States (NSCL, 2001). The contested results and ongoing controversy brought back into the forefront the 1975 FEC report that initially exposed the flaws in the existing voting systems. Inconclusive election results triggered statewide hand recounts, legal challenges and delays. No voting system was without criticism of some sort.

Though ultimately the election was called on Dec 13, 2000, 37 days after the vote was taken, it left many election officials, government legislators and citizens asking if there were better ways to conduct future elections. The victor won by 537 popular votes from the State of Florida, which gave him the needed electoral votes to win the election. The General Accounting Office, however, in a report to the Ranking Minority Member of the House of Representatives, found that 1.6 million votes nationwide were never counted (GAO, 2001). These votes were discarded for a variety of operational reasons.

The problems that occurred during the 2000 election were not unique, but were the same problems that had been reported for many years yet had continued to be overlooked for mandatory reform (Nilsson, 2001). During the 37 days of waiting for the decision on who was elected President in the 2000 election, the disparity in technology used to record and count votes and the timeliness of collecting and counting absentee or mail in ballots were two areas of key

concern (Election Reform Information Project, 2001). Americans began also critically looking at the ballots themselves, specifically their design and layout (Fischer, 2001). It was suggested that the flawed design of ballots was a major contributor to the problems that occurred in the 2000 election (Fresh Air, 2000). Interestingly, two earlier reports had previously identified poor ballot design as a concern to the integrity of elections. A 1984 report issued by a panel of the National Clearinghouse of the Federal Election Commission identified "the need to look at related human engineering standards; panelists stated that neither the manufacturer of the voting systems nor most state and local election offices pay much attention to how the voter interacts with the various voting devices" (Roth, 1998). Susan King Roth, through ballot usability tests conducted in Franklin County, Ohio, had also identified many of these ballot design shortfalls as early as 1998 (Roth, 1998).

The contested results of this election brought the design, layout and readability of ballots to the center of reform discussions (Drinkard, 2001). Previous reports had always focused on the mechanical system itself, its accuracy and privacy for the voter (Roth, 1998). The 2000 election brought to the attention of the general voting public the significant problems that could occur due to poor ballot and voting machine design (Alexander, 2000). The voters themselves were directly affected by confusing or unclear ballot layouts and this was reported by many voters to have resulted in a broken relationship between voters intentions and their actual recorded votes (Roth, 1998 and CSPR, 2001).

With the significant advances in technology that the United States has seen in the last half century, it was only a matter of time before Americans would consider applying that technology to the voting process (Hunter, 2001, p. 1). The changes however, are far from simple and require a great deal of research into ballot design, accuracy, timeliness, privacy, and accessibility for the

plethora of demographic groups that create the voting public (CVF, 2002). "Effective ballot design involves balancing the fairness and clarity of presentation, as well as goals such as promoting completion of the entire ballot by voters" (Fischer, 2001). Ballot design and layout is critical to accurate, intentional voting and a focus on the numerous voting demographic groups illustrates that one design does not fit all (Roth, 1998).

The most significant residual effect of the controversial 2000 election has been the American voter's skepticism and distrust of the election system (Clark et al, 2000). The high number of uncounted votes caused citizens to question their confidence that individual votes are meaningful in the United States. "The right to vote is perhaps the most basic and fundamental of all the rights guaranteed by the U.S. democratic form of government. Implicit in that right is the right to have one's vote count and the right to have as nearly perfect an election proceeding as can be provided" (NSCL, 2001).

The decision on which voting methods will be used is largely driven by the citizens in each jurisdiction bringing forward the issue to state and county governments (Alexander, 2000). Voters remain, however, underinformed about the sheer number of voting systems used in elections nationwide, their histories, developers, flaws and strengths (Grossman, 2001). According to the Center for Voting and Democracy, "great interest in election administration reform provides an excellent opportunity to lift our nation's voting equipment to new heights" (2002). Well-informed citizens could propose to legislators that specific technologies be reviewed for implementation in their districts and they could propose to have certain methods removed from future elections. No system is flawless but a critical examination of each system is the right of every voter to make informed choices about how they cast votes.

CHAPTER II

Review of References

The review of references section provides an annotated bibliography of the primary references that are used to develop the content of the study. It provides descriptions of the primary documents gathered to support the purpose of the study: to examine voting methods and ascertain history, performance characteristics and current applications. Primary references used to develop these areas are outlined as well as references used to develop the method of data analysis. The references are grouped into the following content categories: history, performance characteristics, usability/reliability/performance and new methods. For each reference the following areas are discussed:

- Key aspects of the reference relative to the purpose and problem of the study
- The role that the reference plays in the content of the paper
- The criteria used to select that reference

Resources Pertaining to the History of Voting Methods

Learning about the history of the various voting methods used in the United States helps voters to understand how these methods came to be developed and, in many instances, how little they have changed through the years. The following references provide detail on when the method was developed and what (if any) changes have occurred through the years with regards to its implementation and use.

Fischer, E. (2001). *Voting Technologies in the United States: Overview and Issues for Congress*. Retrieved April 8, 2002 from <http://cnie.org/NLE/CRSreports/Risk/rsk-55.cfm>.

Eric Fischer provides a brief history of each voting method used in the 2000 Presidential election, defining them by the following categories: paper ballots, punchcards, electronic machines, computer-based and remote systems. The purpose of this report, which was conducted by Fischer for the Congressional Research Service, is to provide the US Congress an overview of the current voting methods used in the United States and to outline for Congress what specific issues have been raised for their review.

This reference plays a critical role in defining exactly what the categories of voting methods are and how each one came to be in use. Fischer's work provides the foundation for the Full Purpose and Method portions of this study. His categories lend structure to the taxonomy that provide the data presentation.

Hunter, G. (2001). The role of technology in the exercise of voting rights [Electronic version]. *Law Technology*, 34, 1-14.

Hunter's journal article also provides a brief history of the voting methods used in the 2000 election, but more importantly Hunter provides a history of the voting systems standards discussion that began in the United States in the mid-1970's. Hunter explains in short but precise detail how the concerns raised in 1975 prompted the FEC and the National Bureau of Standards to conduct the first in-depth study of voting systems. This ultimately led to the development of the first performance and test standards for three voting methods (punchcard, marksense and DRE). Hunter's work provides content to the Significance portion of the study by lending structure to the history discussion. This reference is used because it supports a discussion of why the performance and test standards were developed and what the significant impact these standards would have on voting in the US.

Oregon Secretary of State (1998). *A Brief History of Vote-By-Mail*. Retrieved April 15, 2002 from <http://www.sos.state.or.us/executive/policy-initiatives/vbm/history.html>.

The Oregon Secretary of State web site has a variety of pages dedicated to Oregon's use of vote-by-mail in all elections. This particular web page describes in a date by date format how Oregon came to be the first (and so far only) state that conducts every election solely through vote by mail. Playing a key role in the Significance, Data Analysis and Results portions of the study, this history lists each legislative step the vote by mail decision took in Oregon, starting in 1981 and resulting in statewide implementation in 1998.

Resources Pertaining to the Performance Characteristics of Voting Methods

Before examining the usability and performance issues surrounding any voting method, it is important first to understand simply how each method works. Knowing what steps the voter goes through the cast a vote with each system provides the basis upon which critiques of usability can be based.

Caltech/MIT Voting Technology Project (2001). *Residual Votes Attributable to Technology. An Assessment of the Reliability of Existing Voting Equipment*. Retrieved April 15, 2002 from http://www.hss.caltech.edu/%7Evoting/CalTech_MIT_Report_Version2.pdf.

The Caltech-MIT Voting Technology Project was established in December 2000 as a direct result of the controversial 2000 Presidential election. Its purpose is to prevent a recurrence of the problems that threatened that election by combining the efforts of technology experts/professors from these two schools. As one of their earliest publications, this reference is chosen because it satisfies the goal of examining briefly each voting method and specifics about how it works to cast a vote. The methods are described in unbiased detail, but it falls short of

acknowledging the existence of remote voting methods (i.e. vote by mail). This reference lends content to the Results portion of the study, providing information for the history section of the taxonomy of voting methods.

Saltman, R. (1988). *Accuracy, Integrity, and Security in Computerized Vote-Tallying*. NBS Special Publication 500-158. Retrieved May 11, 2002 from <http://www.itl.nist.gov/lab/specpubs/500-158.htm>.

This study is Roy Saltman's seminal National Institute of Science and Technology paper on elections systems, probably the most-cited work on electronic vote-counting (CSPR, 2002). This study was completed solely with funding provided by the John and Mary R. Markle Foundation of New York City (no NIST dollars were applied). The Markle Foundation requested that this study be conducted because of concerns about the potential for fraud or inaccuracy in computerized voting methods. This reference proved to be a central one, providing much of the content to the Results section of the study and providing framework to the Significance section as well. Saltman's publication is cited in many other documents gathered and appears to be a document of origin for many other studies. In this paper, Saltman, who is now retired from the NIST and is a consultant on Election Policy and Technology, painstakingly describes in detail the types of vote-tallying systems, their vulnerabilities and their national distribution (in 1988). The study also reviews some past elections in which difficulties with accurate vote tallying occurred and offers recommendations in relation to the identified problems.

Resources Pertaining to the Usability/ Reliability /Performance of Voting Methods

Researchers suggest that the flawed design of ballots and voting systems was a major contributor to the problems that occurred in the 2000 election. Interestingly, however, these

problems were being discussed as early as 1975 but mandatory reform has, to date, not been implemented. Understanding what the specific flaws are in each design is a good beginning step to understanding what reforms might need to be made.

Center for Voting and Democracy (2000). *Vote-By-Mail*. Retrieved April 21, 2002 from <http://www.fairvote.org/turnout/mail.htm>.

The Center for Voting and Democracy is a non-profit organization dedicated to fair elections where every vote counts and all voters are represented. The organization conducts research, analysis, education and advocacy to build understanding of and support for more democratic voting systems (Center for Voting and Democracy, 2000). This reference is found on their web site and provides an unbiased account of the advantages and disadvantages of voting by mail. This reference is helpful in understanding all aspects of vote by mail as a voting method and augments the fairly one-sided information that is found on the web site for the Oregon Secretary of State. The information provided is applied in the Results section of the study.

Mercuri, R. Web site dedicated to Electronic Voting links and full papers and articles. <http://www.notablessoftware.com/evote.html>.

This web site, developed and maintained by Dr. Rebecca Mercuri, is integral in providing additional bibliographic references to papers, studies and Congressional testimony surrounding the topic of electronic vote tabulation. Dr. Mercuri is known in this field as an electronic voting expert (Rosati, 2001), successfully defending her Ph.D. thesis, entitled "Electronic Vote Tabulation Checks & Balances" at the School of Engineering and Applied Science at the University of Pennsylvania on October 27, 2000, just days before the national election. She has provided Congressional testimony, provided a sworn affidavit to the 11th Circuit Court of Appeals after the disputed election and published many official comments and studies on voting

automation and integrity. Mercuri's site also provides links to papers published by Roy Saltman and Susan Roth, which lends additional credibility to their publications. This web site provides links that helped form the content for many sections of this study, particularly the Significance and Results sections.

Roth, S.K. (1998). *Disenfranchised by design: voting systems and the election process.*

Retrieved April 8, 2002 from <http://www.informationdesign.org/pubs/roth1998.html>.

Susan Roth's study published in 1998 is cited and cross-referenced extensively in searches conducted during the course of this study. Published in the Information Design Journal, the study concluded that "greater attention to the usability and accuracy of voting systems during the development and evaluation stage would raise awareness and prevent disenfranchisement by design." Roth's study was conducted in 1993 and was conducted with a select sample of the voting population in Ohio (19 people total) under conditions simulating those found in polling places. Roth's focus on usability and accessibility in ballot design was the first of its kind and provided the framework for many discussions after the 2000 election. This study provides content to the Results portion of the study, specifically to the usability of mechanical lever machines and DRE devices. Roth's study is chosen for inclusion in this study because of its extensive citing by other researchers and its discussion on ballot design and how that affects voting results.

Resources Pertaining to New/Emerging Voting Methods

Understanding the voting methods in place today is important for election officials and voters, but equally important is learning about new methods that are under development, in testing or are being proposed for possible use in future elections. With this information, well-

informed citizens could propose to legislators that specific new technologies be reviewed for implementation in their districts. A critical examination of each system is the right of every voter to make informed choices about how they cast votes.

The following three references are vendor web sites, which all provide information on their particular voting system. The information provided on each product is understandably one-sided and presented in a marketing fashion. The Limitations section of this study explains that these new methods have never been tested in a presidential election and also have not been critically studied by any researchers, therefore the only available information of the products usability, accuracy and implementation is available through the vendor. The product information gathered from each web site is used solely in the Results section of the study.

Election Systems and Software web site.

<http://www.essvote.com/index.php?section=products&rightnav=products>

The ESS web site is comprehensive in its overview of its products and also ESS's relation to all aspects of election day. ESS currently provides election solutions to many elections including presidential elections. Their solutions currently include voter information and education, equipment maintenance and on site systems support. The iVotronic is their offering to new voting systems. Presented in a one-page PDF file, the information on the iVotronic device explains in detail the specifics of the device and how voters use it to cast votes. The web site offers feedback from clients and provides detailed documents on both the hardware and software portions of the iVotronic.

Hart Intercivic web site. <http://www.internetvoting.com/>.

This web site is the only site surveyed that provides an interactive guide to using their voting device. This device, which is PDA style in design, has been tested in two local county

elections and the results of those elections are posted along with a page that explains in detail the three devices available, the e-slate 3000 for the voting booth, the Judges' Booth Controller (JBC) 3000 for managing the election in the precinct and the Disabled Access Unit (DAU) 5000 which is a ADA accessible device. The Hart Intercivic web site is very forthcoming with product information and the simple page design made it easy to gather information needed to present this product in the Results section.

Safevote Delta web site. <http://www.safevote.com/products.htm>

In contrast to the Hart Intercivic web site, the web site presenting the SafeVote Delta voting system is very limited on product information and testing results. Reports from product tests require completion of an online request form and the information on the product's details are limited to a simple one paragraph overview.

Alexander, K. and Jefferson, D. (2000). *Internet Voting: Proceed Cautiously.*

Retrieved April 15, 2002 from

<http://www.calvoter.org/publications/internetvoting051600.html>.

The California Voter Foundation (CVF) is a non-profit group whose mission it is to advance new technologies to improve democracy. Kim Alexander is the President of the CVF and this article was written to discuss the need to move slowly towards full-scale implementation of Internet voting. Alexander defines two categories of Internet voting, Type I (county-controlled) and Type II, in which election officials do not control the machine used for voting. This reference is chosen because Alexander is the only researcher found who clearly defines the intricacies of Internet voting and details the dangers as well as the strengths in this voting method. Her findings are applied in the results section of the study.

Resources Pertaining to the Method of Data Analysis

The method chosen to analyze the documents collected in this study is conceptual content analysis. Resources are consulted that provide both theoretical framework and also real-time procedures for implementation. The information gathered from these references is used in the Data Analysis section of the study.

Palmquist, M (2002). Web site providing overview to content analysis. Retrieved April 22, 2002 from <http://writing.colostate.edu/references/research/content/index.cfm>.

This web site, produced by graduate students at the University of Colorado, provides an easy to read, useful introduction to the content analysis methodology. The site provides an overview on content analysis and is referenced specifically for its discussion and examples on conducting conceptual analysis. This web site is chosen to work alongside Weber's work because it is helpful in developing and understanding the steps involved in effective content analysis.

Weber, R.P. (1990). *Basic Content Analysis (2nd ed.)*. California: Sage Publications, Inc.

Weber's book provides a theoretical framework for content analysis and also discusses steps involved in effective implementation. For the purposes of this study, the Introduction section and Chapter 3 are used to provide a definition of content analysis, issues surrounding its use and techniques for document selection.

CHAPTER III

Method

This section describes the approach used to examine voting methods and ascertain history, performance characteristics and current applications. The section consists of an explanation of the research method chosen, followed by explanations of data collection methods, data analysis and the approach to data presentation.

A qualitative research method is used to study the variety of voting methods that were used in the 1996 and 2000 presidential elections. Qualitative research is defined by Palmquist as "empirical research in which the researcher explores relationships using textual, rather than quantitative data" (2002). The purpose of qualitative research is to describe and explain with flexible guidelines but staying bound by the context (Leedy, 1997). A qualitative approach leads to context-bound information and patterns that help in explaining a phenomenon (Leedy, 1997).

The research method chosen to study the articles and commentary written about voting methods is literature review. As posted on the writing web site for the University of Toronto, "A literature review is an account of what has been published on a topic by accredited scholars and researchers. In writing the literature review, your purpose is to convey to your reader what knowledge and ideas have been established on a topic, and what their strengths and weaknesses are"(2002). The scope of this paper is to provide an account of what has been published by scholars and researchers about voting methods, their specific performance characteristics and current applications. Analysis of the various perspectives and arguments is beyond the scope of the paper. Literature review is the best method to illustrate that this topic has been studied for many years and continues to be a topic of government and independent research.

Once selected, the literature is then subjected to content analysis, which is a research tool used to determine the presence of certain concepts within a set of texts (Palmquist, 2002).

According to Weber (1990), the central idea in content analysis is that the many words of the text are classified into fewer content groups. Therefore content analysis is appropriate to assist in breaking down the related literature into groups discussing the history of each voting method, performance characteristics, usability/reliability/performance and new methods. The method of content analysis chosen to review the literature is conceptual analysis, in which the focus is on looking at the occurrence of selected terms within a text or texts, although the terms may be implicit as well as explicit (Palmquist, 2002).

Data Collection

Several reference sources are used to identify key literature reviewing voting methods. In all searches, the following key terms and different combinations of them are used:

- Voting Methods
- Voting Machines
- Voting systems
- Voting Technology
- 2000 Presidential election
- Election technology
- Election reform
- Ballot design

Since the purpose of this study is to identify and examine voting systems used in presidential elections in the United States, the terms voting systems and voting methods (which are used interchangeably) are queried in the search process. Much of the research gathered discusses problems with current systems and suggested reforms, therefore election reform and ballot design are also used as key search terms. Other terms are extracted from studying key search

terms used in related documents. Many of the documents gathered discuss suggestions for voting method reform with specific emphasis on the 2000 Presidential election.

Discussions surrounding specific voting methods and particularly discussions on performance characteristics are found in abundance in a variety of different locations. For this study, document gathering is conducted from the following sources:

The Internet:

Search engines used on the World Wide Web are www.google.com, and www.northernlight.com. Rated by CNET.com as "one of the smartest search engines around", www.google.com provides no frills searches and precision results. ZDNet Reviews called www.northernlight.com "A tremendously powerful search engine with unparalleled capabilities and resources." These two search engines provide much of the data collected regarding significance, problem area of the study and performance characteristics of the chosen voting methods. Documents gathered on the Internet are limited to those written between March 1982 and April 2002. March 1982 is the established beginning date of this review because on this date the Federal Election Commission published its second review of voting systems available on the market and this publication has not been re-published since that date (NCEA, 1982, introduction section). Much of the information found through these search engines is editorial in nature which results in their application primarily to the significance/problem area section of the study.

The NEC Research Index is also used to locate research articles on performance tests and usability studies. NEC Research Institute (NECI) is a research institute which conducts long-term, fundamental research in computer and physical sciences (NECI, 2002). Searches are

conducted through an index of their research located at <http://citeseer.nj.nec.com/cs>. These documents are research-based studies and their results provide content to the significance and analysis portions of the study.

The Internet is also used to gather product information on the new voting methods chosen for this study. This information is found solely on vendor web sites for each of the products.

Journals and other publications:

A search for academic journals and other publications is conducted using Janus Online Information System available through the University of Oregon library system. Sources consulted include Orbis Union Catalog and WorldCat. Sources are retrieved both electronically and also from the Portland State University library. As with the other sources, documents gathered are limited to those written between March 1982 and April 2002 due to the FEC 1982 publication of its second (and most recent) review of voting systems available on the market (NCEA, 1982, introduction section).

Library Collections:

The Portland State University online database is used to gather published studies and hearings from United States House of Representatives, the Federal Election Commission, and the General Accounting Office. Further documents are gathered from thorough scans of library shelves containing similar material. The documents gathered in this library collection provide historical information on voting issues and text publications of government studies and resolutions surrounding the topic of voting methods in the United States.

Bibliographies:

As documents gathered from the above methods are reviewed, additional sources are discovered through review of their bibliographies.

The above searches produce a plethora of related literature and therefore all documents are reviewed for the following limiting criteria. Documents are chosen for inclusion if they meet one or more of the following criteria. Each of these criteria are formed directly from the stated limitations of this study.

1. Discussion of specific voting methods still currently in use and how they work to cast a vote.
2. Discussion of specific problems with voting methods that were found during the Presidential elections of 1996 and 2000.
3. Discussion on the history of voting methods, usability for the voter and reporting reliability by research and/or government institutions.
4. A research based approach vs. editorial-style writing.
5. Statistics produced which lend detail to described problems.
6. Discussion solely on elections in the United States. No foreign applications of the same voting methods are considered.

Data Analysis

The approach to data analysis for this study is conceptual content analysis. As defined above, the central idea in content analysis is that the many words of the text are classified into fewer content groups (Weber, 1990). The first stage of data analysis according to Palmquist (2002) involves the organization of collected documents based on their content. "To conduct a content analysis on any such text, the text is coded, or broken down, into manageable categories on a variety of levels--word, word sense, phrase, sentence, or theme" (Palmquist, 2002).

Documents are first sorted by content into the following content groups: history, performance characteristics, usability/reliability/performance and new methods. These groups are chosen because, although different in perspective, the combination of all of them provide the framework for the taxonomy of voting methods resulting from this study. After sorting, the documents are then examined for amount of information contained on its content group. The documents are also examined for writing style, with editorial style writings incorporated only into the Significance section of the study and research based approaches providing content to the significance and analysis portions of the study.

For this study, conceptual analysis occurs at the second stage of data analysis. This stage involves identification in the selected literature of both implicit and explicit terms. Explicit terms such as "ballot design, 2000 election, and voting methods" and implicit terms such as "election reform" are used to identify literature directly related to the study.

In the third stage of data analysis, voting methods are separated into the following categories: paper ballots, punchcards, electronic machines, computer-based and remote systems (Fischer, 2001, summary section). Although there are a variety of different voting methods, all existing methods can be classified into one of the above categories (Fischer, 2001). Each voting method identified through the literature is further defined by what category it is, its development history, performance characteristics and extent of application in the 1996, 2000 and future elections.

The results of the three stages of content analysis provide information used to create the structure for the resulting taxonomy of voting systems, developed through this study. Editorial-style writings and argumentative writings are not included for the resulting taxonomy. These documents are used solely to support the Significance section.

Data Presentation

The documents selected during literature collection and then analyzed are examined to gather information on specified voting methods, their history, performance characteristics and application in the election process of the United States. The resulting information is presented in a taxonomy of voting methods used currently in the United States. This taxonomy is presented as the final outcome in the Analysis of Data section of this paper.

In the taxonomy, the specified voting methods are classified by their category (paper ballots, punchcards, electronic machines, computer-based and remote systems). Each method is listed in its proper category along with discussion on its history, performance characteristics (including strengths and weaknesses) and current application. A taxonomy presentation was chosen to simplify the classifications for the intended audience. The taxonomy resulting from this study is intended to assist officials as well as the voting public in understanding the voting methods used across the country and those under development for possible use in future elections.

CHAPTER IV

Analysis of Data (Results)

Using the data collection techniques outlined in the Methods chapter, twelve documents and web sites are selected for content analysis. These references provide information on the eleven identified voting methods, specifically their history, performance characteristics and extent of application in United States elections. The first stage of data analysis according to Palmquist (2002) involves organization of the references by content group, in this case, history, performance characteristics, usability/reliability/performance and new methods. The following are the references selected:

Resources Pertaining to the History of Voting Methods

- Fischer, E. (2001). *Voting Technologies in the United States: Overview and Issues for Congress*.
- Hunter, G. (2001). The role of technology in the exercise of voting rights
- Oregon Secretary of State (1998). *A Brief History of Vote-By-Mail*.

Resources Pertaining to the Performance Characteristics of Voting Methods

- Caltech/MIT Voting Technology Project (2001). *Residual Votes Attributable to Technology. An Assessment of the Reliability of Existing Voting Equipment*.
- Saltman, R. (1988). *Accuracy, Integrity, and Security in Computerized Vote-Tallying*.

Resources Pertaining to the Usability/ Reliability /Performance of Voting Methods

- Center for Voting and Democracy (2000). *Vote-By-Mail*.
- Mercuri, R. Web site dedicated to Electronic Voting links and full papers and articles.
- Roth, S.K. (1998). *Disenfranchised by design: voting systems and the election process*.

Resources Pertaining to New/Emerging Voting Methods

- Election Systems and Software web site

- Hart Intercivic web site
- Safevote Delta web site
- Alexander, K. and Jefferson, D. (2000). *Internet Voting: Proceed Cautiously*

The data analysis section of the Methods chapter also outlines the second stage of analysis in which the eleven voting methods are reduced into the following five categories: paper ballots, punchcards, electronic machines, computer-based and remote systems (Fischer, 2001). Each of the twelve references is analyzed and its content is incorporated into one or more of these five voting method categories.

A summary of the analysis is presented in this chapter. The summary is organized into the larger five voting method categories from the second stage of analysis. A discussion of each of the eleven voting methods is presented in full in terms of information on the history, performance characteristics and extent of application, in the appropriate larger category. Presenting a full discussion of each voting method is designed to aid the audience if they only seek information on a particular voting method.

The eleven voting methods presented are:

- Direct Recording Electronic
- Traditional paper ballots
- Hart Intercivic e-slate
- Internet
- Mechanical Lever
- Optical Scan (Marksense)
- Punchcards (Datavote and Votomatic)
- Safevote Delta
- Vote by Mail
- Election Systems and Software iVotronic

Paper Ballots

Traditional Paper Ballots

Paper ballots are ballots printed on paper and designed to be read by humans rather than machines (Fischer, 2001). The names of the candidates are listed and voters use a writing tool to mark their choices. The most common form of a paper ballot has the candidates listed by office although at times the ballot can be organized by party, allowing the voter to vote for an entire slate with one mark. The completed ballots are deposited into a general ballot box, which is then emptied by election officials and the votes counted by hand (Fischer, 2001).

The paper ballot used in the United States is known as the "Australian ballot" because it was first adopted for use in the Australian state of Victoria in 1856 (Saltman, 1988). The Australian ballot had its first United States statewide application in New York in 1889 and it was widely adopted because of a series of previous scandals involving vote-buying, lack of secrecy and other integrity problems. Prior to the use of this paper ballot, typical United States elections required citizens to announce their votes publicly or tell them to a sheriff who recorded them. There were also party-specific paper ballots, with different colors revealing party choice (Saltman, 1988).

In the years after it was first adopted, paper ballots solved many of the voting problems that were being experienced in the United States. They provided secrecy and reduced vote buying and intimidation. But paper ballots are still vulnerable to fraud, inaccurate counting and maliciousness. Ballot stuffing, in which extra ballots are fraudulently placed in a ballot box, is a common problem with paper ballots. Proper accounting for ballots distributed and entered is the best way to ensure this problem is minimized (Saltman, 1988). Hand counting of ballots is generally inaccurate and subject to human error. It is not uncommon as well for paper ballots to be maliciously invalidated by extra marks being made on the ballot, causing them to be thrown

out. As of 2001, paper ballots are still used in about 3% of precincts in the U.S., down from 11% in 1988 (Fischer, 2001). Precincts that use paper ballots tend to be in less populous areas and rural communities.

Optical Scan (Marksense)

Optical scan, or Marksense ballots are not commonly categorized as paper ballots and a thorough examination illustrates that this ballot type is a combination of paper ballot and computerized voting. This section describes the paper ballot qualities of the optical scan. The computerized aspects are described under the section for computer-based voting.

The technology behind Marksense has been used for decades in the United States in standardized testing. It became available for voting in the 1980's (Saltman, 1988). With a Marksense ballot, ballot choices are listed on the paper next to a small rectangle or circle. The voter makes a mark with a pen or pencil in the small rectangle or circle on the paper ballot to indicate the vote. The ballot itself is usually larger than other ballot types because the names of the candidates and issues are printed directly on the ballot. Write-in votes can be placed on the ballot as well. As of 2001, approximately 25% of precincts in the United States use Marksense ballots, almost double the amount since 1992 (Fischer, 2001).

Punchcards

The first voting method to utilize computers and technology was the punchcard system (Saltman, 1988). Designed and first used in the United States in 1964, this method requires the voter to record a vote by punching holes in appropriate locations on a paper ballot. That ballot is later fed into a machine that reads the holes and records the votes (Saltman, 1988).

The punchcard voting method was developed at a time when punch card input into mainframe computers was commonplace and this design was the template for the new system (Saltman, 1988). At the time, punch cards and punch card readers were widely available and the standards used for mainframe systems were adopted, specifically the size of the punchcards and the arrangement of the holes. The standard punch card used for mainframe input had a very specific code that was adhered to for arrangement of holes (the hole pattern represented characters). Using a punchcard to record votes required more flexibility in the hole locations but the card readers still required that the holes be arranged in a single column with certain locations on the ballot restricted.

There are two types of punchcard systems used in the United States: Votomatic and Datavote (Fischer, 2001).

Votomatic

In the votomatic punchcard design, the locations on the card where voters may punch holes are assigned numbers. The number is the only information printed on the card (Saltman, 1988). Because of the lack of text, there is more space available on the card, reducing the total number of cards needed per voter. The votomatic design is cost-effective because it is generic for any election and, although using only one side of the card, the cards are designed to allow for 228, 235 or 312 vote locations (depending on the size of the card chosen) (Saltman, 1988).

The voter slips the votomatic punchcard onto a stub with two holes located on a mechanical holder. The holes are designed to prevent the voter from inserting the card upside down or backwards. A hinged booklet containing the names of candidates and issues is attached to the mechanical holder and is centered over the punchcard. As the voter turns the pages of the booklet, the appropriate vote locations on the punchcard are exposed for the votes being

presented on that page. Each time the page is turned different vote locations on the punchcard are exposed (Saltman, 1988).

The votes are cast by the voter using a simple stylus tool and punching out the hole at the location they wish. Votomatic cards are typically pre-scored but nonetheless sufficient pressure is required to completely punch out the desired hole. There is also a spring-loaded stylus that can be used, eliminating the need for pre-scored cards. The piece of paper that results when the hole has been punched out is called a chad (Fischer, 2001).

The 2000 Presidential election brought back into the forefront vulnerabilities with the votomatic punchcards that were identified by Saltman in 1988 and discussed in the years that followed. According to Saltman (1988), the primary problems with these cards center around voter confusion while associating the number on the card to their desired candidate and also incomplete punching of the holes (known as hanging chads). Pre-scored cards have been known to have chads fall out unintentionally while partially punched out holes can be set back into place when the cards are all stacked together.

The votomatic system is also criticized for its poor usability. This system requires voters to turn over many successive pages to see all of the choices and at times voters will fail to see all of the pages in the booklet (Saltman, 1988). In addition, write-in votes must be written on the outside of the ballot envelope provided to the voter. Unintentional votes can also result if the mechanical holder and the booklet are not perfectly aligned. Poor assembly and maintenance of the mechanical holder can also result in holes not being punched thoroughly. These problems can all result in a vote being invalidated. The votomatic ballot readers are also vulnerable to problems when reading the completed punchcards. Cards can jam in the machine, leaving the

question of whether or not the card was counted. The machines can also accidentally pull in two cards at a time, resulting in inaccurate reading.

Despite the identified problems, however, this method is currently used in 33% of all precincts in the United States, particularly due to costs (Fischer, 2001). Blank punchcards cut down significantly on costs associated with elections and the low price of mechanical holders allows each precinct to own several of them. Because of this many voters may vote simultaneously and the voting process can be more efficient. Additionally, the ballot readers are manufactured to specific dimensions and standards. Consistent use of these standards, along with proper training of election officials, helps to reduce the occurrence of problems.

Datavote

In the datavote punchcard design, the name of the candidate or issue is printed on the card directly next to the location where the hole is to be punched (Saltman, 1988). Because of the text printed on the card and the spacing used between lines, there are fewer selections that can be printed on each card but the datavote card provides a simple line under each category for write-in votes. The punch locations are on the right hand long edge of the cards and the datavote cards can also be turned over so that the other long edge is on the right, providing more voting locations per card.

Unlike the votomatic punchcard system, with the datavote system there is no ballot book. The voter places the punchcard in a stapler-like tool on a slide. The tool creates a hole and the cards are not pre-scored. The voter moves the tool up and down the slide, positioning it to the desired location and then punching a hole. The low cost of the stapler-like tool allows each precinct to own several and therefore multiple voters can vote simultaneously, making the voting process more efficient (Saltman, 1988).

The datavote system is more user-friendly than the votomatic system because the holes line up directly with the candidate or issue, eliminating cross-referencing between the ballot book and card (Saltman, 1988). This system eliminates any problems with incomplete punching and hanging chads, but the use of text directly on the card can result in the need for multiple cards per voter. Additional cards increase expenses for the precinct and there is a possibility that the voter may forget to turn all of their cards in to be tabulated. When more than one datavote card is issued to each voter, the time to process votes increases. For these reasons, the datavote punchcard system is only used in about 4% of precincts in the United States as of 2001 (Fischer, 2001).

Machines -Mechanical and Electronic

Mechanical Lever

Mechanical lever machines were first introduced in New York in 1892 (Saltman, 1988). This voting method is categorized as an electronic machine because there is no paper ballot involved except for write-ins. In this machine, horizontal levers are arranged on the face of the machine and each candidate or issue is assigned a particular lever. The levers all begin in the same horizontal position. A piece of paper is visible to the voter and tells them which lever corresponds to each selection.

The voter enters the machine booth and pulls a handle that turns the machine on and closes a privacy curtain. To record choices, the voter pulls down the desired levers. Once voting is completed, the voter opens the privacy curtain with the handle and exits the booth. The machine then returns all levers to their original position. As each lever returns, a counting mechanism inside the machine turns one-tenth of one rotation. The position of each counter, read

by poll workers at the end of the voting period, indicates the number of votes that were cast for that lever/voting choice. Write-in votes must be written on separate paper ballots.

Fraud and other problems that were being experienced with paper ballots caused the United States to embrace the mechanical lever machines and until the introduction of punchcards, lever machines were in place in nearly half of the voting districts (Saltman, 1988). Like all systems, however, there are vulnerabilities and possibilities for problems along with benefits.

With the mechanical lever machines, there are no ballots so there is no audit trail of an individual voters' entries. Once the voter leaves the booth, their entries are recorded into the counter and the levers are reset for the next voter. Mechanical lever machines also offer no true recount capability. Counter values can be verified but there is no additional place votes can be checked. The machines are large and heavy, requiring additional expense to store and transport them. Setting up the machines on election day requires knowledge in setting up interlocks, which prevent overvotes, and maintaining the counters throughout the day for accuracy.

Write-in votes also present difficulty because the lever machines are not programmed to respond to individual choices. Therefore write-in selections can be added, but at some difficulty and loss of privacy for the voter.

Roth, in her study *Disenfranchised by Design: voting systems and the election process* (1998), studied the usability of mechanical lever machines with nineteen subjects from all age groups. The study concluded that there was "a failure to consider human factors and human scale in the design of the machine displaying the ballot" (Roth, 1998). Many of her subjects reported that type size on the ballot papers was often too small to read but the layout of the ballot (in traditional Western reading order of left to right and top to bottom) made following the process

easier. The subjects also reported that the display height of the ballots tended on average to be above eye level, causing subjects to not see some ballot items. Poor organization of information on the ballot also caused some confusion for the subjects as to which lever was associated to which selection.

Mechanical lever machines do, however, have their strengths and are still a voting method used regularly. Although the machines are no longer manufactured, maintenance is not very high and parts are still available. The machines have interlocks which prevent overvotes and each position has flashing red lights which stop flashing when a vote is recorded, decreasing undervotes (Saltman, 1988). The use of these machines is decreasing but they are still used in approximately 22% of all precincts (Fischer, 2001).

Computer-Based

Direct Recording Electronic

Direct Recording Electronic machines (DRE) are currently used in only 7% of precincts in the United States but their use has doubled since 1992 and is expected to continue to increase (Fischer, 2001). First introduced in the 1970's, this method is a computerized version of the mechanical lever machine (Saltman, 1988).

Like the mechanical lever machine, the DRE has no paper ballot. The voting choices are displayed to the voter on the computer screen or sometimes on a ballot posted on the machine. Voters make their choices by touching the screen, using a keyboard or pushing a button. The votes are stored in computer memory and at the end of the voting period summaries of all the votes are downloaded.

DRE technology is becoming increasingly popular and its flexibility allows for various implementations. Precincts can provide multiple independent computers for vote entry or provide

multiple stations all connected to a central server located at the precinct (Saltman, 1988). The latter is more cost-effective, with the votes all summarized in one computer, but the chance of data loss increases if the server fails. Overvotes are prevented on DRE machines and the voter is presented with a summary of their choices before they are recorded by the computer, reducing undervotes. Write-in votes are aided if the DRE uses a keyboard (Saltman, 1988).

As with any voting method, however, DRE machines have vulnerabilities. Each DRE machine receives the ballot information to be presented to the voter from a central source. While this reduces the amount of errors at the precinct and increases efficiency, if a mistake is made at the central source it is propagated throughout the system. The DRE machines also do not provide an audit trail of individual voter choices. The voter is presented with a summary of their votes before submission, but there is still no proof that those choices are ultimately recorded correctly into the system memory.

The lack of individual ballots also raises concerns about the possibility for fraud and tampering with the system memory. The software used must be free of errors, secured from tampering, and the download process must be reviewed and maintained for accuracy.

DRE technology is cost-effective and if developed correctly the software can be used in multiple elections. Sufficient safeguards must be implemented, however, to ensure that the software and hardware accurately collect and tabulate the data entered by the voter.

Hart Intercivic e-Slate (<http://www.internetvoting.com/>)

Hart Intercivic is a company that states that they are dedicated to developing technology to aid state and local governments in providing more efficient, effective and accessible election solutions. Hart InterCivic produces the e-Slate electronic voting system which is an iteration of the DRE voting method.

E-Slate automates the recording of votes through a PDA-style device known as the e-Slate 3000. Voters hold the palm sized device in their hands and enter votes using a rotary button and enter button located on the front of the device. The ballot choices are displayed on the polycarbonate screen. E-Slate prevents overvoting and alerts voters when an undervote has occurred. At the end of voting, the device provides a summary of undervotes and provides voters with visual confirmation of cast votes. Voters press a button labeled "cast ballot" to enter their final choices. The results are then transmitted via modem by precinct officials to a central location.

Voters are provided with an individual access code which is used when entering votes. This allows the e-Slate to provide an audit trail for each voter and the results are stored in three separate computerized locations, reducing the chance of data loss. Unlike the other voting methods, the e-Slate has a Disabled Access Unit that is specially designed for people with disabilities. Similar in size and design to the e-Slate 3000, this unit includes special interfaces for the physically challenged, including head movement switches and "sip and puff" switches (that allow voters to cast their ballot using only their breath). There is also an audio ballot reader to support visually impaired voters, including audible signals that provide confirmation with each selection. The e-Slate is portable and wireless, allowing for curbside voting and adjustment to wheelchair height.

The e-Slate election system includes a Judges' Booth Controller (JBC 1000) which is used by election officials to manage the election at the precinct. This device manages twelve e-Slate 3000 devices and also controls the modem transmissions to the central location. The JBC 1000 can also see which devices are currently in use.

The e-Slate system was used in three counties during the 2000 presidential election. Two of those counties used the system for early voting and one county used the system on election day. The Hart Intercivic web site provides feedback from these counties and their local newspapers supporting this product for its ease of use, accessibility to disabled voters, and fast, efficient ballot tabulation.

Safevote Delta (<http://www.safevote.com>)

Safevote is a software company dedicated to developing private and secure voting solutions. Safevote also offers internet or remote voting systems. At the forefront of their products are the essential qualities of voter privacy, vote secrecy and election integrity. Their main product, known as Delta, is software that is made for DRE systems. Delta includes the Witness-Voting system which is able to verify whether what the voter confirms on the screen is what is actually recorded and counted. However, paper ballot printouts may be added if desired. The Safevote Delta software provides each voter a Digital Vote Certificate (DVC) which ensures privacy and also ensures an audit trail for each voter's entries.

Specific information on how the Safevote Delta is used or implemented is unavailable on the company web site or elsewhere. In addition, there is no information on Delta's accessibility for disabled voters. The Safevote web sites does, however, provide information on their March, 2000 participation in Sweden's first Internet election, lending credibility to the company's mission of being a technology leader in remote election solutions. Feedback on their web site from Swedish election officials support their use of Delta in the future.

Election Systems & Software (ES&S) iVotronic

(<http://www.essvote.com/index.php?section=products&rightnav=products>)

The ES&S iVotronic is a DRE style system similar to the Hart Intercivic e-Slate. The iVotronic is a touchscreen voting system that weighs just less than ten pounds and is one foot square in size. The system has a Personalized Electronic Ballot that is downloaded onto the device for each voter by an election official. A 12" or 15" backlit screen is the main interface for voters. It has full color capabilities and displays ballots, pictures, and multiple languages. An attached stylus or fingers can be used to enter selections on the touchscreen.

The iVotronic presents a summary screen when voting has been completed and gives the voter an opportunity to go back and change any votes. The device does not allow overvotes and alerts the voter when undervotes have occurred. At the arrival of the summary screen, a button labeled VOTE illuminates. Pressing this button casts the final votes and saves them into the system memory.

The iVotronic has audio capabilities for hearing impaired voters with the use of headphones ensuring privacy. There are also Braille selection buttons on the device for visually impaired voters. The ballot selections are presented through a computerized "voice" and headphones are again used to ensure privacy. Like the Hart Intercivic e-Slate, the iVotronic is portable and wireless, allowing for curbside voting and adjustment to wheelchair height.

The integrity of the votes gathered with the iVotronic is ensured as votes are recorded in three computer memory locations to reduce the threat of data loss. The device also has a patented recount system which allows replication of the entire election process including production of all ballot images for validation.

No information on protection against voting fraud was presented on the vendor web site or elsewhere. It is unclear how the device ensures that every voter only votes once. There was also no specific information regarding anonymity of the voter and their choices. The iVotronic

has not been used in any presidential election, but in February, 2002, the state of Florida purchased 7,250 iVotronic devices to use in 25 counties in upcoming elections.

Optical Scan (Marksense)

This section will describe the computerized aspects of the optical scan or Marksense voting method. After the voter completes voting by marking selected choices on the paper ballot, the ballots are placed into a machine which uses light as a sensor. The light is beamed onto the voting locations on the ballots and the quality of the beam reflection tells the machine if a mark is present or not (Saltman, 1988).

As with any of the machines detailed, accuracy of the ballot reader is fundamental. Marksense systems are vulnerable to being too sensitive, recording erased marks, and also not sensitive enough, failing to record marks that are not very dark. Jams in the machine can cause workers to question if the ballot was counted. With the Marksense readers there also seems to be a fraction of all cards that are rejected by the machine and fail to be read for unknown reasons. Typically these ballots are reentered into the reader and given another chance. There is no process in place for hand counting those ballots that remain unreadable by the machine.

Remote Systems

Internet

The possibility of Internet voting has captured the interest of election officials and voters as a modern-day alternative to paper ballots and traditional methods (Alexander & Jefferson, 2000). It seems to many people the next logical step in a society which has embraced the Internet and all that it offers. Internet voting is different from DRE systems because voting is completed on a general purpose computer instead of a specially designed voting machine. Results of Internet voting are not accumulated at a central polling location but rather are sent to a central

computer located elsewhere. Results are transmitted via the Internet instead of a direct secure connection (Alexander & Jefferson, 2000).

The California Voter Foundation is a non-profit, non-partisan organization established in 1994 to study and advance new technologies that improve democracy. The topic of voting over the Internet has been one of their central interests since the controversy surrounding the 2000 presidential election. Their research has concluded that there are two categories of Internet voting, Type I systems and Type II systems (Alexander-Fresh Air, 2000 and Alexander & Jefferson, 2000).

Type I systems are controlled by the precinct, with the voting hardware and software located in central places under the control of election officials (Alexander-Fresh Air, 2000). Examples in this category would be Internet voting machines at poll stations or Internet kiosk machines (resembling ATM machines) located at selected places around the county. These locations would typically be open to voters for days or weeks prior to the election, allowing many more locations and more time to vote.

Type II systems are those systems which are not in central places and are not under the control of election officials (Alexander-Fresh Air, 2000). Examples in this category would be school or office computers, systems that allow for voting from home or remote computers located around the world.

With both types of systems there are concerns regarding security, privacy and accessibility for all voters. Both types of systems are vulnerable to the same denial-of-service or other malicious computer attacks that all network computers are open to. Type I and II systems are also vulnerable to virus attacks, which could result in unauthorized spying on people's computers or even intercepting and/or changing their vote during transmission (Alexander &

Jefferson, 2000). Encryption techniques and firewalls are helping to avoid these problems but are not fail-safe yet.

Type II systems are vulnerable to breaches in privacy, primarily because these computers can exist in unsecured settings. Vote-coercion by influential people could disrupt the integrity of the vote and businesses that use employee-monitoring software could undermine voter privacy for those voting at work (Alexander & Jefferson, 2000).

Accessibility is also a key criticism of Internet voting. Type I systems are more apt to enable voting by all people, regardless of age, demographic group or physical ability. Type I systems, because they are controlled by election officials, would be legally bound to provide disabled access and to provide election workers to help voters with any confusion they experience while voting. Type II systems, in contrast, would show preference to prosperous people who own their own computers and those who are employed and have access to a computer (Alexander & Jefferson, 2000). Older generations might be disadvantaged because of a lack of computer experience and comfort with that technology.

There are also questions raised about how to ensure that each voter only votes once and what type of audit trail or recount procedures would be provided. In our democracy citizens have the right to witness counting of votes, something that would be virtually impossible if the votes were all entered electronically over the Internet to one central computer location (Alexander & Jefferson, 2000).

Internet voting has not been widely implemented but experimentation with this new method is occurring. In 2000, Arizona conducted their Democratic Primary over the Internet and that same year 200 overseas personnel were allowed to cast their November election ballots online (Alexander-Fresh Air, 2000). Other countries have also tried local online elections as have

some public companies. But results have been mixed, with some evidence of vote tampering and lack of secure transmission. Although it is being examined critically, there are no states or counties completely embracing Internet voting at this time.

Vote By Mail

Vote-by-Mail is a method of conducting an election by sending a ballot to the registered voter through the mail. The ballot is completed and then returned through the mail to the election office (Oregon Secretary of State, 1998). Vote-by-mail ballots tend to be Datavote punchcards or optical scan cards. The cards are mailed to registered voters in envelopes that include the ballot, a secrecy envelope and a return envelope. The completed ballot is placed in the secrecy envelope (which allows the vote to be cast anonymously) and both pieces are placed in the return envelope (Oregon Secretary of State, 1998). Election officials discard the return envelopes immediately, ensuring the anonymity of the ballots when they are tabulated.

Voting by mail is sometimes mistaken for absentee voting but there are distinct differences between the two methods. Absentee voting provides a means for registered voters to participate in elections if they are unable to go to the polls on election day. Members of the military living abroad make up a large portion of absentee voters, as do people with jobs in other states and students. Voting by mail is an alternative to traditional polls in which a ballot is automatically mailed to the registered voter in lieu of going to a polling location.

It is unclear when the first instance of voting by mail occurred but reports indicate that this method was tried as early as 1977 in California (Center for Voting and Democracy (2000)). Voting by mail has been slow to be adopted in the United States, but some states were more open to early testing of the method. North Dakota held the country's first vote-by-mail presidential primary in 1996 with the state of Oregon following just weeks later (Center for Voting and

Democracy (2000). The state of Oregon actually began testing this method in 1981 and through a series of small local elections, confidence grew until they moved on to test statewide elections. In 1998 Oregon voters expanded voting by mail to all future primary and general elections, the first and only state to do so. Polls in Oregon were eliminated by this vote (Oregon Secretary of State, 1998).

The Oregon legislature proceeded very cautiously when examining vote-by-mail, aware of the concerns involved with this method. Similar to the risks involved with Internet voting, vote-by-mail requires strict safeguards to ensure privacy while voting and protection against vote-coercion. Critics have also questioned the requirement of affixing a postage stamp to send the ballot in and have likened this to a poll tax (Center for Voting and Democracy (2000).

Oregon addressed that concern with the stationing of ballot drop boxes at numerous locations around the cities, although the concern still exists for those who are homebound or unable to get to a drop location. An additional concern surrounds those voters who send in their ballots early, only to change their minds on their vote choices. Once the ballot has been mailed, there is no way to change one's vote.

While there are concerns about vote-by-mail that cause its widespread implementation to move slowly, there are also advantages to this voting method over traditional polling. Vote-by-mail is reported by Oregon to be cost-effective, saving the state over \$1 million between 1995 and 1997 (Center for Voting and Democracy (2000). The Federal Election Commission book "Innovations in Election Administration 11: All-Mail-Ballot Elections" discusses the cost advantages for vote-by-mail:

No pollworkers includes: no recruitment; no notices to be sent; no classes to conduct; no distribution and retrieval of election day supplies; no last-minute cancellations from workers who had agreed to serve; no paychecks to cut and mail; no W-2 s to send; no pre-dawn election-day hours to line up replacement workers. No polling places includes no polling place leases,

telephones, utilities; no searching for or preparation of accessible locations; no frantic phone calls about locked doors; no preparation, set-up, tear-down, or emergency repairs of voting machines or devices; no confusion about where people must go to vote (Center for Voting and Democracy (2000)).

States that have tried smaller versions of vote-by-mail have reported, along with Oregon, an increase in voter turnout, more accurate lists of registered voters and more time for voters to study the ballot and research their decisions.

As of 2002, Oregon is the only state to change to all vote-by-mail for all elections. Colorado, Florida, Kansas, Minnesota, Missouri, Montana, Nevada, New Mexico, North Dakota, and Washington State allow mail-in voting at one level or another (Center for Voting and Democracy (2000)).

CHAPTER V

Conclusions

This study provided information about eleven selected voting methods that are currently used in the United States or are proposed for use in future presidential elections. Each of the eleven methods was classified into one of five categories identified by Fischer: paper ballots, punchcards, mechanical or electronic machines, computer-based and remote systems (2001): Information about the history, performance characteristics and extent of application was also provided for each system.

The intent of this study was not to offer a judgement of which systems should be eliminated and which should be retained. Instead, the intent of this study was to provide comprehensive information about a range of voting systems to voters and election officials. This information should aid in decisions about possible changes to voting systems in precincts around the country.

While studying the selected voting methods, it became apparent to this researcher that, although each system has strengths and weaknesses, there are several key characteristics that are critical to every voting system. These characteristics are (1) the presence of an audit trail, (2) usability, (3) privacy for the voter and (4) security of the data collected. The lack of these characteristics can potentially jeopardize the integrity of the election results. Following is a discussion of each characteristic:

(1) An audit trail ensures that the data collected can be recounted if necessary and votes can traced to an individual anonymous voter (Saltman, 1988). Audit trails are critical in situations such as the 2000 presidential election, where several counties required recounts of collected ballots. Audit trails also ensure that each voter only votes once. Systems such as

mechanical lever machines, DRE systems and Type II Internet do not provide audit trails (Saltman, 1988 and Alexander and Jefferson, 2000) and the lack of this feature can cause problems if an election result is contested.

(2) Usability of the ballot is also critical to ensuring that the voters intentions are what they actually record as their vote. Roth, in her study, *Disenfranchised by design: voting systems and the election process* (1998) found that the mechanical lever machines were not flexible in their arrangement. Voters were disadvantaged because some of the ballot choices were too high for them to see. The text on the ballot was also reported to be too small and not legible for every voter. Roth also discovered problems with the Votomatic punchcards that would come to light again in the 2000 presidential election. Confusion while matching the vote choice to the number on the punchcard caused many voters to record the wrong votes. It also resulted in overvotes which invalidated that ballot choice. Roth (1998), Alexander (2000), and Saltman (1988) all indicate that human factors are important when designing voting methods and should not be overlooked.

(3) The privacy of the individual voter while casting votes is integral to the accuracy and integrity of that vote. If the privacy of the individual is not protected, situations such as vote coercion could occur, where someone of authority influences the individual to vote a certain way (Alexander and Jefferson, 2000). Any time the privacy of the voter is diminished, that voter is subject to a variety of external influences which could result in the casting of a less than honest ballot.

(4) In addition to ensuring the privacy of the voter, the security of the data collected must also be ensured. Many of the new systems proposed have engineered system checks which protect the data from external threats. The Internet, while being studied extensively, at this time

does not have engineering in place that provides a fail-safe protection against external data tampering (Alexander and Jefferson, 2000). Interestingly, however, some of the systems that have been in place for many years, such as paper ballots and Marksense, are also open to tampering if the opportunity arose. Security is an issue that exists now and should be remembered as new voting systems are proposed.

Although the lack of uniform voting methods in the United States can be frustrating and confusing, voting systems cannot become uniform across all counties because the choice of voting system is often dictated by region and culture. The Eastern and Southeastern states are reliant on mechanical lever machines. Midwestern states tend to use paper ballots. The West and Southwest rely primarily on punchcards and Marksense (Caltech/MIT, 2001). One voting system does not fit all but implementing voting systems that include the necessary safeguards can protect the integrity of the votes cast. The information in this study can aid voters and election officials in understanding the various systems and evaluating if those safeguards are present.

APPENDIX A

The Taxonomy of Voting Methods

Voting Method	Audit Trail	Date First Used	Category	Degree of Use	Performance Benefits	Performance Concerns
Direct Recording Electronic	No	1970's	Computer	7%	Simultaneous voting for many voters, overvotes prevented, notifies of undervotes, cost-effective	Chance of software tampering/fraud
Paper Ballots	Yes	1856	Paper	3%	Secrecy, easy to use, write-in easy	Fraud, inaccurate hand counting, extra marks
Hart Intercivic e-slate	Yes	2000	Computer	Three U.S. counties	Prevents overvotes, notifies of undervotes, easy to use, accessible, prevention against data loss	N/A
Internet (Type I and II)	Type I: Yes Type II: No	2000	Remote	1 state primary, 200 overseas citizens	Convenient, Comfort level with internet transactions	Not secure, older people/poor disadvantaged, no citizen witnessing of ballot counting, denial-of-service attacks,
Mechanical Lever	No	1892	Electronic	22%	Maintenance is low, prevents overvotes, notifies of undervotes	Write-in difficult, font too small, hard to read, hard to follow
Optical Scan (Marksense)	Yes	1980's	Paper & Computer	25%	Easy to use, write-in easy	Sensitivity of optical reader
Punchcards (Votomatic and Datavote)	Yes	1964	Punchcard	Votomatic: 33% Datavote: 4%	Votomatic: cost effective, standard ballot readers Datavote: easy to follow, no hanging chads	Votomatic: confusing, hard to punch holes Datavote: costly multiple cards needed per voter, write-in hard for both
Safevote Delta	Yes	2000	Computer	N/A	Witness-Voting system	N/A
Vote by Mail	Yes	1977	Remote	11 states	Convenient, secure, higher voter turnout, cost-effective	Accessibility of ballot drop locations, vote-coercion, privacy threats,
Election Systems and Software iVotronic	Yes	N/A	Computer	N/A	Prevents overvotes, notifies of undervotes, easy to use, accessible, prevention against data loss	N/A

Definitions

Ballot- "The ballot is the component of a voting system that displays information supporting decision-making for a large and diverse population" (Roth, 1998).

"A piece of paper used to cast a secret vote" (Merriam-Webster, 2002).

Ballot Fatigue- "Refers to a voter completing only the first part of a ballot" (Fischer, 2001).

Chad- "Voters use pins to mark punchcards by hand. The resulting leftover piece of paper is referred to as a piece of chad" (Hunter, 2001).

Datavote Punchcard- Voters punch holes next to the names of candidates or other ballot choices that are printed on the cards themselves. The voter places the ballot card in a voting apparatus that has a stapler-like punching mechanism on a slide.

Direct Recording Electronic (DRE)- "Rather than marking a paper ballot, the voter chooses candidates from a posted ballot. Depending on the equipment used, the ballot may be printed and posted on the voting machine, or it may be displayed on a computer screen. Voters make their choices by pushing a button, touching the screen or using a similar device. Votes are directly stored in a computer memory device such as a removable disk or nonvolatile memory circuit" (Fischer, 2001).

Federal Election Commission (FEC)- " In 1975, Congress created the Federal Election Commission (FEC) to administer and enforce the Federal Election Campaign Act (FECA) - the statute that governs the financing of federal elections. The duties of the FEC, which is an independent regulatory agency, are to disclose campaign finance information, to enforce the provisions of the law such as the limits and prohibitions on contributions, and to oversee the public funding of Presidential elections" (FEC, 2002).

General Accounting Office (GAO)- " The General Accounting Office is the investigative arm of Congress. GAO exists to support the Congress in meeting its Constitutional responsibilities and to help improve the performance and accountability of the federal government for the American people. GAO examines the use of public funds, evaluates federal programs and activities, and provides analyses, options, recommendations, and other assistance to help the Congress make effective oversight, policy, and funding decisions. GAO's activities are designed to ensure the executive branch's accountability to the Congress under the Constitution and the government's accountability to the American people" (GAO, 2002).

Internet- an electronic communications network that connects computer networks and organizational computer facilities around the world (Merriam-Webster, 2002).

Marksense- AKA Optical scan

Mechanical Lever- "A voter enters the voting booth and chooses candidates listed on a posted ballot by pulling a lever for each candidate choice. The votes are recorded by advances in a counting mechanism that are made when the voter leaves the booth. Poll workers read the numbers recorded by the counters" (Fischer, 2001).

National Bureau of Standards- Now known as the National Institute of Standards and Technology. Founded in 1901, NIST is a non-regulatory federal agency within the U.S. Commerce Department's Technology Administration. NIST's mission is to develop and promote measurements, standards, and technology to enhance productivity, facilitate trade, and improve the quality of life (NIST, 2002).

Optical scan- "These systems are similar to the systems used to administer college entrance exams and other standardized tests. Voters use a pen or pencil to fill in an oval or connect dots on a paper ballot. A machine scans these ballots to count the votes" (Nilsson, 2001).

Overvote- A vote for more candidates for a particular office than is permitted. An overvote on a ballot item invalidates the vote for that item (Fischer, 2001).

Paper Ballots- Ballots printed on paper that are designed to be read by humans rather than machines (Fischer, 2001).

Personal Digital Assistant (PDA)- "A handheld device that combines computing, telephone/fax, and networking features. A typical PDA can function as a cellular phone, fax

sender, and personal organizer. Unlike portable computers, most PDAs began as pen-based, using a stylus rather than a keyboard for input. This means that they also incorporated handwriting recognition features. Some PDAs can also react to voice input by using voice recognition technologies. PDAs of today are available in either a stylus or keyboard version" (Webopedia, 2002).

Remote voting- Method of voting that does not require submission at designated polling locations. Examples include absentee or other mail in balloting (Fischer, 2001).

Undervote- This may or may not be a voter error, but results when a vote is not registered for a particular item. At times an undervote may occur when a voter did not mark a ballot properly (Fischer, 2001).

Vote-"To express your choice or opinion, esp. by officially marking a paper or by raising your hand or speaking in a meeting" (Cambridge Dictionary Online, 2002).

Vote by Mail- Instead of using traditional polling places where voters go to cast ballots on election day, a ballot is automatically mailed to each registered voter. The ballot is then voted and returned to the county clerk to be counted (Oregon Secretary of State, 1996).

Voting system-"A voting system is a combination of mechanical, electromechanical and electronic equipment-including the software and firmware required to program and to control the equipment-that is used to cast and count votes. Equipment that is not an integral part of a voting

system, but that can be used as an adjunct to it, is considered to be a component of the system" (FEC, 1990).

Votomatic Punchcard- The Votomatic cards are printed with rows of marks where holes can be punched. The names of the candidates/issues are not printed on the cards themselves, but rather on a ballot holder device that looks something like a book with cardboard pages. When the card is inside the ballot holder, one column of holes is visible through the "spine". Each hole lines up with the name of the candidate/issue. Voters place votes by using a mechanical hole punch device through the hole that corresponds to their selection (Nilsson, 2001).

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