CALTECH/MIT
VOTING TECHNOLOGY PROJECT

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THE VOTER VERIFIABLE AUDIO AUDIT TRANSCRIPT TRAIL (VVAATT)

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1. Introduction

The debate about verifiable voter audit trails has prematurely narrowed into two camps: those who categorically deny the need for any back-up records and those who advocate the Voter Verifiable Paper Audit Trail (VVPAT). As jurisdictions and watch-dog groups prepare to define their election processes we should consider all alternatives.

This paper describes a new approach for a verification audit trail, the Voter Verifiable Audio Audit Transcript Trail (VVAATT), which improves the recount process because it produces a transcript of ballots that can be counted either by hand or by computer (or by both methods). Because it allows voters to confirm selections as they proceed, rather than after the fact, it simultaneously reduces adjacency errors (i.e. inadvertent selections of candidates whose names appear next to the desired choices)[2]. The audio transcript format makes it beneficially difficult for individual votes to be accidentally or maliciously separated out from the larger group. The system is also inexpensive and easy to implement using current technologies.

2. What is VVAATT?

VVAATT uses the audio capability in voting machines for the blind to create a verification trail. Externally, it requires a set of earphones and a voice-activated tape recorder with three heads (one for recording, one for playing and one for erasing), which are attached to an electronic voting machine. As the voter selects each candidate on the computer touch-screen an audio prompt states the chosen name, for example, "presidential candidate A selected." The voter will know immediately if this is not the intended choice and can then make a correction, which is confirmed by an audio prompt such as "Presidential candidate A deselected," or, if a problem persists, notify a poll worker.

The direct register electronic machine (DRE) speaks the selections. However, using earphones, the voter actually listens to them played off of the play head of the tape recorder. The separate record head records the entire sequence of audio prompts (not voters' voices) to create an independent back-up transcript of the machine's tally.

After the election, the tape may be listened to by a person or by a computer. A computer can also easily forward the tape to any contentious spots for closer analysis of what happened.

3. How does VVAATT work?

Before the polls open, a voting official unpacks the tape recorder and places new batteries in it. A sealed audiocassette from a reputable commercial company is unwrapped and put into the recorder. The tape recorder is plugged into the voting machine and the earphones are plugged into the tape recorder. The official then records the name of the voting machine, serial number, the name of the tape, or the date of the election (depending upon how the procedure is scripted). The precinct name and opening time of the balloting day are also recorded as part of the transcript. [Note: the Caltech / MIT Voting Technology Project strongly recommends that a Democrat, a Republican, and an independent third-party observer monitor this and every stage of the election process.]

Upon entering the booth, the voter puts on the earphones. As each vote is selected on the computer screen, a recorded message states the name of the chosen candidate, for example, "presidential candidate A selected." The person listening at the earphones will instantly recognize whether or not this was the intended choice. If an error has been made, the voter can then push, for example, the button for presidential candidate B. A confirmation message such as, "presidential candidate A deselected; Presidential Candidate B selected," will then play to allow the voter to know that the mistake has been successfully corrected. As voters proceed through the ballot, the process is recorded in a linear sequence to create an indelible audio transcript. The voice-operated relay in the recorder turns on the machine as voting progresses.

When the polls close, an official records the time and precinct number. The tape is taken from the recorder, the batteries are thrown out, and the voting machine is then disassembled in the normal way. As each tape is removed, it is marked with the name of the machine it came out of before being sent to election headquarters.

If a recount is necessary, the tapes may be listened to by officials, who can hand-tally the selections recorded by the audio transcript, or analyzed by a computer. To strongly corroborate results both methods may be employed.

The VVAATT can be easily tallied later by a computer because the numbers of candidates and races are finite and limited. For example, if there are five hundred possible choices in a given ballot (a very large election), only five hundred WAV files of actual audio samples describe all the necessary words and names.

4.   What are VVAATT's advantages over VVPAT?

The numerous failings of the so-called Voter Verifiable Paper Audit Trail are detailed in a separate paper (3). Briefly summarized, the paper fixation originated with Rebecca Mercuri, who in 1992 theorized that the ability to audit voting machines would be improved by allowing voters to review a paper printout of their selections after voting electronically. Since then, Verified Voting and other organizations have mistakenly insisted that this be the required method for an audit trail of election results.

Unfortunately, Mercuri's theory is based on a false assumption. She assumed that it would be harder to tamper with printed receipts that poll-workers can touch and see than it would be the invisible machinations of computerized systems. However, it is, in fact, entirely possible to tamper with VVPAT results. Few voters ever take the time to review their receipts even when told that there is a discrepancy between their receipt and their electronic choices. Worst of all, because voters only get to review their selections in an unfamiliar format and only after they have finished voting VVPAT increases the complexity and confusion of the process.

An examination of the ballots in the 2003 Governor recall race in California demonstrated that with punch cards people make .5% errors in adjacency. That is, they accidentally vote for the candidate whose name appears adjacent to the one that they planned to select. Such problems might be eliminated if people instantaneously learned of these errors and could quickly fix them without unduly interrupting their voting process or adding another task to it.

Many people enter voting booths with more than one potential candidate in mind and only make their decision while standing at the machine. Some forget which selection they finally made. This is especially possible when numerous races appear on the same ballot (we have witnessed some with over 100 races on them). To precisely remember and check each of these races afterwards is a difficult memory task, especially if one doesn't have a reference card or must search for the relevant names on a card printed in a different layout from either the paper receipt or the screen (which voters must do with VVPAT). The extra step of separately checking the paper receipt increases the stress and time of voting. Many people are liable to find the task too onerous to attempt and will simply hand in their receipts without reviewing them at all, a statistical probability which hackers could easily take advantage of.[3] Unfortunately, VVPAT has no mechanism to determine whether or not a voter has examined the printed receipt.

By contrast, VVAATT verification actually simplifies voting because verification is done as people proceed through a ballot and relies upon the use of perceptual short-term memory comparison, rather than cognitive memory. A person listening to feedback from a set of earphones while in the act of voting can easily identify errors. For example, if one meant to select candidate A but heard the earphones state, "candidate B selected," the discrepancy would be obvious. Moreover, a voter is likely to correct this mistake because switching to the intended candidate will entail no more effort than pressing another button before continuing through the remainder of the ballot.

The audio format will be especially helpful in reducing the errors of voters with bad eyesight or poor literary skills—groups with especially high rates of adjacency errors, and thereby uncounted votes.

VVAATT also provides a more reliable voting transcript than VVPAT in the event of a recount. One of the most frequent criticisms of VVPAT is that paper, especially the thermal paper used for "Paper Trail" receipts, cannot be accurately read by a computer. Thermal paper is also worrisome because it disintegrates rapidly (a process that can be accelerated by the application of heat) and because it can be easily altered. In addition, hand-counting alone is susceptible to errors that cannot be traced or isolated.

Paper ballots tend to be hand-counted and recounted with an accuracy of two to three errors per thousand. Whether or not tallying an audio transcript instead of paper ballots would alter this statistic, the ability to cross check results with an independent, automated system improves the capacity to analyze and verify the results.

One of the most exciting aspects of VVAATT is that if somebody is sequentially marking down selections for different candidates by listening to the audio transcript and if the computer is also analyzing it, the computer can cue up the tape to the exact position where a person has made a mistake so that an error can be retested. In fact, using a program such as Dragon Dictate or the IBM Via Voice, the Audio Verification Transcript Trail actually allows human errors in the recount to be audited and corrected. This is far preferable to having to recount the entire set of ballots.

5. How secure is VVAATT?
a) The Machines
Computer technology should not be dismissed as a viable means to create either a secure vote or a separate verification trail. However, like all other aspects of the voting process, hardware and software must be carefully tested for integrity and security at every stage. As Eric Fischer's paper points out, different ways exist to demonstrate that an electronic voting machine is indeed collecting and recording votes as it is described [1]. The best are the family of end-to-end tests that ensure that no renegade programming has been installed to make the machine behave differently on Election Day than at other times.

Some current electronic voting machines have internal clocks. These can be tested for possible tampering by changing the date to that of the election and testing a sufficiently large sample of machines. Alternatively, on the day of the election specific machines can be parallel tested on other voting systems to demonstrate their integrity. Such testing is recommended for all voting machines, regardless of the audit trail system implemented.

b) The Audio Transcript
Because the tape recorder, connected via one cable to the voting machine, has no computer in it, it can only record exactly what the voter hears. The audio transcript is therefore not susceptible to software manipulation by a hacker, as is the case with VVPAT.

While it is possible to erase an audiotape, several techniques exist to reconstruct the deleted material. In fact, there are some famous examples of this, such as the 18-minute omission in Nixon's tapes that we still remember. The integrity of VVAATT is far above that of any other systems that have been described as a verifiable voter audit trail.

The main disadvantage to VVAATT is that it does not randomize the taping of the ballot. (This is also a problem with voting methods such as optical scan ballots, which have the further drawback of revealing choice of language.) This problem could be eliminated if each voter chooses a tape recorder at random and plugs it into the voting machine. However, this might be an unwarranted complication. The fact that most precincts have several voting machines will randomize the order of whose vote is recorded on which VVAATT in those areas.

6.   How quickly could VVAATT be put into place?
The Voter Verified Audio Audit Trail could be in place by November. It requires only off-the-shelf equipment and machines that are available today. The system costs a fraction of upgrading the machines with other kinds of technology.

All but the oldest electronic voting machines, the Danaher models used in Philadelphia, allow audio cards to be inserted or already have electronics in them that produce audio. Voting machine producers Sequoia, ES&S and Diebold have each stated that they can easily demonstrate and program VVAATT immediately. This is very encouraging.

The only new technical requirements are the tape, recorders, earphones, and standard cables. The earphones should have volume controls in them because no one should touch the tape recorders. These are available at typical audio or electronic stores.

Three-headed tape recorders are widely available at low cost. A used Sony TC-K71 recently sold on E-bay for $9.99. A new standard Sony cassette recorder retails for $19.95. The tape recorders need to be locked so that voters cannot compromise them.

A 60-minute cassette tape has enough space to record 12,000 words spoken at 200 words per minute. If each possible selection in the ballot has three words, for example, "Candidate B Selected," this could record the choices of 120 people for 30 different races. This is sufficient for the 500 voters and four machines, which can be assumed at most voting places. A standard 120-minute cassette could guarantee enough excess tape to allow for an unusually large voter turnout, extensive ballot, and/or multiple instances of corrected votes.

7. How could verified voting audit systems be improved in the future?

CDs record onto aluminum oxide, which is archival, as opposed to the magnetic oxide of audiocassettes, which slowly changes polarization over time. However, today's MP3 players are not recommended because they cannot create an indelible record of when and how many times a recording is made. In the future, special voting software could be designed to provide this information. In addition, this software could randomize where ballots are stored on the CD. In order to avoid collusion the software would need to be made by people ignorant of the voting machine code.

Like all technologies in the voting process, the software would, of course, have to be tested. Listening to a randomly stored test ballot through audio earphones, which are mechanically attached to the signal output of the CD player instead of the computer, would suffice to verify lack of software intervention.

A further improvement to VVAATT would be to use one channel of a stereo recorder to record ambient sound in the precinct. This sound could be compared with other transcripts to demonstrate that they were all in the same room.

References:

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