A Better Ballot Box?

New electronic voting systems pose risks as well as solutions

BY REBECCA MERCURI
Bryn Mawr College

Florida's voting systems were in the news again last month. A 10 September primary election marked the state's first large-scale roll-out of tens of thousands of sleek new touch-screen voting machines, the cornerstone of Florida's plan to resolve the problems of the 2000 U.S. presidential election by replacing many of their punch-card and other older machines.

The confusing butterfly ballots and hanging chads of two years ago are indeed gone. But in their place voters found touch-screen devices that didn't work properly or, in some cases, at all. A few machines in Miami-Dade County reset themselves while voters were trying to vote. Precincts in Palm Beach County reported problems activating some of the electronic cards used to authenticate the voters. Even mark-sense ballots designed to be read by optical scanners proved troublesome. In Union County many votes had to be hand-counted because the optical scanning system reported all votes as being cast for just one party's candidate.

Will the November general elections in Florida be less chaotic? To judge from these primaries—and from Palm Beach County's municipal elections in March, which had a number of electronic voting problems as well—probably not. Using the new machines, it is still possible to inadvertently cast a ballot for a candidate that the voter never intended to select. Will the results be more reliable? There will simply be no way to ever know, because the new equipment does not make an independent recount possible.

Around the globe, election officials are examining technologies to address a wide range of such voting issues. The problems observed in the November 2000 election accelerated existing trends to get rid of lever machines, punch-cards, and hand-counted paper ballots and replace them with mark-sense balloting, Internet, and automatic teller machine (ATM) kiosk-style computer-based systems [see table, p. 48]. An estimated US $2–$4 billion will be spent in the United States and Canada to update voting systems during the next decade.

It seems plausible to imagine that computerized methods for ballot casting and tabulation could alert the voter to mistakes—for example, by flagging overvoting, when more candidates are chosen than is allowed, and by reducing undervoting, when some selections are skipped. New vote-tallying systems, which count the marks made on ballots, should be faster, more accurate, and cost-effective, and better able to prevent certain types of tampering (such as ballot-box stuffing) than older products.

And voting online might enable citizens to vote even if they are unable to get to the polls. Yet making these methods work right turns out to be considerably more difficult than originally thought.

As it turns out, many of the voting products currently for sale provide less accountability, poorer reliability, and greater opportunity for widespread fraud than those already in use. These problems result from an underlying fundamental conflict in the construction of electronic voting (e-voting) systems: the simultaneous need for privacy and auditability, which is the ability, when necessary, to recount the votes cast. Privacy is critical to a fair election, necessary to prevent voter coercion, intimidation, and ballot-selling. But maintaining the voter's privacy precludes the use by computer-based products of standard audit and control practices: logging transactions and identifying them from end to end. In other words, the privacy constraint directly conflicts with the ability to audit the ballot data.

For the system to work, there must be a way to backtrack vote totals from actual ballots that come from (and must be independently verified by) legitimate voters voting no more than once. In turn, the ballot must in no way identify or be traced back to the voter after it is cast. These constraints, many experts say, cannot be mutually satisfied by any fully automated system.

Such problems plague all electronic voting products, whether kiosk systems, where voters go to a polling station, or Internet-based, where voters can submit a ballot from their homes, offices, or any site connected to the global network. Unlike automated teller machines at banks, where videocameras are used to deter theft, receipts are issued, cash provides a physical audit mechanism, and insurance covers losses, the privacy requirement means that analogous checks and balances cannot be employed to protect ballots in e-voting systems.

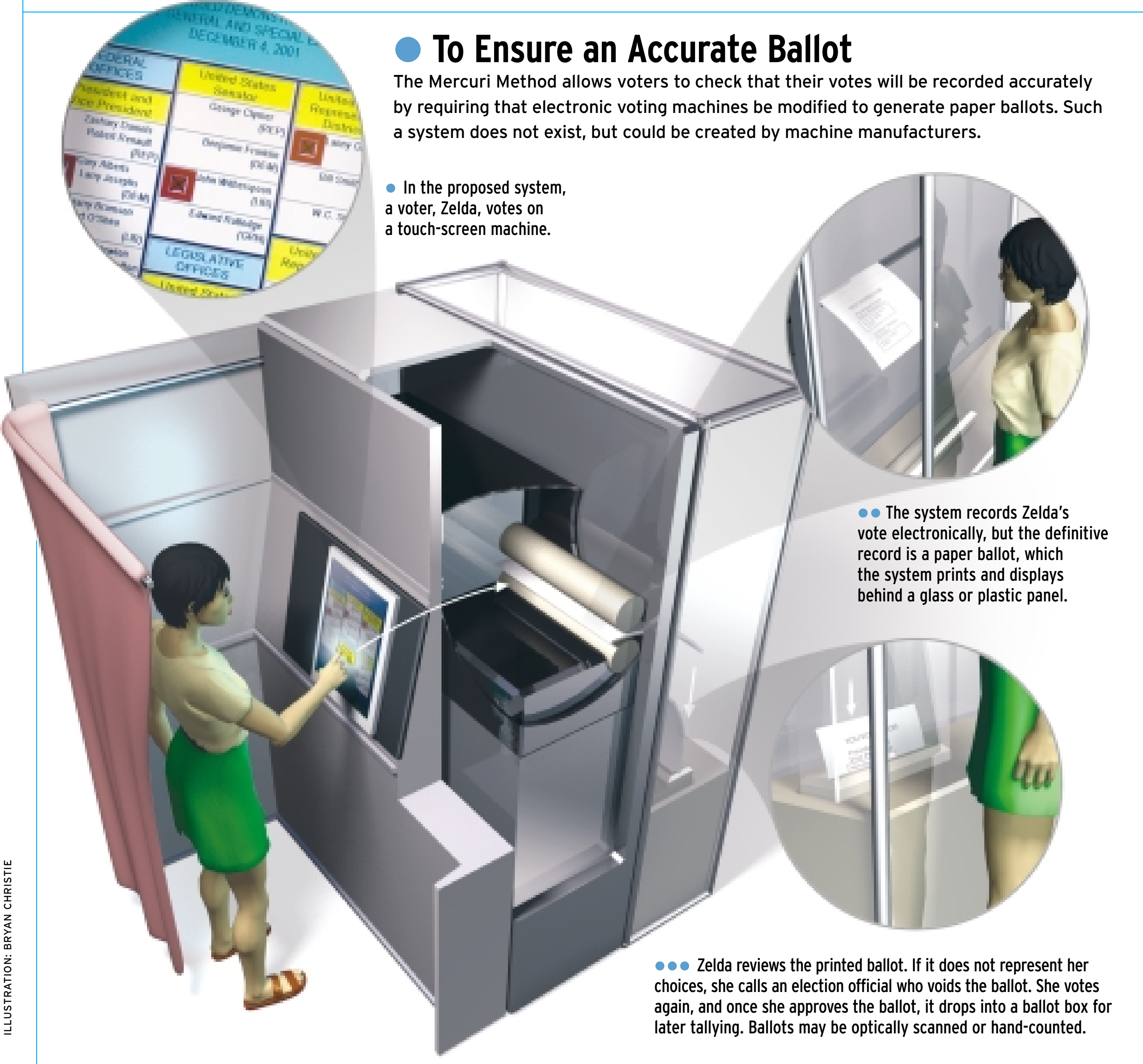
Internet voting is further flawed because authentication of the voter must be performed by the same system that records the ballots, and this compounds the auditability and privacy problems.

Just verifying a person's right to vote is difficult. Civil rights groups have objected, for example, to the use of bio-identification through fingerprints and retinal scans, fearing that the data will be used for criminal investigations or other purposes. Alternative log-in mechanisms, like personal identification numbers or smart cards, are not viable since they can be easily transferred, sold, or faked. To quote cryptographer Bruce Schneier, founder of Counterpane Internet Security Inc. (Cupertino, Calif.): "A secure Internet voting system is theoretically possible, but it would be the first secure networked application ever created in the history of computers."

Electronic voting offers fewer problems when used for such things as shareholders' meetings, public policy initiatives, award nominations, opinion surveys, and school, club, and association elections. These systems will have different requirements for security and auditability, depending upon their use. Web-based shareholder balloting has grown in popularity despite fears of computer security experts. Peter Neumann, principal scientist of SRI International's Computer Science Laboratory (Menlo Park, Calif.), is one expert who for years has warned that "the Internet is not safe for elections, due to its vast potential for disruption by viruses, denial-of-service flooding, spoofing, and other commonplace malicious interventions." Such a problem occurred in April 2002, when the financially troubled media conglomerate, Vivendi Universal (Paris), fell victim to a hacking attack that caused the ballots of some large shareholders to be counted as abstentions. Fortunately, since shareholder balloting is not anonymous (votes must be identified with their owners during tabulation), this particular breach was detectable.

● To Ensure an Accurate Ballot

The Mercuri Method allows voters to check that their votes will be recorded accurately by requiring that electronic voting machines be modified to generate paper ballots. Such a system does not exist, but could be created by machine manufacturers.



● In the proposed system, a voter, Zelda, votes on a touch-screen machine.

●● The system records Zelda's vote electronically, but the definitive record is a paper ballot, which the system prints and displays behind a glass or plastic panel.

●●● Zelda reviews the printed ballot. If it does not represent her choices, she calls an election official who voids the ballot. She votes again, and once she approves the ballot, it drops into a ballot box for later tallying. Ballots may be optically scanned or hand-counted.

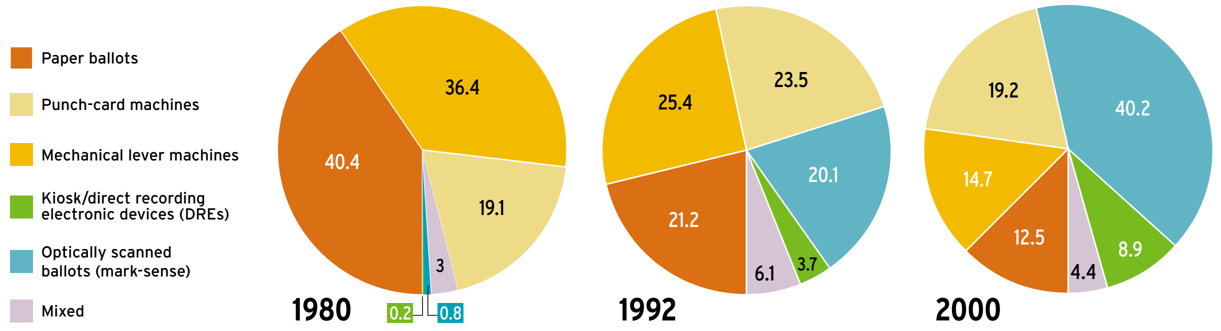
PHOTO TOP: MARK DUNCAN/AP
ILLUSTRATION: BRYAN CHRISTIE

The difficulties with Internet security are insurmountable, yet government officials have announced online voting initiatives in many countries, including France, Germany, Australia, and Estonia. In the United States, Internet voting was used in the Alaska and Arizona primaries in 2000, and some military personnel tested an experimental product later that year. The lure of increased voter participation seems to be the primary motivation for deploying Internet voting systems, although actual elections have demonstrated that such improvement may be relatively insignificant.

For example, last March, in local UK elections where online balloting was available, some districts saw a modest (1–5 percent) increase in voter turnout, while others did poorly. David Allen, a proponent of e-voting and spokesman for the St. Albans Labour party, was quoted as saying: “We were extremely disappointed with the results, turnout was worse than last year. People were actually deterred by the systems.”

On the Road Toward Electronic Balloting

Twenty years ago, three-fourths of all U.S. counties voted by paper ballot or mechanical lever machines. In 2000, fewer than a third of them used such methods. Optically scanned, mark-sense ballots had the largest share (40. 2 percent of counties), with direct-recording electronic devices (8.9 percent) moving up. Punch card machines still maintained a hold (19.2 percent) but will drop off sharply.



Medium	Paper ballot	Mechanical lever machine	Kiosk/DRE[a]	Punch-card machine	Mark-sense[b]
Input	Pencil	Switches	Push-button, touch-screen, or keypad	Metal punch	Circle darkened or arrow drawn by voter
Counting method	Manual	Running tally by machine	Running tally by machine	Cards sorted and tallied by computer	Optically scanned
Audit trail	Original ballots	Subtotals remain on machine	Tallies collected on disk	Original cards	Original ballots

[a] Direct recording electronic device [b] Optically scanned paper ballots Sources: Caltech/MIT Voting Technology Project (2001) and *The Election Data Book* (1993)

Despite manufacturers’ statements to the contrary, it is beyond the scope of present computer science and engineering principles to design a fully electronic, self-auditing voting system that sufficiently guarantees that all ballots are recorded and tallied in accordance with the voters’ intentions. Even so, e-voting systems are often viewed as an improvement by some communities, such as those in Florida or Brazil (in 2000, the first to use fully computerized balloting nationwide) that have suffered from earlier election scandals or difficulties. But reliance on this type of so-called fail-safe system design is risky, as Counterpane’s Bruce Schneier has noted: “Computerized voting machines, whether they have keyboard and screen or a touch-screen ATM-like interface, could easily make things worse. You have to trust the computer to record the votes properly, tabulate the votes properly, and keep accurate records.”

In truth, no manner of self-reporting by the e-voting system is sufficient to ensure that intentional tampering, equipment malfunction, or erroneous programming has not affected the election results. Neither is any examination of the system, before, during, or after the election, no matter how thorough, sufficient to assert that such problems did not exist. This is due, in part, to the inherently insoluble task of making certain that computer-based products do not contain unknown additional features.

Trusting trust

Almost 20 years ago, in a classic paper, “Reflections on Trusting Trust,” Ken Thompson, a co-inventor of the Unix operating system at AT&T’s Bell Laboratories, said: “You can’t trust code that you did not totally create yourself.…No amount of source-level verification or scrutiny will protect you from using untrusted code.…A well-installed microcode bug will be almost impossible to detect.” This computational reality has profound implications for voting systems. Whereas earlier technologies required that election fraud be perpetrated at one polling place or machine at a time, the proliferation of similarly programmed e-voting systems invites opportunities for large-scale manipulation of elections.

Appropriate system testing, though, often reveals the presence of some of these flaws, so organizations such as the IEEE, the U.S. National Institute of Standards and Technology, and the U.S. Federal Election Commission have begun efforts to formulate criteria for the evaluation of voting equipment. It should be noted that in the United States, elections are not run by the federal government but by states and local jurisdictions. Therefore, the legislative bodies responsible for the administration of elections would need to mandate the use of these standards.

But even when standards and testing have been applied to voting systems, problems have occurred. This is due, at least in part, to the fact that all brand-new equipment is still being inspected to measure up to the Federal Election Commission's (now outdated) 1990 guidelines. The aforementioned Palm Beach County, the same locale plagued by the chad-recount issue in November 2000, purchased 3800 new touch-screen voting machines from Sequoia Voting Systems (Oakland, Calif.) for US $14.5 million in 2002.

These machines were first used in March for various municipal elections, with problems that presaged the September primary election debacle. When the results were tallied, a large number of undervotes was indicated. Two losing candidates, the former Boca Raton Mayor Emil Danciu, whose race showed an 8 percent undervote, and Albert Paglia, who lost a runoff election (in which there were only two candidates) by only 4 votes with a 3 percent undervote, both decided to contest the election results.

Many voters came forward with sworn affidavits describing anomalies at their polling places. These problems included difficulties in selecting candidates ("When I touched the screen, nothing happened"), the machine "freezing up" while voting, voting-authorization smart cards being rejected, and manipulation of voting machines (such as turning it off and on, or pressing buttons on the back panel) by poll workers during the balloting session.

The Danciu case proceeded to Palm Beach County's 15th Circuit Court with a request for an independent evaluation of the voting equipment used in the election. There, Teresa LePore (Palm Beach County supervisor of elections, and a defendant in the case) revealed that the county's purchase contract included trade-secret clauses that would make it a third-degree felony to disclose details of the specifications or internal functioning of the machines. LePore also testified that she couldn't understand why anyone would want to take apart the machines since, in her words, "there's not much inside there."

Further, she noted that the vendor would void the warranty on the machines if they were opened for inspection. Effectively, any independent verification of proper operation was limited to examining the outside of the box.

Subsequently, Judge John D. Wessel allowed Danciu only "a walk-through inspection of all equipment used in the election." It was discovered that though automated procedures were used for pre-election testing, only votes for the first candidate in each race had been checked via the machine's screen. Since Danciu was listed third, the actual election may have been the first time an attempt was made to activate his ballot position. After the election, the machines switched into a mode to prevent ballots from being cast, so it was impossible to ascertain (without an internal examination) whether malfunction or poor programming resulted in improper logging of votes for any of the candidates. The matter remains under investigation.

Beyond all of this, the machines produced by various vendors and adopted for use in Florida, California, and other localities suffer from additional major flaws. It is possible, for example, to activate a candidate position that has not been touched by pressing the screen in two positions simultaneously. Unintended voting choices—exactly the problem that precipitated Florida's election troubles back in 2000—were thus not prevented by this new equipment.

Even more risky is the fact that at least one machine's firmware, that of the Sequoia Edge, can be reprogrammed through a port on the voting machine kiosk. Although this port is "secured" during the voting session by a flimsy, numbered, plastic tab, it is exposed after the election, providing essentially no protection against reprogramming.

E-voting products from other companies have also proved problematic. The systems involved in the 10 September voting snafus in Miami-Dade and Broward counties were from Election Systems & Software Inc. (Omaha, Neb.). Problems included machines that took three times longer than expected to boot up, that reset themselves spontaneously, and, in one precinct, that apparently failed to record about 1800 votes.

Recently, an evaluation performed by the University of Maryland on a system being considered by four Maryland counties—the AccuVote-TS touch-screen system from Diebold Election Systems Inc. (Canton, Ohio)—produced evidence of a digital divide. Individuals familiar with computers found the system easier to use than those with less computer experience. The study also revealed reliability problems during the system's first use in an April school board election when smart cards for authenticating voters had been produced to incorrect specifications, delaying voting at some sites. Nevertheless, last May, Diebold won a $54 million contract from the state of Georgia, which plans to use the systems in all 159 counties.

Trade secrecy, usability, privacy, security, and other inherent computer issues result in a dangerous "trust us" mentality on the part of manufacturers

Trust, but verify

The combination of the lack of standards, legislative loopholes, trade secrecy, usability problems, privacy, security, and other inherent computer issues results in a dangerous "trust-us" mentality. Transparency in the process is essential, not only to provide auditability, but also to enhance voter confidence.

This can be provided, quite simply, through the use of a voter-verified physical audit trail for use in recounts.

A method of voting described by this author over a decade ago, referred to as the Mercuri Method, requires that the voting system print a paper ballot containing the selections made on the computer [see illustration, p. 47]. This ballot is then examined for correctness by the voter through a glass or screen, and deposited mechanically into a ballot box, eliminating the chance of accidental removal from the premises. If, for some reason, the paper does not match the intended choices on the computer, a poll worker can be shown the problem, the ballot can be voided, and another opportunity to vote provided.

At the end of the election, electronic tallies produced by the machine can be used to provide preliminary results, but official certification of the election must come from the paper records. Since the ballots are prepared by computer in machine- and human-readable format, they can be optically scanned for a tally, or hand-tabulated for a recount. After the election, yet other entities (such as the League of Women Voters or a news organization like Reuters) can verify the ballots using their own scanning equipment, if the format is produced in a generic way.

This type of system is cost-effective. No longer must blank ballots be prepared in advance, as with mark-sense or other paper-based voting systems. Incidentally, mark-sense products—pre-printed ballots with circles or ovals that a voter fills in with a pencil or pen—do provide a physical record that is available for recount. They have the lowest undervote rate of all the computerized tabulation systems, according to a number of studies, including one by the Caltech/MIT Voting Technology Project [see "On the Road Toward Electronic Voting," p. 48].

One e-voting system, still only at a trial stage, from Populex Systems (West Dundee, Ill.), is similar to the Mercuri Method. As company founder Sanford Morganstein puts it, "The count is not something that's kept in a computer, but one that is tangible, that you can look at." Nonetheless, it differs in an important respect: voters use a touch screen to generate a printed ballot that contains only a bar code to indicate the votes. Thus, the system is open to vote tampering, according to Doug Jones, a computer science professor at the University of Iowa who examines e-voting technologies, since many voters won't check that the bar code matches their choice.

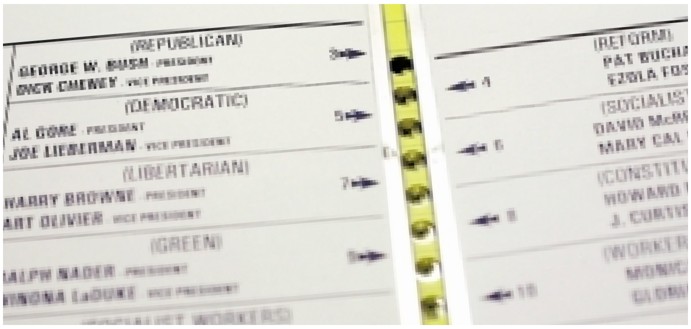
According to Jones, an election could be rigged by altering at random, say, one ballot in 100, enough to swing many close elections. "If only 1 voter in 100 bothers to check, that means that only 1 in 10 000 will find an error," Jones says. And who's to know that the bar-code reader hasn't been programmed to misread ballots? Hence, the Mercuri Method requires a human-readable plain text printout.

Besides its utility in recounts, the fact that the voter sees the final ballot on the screen as well as on paper has been shown to help voters catch their own mistakes. Visually impaired or illiterate voters can be allowed to use voice-feedback scanners to read the paper ballot, so they would not be disenfranchised by this process.

The Mercuri Method recount concept has been incorporated into recent voting legislation reforms (including some in Florida, California, and Maryland) that require the voting systems to produce paper audit trails. Brazil will use the method for 3 percent of its voting systems in an upcoming election.

Although some vendors, such as Avante Systems (Princeton, N.J.), have started to incorporate voter-verifiability into their products, the largest companies have oddly interpreted these laws to mean that audit trail printing can be done from the internally recorded ballots after the election. Their claim is that cryptography and redundancy will be used to secure the data. But these techniques are insufficient to ensure end-to-end correctness, since voters cannot verify that the ballots produced are indeed the ones they cast. Furthermore, data can be corrupted (intentionally or accidentally) early in the process, resulting in stored information that seems correct, but may not be.

Cryptography can, though, be effectively used along with a voter-verifiable ballot to prevent ballot-box stuffing, and to make certain that the paper tallies match the electronic results. David Chaum, a Palo Alto, Calif., cryptologist who, 20 years ago, invented electronic cash, has a technique that provides the best of all possible worlds: a computer-generated, voter-verified physical ballot that also gives the voter a receipt that can be used to determine that his or her vote was tabulated correctly, without revealing its contents.



Palm Beach County's infamous butterfly ballot confused some voters in November 2000. Intending to pick the second choice in the left-hand column [Gore/Lieberman], they used the second circle from the top, which was actually a vote for the topmost choice in the right-hand column [Buchanan/Foster].

AMY E. CONN/AP

One drawback of Chaum's method is that to demonstrate that the votes are tallied correctly requires a lot of math. As a result, it is difficult to explain to election officials, poll workers, and voters how it establishes the correctness of the balloting and tabulation process. But it gives a glimpse of the type of voter-verifiable systems that may be used for future elections.

An observer of voting technology once remarked: "If you think technology can solve our voting problems, then you don't understand the problems and you don't understand the technology." Computerization alone cannot improve elections. Those designing and those buying election systems must be aware of their inherent limitations, mindful of the sometimes conflicting needs for privacy, auditability, and security in the election process, and willing to seek out-of-the-(ballot)-box solutions. ●

Steven M. Cherry, *Editor*