Elections, Computer Security, and Electronic Voting

CS 334 Fall 2012
Thanks to David Wagner, UC Berkeley for providing these slides.
For Delegate to Congress.
FRANCIS GEHON.
For Representatives.
John Forreston
A.S. Lathrop

For County Commissioners.
Abner Wolcott
John Morford

For Treasurer.
John Aigins

For Surveyor.
Charles Louden

For Assessor.
S.B. Mulholland

For Coroner.
John Hawkers

For Constable.
John Ryal
D.W. Lockyer
Thurf
A.D. Hushmur
REPUBLICAN TICKET.

For Mayor,
M. F. FAIRCHILD.

For City Solicitor,
J. P. DOLLIVER.

For City Assessor,
L. G. SPRING.

For City Treasurer,
BETH VINCENT.

For Councilman—4th Ward,
A. H. JOHNSON.
10th District.

ADMINISTRATION

UNION TICKET

For Mayor,
CALEB T. FAY

For County Judge,
THOS. W. FREELON

For District Attorney,
CHARLES H. PARKER

For County Clerk,
JOHN A. MONROE

For Sheriff,
THOMAS J. POULTERER

For Recorder, to fill the vacancy for the unexpired term of O. W. Beck, resigned.
GEORGE B. REEVE

For County Recorder,
GEORGE B. REEVE

For City and County Treasurer,
ASA T. LAWTON

For City and County Assessor,
THOS. D. MATHESON

For City and County Surveyor,
REED BIGLER

For Coroner,
DR. B. A. SHELTON

For Harbor Master
CAPT. N. PROCTOR SMITH

For Superintendent of Common Schools
JOHN H. BREWER

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For Superintende
Security Goals for an Election

- Integrity: No election fraud

- Transparency: Everyone must be able to verify that the election was conducted appropriately

- Privacy: No one learns how the voter has voted

- Secret ballot: Voter cannot prove how she voted
Breakthrough! — the Australian secret ballot.

Ballot printed by govt. Ballot boxes monitored by observers. Ballots counted, by hand, in public. Competing interests keep each other honest.
Palm Beach County

"Butterfly Ballot"
Confusion at Palm Beach County polls

Some Al Gore supporters may have mistakenly voted for Pat Buchanan because of the ballot’s design.

Although the Democrats are listed second in the column on the left, they are the third hole on the ballot.

Punching the second hole casts a vote for the Reform party.
Voting on an iVotronic is as easy as 1, 2, 3

1. Make your selections
   Touch the candidate on the screen to make your selection.
   Use the Next and Back buttons to view the ballot pages.

2. Review your selections
   Touch the contest or the candidate on screen to make changes.

3. Cast your ballot
   Press the Vote button at the top of the voting machine when it begins to flash OR press the "Cast your ballot now" when it appears on screen.

Best Automobile Manufacturer
Vote For ONE

- BMW
- MERCEDES
- GENERAL MOTORS
- HONDA
- FERRARI
- JAGUAR
- FORD
- VOLVO
- Write-In

Best Vocal Artist
(Vote for Not More Than TWO)

- FRANK SINATRA
- ELVIS
- PATSY CLINE
- JANIS JOPLIN
- BUDDY HOLLY
- BARRY WHITE
- BILLIE HOLIDAY
- STEVIE RAY VAUGHAN
- "MAMA" CASS ELLIOT
- Fifi
- Write-In

01 / 02 ?
Next
Summary Ballot Instructions

Press the candidate name or contest title to return to a contest.

Vote button will light up when you may cast your ballot.

Best Automobile Manufacturer
Vote For ONE

FORD

Best Vocal Artist
(Vote for Not More Than TWO)

No selection made.

Best Ice-Cream Flavor
Vote For ONE

No selection made.

Proposition 1

No selection made.

Proposition 2

No selection made.
Question: How do election security goals apply to touchscreen (DRE) electronic voting machines?

1. Machine must allow each authorized voter to vote exactly once; must prevent tampering with votes after they are cast.

2. Machine should be verifiably trustworthy.

3. Machine must randomize the order in which votes were cast.

4. Machine must not give voter a “receipt”.

Security Goals for an Election:
- Integrity
- Transparency
- Privacy
- Secret ballot
Nov 4, 2002:
State of Georgia votes on Diebold DREs.

March 18, 2003:
Diebold source code leaks.

July 23, 2003:
Tadayoshi Kohno, Adam Stubblefield, Avi Rubin, Dan Wallach, “Analysis of an Electronic Voting System”.
The voter authorization protocol

QueryStatus

ACTIVE (0x01)

(record vote)

SetStatus CANCELED (0x08)

Status = CANCELED

Succeeded
The voter authorization protocol

QueryStatus  [Are you a valid card?]

ACTIVE (0x01)  [Yup.]

(record vote)

[Please cancel yourself.]
SetStatus CANCELED (0x08)

Status = CANCELED

Succeeded  [Ok.]
Attack!

- **QueryStatus**
  - ACTIVE (0x01)

(record vote)

- **SetStatus** CANCELED (0x08)
  - Succeeded

(record another vote)

- **QueryStatus**
  - ACTIVE (0x01)

- **SetStatus** CANCELED (0x08)
  - Succeeded

malicious smartcard
Authenticating election officials

What kind of card are you?
- An administrator card.

What’s the secret PIN?
- 2301

What’s the secret PIN?
- 2301

Ok, you have admin access.
Source code excerpts: code to encrypt electronic vote files and audit logs

#define DESKEY ((des_key*)"F2654hD4")

DESCBCDecrypt((des_c_block*)tmp,
(des_c_block*)record.m_Data, totalSize,
DESKEY, NULL, DES_DECRYPT);

This parameter is the initialization vector (IV) for “cipher block chaining”. It is set to zero. That is a confidentiality flaw. How would you fix this confidentiality flaw?
Source code excerpts

// LCG - Linear Congruential Generator -  
// used to generate ballot serial numbers  
// A psuedo-random-sequence generator  
// (per Applied Cryptography, Bruce Schneier)

int lcgGenerator(int lastSN) {
  return ((lastSN*1366) + 150889)%714025;
}

“Unfortunately, linear congruential generators cannot be used for cryptography.”
— Applied Cryptography, p.369
Princeton E-vote Demo Video
Trojan Horses and the Insider Threat

Ronald Dale Harris

Employee, Gaming Control Board, 1983-1995

Arrested, Jan 15, 1995
Convicted, Sept 23, 1997, for rigging slot machines
... 
schedule();
goto repeat;
}
if (((options == (__WCLONE|__WALL)) && (current->uid == 0))
    retval = -EINVAL;
retval = -ECHILD;
end_wait4:
current->state = TASK_RUNNING;
...
Trojan Horses and Voting Machines

Malicious logic hidden by an insider might, e.g., record votes incorrectly to favor one candidate. Extremely difficult to prevent or detect.

Potential solutions:

- Verify that the software is free of Trojans. (beyond the state of the art)
- Verify that output of the sw is correct.
  - Voter-verified paper audit trail, 1% audits
  - Optical scan (paper ballots)
  - Ballot marking devices (paper ballots)
### Candidates for President
- ABRAHAM LINCOLN
- POET LAUREATE

### Candidates for Commissioner of National Pastimes
- CARL SANDBURG

### Candidates for Commissioner of American Literature
- No Vote Cast

### Candidates for Minister of Transportation
- CHUCK YEAGER

### Candidates for Minister of Comic Relief
- CAROL BURNETT

### Candidates for Minister of Art
- ALEXANDER CALDER

### Ambassadors of the American

---

**NOTE:** You may reject your printed ballot a maximum of **two** times, after which you will no longer be allowed to make changes and printing your ballot will cast your vote. Contact a pollworker if you are experiencing difficulty with this process.
Statistical audit

• After election, randomly choose 1% of machines and manually recount the paper records on those machines. If paper count \( \neq \) electronic count, there was fraud.

• If » 100 machines cheat, detection is likely. Consequently: If paper count = electronic count, then no more than ~100 machines cheated.

The tallies are \( t_1, \ldots, t_n \)

Prover

Show me the paper for machine \( i \).

(voter-verified paper audit trail)

Verifier
### FAMOUS NAMES DEMONSTRATION BALLOT

Darken the oval provided to the left of the candidate indicating the way you desire to vote.

<table>
<thead>
<tr>
<th>PRESIDENT (Vote for One)</th>
<th>COMMISSIONER OF AMERICAN LITERATURE (Vote for One)</th>
<th>MINISTER OF COMMERCE (Vote for One)</th>
</tr>
</thead>
<tbody>
<tr>
<td>THOMAS JEFFERSON</td>
<td>ERNEST HEMINGWAY</td>
<td>LUCILLE BALL</td>
</tr>
<tr>
<td>ABRAHAM LINCOLN</td>
<td>WILLIAM FAULKNER</td>
<td></td>
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<tr>
<td>JOHN F. KENNEDY</td>
<td>JOHN STEINBECK</td>
<td></td>
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<tr>
<td>DWIGHT D. EISENHOWER</td>
<td>SINCLAIR LEWIS</td>
<td></td>
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<tr>
<td>FRANKLIN D. ROOSEVELT</td>
<td></td>
<td></td>
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</tbody>
</table>

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<thead>
<tr>
<th>POET LAUREATE (Vote for One)</th>
<th>COMMISSIONERS FOR NATIONAL PASTIMES (Vote for Two)</th>
<th>MINISTER OF TRANSPORTATION (Vote for One)</th>
<th>MINISTER OF ART (Vote for One)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MARIANNE MOORE</td>
<td>JIM THORPE</td>
<td>AMELIA EARHART</td>
<td>ANDREW WYETH</td>
</tr>
<tr>
<td>ROBERT FROST</td>
<td>BILL RUSSELL</td>
<td>CHUCK YEAGER</td>
<td>ALEXANDER CALDER</td>
</tr>
<tr>
<td>CARL SANDBURG</td>
<td>JOE DIMAGGIO</td>
<td>ORVILLE WRIGHT</td>
<td></td>
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<tr>
<td>T.S. ELIOT</td>
<td>PEGGY FLEMING</td>
<td>NEIL ARMSTRONG</td>
<td></td>
</tr>
<tr>
<td>EZRA POUND</td>
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</tbody>
</table>

**VOTE BOTH SIDES**

FRONT Card 1 RepUx 10 "PRECINCT 1" English
Conclusions

• E-voting security is hard, because computers aren’t transparent.
• All known solutions use paper. Secure paperless voting is an open research problem.
• Computer science is deeply relevant to democracy.

• Technical principles:
  - Two-person control, separation of duties
  - Statistical audit
  - Security against malicious insiders
  - Security through obscurity
THE HAZARDS OF ONLINE VOTING...

[Image of a man looking at a computer screen with a list of candidates to vote for, including:
- President of the United States
- George W. Bush (R)
- John F. Kerry (D)
- Ralph Nader (I)
- Low-Cost Home Mortgage
- Generic Viagra
- Enlarge Your Thingy

And a message on the bottom saying: GREETINGS! I AM NDUGU SCAMU, EX-INTERIOR MINISTER OF NIGERIA, AND I NEED YOUR HELP TO TRANSFER $150,000,000 IN FUNDS TO A BANK]
More than 4,500 North Carolina votes lost because of mistake in voting machine capacity

JACKSONVILLE, N.C. (AP) — More than 4,500 votes have been lost in one North Carolina county because officials believed a computer that stored ballots electronically could hold more data than it did. Scattered other problems may change results in races around the state.

Officials said UniLect Corp., the maker of the county’s electronic voting system, told them that each storage unit could handle 10,500 votes, but the limit was actually 3,005 votes.
Machine error gives Bush 3,893 extra votes in Ohio

By John McCarthy, Associated Press

COLUMBUS, Ohio — An error with an electronic voting system gave President Bush 3,893 extra votes in suburban Columbus, elections officials said.

Franklin County’s unofficial results had Bush receiving 4,258 votes to Democrat John Kerry’s 260 votes in a precinct in Gahanna. Records show only 638 voters cast ballots in that precinct. Bush’s total should have been recorded as 365.
Broward Vote-Counting Blunder Changes Amendment Result

POSTED: 1:34 pm EST November 4, 2004

BROWARD COUNTY, Fla. -- The Broward County Elections Department has egg on its face today after a computer glitch misreported a key amendment race, according to WPLG-TV in Miami.

Amendment 4, which would allow Miami-Dade and Broward counties to hold a future election to decide if slot machines should be allowed at racetracks, was thought to be tied. But now that a computer glitch for machines counting absentee ballots has been exposed, it turns out the amendment passed.

The software is not geared to count more than 32,000 votes in a precinct. So what happens when it gets to 32,000 is the software starts counting backward," said Broward County Mayor Ilene Lieberman.

That means that Amendment 4 passed in Broward County by more than 240,000 votes rather than the 166,000-vote margin reported Wednesday night. That increase changes the overall statewide results in what had been a neck-and-neck race, one for which recounts had been going on today. But with news of Broward’s error, it’s clear amendment 4 passed.
count level data is stored in a binary computer format known as two's complement. Data on ERM results reports are printed as the absolute value of the two's complement of the associated data in the ERM database. This means that once the 32,767 limitation is reached, additional incremental tallies of vote results would not be printed correctly (32,768 through 65,536 would actually be represented as 65,536 to 32,768).

While this value, 32,767 is certainly higher than any practical value that could be tabulated in a single election day precinct, the consideration of reporting all absentee ballots or early voting into a single absentee or "One Stop" precinct does hold the possibility of yielding much higher totals than what may be possible in single election day precincts.

While the discrepancy in preliminary vote totals did cause some early confusion, it is very important to note that the final results reported to the state were accurate and complete. Final counts based on the Votronic systems and paper tapes were fully accurate and correct.

To avoid this limitation in elections where the One Stop early voting totals may exceed the 32,767 limitation, ES&S would recommend one of the following:

1. Using the Unity EDM software, code multiple precincts to support the larger counts. Create a split for each ballot style for each precinct. Configure early voting terminals and follow vote collection procedures that would ensure no individual precinct totals would approach the 32,767 limitation.

2. Collect early voting "One Stop" and other absentee votes into Election Day precincts.

3. Upgrade systems and software to the Unity 2.5 or Unity 3.0 versions, when available in North Carolina. The ERM database has been expanded in these versions to accommodate vote totals in excess of millions of votes in any individual precinct.

Heretofore, in previous elections, Guilford County had configured, collected and distributed the early voting results into multiple separately defined precincts (as suggested above, avoiding this limitation). ES&S was not aware that this practice had changed. Had we been aware of this change, we would have advised Guilford County of this limitation and suggested one of the other configuration options.

ES&S shares Guilford County's commitment to making sure every vote cast is counted accurately. We are absolutely confident in the accuracy of the final results that were reported. If you have additional questions on this issue, please do not hesitate to contact me.

Sincerely,

Ken Carbullido
Senior Vice President, Product and Software Development
Election Systems & Software Inc.

November 8, 2004

George Gilbert
Director of Elections
Guilford County Board of Elections
Greensboro, NC

Dear George,

As you know, Tuesday's election drew an unprecedented number of voters to the polls. This unanticipated level of voter participation was a challenge that we believe was managed very well in Guilford County.

On behalf of the team at Election Systems & Software, I would like to congratulate you and your staff on running a very successful election. And, all of us at ES&S want to thank you for the opportunity to partner with you to carry out our important roles in the democratic process. The success of this election was the result of a tremendous amount of hard work from everyone involved. Where challenges did arise, we worked together to address them quickly and effectively so the election process continued uninterrupted. The countless hours of preparation paid off, and all in all, it was a very good day.

One challenge we did face was the incorrect information contained in preliminary and unofficial returns for certain contests in the Guilford County "One Stop" precinct used to collect totals for early voting. As you know, this occurred because exceptional voter participation generated a number of ballots and votes cast that exceeded the capacity of single precinct vote counters accepting this amount of data in the Election Reporting Manager results reporting software.

This limitation in the results reporting software was previously documented and known to ES&S. To clarify further, the limitation has nothing to do with the Votronic tabulation systems. No votes were lost. All ballot data and vote counts were correctly captured and reported by the Votronic touch screen tabulation systems.

We regret any confusion the discrepancy in early vote totals has caused.

We would like to explain in further technical detail what caused this issue, should you or others at the county have questions. The 32,767 capacity limitation at a single precinct level is a function of the design and definition of the results database used by ERM. The data storage element used to record votes at the precinct level is a two byte binary field. 32,767 is 2 to the 15th power, which is the maximum number held by a two byte word (16 bits) in memory, where the most significant bit is reserved as the sign bit (a plus or minus indicator). Additionally, ERM precinct

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PHONE: (402) 593-0101 ■ Toll Free: 1 (800) 247-8683 ■ FAX: (402) 593-8107
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www.essvote.com
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