Hack-a-Vote: Studying Security Issues with E-Voting

Dan Wallach
Rice University

Collaborators:
Jonathan Bannet
David W. Price
Algis Rudys
Justin Singer
Perception vs. reality

- Voter feels that
  - Vote was counted
  - Vote was private
  - Nobody else can vote more than once
  - Nobody can alter others’ votes
- People believe that the machine works correctly
- These have to do with perception

It is also important that these perceptions are true.
Reliance on certification

Independent Testing Authorities

- Allowed to see the code
  - Nobody else looks
- Certify satisfaction of FEC standards
- Required by many states

Result: “Faith-based voting”
Inspiration

Have an e-voting system to “demonstrate” insider flaws

- Original idea from David Dill
- Original code by David W. Price
  - Written summer 2003
  - About 2000 lines of Java

Unnecessary after Diebold findings
Second application?

- How about in-class use?
- Old project: “smart card soda machine”
  1) design & formally model crypto protocol
  2) swap with other groups
  3) implement with real cards

- Real smart cards are painful
Hack-a-Vote project

Remove “cheating” code
~150 lines, mostly in one file

Three phase assignment
1) Be evil (2 weeks)
2) Be an ITA (1 week)
3) Design / formally model better version of Diebold smartcard (2.5 weeks)
**Be evil?**

- Students’ role: corrupt developer inside vendor
- Code must still pass tests
- “Minimal” code changes
  - Multiple hacks encouraged
- Code should appear “normal”

**Deliverables:** Code + Written Report
Be an ITA?

- Swap code from groups
- Every group audits two versions
  - Honor code: no running diff
- Imperfect simulation of real ITAs
  - Student familiarity with code
  - Smaller codebase

Deliverables: Written Report
Better smartcard protocols?

- Lectures have prepared students
- cryptyc for protocol modelling
  - (Relatively) usable type checker
  - cryptyc.cs.depaul.edu

Deliverables: Model + Written Report
Diebold’s smart card protocol

**Terminal**

My password is (8 bytes) → **Card**

Okay

Are you valid?

Yup

Cancel yourself, please.

Okay
Hack-a-Vote software

Inspiration: Hart InterCivic eSlate
eSlate protocol (hopefully)

- Base station
  - Pin: 1234

- Voting machine
  - Pin: 1234

  Valid? 1234
Hack-a-Vote live demo
Hack-a-Vote design

Valid PIN numbers:
- 4841
- 5541
- 5060
- 7413
- 9805
- 8743
- 5975
- 5701
- 6966
- 4561

Input your PIN:
4841 [OK]
Hack-a-Vote design

Valid PIN numbers:
- 5541
- 5060
- 7413
- 9805
- 8743
- 5975
- 5701
- 8966
- 4561

Vice President:
- Terry Gilliam (Python)
- Adam Sandler (SNL)
- Jay Leno (Independent)

Hack-a-Vote
Trust us, it works fine

Ballot 2 of 2

Previous  Next  Finish voting
Hack-a-Vote design

Valid PIN numbers:
5541
5060
7413
9805
8743
5975
5701
6966
4561

Please review your votes:
President: John Cleese (Python)
Vice President: Terry Gilliam (Python)

Hack-a-Vote
Trust us, it works fine

Administer machine

Confirm these votes  Start over

Previous  Next  Finish voting
Hack-a-Vote design

Valid PIN numbers:
- 5541
- 5060
- 7413
- 9805
- 8743
- 5975
- 5701
- 8966
- 4561

Vote totals:

President
Bill Murray (SNL) received 62 votes.
John Cleese (Python) received 74 votes.
Robin Williams (Independent) received 30 votes.

Vice President
Jay Leno (Independent) received 43 votes.
Terry Gilliam (Python) received 79 votes.
Adam Sandler (SNL) received 53 votes.
Wide gamut of attacks

- Manipulate election results
- Violate voter anonymity
- Crash / DoS voting machine
Clever hacks

- Overload `equals() / hashCode()`
- Variable with same name as class
  - Unusual control flows

- Reuse constants in the code
  - Network port: 1776
  - Use as backdoor PIN

- “Start over” also submits a vote
Deeper hacks

- Weak random number generator
  - Easier to guess valid PINs

- RNG for vote shuffle seeded with terminal ID
  - Attacker can undo shuffle

- Only cheat if terminal ID > 2
  - Less likely to occur in testing
## Did the ITAs catch the hacks?

<table>
<thead>
<tr>
<th>Hack</th>
<th>Attempts</th>
<th>Found once</th>
<th>Found twice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modify already-cast votes</td>
<td>6</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Cast multiple votes</td>
<td>7</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Violate voter anonymity</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Denial of service</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>
Implications for real ITAs

Can real ITAs do better?
+ They can run **diff**
+ They can perform "parallel testing"
  - Codebases are much larger
  - Are they expecting Trojan Horses?
  - How closely do they read the code?

Very little support from tools
Uglier issues for certification

- Toolchain tampering (Thompson)
- Tampering with “embedded” OS
- Audited code = actual code in machine?
Publicity

IEEE Security & Privacy, Jan/Feb 2004
- Reprinted in Computer User
- Story on local TV news
- Impact on vendors/ITAs?
Choose Hack-a-Vote!

www.cs.rice.edu/~dwallach/courses/comp527_f2003/voteproject.html

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