Technology at the Ballot Box

HEART Computer Security and Privacy for the Modern World

💙 EN.600.111(33)

November 4, 2021

Tushar Jois

Technology at the Ballot Box

HEART Computer Security and Privacy for the Modern World

🧡 `EN.600.111(26)`

November 10, 2021

Tushar Jois

Recap

- Smart home are built around devices, mobile apps, and cloud systems
- Potential attacks against smart home devices occur at every level
- We can patch IoT devices, but it’s better to design security by default

Lesson objectives

- Describe e-voting systems and their potential flaws
- Understand the design considerations inherent to e-voting
- Explain the societal implications of using e-voting systems

“Security considerations for e-voting”

Avi Rubin

Johns Hopkins University

My PhD advisor

Pays for my stipend and tuition

Takeaways on Trump, Voter Fraud and the Election

A New York Times Magazine investigation finds that misleading and false claims about widespread voter fraud are part of a long disinformation effort that the president has taken to new extremes.

Early voting in Ann Arbor, Mich., on September 24. Emily Elconin/Reuters

By Daniel Victor

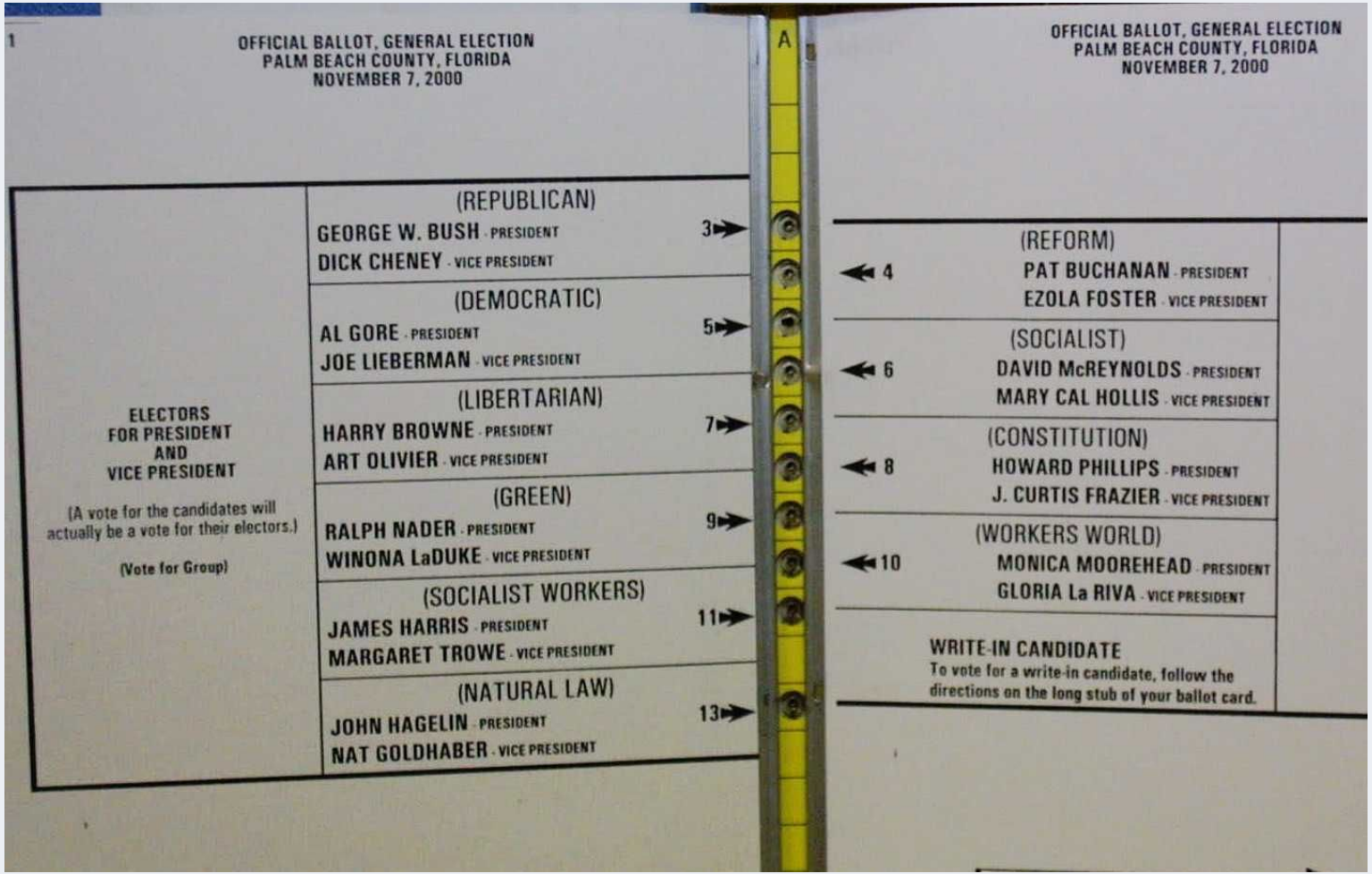
Sept. 30, 2020

The specter of widespread voter fraud has been a cornerstone of

There was
no credible evidence
of voter fraud in the
2020 US election.

Can we do better?

It all started in 2000...



1

OFFICIAL BALLOT, GENERAL ELECTION
PALM BEACH COUNTY, FLORIDA
NOVEMBER 7, 2000

ELECTORS FOR PRESIDENT AND VICE PRESIDENT

(A vote for the candidates will actually be a vote for their electors.)

(Vote for Group)

(REPUBLICAN)
GEORGE W. BUSH - PRESIDENT
DICK CHENEY - VICE PRESIDENT
3

(DEMOCRATIC)
AL GORE - PRESIDENT
JOE LIEBERMAN - VICE PRESIDENT
5

(LIBERTARIAN)
HARRY BROWNE - PRESIDENT
ART OLIVIER - VICE PRESIDENT
7

(GREEN)
RALPH NADER - PRESIDENT
WINONA LaDUKE - VICE PRESIDENT
9

(SOCIALIST WORKERS)
JAMES HARRIS - PRESIDENT
MARGARET TROWE - VICE PRESIDENT
11

(NATURAL LAW)
JOHN HAGELIN - PRESIDENT
NAT GOLDHABER - VICE PRESIDENT
13

A

OFFICIAL BALLOT, GENERAL ELECTION
PALM BEACH COUNTY, FLORIDA
NOVEMBER 7, 2000

(REFORM)
4
PAT BUCHANAN - PRESIDENT
EZOLA FOSTER - VICE PRESIDENT

(SOCIALIST)
6
DAVID McREYNOLDS - PRESIDENT
MARY CAL HOLLIS - VICE PRESIDENT

(CONSTITUTION)
8
HOWARD PHILLIPS - PRESIDENT
J. CURTIS FRAZIER - VICE PRESIDENT

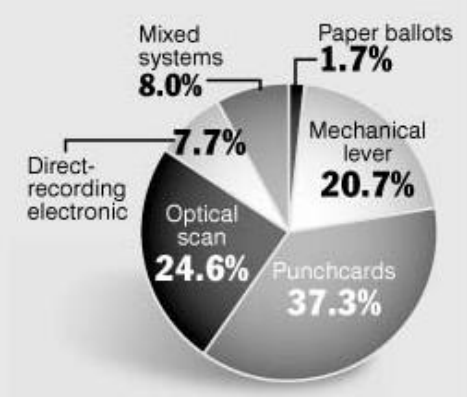
(WORKERS WORLD)
10
MONICA MOOREHEAD - PRESIDENT
GLORIA La RIVA - VICE PRESIDENT

WRITE-IN CANDIDATE
To vote for a write-in candidate, follow the directions on the long stub of your ballot card.

There has to be a better way, right?

Voting systems

1996 Presidential election



Type of voting system	How the system works	Advantages	Disadvantages
Paper ballots	Voters mark choices on ballots and drop them in a sealed box.	Inexpensive; used mostly in rural areas.	Counting votes is slow and labor-intensive.
Mechanical lever	Voters pull a lever assigned to a candidate.	Easy to use; prevents multiple votes for the same race.	Machines can weigh 900 pounds and are no longer manufactured.
Punchcards	Voters punch holes in a ballot; ballots are then read by a computer.	Cheaper; more portable.	Can be inaccurate and unreliable; hand recounts pose problems.
Optical scan	Voters darken an oval or rectangle next to their choice; ballots are then read by a computer.	Easy to use; the process is similar to marking lottery tickets or standardized tests; hand recounts are possible.	Improperly marked ballots may not be recorded; high cost.
Direct-recording electronic	Touch-screen electronic display.	Easy to use; vote totals can be instantly printed on tape and recorded on a cartridge.	Computers provide no external way to verify vote accuracy.

Desirable properties of voting systems

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 and that its behavior cannot be modified

These have to do with perception.

It is also important that these perceptions are true.

"The purpose of an election is to convince the supporters of the losing candidate that they lost"

J. Alex Halderman, University of Michigan

Audit trail

- It is important that all phases of the vote casting and counting be auditable
- Recounts must be possible
  - If results come into question
- For electronic systems, need to audit
  - Hardware and software development
  - System deployment
  - All system binaries (compiled code, as well as compiler)
  - Use of system

Currently, such audit of hardware and software is not common, and is considered very difficult, if not impossible.

minimizing trust

Voter verifiable audit

An audit trail (probably involving paper) that enables recounts and makes it harder to tamper with an election. The very piece of paper that is verified by the voter is used in the recount.

What could possibly go wrong?

Failure modes of electronic systems

- Several well understood concepts
  - The more software, the more flaws
  - Electronic systems are expected to fail at times
- Software security
  - It is very difficult to examine software and understand its behavior
    - Especially with malicious programmer
  - It is difficult to know that a particular source code matches a particular binary
  - It is difficult to know that a particular binary is installed on a particular platform
- Many anecdotes of voting systems failing
  - To be clear, a *failure*, is not necessarily a *vulnerability*
  - To the right attacker, this is a distinction without a practical difference, though

The Washington Post
Democracy Dies in Darkness

Fairfax Judge Orders Logs Of Voting Machines Inspected

By **David Cho**
November 6, 2003

School Board member Rita S. Thompson (R), who lost a close race to retain her at-large seat, said yesterday that the new computers might have taken votes from her. Voters in three precincts reported that when they attempted to vote for her, the machines initially displayed an "x" next to her name but then, after a few seconds, the "x" disappeared.

In response to Thompson's complaints, county officials tested one of the machines in question yesterday and discovered that it seemed to subtract a vote for Thompson in about "one out of a hundred tries," said Margaret K. Luca, secretary of the county Board of Elections.

Software dangers

- Software is complex
  - top metric for measuring number of flaws is lines of code
- Windows/Mac/Linux Operating Systems
  - tens of millions of lines of code
  - new “critical” security bug announced every week
- Unintended security flaws unavoidable
- Intentional security flaws undetectable

Insider threats

- Easy to hide code in large software packages
- Virtually impossible to detect back doors
- Skill level needed to hide malicious code is much lower than needed to find it
- Anyone with access to development environment is capable
- Requires:
  - background checks
  - strict development rules
  - physical security

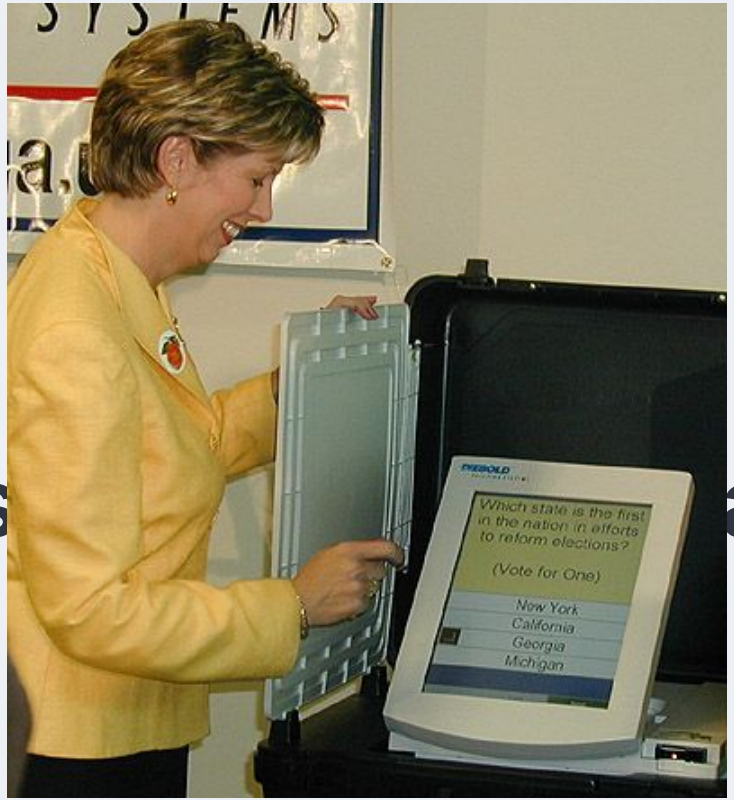
Example insider threat

- Ronald Harris
  - A computer programmer for the Nevada Gaming Control Board in the 1990s
  - Wrote anti-cheating code for slot machine for casinos
- Malicious code in testing unit
  - When testers checked slot machines, it downloaded malicious code to slot machine
  - A special sequence of coins activated the “winning mode”
- He and an accomplice walked away with thousands of dollars
  - Remained undetected
- Caught when greed sparked investigation
  - $100,000 jackpot

What are some other insider threats?

- Facebook
- Johns Hopkins University
- Intelligence agency (NSA/CIA)
- County board of elections

Analys achine



DIEBOLD
We won't rest.

Code analysis

- 56-bit DES in CBC mode with static IVs used to encrypt votes and audit logs

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

- Unkeyed public fun protection
- No authenticat
  - (the PIN authe
- Insufficient coc

```
// LCG - Linear Conguential Generator
// used to generate ballot serial numbers
// A psuedo-random-sequence generator
// (per Applied Cryptography,
// by Bruce Schneier, Wiley, 1996)
```

`BallotResults.cpp`

Diebold Election Systems

“Unfortunately, linear congruential generators **cannot be used for cryptography**”

Bruce Scheiner
Applied Cryptography (Wiley, 1996)
Page 369

```
/* this is a bit of a hack for now. */
```

AudioPlayer.cpp

```
/* the BOOL beeped flag is a hack so
we don't beep twice. This is really a
result of the key handling being
gorped. */
```

WriteIn.cpp

```
/* the way we deal with audio here is
a gross hack. */
```

BallotSelDlg.cpp

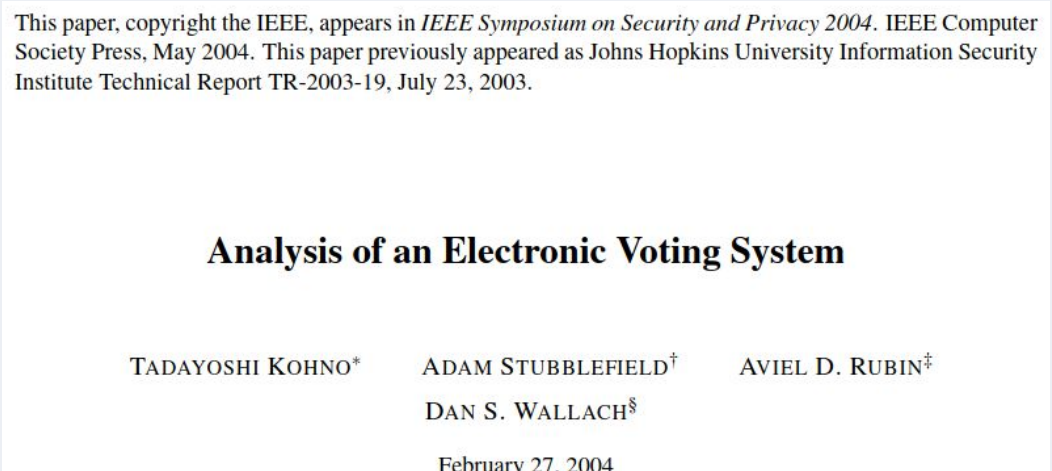
```
/* need to work on exception *caused
by audio*.  I think they will
currently result in double-fault. */
```

BallotDlg.cpp

```
void CBallotRelSet::Open(const CDistrict* district, const CBaseunit* baseunit,
const CVGroup* vgroup1, const CVGroup* vgroup2)
{
 ASSERT(m_pDB != NULL);
 ASSERT(m_pDB->IsOpen());
 ASSERT(GetSize() == 0);
 ASSERT(district != NULL);
 ASSERT(baseunit != NULL);
 if (district->KeyId() == -1) {
   Open(baseunit, vgroup1);
 } else {
   const CDistrictItem* pDistrictItem = m_pDB->Find(*district);
   if (pDistrictItem != NULL) {
     const CBaseunitKeyTable& baseunitTable = pDistrictItem->m_BaseunitKeyTable;
     int count = baseunitTable.GetSize();
     for (int i = 0; i < count; i++) {
       const CBaseunit& curBaseunit = baseunitTable.GetAt(i);
       if (baseunit->KeyId() == -1 || *baseunit == curBaseunit) {
         const CBallotRelationshipItem* pBalRelItem = NULL;
         while ((pBalRelItem = m_pDB->FindNextBalRel(curBaseunit, pBalRelItem))){
           if (!vgroup1 || vgroup1->KeyId() == -1 ||
              (*vgroup1 == pBalRelItem->m_VGroup1 && !vgroup2) ||
              (vgroup2 && *vgroup2 == pBalRelItem->m_VGroup2 &&
              *vgroup1 == pBalRelItem->m_VGroup1))
```

Disclosure

- Researchers retained an EFF Attorney (Cindy Cohn)
  - Worry about Diebold suing for copyright violations, leaking of trade secrets (DMCA)
- Also worked with general council at Hopkins, Rice
- No election pending at the time of disclosure
- Technical paper eventually published at IEEE S&P



Analysis of an Electronic Voting System

TADAYOSHI KOHNO* ADAM STUBBLEFIELD† AVIEL D. RUBIN‡
DAN S. WALLACH§

February 27, 2004

minimizing trust

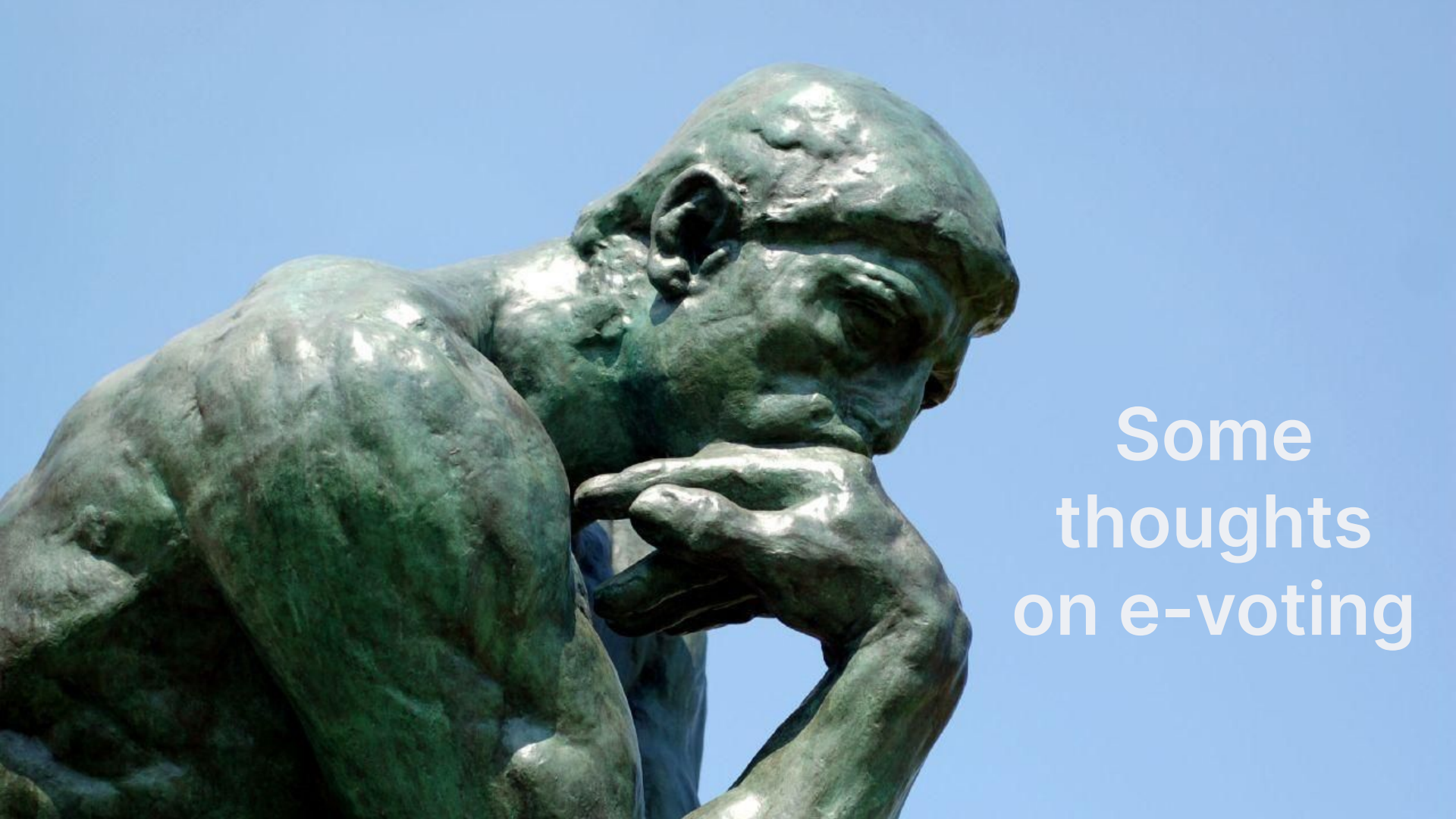
Separate vote casting from tabulating

A touch screen machine produces paper ballot that a voter can use or destroy. Then, a scanning and tabulating machine (with a small, open-source, verified code base) tallies the screen-generated ballot.

minimizing trust

Design transparency

Require machine design and source code to be public and verified by security experts. Create standardization bodies that vet voting machine manufacturers and the machines themselves.


Some
thoughts
on e-voting

Threat modeling

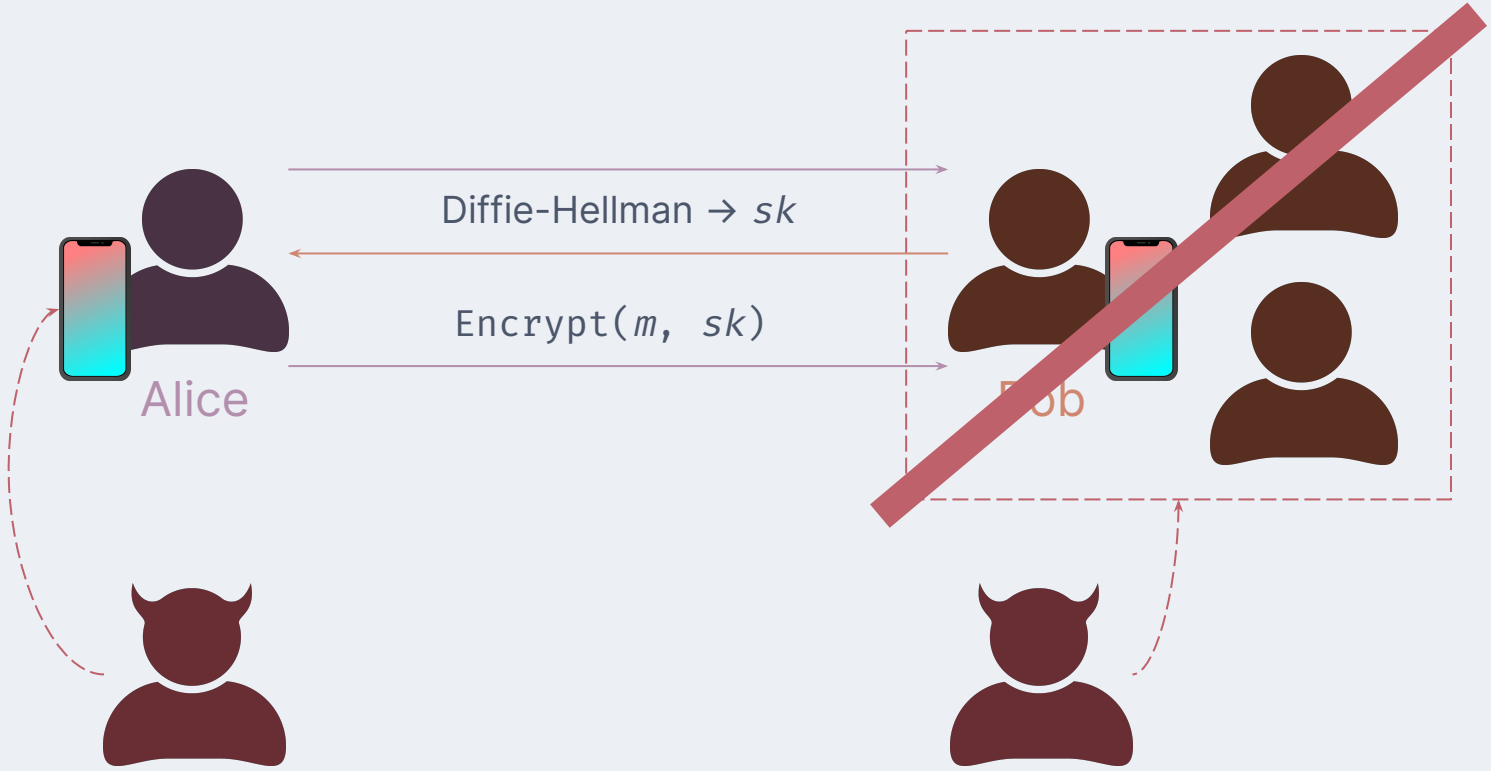
- Type of election (public vs. private)
- Consequences of a successful attack
- Value of election outcome to potential adversaries
- Expertise, skill & resources needed to disrupt
- Level of motivation of potential attackers
- Amount of disruption needed to sway the election or call its outcome into doubt
- Consequences of a perception of unfair outcome

Platform issues

- Hardware manufacturer
- OS vendor
- Applications (Office, web browser, remote control, anti-virus)
- Physical access (insider threat, forensic adversary)
- Software bugs/vulnerabilities

Would these be used to subvert an election?

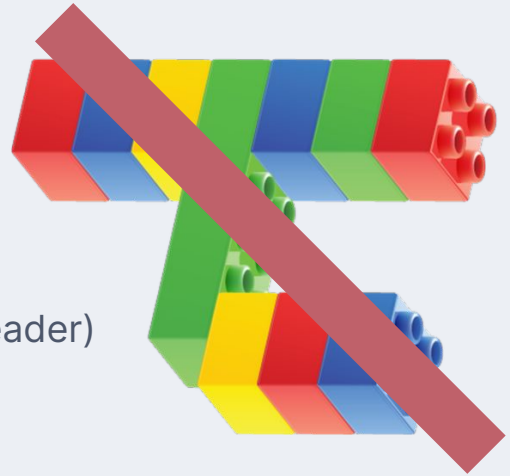
It depends on the threat model, the importance of the election, and the resources of the adversary.


Diffie-Hellman → sk
Encrypt(m, sk)
Alice
Bob

Internet voting in public elections

- Social issues:
  - Vote coercion
  - Vote sale
  - Vote solicitation (click here to vote, banner ads)
- Technical issues:
  - Securing the platform
  - Securing the communications channel
  - Assuring availability of the network
  - Registration issues, one vote per person, no dead voters
  - Authentication in each direction
  - Maintaining equitable costs (no poll tax, e.g. smartcard reader)

Please never do this



Opinions

1. The Windows/Mac/Linux/Mobile environments are totally inadequate as a voting machine in public elections.
2. The current Internet is totally inadequate as a communications infrastructure in public elections.
3. The *level of threat* to *difficulty of attack* ratio for public elections in today's environment is too high.
4. Even if we could solve the technical issues, there are still social issues that are deal breakers for Internet voting in public elections.
5. Stick to optical scanning with poll-site tallying!

The security of voting should be a non-partisan issue.

Too much is at stake for party politics.

Looking ahead

- Your presentation sides are due before class 🧡 Wed Nov 17, 💙 Thu Nov 11 (next time!)
  - Make sure you've practiced your presentation as a group at least once
  - Please come on time (randomized presentations + respect for classmates)
- Re-read (or at least re-skim) "Reflections on Trusting Trust"
  - Go back through the previous slides, and think about the ways we've minimized trust
  - Come prepared with your takeaways from this class
- Exit ticket before class is done

Lesson objectives

- Describe e-voting systems and their potential flaws
- Understand the design considerations inherent to e-voting
- Explain the societal implications of using e-voting systems