
COMPUTER SECURITY LAB
RICE UNIVERSITY

Computer Security Trends and Applications

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Defend against the right threat

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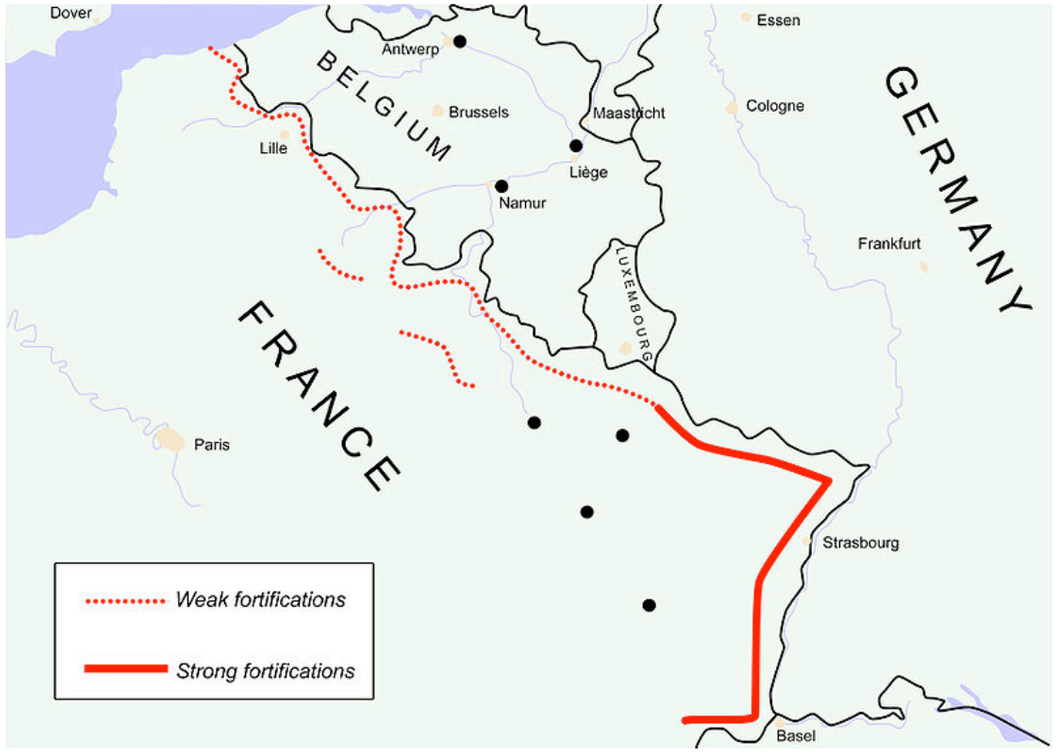

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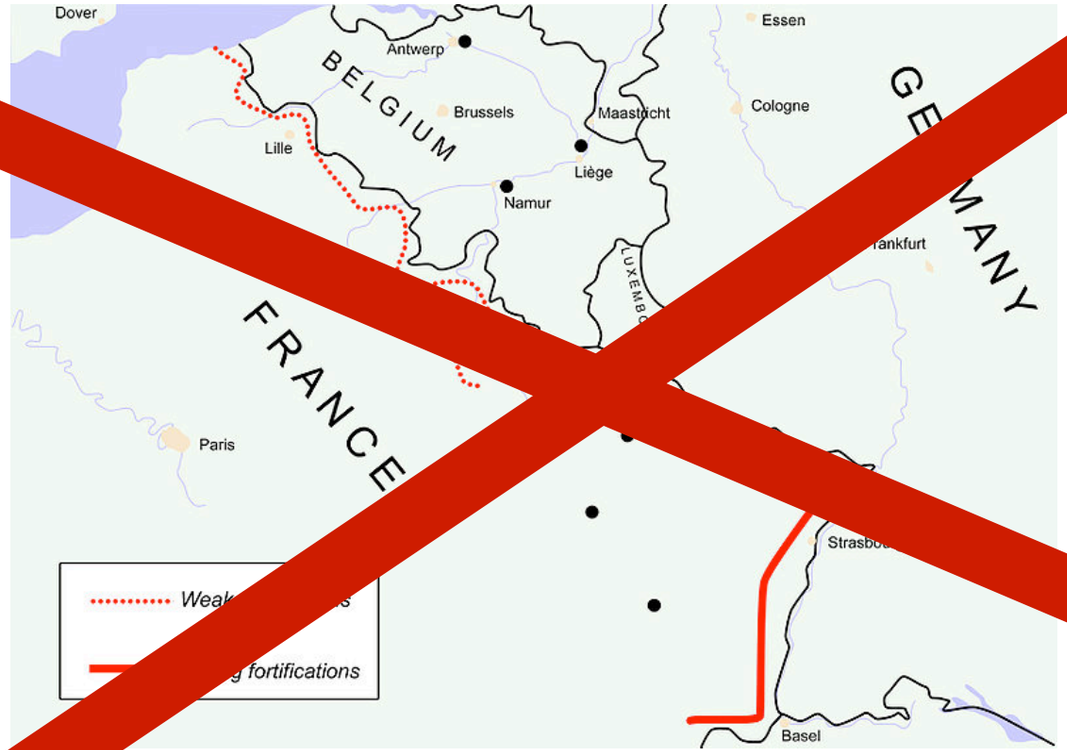

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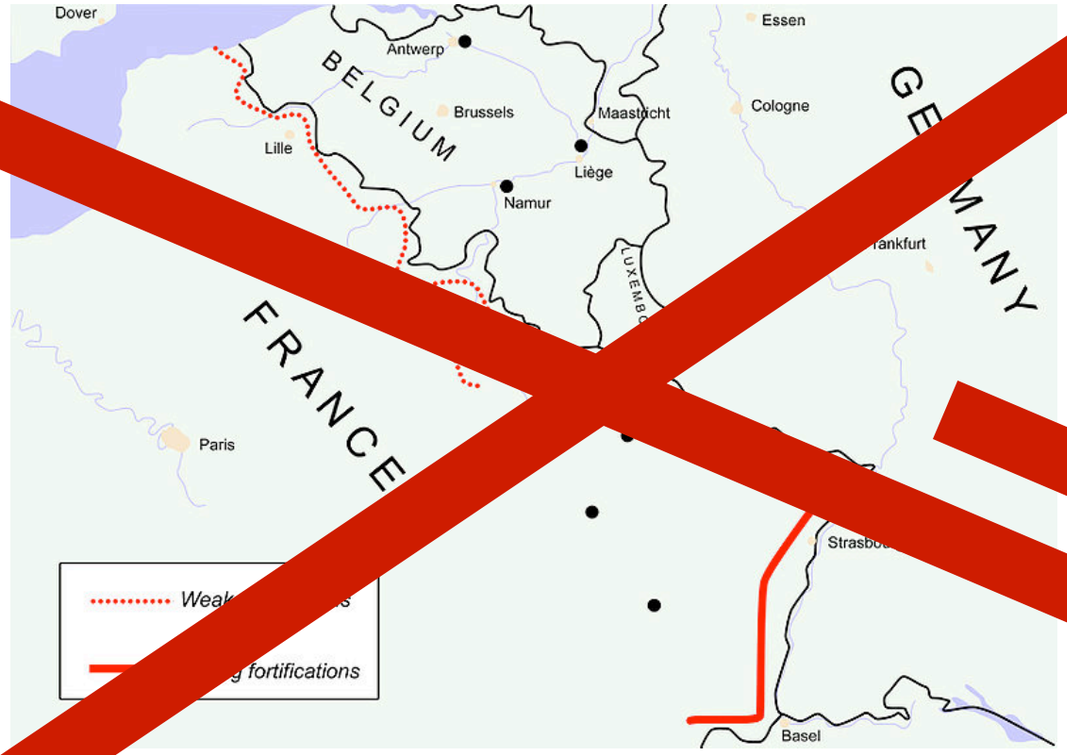


Big trends in computer security

Cyber threats are everywhere

Any computer could be compromised

Worms/botnets on clients

Drive-by downloads on servers

Skills are easy to learn

Broad literature

Experiment at home

Dual-use tooling

Security auditing tools can also find and exploit vulnerabilities

The attackers are winning (?)

Defenders must fix all bugs

Attackers need only find one vulnerability

Nobody installs patches

But they’re exploited quickly

Insider threats

Nation-state adversaries raise the bar

Stuxnet allegedly targeted Iranian uranium centrifuges

“Cyberwar” is poorly defined

Attackers don’t care about crashing “innocent” machines

If a botnet kills 1% of its targets, that’s not really a problem

Defenders can’t respond in kind

Difficult to disrupt without collateral damage

Difficult to attribute to the actual source

“Proportionate” response?

Legality of operating outside of your country?

Coordination with foreign governments?

Stuxnet infections

Country	Infected Computers
China	6,000,000
Iran	62,867
Indonesia	13,336
India	6,552
United States	2,913
Australia	2,436
United Kingdom	1,038
Malaysia	1013
Pakistan	993
Finland	7
Germany	5

Data from Wikipedia, Symantec, etc.

New attack surface: phones

Smartphones are real computers

Every bit as vulnerable to attacks as desktop computers

Less manageable by systems administrators

Huge opportunities for targeted attacks

Microphone

GPS tracking

Phone networking

Perfect for spycraft

“I’m still clinging to my BlackBerry,” Mr. Obama said Wednesday [7 Jan ’09]. “They’re going to pry it out of my hands.” The New York Times

Example challenge: Updates

Updates from the phone carrier?

UAE phone carrier, *Etisalat*, BlackBerry spyware (July ‘09)

What about the docking connector?

FlexiSpy and other commercial spy products

Vendor digital signatures on code?

Limits freedom of phone owners

TI calculator private keys were cryptanalyzed (Sept ’09)

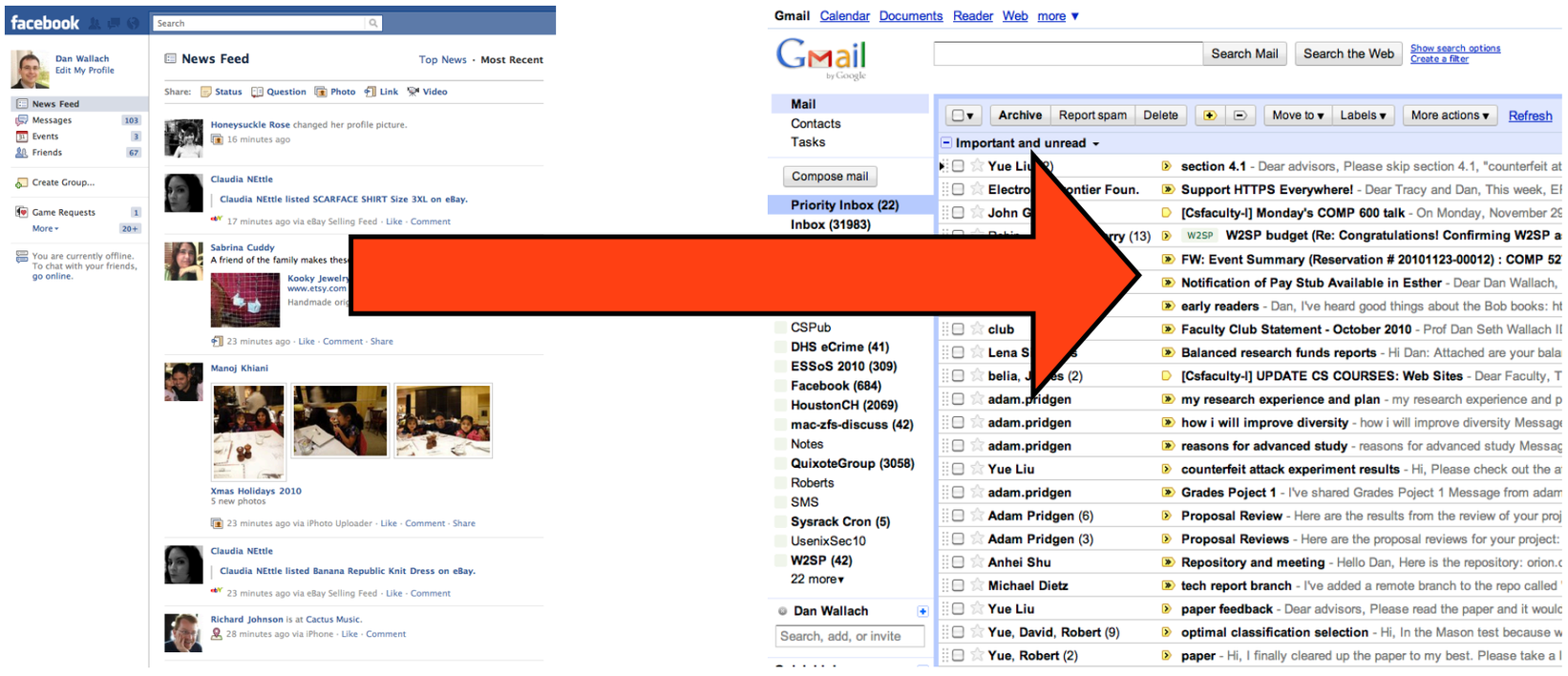
New attack surface: browsers

Web browsers are multi-“user” systems

Any web page might want to attack another

New browser features evolving rapidly

Engineering challenge: Isolation vs. collaboration



Good web sites go bad

Syndicated advertisements, web host attacks

Even hit the New York Times' web site

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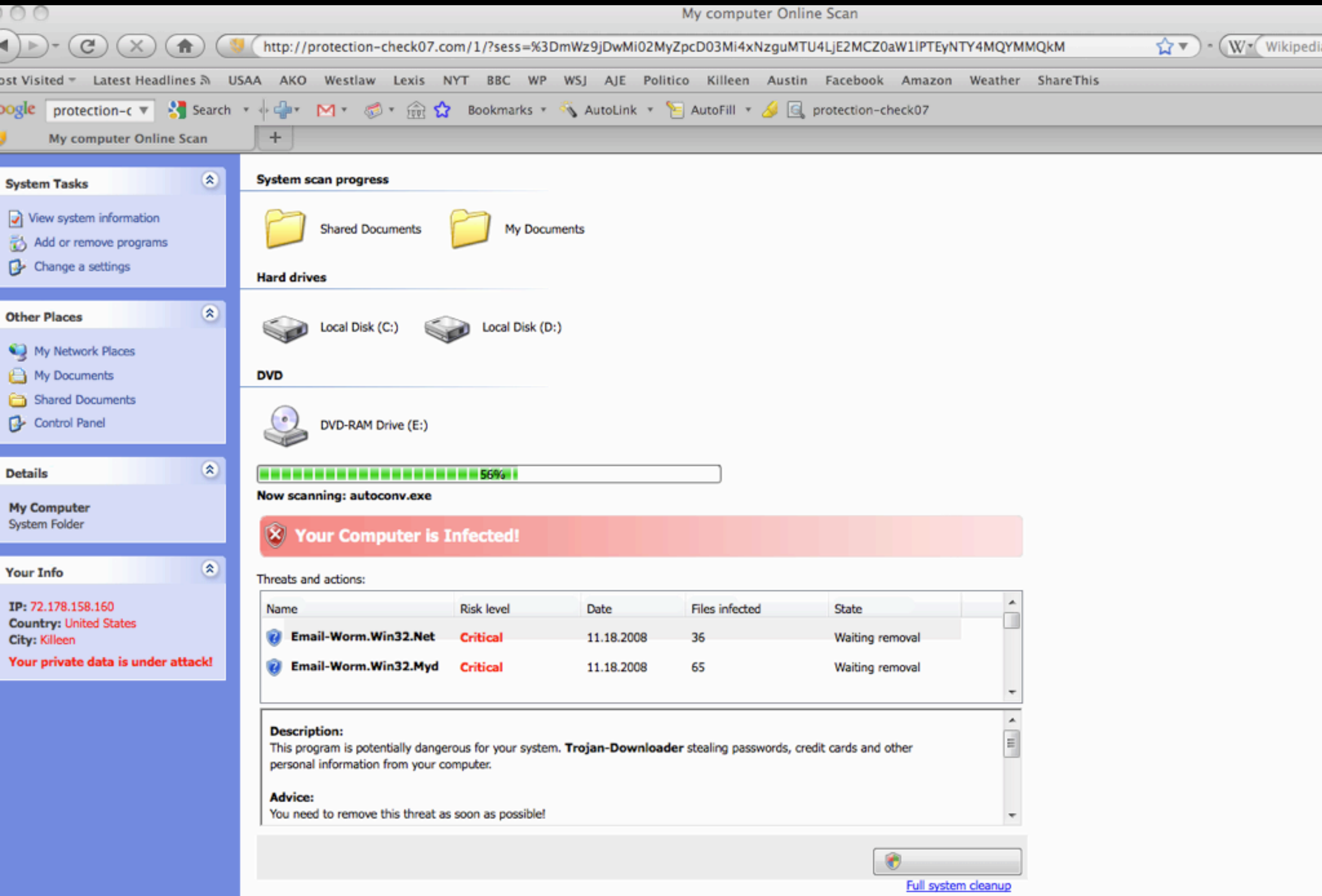
Even hit the New York Times' web site

Technical analysis of the NY Times attack:
http://troy.yort.com/anatomy-of-a-malware-ad-on-nytimes-com



How *not* to respond

How *not* to respond

Typical government policy (U.S. Marines, etc.)

Internet SNS are defined as web-based services that allow communities of people to share common interests and/or experiences (existing outside of DoD networks) or for those who want to explore interests and background different from their own. These Internet sites in general are a proven haven for malicious actors and content and are particularly high risk due to information exposure, user generated content and targeting by adversaries. The very nature of SNS creates a larger attack and exploitation window, exposes unnecessary information to adversaries and provides an easy conduit for information leakage that puts OPSEC, COMSEC, personnel and the MCEN at an elevated risk of compromise. Examples of Internet SNS sites include Facebook, MySpace, and Twitter.

http://www.marines.mil/news/messages/Pages/MARADMIN0458-09.aspx (August 2009)

How *not* to respond

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Access is hereby prohibited to Internet SNS from the MCEN NIPRNET

Ban pushes personnel to use personal resources

Smartphones, Internet via private ISPs

The need for cryptography

Mid-90's debate: Strong crypto vs. key escrow

Debates centered around terrorists using unbreakable crypto

Government key escrow: Vulnerable to attack?

Conclusion: Strong crypto was essential for commerce

Strong crypto won, used most everywhere

Internet / Web standards: Carefully analyzed

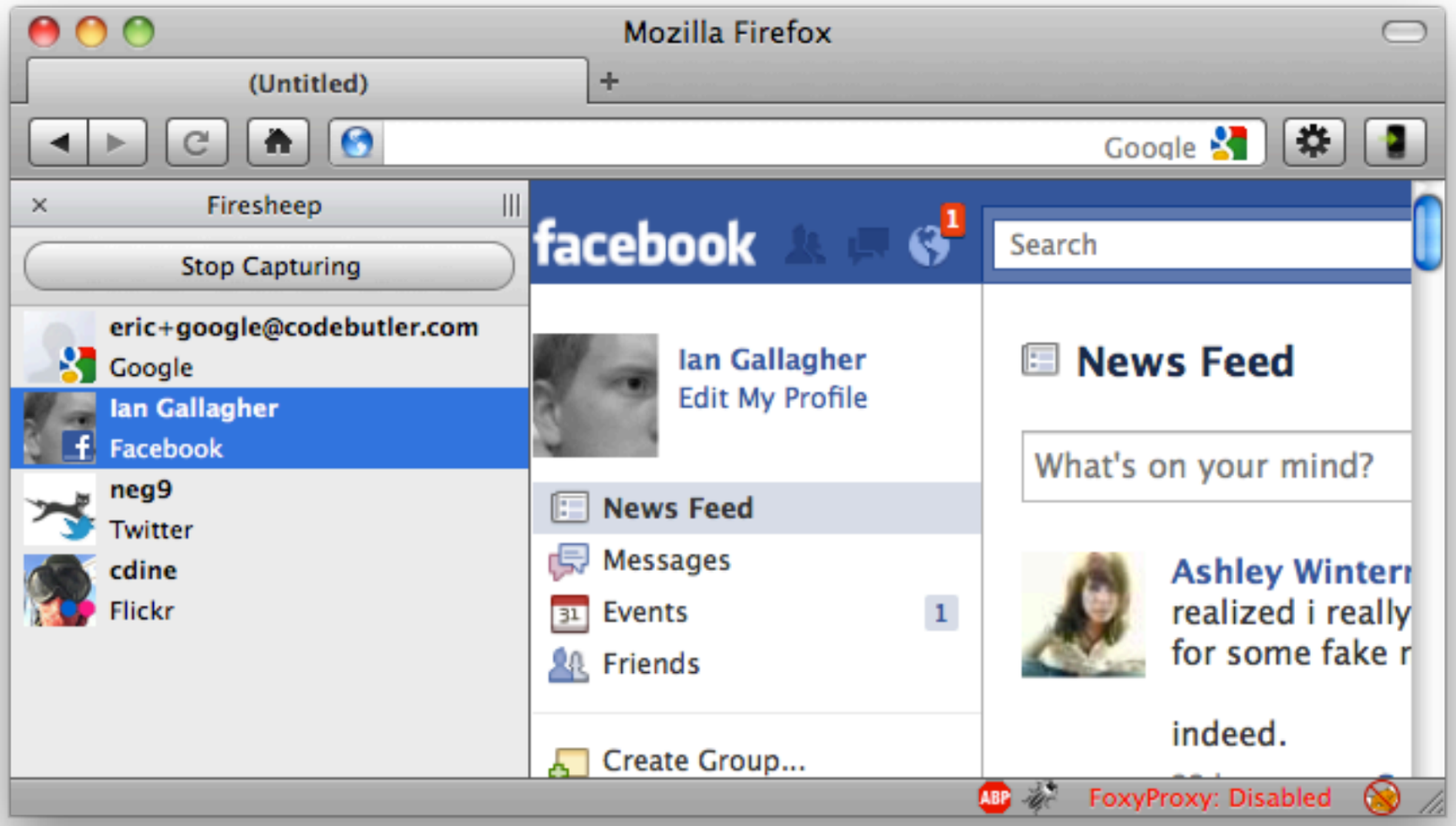
Other industries (e.g., SCADA, e-voting): Often very weak

Many web sites don't use crypto

Vulnerabilities were "hypothetical"

Firesheep

codebutler.com/firesheep



Single-click attacks

Wi-Fi sniffer

Browser integration

Instant login / exploit

Solution? HTTPS everywhere (e.g., *encrypted.google.com*)

HTTPS everywhere?

Performance issues

Increased server cost

Complicates caching

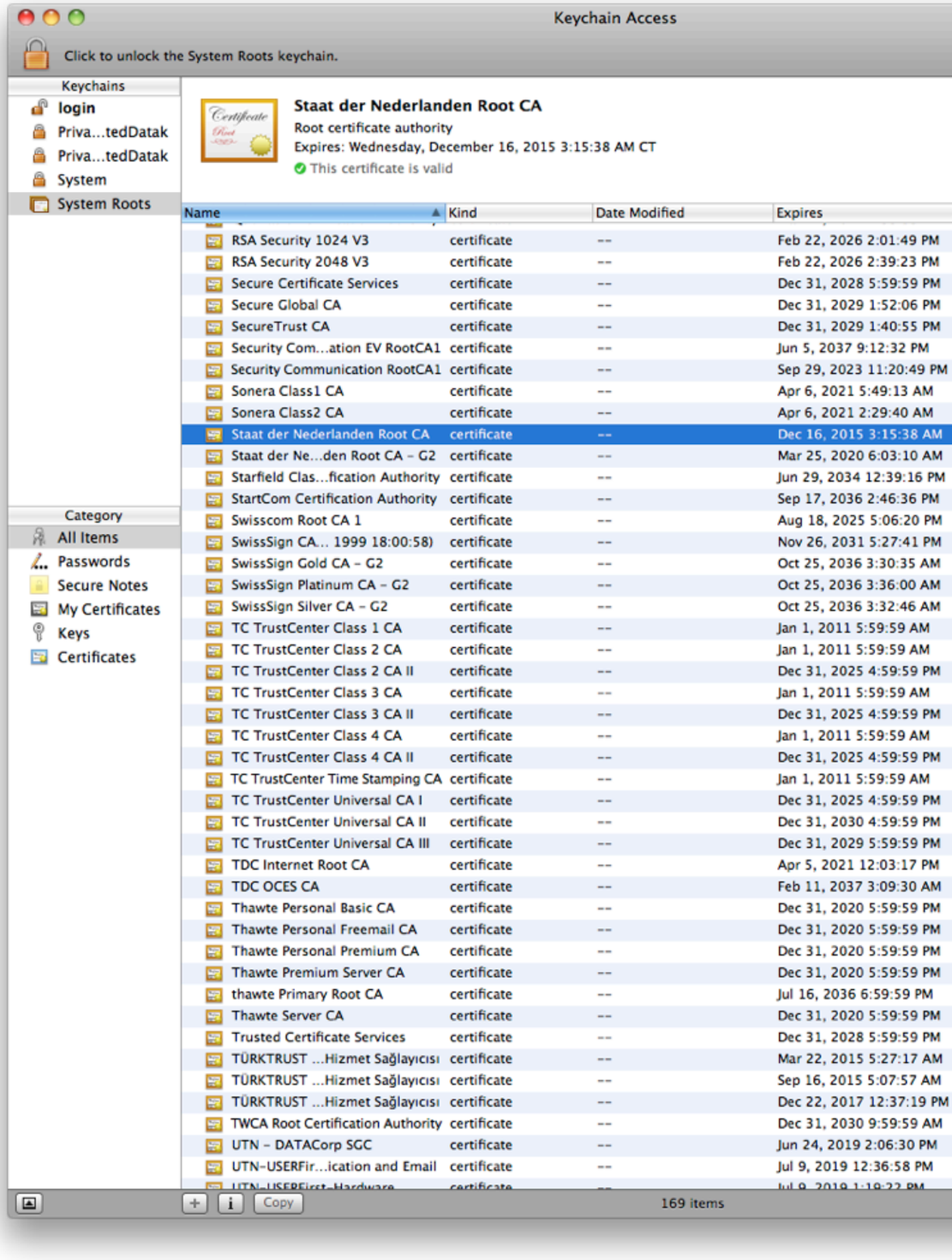
Trust issues for certification authorities

Browsers have hundreds of “roots” of trust

Who do ***you*** trust?

Defeats traffic monitoring

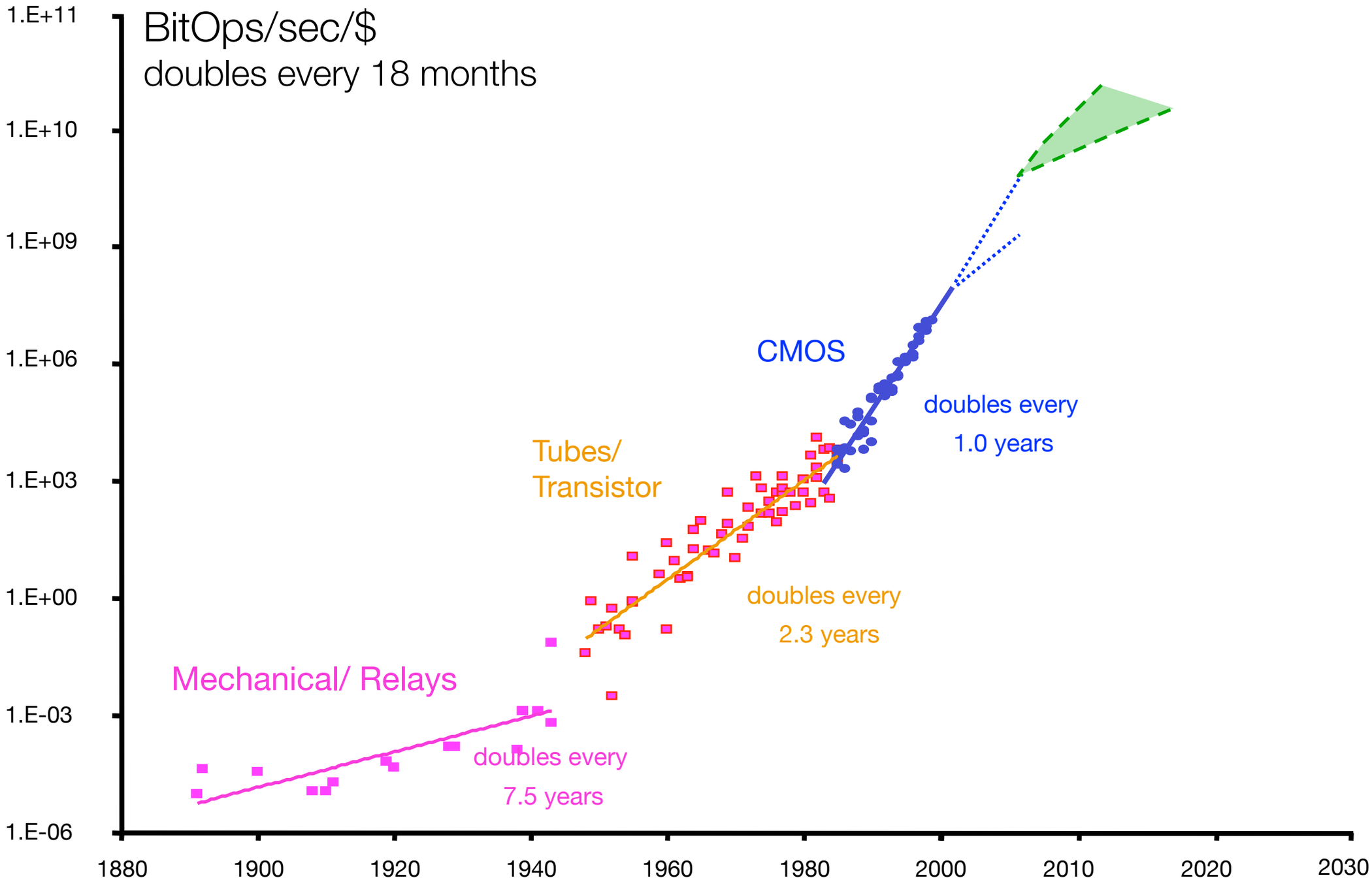
Great Firewall of China wouldn’t know what you were doing



Can we beat the hackers?

Increasing computer power

Faster CPUs, more RAM, disk, network, etc.



Impact on computer security

Remember everything!

Network monitoring / email / web history / backups

Post-facto forensics, corporate auditing

Process and filter everything!

Anti-spam / anti-malware (also anti-pornography)

Potential to get ahead of the attackers

Caveat: Big data collection leads to serious privacy concerns

Better software engineering

Software auditing tools (e.g., Coverity and Fortify)

Scanning legacy code to detect large classes of bugs

New programming languages

Important classes of errors are flagged during development

“Security” as priority in the development cycle

Example: Microsoft will now favor security over backward compatibility in its engineering process

U.S. DHS Research Roadmap

http://www.cyber.st.dhs.gov/docs/DHS-Cybersecurity-Roadmap.pdf

1. Scalable trustworthy systems
2. Enterprise-level trustworthiness metrics
3. System evaluation life cycle
4. Combatting insider threats
5. Combatting malware and botnets
6. Global-scale identity management
7. Survivability of time-critical systems
8. Situational understanding and attack attribution
9. Provenance
10. Privacy-aware security
11. Usable security

Applied Security: *Electronic Voting*

DRE voting machines (Direct Recording Electronic)

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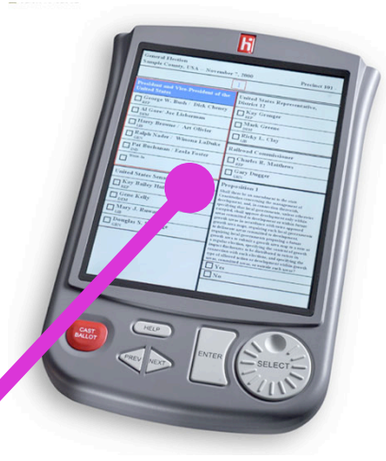
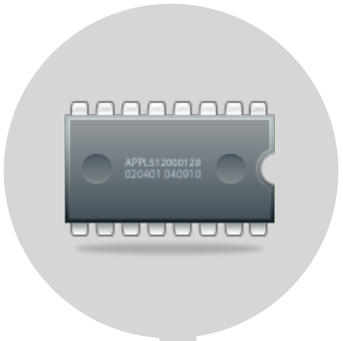


touch screen / buttons
graphical display

flash memory



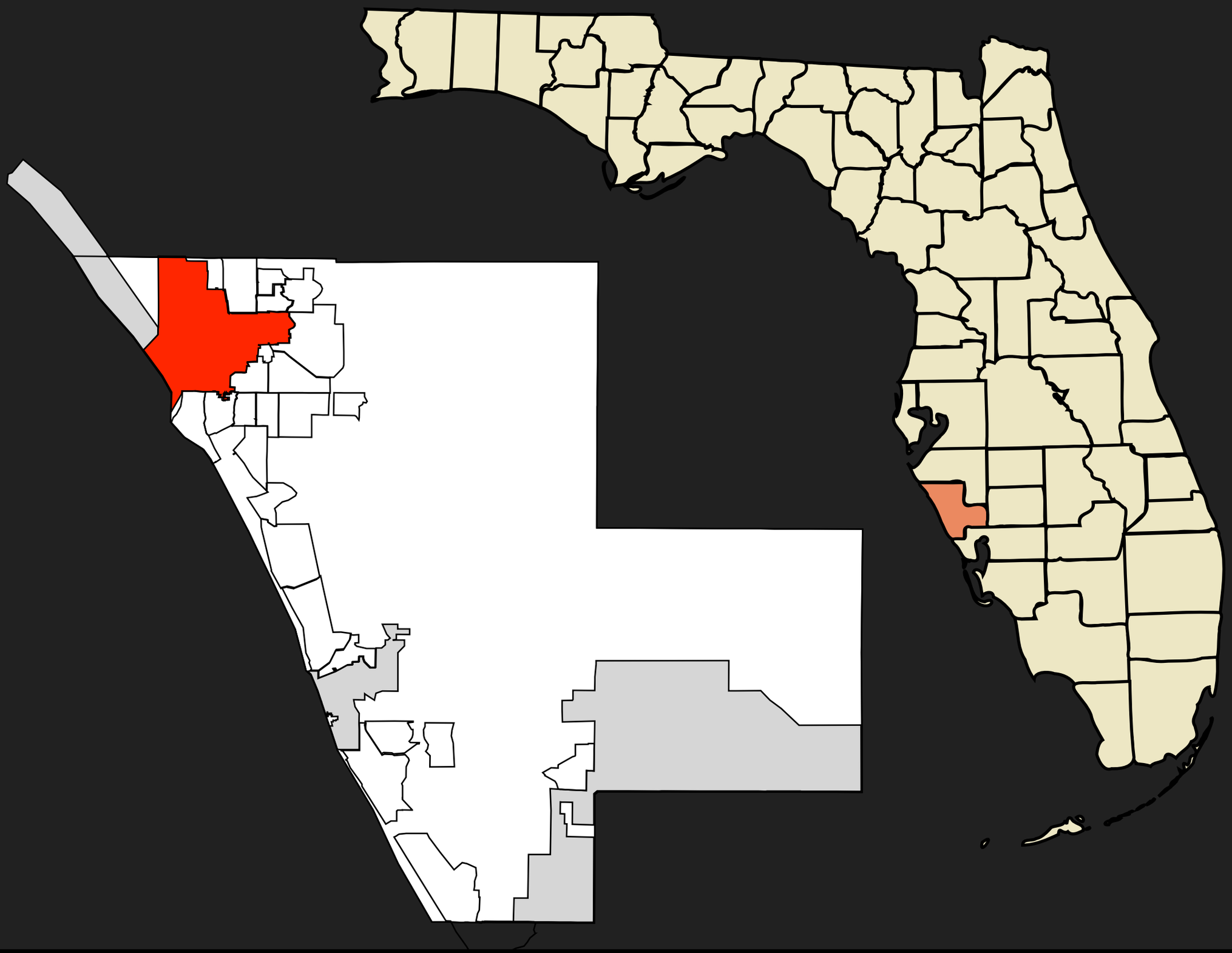
DRE voting machines (Direct Recording Electronic)

touch screen / buttons
graphical display

Sarasota, Florida

CD-13 Race, November 2006

Christine Jennings v. Vern Buchanan



In a nutshell...

Did voting machines steal a Democratic victory?

In Katherine Harris' old Florida district, more than 18,000 votes went missing -- and a Republican won a House seat by 369 votes.

By Katharine Mieszkowski

The recount is over in the 13th Congressional District in Florida. The lawyers have won -- and the Democrat has lost. As in the presidential election of 2000, that loss appears to have been caused by a glitch in the voting process. But this time, the controversy centers on the very electronic voting machines many counties around the country purchased after the 2000 election in hopes of avoiding the sort of debacle that produced Bush v. Gore.

On Monday, Florida election officials named Republican Vern Buchanan the victor in the race for the House seat that Katherine Harris -- the Katherine Harris who was Florida's secretary of state during the 2000 recount -- vacated to run for the Senate. The Florida Elections Canvassing Commission, which is made up of Gov. Jeb Bush and two other elected Republican officials, said that the results of the recount showed Buchanan had beaten Democrat Christine Jennings by 369 votes in a race where nearly 240,000 votes were cast. The commission awarded the victory to Buchanan despite the fact that the mystery of more than 18,000 missing votes has not been resolved.

Photo: AP/J. Scott Applewhite

Christine Jennings, the Democratic candidate in Florida's unresolved 13th Congressional District, second from left, after posing with freshman members of the House for a group photo on the steps of the Capitol in Washington on Nov. 14, 2006.

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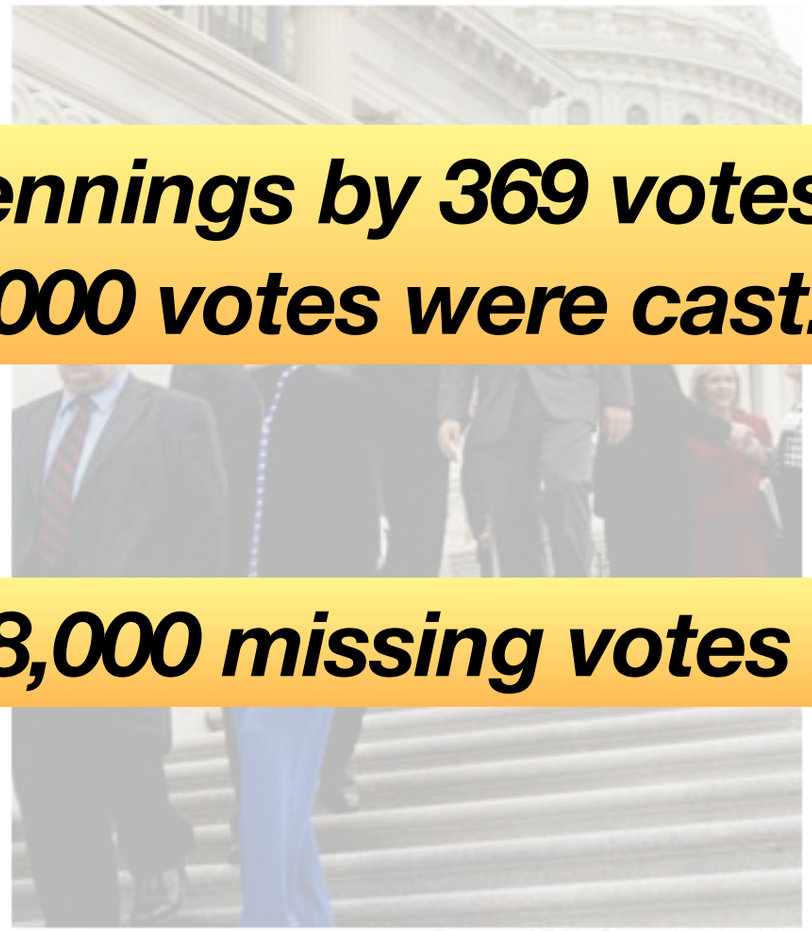

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Christine Jennings, the Democratic candidate in Florida's unresolved 13th Congressional District, second from left, after posing with freshman members of the House for a group photo on the steps of the Capitol in Washington on Nov. 14, 2006.

Buchanan had beaten ... Jennings by 369 votes in a race where nearly 240,000 votes were cast.

... mystery of more than 18,000 missing votes ...

Undervote rates by race

U.S. Senate	1.14%
Congress	12.90%
Governor	1.28%
Atty General	4.36%
C.F.O.	4.43%

Absentee	2.5%
ES&S iVotronic	14.9%

Theory #1: Rational abstention

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Nobody seriously believes this.

Theory #2:
Human factors

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Were voters confused by the ballot design?

OFFICIAL GENERAL ELECTION BALLOT
SARASOTA COUNTY, FLORIDA
NOVEMBER 7, 2006

CONGRESSIONAL

UNITED STATES SENATOR
(Vote for One)

Katherine Harris	REP	☐
Bill Nelson	DEM	☐
Floyd Ray Frazier	NPA	☐
Belinda Noah	NPA	☐
Brian Moore	NPA	☐
Roy Tanner	NPA	☐
Write-In		☐

U.S. REPRESENTATIVE IN CONGRESS
13TH CONGRESSIONAL DISTRICT
(Vote for One)

Vern Buchanan	REP	☐
Christine Jennings	DEM	☐

STATE

GOVERNOR AND LIEUTENANT GOVERNOR
(Vote for One)

Charlie Crist Jeff Kottkamp	REP	☐
Jim Davis Daryl L. Jones	DEM	☐
Max Linn Tom Macklin	REF	☐
Richard Paul Dembinsky Dr. Joe Smith	NPA	☐
John Wayne Smith James J. Kearney	NPA	☐
Karl C.C. Behm Carol Castagnero	NPA	☐
Write-In		☐

Theory #3: Machine malfunction

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Did engineering failures of the machines *induce* the underotes?

Did voters *see* their undervotes on the summary screen?

Poor touchscreen calibration

Poor touch sensitivity

Hardware and software failures

Manufacturing defects

Dan Rather Reports had a long piece on this issue

Angle of view to the screen

Theory #4:
Fraud!

No evidence to support this.

Exceptionally difficult to prove.

Never ascribe malice to what can adequately be explained by incompetence. – Napoleon

Machine vs. human error

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Critical concept relative to Florida law

If the summary screen showed “Jennings” and the machine recorded “none”, then Jennings should win

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Critical concept relative to Florida law

If the summary screen showed “Jennings” and the machine recorded “none”, then Jennings should win

Regardless, the machines failed to capture voter intent

Experts on both sides agree Jennings would have won

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“Recount”

Same results as before (largely meaningless)

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“Parallel” election tests

Poorly conducted, inconclusive results

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Same results as before (largely meaningless)

“Parallel” election tests

Poorly conducted, inconclusive results

Software examination

Found nothing (but significant / unrelated security holes)

Never looked at the hardware

What happened?

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State lawsuits

Judge denied plaintiff's discovery motion

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Congressional Committee on House Administration

GAO investigation affirmed result (Jennings conceded)

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Florida banned electronic voting systems

Jennings ran again and lost to then-incumbent Buchanan

What’s next?

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Four years later, we still don't know what happened

Rice study: bad layout causes errors, but voters fix them

Iowa study: slow touchscreens increase error rate

Theory: Sarasota suffered from both problems

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We need better recount / challenge procedures

Transparency is more important than vendor trade secrets

Research goals

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Make it easier to audit results after the election

every vote included is valid; every valid vote is included

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How?

Connect the machines together.

VoteBox's approach

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VoteBox's approach

Store everything everywhere

Massive **redundancy**

Stop trusting DREs to keep their own audit data

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Link all votes, events together

Create a **secure timeline** of election events

Tamper-evident proof of each vote's legitimacy

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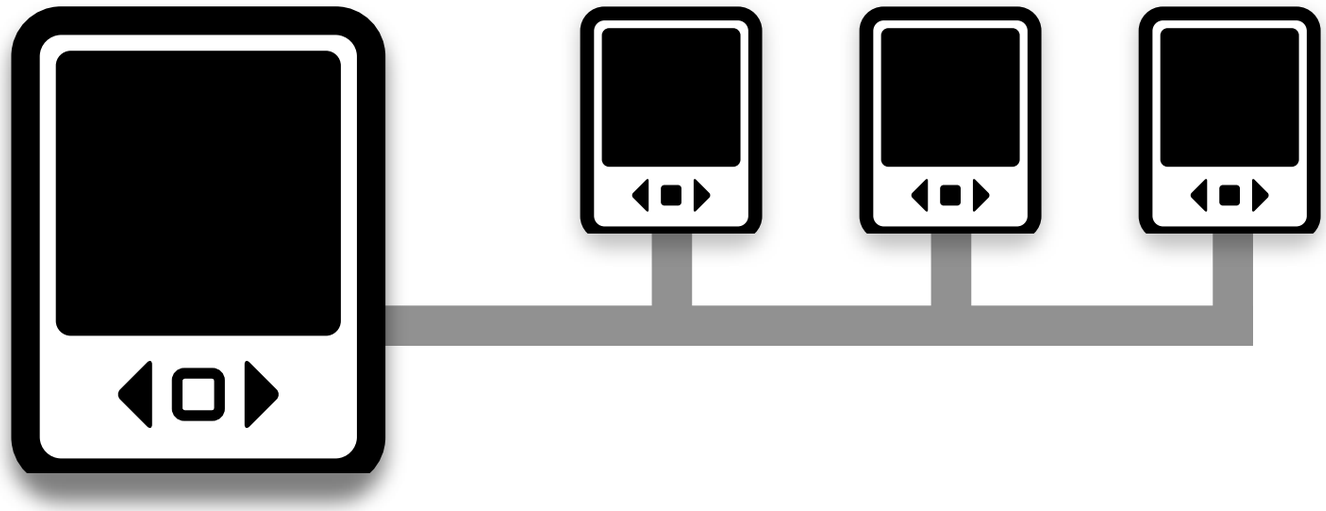
How can I be sure my vote is faithfully captured by the voting machine?

polling place



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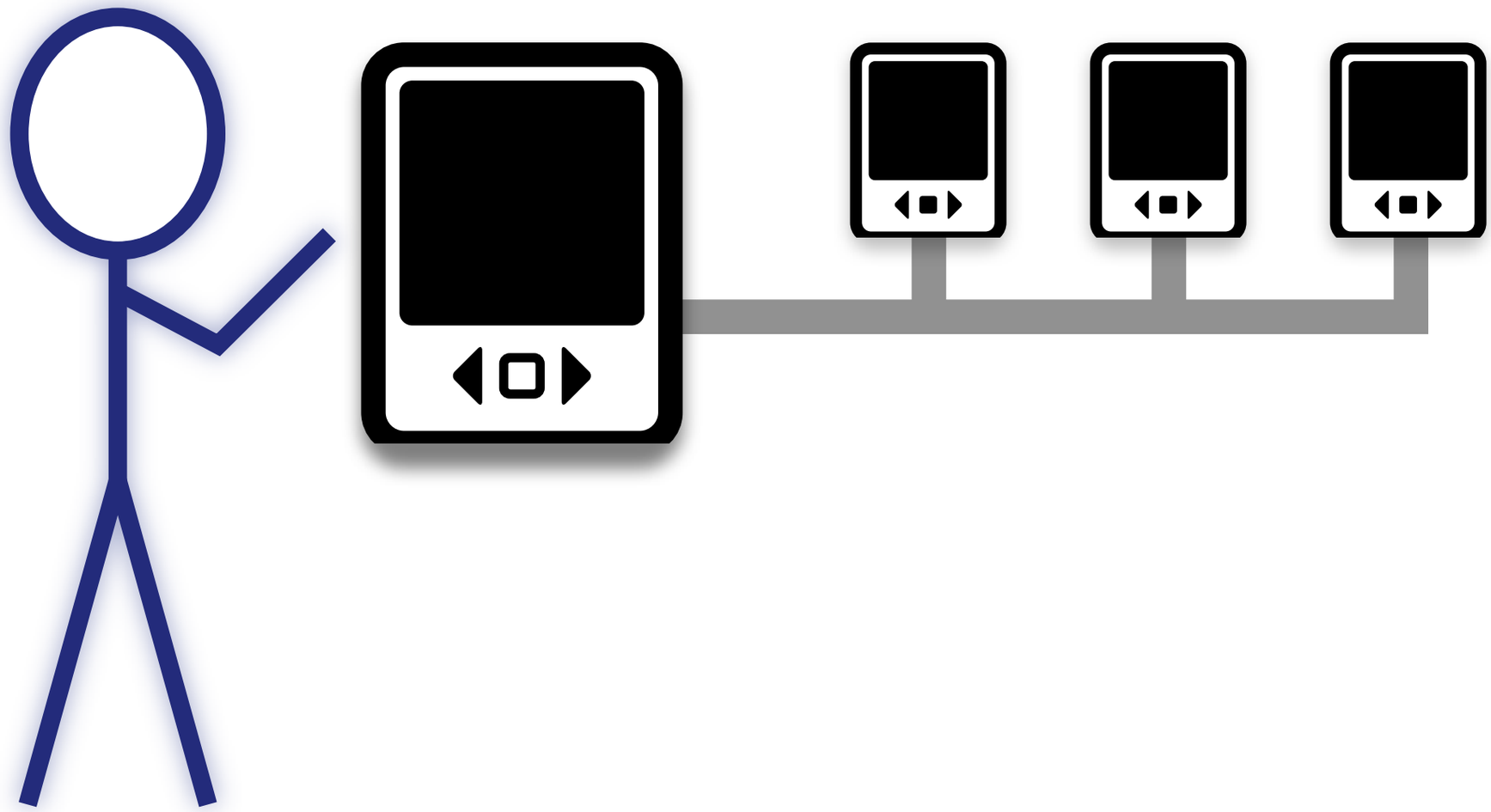

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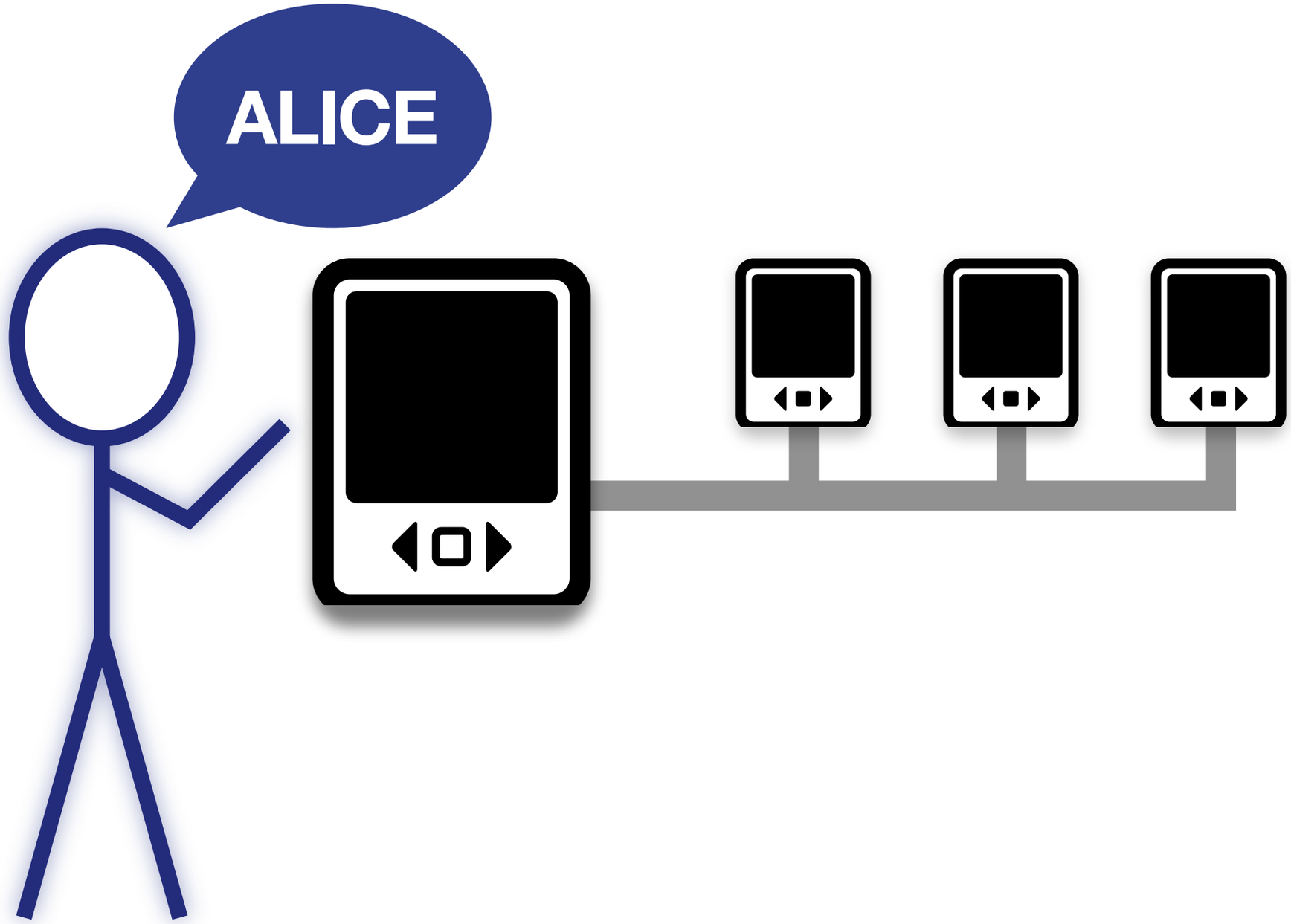

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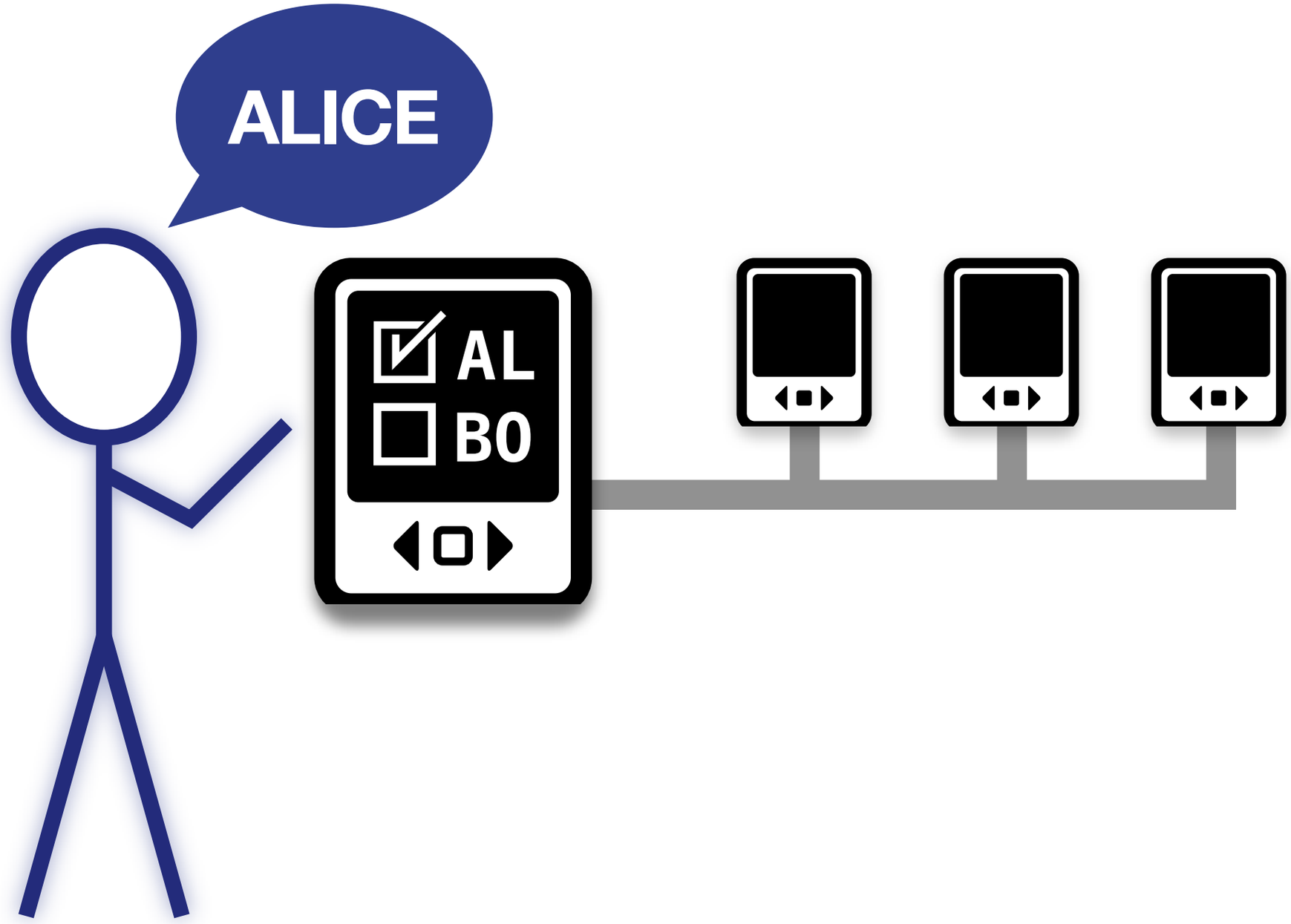

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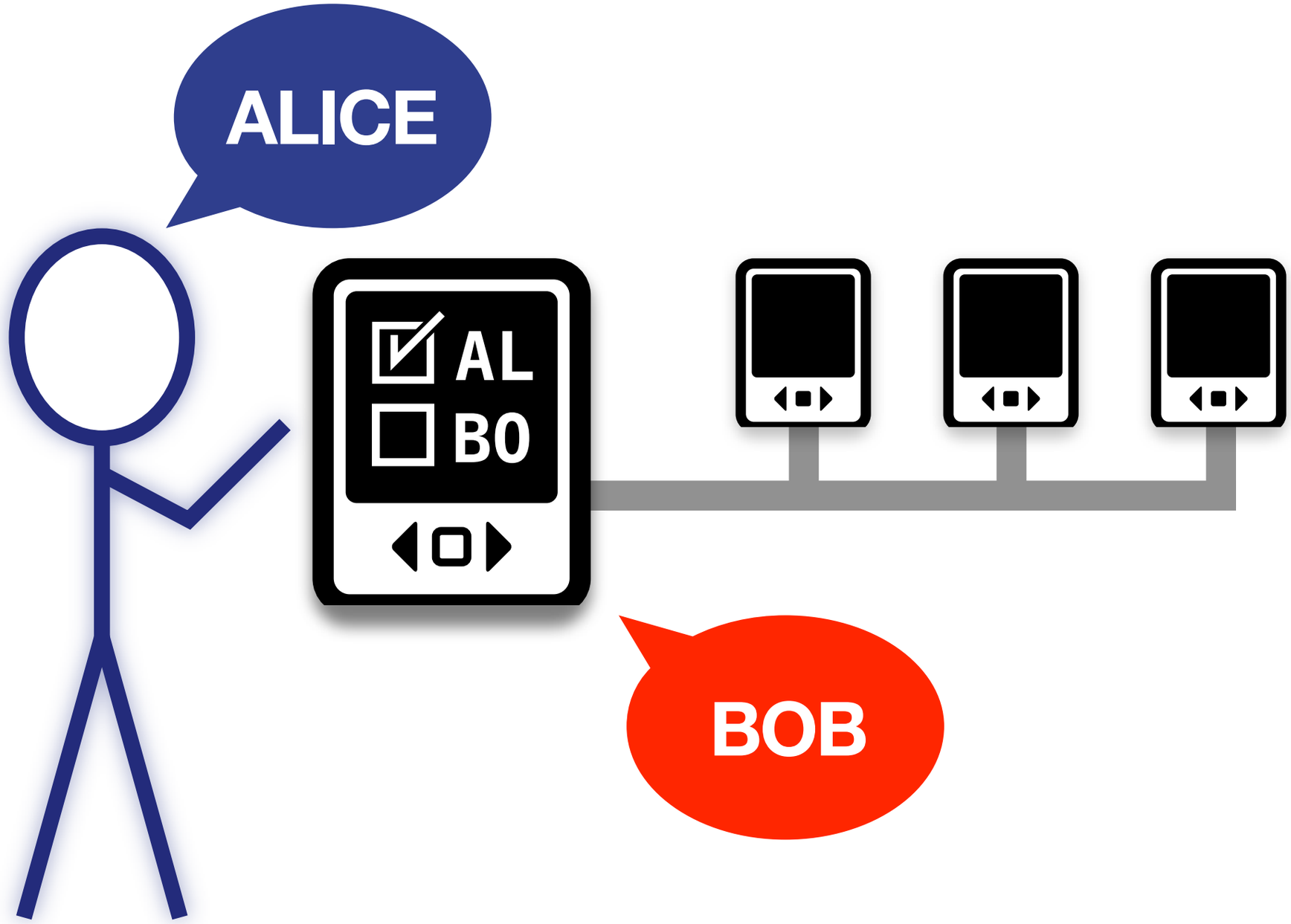

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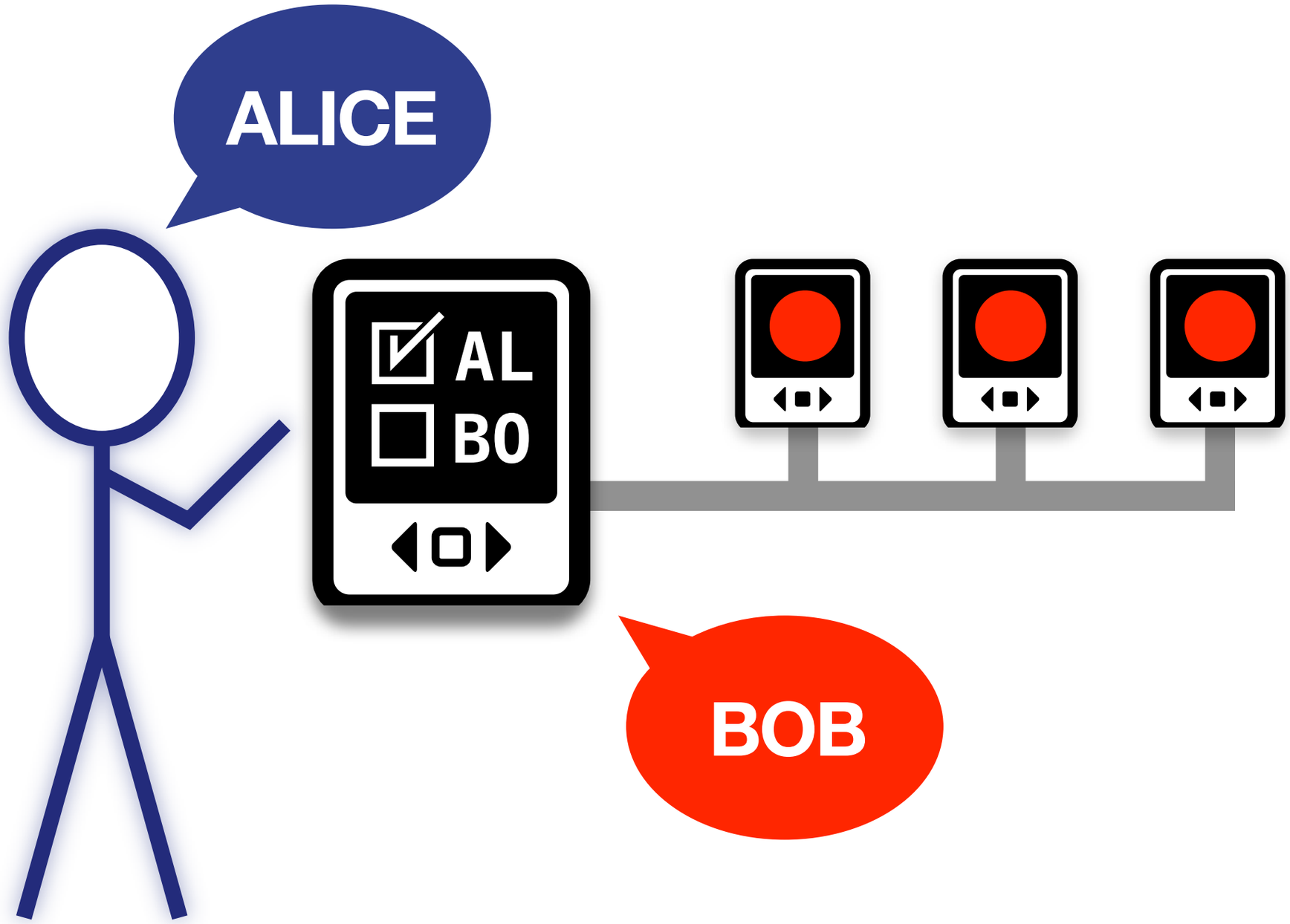

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at the end, instead of casting your ballot:

force the machine to **show it to you**

ballot challenge

a technique due to Benaloh [2007]

at the end, instead of casting your ballot:

force the machine to **show it to you**

this happens on election day

no artificial testing conditions (versus “logic & accuracy tests”)

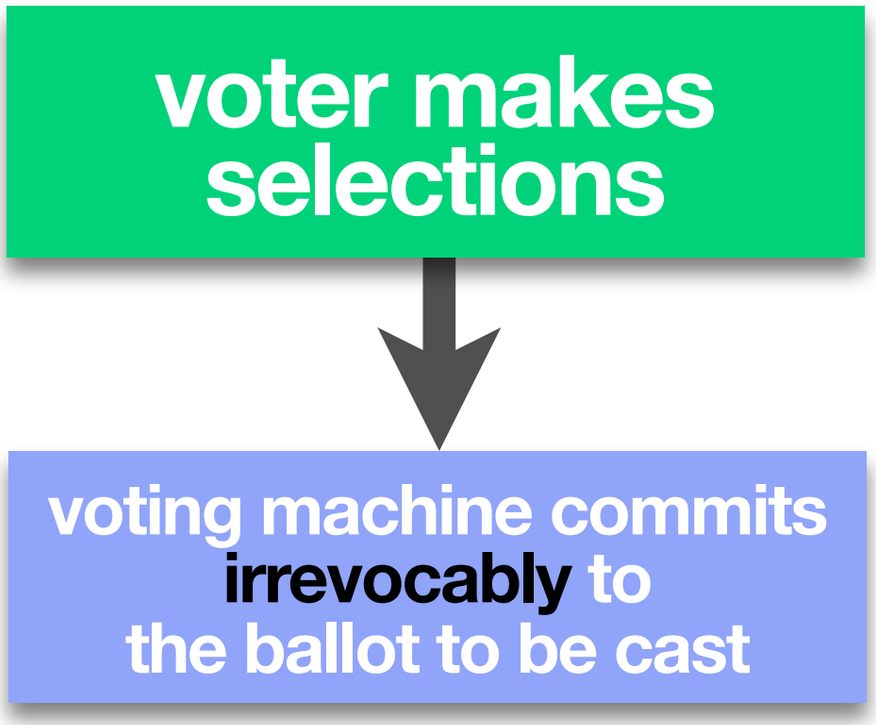
the voting machine cannot distinguish this from a real vote until the challenge

ballot challenge

ballot challenge

voter makes selections

ballot challenge



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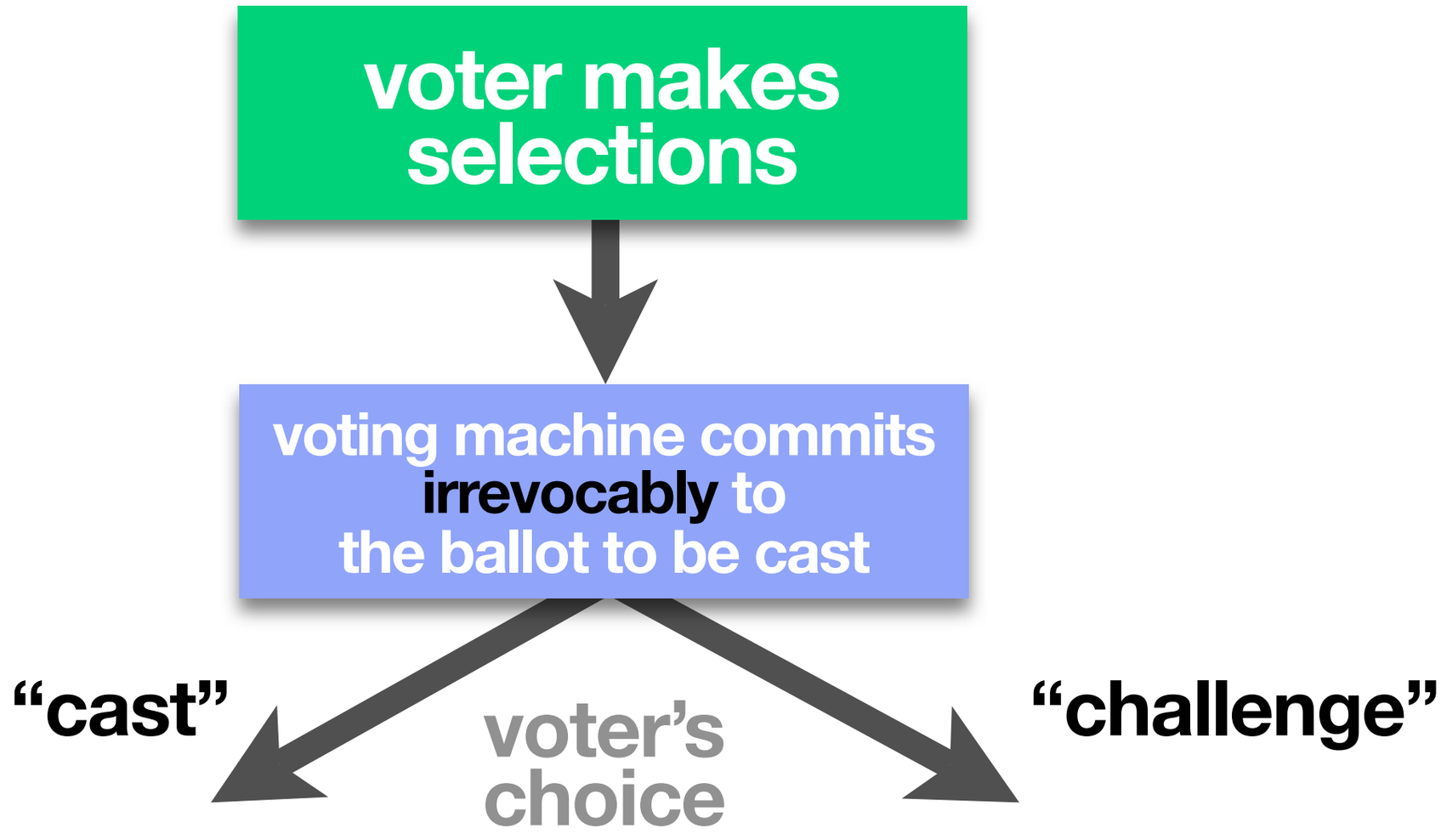

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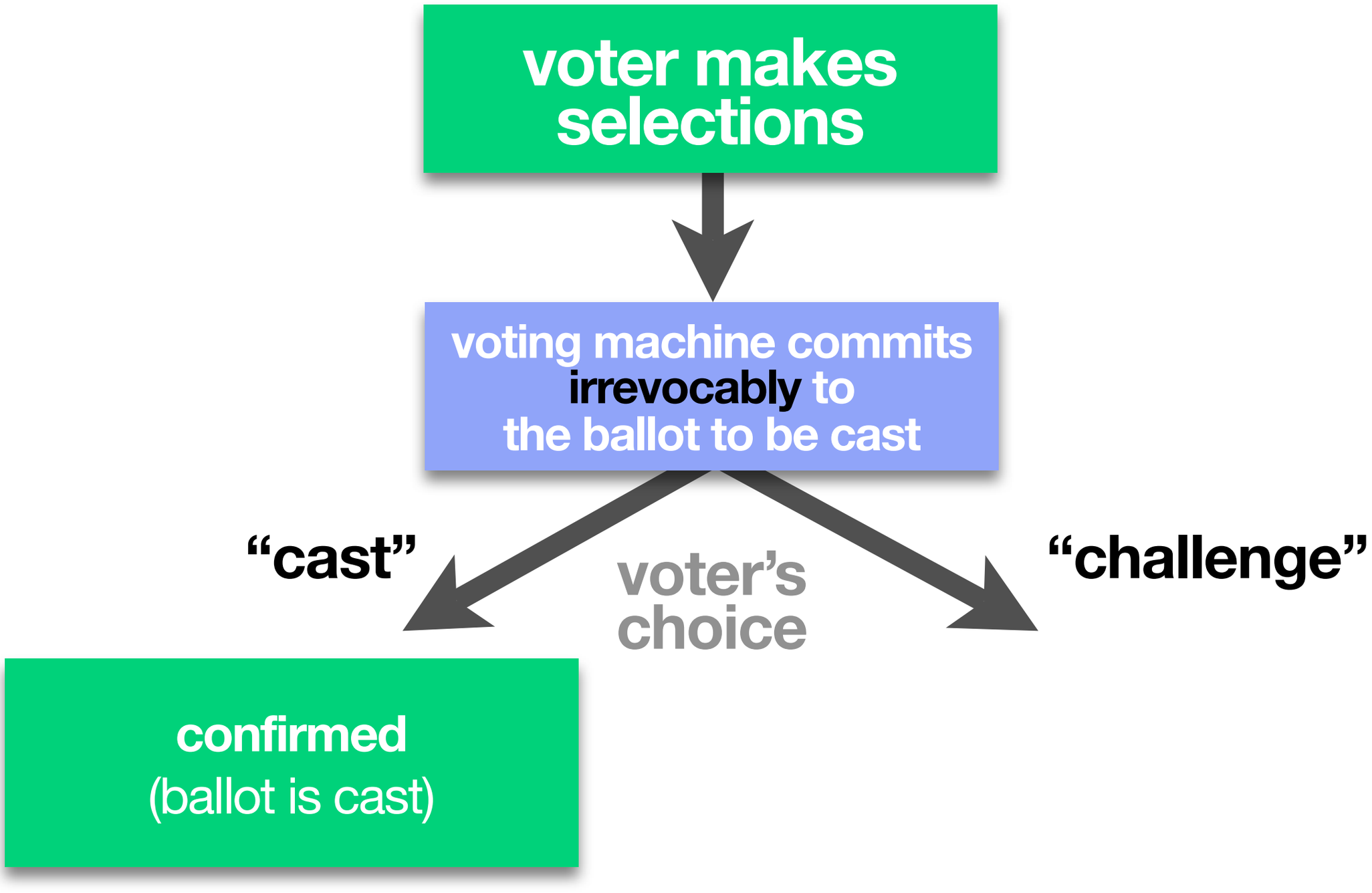

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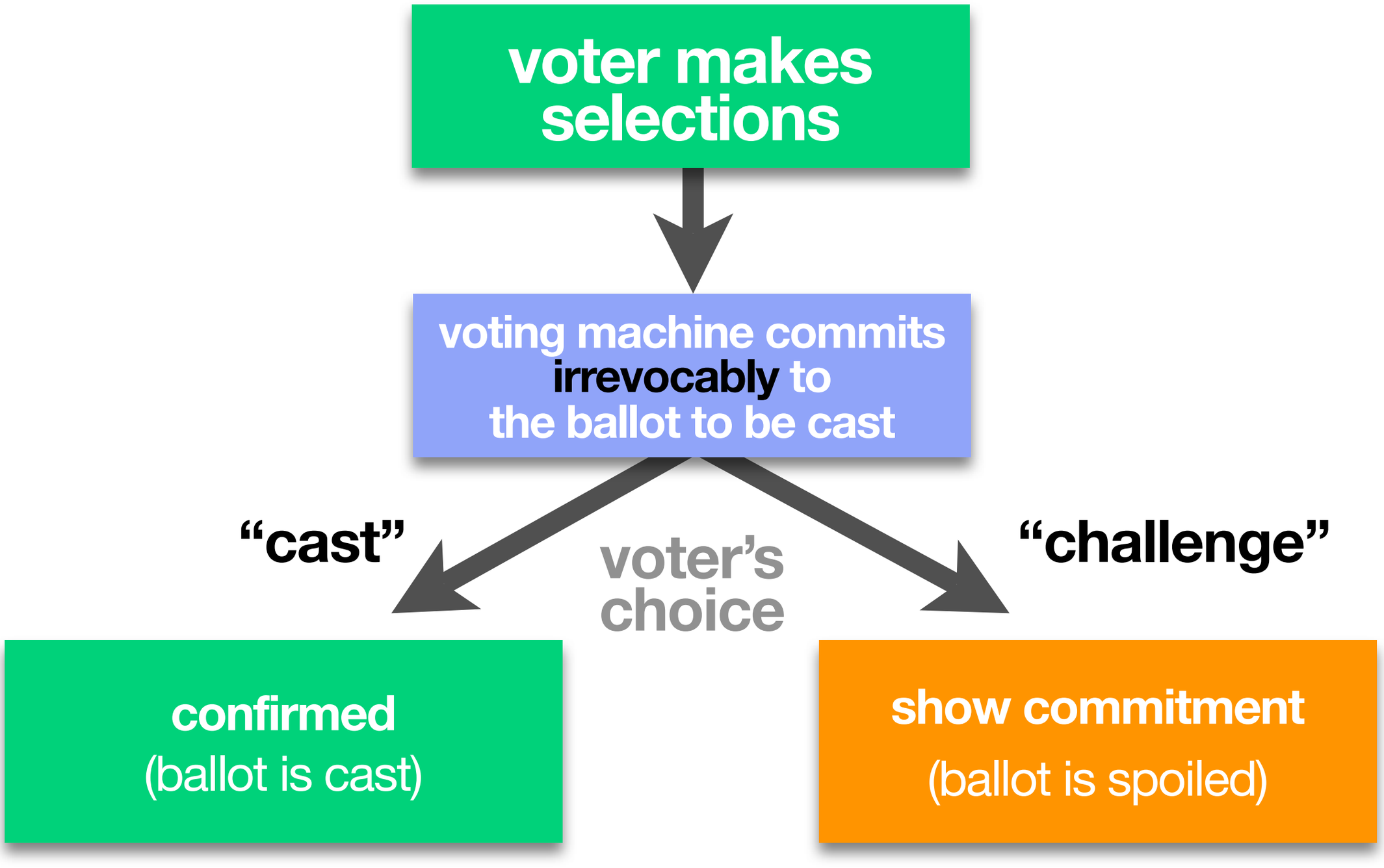

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How do we force the machine to produce proof of what it's about to cast on the voter's behalf?

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Print the encrypted ballot behind an opaque shield.

You can't see the contents, but you can see the page.

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How do you test the commitment?

View and decrypt it.

But decryption requires the private key for tabulating the whole election!

challenging the machine

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When challenged, the machine must reveal *random nonce* (part of the cryptosystem)

We can then decrypt this ballot (only) and see if it's what we expected to see

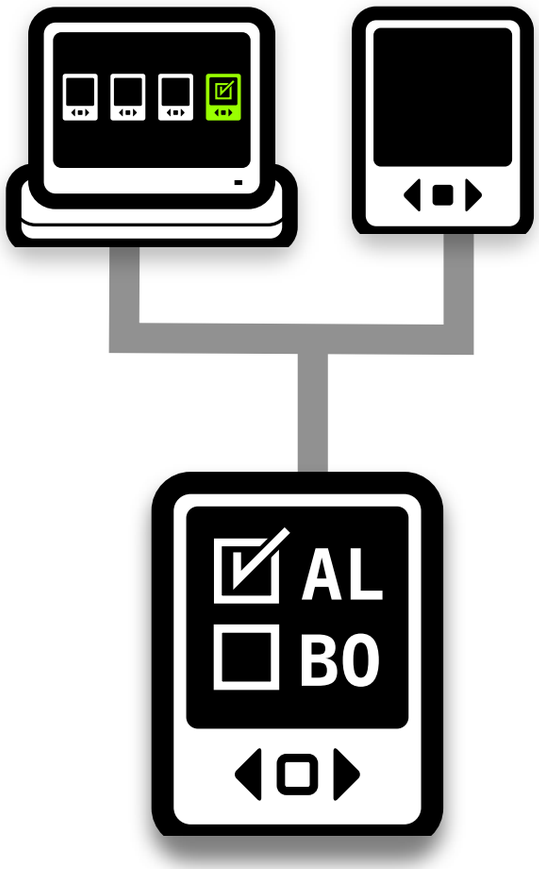
In Benaloh, the encrypted ballot is on paper

An **irrevocable** output medium

decrypting requires additional equipment

VoteBox's network serves the same purpose

polling place



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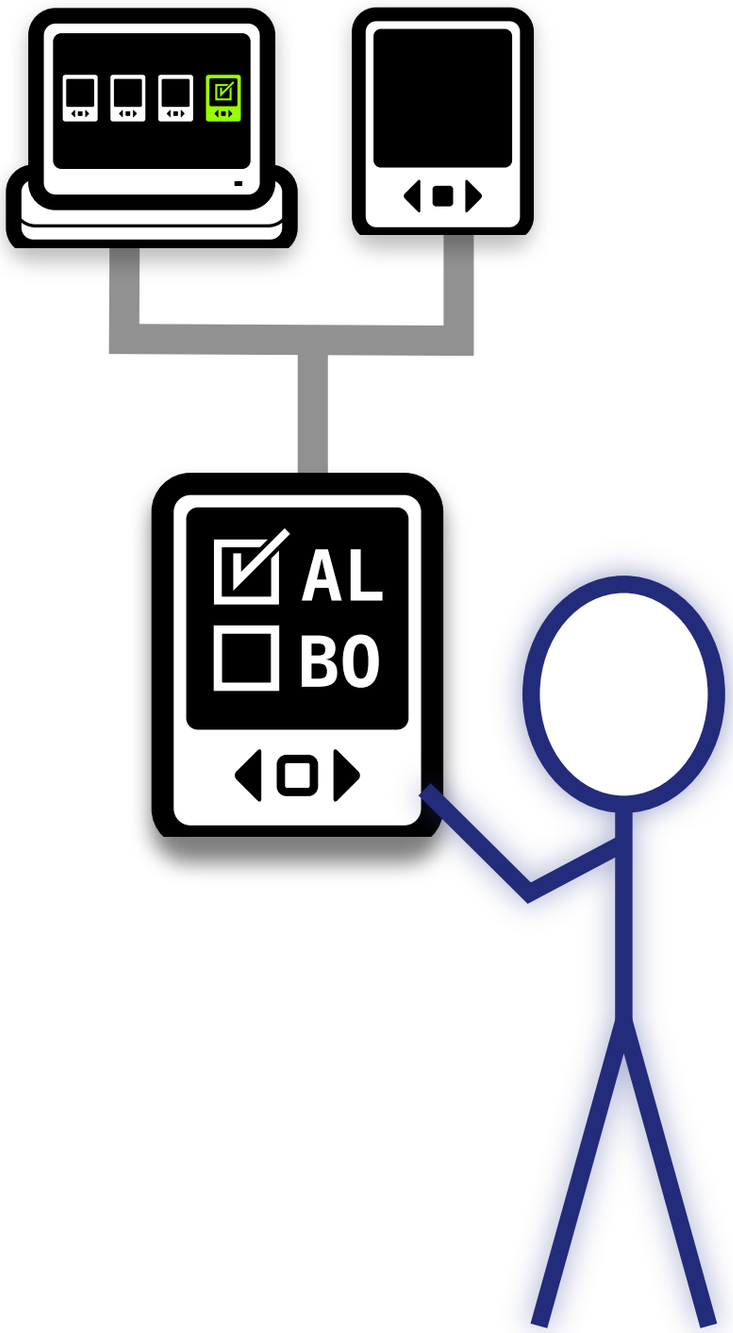

voter

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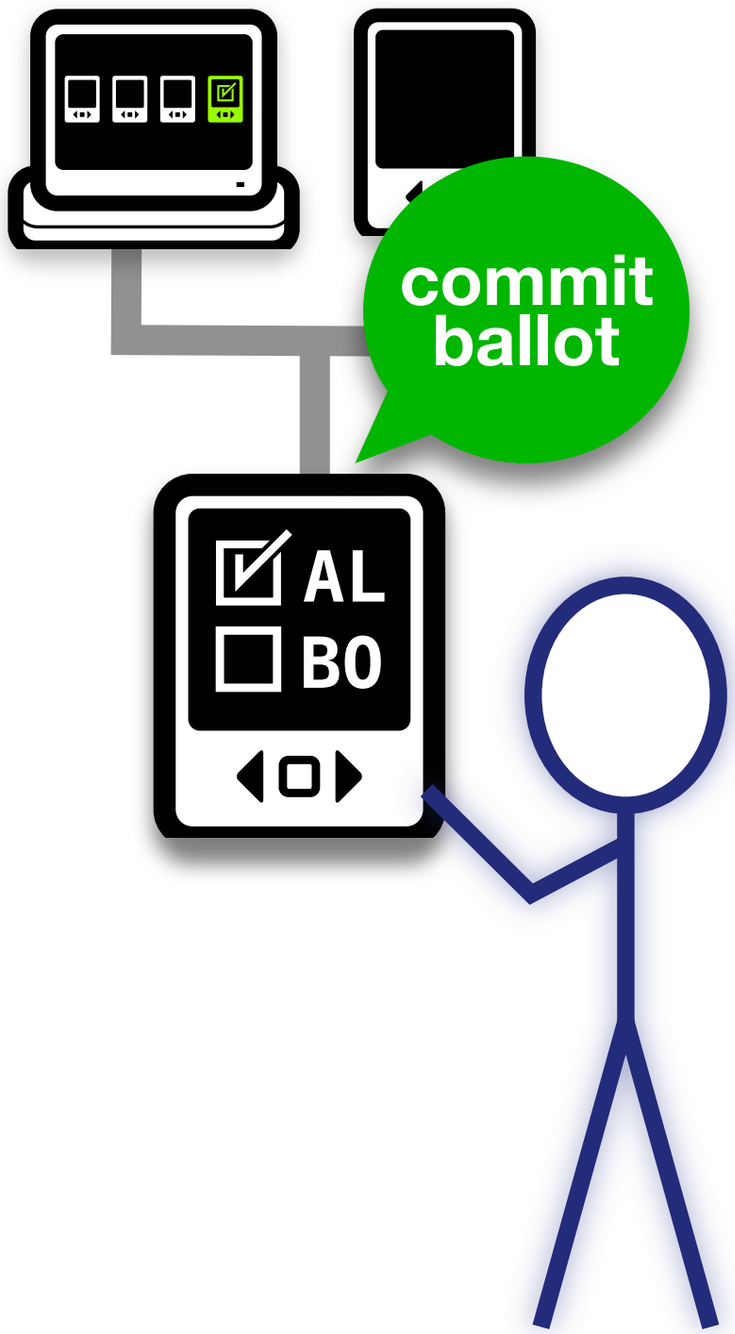
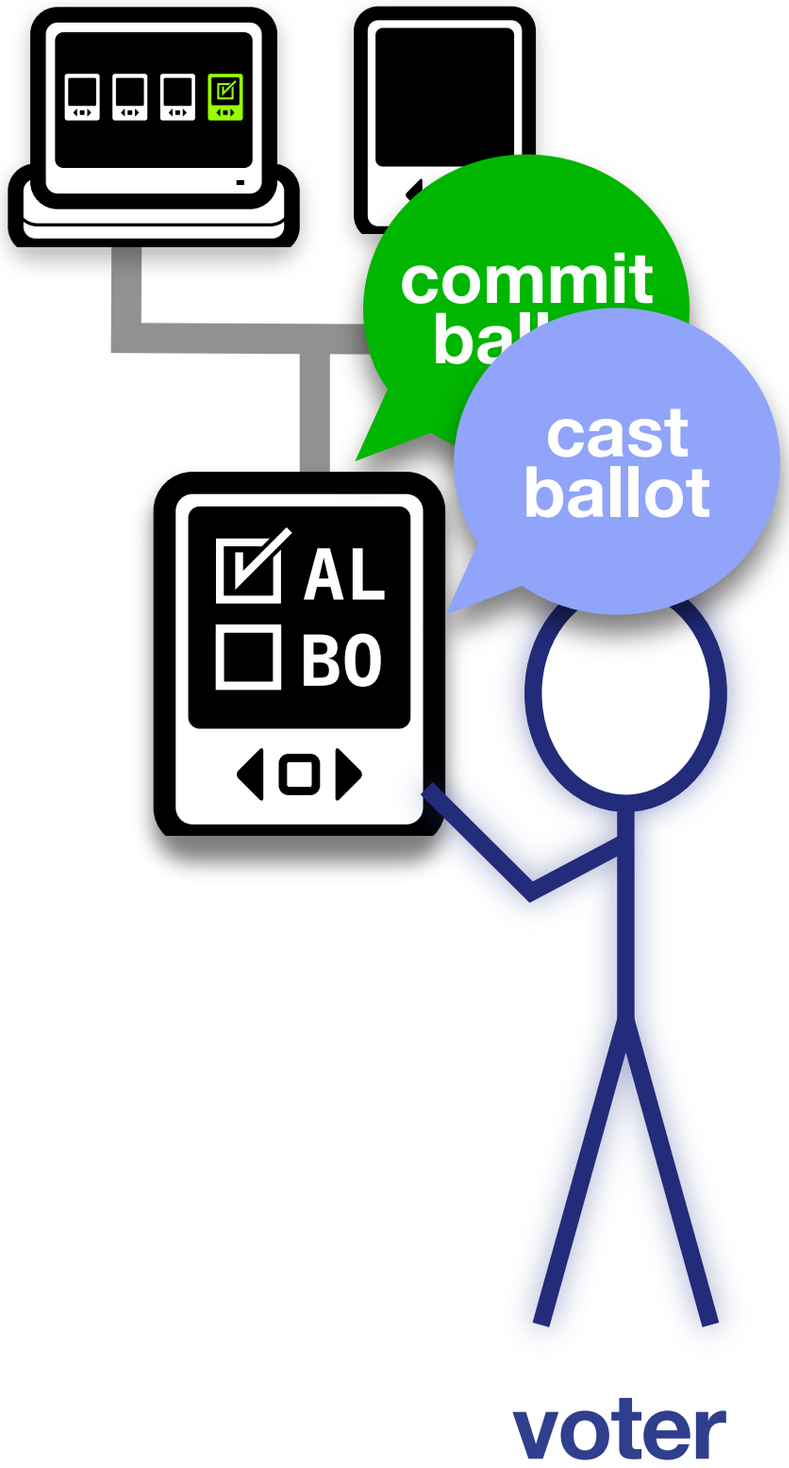
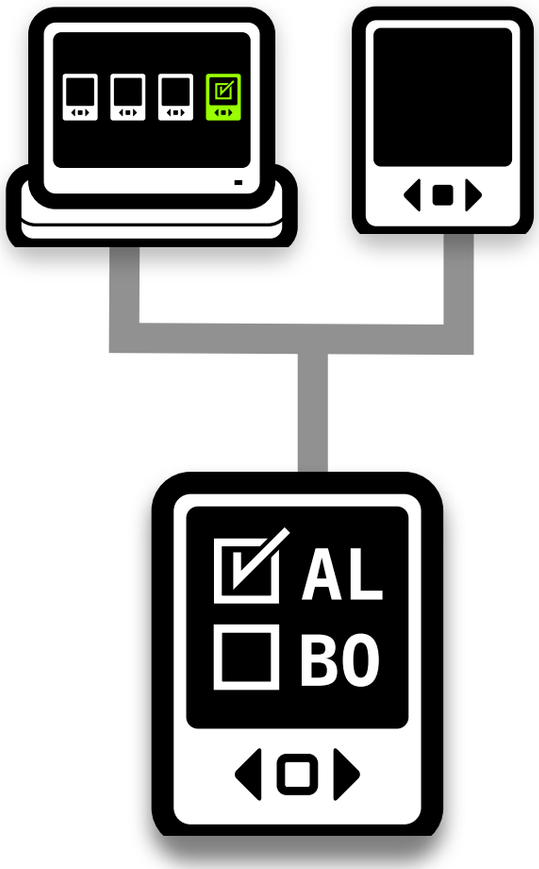


voter

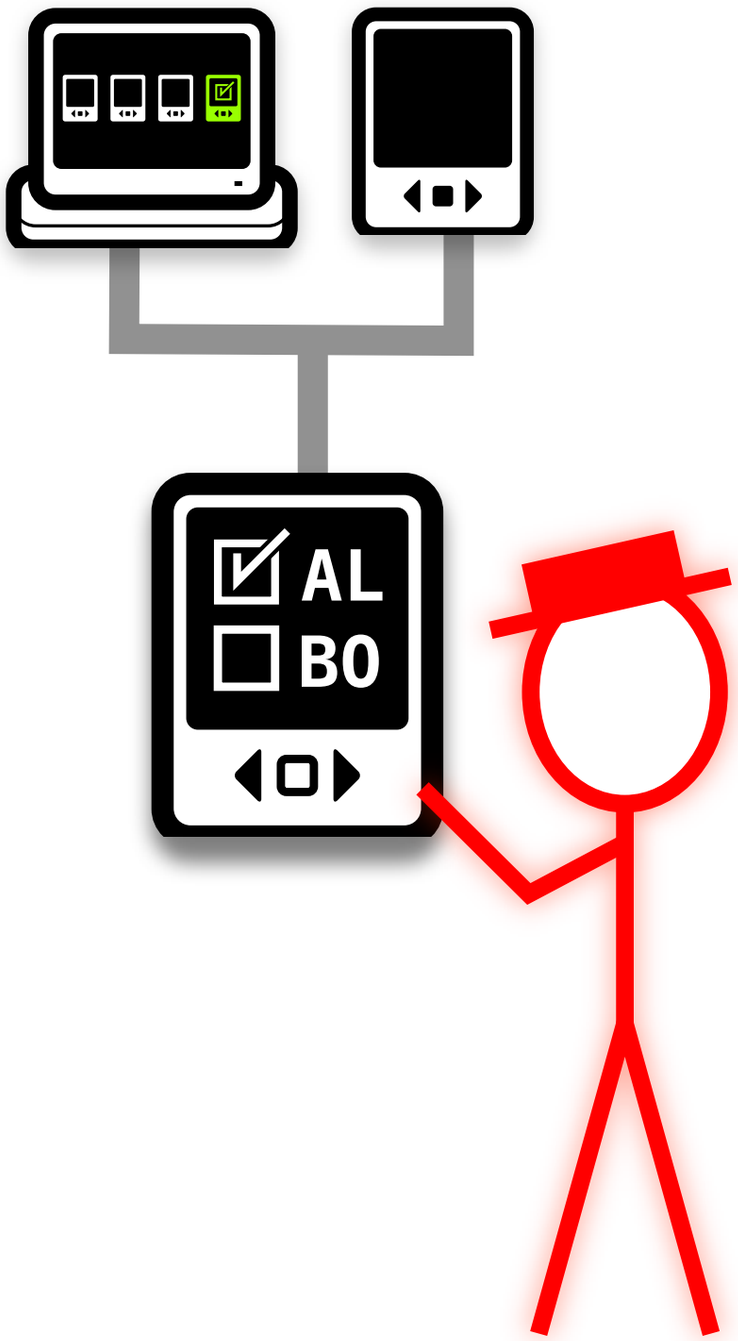
polling place



polling place

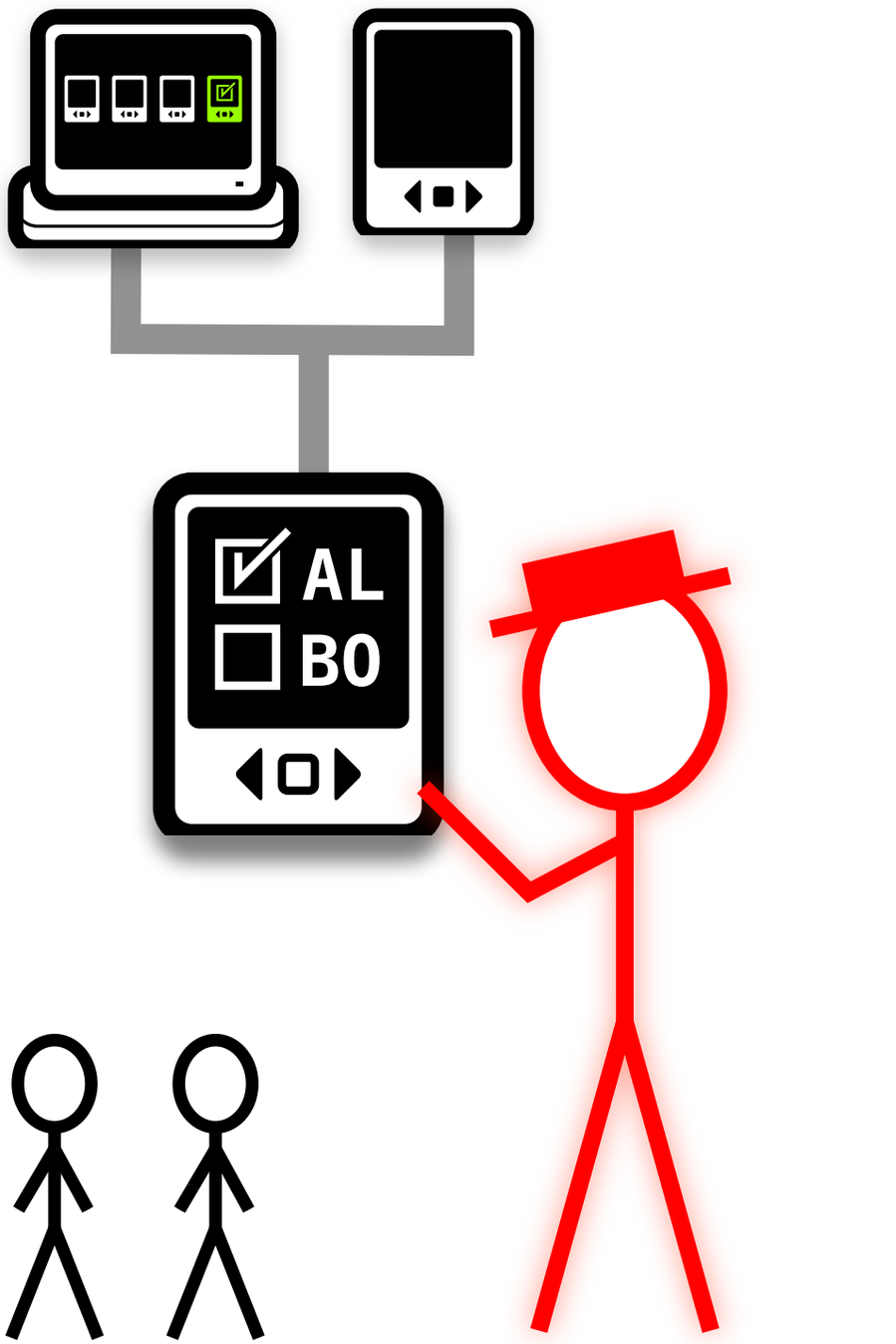


polling place



challenger

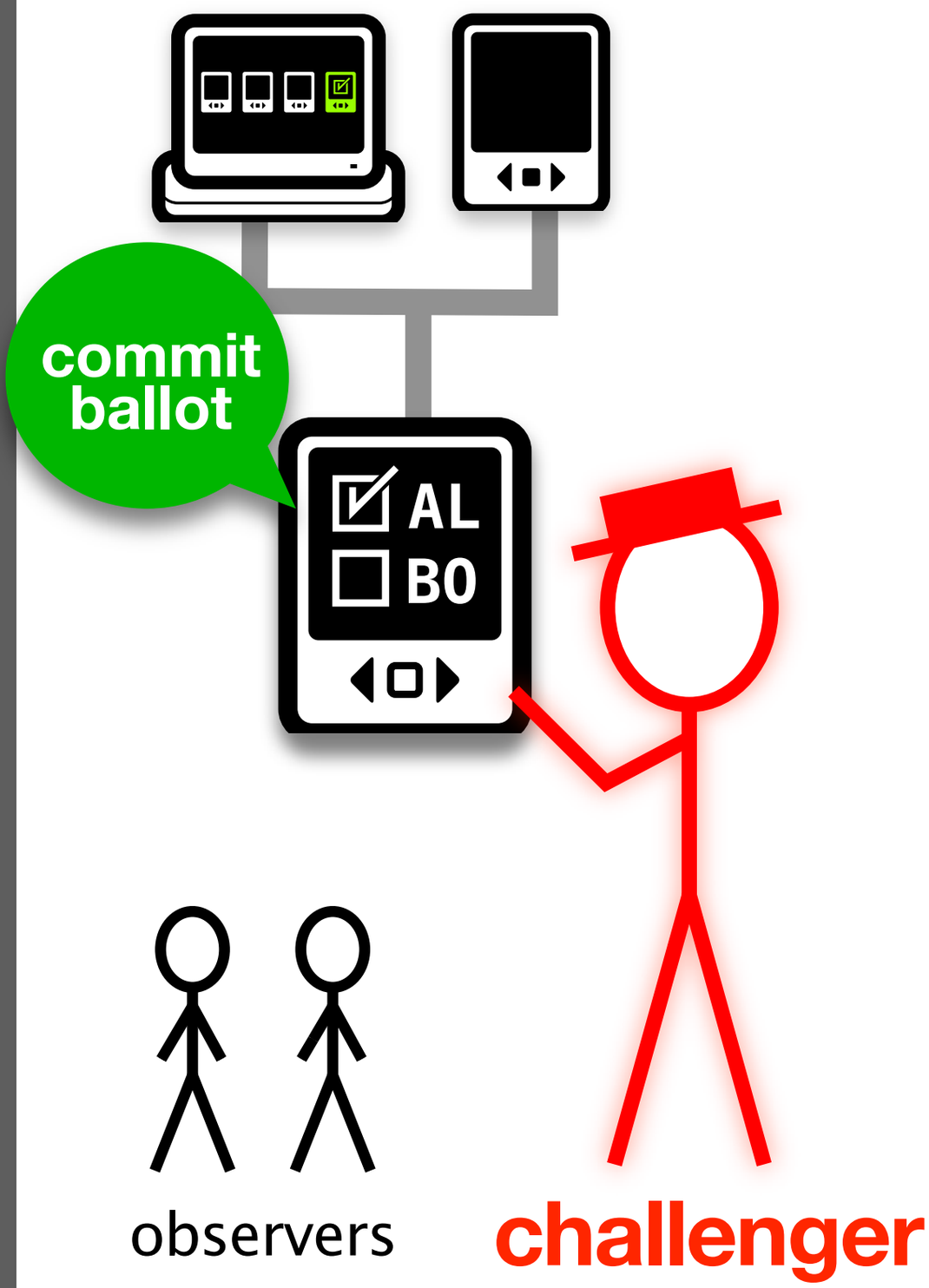
polling place



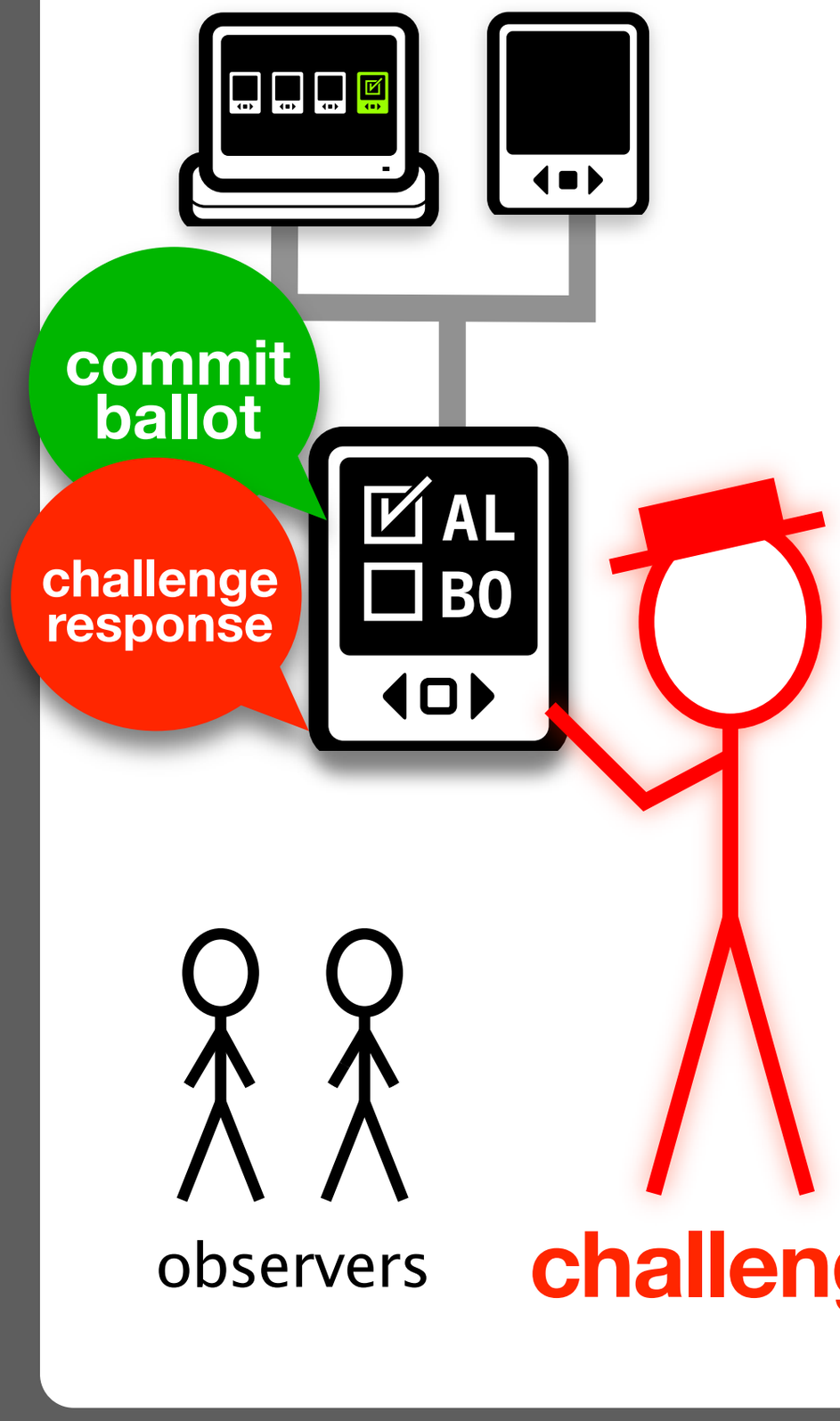
observers

challenger

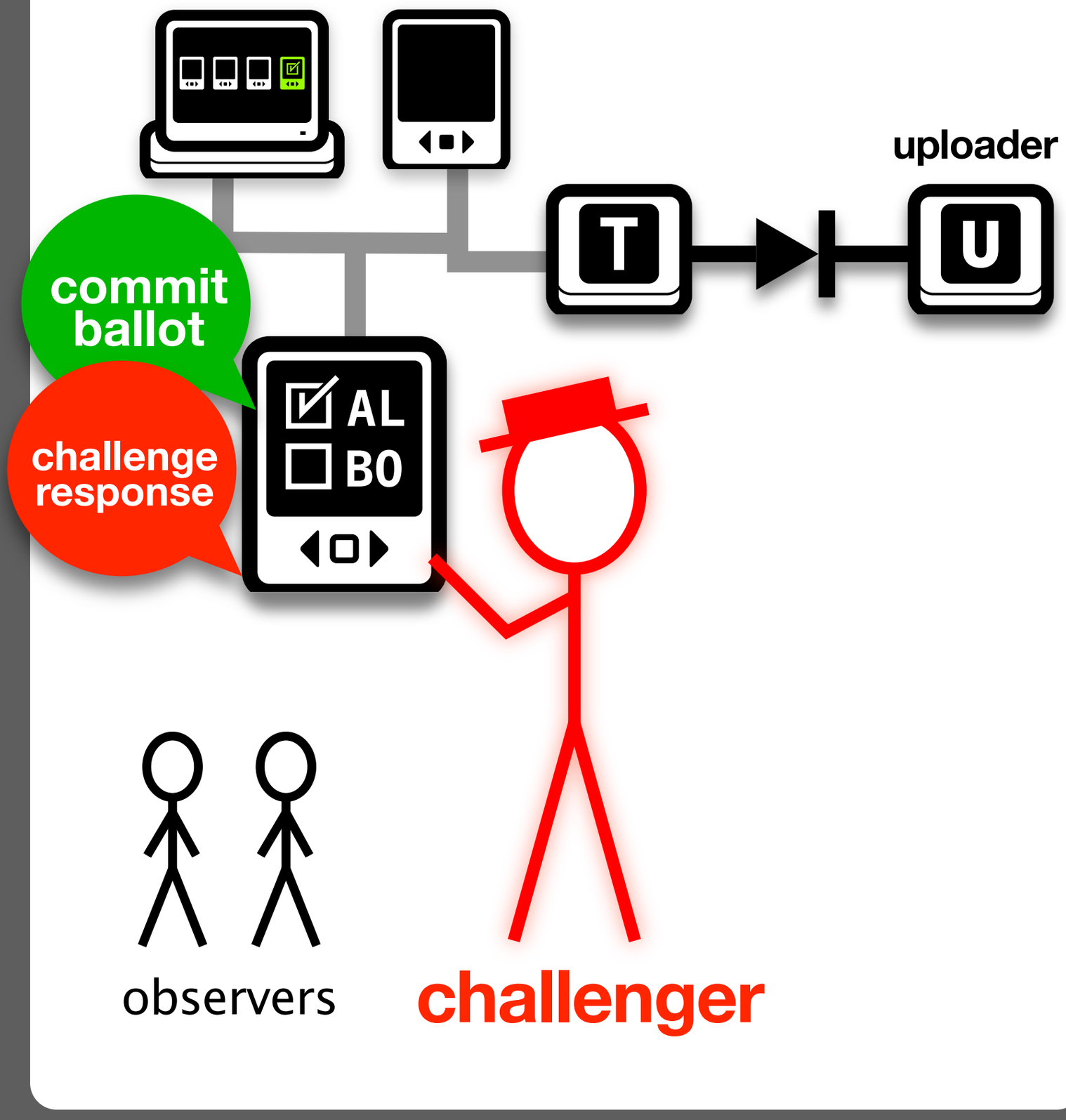
polling place



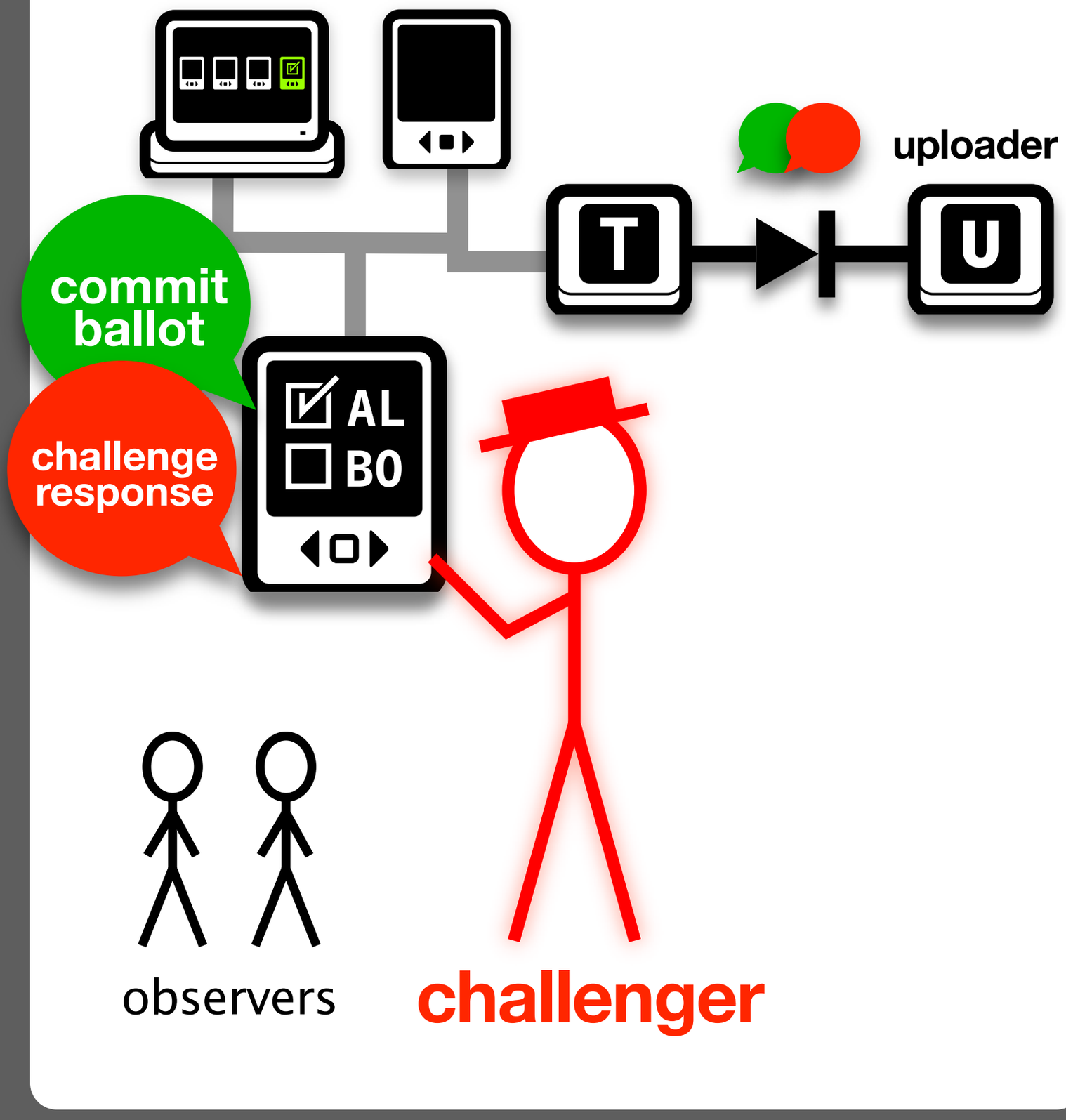
polling place



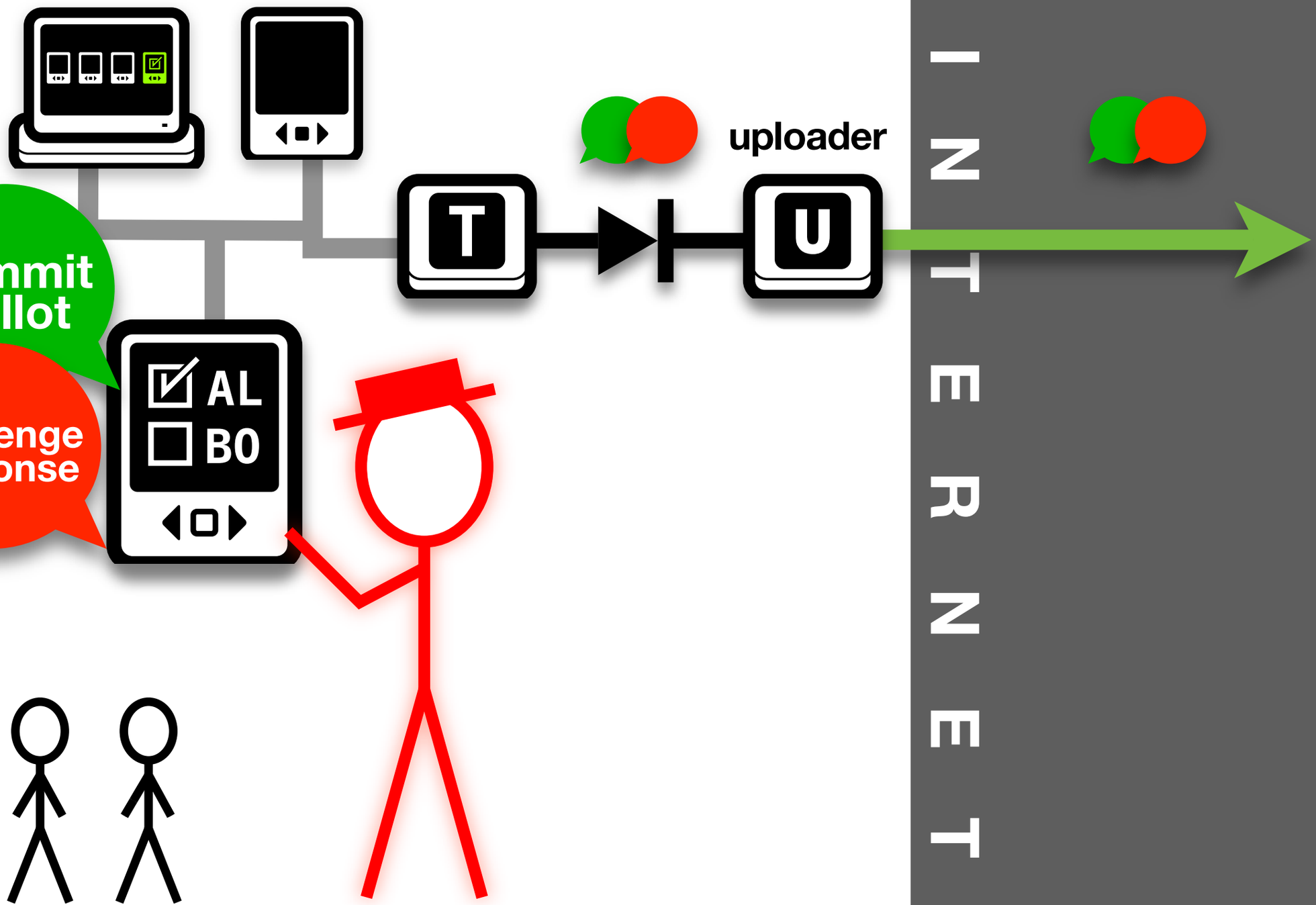
polling place



polling place



polling place



INTERNET

polling place

challenge center

INTERNET

uploader

T

U

commit ballot

challenge response

AL

BO

observers

challenger

polling place

challenge center

INTERNET

commit ballot

challenge response

T

uploader

U

AL

B0

challenge verification results

observers

challenger

polling place

challenge center

INTERNET

commit ballot

challenge response

T

uploader

U

AL

BO

ALICE

challenge verification results

observers

challenger

What’s next?

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Overseas/military remote voting

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Usability (e.g., Benaloh scheme)

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Pushing research out of the lab

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http://votebox.cs.rice.edu

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(Open source software distribution)