

# The Risks of Electronic Voting

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# 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.*

# Human factors issues

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

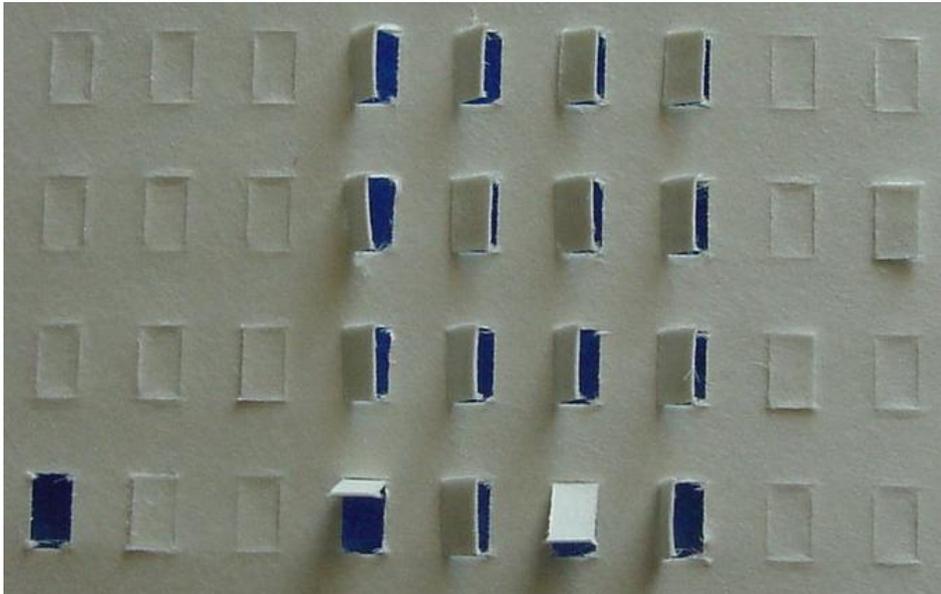
OFFICIAL BALLOT, GENERAL ELECTION  
PALM BEACH COUNTY, FLORIDA  
NOVEMBER 7, 2000

<p><b>ELECTORS FOR PRESIDENT AND VICE PRESIDENT</b></p> <p>(A vote for the candidates will actually be a vote for their electors.)</p> <p>(Vote for Group)</p>	(REPUBLICAN)	3 →	
	GEORGE W. BUSH - PRESIDENT DICK CHENEY - VICE PRESIDENT		
	(DEMOCRATIC)	5 →	
	AL GORE - PRESIDENT JOE LIEBERMAN - VICE PRESIDENT		
	(LIBERTARIAN)	7 →	
	HARRY BROWNE - PRESIDENT ART OLIVIER - VICE PRESIDENT		
	(GREEN)	9 →	
	RALPH NADER - PRESIDENT WINONA LaDUKE - VICE PRESIDENT		
	(SOCIALIST WORKERS)	11 →	
	JAMES HARRIS - PRESIDENT MARGARET TROWE - VICE PRESIDENT		
	(NATURAL LAW)	13 →	
	JOHN HAGELIN - PRESIDENT NAT GOLDHABER - VICE PRESIDENT		

A

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

# Mechanical flaws



# Ugly failure modes

## Ballot stuffing

- Absentee (mail-in) votes from deceased voters
- 100% of votes in Oregon are mail-in!

## Post-election ballot tampering

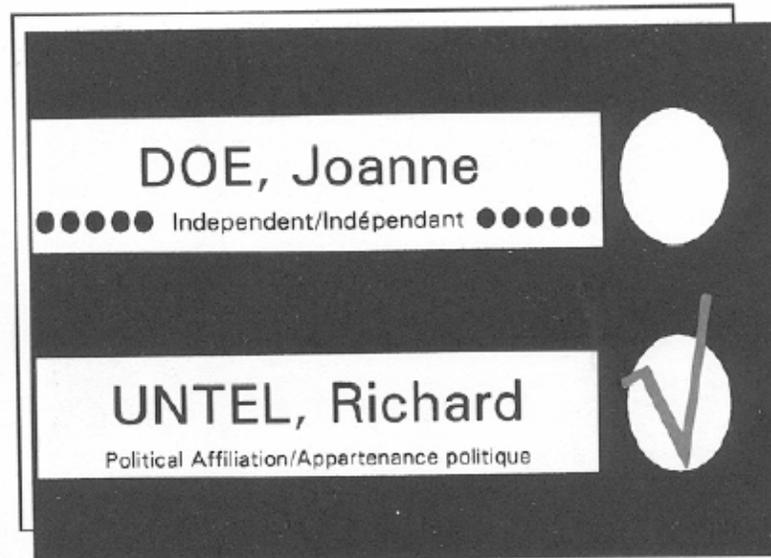
- Fraudulent behavior by election officials

## Bribery or coercion



# Traditional anonymous voting

- One paper card per office, list of candidates
  - Easy to count (just make two piles)
  - Easy to recount
  - Used in most countries



# Mechanical voting systems

## Odometer-style rotors inside

- Hidden during election
- Visible after election

## Post-election...

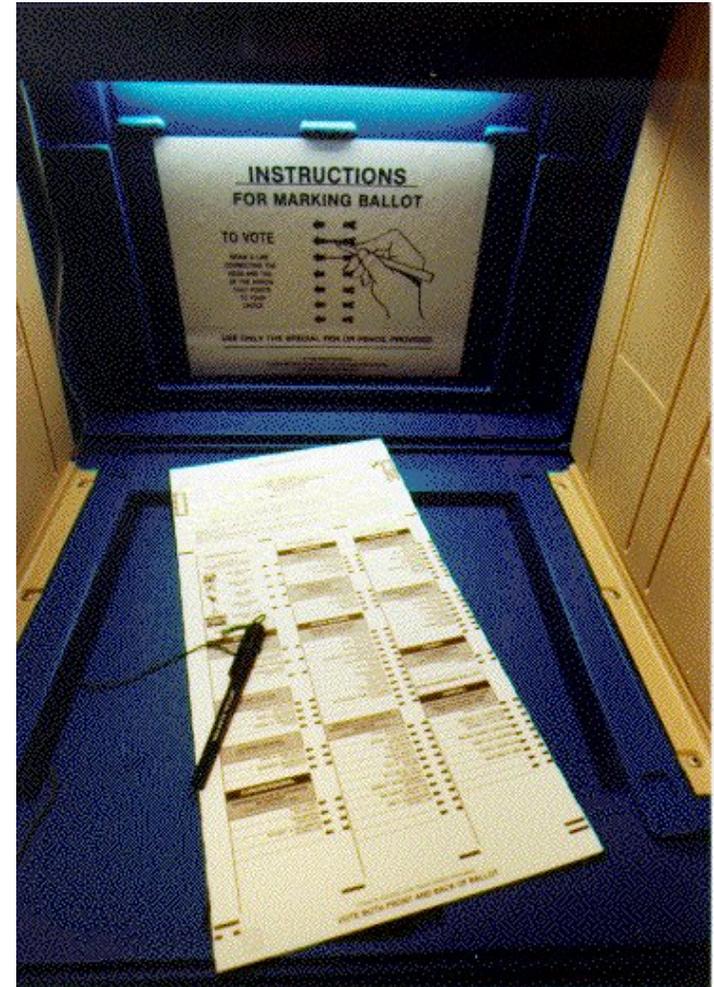
- Machines impounded
- Can be inspected for fraud



# Optical sense systems

Comparable to punch cards

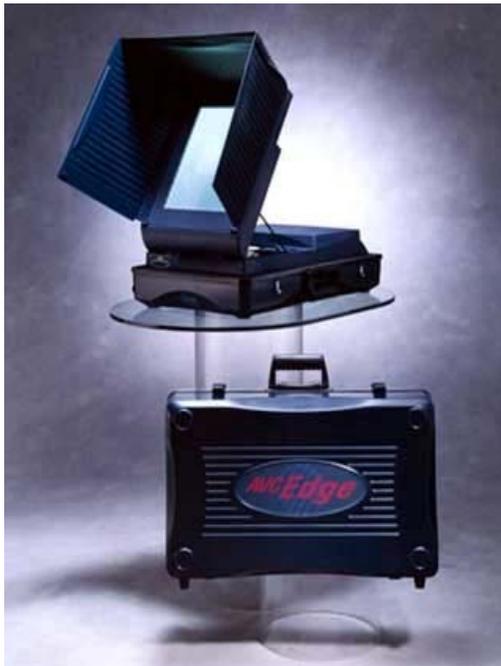
- Human-factors issues
- Possible to hand-recount
- High accuracy



# What about e-voting?

## Several different forms

- Internet voting (used on many college campuses)
- Computerized voting machines (DRE)



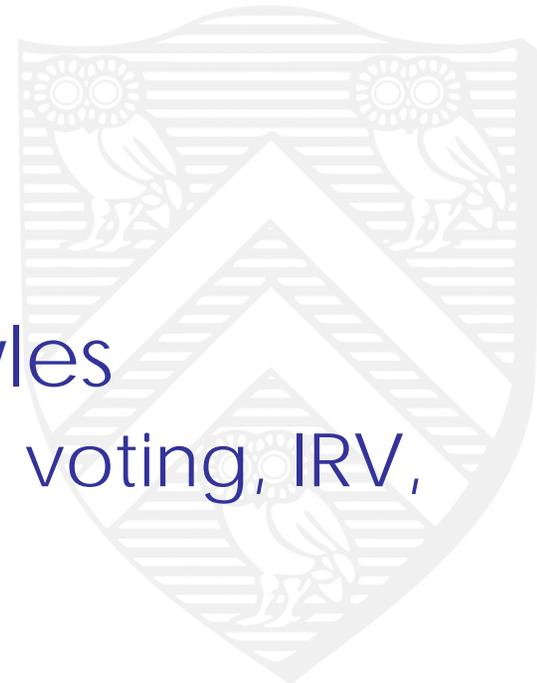
# Obvious benefits

## Better human factors

- Can check for “overvoting”
- Can review for mistakes
- Accessible interfaces (no need for helpers)

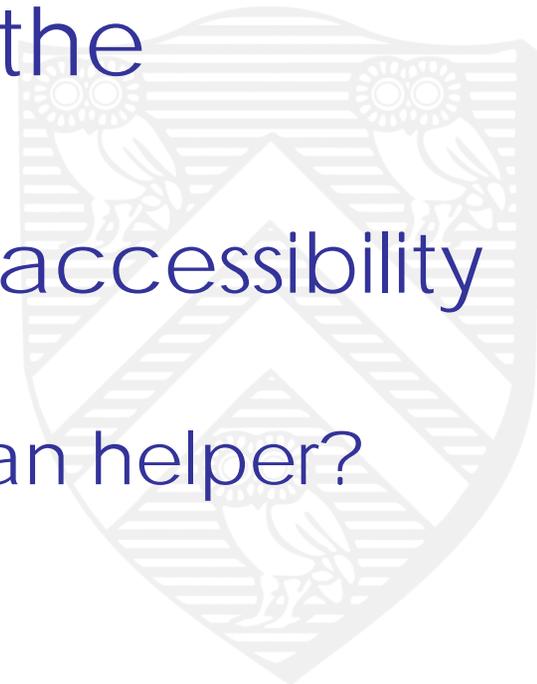
## It's new

- No antiquated machinery
- Non-traditional election styles
  - ▶ Condorcet voting, approval voting, IRV, etc.



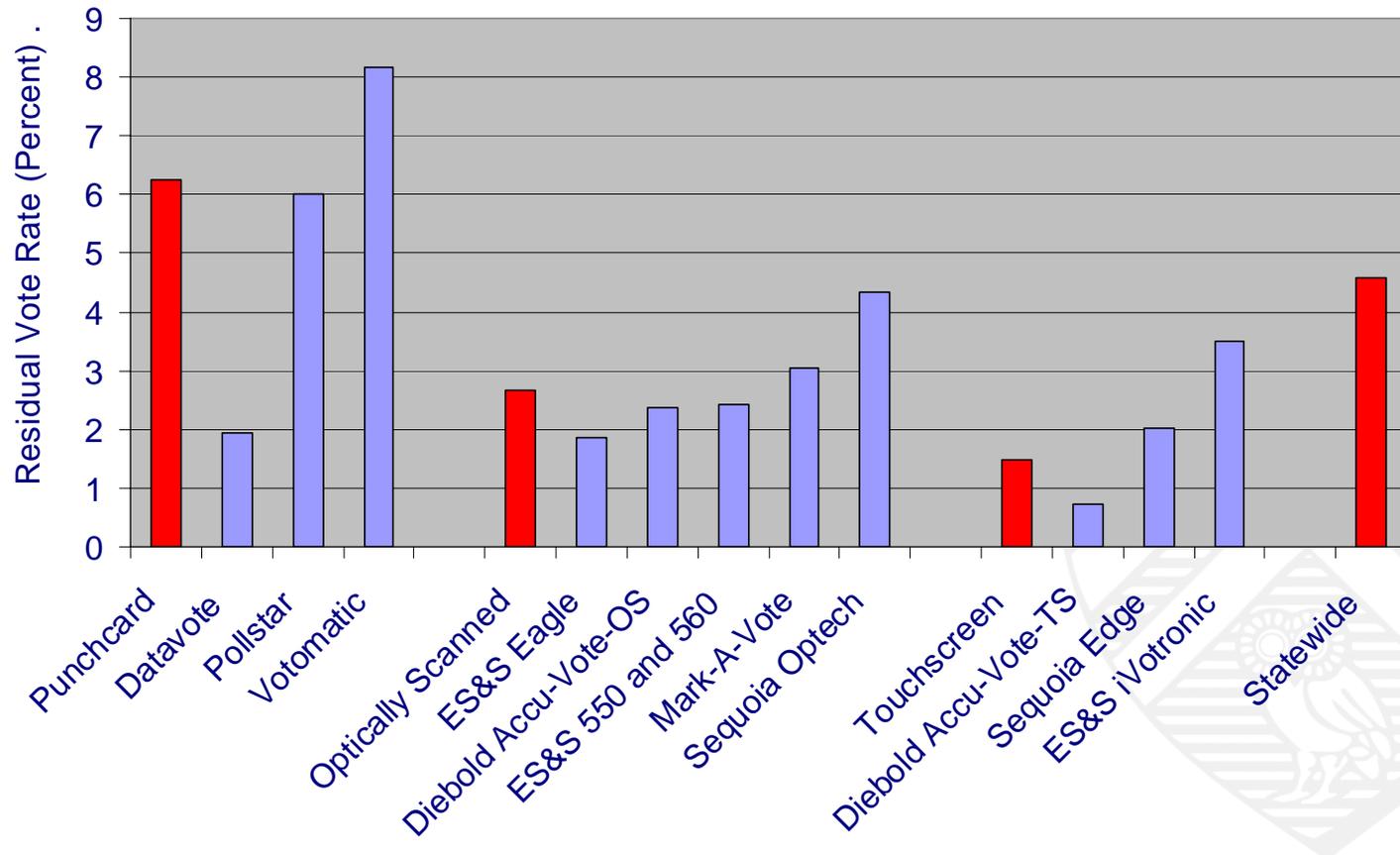
# Obvious flaws

- Indication to voter that vote is recorded?
  - No paper to drop in ballot box
- Why should you trust that the computer worked?
  - Same argument made by accessibility community
    - Why should you trust a human helper?
  - No voter-visible evidence



# Accuracy of voting systems

- California recall election (October 2003), residual vote rate
  - Percentage of “incomplete” / undervoted ballots (source: Rebecca Mercuri)



# Reliance on certification

## Independent Testing Authorities

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

**Result: “Faith-based voting”**



# Trust issues

- All code *must* be correct
  - No fall-back position if code is buggy
- No independent verification that code works
  - Should voting machines be closed source?
    - Alternative: Government pays for 3<sup>rd</sup> party developer
    - Give source code away to everybody (Australia)



# Hacked voting machines?

- Can a DRE system employee throw the election?
  - Is it *technically* feasible?
    - Yes
  - Would there be any evidence?
    - Probably not
  - “Logic and accuracy tests”?
    - Easily faked



# Trusted Computing Base

- Essential concept when doing a security analysis
  - The portion of the system that *must* be secure
  - Smaller TCB → more secure system



# TCB: Optical scan vs. DRE

DRE has a much larger TCB

- In-house software developers
- Pre-election storage of machines
- Pre or post-election manipulation of storage cards

➔ Hand recounting removes software from TCB



# How to build e-voting correctly

- Option 1: Print onto plain paper
  - Deposit in ballot box
  - Accessible interface
  - Inside: normal inkjet printer

(AccuPoll AVS1000)



# How to build e-voting correctly

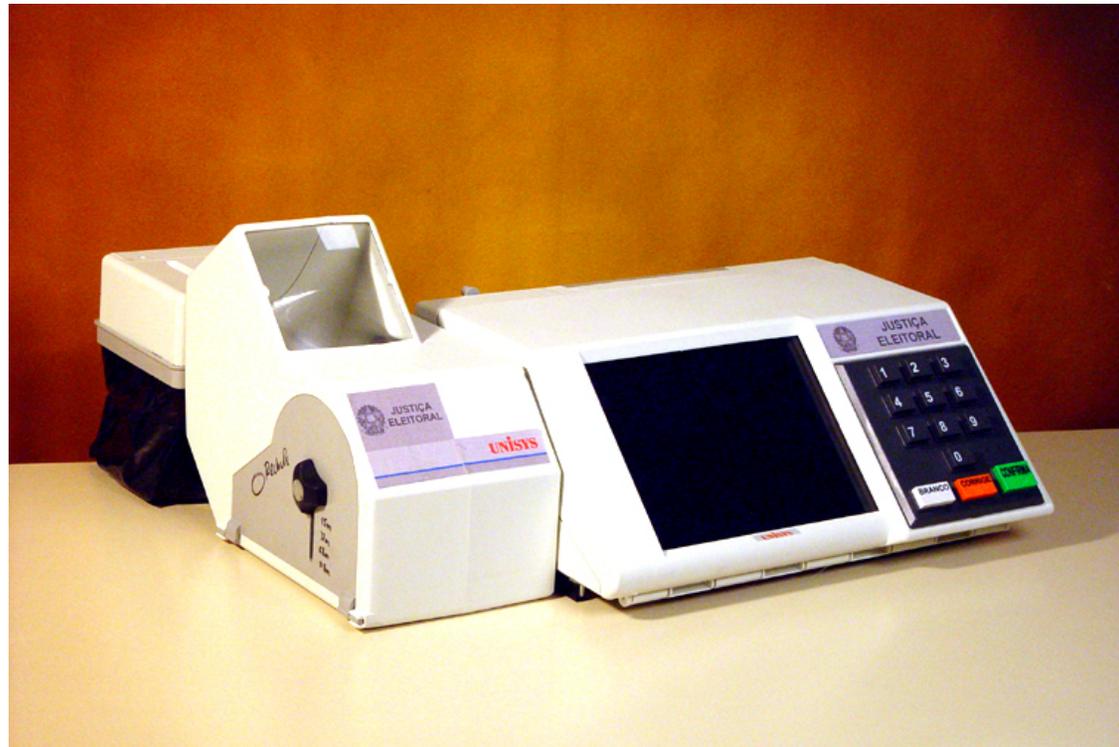
- Option 2: Print onto existing optical-scan ballots
  - Accessible interface
  - Only need one per precinct

(ES&S Automark)



# Ballot under glass

- Option 3: Brazilian *urnas*
  - Ballot under glass
  - Voters type number for candidate
- Recently cancelled (unclear why)



➔ “Mercuri method”

# Benefits of a hybrid system

- Human factors benefits via computer input
- Fast computer counting
  - “Estimated results”
- Useful re-counting
  - Computer (OCR)
  - Human
- ◆ No vendor trust *needed*
- ◆ No vendor lock-in
  - ◆ Standardize cards, fonts, etc.



# Track Record for DRE in U.S.?

- Diebold AccuVote-TS Adopted by Georgia for Nov. 2002 election
- But then something interesting happened...



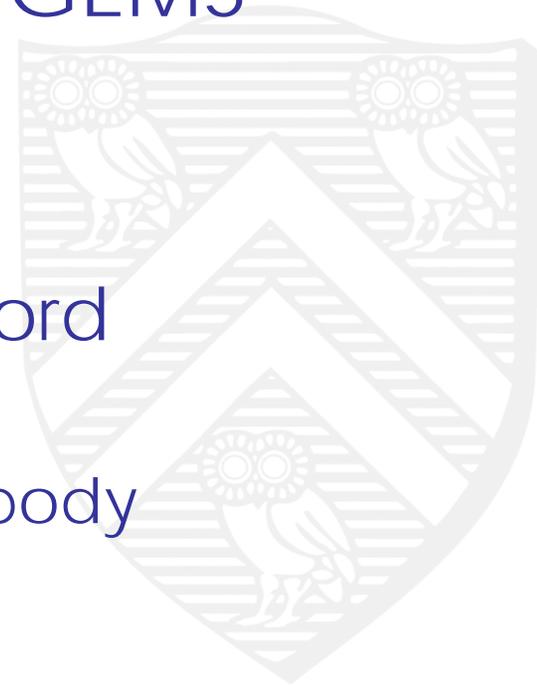
# Bev Harris' findings

March 18, 2003: Bev Harris announces:

- Open FTP site from Diebold with many GB of data
  - Source code, sample ballots, etc.

July 8, 2003: Security holes with GEMS

- Uses Microsoft Access
- Audit logs can be bypassed
- All users have the same password ("password")
  - ➔ If it's online, it's editable by anybody



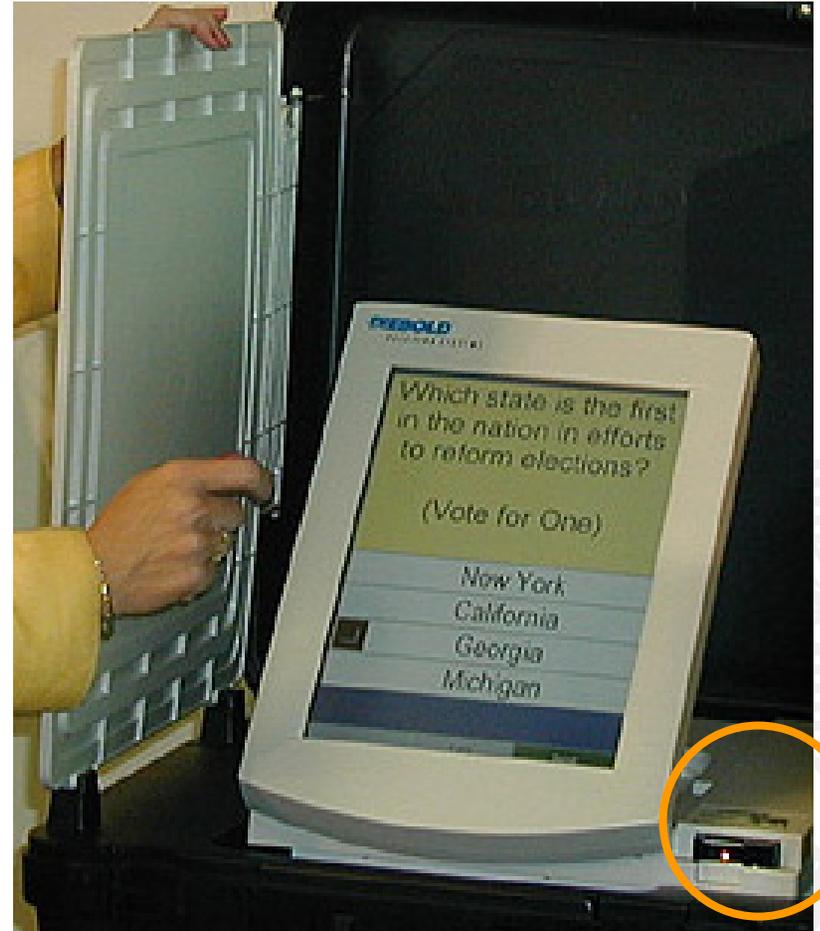
# Our findings

- Smart card issues
- Incorrect use of cryptography
- General software engineering notes

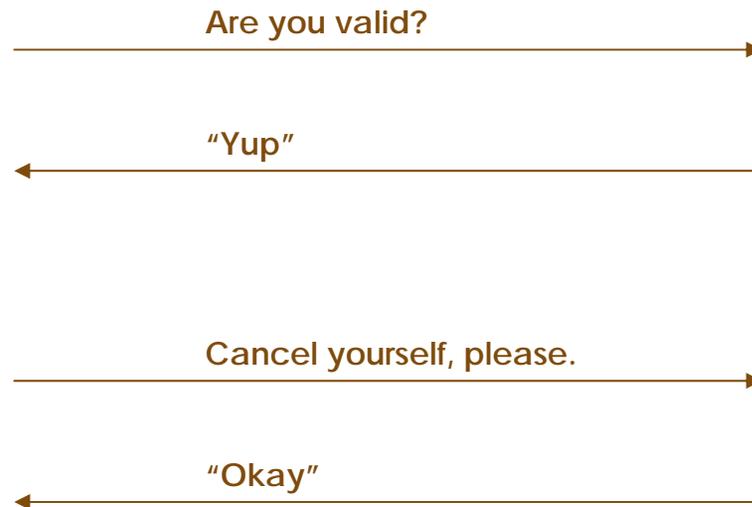
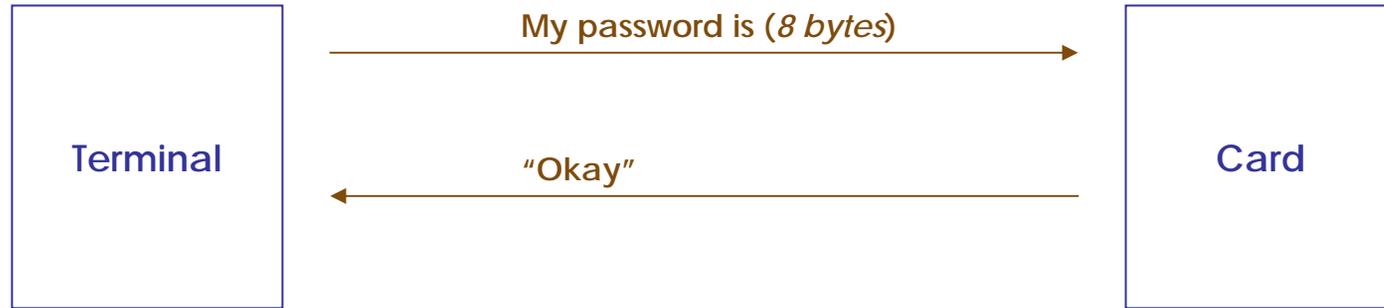


# Smart cards

- Voting terminals are offline during the election
- Voter gets “voter card” after authentication
- Insert card
- Vote
- Machine cancels card
  
- Other cards
  - “Ender card”
  - Administrator card



# Diebold's smart card protocol

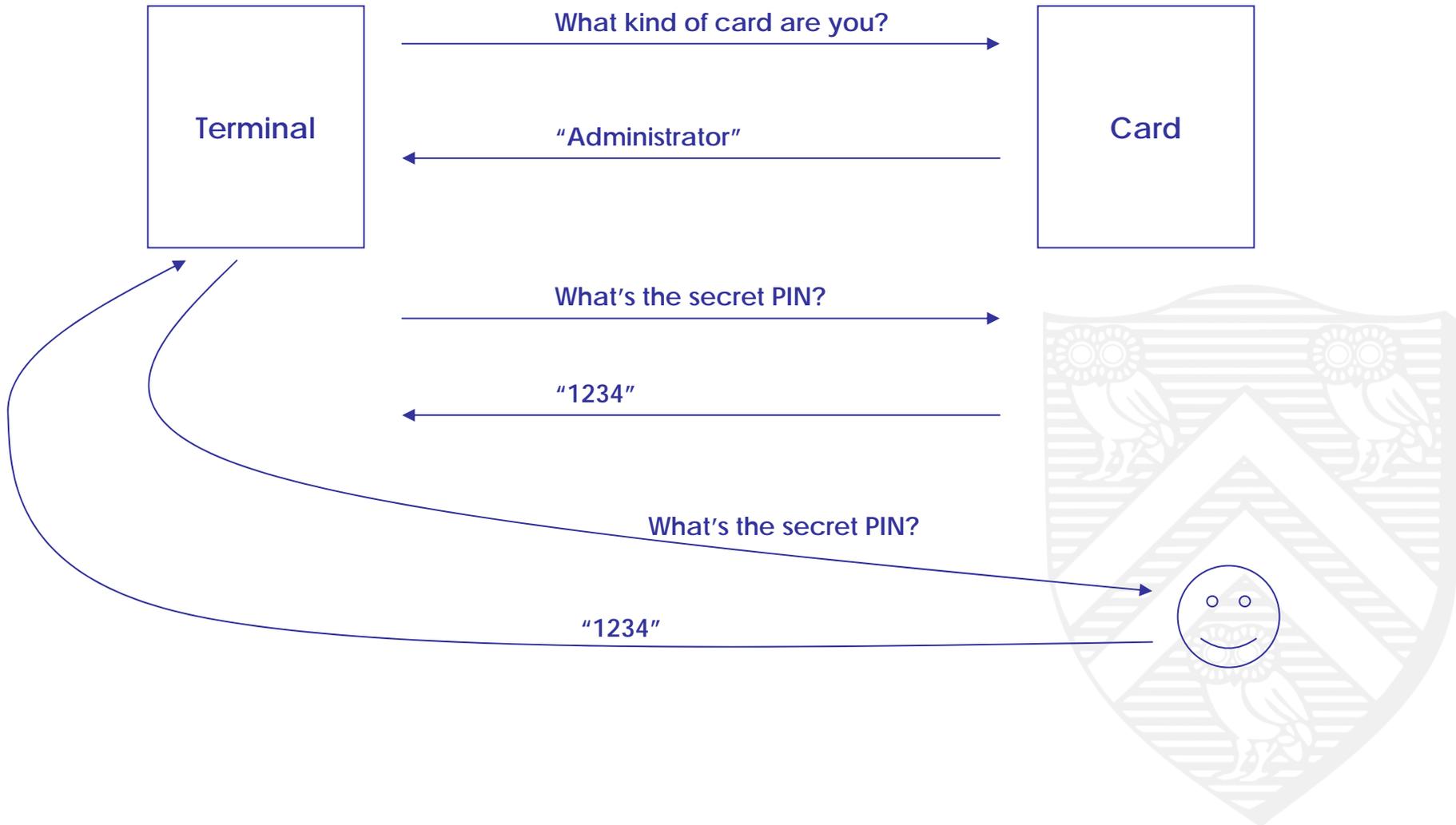


# Administrator cards

- Administrator / ender cards require a PIN
  - End election
  - Print records
  - Etc.



# Administrator card protocol



# Malicious poll workers?

- Private access to voting machines / storage cards?
- Before election, rearrange the order of the candidates
  - Votes are recorded by their order, not by name
    - ▶ Candidate #1 got 5 votes
    - ▶ Candidate #2 got 3 votes
  - Change the order → change who gets credited
  - Come back at the end of the day to fix it
- Voting machines can never be left alone!



# Cryptography

- After election is closed, voting terminals phone home
  - Fast “preliminary” tabulation of voting results
- Data also hand-carried via memory card
- Encryption to protect data confidentiality...



# How *not* to encrypt data

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

- One key for every voting machine, everywhere
- Doug Jones (Iowa official) found this in 1997!
  - Bug still exists in early 2004
  - Fixed now?



# How else not to encrypt data

```
DesCBCEncrypt( (des_c_block*)tmp,  
              (des_c_block*)record.m_Data,  
              totalSize, DESKEY, NULL,  
              DES_ENCRYPT);
```

- Initialization vector is always zero
  - Encryption is deterministic
  - Vulnerable to chosen-plaintext attacks



# If the crypto fails...

- Plaintext data has votes *in the order they were cast*
  - Trace votes to who cast them
  - Vote buying / voter coercion is now possible
- Active adversary can modify the data
  - Confuse preliminary totals
  - Threat to storage cards (in transit and post-delivery)



# Software engineering

- Software written in C++, runs on WinCE
  - Some effort to prevent buffer overflows
  - In public filings, Diebold has admitted problems



# Software process

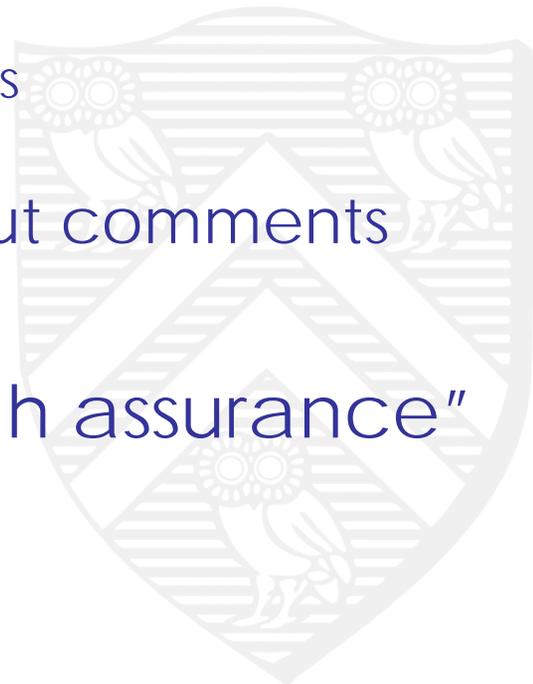
## ■ Assorted bad practices

- `#ifdef 0 / #ifdef xxx / #ifdef LOUISIANA`

## ■ Poor documentation

- No evidence of (useful) high-level design docs
  - ▶ Nothing checked into the archive
  - ▶ No comments quoting from design docs
    - ▶ Some quotes from algorithms textbooks
- Numerous complex functions without comments

## ■ Code quality well below any “high assurance” system



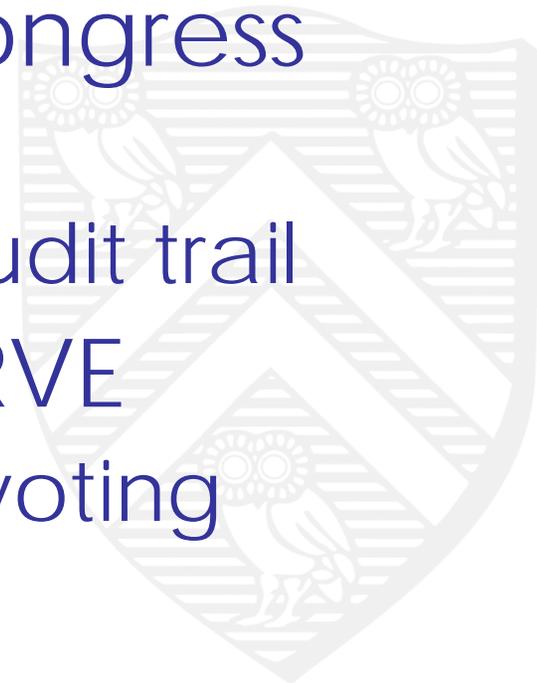
# Thoughts

- Our democracy is depending on these machines!
- Election officials rely on independent testing authorities (ITAs)
  - Diebold certified despite its poor design
  - Raises questions about other vendors
- Vendors don't understand computer security
- Features vs. security
  - Adding wireless capabilities to voting terminals?



# Impact of our work

- Our results confirmed by several independent studies
- California, Nevada, some others will require voter-verifiable audit trails
- Holt bill pending in U.S. Congress (H.R. 2239)
  - Requires voter-verifiable audit trail
- U.S. military cancelled SERVE
  - Paperless, Internet-based voting system



# What *you* can do

Think globally, act locally

- Every state is different
- Often, every county is different

Read any policy & procedure docs

- Machine storage & maintenance?
- Offer to help improve policies

Be an election judge

Get to know your representatives

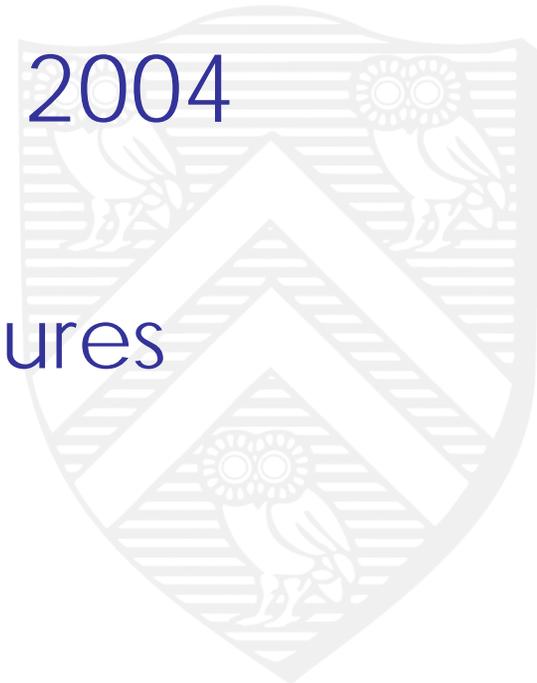


# If they're still using DREs

Leadership Council on Civil Rights  
/ Brennan Center Report  
([www.civilrights.org](http://www.civilrights.org))

Recommendations for Nov. 2004

- Independent audits
- Better policies and procedures
- Parallel testing
- Etc.



# Conclusion

- Paperless DRE voting systems are unacceptable
  - “Security through obscurity” arguments are fallacious
  - Independent certification is (currently) meaningless
  - Best today: precinct-based optical scan

*Everything worked fine in our last election.  
How do you know?*

# Further reading

- Our study of Diebold's system

<http://avirubin.com/vote/>

- More about voter-verifiable audit trails

<http://www.verifiedvoting.org/>

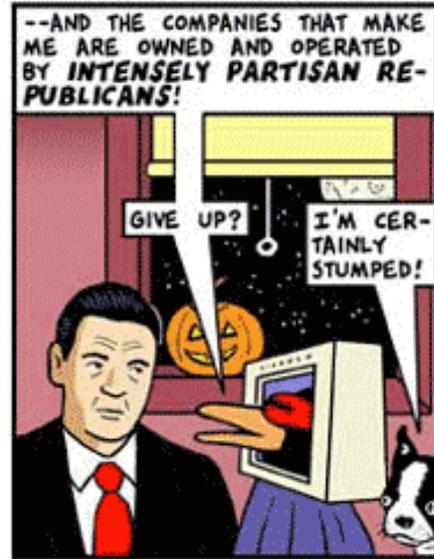
- See also, Bev Harris

<http://www.blackboxvoting.com/>



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