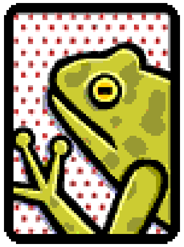
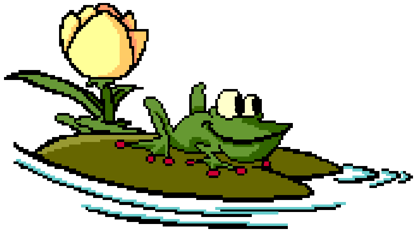


A Modular Voting Architecture ("Frogs")

Shuki Bruck (CalTech)
David Jefferson (Compaq)
Ronald L. Rivest (MIT)



(WOTE, August 28, 2001)

Outline

- Moving from paper → electronic
- Voting with frogs
- Advantages of frogs
- Security
- Conclusions

What’s next in voting?

- We propose a practical voting system for the near term (2004?) that
  - moves from paper to electronic
  - *emphasizes and standardizes a clean separation between “vote generation” and “vote casting” components* (for many good reasons).
  - uses digital signatures to witness “votes cast”

Where are we now? Op-scan

- Ballots are printed beforehand.
- On election day, voter:
  - Identifies himself
  - Receives ballot
  - Fills out ballot (“vote generation”)
  - Casts ballot (“vote casting”)
- Ballots scanned; results tabulated.
- Problems: UI, printing and storage costs, scanning accuracy, security.

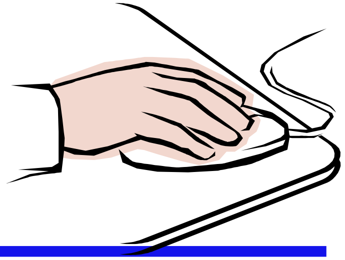
Move from paper to electronic?

- Preserve “voting experience”
- Paper ballot → electronic “frog” (term intended to be neutral as to technology)
- Frog might be “dumb” flash memory card (4K bytes) with “freeze” (lock) capability. (No software on frog to validate/certify!)

Voting with Frogs: (1) Sign-in

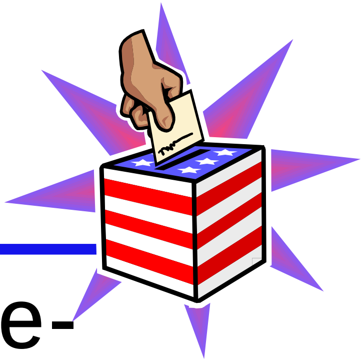
- Voter identifies himself to pollworker.
- Pollworker takes blank frog, and "initializes" it. (Election specification, ballot style written on frog.)
- Pollworker gives frog to voter.

(2) Vote Generation



- Voter inserts frog into “vote generation” equipment.
- Vote generation equipment reads ballot style, provides superb UI for voter to indicate his selections.
- Voters selections are written onto frog in a standard format.
- Voter removes frog.

(3) Vote-casting



- Voter inserts his frog into vote-casting equipment.
- Voter sees frog contents displayed.
- If voter pushes “Cast” button:
  - Frog is digitally signed; same signing key(s) used for all votes.
  - Frog is frozen and deposited in frog bin.
  - Electronic copy(s) of vote → storage.
- Else frog is returned and voter goes back to (2) vote generation.

(4) Web posting/Tabulation

- Once election is over, election officials for each precinct post on Web, as separate, unmatched lists in random order:
  - Names of all voters who voted.
  - All cast ballots (with digital signatures)
- Everyone can verify signatures on ballots, and compute total.

Advantages of frogs

- Electronic: no “scanning errors”
- Frogs can be kept as “physical audit trail” after election.
- No printing costs: frogs can be purchased “blank” in bulk (20 cents?)
- Frogs can be stored compactly (size of business card?)
- Frog can be “frozen” when cast making it “read-only” (unmodifiable).

Advantages of frogs

- Frogs are *digital:* so they are compatible with cryptography (e.g. digital signatures).
- Frog is just a carrier for a digital representation of ballot; technology can evolve while keeping underlying data formats constant (our proposal is technolgy-neutral).

Standardized Frog Format

- This may be the most important part of our proposal:

  Standardize the format
  of electronic ballots !!!

- Standard data file format:
  header + one line/race,
  standard character set (UTF-8).

- This should be vigorously pursued, independent of whether the rest of our proposal is adopted.

Standardized Frog Format

```
Massachusetts, Middlesex County, Precinct 11
Election Closes November 7, 2004 at 8pm EST
Ballot: MA/Middlesex/1; English; No rotation
Ballot Initialized by Election Official 10

You have chosen:
U.S. President: Mary Morris
U.S. Vice President: Alice Applebee
Middlesex Dog Catcher: Sam Smith (write-in)
Proposition 1 (Casino): FOR
Proposition 2 (Taxes): AGAINST
Proposition 3 (Swimming Pool): FOR
Proposition 4 (Road Work): NO VOTE
```

Standardized Frog Format

- Is both human and machine-readable.
- Provides a clean interface between vote-generation (frog-writing) and vote-casting (frog confirmation/ freezing / depositing).
- Allows *different* manufacturers to build different vote-generation equipment (varying UI’s) compatible with *same* vote-casting equipment.

Security

- In near term, the only trustworthy equipment available to voter will be that provided by election officials. (PC's/handhelds/phones all vulnerable. Thus, no individual digital signatures, and no voting from home.)
- In effect, vote-casting equipment is "proxy" for voter in electronic voting scheme.

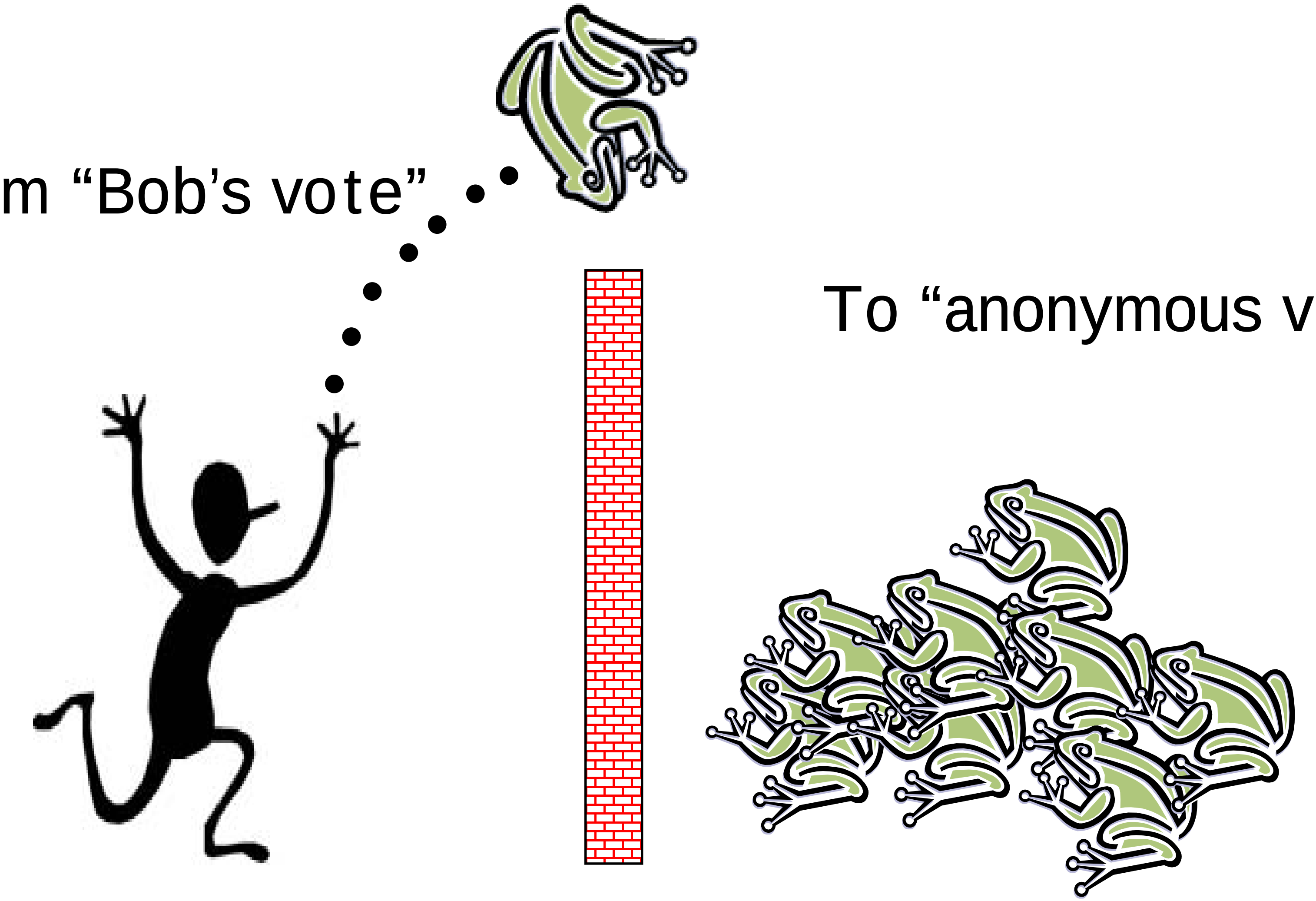
Security

- A secure system needs to be *simple. Very simple. Very very simple.*
- A good user interface is *complex. Quite complex. Really very complex.*
- It follows that the sophisticated user interface should be separated from the security-critical components.

What is *most* security-critical?

- *Vote-casting*, wherein voter
  - *Confirms* that his selection are recorded accurately,
  - *Officially casts* his recorded selections.
- This operation needs to be exceptionally trustworthy.
- With electronics, records are *indirect;* voter is much like a blind man voting with someone's assistance.

Vote-Casting: the critical instant



From “Bob’s vote”

To “anonymous vote”

Vote-casting equipment should:

- Display *exactly and completely* whatever is in frog.
- Be *stateless* (no test/real modes!)
- For cast vote, *digitally sign* whatever is in frog, using one key (election official) or more (political parties too).
- Send copies of cast votes → storage units.
- Be *open source.*
- Be long-term purchase.

Vote-generation equipment:

- Is less security-critical.
- May have proprietary design/code.
- Has less stringent certification requirements, and so can evolve more quickly with technology.
- May be leased rather than purchased.

Notes:

- Anonymity up to precinct level; should be OK.
- Write-ins might be handled by "splitting" into write-in/non-write-in components to preserve privacy.
- Provisional ballots can be handled as usual. (Put aside in envelope.)
- Voter may prepare ballot at home and bring it to poll-site for final editing/casting.

Conclusion

We have presented a practical proposal for a modular architecture for near-term pollsite voting that can achieve a high degree of security while simultaneously enabling innovation.

(The End)