Challenges and Advances in E-voting Systems

Technical and Socio-technical Aspects

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Outline

- The problem.
- Voter-verifiability.
- Overview of "Prêt à Voter".
- Resilience and socio-technical aspects
- Conclusions.
- Future work (in ReSIST)

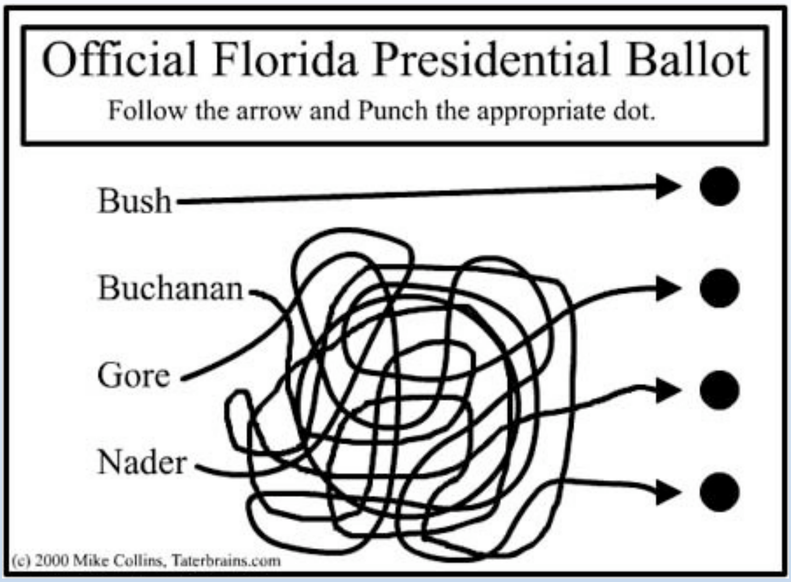
The Problem

- Highly adversarial: system trying to cheat voters, voters trying to cheat the system, coercers trying to influence voters, voters trying to fool coercers etc.
- The Ancient Greeks experimented with primitive technological solutions to try to shift the trust from people (officials) to mechanical devices.
- In the US technological devices for voting have been used for over a century: e.g., lever machines since 1887, punch cards, optical scans, touch screen etc. prompted by high instance of fraud with paper ballots!
- All have problems, see “Steal this Vote” Andrew Gumbel.

“The Computer Ate my Vote”

- In the 2004 US presidential election, ~30% of the electorate used DRE, touch screen devices.
- Aside from the “thank you for your vote for Kerry, have a nice day” what assurance do they have that their vote will be accurately counted?
- What do you do if the vote recording and counting process is called into question?
- Need to trust the (proprietary) software.
- Voter Verifiable Paper Audit Trail (VVPAT) and “Mercuri method” have been proposed. But paper trails are not infallible either.
- Nedap machines in the Netherlands etc.

Florida 2000



The challenge

- Digital voting technologies hold out promise of accessible and efficient democracy.
- Want high assurance that all votes are accurately recorded and counted-whilst maintaining ballot secrecy.
- The challenge is to reconcile these two conflicting requirements whilst minimising, ideally eliminating, dependence on the components (devices, tellers, software, hardware, officials etc.) of the scheme.
- Needs to be usable and sufficiently understandable to be widely trusted.

Technical Requirements

- Elections should be “free and fair”.
- Typical, key requirements:
  - (unconditional) integrity: count accurately reflects votes cast.
  - Ballot secrecy: the way a voter cast their vote should only be known to the voter.
  - Voter verifiability: the voter should be able to confirm that their vote is accurately included in the count and prove to a 3rd party if it is not (without having to revealing their vote).
  - Universal verifiability: anyone should be able to verify the count.
  - Availability: all eligible voters should be able to cast their vote without let or hindrance throughout the voting period.
  - Ease of use, public understanding and trust, cost effective, scalable etc. etc…..

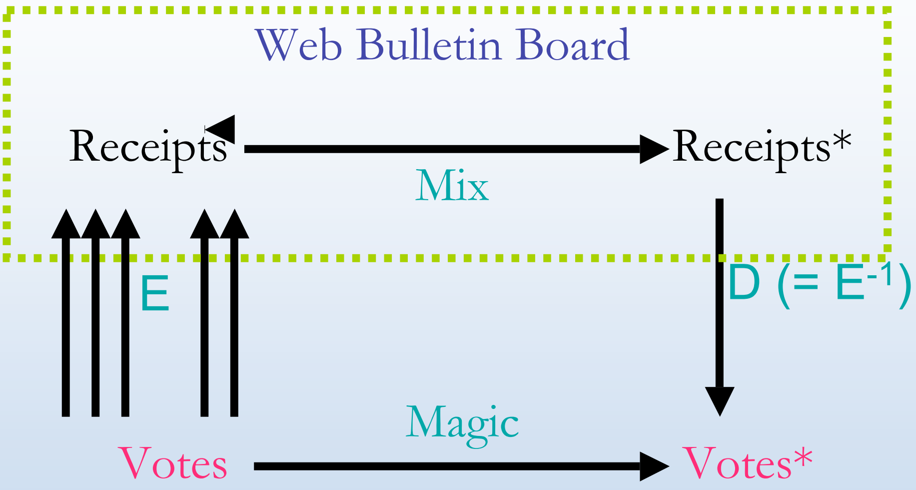
Assumptions

- For the purposes of the talk we will make many sweeping assumptions, e.g.:
  - An accurate electoral register is maintained and available.
  - Mechanisms are in place to ensure that voters can be properly authenticated.
  - Existence of a secure Web Bulletin Board.
  - Crypto algorithms are sufficiently secure.
  - Etc.

Voter-verifiability in a nutshell

- Voters can confirm that their vote is accurately but not prove to a third party how they voted.
- Voters are provided with an encrypted “receipt”.
- Copies of the receipts are posted to a secure web bulletin board. Voters can verify that their (encrypted) receipt is correctly posted.
- A (universally) verifiable, anonymising tabulation is performed on the posted receipts.
- Checks (random audits) are performed at each stage to detect any attempt to corrupt the encryption and the decryption or the receipts.
- The guarantees of integrity are not dependent on correct behaviour of software, hardware, officials etc.

Voting with commuting diagrams



Prêt à Voter

- The key innovation of Prêt à Voter is to encode the vote by randomising the candidate order.
  - Voter experience simple and familiar.
  - Votes are not directly encrypted, just the frame of reference in which votes encoded. Hence:
    - The vote recording device doesn't get to learn the vote.
    - No need for ZK proofs of correct encryption of votes-but onus of proof shifts to showing the well-formedness of the ballot forms.
    - Avoids subliminal, kleptographic and side channels.
- Prior work: Chaum, Benaloh, Neff,…

Typical Ballot Sheet

Obelix	
Asterix	
Idefix	
Panoramix	
Geriatrix	
	$rJ9*mn4R&8

Voter marks their choice

Obelix	
Asterix	✗
Idefix	
Panoramix	
Geriatrix	
	$rJ9*mn4R&8

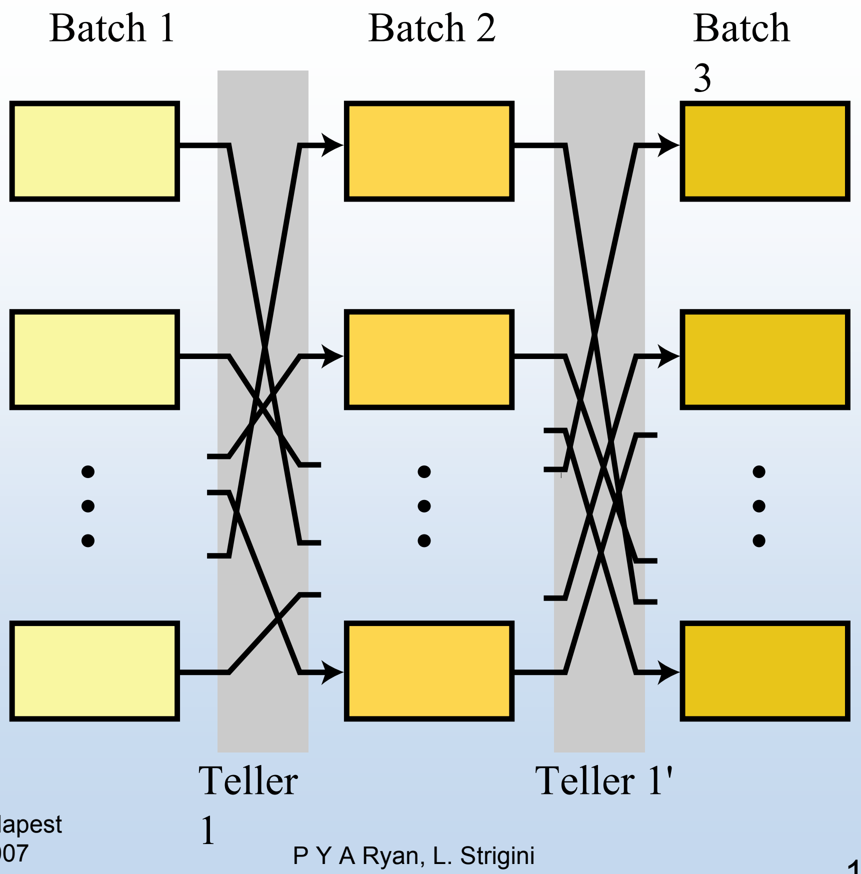
Voter's Ballot Receipt

✗
$rJ9*mn4R&8 449034729948

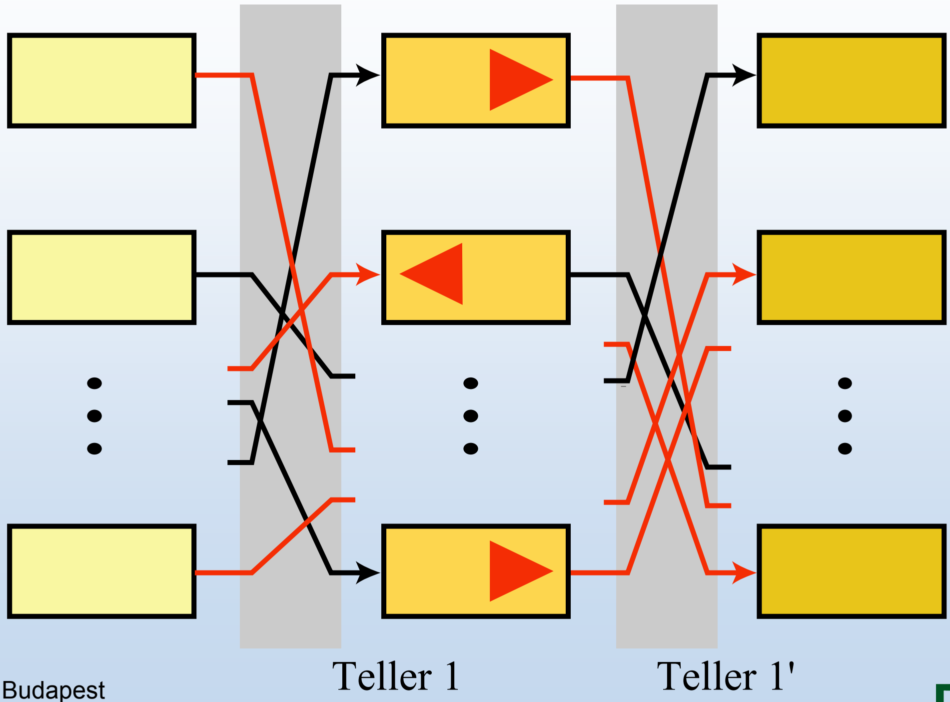
Cast-valid

After the voting phase

- Once the election is closed, digital copies of the receipts are posted to the Web Bulletin Board (WBB).
- The voters can visit the WBB and confirm that their receipt appears correctly.
- Additionally, checks could be performed by independent entities between the (encrypted) paper audit trail and posted receipts.
- A verifiable, anonymising tabulation is performed with all intermediate stages posted to the WBB.



Auditing the tellers



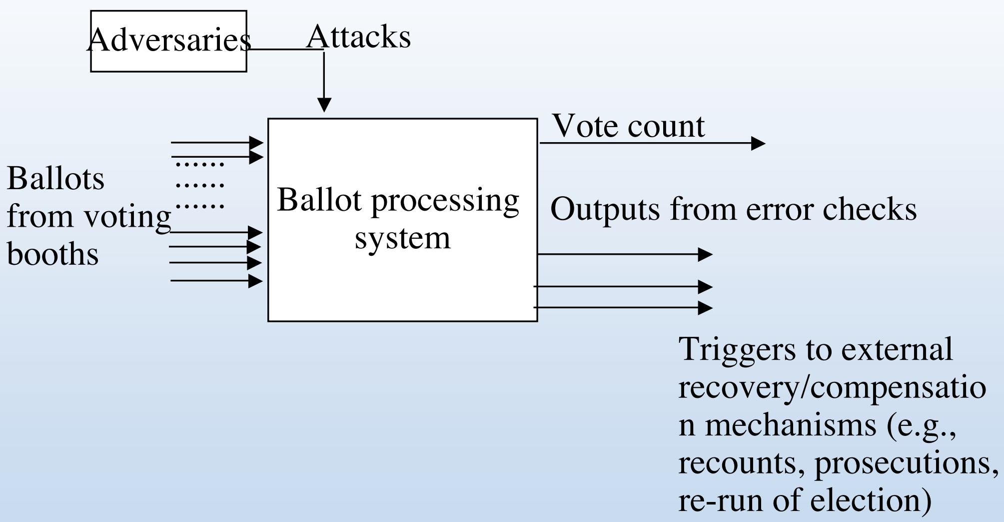
Enhancements

- Vulnerability analysis.
- Randomising encryption and re-encryption mixes.
- Distributed generation of encrypted ballots.
- On-demand decryption and printing of ballot forms.
- (A variant of) Adida/Rivest off-line audit mechanism.
- Coercion-resistant remote variants (with Cornell).
- Crypto-free, scratch card version.

Resilience aspects

- cryptography-supported voter-verifiability promises much
  - *more* integrity and privacy than paper systems
  - run-time monitoring reduces need for special, heavily verified machinery
- but there is more to a voting *system*
  - error/attack detection does not make error/attack tolerance
  - .. recovery delegated to human part of system

ICT fault tolerance in the election system



Effects of strong error detection

- election corruption is made more difficult
- but detected errors are expensive, so:
  - error recovery (automated and human) is important
  - better coverage may shift attackers' preference, e.g. from attempting *undetected* vote corruption to simply sinking the election
  - good integrity and privacy; *availability* issues
    - e.g. DDoS attacks on bulleting boards?
    - increased requirements for ICT support to be robust/resilient

Wider socio-technical aspects

- attacker's target might become simply the *reputation* of the election system
- implications cross the boundary between what can be designed (hardware, procedures) and political management
- so, a range of issues
  - from user-friendliness, HCI of voting machines
  - to choice of algorithms that public will be able to trust
  - to ensuring enough parties do perform the checks that anyone *may* perform
  - to ensuring *correct* perception of trustworthiness of each specific election

Conclusions

- we have presented: a technical problem, some solutions
  - Maximal transparency (consistent with ballot secrecy).
  - Accuracy independent of software, hardware, etc.
  - High assurance of detection of corruption.
  - Verify the election not the system!
- And open issues

Conclusions cont.

- E-voting is a ReSIST problem par excellence..
  - large distributed system, complex dependability requirements, evolving threats
  - "must work well the first time around", *every* time - implying need for resilience
  - ICT entwined with users and their reactions

Future work

- Further enhancements (simplifications!?)
- Further analysis of the resilience of the system
- Investigate recovery mechanisms and strategies
- Investigate socio-technical aspects
- Investigate public understanding and trust
- Basis for a ReSIST case study