Voting

Lecture 20
Requirements
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- Integrity/End-to-End verifiability
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  Collected as cast: Each voter should be convinced that their vote was collected correctly
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- Secrecy
  - Honest voters’ votes are not revealed by the system (beyond what the tally reveals)
  - Incoercibility: Even corrupt voters should not be able to convince an adversary about their vote (i.e., no vote-buying)
A Voting Architecture
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Produce a public list which encodes all the votes cast
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Front-End
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  - Ballot Preparation
    - Vote capturing/Receipt issue
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Back-End
- Verification
- Tallying/Verification
Use MPC?
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- In the front-end, want voters not to have to do crypto, and arrive/leave one by one
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- Impractical
  - In the front-end, want voters not to have to do crypto, and arrive/leave one by one
  - OK in the back-end, but needs to be very efficient if a large election
  - Doesn't account for incoercibility (unless security requirement augmented)
Incoercibility
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Coercion: voters can get rewards from adversary by following adversary’s instructions in a detectable fashion
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What is not coercion?
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- But unavoidable coercion (even in the Ideal world)
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- e.g. Adversary rewards the entire set of voters if all votes are for candidate A
  - Is coercion: Voters cannot behave arbitrarily and still collect the reward
  - But unavoidable coercion (even in the Ideal world)

We need to protect against further coercion than is possible in the Ideal world
Defining Incoercibility

Real as incoercible (and secure) as Ideal if:
Defining Incoercibility

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Real as incoercible (and secure) as Ideal if:

∀ and
∃ and s.t.
∀
IDEAL/c ≈ REAL/c
and
IDEAL/u ≈ REAL/u
Defining Incoercibility

Real as incoercible (and secure) as Ideal if:

\[
\forall \text{ and } \exists \text{ and s.t. }
\]

\[
\text{IDEAL/c } \approx \text{ REAL/c and IDEAL/u } \approx \text{ REAL/u}
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Hence REAL/c and REAL/u only as distinguishable as IDEAL/c and IDEAL/u
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i.e., if coercion can be simulated in Ideal, it can be simulated in Real too
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Definition says nothing about the existence/choice of the Ideal coercion simulator.
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Definition says nothing about the existence/choice of the Ideal coercion simulator.

Meaningful only if Real/u simulator is credible.
e-Voting: First Try
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Front-end:
e-Voting: First Try

Front-end:
- Voters encrypt their votes using a threshold encryption scheme, and submit the vote; receives a receipt showing the ciphertext
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Back-end:
- A mix-net shuffles, decrypts the set of votes. Publicly tallied
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Requires voters to use/trust computational devices.
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Provide encryption devices that have been “verified” by the public? (Perception of) threats: difficulty in verifying devices, substituting devices...
Challenge
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- Keep it simple for the voter
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- No crypto to ensure vote collected as cast
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Challenge

- Keep it simple for the voter
  - No crypto to ensure vote collected as cast
- Public list will contain information that proves to the voter that the vote collected is as cast
- Should not allow voter to prove to a vote-buyer how the vote was cast
Prêt à Voter
Prêt à Voter

Ballot has two parts
Prêt à Voter

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Prêt à Voter

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Prêt à Voter

Ballot has two parts

Left-hand side: Candidate list

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Ballot has two parts

- Left-hand side: Candidate list
- Right-hand side: Vote-mark and encrypted candidate list (and a serial number)
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- Voter retains a copy of the right-hand part (possibly with a digital signature, verified by helpers outside the booth, to prevent false claims) as a receipt to verify the publicly posted vote. Left-hand part must be destroyed before leaving the polling-booth.
Prêt à Voter

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- Additive homomorphism: Use Paillier, or El Gamal with messages in the exponent (since only a few messages possible)
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If no errors found in a large random sample (say half the ballots) probability of more than a few bad ballots is very small (say, $2^{-t}$ probability that more than $t$ bad)
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For secrecy, need to ensure LHS of ballot-paper remains secret (till voting) and encryption in the RHS is honest (i.e., randomly generated)

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Can be audited by the voter: choose one of (say) two ballot sheets for auditing later; printer’s key kept shared among auditors who can audit sheets selected by the voters

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Threats/Remedies
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**Chain voting:** One ballot-sheet smuggled out and marked. Then repeatedly coerce voters to use the marked ballot-sheet and return with a blank ballot-sheet
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Officials should ensure ballot-sheet turned in is the same as ballot-sheet given
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Randomization attack: Coercer can ask voters to mark the first candidate, thereby ensuring they vote randomly.
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Ensure it is destroyed. Also make decoys available
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- **Printer’s key known**: Attack if also (LHS,RHS) pairing known.
Some Other Schemes
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Several schemes
Some Other Schemes

- Several schemes
- Few security definitions/proofs
Some Other Schemes

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- Punchscan
Some Other Schemes

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- Punchscan variant
Some Other Schemes

- Several schemes
- Few security definitions/proofs
- Punchscan
  - Two-layer ballot-sheet
- Scratch-and-Vote
  - Punchscan variant
  - To audit a ballot-sheet, scratch off and obtain randomness used in encryption
Back-Ends
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  - In Prêt à Voter, information on RHS: encryptions of the shifted value to be added for each possible mark
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  - Coercion is hard to prevent, but can be mitigated by allowing voters to change votes any time
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Front-end and back-end need to be modified
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- Several proposals for electronic voting
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A cyber-physical system with avenue for new protocol techniques and attacks
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- Crypto tools based on homomorphic encryption
- Aims to get unprecedented level of confidence from individual voters and public auditors (E2E security)
  - Challenge: Increases risk of coercion
- A cyber-physical system with avenue for new protocol techniques and attacks
- Few satisfactory security definitions yet (let alone proofs)