Formalising Receipt-freeness

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privacy in voting

Receipt-freeness is a particular notion of anonymity in voting.

There are more notions.

- anonymity
- receipt-freeness
- coercion-resistance

No privacy = no free voting

Roughly:

- anonymity

privacy notions

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- anonymity
  no observer knows how any voter voted

- receipt-freeness

privacy notions

Roughly:

- anonymity
  no observer knows how any voter voted
- receipt-freeness
  no votebuying
- coercion-resistance

privacy notions

Roughly:

- anonymity
  no observer knows how any voter voted
- receipt-freeness
  no votebuying
- coercion-resistance
  a voter can always fool an observer and still vote freely

Hugo's guide to convincingly selling your vote

1. cast signed vote
2. point to vote in result
3. rich!

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1. cast encrypted vote
2. point to vote in result, give key
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Problem . . . new guide. . . problem. . .

classical RF

Definition 1 (classical receipt-freeness) *A voting protocol has a receipt iff after execution of the protocol, the voter can provide the intruder with information that proves how she voted.*

A protocol that does not have such a receipt is (classical) receipt-free.

Corollary. Take *extreme* care with voter-supplied randomness!

special channels

Example: using randomness from the voting authority (BT94):

1. Auth provides list of encypted ballots listing all options:
   Ballots $(a_0, b_0), \ldots, (a_n, b_n)$, s.t.
   $\forall i \colon (a_i, b_i) \in \{0, 1\}_{ki} \vee (a_i, b_i) \in \{1, 0\}_{ki}$

2. Send decryptions of a_i to voter over private, untappable channel (commit)

3. Prove that all ballots match ballot 0 (by opening half and linking other half)

4. Voter: send a_0 or b_0 to cast vote of choice.

types of channels

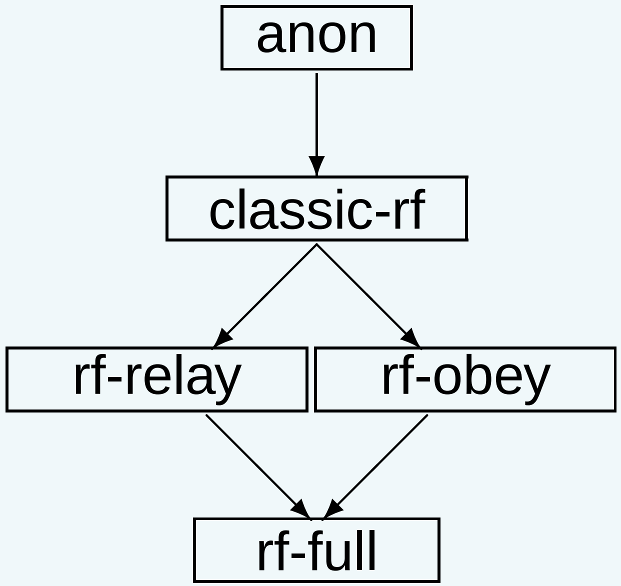
a. public channel

c. untappable channel authority $\rightarrow$ voter

d. untappable channel voter$\rightarrow$ authority

e. untappable channel voter$\leftrightarrow$ authority

privacy attackers



formal model

- voters $\mathcal{V}$, authorities $Auth$, choices $\mathcal{C}$, terms.
- terms are communicated: events.
- events follow eachother: traces.

- parameterize over choice function $\gamma \colon \mathcal{V} \to \mathcal{C}$
- focus on the communication between the parties
  $\Longrightarrow$ different primitives for different channels
- expressed in process algebra (trace semantics)

- idea: measure privacy in anonymity groups

choice groups

Definition 2 (choice groups) *the choice group of voter v in trace $t1$ contains all those candidates, on who v could have voted according to the intruder, who has observed trace $t1$.*

$$cg(v, t1) = \{\gamma_{t2}(v) \mid t2 \in Tr(\mathcal{VS}) \wedge t1 \sim t2\}$$

choice groups

Definition 4 (choice groups) *the choice group of voter v in trace $t1$ contains all those candidates, on who v could have voted according to the intruder, who has observed trace $t1$.*

$$cg(v, t1) = \{\gamma_{t2}(v) \mid t2 \in Tr(\mathcal{VS}) \wedge t1 \sim t2\}$$

Definition 5 (observational equivalence of traces) *Traces t, t' are observationally equivalent with respect to knowledge set K, notation $t \sim t'$, if*

$$\exists \pi : \pi \text{ is a reinterpretation } \wedge t = \pi(t).$$

reinterpretation

Definition 6 (reinterpretation of messages) *(by Garcia et al)*
Let π be a permutation on the set $Terms$ of terms and let K_I be a knowledge set. The map π is said to be a reinterpretation under K_I *if it and its inverse satisfy the following:*

$$\begin{aligned}
\pi(p) &= p && \text{for } p \in \mathcal{C} \cup Nonces \cup Keys \\
\pi((\varphi_1, \varphi_2)) &= (\pi(\varphi_1), \pi(\varphi_2)) && \\
\pi(\{\varphi\}_k) &= \{\pi(\varphi)\}_k && \text{if } K_I \vdash \varphi, k \ \vee \ K_I \vdash \{\varphi\}_k, k^{-1}
\end{aligned}$$

concluding

Learned:

- different attacker models for privacy
- quantify privacy in voting

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Future work:

- reinterpretation of functions
- write thesis

final slide

Thank you for your attention.

Questions?