Thoughts on JCJ05

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Swissvote

15. April 2010

What it is all about

For an e-voting system to be secure, it has to function without vulnerabilities in potentially insecure environments such as the internet. For this, it has to be implemented according to an intrinsically secure design. Despite the complexity of designing and implementing such a system, some criteria seem to be unanimously accepted as the core security requirements for e-voting systems.

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Privacy: if no casted vote can be linked to its voter, neither by voting authorities nor anyone else (anonymity), and no voter can prove that he or she voted in a particular way (receipt-freeness).

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Privacy: ...

Verifiability: individually verifiable if voters can independently verify that their own votes have been counted correctly in the final tally and universally verifiable, if everyone can do that.

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- **Accuracy:** ...
- **Democracy:** ...
- **Privacy:** ...
- **Verifiability:** individually verifiable if voters can independently verify that their own votes have been counted correctly in the final tally and universally verifiable, if everyone can do that.
- **Fairness:** if no intermediate results can be obtained before the voting period ends.

E-Banking < E-Voting

What makes E-Banking so easy and E-Voting so hard:

E-Banking: ctrl-z A wrong transaction can be undone (no privacy)

E-Voting: ctrl-z A wrong transaction can not be undone (privacy)

E-Banking The bank wants to have a trustworthy system

E-Voting The party in power wants to stay in power

Enemies of an E-Voting system

- Voters
- External parties
- Internal parties
- The party that rules the country
- The men running the e-voting system

How to gain Power

- Buy
- Bribe
- Coerce

But 2005 privacy and Coercion-Resistance has been redefined:

Privacy < Coercion-Resistance

privacy Even if someone observes the voter (passively) during the actual voting process, the voters will should not be unveiled.

coercion-resistance Even if someone actively interacts with the voter during the voting process, the voters will should not be unveiled.

Even: Neither the observer / coercer **nor the voter** should be able to unveil the voters will

Grail-Elements

Homomorphic calculations E-Voting systems based homomorphic schemes were introduced in 1994 by Benaloh and Tuinstra

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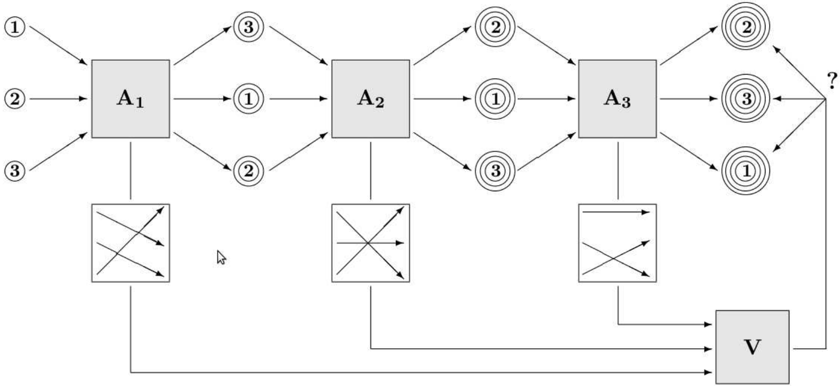
Non-Transferable-Verifiability An important security aspect within E-Voting systems: Voter can not prove the will on the casted vote to a third party. (Also known as receipt). First working system showed in 2000 by Hirt and Sako.

Hrt00



Unacceptable Constraint

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- The system has to disable the voter to prove the act of a vote casting to a third party.

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- The system has to allow the voter to distribute false identity-mark (credentials)

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- Non-Transferable-Verifiability
- Coercion resistant

Players and Their Abbreviation

R Registration Authority (multiple instances)

[a]The sender can verify (designated), The receiver does not know the origin
[b]The sender looses track, the receiver is allowed to know the sender

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- AN Anonymous Net (Preserving 'shape' and temporal order)[a]

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AN	Anonymous Net (Preserving 'shape' and temporal order)[a]
MN	Mixed Net (changing 'shape' and temporal order)[b]

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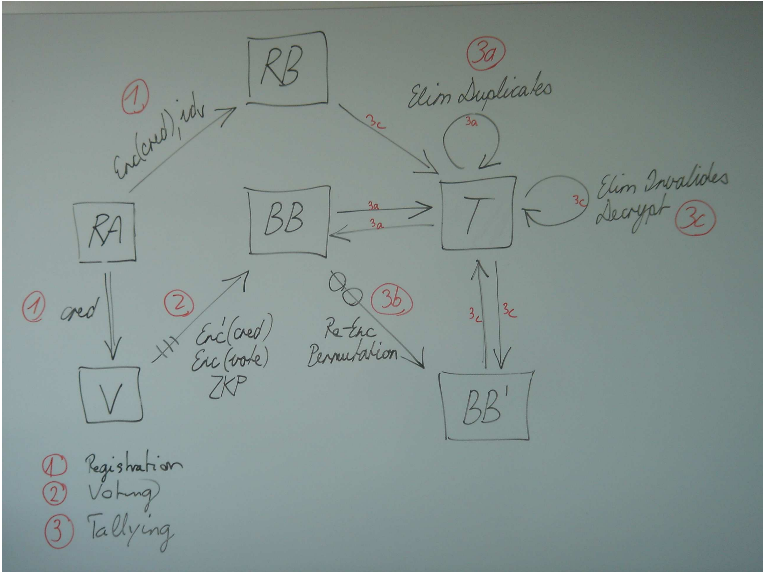
Overview



RB
3a
Elim Duplicates
1
Enc(cred), idv
3c
3a
RA
BB
3a
3a
T
3c
Elim Invalides
Decrypt
3c
1
cred
2
Enc'(cred)
Enc(vote)
ZKP
3b
Re-Enc
Permutation
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3c
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5. **Verification** Any player, whether or not a participant in the election, can refer to BB, P and L to verify the correctness of the tally produced by T in the previous phase.

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Credentials

1. V_i goes to (=untappable channel) the R and proofs eligibility

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5. R puts id of V_i and S_i to the voter roll L [b]

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- ... that V_i can get a proof for ANY credential in p-time (and within 'usability')
- This problem-domain is discussed in Schweisgut07

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V voting

Candidate choice $E_1^{(i)} = (\alpha_1, \alpha_1', \beta_1) = (g_1^{a_1}, g_2^{a_1}, c_j h^{a_1})$,
NIZKPK of knowledge of c_j AND $c_j \in C$.

Voter Credential $E_2^{(i)} = (\alpha_2, \alpha_2', \beta_2) = (g_1^{a_2}, g_2^{a_2}, \sigma_i h^{a_2})$
NIZKPK of knowledge of σ_i

NIZKPK that α_i, α_i' have the same discrete log with respect to g_1 and g_2

1.NIZKPK: Otherwise V can be forced to submit an observable invalid choice

2.NIZKPK: Makes it (non-malleable) impossible to validly copy an encrypted credential for *BB* for a new ballot

Vote casting

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- In JCJ05 V is only able to read BB after the vote-casting phase is over.[a]

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After-Thought BB

It seems as if BB can be made public all the time:
After a vote-casting, the casted vote can be identified and the credential can be reconstructed and proven by the vote-sender. But no proof can be forced to show that the credential in question is a valid credential.

Duplicate Vote Elimination

- T eliminates (pair-wise) votes with same credentials (PET)[a]
- ZKPK for each action

[a] It marks the 'last' vote

MixNet-Re-Encryption-Shuffling

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- If the size of the two lists are equal, this proves equality of the two lists.

Elimination of Invalid Votes

- T eliminates votes with invalid credentials. Done by a (PET)[a] with the Voter Slate
- ZkPK for each action

[a] Threshold decryption

Decryption

- T decrypts each vote[a]
- ZkPK for each action

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Questions?

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- $(x_1/x_2, y_1/y_2) = (x_3, y_3)$ ... (x_3^z, y_3^z) where $z \in_R$
- $dec(x_3^z, y_3^z) = y_3^z x_3^{-sz} = (g^s)^{r_3 z} \frac{m^z}{m'^z} (g^{r_3})^{-sz} = (\frac{m}{m'})^z =^? 1$
- Solution: PkZk works if $m = m'$ and $m \neq m'$

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- This is feasible as long as $|J| \geq t$ where t is a certain threshold.

Threshold keyGeneration

986220914.pdf p. 59

Thoughts on Anonymous Channel / Re-Voting

- JCJ05 allows multiple vote-casting by V_i
- JCJ05 needs the order of the entries in BB (latest vote wins)
- Therefore no mix-Net approach with shuffling allowed or...
- ... some 'encrypted' timestamp within the ballot which makes the vote traceable
- But multiple vote casting does not strengthen the system against a coercer
- Weber eliminates this by counting the first (temporal) vote only

Shouldersurfing Resistance

- JCJ05 allows ONE correct credential σ and 'unlimitted' fake credentials
- if the voting legitimation $enc_T(\sigma)$ has to be calculated under observation...
- ...then Shouldersurfing resistance (over several Votings) requires that at least One correct and independent credential per Voting-session