Scratch, Click & Vote

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Scratch, Click & Vote

- Miroslaw Kutylowski, Filip Zagorski
  Scratch, Click & Vote: E2E voting over the Internet
  `http://eprint.iacr.org/2008/314`

Scratch, Click & Vote – properties

- verifiable hybrid voting scheme (ballots are sent to voters, voting over the Internet)
- voter's computer is not trusted
- PC does not learn voter's choice
- PC cannot change voter's choice even into a random one (virus immunity)
- receipt obtained by a voter does not prove voter's choice

Scratch, Click & Vote – idea

- backend of the scheme is based on Punchscan and ThreeBallot ballot ideas – assures veryfiability
- frontend – assures immunity against evil PC
- there are two authorities in the system:
  - **Election Authority** responsible for voting cards preparation,
  - **Proxy** prepares coding cards, Proxy is “a virtual ballot box”

Terminology

- *voting card* – sheet of paper which a voter obtains from the Election Authority
- *ballot* – part of a filled up *voting card* which is cast by a voter
- example: ThreeBallot – voting card consists of three ballots

PS, PaV, STG, STG II

receipt	scanner/ballot box	bulletin board	partially decoded	results
		x	y	c
		x	y	c
		x	y	c
		x	y	c
R	R	x	y	c
		x	y	c
		x	y	c
		x	y	c
		R	y	c

- similar backends are used in Punchscan (PS), Pret a Voter (PaV), Scantergrity (STG), Scantegrity II (STG II)

PS, PaV, STG, STG II

receipt	scanner/ballot box	bulletin board	partially decoded	results
		x	y	c
		x	y	c
		x	y	c
		x	y	c
R	R	x	y	c
		x	y	c
		x	y	c
		x	y	c
		R	y	c

- verifiability step 1: voter checks if her receipt R appears on the bulletin board (Punchboard)

PS, PaV, STG, STG II

receipt	scanner/ballot box	bulletin board	partially decoded	results
		x	y	c
		x	$d_1(R)$	c
		x	y	c
		x	y	c
R	R	x	y	c
		x	B	c
		x	y	c
		x	y	$d_2(B)$
		R	y	c

- veryfiability step 2: veryfication of decoding is performed (post-election Audit)

ThreeBallot, VAV

receipt scanner/ballot box bulletin board = results

R/S/T

- Alice obtains voting card which contains three ballots R, S, T

ThreeBallot, VAV

receipt	scanner/ballot box	bulletin board = results
R/S/T	R & S & T	

- Alice cast a vote - tripple R, S, T, takes a receipt – one ballot: $R/S/T$

ThreeBallot, VAV

receipt	scanner/ballot box	bulletin board = results
		x
		T
		x
		x
R/S/T	R & S & T	x
		x
		S
		x
		R

- EA does not know which one; EA has to publish all of them among other ballots

ThreeBallot, VAV

receipt	scanner/ballot box	bulletin board = results
		x
		T
		x
		x
T	R & S & T	x
		x
		x
		x
		x

- Alice checks if her ballot appears on the bulletin board

Scratch, Click & Vote

receipt	Proxy	bulletin board	partially decoded	results
		x	y	c
		T	y	c
		x	y	c
		U	y	c
R/S/T/U	R & S & T & U	x	y	c
		x	y	c
		S	y	c
		x	y	c
		R	y	c

Scratch, Click & Vote

receipt	Proxy	bulletin board	partially decoded	results
		x	y	c
		T	y	c
		x	y	c
		U	y	c
R/S/T/U	R & S & T & U	x	y	c
		x	y	c
		S	y	c
		x	y	c
		R	y	c

- SCV – simple merge of Punchscan and ThreeBallot backends... but SCV is remote voting, we need different ballot layout.

Voter vs PC part I

- If a machine has the same knowledge as a voter:
  - machine knows exactly how voter voted
  - machine can change voter's choice (in some schemes)
  - online vote selling possible
  - virus attacks possible
- Solution: voter obtains additional information by an independent channel – "voting card" (paper is back?!) prepared by an Election Authority

Voter vs PC part II

- Machine cannot change voter's choice – voter obtains a receipt, which can be used to detect machine's misbehaviour.
- But at the same time, "voting card" and a receipt cannot be used to prove voter's choice
- Achieving these two properties is the hardest part in the system design.

Voter vs Election Authority

- Voter obtains voting card (ballot) from Election Authority
- How does voter know if her voting card is correctly encoded? Pre-election Audit
- How can one protect voter's privacy?
  Use ballot box votes are casted through Proxy

Coding card

- Voter obtains a *voting card* from Election Authority
- Voter obtains many *coding cards* from "Proxy" (many Proxies may be used)
- Voter lays them side by side

Candidate	*R*	*S*	*T*	*U*
2 Jerry				
3 Edgar				
0 Ervin				
1 Donald				
S_l				

voting card (from EA)

	n	Y	n	n
	n	Y	n	n
	Y	n	n	n
	n	n	n	Y
	S_r			

coding card (from Proxy)

Candidate	*R*	*S*	*T*	*U*
2 Jerry	n	Y	n	n
3 Edgar	n	Y	n	n
0 Ervin	Y	n	n	n
1 Donald	n	n	n	Y
S_l	S_r			

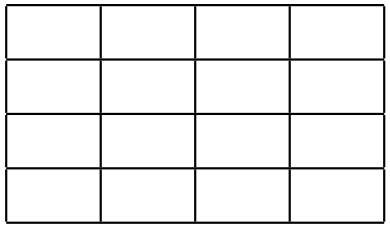
Vote casting

- Voter clicks on the screen on boxes which correspond to `Y` next to her candidate
-

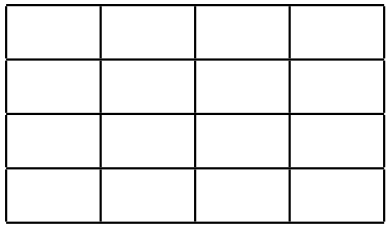
voting card

Candidate	*R*	*S*	*T*	*U*
2 Jerry	n	Y	n	n
3 Edgar	n	Y	n	n
0 Ervin	Y	n	n	n
1 Donald	n	n	n	Y
S_l	S_r			

PC screen



tranform (by Proxy)



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voting card

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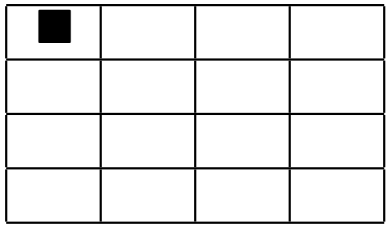
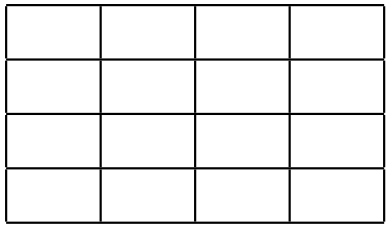
2 Jerry	n	Y	n	n
3 Edgar	n	Y	n	n
0 Ervin	Y	n	n	n
1 Donald	n	n	n	Y
S_l	S_r			

PC screen



tranform (by Proxy)



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voting card

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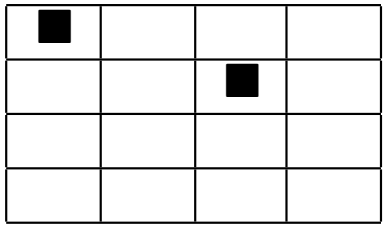
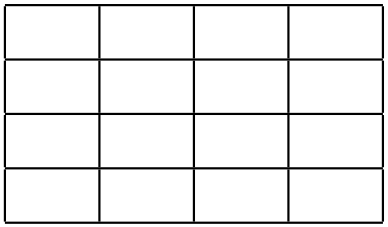
2 Jerry	n	Y	n	n
3 Edgar	n	Y	n	n
0 Ervin	Y	n	n	n
1 Donald	n	n	n	Y
S_l	S_r			

PC screen



tranform (by Proxy)



Vote casting

- Voter clicks on the screen on boxes which correspond to `Y` next to her candidate
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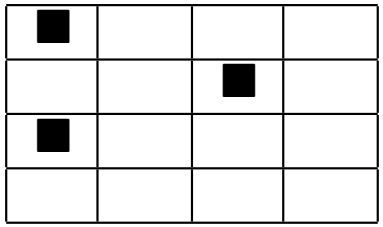
voting card

Candidate	*R*	*S*	*T*	*U*
2 Jerry	n	Y	n	n
3 Edgar	n	Y	n	n
0 Ervin	Y	n	n	n
1 Donald	n	n	n	Y
S_l	S_r			

PC screen



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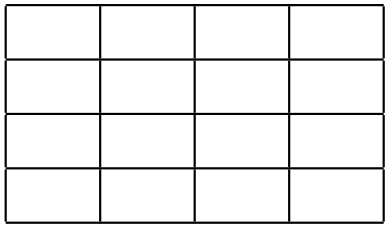

Vote casting

- Voter clicks on the screen on boxes which correspond to `Y` next to her candidate
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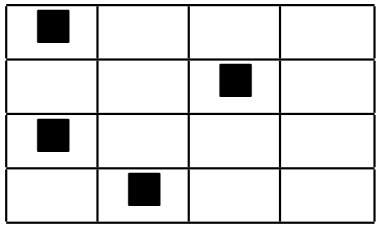
voting card

Candidate	*R*	*S*	*T*	*U*
2 Jerry	n	Y	n	n
3 Edgar	n	Y	n	n
0 Ervin	Y	n	n	n
1 Donald	n	n	n	Y
S_l	S_r			

PC screen



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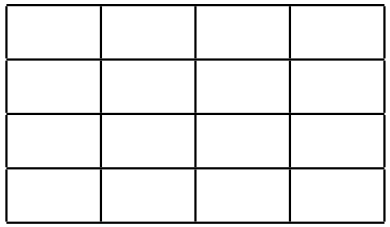


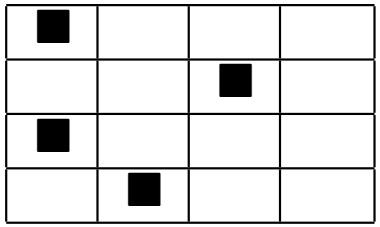
Vote casting

- Voter enters S_r (coding card serial number), proxy "translates" voter's choice into FourBallot form
-

voting card

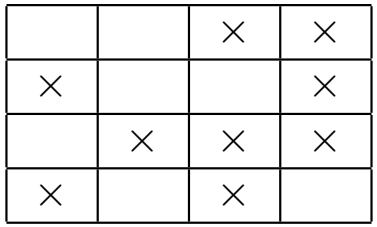
Candidate	*R*	*S*	*T*	*U*
2 Jerry	n	Y	n	n
3 Edgar	n	Y	n	n
0 Ervin	Y	n	n	n
1 Donald	n	n	n	Y
S_l	S_r			

PC screen



S_r

tranform (by Proxy)



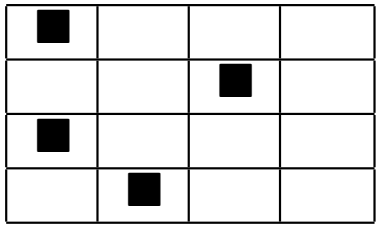
Vote casting

- Voter enters S_l (voting card serial number), Proxy sends FourBallot form to the Election Authority
-

voting card

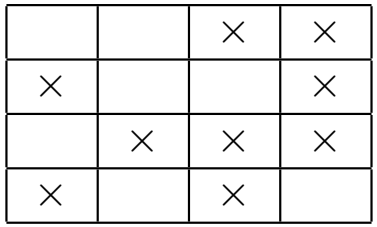
Candidate	*R*	*S*	*T*	*U*
2 Jerry	n	Y	n	n
3 Edgar	n	Y	n	n
0 Ervin	Y	n	n	n
1 Donald	n	n	n	Y
S_l	S_r			

PC screen



S_r

tranform (by Proxy)



S_l

Vote casting

- Voter obtains as a receipt one of the FourBallot form ballots (oblivious transfer like protocol used)

voting card

Candidate	*R*	*S*	*T*	*U*
2 Jerry	n	Y	n	n
3 Edgar	n	Y	n	n
0 Ervin	Y	n	n	n
1 Donald	n	n	n	Y
S_l	S_r			

tranform (by Proxy)

		×	×
×			×
	×	×	×
×		×	

S_l

receipt

T
×
×
×

t

- $t = sign_{EA}(T, S_l)$ - confirmation token (like in Sure Vote)

Security - PC/virus

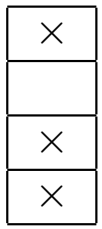
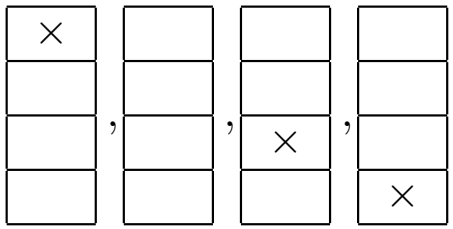
- Voter's PC can change voter's choice (with some probability):
  - PC does not know which row corresponds to the chosen candidate
  - modification can be detected by Proxy – $\frac{1}{3k}$, where k is the number of candidates
  - modification can be detected by voter – receipt ($\frac{1}{4}$)

Security - Proxy, Election Authority

- Proxy can change voter's choice into a random one, but then a receipt will change - detection with probability $\frac{1}{4}$
- Election Authority – neglible probability: Pre- and Post-election audits

Security - other attacks

- There are known attacks on ThreeBallot (Strauss, Appeal):
  - FourBallots is much more immune – better probability distribution – Strauss' attack ineficient
  - moreover, it is easy to implement following modification (only electronic version) – instead of publishing every ballot, every ballot is split into masked ballots:

a ballot column:  , masked ballot columns: 

- Thank you for your attention