Verifiable Student Board Elections with UniVote

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UniVote: Project Overview

Project Overview

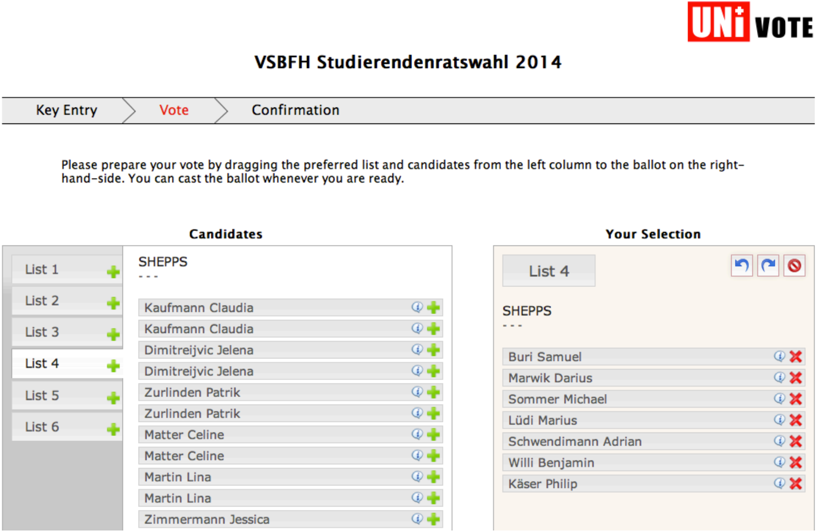
- UniVote = Internet voting system for student board elections at Swiss universities
- 13 months development (February 2012 – February 2013)
  - 1 main developer and server administrator (50% assistant)
  - 1 PhD student (25% developer for UniVote)
  - 4 professors (protocols, specification, system design, . . .)
- Current version: 1.7
- Source code and documentation publicly available:

  https://www.univote.ch/documentation
- Verification software available (independent student project)
- Voting simulator under development (student project at HSR)

Previous and Future Elections

- Complex ballots with party lists (similar to NR elections)
- Previous elections
  - March 2013: University of Bern (11'000)
  - April 2013: Bern University of Applied Sciences (6'000)
  - May 2013: University of Zürich (26'000)
  - September 2013: University of Lucerne (3'000)
  - October 2013: Best Teacher Award, University of Lucerne
- Current and future elections
  - April 2014: Bern University of Applied Sciences
  - October 2014: Best Teacher Award, University of Lucerne
  - Elections in 2015: UniBE, UniZH, UniLU
- Average participation: $\approx 10\%$

UniVote User Interface



VSBFH Studierendenratswahl 2014

Please prepare your vote by dragging the preferred list and candidates from the left column to the ballot on the right-hand-side. You can cast the ballot whenever you are ready.

Candidates

- List 1
- List 2
- List 3
- List 4
- List 5
- List 6

SHEPPS
- - -

- Kaufmann Claudia
- Kaufmann Claudia
- Dimitreijvic Jelena
- Dimitreijvic Jelena
- Zurlinden Patrik
- Zurlinden Patrik
- Matter Celine
- Matter Celine
- Martin Lina
- Martin Lina
- Zimmermann Jessica

Your Selection

List 4

SHEPPS
- - -

- Buri Samuel
- Marwik Darius
- Sommer Michael
- Lüdi Marius
- Schwendimann Adrian
- Willi Benjamin
- Käser Philip

System Properties and Design

Verifiability

“One should verify the election, not the election system.”

Ben Adida

- Individual verifiability: Correctness and inclusion of single vote
- Universal verifiability: Correctness of final election result

System Properties

- PKI based on existing Swiss university eID infrastructure
- Individually and universally verifiable
- Public election board (EB)
  - All election data is published
  - Simplified implementation (no append-only or fault tolerance mechanisms)
- Distribution of trust
  - Shared decryption key (3 decryptors, no threshold)
  - Two mix networks (each with 3 mixers, no proof yet)
- Extended voter privacy
  - Secrecy: mixing the votes
  - Anonymity: mixing the public signature keys
- Transparency (source code and documentation)

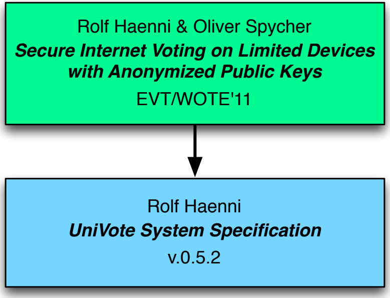
Design and Specification

Rolf Haenni & Oliver Spycher

Secure Internet Voting on Limited Devices with Anonymized Public Keys

EVT/WOTE'11

Design and Specification



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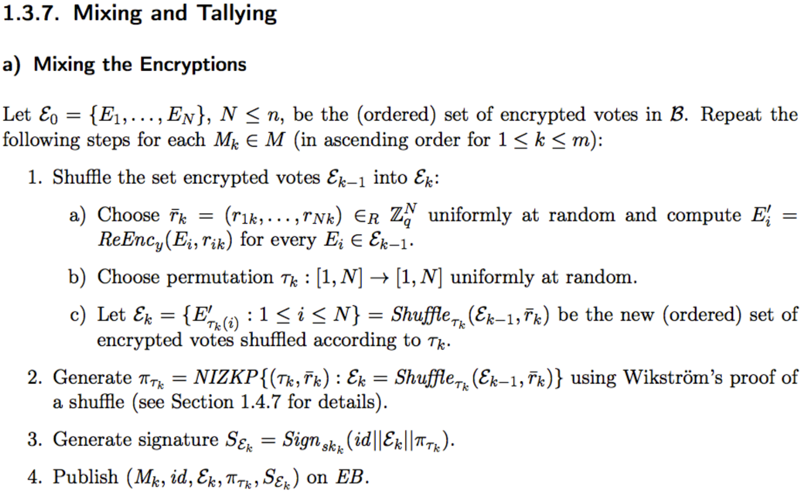
UniVote System Specification

v.0.5.2

Design and Specification



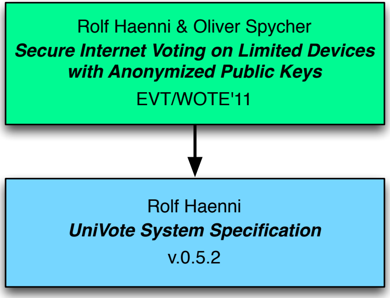
1.3.7. Mixing and Tallying

a) Mixing the Encryptions

Let $\mathcal{E}_0 = \{E_1, \ldots, E_N\}$, $N \leq n$, be the (ordered) set of encrypted votes in $\mathcal{B}$. Repeat the following steps for each $M_k \in M$ (in ascending order for $1 \leq k \leq m$):

1. Shuffle the set encrypted votes $\mathcal{E}_{k-1}$ into $\mathcal{E}_k$:
   - a) Choose $\bar{r}_k = (r_{1k}, \ldots, r_{Nk}) \in_R \mathbb{Z}_q^N$ uniformly at random and compute $E'_i = \mathit{ReEnc}_y(E_i, r_{ik})$ for every $E_i \in \mathcal{E}_{k-1}$.
   - b) Choose permutation $\tau_k : [1, N] \rightarrow [1, N]$ uniformly at random.
   - c) Let $\mathcal{E}_k = \{E'_{\tau_k(i)} : 1 \leq i \leq N\} = \mathit{Shuffle}_{\tau_k}(\mathcal{E}_{k-1}, \bar{r}_k)$ be the new (ordered) set of encrypted votes shuffled according to τ_k.
2. Generate $\pi_{\tau_k} = \mathit{NIZKP}\{(\tau_k, \bar{r}_k) : \mathcal{E}_k = \mathit{Shuffle}_{\tau_k}(\mathcal{E}_{k-1}, \bar{r}_k)\}$ using Wikström's proof of a shuffle (see Section 1.4.7 for details).
3. Generate signature $S_{\mathcal{E}_k} = \mathit{Sign}_{sk_k}(id||\mathcal{E}_k||\pi_{\tau_k})$.
4. Publish $(M_k, id, \mathcal{E}_k, \pi_{\tau_k}, S_{\mathcal{E}_k})$ on EB.

Design and Specification



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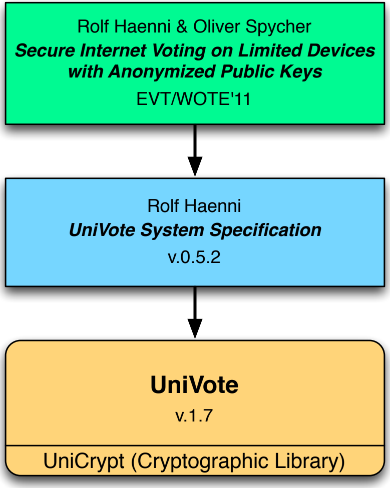

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UniVote System Specification

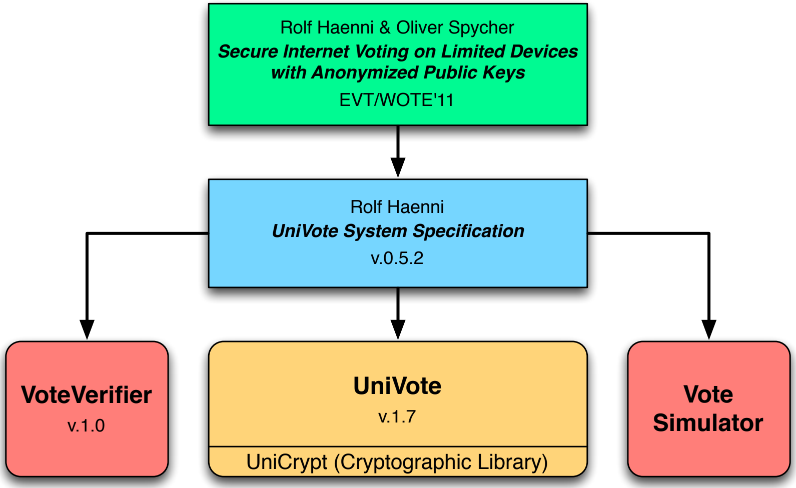
v.0.5.2

UniVote

v.1.7

UniCrypt (Cryptographic Library)

Design and Specification



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UniVote System Specification

v.0.5.2

VoteVerifier

v.1.0

UniVote

v.1.7

UniCrypt (Cryptographic Library)

Vote Simulator

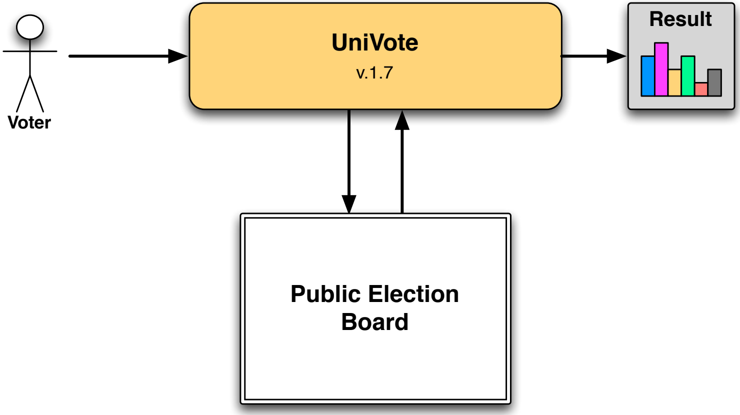
Tools and Components

UniCrypt

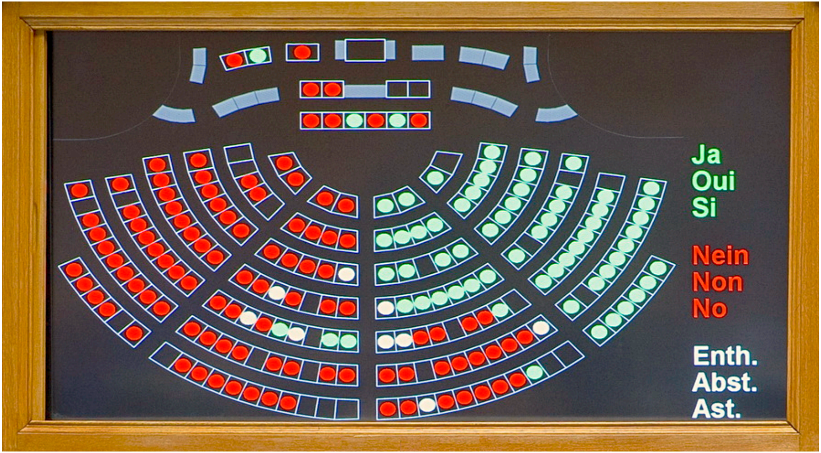
- Java library for advanced cryptographic tasks
  - ElGamal encryptions
  - Commitments
  - Secret sharing
  - Re-encryption mixnets
  - Zero-knowlede proofs
  - Elliptic curves
  - Random oracles
  - Common reference strings
- Design goal: Clean and easy-to-use programming interfaces
- Version 2.0 to be released soon (summer 2014)
- Open-source project on GitHub:

https://github.com/bfh-evg/unicrypt

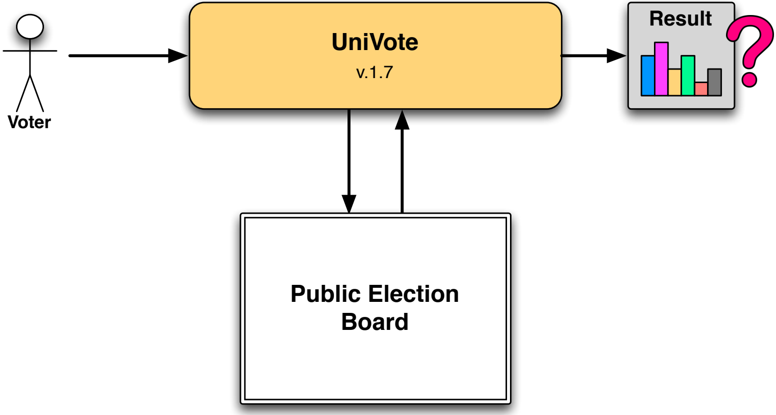
Public Election Board



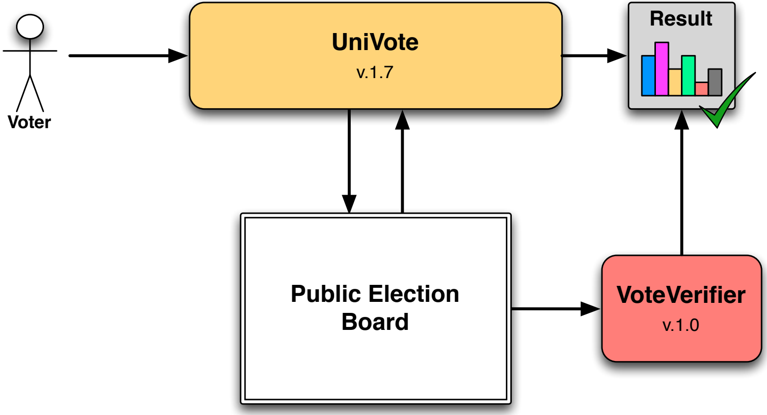
Public Election Board



Public Election Board

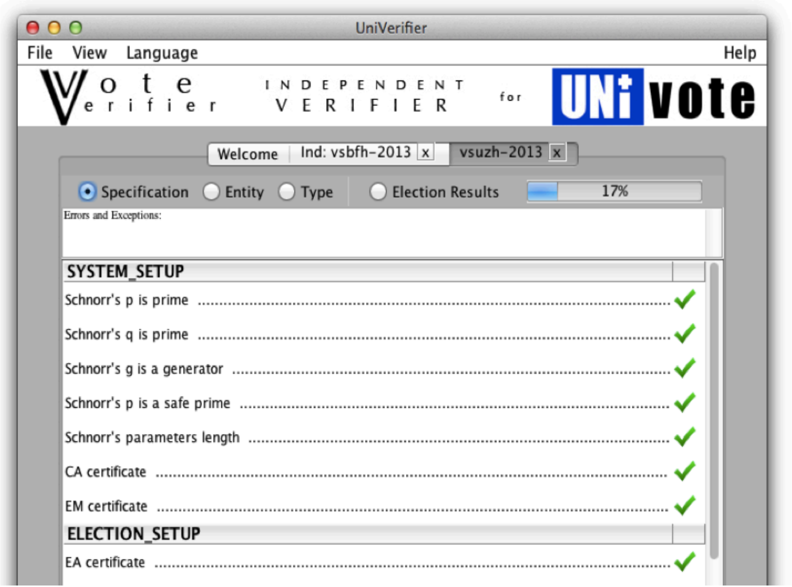


Public Election Board



Voter Verifier

- Student project (bachelor thesis 2013)
- Developed independently from specification
  - Disjoint code base
  - No help from UniVote source code
- Individual verification:
  - Reads encrypted vote from QR-code
  - Checks if encrypted vote has reached the election board
  - Displays vote intention on trustworthy device
- Universal verification:
  - Reads election data from public election board
  - Checks consistency of election data
  - Total of 61 checks: parameters, signatures, crypto-proofs
  - Re-computes final election result



● Specification ○ Entity ○ Type ○ Election Results 17%

Errors and Exceptions:

SYSTEM_SETUP

Schnorr's p is prime .... ✓

Schnorr's q is prime .... ✓

Schnorr's g is a generator .... ✓

Schnorr's p is a safe prime .... ✓

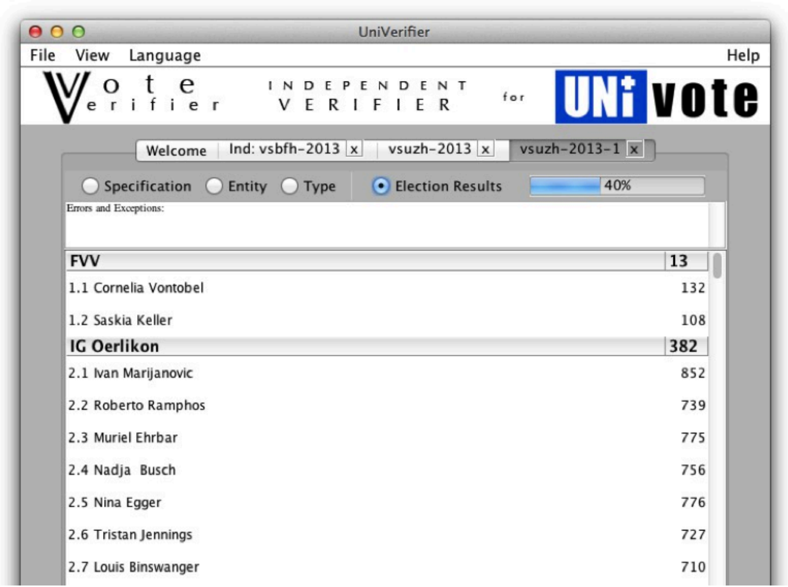
Schnorr's parameters length .... ✓

CA certificate .... ✓

EM certificate .... ✓

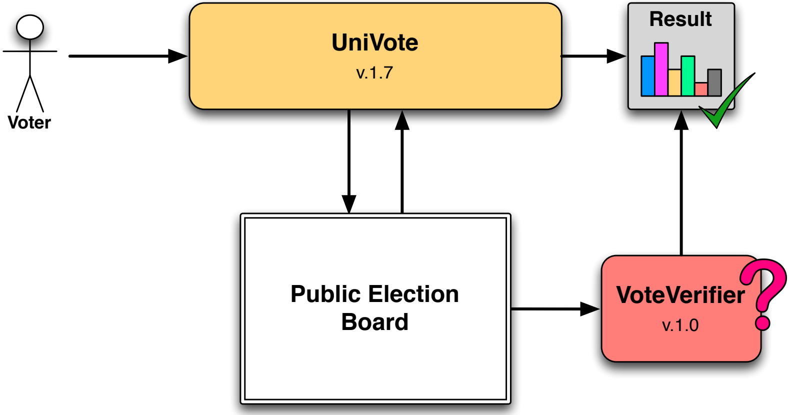
ELECTION_SETUP

EA certificate .... ✓



FVV	13
1.1 Cornelia Vontobel	132
1.2 Saskia Keller	108
IG Oerlikon	**382**
2.1 Ivan Marijanovic	852
2.2 Roberto Ramphos	739
2.3 Muriel Ehrbar	775
2.4 Nadja Busch	756
2.5 Nina Egger	776
2.6 Tristan Jennings	727
2.7 Louis Binswanger	710

Vote Verifier



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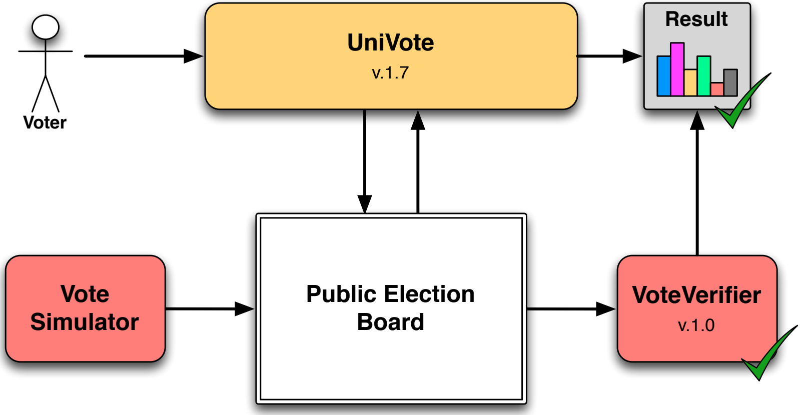

VoteSimulator

- Answer to question: “Who checks the VoteVerifier?”
- Student project at HSR (work in progress)
- Developed independently from specification
  - Disjoint code base
  - No help from UniVote source code
  - No help from VoteVerifier source code
- Writes data for arbitrary-sized elections to election board
  - Good case: consistent data only
  - Bad case: inconsistent data from simulated attacks

Conclusion and Future Work

Conclusion

- For academics, it is very instructive . . .
  - to develop a real-world election system
  - to run real elections
- Student board elections are a great testbed
- Very positive feedback . . .
  - from voters
  - from research community
- Major problems
  - Small budget
  - Restricted manpower
  - Time management
  - Browser incompatibilities
  - Software maintenance (students disappear after graduating)

UniVote 2.0

- UniVote 2.0 = Complete redesign of UniVote 1.7
  - Independent append-only public election board (UniBoard)
  - Improved underlying cryptographic library (UniCrypt)
  - Extended independent registration service (UniCert) for Google+, Facebook, Twitter, etc.
  - GUI support for multiple election types
  - Improved election administration tools
  - Comprehensive documentation
- Enlarged project team
  - 2 PhD students
  - 1 full time assistant
- Lack of project funding

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