A Homomorphic E-Voting Protocol Based on El-Gamel Cryptosystem

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Outline

1. E-Voting Protocols

2. Algorithms of Protocols

3. Numerical Results

Steps

Steps of a Typical E-Voting Protocol

1. Set Up
2. Vote Casting
3. Tally Computing

Categories

Main categories of E-Voting Protocols

1. Blind Signature: Using Token, Proof of Authentication for the Ballots.
2. Mixers: blind the name and vote of a voter by permutating the ballots.
3. Homomorphic: Sum of Encrypted votes is equal to the Encryption of Sum of Votes (i.e. Encrypted Tally is equal to Tally of Encrypted).

Properties

Main Properties of E-Voting Systems

1. **Fairness**: The result of voting should not be announced before the end of vote casting.
2. **Privacy**: Ensures that no one links the ballot to the voter. (i.e. there is no difference for C, if A votes V_1 and B votes V_2 or A votes V_2 and B votes V_1).
3. **Eligibility**: Only the eligible voters, who pass the authentication process, can be allowed to vote once.
4. **Robustness**: If the protocol can recover from the faulty or betray of any (reasonably sized) subset of parties.
5. **Coercion-resistant:** If an adversary cannot force a voter to behave as he/she wants.

Discrete Logarithm Problem

Let G be a group. Finding k where $y = g^k$ and $g, y \in G$ are known.

El-Gamel Cryptosystem

1. Step one: Alice and Bob with private keys $a, b \in \mathbb{F}_p$ send their public keys aP, bP and compute a table of all $\{vP | v \text{ is plaintext}\}$.
2. Step two: Then Bob chooses random number $k \in \mathbb{F}_p$ and sends $(x, y) = (kP, vP + kaP)$.
3. Step three: Alice can compute $y\hat{a}ax$ and checks vP in the table in order to find v.

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Protocol

1. Step Up: center chooses s, p, E_p and P where $s \in \mathbb{F}_p$ as its secret key and P as a primitive point on E_p. The center announced h = sP as its public key in the bulletin board. Voters are registered and are given a secret key in order to prove their authentication.
2. Vote Casting: voter i chooses random number $a_i \in \mathbb{F}_p$ and $v_j \in \{1, â1\}$. Then he/she sends $B_i = (B_{i,1}, B_{i,2}) = (a_i P, v_j P + a_i sP)$ with some proofs of authentication.
3. Tally Computing: The center computes and announces $s \sum_{j=1}^{N} B_{j,1}$ with a proof of authentication. So it can compute $(\sum_{j=1}^{N} a_j)sP$ and finally $(\sum_{j=1}^{N} v_j)P$ from $\sum_{j=1}^{N} B_{j,2} - s \sum_{j=1}^{N} B_{j,1}$. Next, $\sum_{i=1}^{N} v_i$ can be found according to the table $\{-NP, \cdots, -P, 0, P, \cdots, NP\}$ which is formed by the tallier.

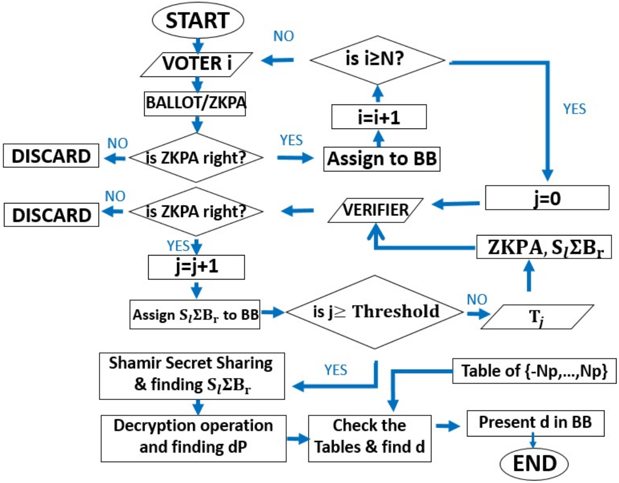

Figure: The flowchart of the protocol proposed in [2].

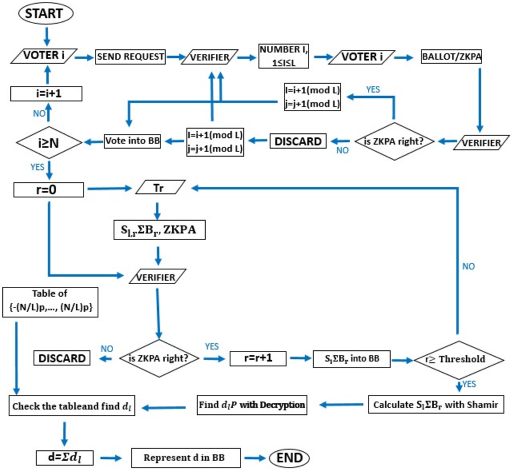

Figure: The flowchart of the proposed protocol.

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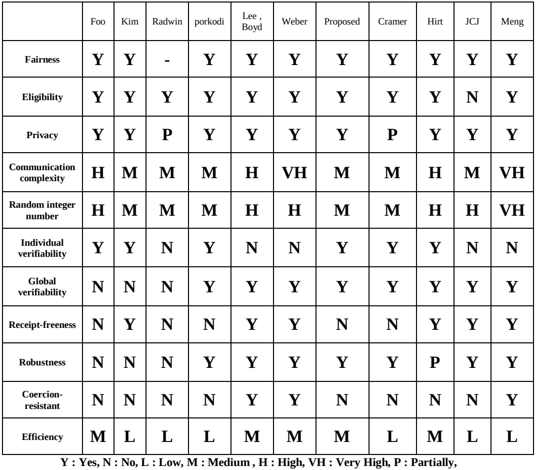

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Fairness	**Y**	**Y**	**-**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
Eligibility	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**N**	**Y**
Privacy	**Y**	**Y**	**P**	**Y**	**Y**	**Y**	**Y**	**P**	**Y**	**Y**	**Y**
Communication complexity	**H**	**M**	**M**	**M**	**H**	**VH**	**M**	**M**	**H**	**M**	**VH**
Random integer number	**H**	**M**	**M**	**M**	**H**	**H**	**M**	**M**	**H**	**H**	**VH**
Individual verifiability	**Y**	**Y**	**N**	**Y**	**N**	**N**	**Y**	**Y**	**Y**	**N**	**N**
Global verifiability	**N**	**N**	**N**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
Receipt-freeness	**N**	**Y**	**N**	**N**	**Y**	**Y**	**N**	**N**	**Y**	**Y**	**Y**
Robustness	**N**	**N**	**N**	**Y**	**Y**	**Y**	**Y**	**Y**	**P**	**Y**	**Y**
Coercion-resistant	**N**	**N**	**N**	**N**	**Y**	**Y**	**N**	**N**	**N**	**N**	**Y**
Efficiency	**M**	**L**	**L**	**L**	**M**	**M**	**M**	**L**	**M**	**L**	**L**

Y : Yes, N : No, L : Low, M : Medium , H : High, VH : Very High, P : Partially,

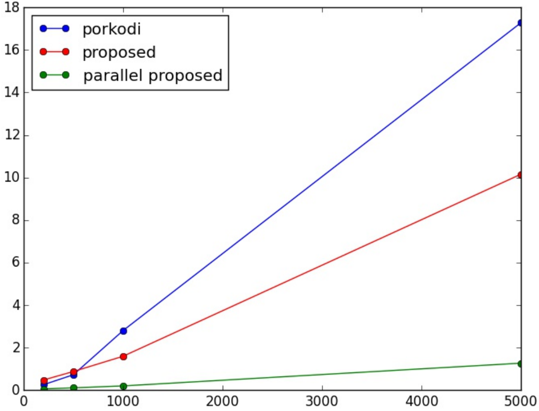


Figure: Time consuming of the proposed protocol with one server and multiple servers (parallel) and the protocol in [2]with $200 \leq N \leq 5000$.

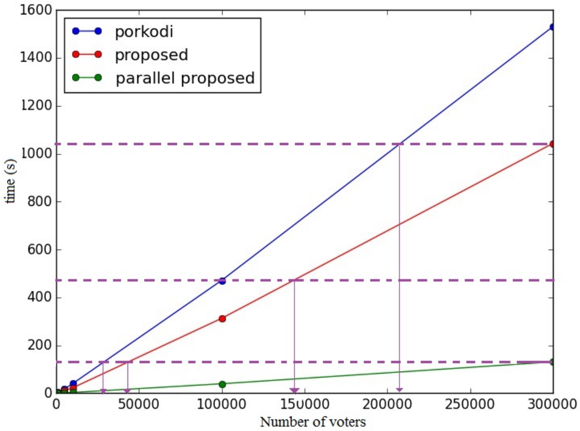
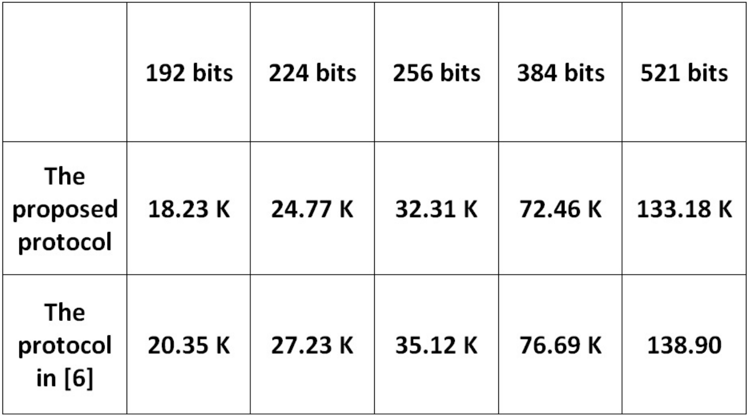


Figure: Estimated number of voters in the same time consuming in the proposed protocol with one server, multiple servers (parallel) and protocol in [2].



	192 bits	224 bits	256 bits	384 bits	521 bits
The proposed protocol	18.23 K	24.77 K	32.31 K	72.46 K	133.18 K
The protocol in [6]	20.35 K	27.23 K	35.12 K	76.69 K	138.90

Table: Memory consumption with 10 subsystems, 200 voters, and different prime numbers.

References

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Thank You

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