Reversing, Breaking, and Fixing the French Legislative Election E-Voting Protocol

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Brussels, May 23rd 2024

Loria
Laboratoire lorrain de recherche en informatique et ses applications

Inria

FRANCE 2030

Context

+1.5 millions legitimate voters (French citizens resident overseas only)

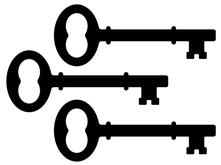
+500 000 ballots cast over the Internet (~77% of all the expressed votes)

11 deputies chosen for 5 years (11 constituencies split in ~200 consulates)

This protocol was based on a new protocol (FLEP), better be sure it is secure!

The different roles

Decryption Trustees



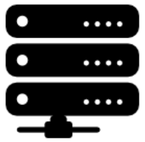
by representatives
and officials

Voter

At home

Voting Client

Javascript running in a browser



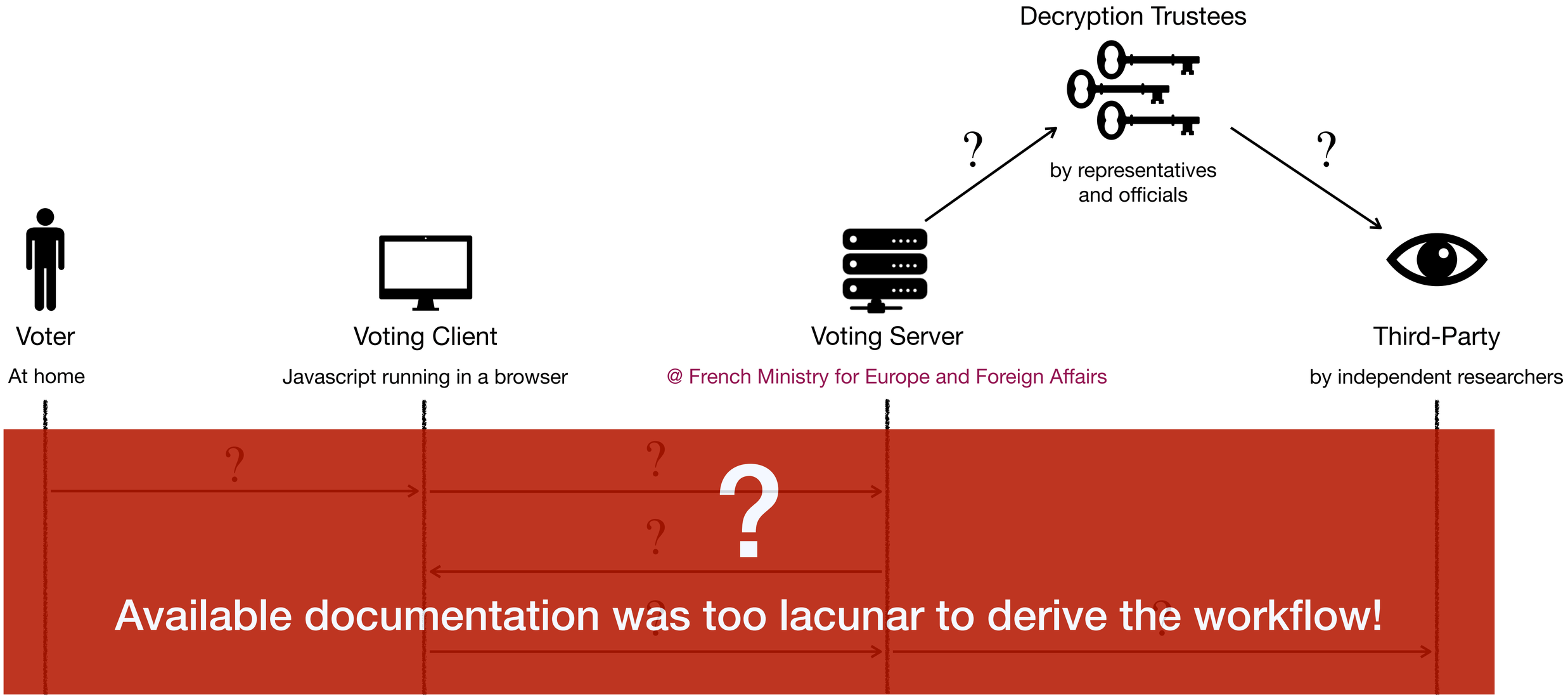
Voting Server

@ French Ministry for Europe and Foreign Affairs

Third-Party

by independent researchers

The different roles



Contributions

First public and comprehensive specification of the protocol
➡ by reversing the obfuscated voting client (Javascript & HTML)

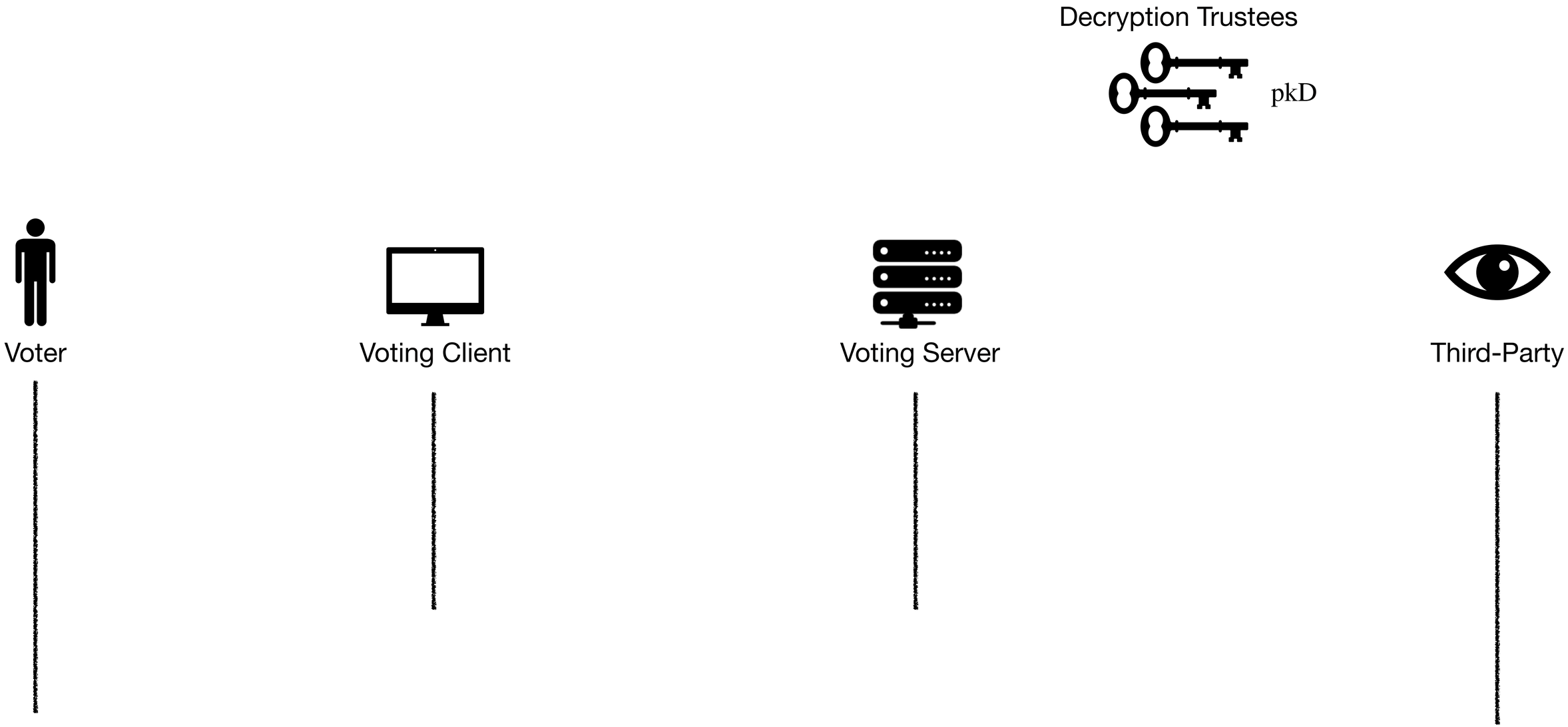
Verifiability and vote privacy can be attacked by a channel/server attacker:

- design an implementation vulnerabilities
- 6 attack variants

We proposed 6 fixes, most of them implemented for the 2023 elections

Lessons for the organisation of future e-voting elections

The workflow



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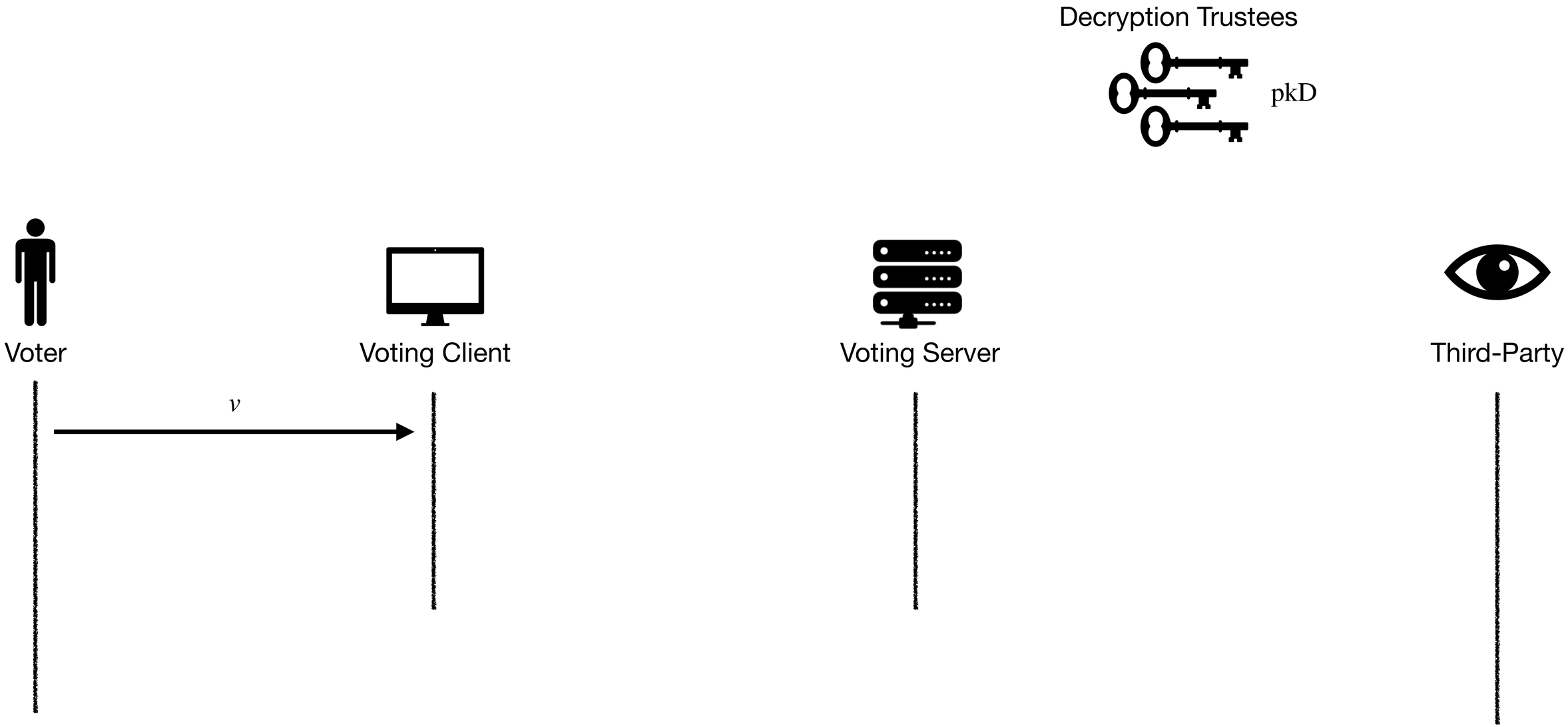

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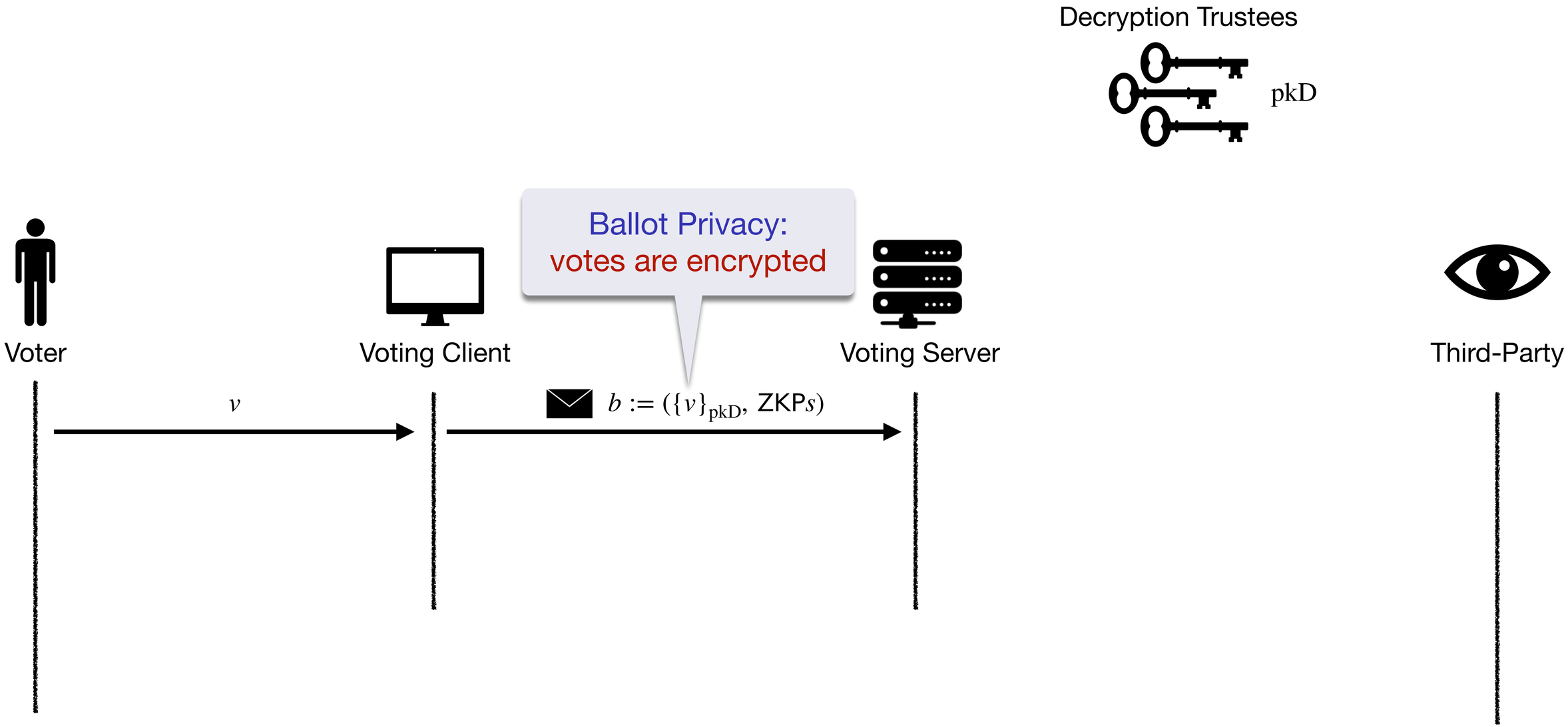

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ballotBox for each consular (~city)

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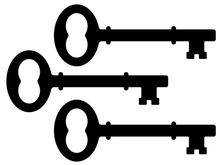
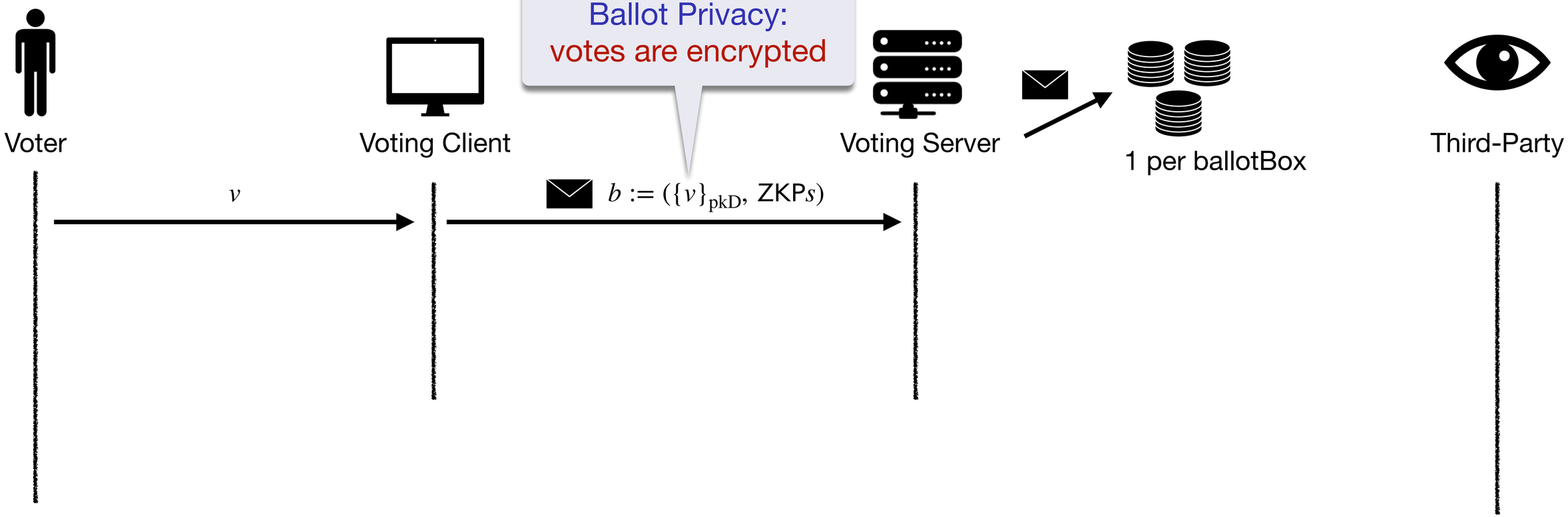


pkD

Ballot Privacy:
votes are encrypted



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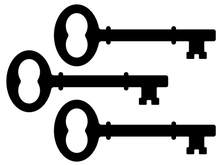

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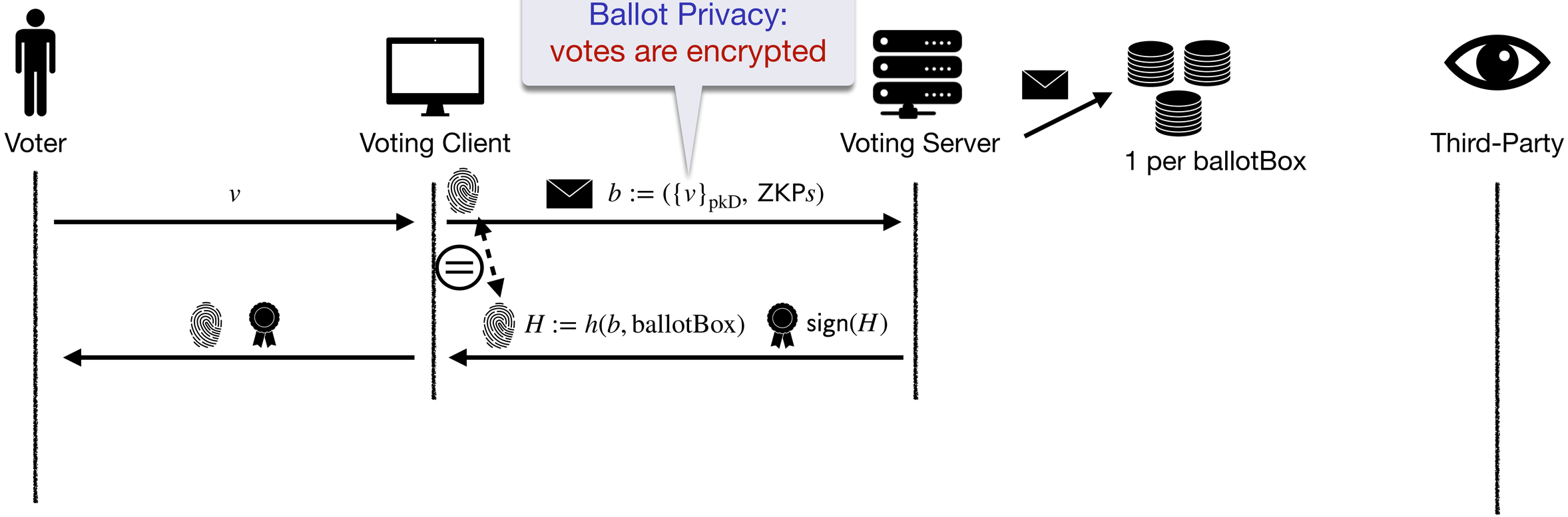

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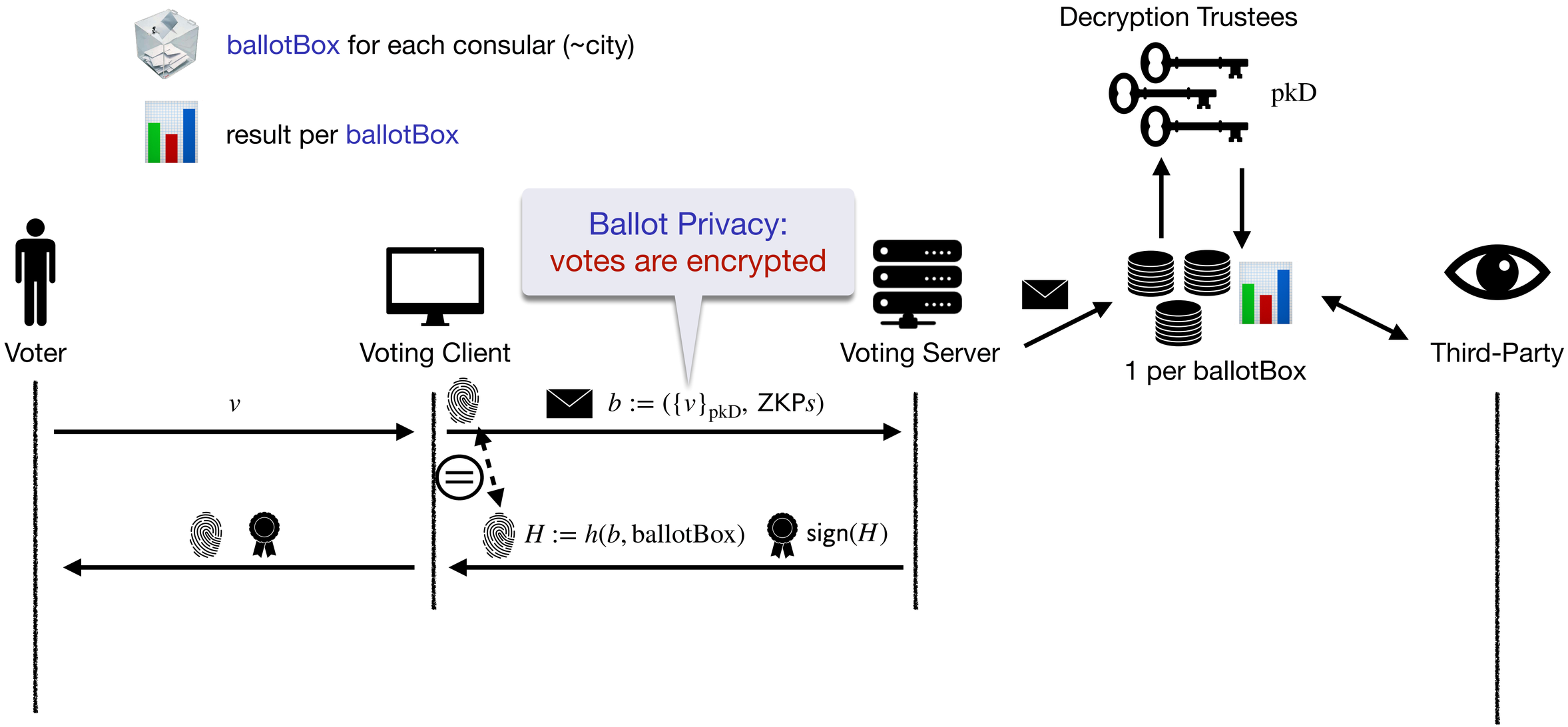

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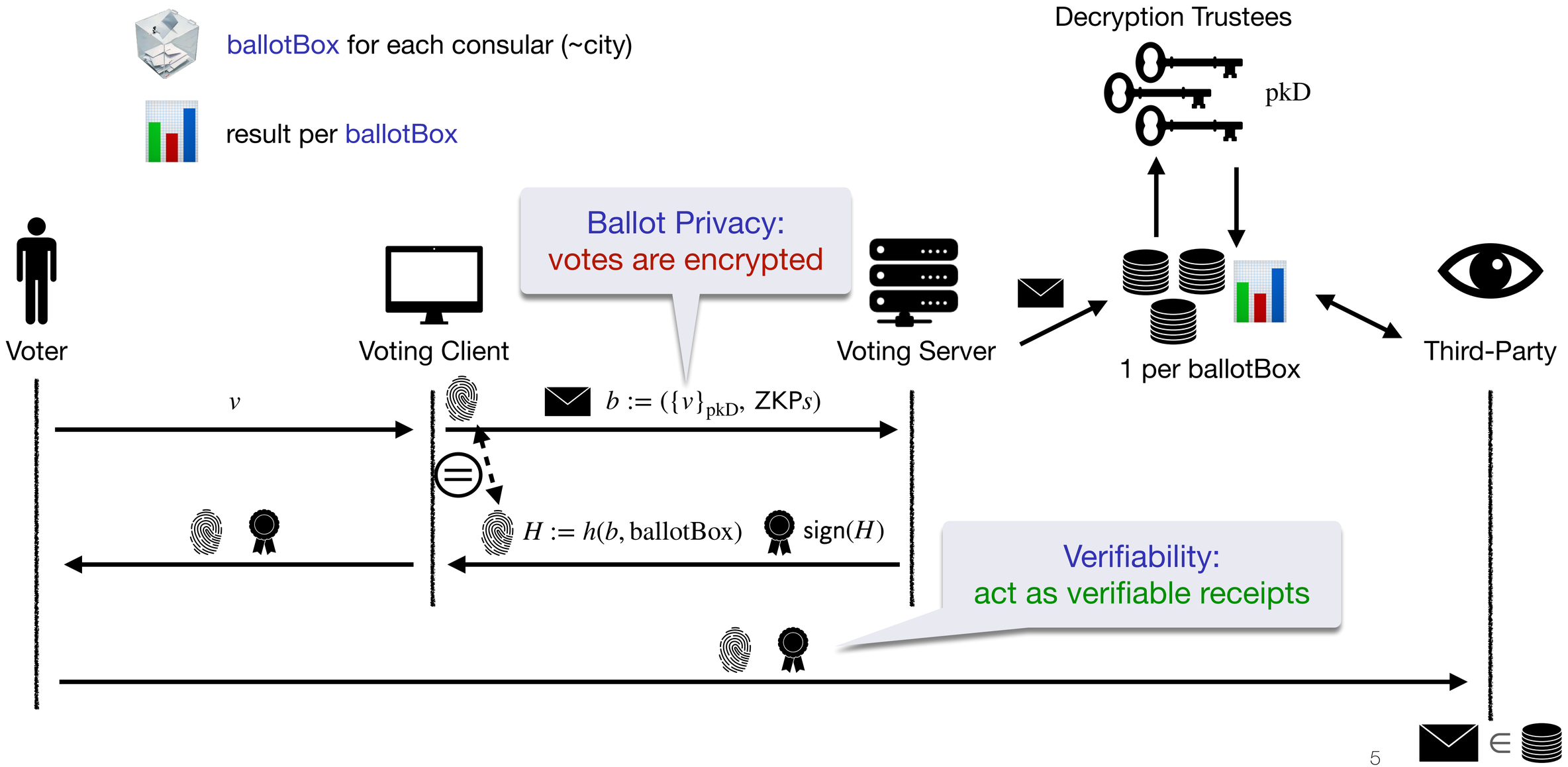
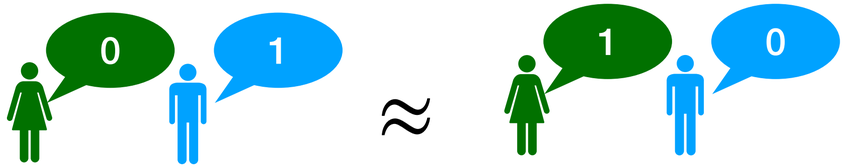


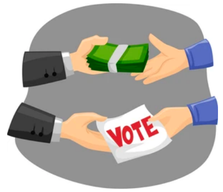
What security do we have?

Confidentiality of the votes

Vote privacy

"No one should know who I voted for"





Receipt-freeness

"No one should know who I voted for
even if I want to sell my vote"

Coercion resistance

"No one should know who I voted for
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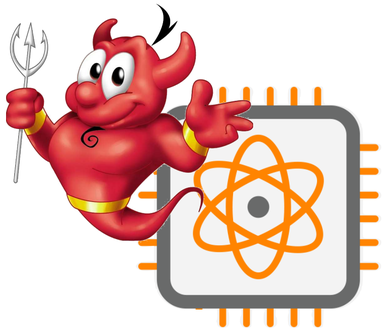
and/or someone wants to coerce me "

Everlasting privacy

Vote secrecy must still hold in
10, 20, …, 100 years!



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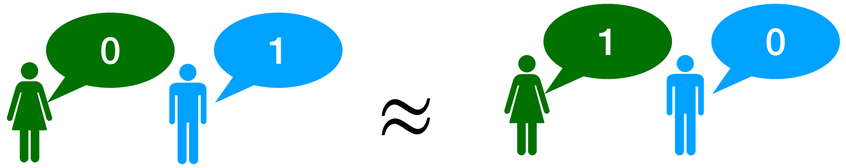

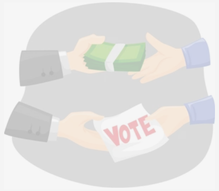

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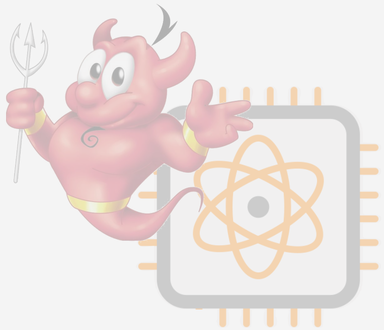
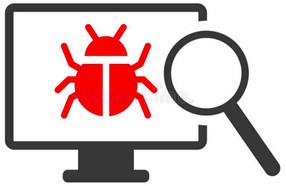
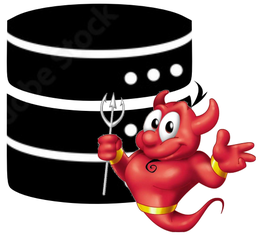


Trivial since nothing is made public

Verifiability - “ No one can modify the result of the election”



Cast-as-intended - “The cast ballot corresponds to the voter’s intent”



Recorded-as-cast - “The cast ballot is correctly added in the ballot-box”

Eligibility - “The ballot-box contains ballots cast by legitimate voters only”

Tallied-as-recorded - “The result corresponds to the ballot-box”

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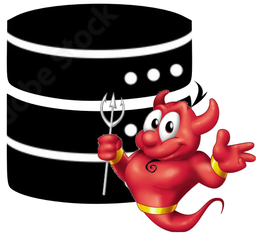

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Very weak claims…

Tallied-as-recorded - “The result corresponds to the ballot-box”

Threat models

Vote secrecy - "No one should know who I voted for" 

Verifiability - "No one can modify the outcome of the election" 

Threat models —

	Voter	Voting Client	Communication Channel	Voting Server	Decryption Trustees	Third-Party
Vote privacy	😇	😇	😈	😈	😇	😇
Verifiability	😇	😇	😈	😈	😈	😇

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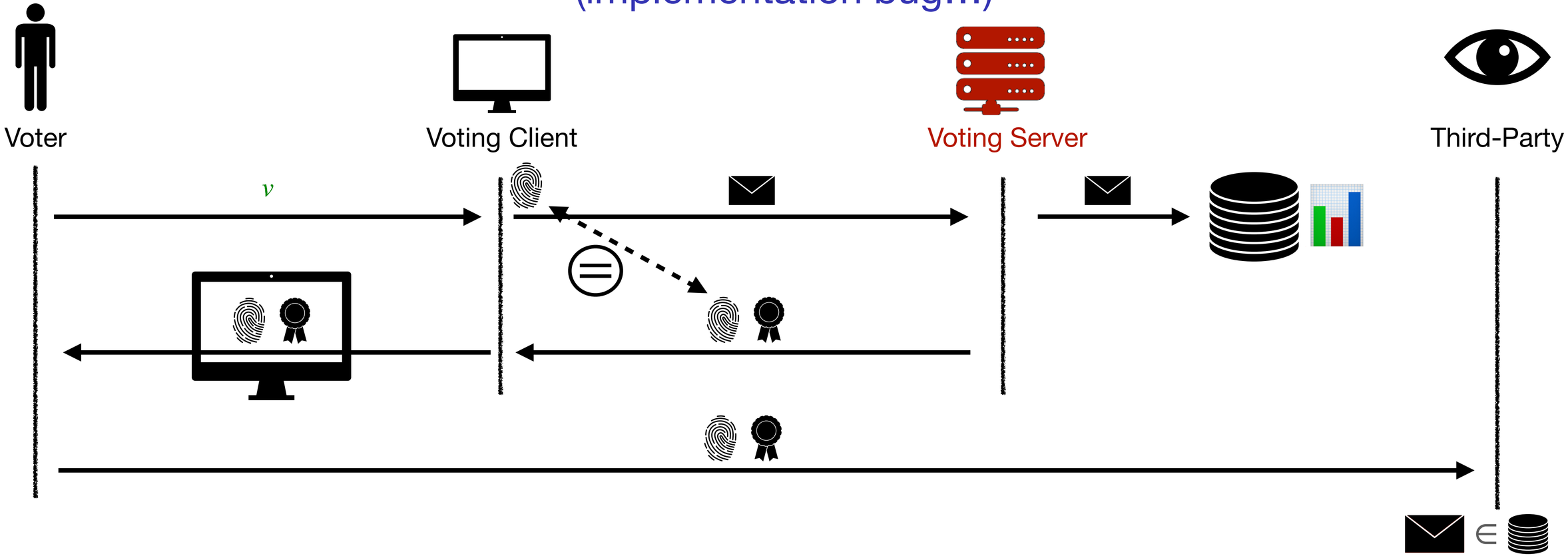
Attack against verifiability

(implementation bug…)



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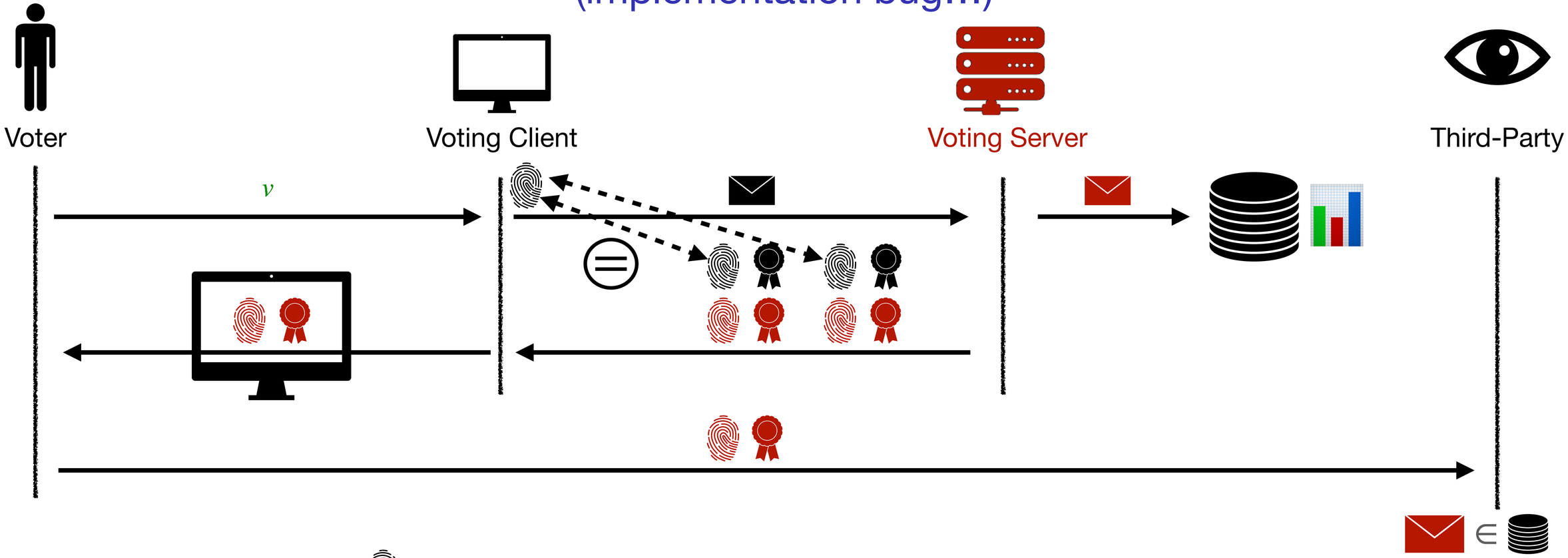

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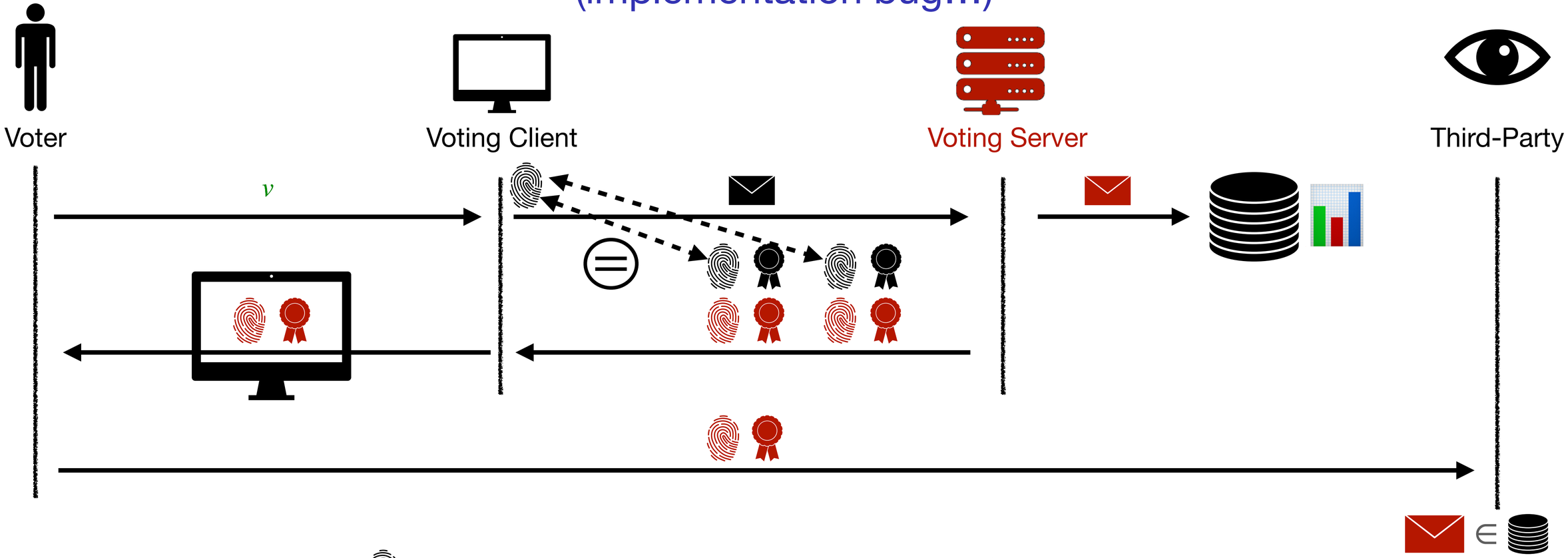

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Impact: channel or server attacker can **stealthily modify the outcome by replacing or dropping ballots**

Attack against vote privacy

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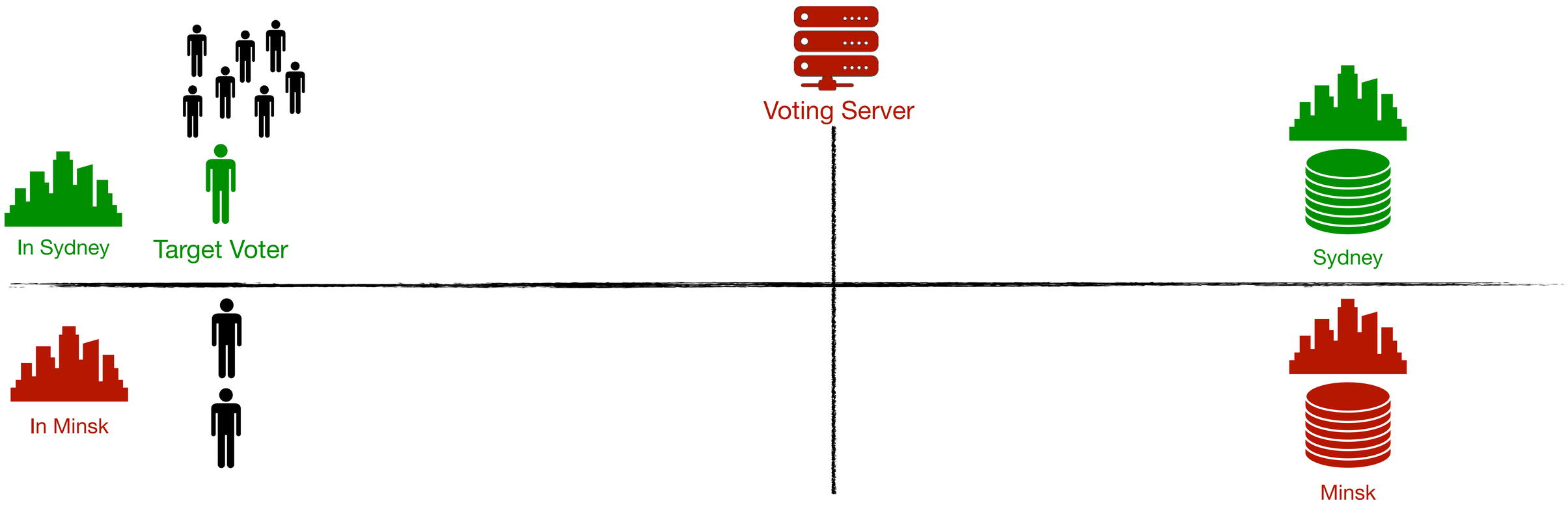

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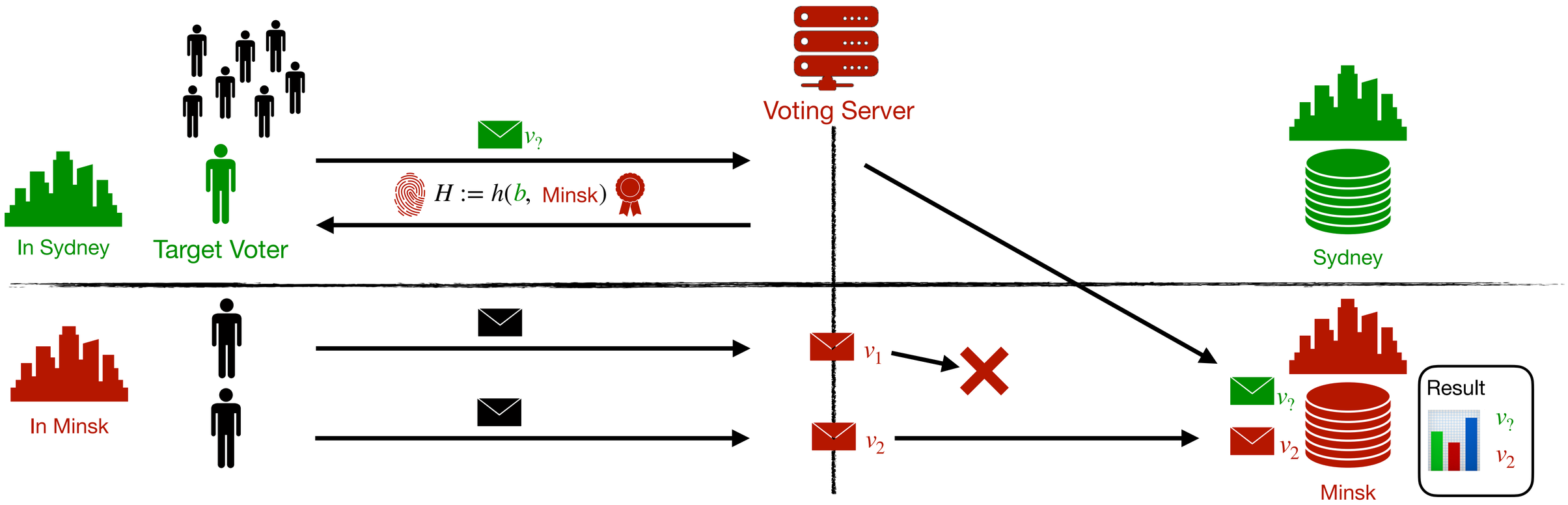

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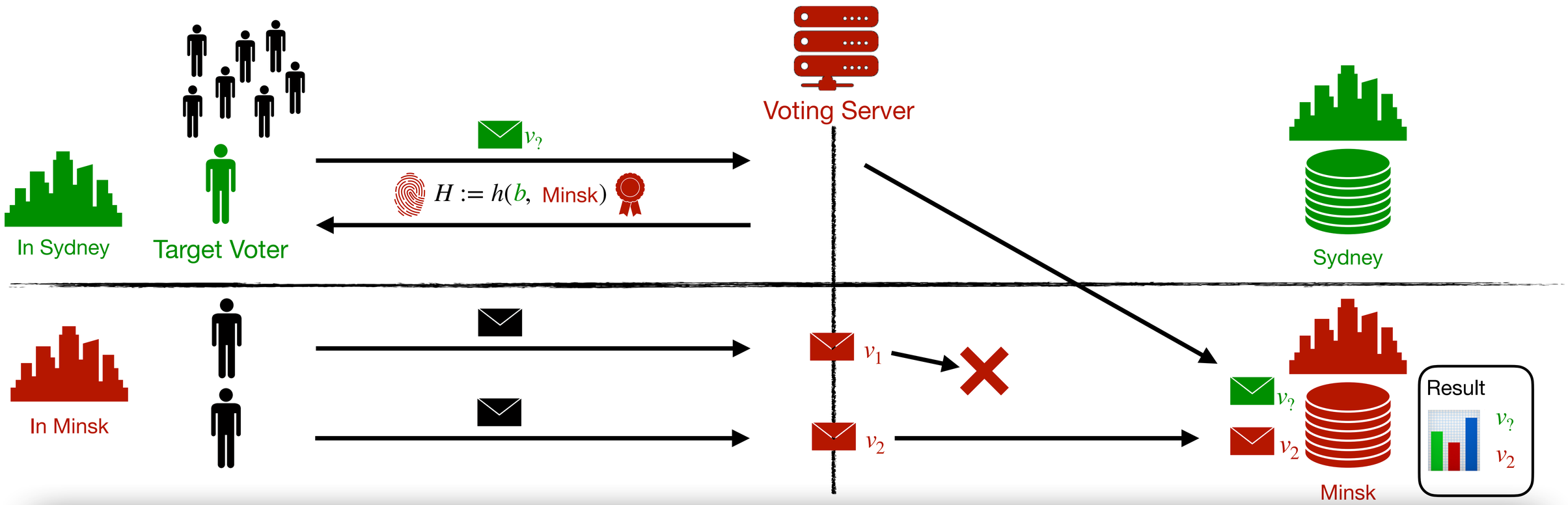

Impact: channel or server attacker can **stealthily learn some target voters' vote** (and perform remote coercion)

Fixes for future elections

We proposed 6 fixes and notably:

1. Display and check  instead of 
2. Binds ballotBox to the ballot ZKPs
3. Third-Party checks ballotBox

(Attacks and fixes were responsibly disclosed to the vendor and stakeholders.)
Special thanks to the ANSSI who have been proactive in this process.

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Story summary

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State-of-art protocol

affected by none of the attacks

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Adapt the design →

FLEP Protocol

- downloadable receipts
- adapt authentication
- support for multiple ballot-boxes

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FLEP Protocol

Implement, Deploy, Audit

- customized front-end
- deployment in a specific infrastructure

2022 Election

FLEP 2022

affected by 6 attacks

+ other concerns not discussed here

Lessons learned
(recommandations and research questions)

Designing a security protocol is highly error-prone and…

➡ state-of-the art solutions lack features
- multi-ballot-box for announcing fine-grain results
- downloadable receipts

➡ state-of-the-art solutions propose unpractical solutions
- voters authentication currently relies on a single-point-of-trust
- distributed key generation and decryption is actually centralized on a single machine

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➡ transparency and openness
- clear security objectives and threat models
- open specification, promote public scrutiny (e.g. as in Switzerland)

➡ identify the (most) critical components, e.g. Voting client > Server
- make it auditable (specification, open source, etc)
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Any component that **needs to be trusted** is **critical**

Conclusion

☞ https://eprint.iacr.org/2022/1653

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