Security in E-Voting

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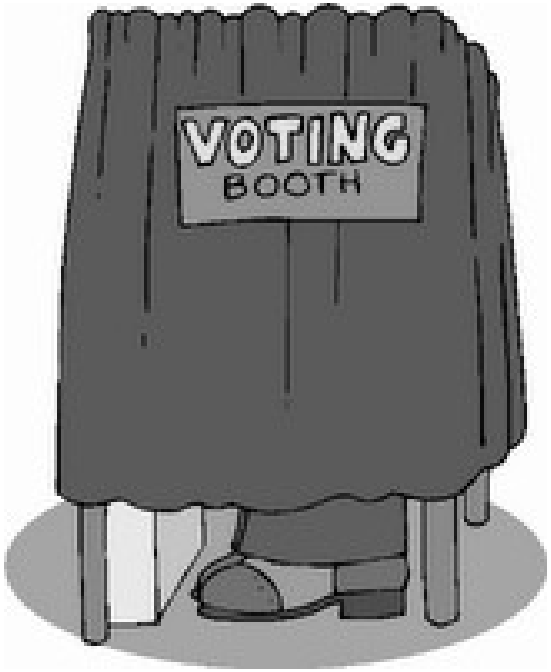
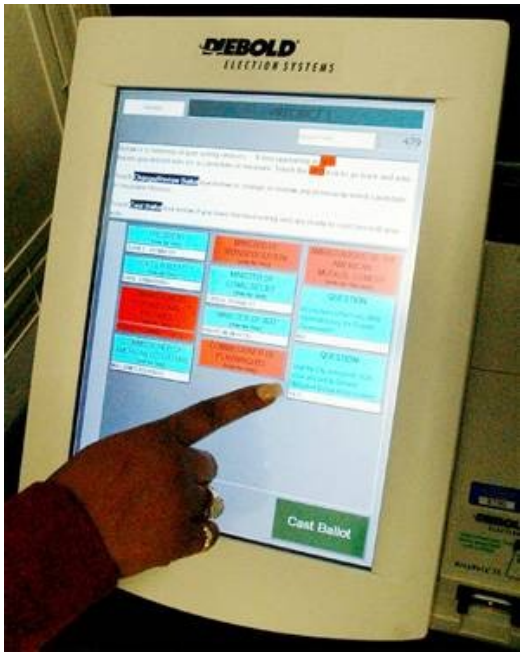
University of Trier
Germany

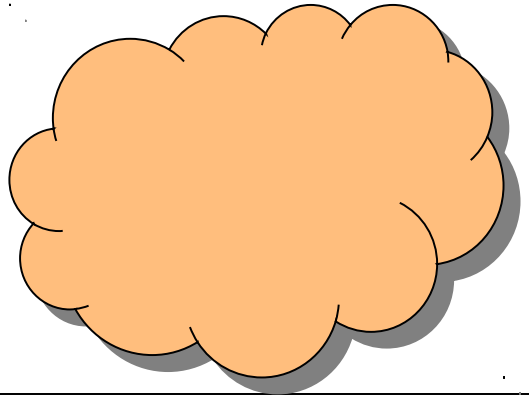
Electronic Voting



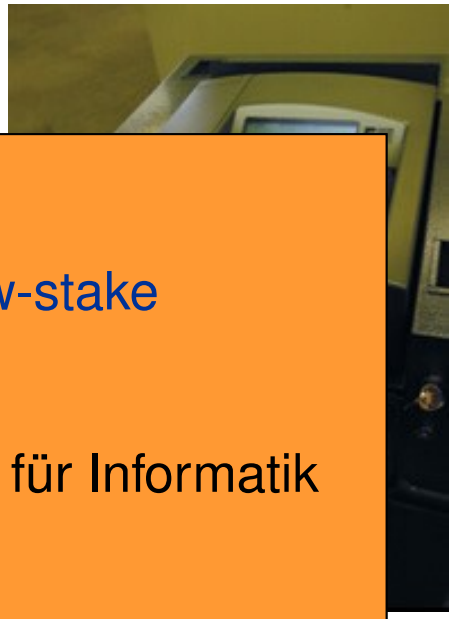


DRE

optical scanner



Electronic Voting



Used in many countries

even for national elections

- USA
- Estonia
- Switzerland
- Brasil
- India
- ...

but also for low-stake elections, e.g.,

- Gesellschaft für Informatik
- Sozialwahl
- ...

Many e-voting companies

e.g., Scytl (Spain), Polyas (Germany)

One project member, Dr. Tomasz Truderung, joined this company.

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Magazine

Election Day, poll workers complained that

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September 14, 2006 1:42 PM PDT

E-voting machines a fire

By Dawn Kawamoto
Staff Writer, CNET News

Concerns about electronic voting reliability has been heavily criticize resurfaced this week in a recently pu University study.

Released on Wednesday, the Princeton res "Security Analysis of the Diebold AccuVote-T Machine," says that the e-voting machine, proc Diebold Election Systems, was vulnerable to ma and potential voter fraud.

The Princeton report (click here for renewed debate over e near and ongi

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Electronic voting

Another election mess in Florida

Like 1

Big doubts about a narrow victory

Dec 7th 2006 | washington, dc | From the print edition

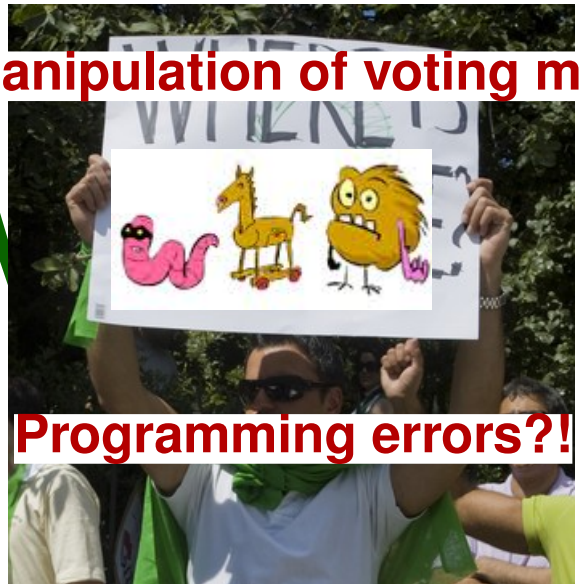
SINCE it is a place where alligator wrestling is a recognised pastime and tou hats with Mickey Mouse ears, you might think that Florida would be immune embarrassment. But after its punch-card ballots threw the 2000 presidentia chaos, the state made a decisive move. It outlawed punch-cards and spen dollars on touch-screen voting machines instead.

"There'll never be a hanging, dangling, or pregnant chad again," vowed Katherine Harris who was Florida's secretary of state at the time of the election. In 2002, Ms Harris was elected to the national House of Representatives.

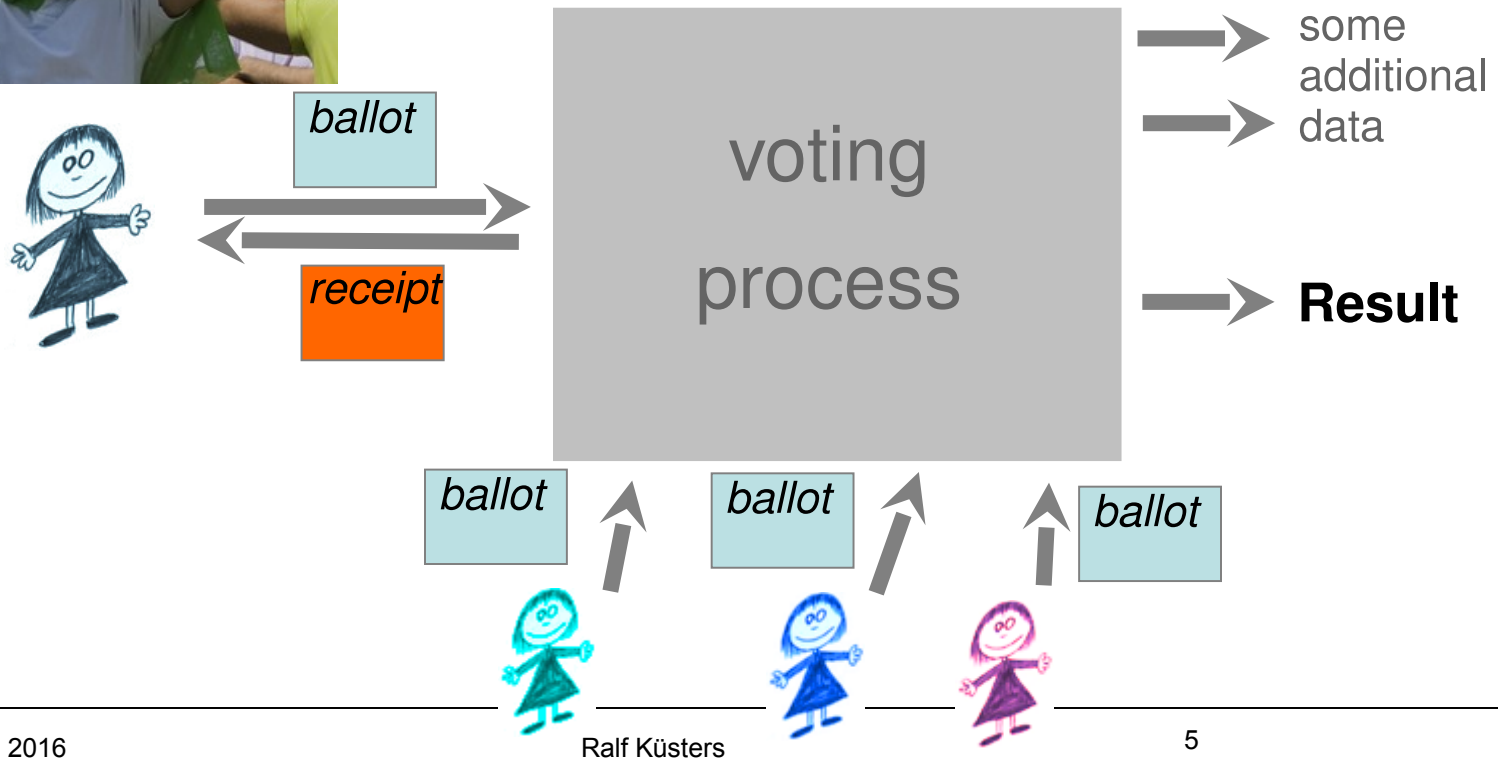
re realising that a mangled

E-Voting

Manipulation of voting machines?!



Many problems with e-voting systems have been reported: USA, Netherlands, India, etc.



Objectives: My Project/E-Voting Reference Scenario

- Implement an e-voting system

  * Privacy and verifiability

  * Demonstrator/benchmark for RS^3

  * Implemented in Java

- Cryptographic aspects of e-voting

  * Widely applicable definitions of central security properties

  * Cryptographic security analysis of prominent e-voting protocols/systems

  * New attacks

  * Systematic design of e-voting systems (including sElect)

[CCS 2010; SP 2011; JCS 2012; SP 2012; SP 2014; EuroSP 2016; SP 2016]

Objectives: My Project/E-Voting Reference Scenario

- Cryptographic code-level analysis of (Java) systems

  * Develop general methods and techniques

  * Combine techniques from

    - Language-based information flow and

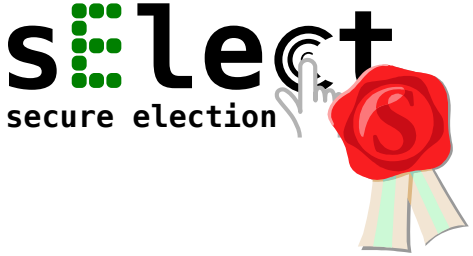
    - Crytography

CVJ Framework
+
Hybrid Approach

- Apply to Java systems that use cryptography

  * Using tools such as Joana (Snelting et al.) and KeY (Beckert et al.)

Ultimate goal:



certified on code level

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New web-based remote e-voting system:

- Lightweight system meant for low-risk elections
  - * design (e.g., simple crypto)
  - * usability
- Fully automated verification (if voter client is trusted)
- Human verifiability (if voter client is not trusted)
- Rigorous cryptographic analysis
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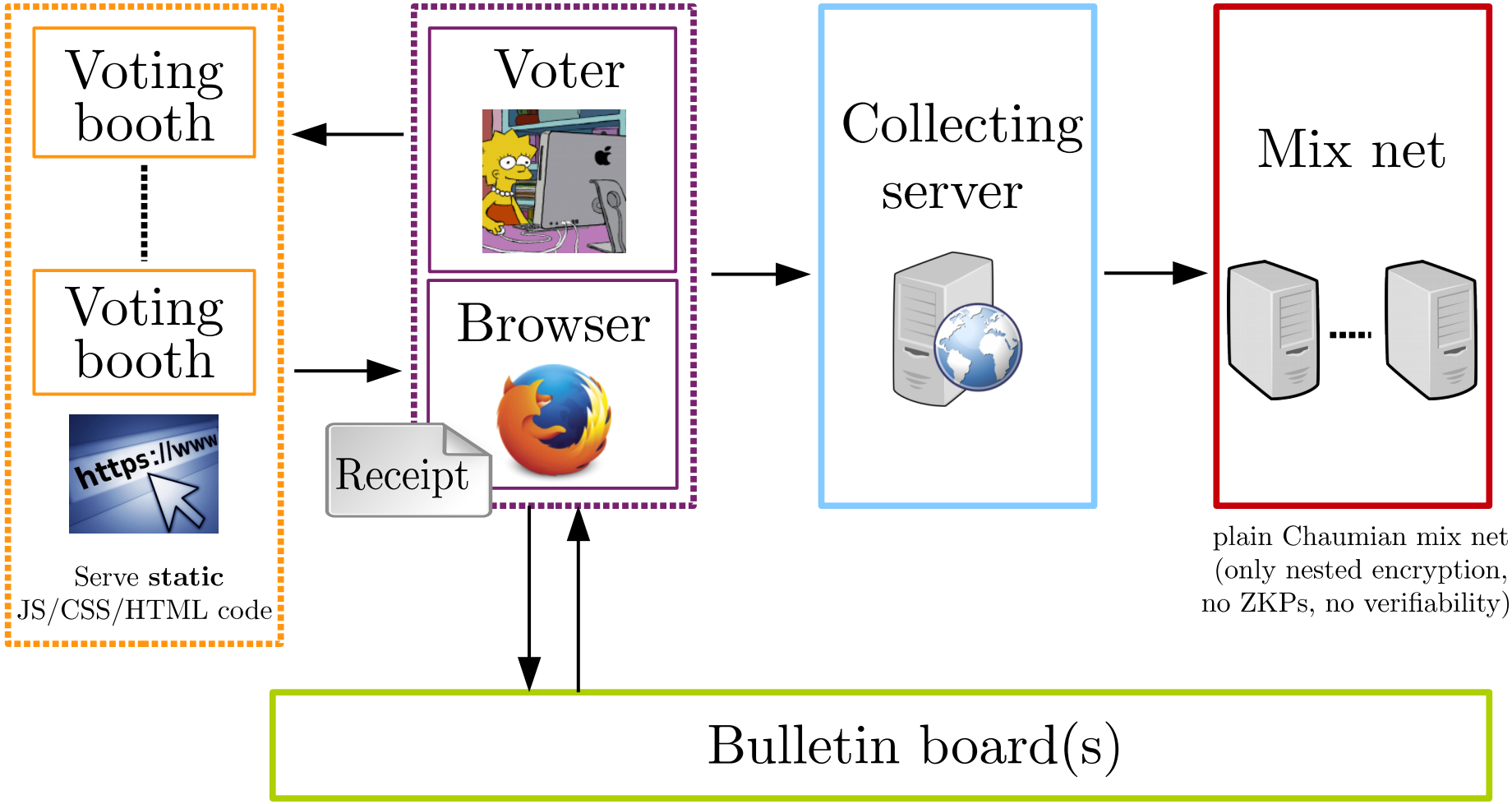
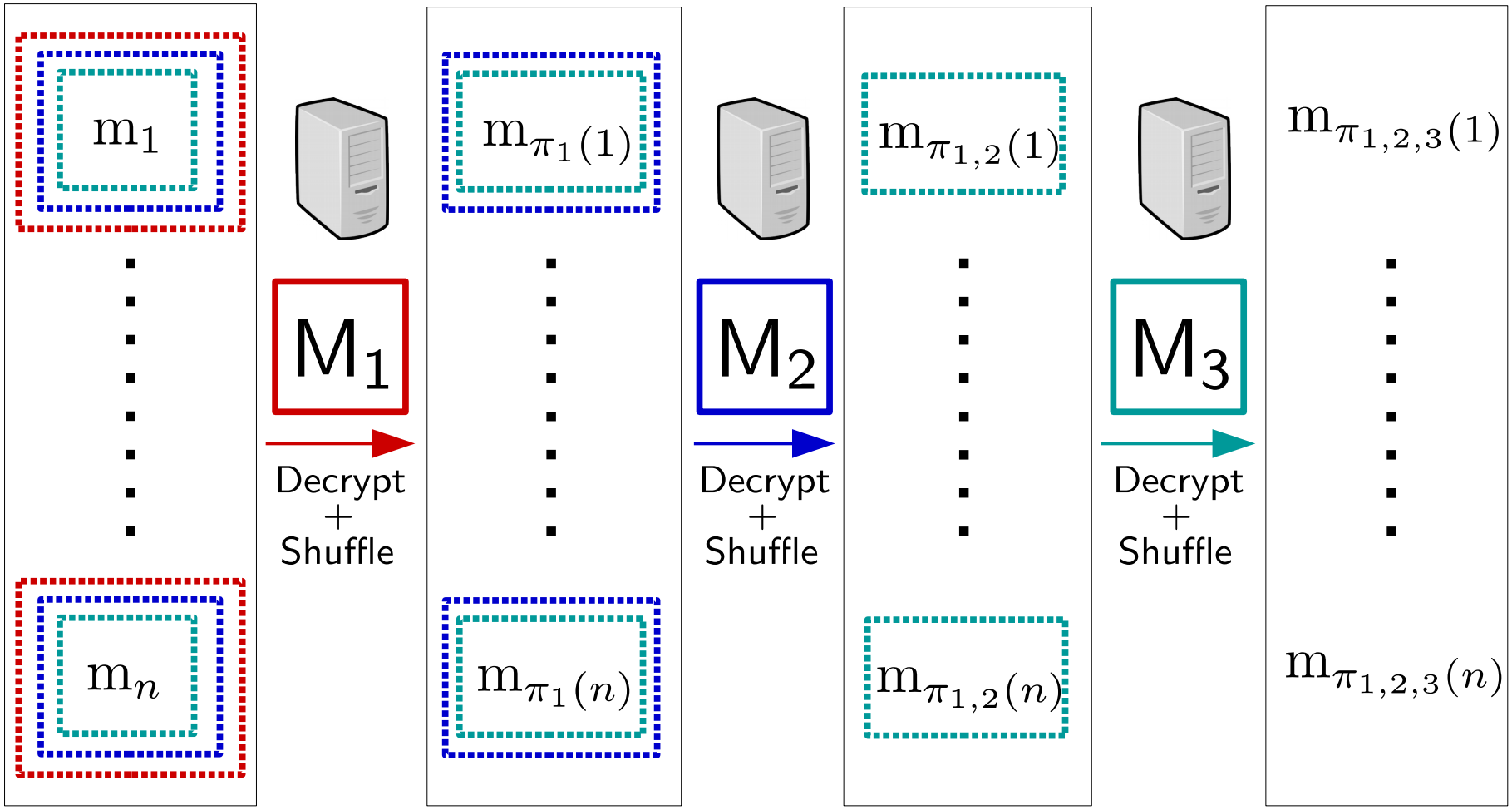
- Has been used in mock elections

Check out the live demo!

sElect: Overview

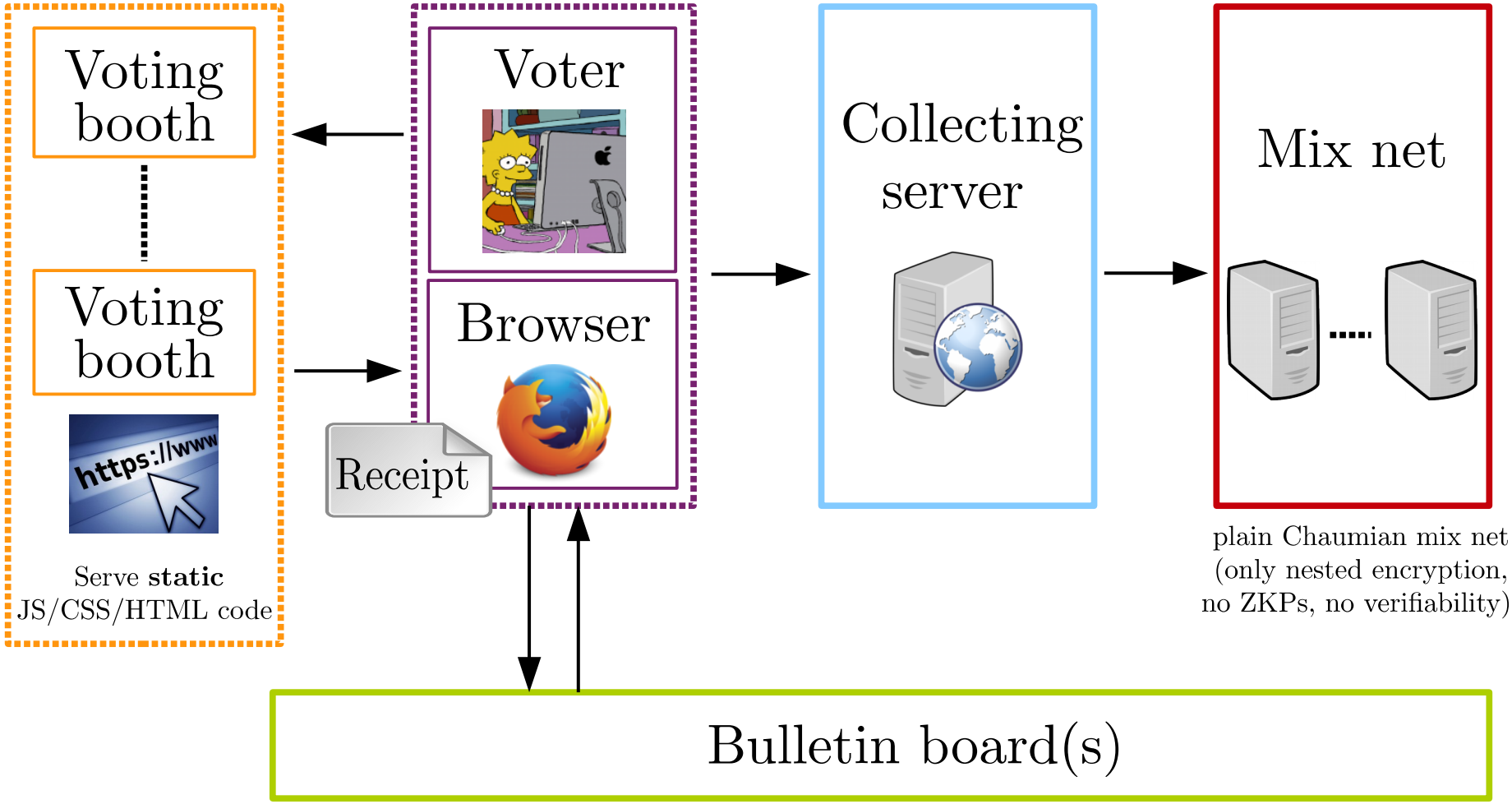


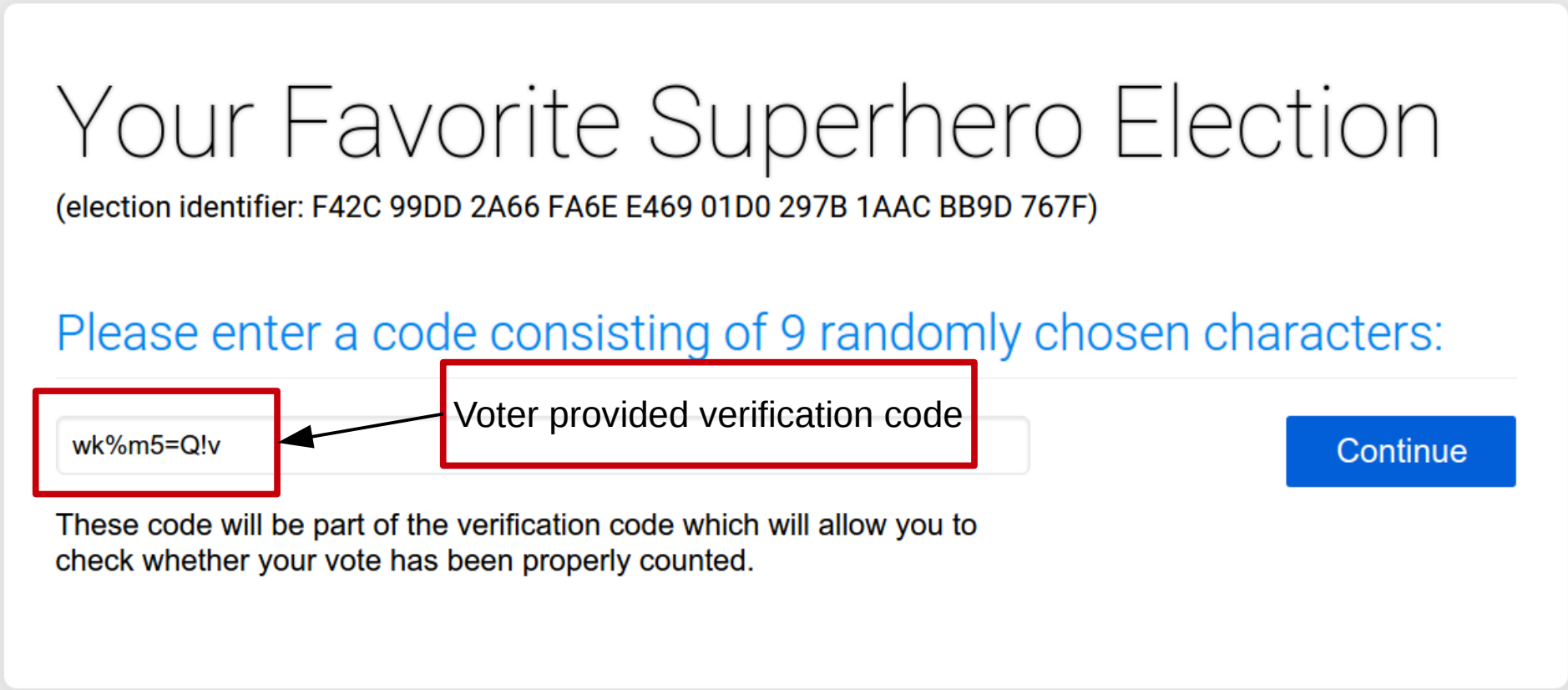
Chaumian Mixnet



Similar to TOR.

sElect: Overview




Your Favorite Superhero Election
(election identifier: F42C 99DD 2A66 FA6E E469 01D0 297B 1AAC BB9D 767F)
Please enter a code consisting of 9 randomly chosen characters:
wk%m5=Q!v
Voter provided verification code
Continue
These code will be part of the verification code which will allow you to check whether your vote has been properly counted.

Your Favorite Superhero Election

(election identifier: F42C 99DD 2A66 FA6E E469 01D0 297B 1AAC BB9D 767F)

Who is Your Favorite Superhero?

- Iron Man
- Batman
- Wonder Woman
- Spider Man
- Dr. Manhattan
- Hulk
- Superman
- **Bugs Bunny**

$$b_i = \mathsf{E}_{\mathsf{M}_m}(\ldots \mathsf{E}_{\mathsf{M}_1}(c_i, v_i)\ldots)$$

wk%m5=Q!v442F0105

Provided by the voter | Generated by the browser

Cast your vote

Your Favorite Superhero Election

(election identifier: F42C 99DD 2A66 FA6E E469 01D0 297B 1AAC BB9D 767F)

Your ballot has been accepted by the collecting server.

When the election is over, you can manually check that your ballot is in the final tally. If you want to do this, you need to

save/write down the following verification code

and look it up in the result of the election: it should appear next to your choice.

Your verification code: **wk%m5=Q!v442F0105** ⇩ Save as a picture

The first 9 characters are the code you entered, while the remaining part was generated randomly by the system.

Thank you!

Your Favorite Superhero Election

(election identifier: F42C 99DD 2A66 FA6E E469 01D0 297B 1AAC BB9D 767F)

The election is closed and the result is ready and available.

To see the result and check your verification code, you can now

go to the result web page

Independently, an automatic verification procedure is being carried out to check that the ballot with the following verification code has in fact been counted: **wk%m5=Q!v442F0105**

Verification successful ✓

Fully automated verification!

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The election is closed and the result is ready and available.

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Independently, an automatic verification procedure is being carried out to check that the ballot with the following verification code has in fact been counted: **&a_1a:8c93823E9CF**

VERIFICATION FAILED: ballot with verification code &a_1a:8c93823E9CF is missing!

Looking for the misbehaving party.

Ballot &a_1a:8c93823E9CF has been dropped by the collecting server

The following data contains information necessary to hold the misbehaving party accountable. Please copy it and provide to the voting authorities.


```
{"electionID":"f42c99dd2a66fa6ee46901d0297b1aacbb9d767f","signature":"7499d1e5e2c10ed849
```

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(election identifier: F42C 99DD 2A66 FA6E E469 01D0 297B 1AAC BB9D 767F)

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Verification successful ✓

Description

This is the election of the Greatest Superhero Ever.

Summary | Verification Codes | List of Voters | Additional Details

List of Votes

Please check that your choice is listed next to your verification code.

verification code	choice
am<:-)62680BDE436	Dr. Manhattan
b27sh:'][11CA826F	Spider Man
vb!{as32FBAA5E3E9	Bugs Bunny
wk%m5=Q!v442F0105	Bugs Bunny

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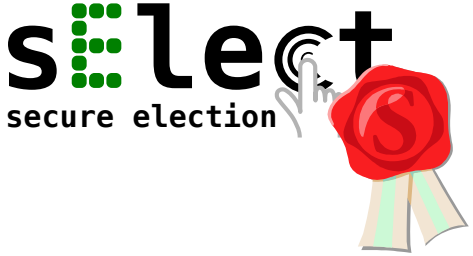

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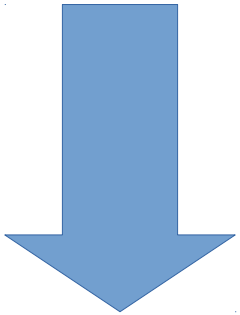
The CVJ Framework

[CSF 2012]

Goal: security/cryptographic analysis
directly on code-level (Java)
(rather than in more abstract cryptographic model)

cryptographic privacy property of Java system

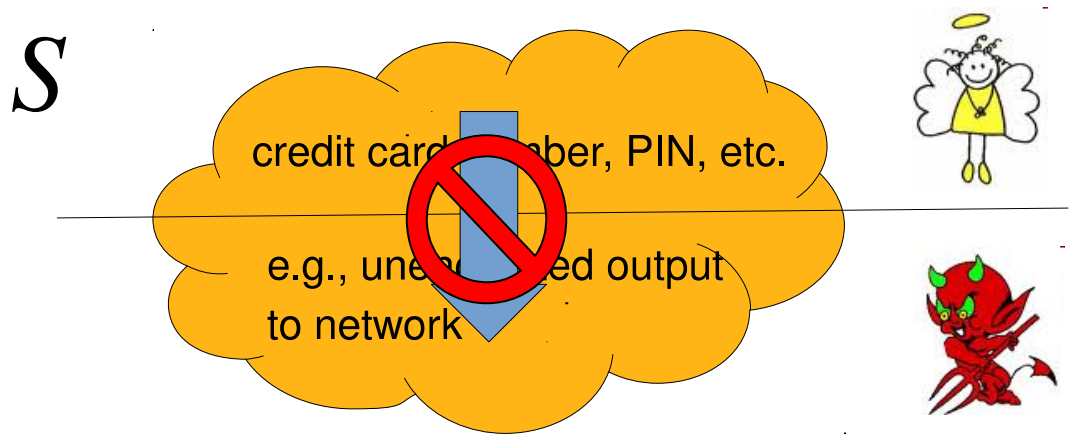
Combination of technique from
cryptography and
language-based security



non-interference property
(language-based security)

Non-Interference

Given: Java system S



Tools for checking NI of Java programs:

Joana, KeY, JIF, Maude, ...

The CVJ Framework

[CSF 2012]

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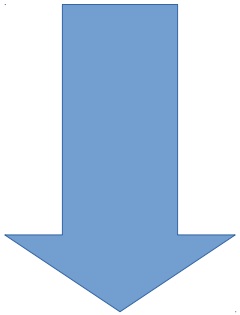


Successfully applied to:

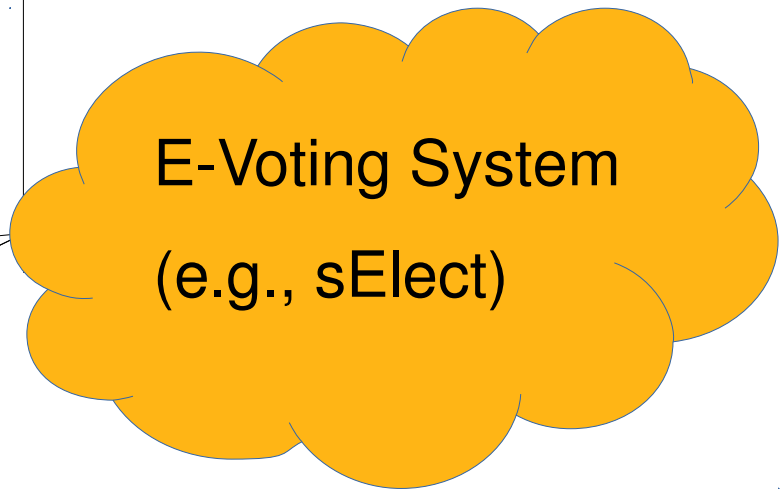
Client/Server-System
Cloud Storage System

using Joana.

non-interference property
(language-based security)

Let's apply this to e-voting systems (sElect)

Cryptographic vote privacy



election result

Cannot be done by fully automated tool

Tool has to prove functional correctness

Requires theorem prover

Hybrid Approach — Main Idea

[CSF 2015]

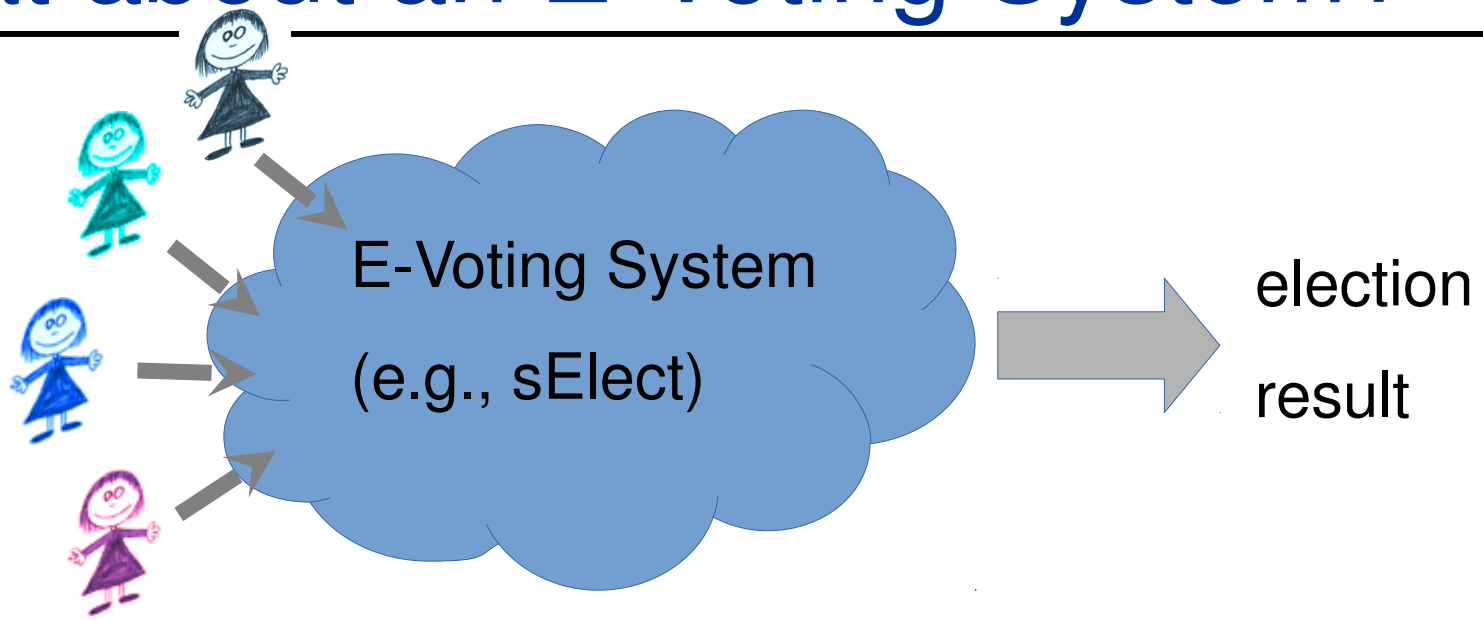
Use

as much as possible → an automated tool for NI

in combination with

only when and where necessary → a theorem prover

What about an E-Voting System?



Cannot be handled by fully automated tool

Tool has to prove functional correctness

Requires theorem prover

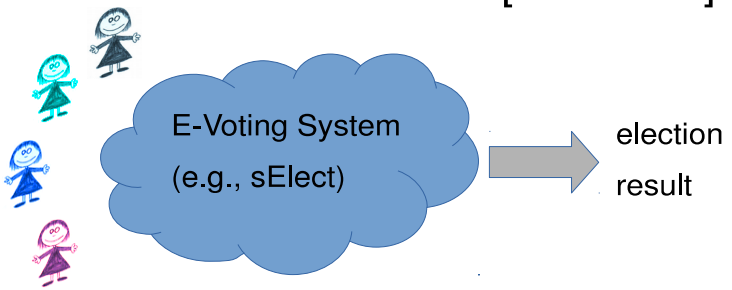
Use hybrid approach

Case studies: E-Voting

[CSF 2015]

Successfully applied to variant of sElect

Analyzed mix server of sElect



Strong cryptographic vote privacy property
(formulated as a cryptographic indistinguishability game in Java)

CVJ Framework: reduced problem to NI checking

Hybrid approach: used combination of Joana and KeY

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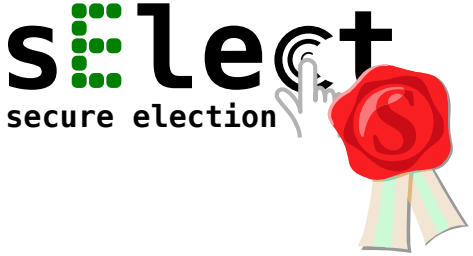

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Objectives: My Project/E-Voting Reference Scenario

Ultimate Goal

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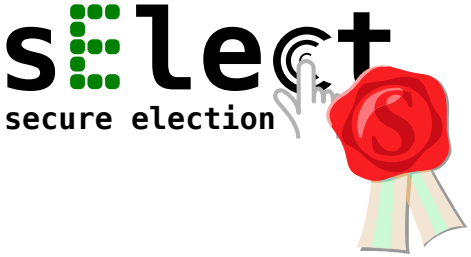

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Beginning of the project

New insights into e-voting systems
CVJ Framework
Hybrid Approach
Several case studies
Greatly improved tools
New e-voting system

now