

Prerendered User Interfaces
for
Higher-Assurance Electronic Voting

Ka-Ping Yee

accessibility folks

computers =
flexible

security folks

computers =
vulnerable

accessibility folks

electronic voting =
empowerment

security folks

electronic voting =
hazard

1 Accessibility vs. security.

vendors

transparency =
liability

security folks

transparency =
reliability

- 1 Accessibility vs. security.
- 2 Proprietary interests vs. transparency.

DIEBOLD

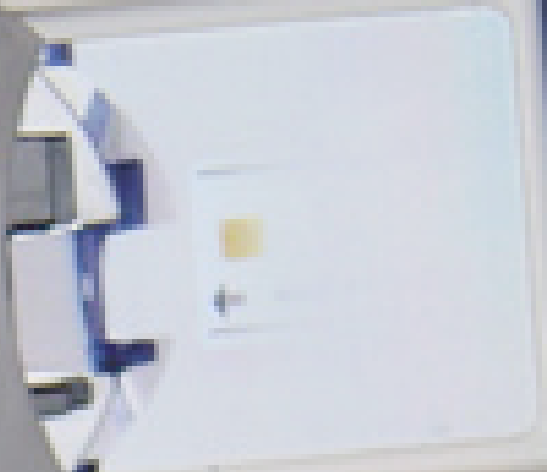
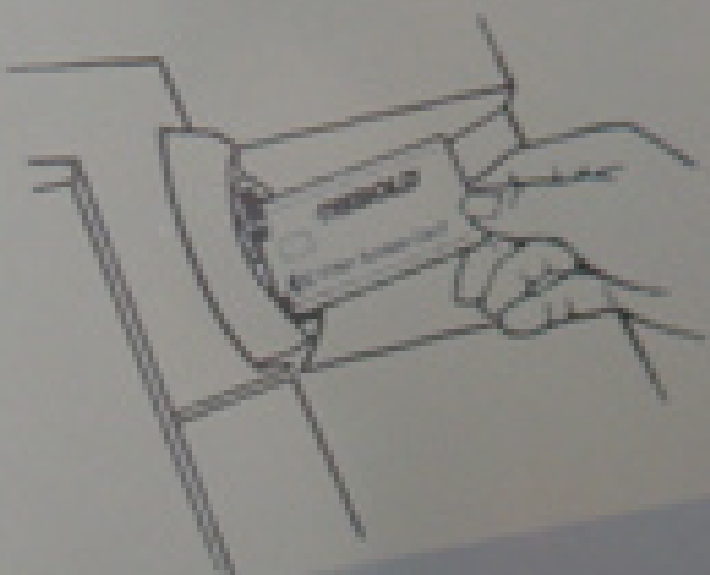
PRE-ELECTION MODE

CONNECT/OUT
DEMONSTRATION

Report Unit 10

Please insert a voter access card to begin.

Insert Card to Begin Voting



Ballot: 0048 Tot: 0005263

AccuVote TS

> 31 000 lines of C++

MFC

Windows CE

millions of
lines of C++

- 1 Accessibility vs. security.
- 2 Proprietary interests vs. transparency.
- 3 Too much code to verify.

AccuVote TS

> 31 000 lines of C++

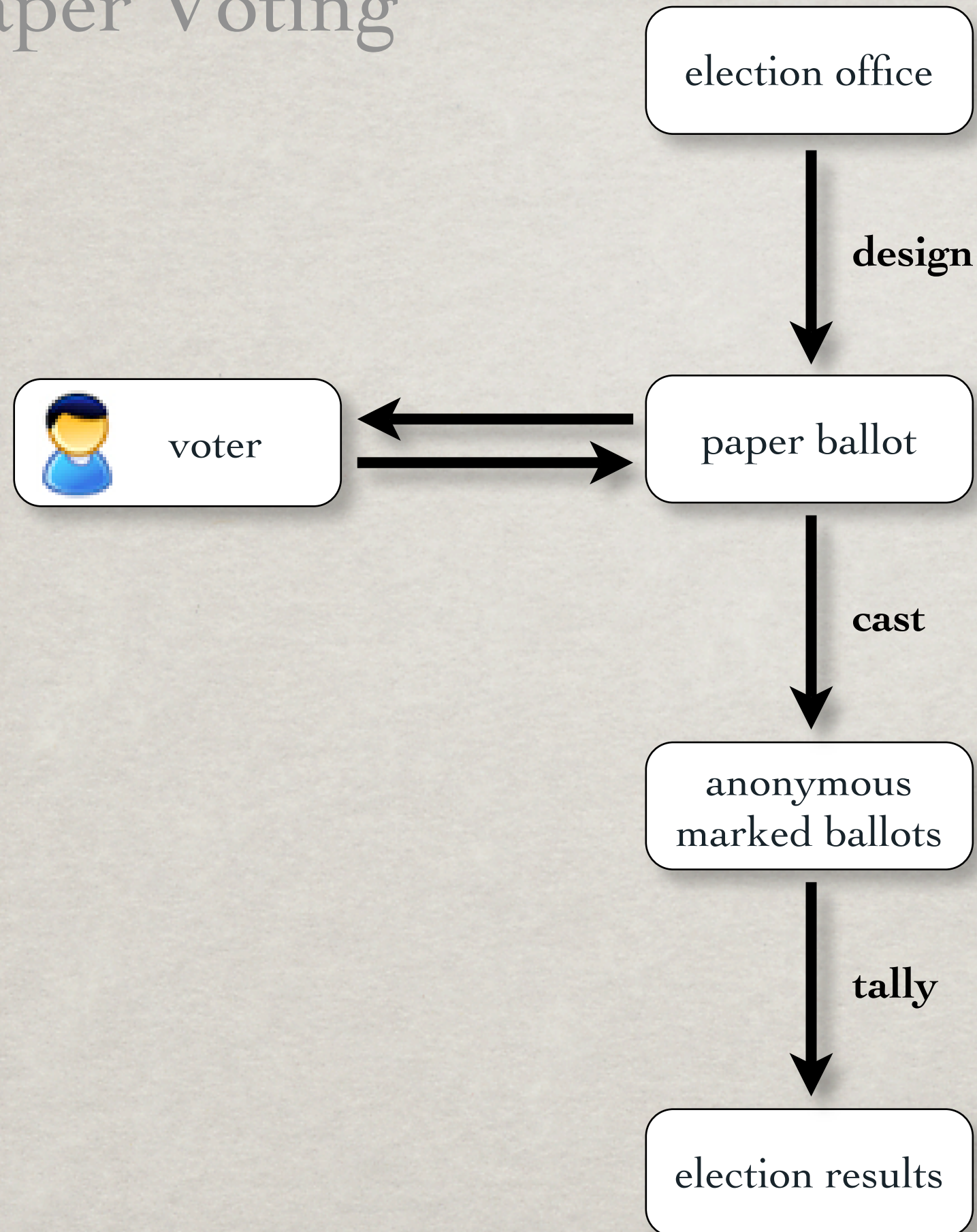
election rules

ballot layout

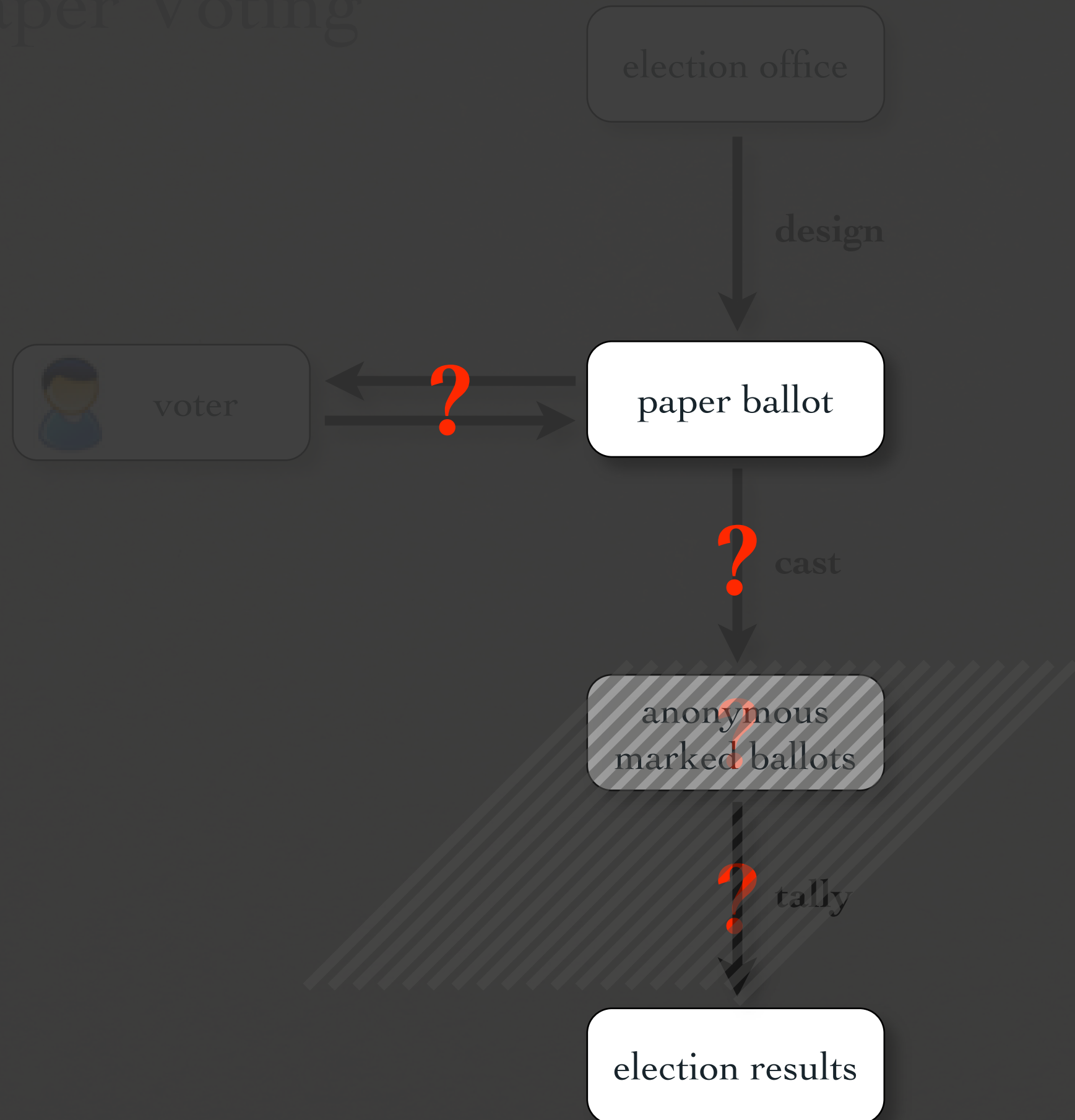
visual style

- 1 Accessibility vs. security.
- 2 Proprietary interests vs. transparency.
- 3 Too much code to verify.
- 4 Code changes too frequently.

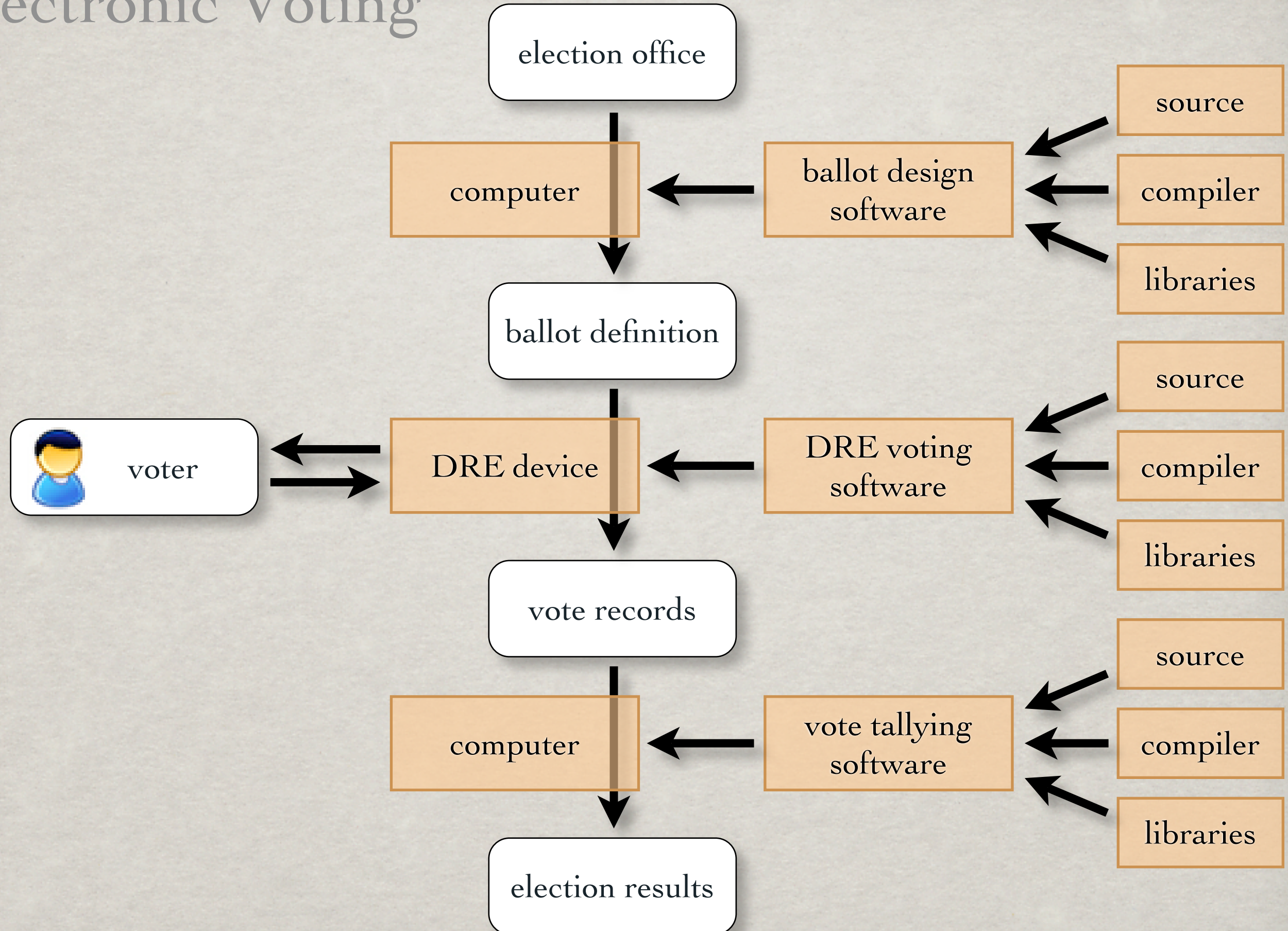
Paper Voting



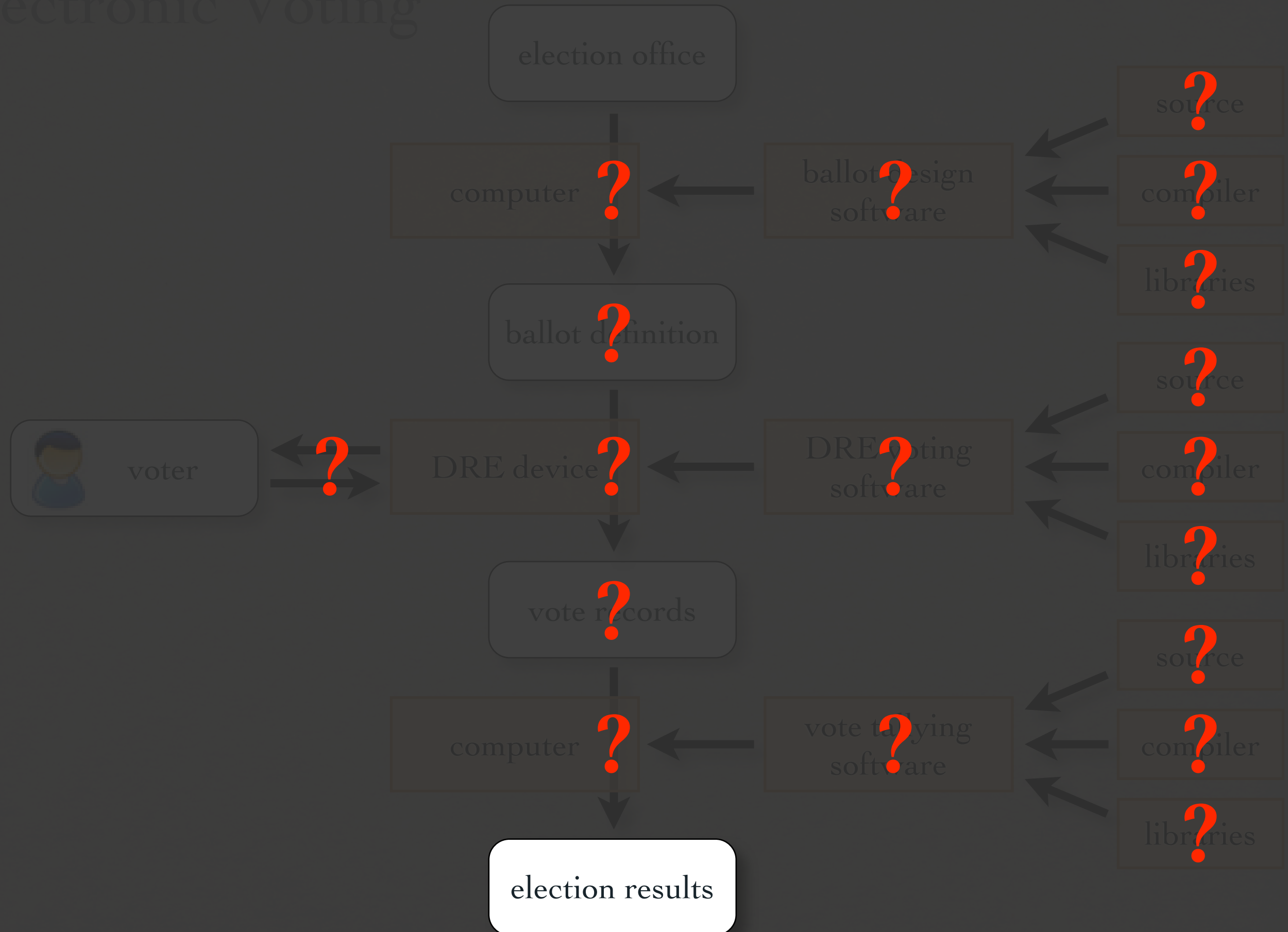
Paper Voting



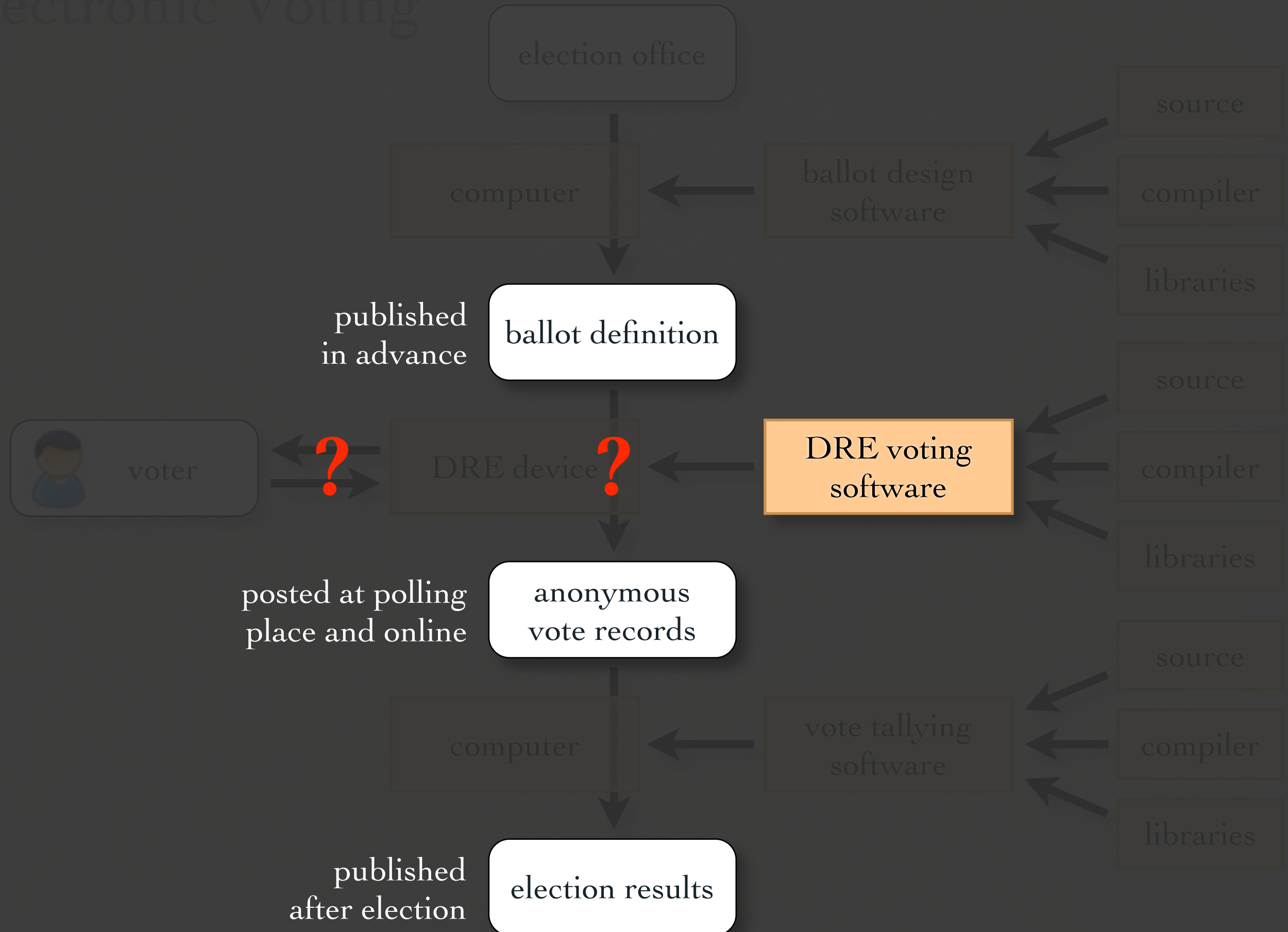
Electronic Voting



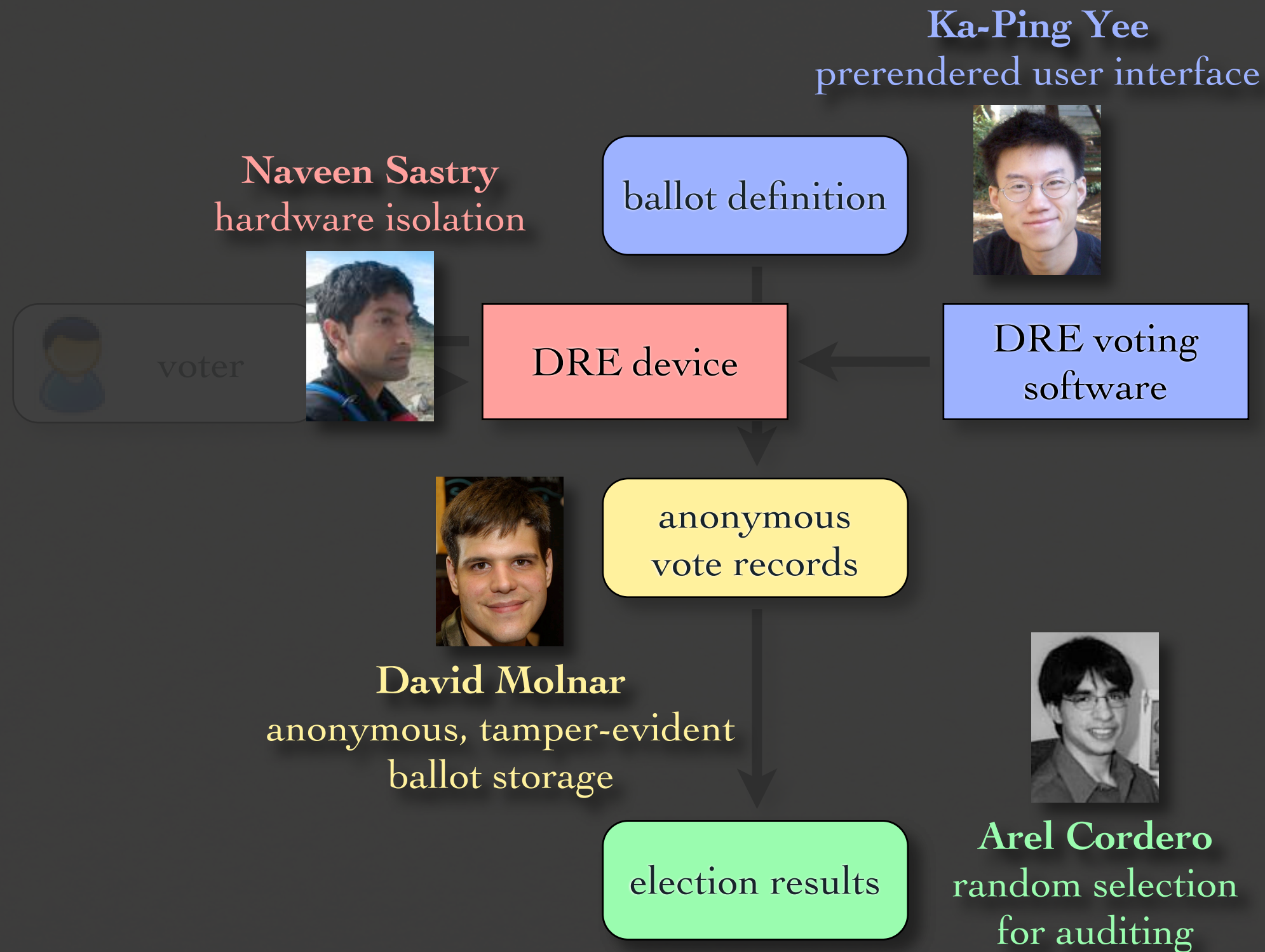
Electronic Voting



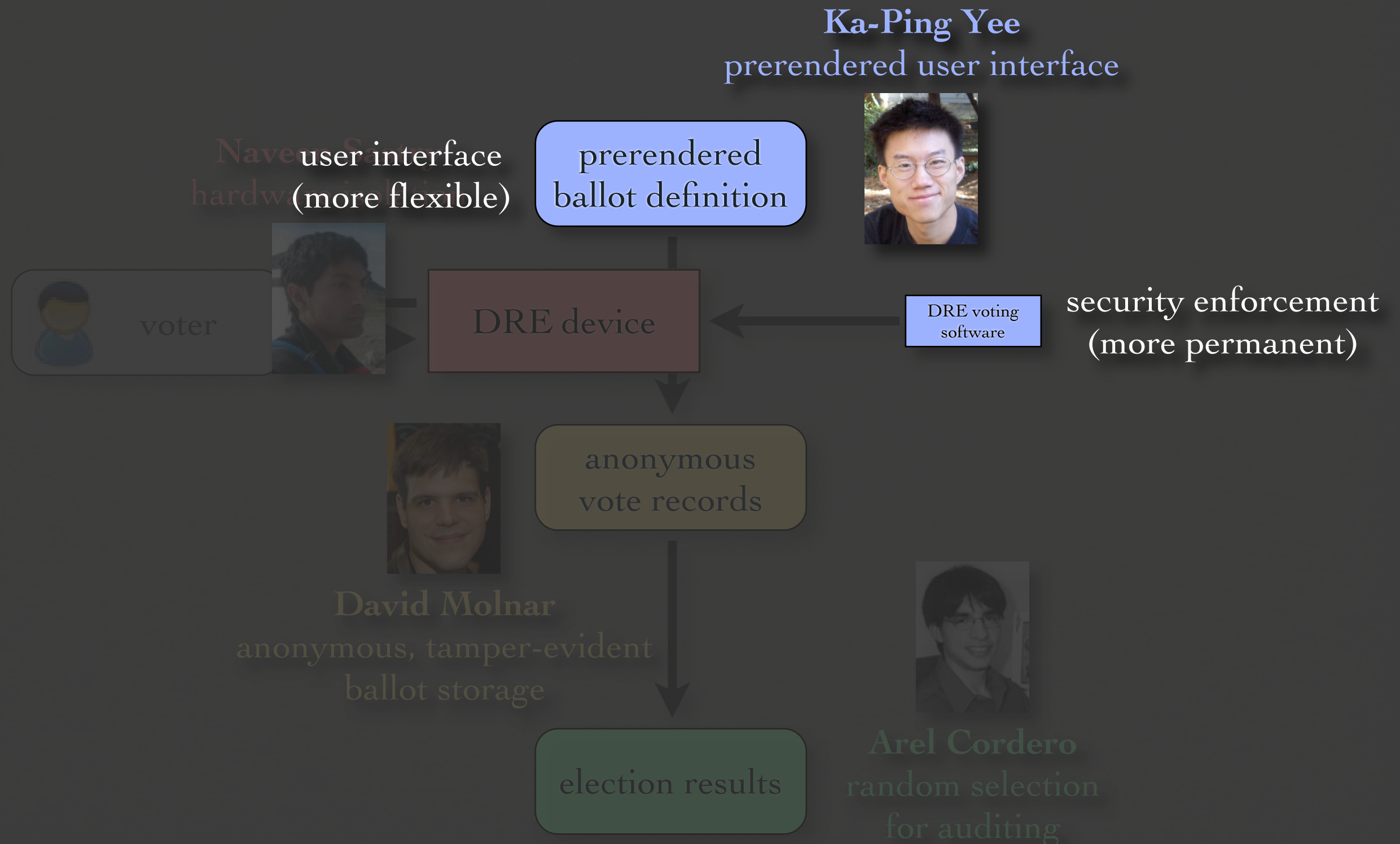
Electronic Voting



Electronic Voting



Electronic Voting



Conventional Ballot Definition

Contest	
title	Mayor
max selections	1
options	Tom Bates John Boushell Shirley Dean
Contest	
title	School Board
max selections	2
options	Karen Hemphill Merrilee Mitchell Joaquin Rivera Kalima Rose John Selawsky



2006 General Election, City of Berkeley, California

November 2, 2006

Mayor (page 1 of 1)

This contest has 4 boxes. Choose ONE box.

Touch a box to select or deselect.

• Tom Bates

• John Boushell

• Shirley Dean

• write in a candidate

Your ballot is **not yet recorded**. Press NEXT PAGE to continue or REVIEW AND FINISH to review your choices and cast your ballot.

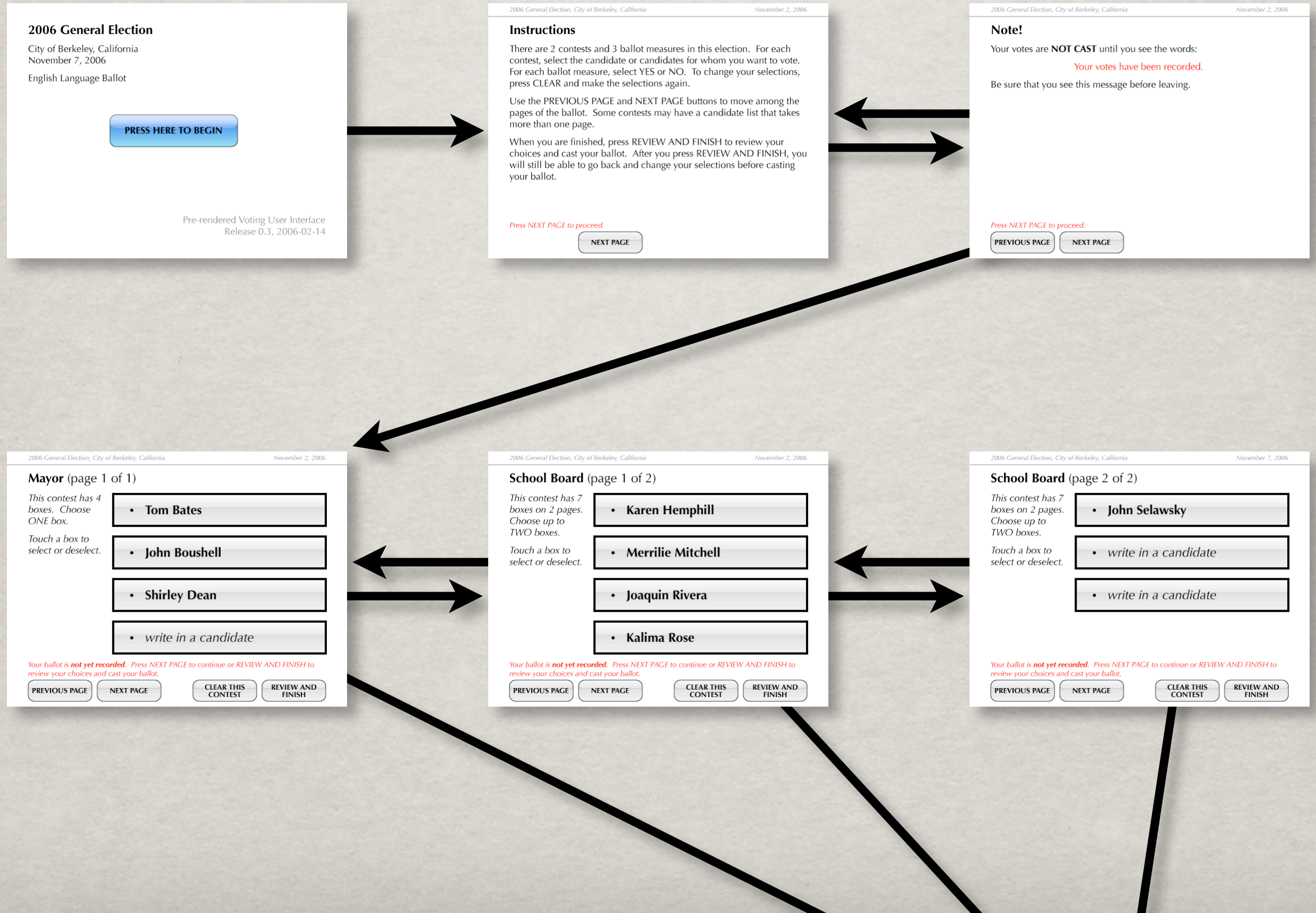
PREVIOUS PAGE

NEXT PAGE

CLEAR THIS CONTEST

REVIEW AND FINISH

Prerendered Ballot Definition



Prerendered Ballot Page

2006 General Election, City of Berkeley, California

November 2, 2006

Mayor (page 1 of 1)

*This contest has 4
boxes. Choose
ONE box.*

*Touch a box to
select or deselect.*

• Tom Bates

• John Boushell

• Shirley Dean

• *write in a candidate*

*Your ballot is **not yet recorded**. Press NEXT PAGE to continue or REVIEW AND FINISH to review your choices and cast your ballot.*

PREVIOUS PAGE

NEXT PAGE

CLEAR THIS
CONTEST

REVIEW AND
FINISH

Prerendered Ballot Page

targets

2006 General Election, City of Berkeley, California

November 2, 2006

Mayor (page 1 of 1)

This contest has 4 boxes. Choose ONE box.

Touch a box to select or deselect.

• Tom Bates

• John Boushell

• Shirley Dean

• write in a candidate

*Your ballot is **not yet recorded**. Press NEXT PAGE to continue or REVIEW AND FINISH to review your choices and cast your ballot.*

PREVIOUS PAGE

NEXT PAGE

CLEAR THIS
CONTEST

REVIEW AND
FINISH

Prerendered Ballot Page

options

2006 General Election, City of Berkeley, California November 2, 2006

Mayor (page 1 of 1)

This contest has 4 boxes. Choose ONE box.

Touch a box to select or deselect.

<input type="checkbox"/>	• Tom Bates
<input checked="" type="checkbox"/>	✓ Tom Bates
<input type="checkbox"/>	• John Boushell
<input checked="" type="checkbox"/>	✓ John Boushell
<input type="checkbox"/>	• Shirley Dean
<input checked="" type="checkbox"/>	✓ Shirley Dean
<input type="checkbox"/>	• <i>write in a candidate</i>

*Your ballot is **not yet recorded**. Press **NEXT PAGE** to continue or **REVIEW AND FINISH** to review your choices and cast your ballot.*

Prerendered Ballot Page

write-in

2006 General Election, City of Berkeley, California November 2, 2006

Mayor (page 1 of 1)

This contest has 4 boxes. Choose ONE box.

Touch a box to select or deselect.

- Tom Bates
- John Boushell
- Shirley Dean
- *write in a candidate*

*Your ballot is **not** yet recorded. Please review your choices and cast your ballot.*

[PREVIOUS PAGE](#)

[NEXT PAGE](#)

[CLEAR THIS CONTEST](#)

[REVIEW AND FINISH](#)

Write-in Subpage

2006 General Election, City of Berkeley, California

November 2, 2006

Write-in Candidate for Mayor

CLEAR



BACKSPACE

Q

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X

C

V

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N

M

SPACE

Use the keyboard above to enter the name of the candidate you wish to write in. Press ACCEPT to vote for this candidate or CANCEL to not vote for this candidate.

CANCEL THIS WRITE-IN

ACCEPT THIS WRITE-IN

Write-in Subpage

character entry
subtargets

2006 General Election, City of Berkeley, California November 2, 2006

Write-in Candidate for Mayor

Q W E R T Y U I O P -

A S D F G H J K L '

Z X C V B N M

SPACE

Use the keyboard above to enter the name of the candidate you wish to write in. Press ACCEPT to vote for this candidate or CANCEL to not vote for this candidate.

Write-in Subpage

character slots

2006 General Election, City of Berkeley, California

November 2, 2006

Write-in Candidate for Mayor

CLEAR

✓

BACKSPACE

QWERTYUIOP-

ASDFGHJKL'

ZXCVBNM

SPACE

Use the keyboard above to enter the name of the candidate you wish to write in. Press ACCEPT to vote for this candidate or CANCEL to not vote for this candidate.

CANCEL THIS WRITE-IN

ACCEPT THIS WRITE-IN

Write-in Subpage

2006 General Election, City of Berkeley, California November 2, 2006

Write-in Candidate for Mayor

CLEAR

✓

BACKSPACE

Q

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SPACE

Use the keyboard above to enter the name of the candidate you wish to write in. Press ACCEPT to vote for this candidate or CANCEL to not vote for this candidate.

CANCEL THIS WRITE-IN

ACCEPT THIS WRITE-IN

clear / backspace
subtargets

Write-in Subpage

cancel / accept
subtargets

2006 General Election, City of Berkeley, California November 2, 2006

Write-in Candidate for Mayor

Q W E R T Y U I O P -
A S D F G H J K L '
Z X C V B N M
SPACE

Use the keyboard above to enter the name of the candidate you wish to write in. Press ACCEPT to vote for this candidate or CANCEL to not vote for this candidate.

Write-in Subpage

2006 General Election, City of Berkeley, California

November 2, 2006

Write-in Candidate for Mayor

CLEAR



MARIE CURIE

BACKSPACE

Q

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SPACE

Use the keyboard above to enter the name of the candidate you wish to write in. Press ACCEPT to vote for this candidate or CANCEL to not vote for this candidate.

CANCEL THIS WRITE-IN

ACCEPT THIS WRITE-IN

Prerendered Ballot Page

2006 General Election, City of Berkeley, California

November 2, 2006

Mayor (page 1 of 1)

*This contest has 4
boxes. Choose
ONE box.*

*Touch a box to
select or deselect.*

• Tom Bates

• John Boushell

• Shirley Dean

✓ MARIE CURIE

*Your ballot is **not yet recorded**. Press NEXT PAGE to continue or REVIEW AND FINISH to review your choices and cast your ballot.*

PREVIOUS PAGE

NEXT PAGE

CLEAR THIS
CONTEST

REVIEW AND
FINISH

Prerendered Ballot Page

character slots

write-in

2006 General Election, City of Berkeley, California November 2, 2006

Mayor (page 1 of 1)

This contest has 4 boxes. Choose ONE box.

Touch a box to select or deselect.

- Tom Bates
- John Boushell
- Shirley Dean

☒

M	A	R	I	E		C	U	R	I	E								
---	---	---	---	---	--	---	---	---	---	---	--	--	--	--	--	--	--	--

*Your ballot is **not yet recorded**. Press NEXT PAGE to continue or REVIEW AND FINISH to review your choices and cast your ballot.*

PREVIOUS PAGE

NEXT PAGE

CLEAR THIS CONTEST

REVIEW AND FINISH

Prerendered Ballot Page

2006 General Election, City of Berkeley, California

November 2, 2006

Review Your Selections (page 1 of 2)

Mayor
(vote for 1)

no selection has been made

School Board
(vote for up to 2)

no selection has been made

no selection has been made

*Your ballot is **not yet recorded**. Touch any box to change your selection for that contest or measure, or press NEXT PAGE to continue reviewing your choices.*

PREVIOUS PAGE

NEXT PAGE

Prerendered Ballot Page

reviews

2006 General Election, City of Berkeley, California November 2, 2006

Review Your Selections (page 1 of 2)

Mayor
(vote for 1)

no selection has been made

✓ **Tom Bates**

School Board
(vote for up to 2)

no selection has been made

no selection has been made

*Your ballot is **not yet recorded**. Touch any box to change your selection for that contest or measure, or press NEXT PAGE to continue reviewing your choices.*

PREVIOUS PAGE NEXT PAGE

Ballot Definition Format

ballot model

contest

int max_sels
int max_chars

subpage

subtarget

int action

page

target

int action
int page_i
int contest_i

option

int contest_i

write-in

int contest_i

review

int contest_i

image library

int width
int height

layout

background

int width
int height
byte[] pixels

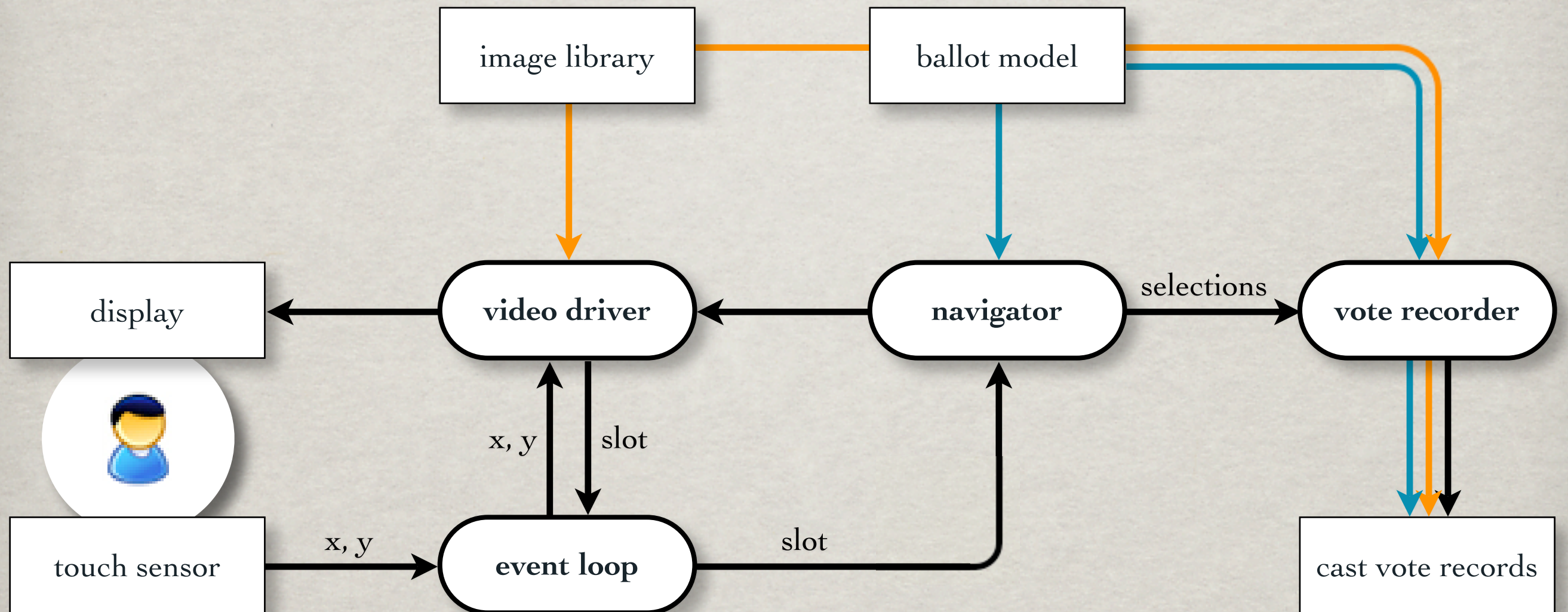
slot

int left
int top
int width
int height

sprite

int width
int height
byte[] pixels

Voting Machine Software



How much code?

How much code?

	everything	UI only
AccuVote TS	> 31 000	> 14 000
our prototype	293	255
	100×	55×

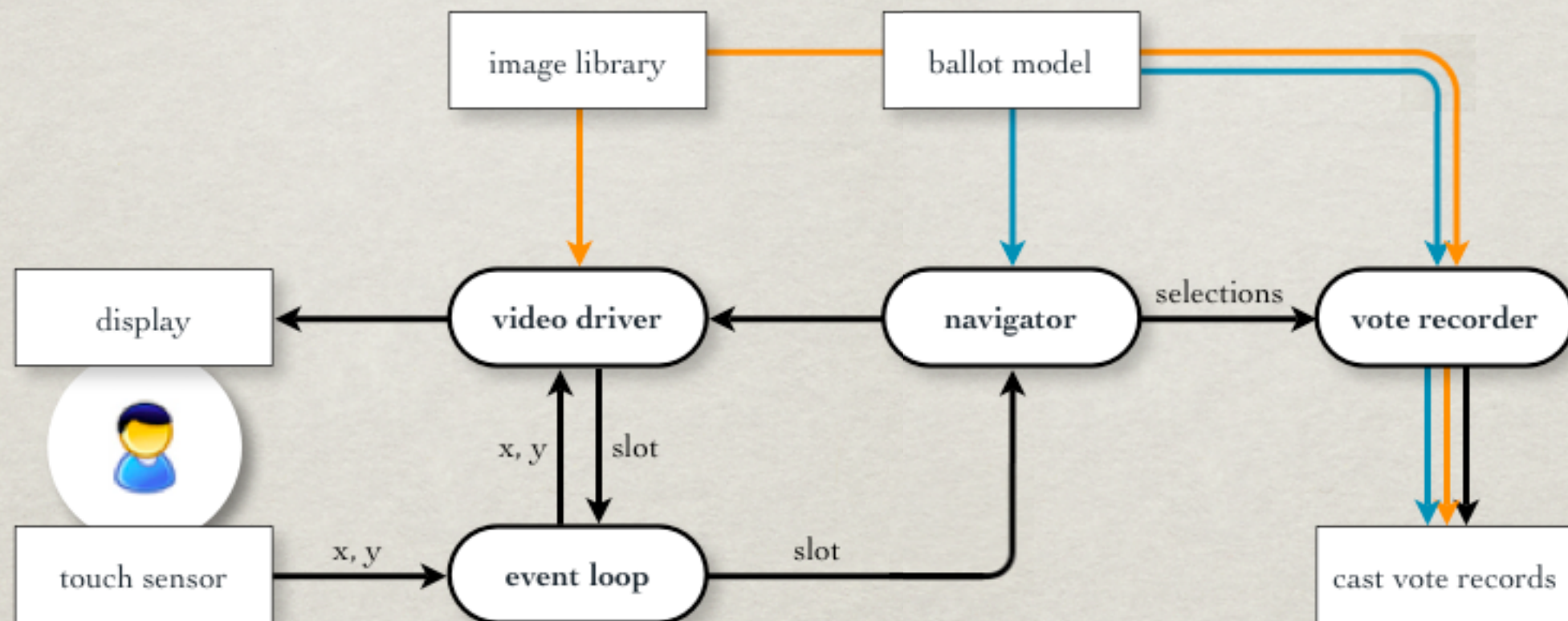
Python features used:

- one standard library module (SHA-1)

- one collection type

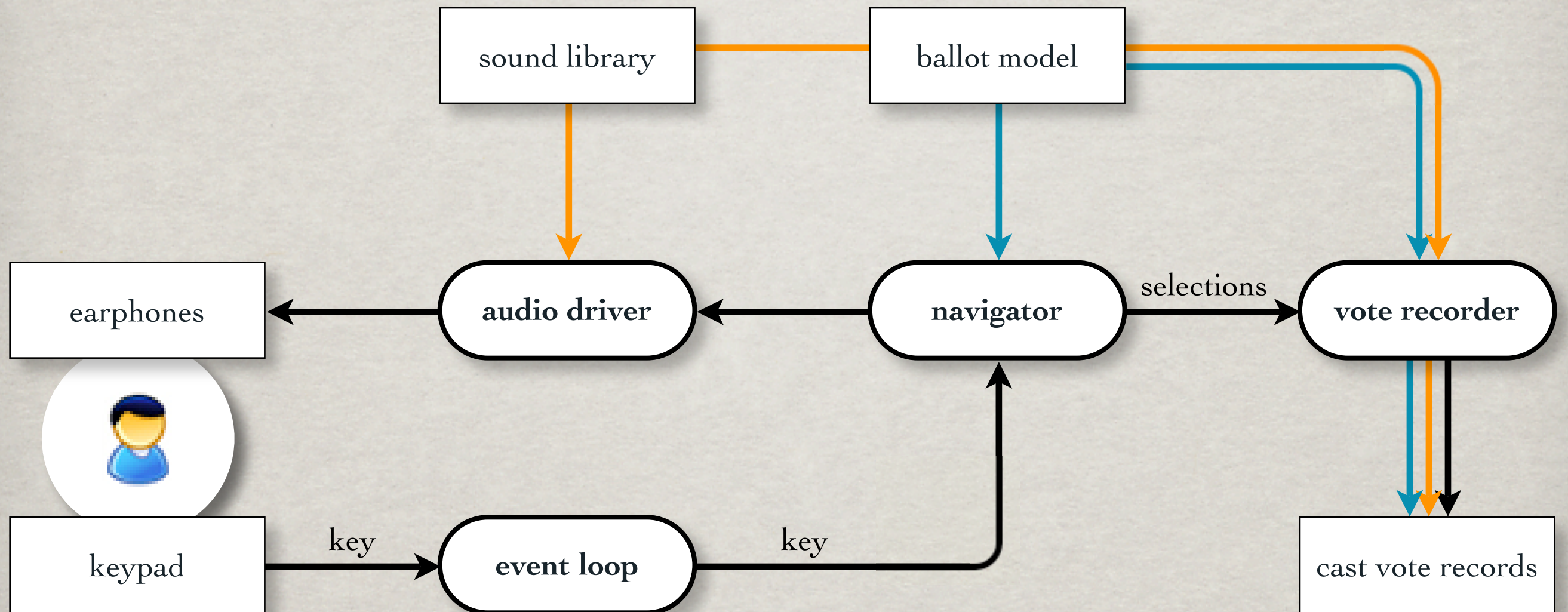
- very few built-in functions

How much code?



ballot loader	126 lines
event loop	13 lines
navigator	94 lines
video driver	22 lines
vote recorder	38 lines

Accessibility



- 1 Accessibility vs. security.
- 2 Proprietary interests vs. transparency.
- 3 Too much code to verify.
- 4 Code changes too frequently.

- 1 Decouple UI design from security.
Open participation in ballot review.
- 2 Isolate code to be disclosed.
- 3 Reduce the trusted code by 10 to 100x.
- 4 Put security responsibility in a VM.

Goal:

an order of magnitude reduction
in voting-specific trusted software

similar or better
accessibility and usability

compared to the state of the art.

Thank you!

<http://zesty.ca/voting>

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