

---

# Software Support for Software-Independent Auditing

Gabrielle A. Gianelli, *Jennifer D. King*,  
Edward W. Felten, William P. Zeller

Center for Information Technology Policy  
Department of Computer Science  
Princeton University

# Goals of Post-Election Auditing

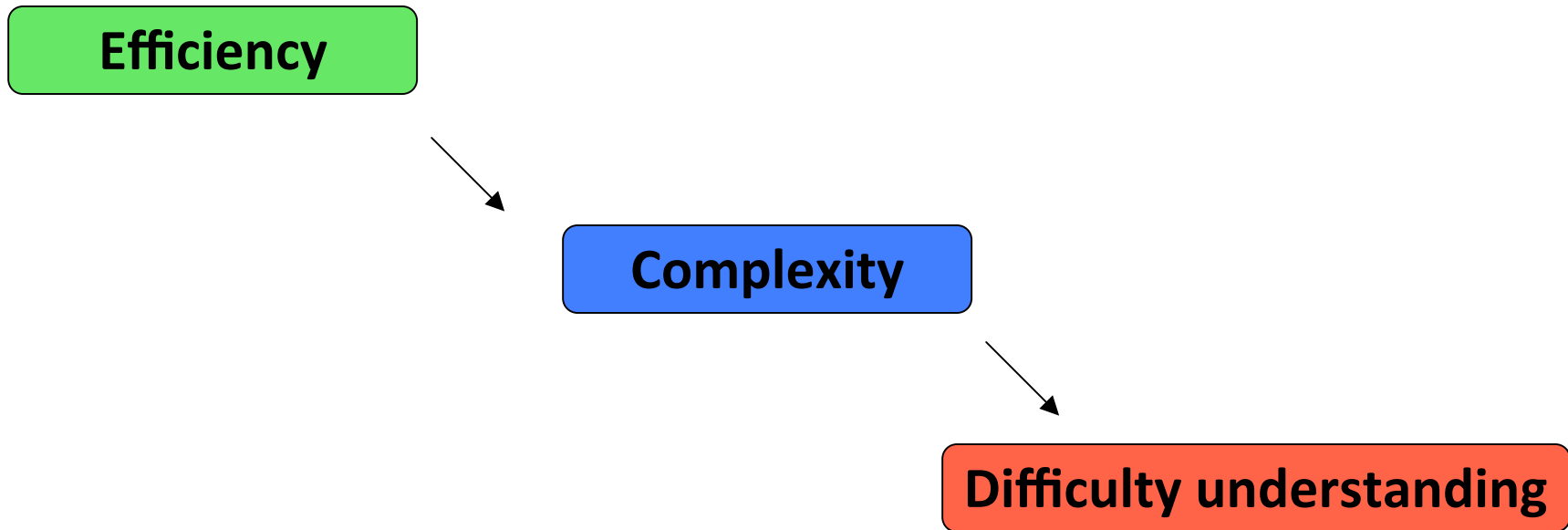
---



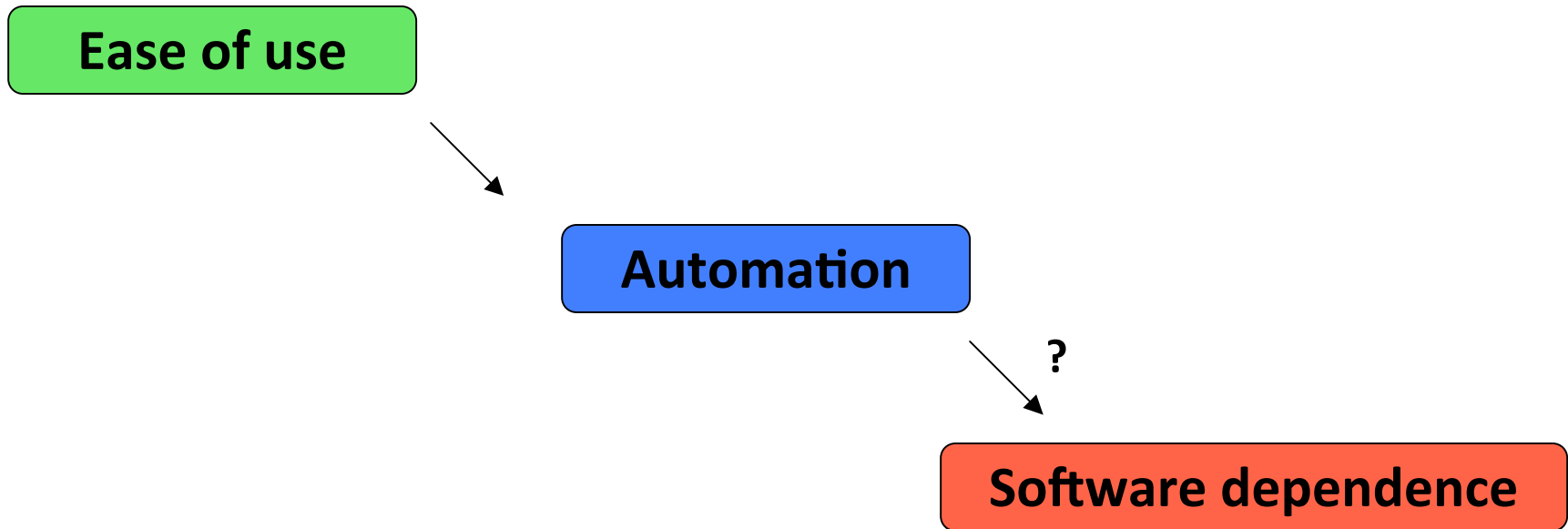
- Valid statistical guarantee
  - Efficient
  - Easy to use
  - Instills confidence in election results for voters and officials
  - Software independent
- 
-

$$n = \min \left\{ u \mid 1 - \prod_{k=0}^{u-1} \frac{N - B - k}{N - k} \geq c \right\}$$

# Possible Solutions



# Possible Solutions



# How to reconcile these tensions?



- One approach: eliminate computers
- Our approach: automate, but verify







# Log



## Attributes of log

- XML: can be easily parsed
- Stores all information necessary to recreate an audit, either by hand or with another machine

A log verifiable by a third party ensures software independence.

# Our Solution



- Web application
- Python with Django web framework

Goal: auditing interface easy for non-expert users

# Post Election Auditing Tool

[Home](#)[Create an Account](#)[Project Info](#)[Logout](#)

## Auditing Steps:

- Choose election
- Select races and algorithms
- Roll die
- Run algorithms
- Download results
- Upload recount results

*Welcome, you are currently logged in.*

## [Begin the audit process](#)

### Snapshot of previous audits:

Audit	Precincts linked?	Dierolls complete?	Races Audited	View Results	Continue audit
1	Yes	✓	29 / 29	<a href="#">Go</a>	<a href="#">→</a>
2	No	✓	29 / 29	<a href="#">Go</a>	<a href="#">→</a>
3	No	✗	0 / 0		<a href="#">→</a>

[Examine election data](#) | [Examine ballot data](#)

# Post Election Auditing Tool

[Home](#)[Create an Account](#)[Project Info](#)[Logout](#)

## Auditing Steps:

- Choose election
- Select races and algorithms
- Roll die
- Run algorithms
- Download results
- Upload recount results

## Select races in election "November 2008 - Humboldt County":

Audit race?	Race name	Algorithm	
<input checked="" type="checkbox"/>	President	Exact Percent	Percent of precincts: <input type="text"/> % (0-100]
<input checked="" type="checkbox"/>	U.S. Representative	Exact Percent	Percent of precincts: <input type="text"/> % (0-100]
<input type="checkbox"/>	Member of State Assembly	Constant Sample Size	Confidence level: <input type="text"/> % (0-100]
<input type="checkbox"/>	Ferndale Mayor	Exact Percent	Percent of precincts: <input type="text"/> % (0-100]

- Exact Percent
- Percent by Probability
- Constant Sample Size
- Varying Sample Size

# Supported Algorithms



---

## Precinct-based algorithms:

- Exact Percent
- Percent by Probability

## Ballot-based algorithms:

- Constant Sample Size
  - Varying Sample Size
- 
-

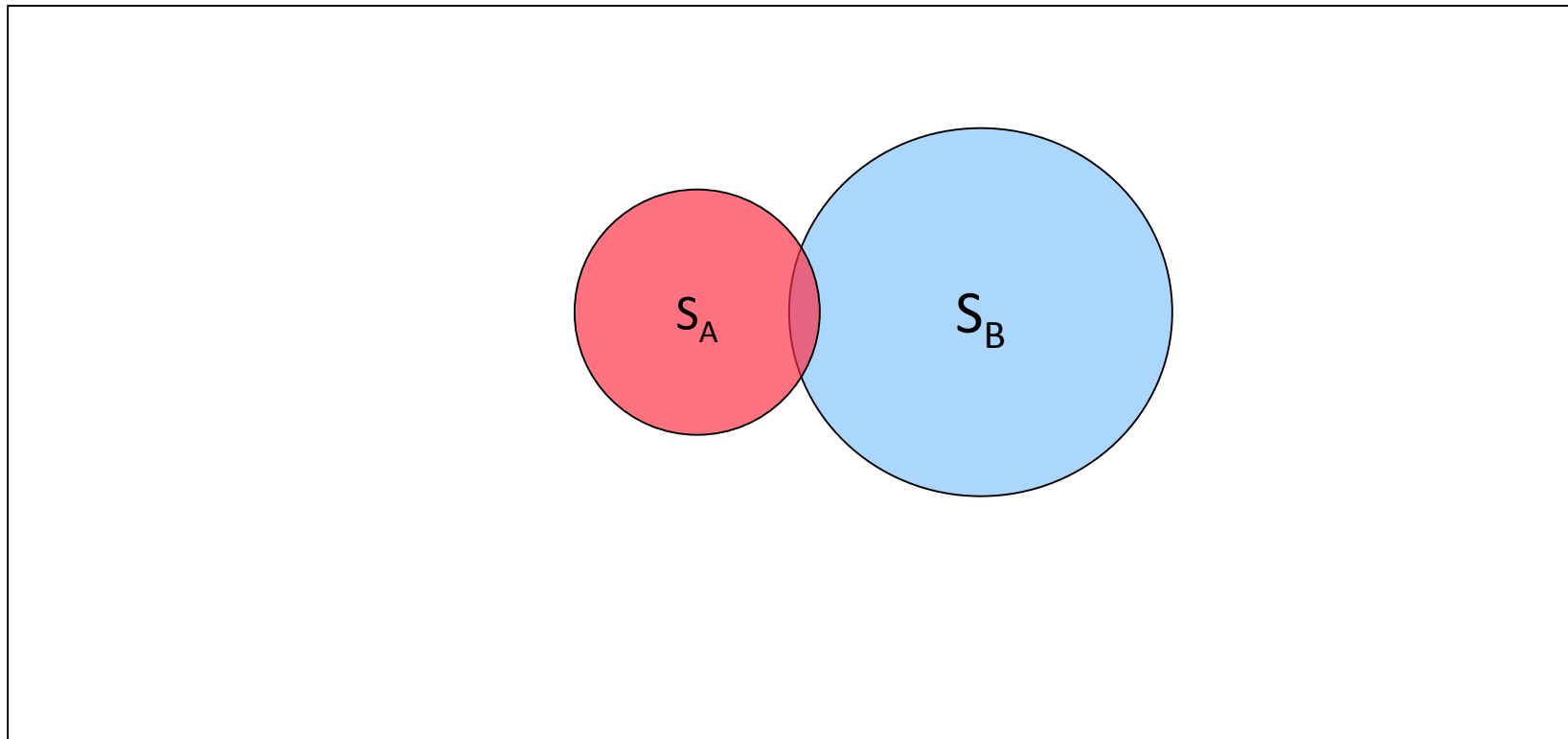
# Linking Precincts



- Assume two races A and B over the same set of precincts
- Goal: choose 2% of precincts for Race A and 3% of precincts for Race B

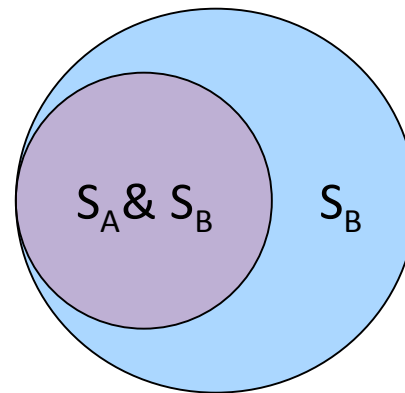
# Unlinked Precincts

Set of all ballots,  $S$



# Linked Precincts

Set of all ballots,  $S$

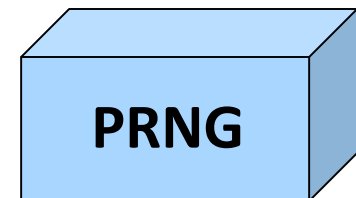
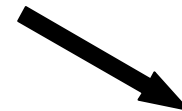




# Pseudorandom Number Generation



“1,2,1,4,4,...”



# Humboldt County Data



- Ballot images from Humboldt County (CA) Election Transparency Project (Nov 2008)
- Textual ballot representations from Mitch Trachtenberg's Ballot Browser program
- 29 races; 145 precincts; 128,144 ballots

# Process



- Loaded the data from individual ballots into our database
- Used the system to run a mock audit
- In order to simulate a manual recount, compared the ballot images against the data in our database

# Results



Audit	Algorithm	Parameter	Precincts chosen	Ballots Chosen	Percent ballots chosen
1	Exact Percent	1% of precincts	33	15,613	12%
2	Exact Percent (linking)	1% of precincts	15	5,768	4%
3	Constant Sample Size	99% confidence	N/A	3,006	2%

# In closing...



---

Automation can

- Make post-election audits more efficient
- Expand the scope of complex auditing algorithms and reduce the number of ballots to be counted

as long as the output can be independently verified.

---

---

---

# Software Support for Software-Independent Auditing

Gabrielle A. Gianelli, *Jennifer D. King*,  
Edward W. Felten, William P. Zeller

Center for Information Technology Policy  
Department of Computer Science  
Princeton University