

*Two new election audit tools:
sampling with k-cut, and
Bayesian audits*

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Audits are about:

- Sampling cast paper ballots at random
 - *Sampling with k-cut*
- Figuring out what the sampled ballots tell you about the reported election results
 - *Bayesian audits*

Sampling with k-cut

Finding a random ballot

- **Counting** is standard method:
 - count down to desired ballot
- ***k*-cut** is new method:
 - Perform $k = 6$ “cuts”
(each moving some top portion to bottom)
 - (By Mayuri Sridhar & me)

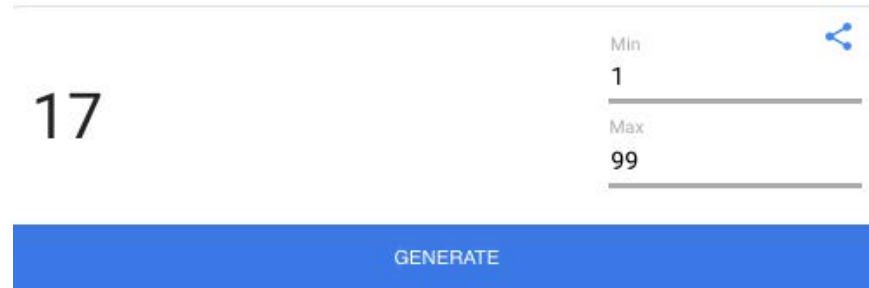
Counting

- Please count to ballot 572 out of these 901 !



k-cut

- Get random number hint H between 1 and 99 (google “random number generator” for app)



A screenshot of a mobile application interface for a random number generator. The interface is white with a blue button at the bottom. On the left, the number '17' is displayed in a large, black, sans-serif font. To the right of the number, there are two input fields: the top one is labeled 'Min' and contains the value '1', and the bottom one is labeled 'Max' and contains the value '99'. A blue share icon is located to the right of the 'Min' field. Below the input fields is a solid blue rectangular button with the word 'GENERATE' written in white, uppercase letters.

- Cut (take) approximately $H\%$ of ballots off top and move to bottom. OK to “eye-ball” it.
- Repeat above $k = 6$ times.
- Take top ballot as randomly selected ballot.

k-cut video



Remarks on k -cut

- Can be about 5X faster (depending...)
- May want to decrease risk limit a tad to account for residual non-uniformity of sampling
- k -cut does not work for *ballot-comparison audits* where you are looking for ballot with specific ID.
- For details, see:
<https://arxiv.org/abs/1811.08811>

Bayesian audits

Audit Rochester Hills MI

- Reported results for Proposition:
22,999 **Yes**
12,343 **No**
1,324 **Other**
- Sample results for Proposition:
50 **Yes**
26 **No**
0 **Other**
- *So... ???*

Compare RLA with Bayesian

- **RLA Question:**

What is current “risk”? (Probability that if reported winner is incorrect, audit would nonetheless accept it if audit stopped now.)

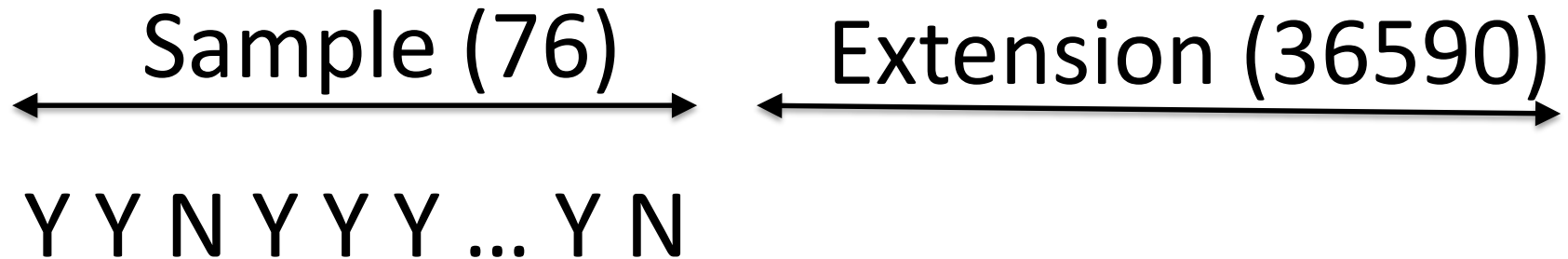
- **Bayesian Question:**

What is probability that reported winner would lose if all ballots were examined? (“upset probability”)

Bayesian Method (ballot polling)

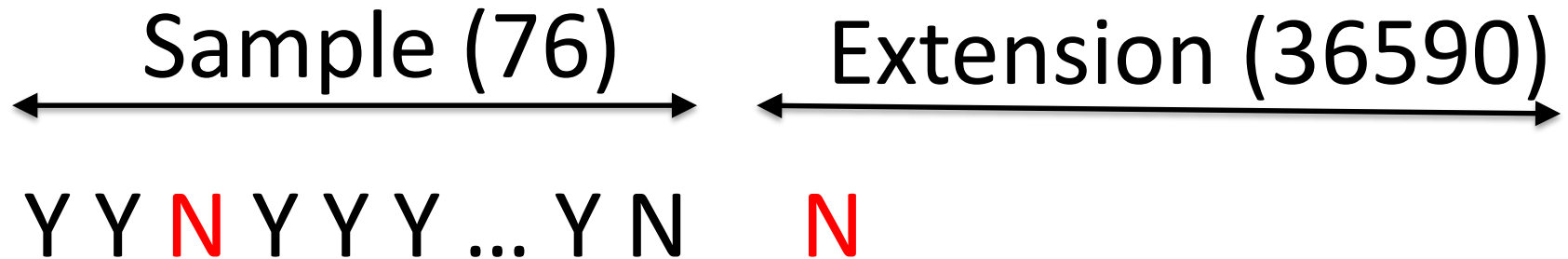
1. Start by drawing sample of paper ballots from population of cast paper ballots.
2. Extend for remaining ballots, but *simulating* what you might see: replace each draw of a paper ballot with copy of random earlier ballot.
3. Find winner for all (drawn and simulated) ballots.
4. Repeat steps 2—3 many times, measuring fraction of time reported winner loses.
5. Repeat with larger sample if fraction $> 5\%$.

Figure



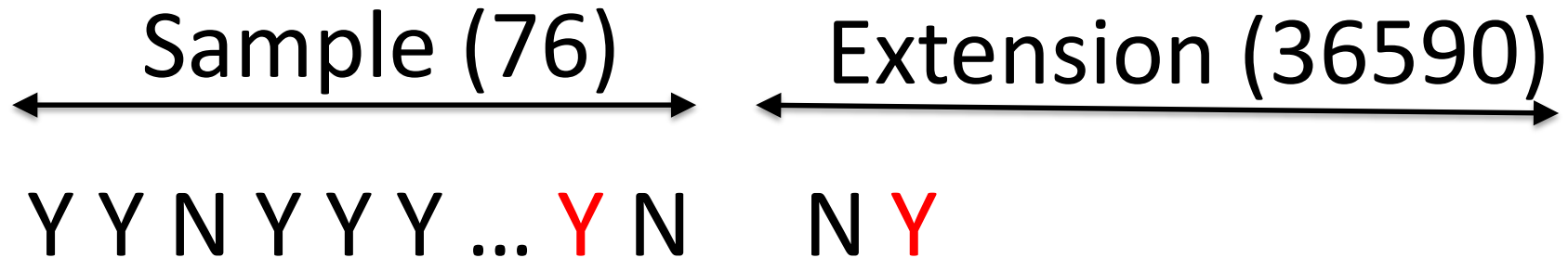
Each new element of extension is copy of random ballot to its left.

Figure



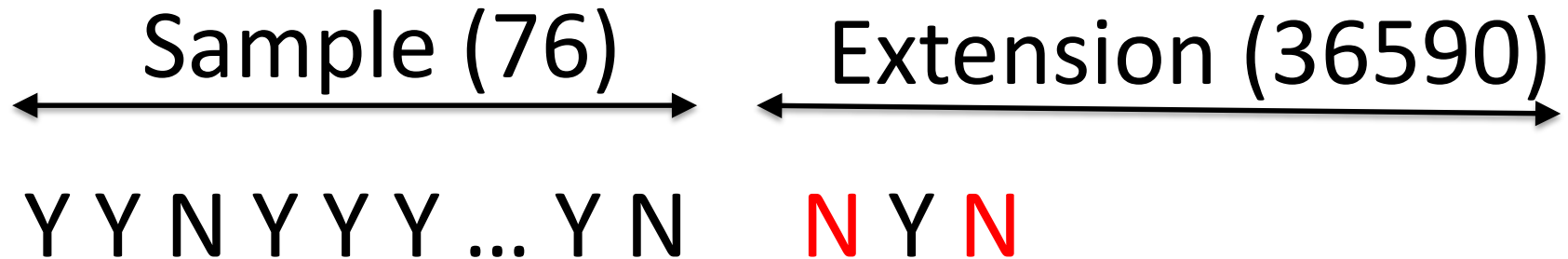
Each new element of extension is copy of random ballot to its left.

Figure



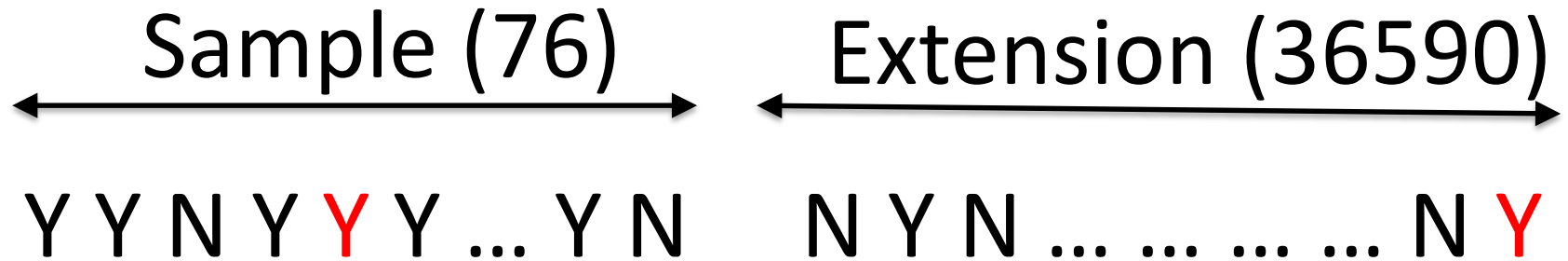
Each new element of extension is copy of random ballot to its left.

Figure



Each new element of extension is copy of random ballot to its left.

Figure



Each new element of extension is copy of random ballot to its left.

Results

- **RLA results:**

Risk measured at 2.1 %

(Kellie Ottoboni using SUITE tool)

- **Bayesian results:**

99.7 % of time **Yes** wins

0.3 % of time **No** wins

(Mayuri Sridhar using BPTOOL)

- **Both methods confirm reported outcome.**

Remarks

- Bayesian methods extend to:
 - Ballot-comparison audits
 - Hybrid audits (CVR and no-CVR strata)
 - IRV (RCV) or other complex voting schemes
(since method uses social choice function as a “black box” at the end of each simulation trial)
- For more details see
<https://arxiv.org/abs/1801.00528>

The End

Thanks for your attention!

(and thanks to NSF CSOI and to
Verified Voting!)