Election Security

Leah Namisa Rosenbloom
Brown University
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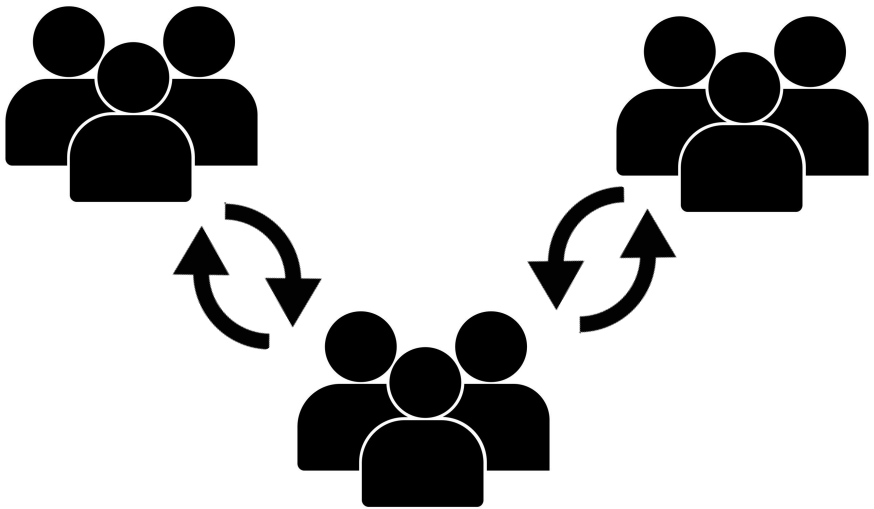

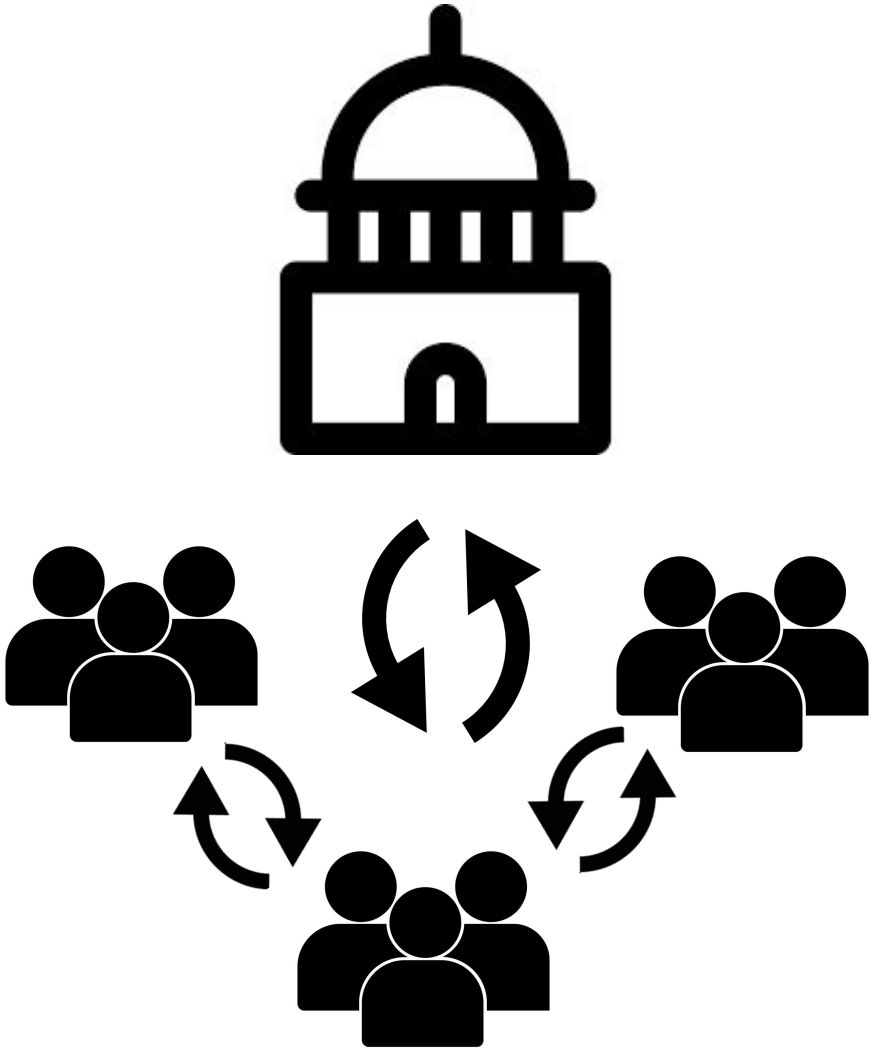

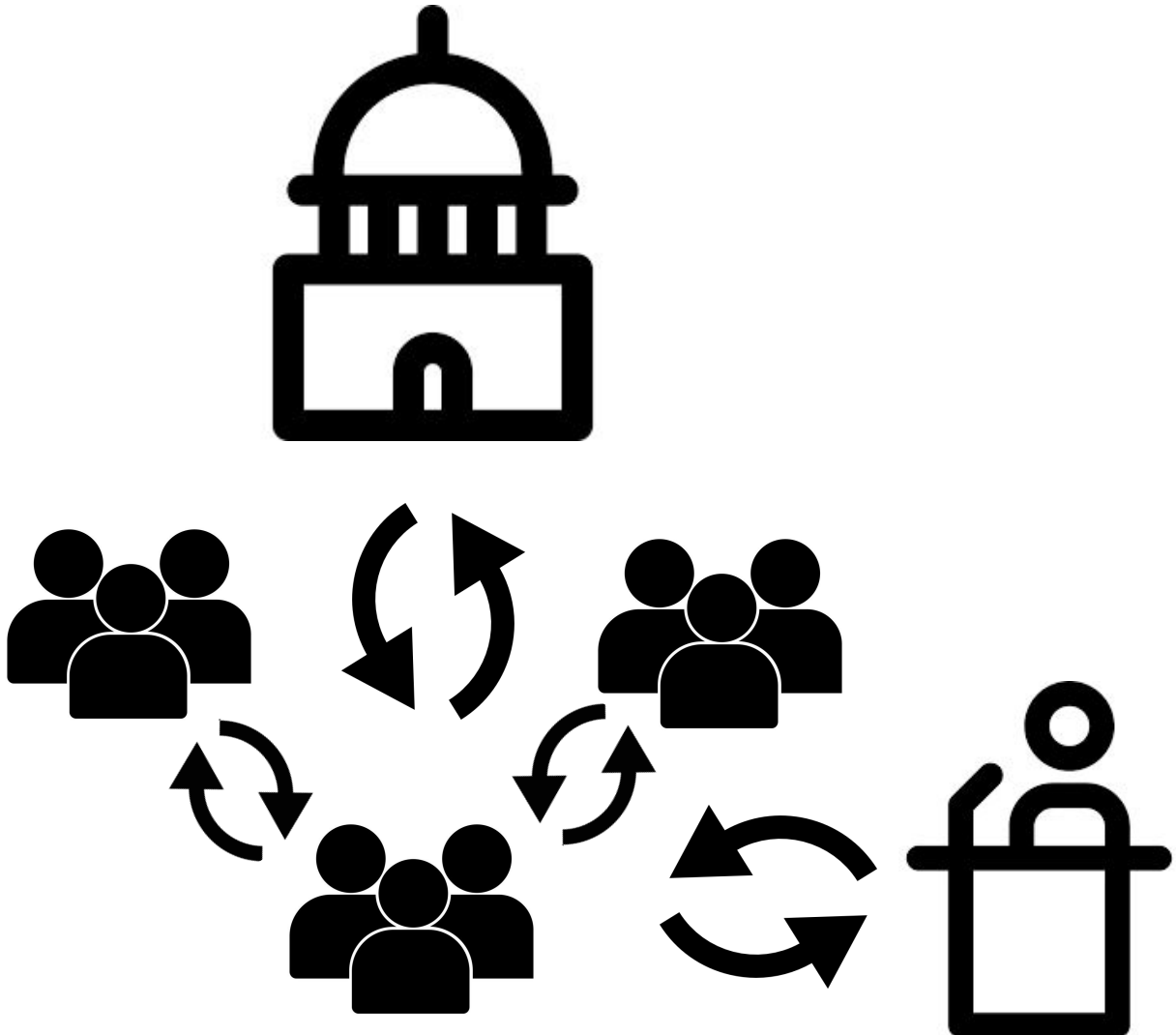

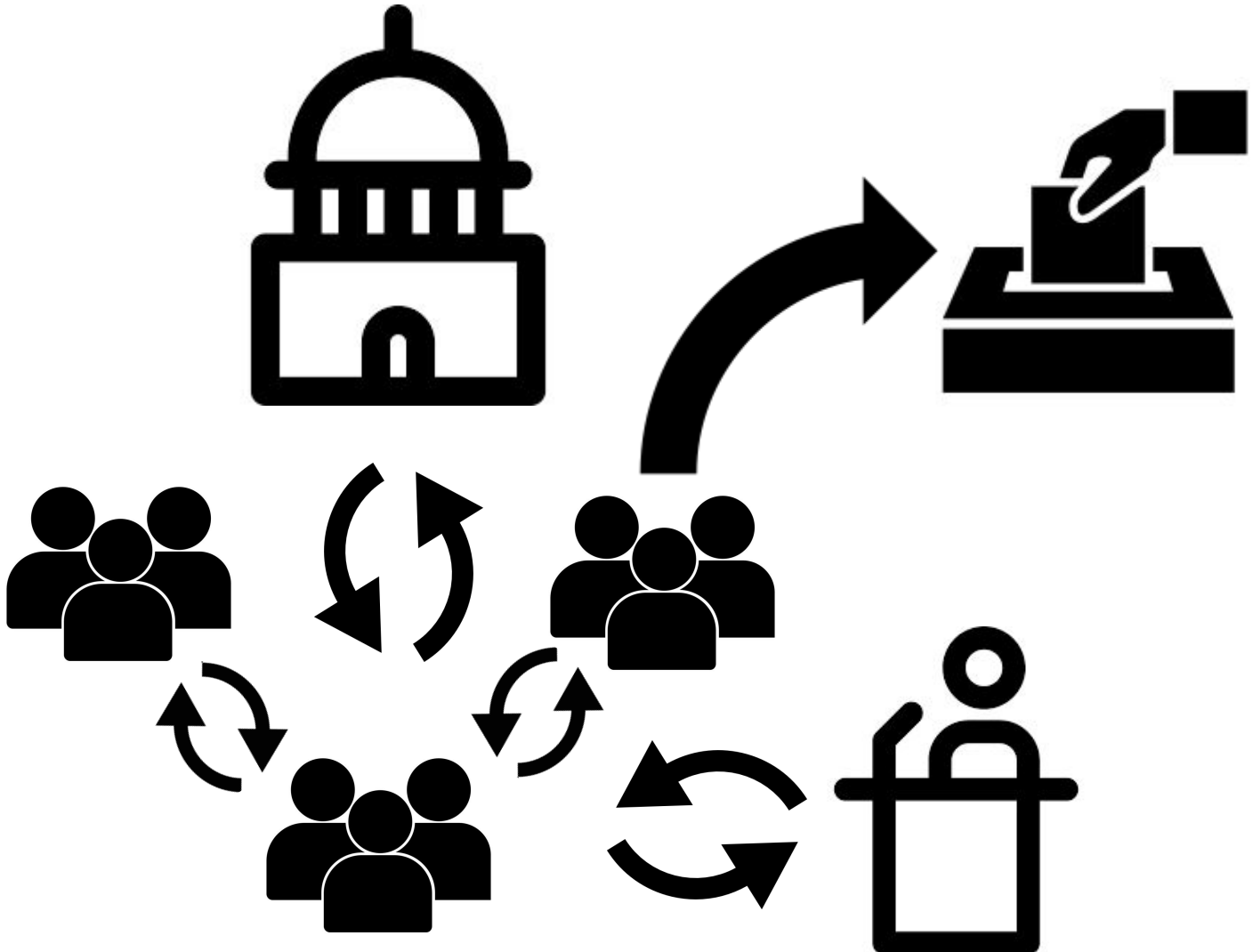

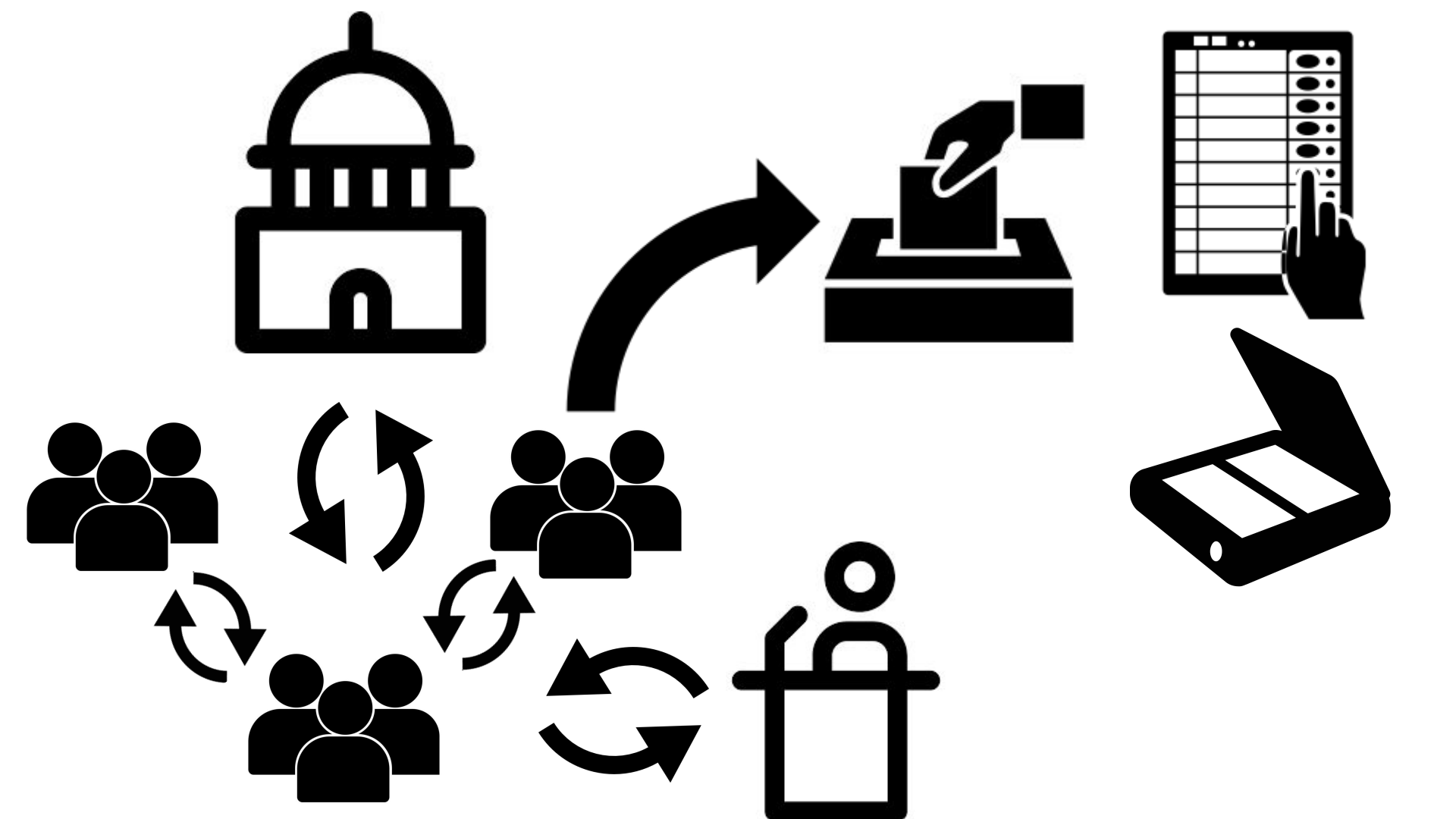

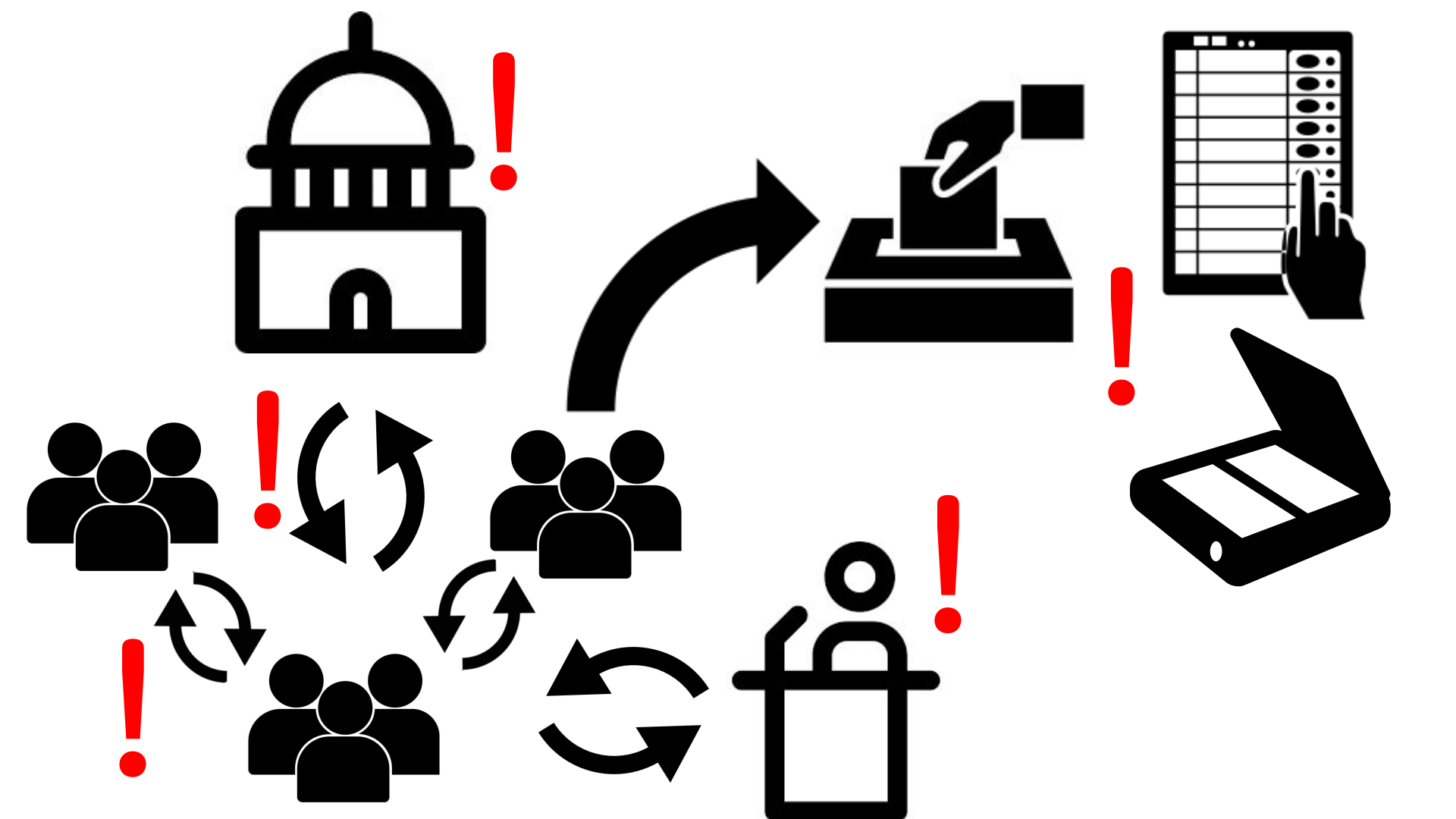

But what is Election Security?

- “Free and Fair” process
- Faith in results
- Peaceful transfer of power

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Your opinion matters.

Lecture Overview

- Electoral process ✓
- Electronic voting systems Then (2006) and Now (2017)
- Regulation v. certification
- Security beyond voting systems
- Security beyond technology

2006: Diebold AccuVote-TS(x)

- *Security Analysis of the Diebold AccuVote-TS Voting Machine*,

  Ariel Feldman, Alex Halderman, Edward Felten (2006)
- Diebold AccuVote-TS(x) widely deployed in US (10%) and Canada
  - Direct Recording Electronic (DRE) voting system:

    general-purpose computers running specialized election software
- First comprehensive analysis of deployed DRE
- Found to be extremely vulnerable

Why? Here's the Setup (Part 1):

- ★ Hardware
  - power switch, keyboard port, two PC Card slots behind lightweight, uniform lock
    - PC Card slot 1: removable flash memory card
    - PC Card slot 2: modem card for transferring ballot definitions and results
  - two switches and jumpers on motherboard control source of bootloader
    - Source 1: on-board flash memory (default)
    - Source 2: erasable programmable (EP) ROM chip in motherboard socket
    - Source 3: proprietary flash memory in "ext flash" slot

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- ★ Software: Windows CE, Diebold BallotStation

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- ★ Software: Windows CE, Diebold BallotStation
- ★ On Boot
  - bootloader copies self into RAM, initializes hardware
  - if memory card in PC Card slot 1, search for update files
    - if fboot.nb0 found, replace bootloader in on-board flash memory with contents
    - if nk.bin found, replace OS image in on-board flash memory with contents
    - if EraseFFX.bsq found, erase file system area in on-board flash memory
  - uncompress OS image, copy to RAM, release control to OS kernel (see Part 2)

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Points of Discussion (5 min)**:**

1. what are the vulnerabilities?
2. what is the severity/scope?
3. what are the solutions?

Bootloader Blues

- bootloader can reprogram itself and the entire OS, overwrite flash memory
- overwriting is permanent (excluding hard reset)
- takes orders from removable media in PC Card Slot 1
- removable media port is behind flimsy lock

⇒ attacker with access to PC Card Slot 1 can permanently reprogram machine

Mitigation

- authenticate updates with digital signatures
- increase physical security and tighten chain of custody

Why vulnerable? Here's the Setup (Part 2):

- ★ On OS init
  - kernel runs Filesys.exe, which unpacks registry and runs programs in \Init
    - shell.exe (Debug Shell), device.exe (Device Manager), gwes.exe (Graphics, Windowing, and Events Subsystem), taskman.exe (Task Manager)
  - Device Manager mounts filesystems
    - on-board flash mounted at \FFX
    - memory card (if present) mounted at \Storage Card using FAT or FAT32
    - root file system mounted at \ in RAM
  - if memory card inserted, Task Manager searches for files
    - if files ending in .ins (proprietary scripts) found, confirm with user and run scripts
    - if explorer.glb found, launch Windows Explorer
      - else, launch BallotStation.exe from \FFX\Bin

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      - else, launch BallotStation.exe from \FFX\Bin
- ★ BallotStation procedures
  - determine mode from \Storage Card\CurrentElection\election.brs (see Part 3)
  - if card is replaced, transition to mode specified by newly inserted card
  - if machine is rebooted, return to mode specified by currently inserted card

Under New Management

- Windows Explorer gives full access to file systems, control panel

  ⇒ attacker with access to PC Card Slot 1 gets access to file systems, control panel
- root file system mounted in RAM ⇒ reboot destroys evidence
- multiple stack-based buffer overflows in .ins script handling
- BallotStation takes orders from removable media in PC Card Slot 2

Mitigation

- authenticate Windows Explorer, BallotStation, script requests
- mount file systems in nonvolatile memory

Why vulnerable? Here's the Setup (Part 3):

- ★ BallotStation modes: Pre-Download, Pre-Election Testing, Election, Post-Election
- ★ Election Setup
  - machines stored in facility with access control, delivered to poll workers pre-election
  - poll workers configure BallotStation with ballot description
    - Option 1: insert memory card into PC Card Slot 2
    - Option 2: download ballot definition by connecting to Windows PC running Diebold's Global Elections Management System (GEMS) server software
  - poll workers test machine for "logic and accuracy" by simulating election, get zero tape

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- ★ Tallying Results
  - poll workers insert "Ender" card, get result tape, check voter count against votes cast
  - results transferred to central tabulator PC running GEMS software
    - Option 1: transfer over LAN, phone line, or serial cable
    - Option 2: "accumulate" results into one machine using memory cards of others
  - if recount, check tape v. memory cards and re-tabulate; if needed examine on-board FS

Cross Contamination

- Network awareness
- Accumulation ⇒ shared removable media
- *Number* of votes consistent ⇒ result tape consistent
- Result tape, memory cards, logs always consistent but not necessarily correct

  ⇒ attacker can tamper with votes and election results will pass audits, recount

Mitigation

- Authenticate updates, restrict communication, limit memory card sharing
- Voter Verified Paper Audit Trails (VVPAT)

Three-Layer Offense (Harri Hursti, 2006)

1. Application software (replace instructions)
2. Operating system (replace person reading instructions)
3. Bootloader (replace supreme entity that creates person)

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Successful Attacks (Feldman et al., 2006)

- Targeted and infectious vote-stealing (stealth mode)
  - check for Election mode, “secret knock”
  - suspend BallotStation, scan result files, alter them arbitrarily
  - simulate normal procedure (pretend to update, confirm changes, etc.)
  - spread like a virus via infected memory cards
- Denial-of-Service (havoc mode)
  - overwrite file system contents of on-board flash memory, memory card(s)
    - destroys all current election results
    - renders machine inoperable
  - modify, corrupt ballot description

Gems from the Diebold Timeline

- 2000: Diebold linked to disappearance of 16,000 votes for Al Gore in Florida
- 2000-2001: Diebold gives $125,000 to the Republican National Committee
- 2003: Diebold deploys untested machines in California, subsequently banned
- 2004: Diebold CEO pledges commitment to Ohio victory for Bush in Republican fundraising letter, Diebold linked again to voting irregularities
- 2010: Diebold settles SEC accounting fraud charge for $25 million
- 2013: Diebold indicted for using bribery, falsifying documents to get business in China, Indonesia, and Russia

2017: A “Sobering” State of Affairs

- *DEFCON 25 Voting Machine Hacking Village: Report on Cyber Vulnerabilities in U.S. Election Equipment, Databases, and Infrastructure*, Matt Blaze, Jake Braun, Harri Hursti, Joseph Hall, Margaret MacAlpine, Jeff Moss (2017)
- 4 days, 25 pieces of election equipment, all breached in some way
  - participants had limited prior knowledge, tools, and resources
- Breaches included remote control, unauthorized access to files and configuration data, default passwords, removable media exploitation, voter data theft
- vulnerabilities threaten confidentiality, integrity, and availability of vote

AVS WinVote (2003-2014)

- remote access over WiFi possible using 2003 exploit
- hacker used Metasploit to gain access to filesystem and escalate privileges to admin
- two unobstructed USB ports on back of machine allow similar access
- unchangeable, universal default password of “adminabcde”

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- EPROM chip socketed not soldered
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Sequoia AVC Edge

- firmware protected by 8-bit cipher

Diebold ExpressPoll 5000

- units not properly decommissioned; contained 650,000 voter records
- physical security of removable media thwarted by standard screwdriver
- default username and password available online
- obsolete OS (Windows CE 5) with no input or software validation
  - same bootloader and OS reflashing issue as AccuVote-TS(x)
- pollbook software reads ExPoll.resources to obtain election parameters
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General Concerns

- this was a limited-scope study; imagine what real attackers could do
- supply chain compromised by foreign-made (hardware and software) components
- voting systems in urgent need of further consideration, regulation

Managing DREs

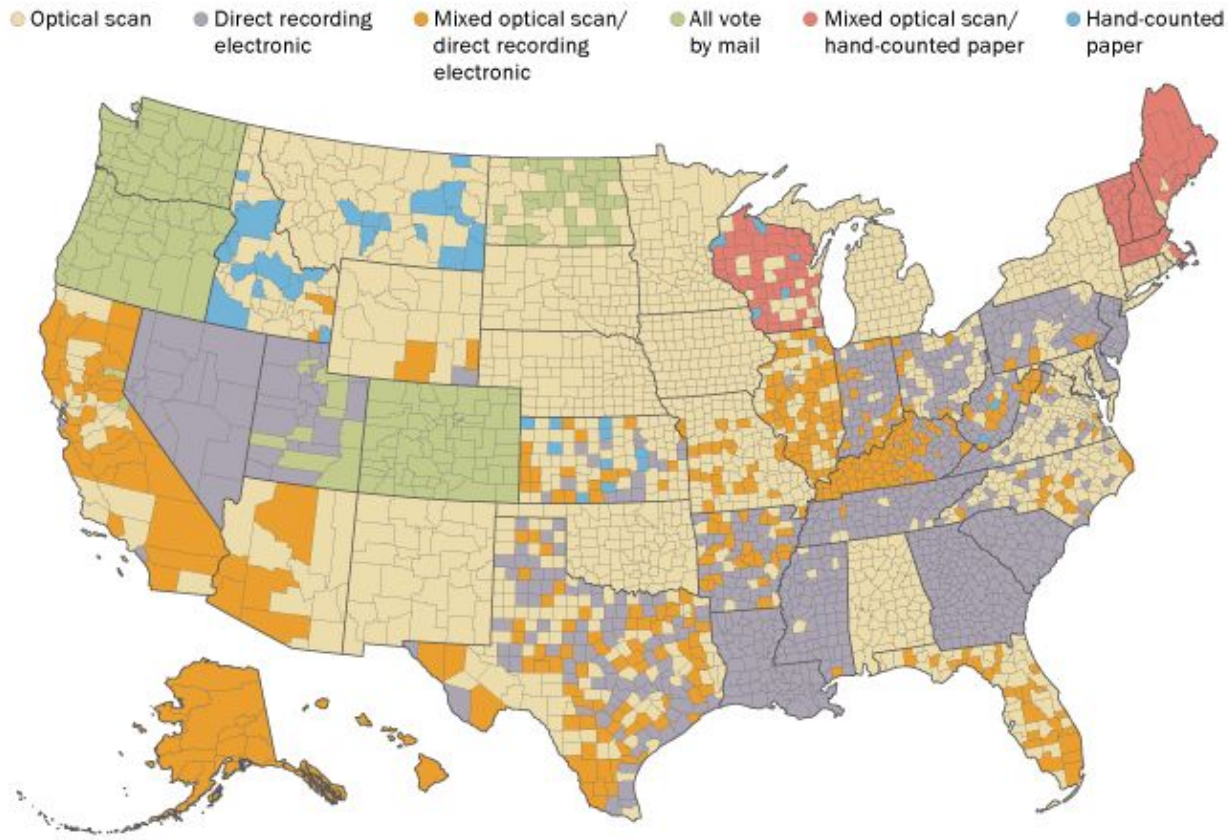
- Voter Verified Paper Audit Trail (VVPAT)
  - voter sees print-out of result, checks for accuracy
  - printed results saved for auditing
- Risk-Limiting Audits
  - random samples taken until results are confirmed with high probability
  - minimal effort if results are correct
  - if incorrect, recount already in progress

Alternatives

- Optical scan paper ballot systems
  - voters mark paper ballots
  - votes tabulated by scanning devices
  - PRO: ideal security-efficiency ratio
  - CON: expensive
- Hand-counted paper ballots
- Vote by mail
- Mechanical lever voting systems (RIP 2010)
- Punch card voting systems (RIP 2016)

Across the U.S., a patchwork of voting methods

Principal voting system, by county



Source: Pew Research Center analysis of data from Verified Voting Foundation.

PEW RESEARCH CENTER

Regulation v. Certification in the US (Gorcenski 2016)

- Regulation: law that carries civil and/or criminal penalty for non-compliance
- Certification: quality assurance standard
- no codified federal voting system regulation; yes federal certification
- states regulate, can mandate federal certification
- software certification standards: style over substance
    - most use automated code-checkers
    - small fraction of code reviewed by humans
- 20 states have no regulations
- $4 billion Help America Vote Act (2002) introduced more tech, failed to fix flaws

Election security: beyond voting systems

- Voter data
  - Russian hackers use spear-phishing to access voter information in 39 states
  - Federal government prosecutes leaker; Republicans vote to eliminate EAC
  - Facebook sells ~~50~~ 87 million users' private data to Cambridge Analytica
- Political party and campaign security
  - DNC hack, Clinton emails
- Social media and "fake news"
  - "Skip the line, vote by SMS" tweets

Election security: beyond technology

- Targeted voter suppression
  - gerrymandering
  - voter ID laws
- Systematic disenfranchisement
  - mass incarceration
  - banning groups based on race, gender, etc.
- Traditional voter fraud
  - ballot-stuffing in Russia