CSE 484 / CSE M 584 (Autumn 2011)

Computer Security and Privacy

Daniel Halperin
Tadayoshi Kohno

Thanks to Dan Boneh, Dieter Gollmann, John Manferdelli, John Mitchell, Vitaly Shmatikov, Bennet Yee, and many others for sample slides and materials ...

Daniel Halperin

- 6th (last!)-year grad student in CSE
- Primary research area is wireless networking; also have worked on and research network security
- Extra-curricular
  - Fluent in Spanish (studied in Barcelona during college)
  - Softball (CSE IM Team Captain), rock climbing, running [slowly]
  - Software, hardware, and real-world hacking -- Build things!

Tadayoshi Kohno

- Associate Professor, Computer Science and Engineering
- Primary Area: Computer Security and Privacy
  - Emerging technologies, embedded systems, consumer technologies
  - Mobile and cloud security
  - Accounting for humans in the design of security systems

High-level information

- Instructors:
  - Daniel Halperin (Dan)
  - Tadayoshi Kohno (Yoshi)
- TAs:
  - Miro Enev, Roy McElmurry
- Course website
  - Assignments, reading materials, ...
- Course email list
  - Announcements
- Course forum
  - Discussion

High-level information

- Recitation sections:
  - Thursday, 1:30-2:20 and 2:30-3:20, in EEB 125
- **No recitation this week (Sept. 29)**

Prerequisites (CSE 484)

- Required: Data Structures (CSE 326) or Data Abstractions (CSE 332)
- Required: Hardware/Software Interface (CSE 351) or Machine Org and Assembly Language (CSE 378)
- Assume: Working knowledge of C and assembly
  - One of the projects involves writing buffer overflow attacks in C
  - You must have detailed understanding of x86 architecture, stack layout, calling conventions, etc.
- Assume: Working knowledge of software engineering tools for Unix environments (gdb, etc)
- Assume: Working knowledge of Java and JavaScript

Prerequisites (CSE 484)

- Strongly recommended: Computer Networks; Operating Systems
  - Will help provide deeper understanding of security mechanisms and where they fit in the big picture
- Recommended: Complexity Theory; Discrete Math; Algorithms
  - Will help with the more theoretical aspects of this course.

Prerequisites (CSE 484)

- Most of all: Eagerness to learn!
  - This is a 400 level course.
  - We expect you to push yourself to learn as much as possible.
  - We expect you to be a strong, independent learner capable of learning new concepts from the lectures, the readings, and on your own.

Course Logistics (CSE 484)

- Lectures: Mon, Wed, Fri: 2:30-3:20pm ;
  Recitations: Thurs: 1:30-2:20pm and 2:30-3:20pm
- Security is a contact sport!
- Labs (40% of the grade)
  - Labs involve a lot of programming
  - Can generally be done in teams of 3 students (see specific lab descriptions for details)
- Homework (25% of grade)
- Participation (10% of grade)
- Final (25% of the grade)

Exceptional work may be rewarded with extra credit

No make-up or substitute exams!

If you are not sure you will be able to take the exam on the assigned date and time, **do not take this course!**

Course Logistics (CSE M 584)

- Same as before, but...
- Labs (35% of the grade) [-5%]
- Homework (20% of grade) [-5%]
- Participation (10% of grade)
- Final (25% of the grade)
- Research readings (10%) [+10%]
  - Read research papers (1 per week for first 9 weeks)
  - Possibly present one of these papers to the class (depending on enrollment)

Late Submission Policy

- Late assignments will (generally) be dropped 20% per calendar day.
  - Late days will be rounded up
  - So an assignment turned in 26 hours late will be downgraded 40%.
  - See website for exceptions
- Many assignments due on Friday

Participation Grade

- Two possibilities:
  - #1: Regular contributions to class forums
    - (You can pick a pseudonym, though course staff will still know who owns each pseudonym)
  - #2: Participation in class
    - We will have a seating chart … at least until we learn everyone’s names.
    - On Friday, please pick a seat that you’d like to have for at least the first part of the quarter

Small class in a large class

- This class has ~60 enrolled students
- Hard to have 1-on-1 interactions; not very personal
- Coffee / tea?
  - Approximately once a week for the first half of the quarter, let's go as a small group for coffee or tea (~8 or 9 students and us)
  - Not required.
  - But an opportunity for all of us to get to know each other better, to discuss security, the broader context, thoughts about the course, current movies, ...
  - Sign up form will be on the website soon

Course Materials

- Textbooks:
  - Daswani, Kern, Kesavan, "Foundations of Security"
  - Additional materials linked to from course website
- Attend lectures.
  - Lectures will not follow the textbooks
  - Lectures will focus on "big-picture" principles and ideas
  - Lectures will cover some material that is not in the textbook – and you will be tested on it!
  - (Also make sure to read the forum)

Other Helpful Books (online)

- Ross Anderson, “Security Engineering” (1st edition)
  - Focuses on design principles for secure systems
  - Wide range of entertaining examples: banking, nuclear command and control, burglar alarms
  - You should all at least look at the Table of Contents for this book.
- Menezes, van Oorschot, and Vanstone, “Handbook of Applied Cryptography”
- Many many other useful books exist (not all online)

Others books, movies, ...

- Pleasure books include:
  - Little Brother by Cory Doctorow
    - Available online here http://craphound.com/littlebrother/download/
  - Cryptonomicon by Neal Stephenson
- Movies include:
  - Hackers
  - Sneakers
  - Die Hard 4
  - WarGames
  - ...
- Historical texts include:
  - The Codebreakers by David Kahn
  - The Code Book by Simon Singh

Ethics

- In this class you will learn about how to attack the security and privacy of (computer) systems.
- Knowing how to attack systems is a critical step toward knowing how to protect systems.
- But one must use this knowledge in an ethical manner.
- In order to get a non-zero grade in this course, you must electronically sign the “Security and Privacy Code of Ethics” form. (Monday, Oct 3) **https://catalyst.uw.edu/webq/survey/dhalperi/144460**

Mailing List

- Make sure you’re on the mailing list
  - We’ll send a test mail after class; everyone enrolled should receive it
- URL for mailing list on course website:
  - http://www.cs.washington.edu/education/courses/484/11au/administrivia/email.html
- Used for announcements

Forum

- We’ve set up a forum for this course to discuss assignments
    - https://catalyst.uw.edu/gopost/board/dhalperi/23892/
- Please use it to discuss the homework assignments and labs and other general class materials

Labs

- Tentative schedule online (future dates subject to change based on progress, etc)
- General plan (tentative):
  - 3 labs
    - October 28, November 11, December 9
    - First one posted online next week
  - Due Fridays at 5pm.
  - Submit to Catalyst system (URL on course page)
  - Groups of three generally allowed (check each project page for details)
- http://www.cs.washington.edu/education/courses/484/11au/projects/index.html

Labs (tentative plan)

- First lab: Software security
  - Buffer overflow attacks, double-free exploits, format string exploits, …
- Second lab: Web security
  - XSS attacks, …
- Third lab: Botnets (tentative)
  - Build a botnet, command and control, leasing, crypto, …
  - Heavy emphasis on building a secure system (a botnet that can't be attacked by others)

Homework

- Approximately 3 or 4 homework assignments distributed across the quarter (with deadlines compatible with the lab deadlines)
- http://www.cs.washington.edu/education/courses/cse484/11au/homework/index.html

What does “security” mean to you?

Two key themes of this course

- How to **think** about security
  - The Security Mindset - “new” way to think about systems
  - Threat models, security goals, assets, risks, adversaries
  - Connection between security, technology, politics, ethics, ...
  - The first few lectures, and the forum
    - http://cubist.cs.washington.edu/Security/ (previous years)
    - http://slashdot.org/
- **Technical aspects** of security
  - Attack techniques
  - Defenses

How to think about security

- Several approaches for developing “The Security Mindset” and for exploring the broader contextual issues surrounding computer security
  - Forum: Current event reflections
  - Forum: Security reviews
  - In class discussions
  - Additional participation in forums

Forum: Current events and security reviews

- Two current events posted by (Nov 4, Dec 2)
- Two security reviews posted by (Nov 4, Dec 2)
- 12 points each
- 1 point extra credit for each week that you are early
- May work in groups of up to 3 people.
  - Working in groups is actually encouraged.
  - Recall: security is a contact sport -- lots of value in discussing security with other people
- Please participate in follow-up discussions on forum

Forum: Current events and security reviews

- Previous courses looked at
  - Nike+iPod Sport Kit
  - Wireless keyboards
  - iPhone
  - Zune
  - SlingBox
  - Nintendo Wii
  - Dodgeball
  - Netflix
  - …
- Past blog URL: http://cubist.cs.washington.edu/Security/
- Past Security Reviews: http://cubist.cs.washington.edu/Security/category/security-reviews/

Technical Themes

- Vulnerabilities of computer systems
  - Software problems (buffer overflows); crypto problems; network problems (DoS, worms); people problems (usability, phishing)
- Defensive technologies
  - Protection of information in transit: cryptography, security protocols
  - Protection of networked applications: firewalls and intrusion detection
  - Least privilege, “Defense in depth”

What This Course is Not About

- Not a comprehensive course on computer security
  - Computer security is a broad discipline!
  - Impossible to cover everything in one quarter
  - So be careful in industry or wherever you go!
- Not about all of the latest and greatest attacks
  - Read bugtraq or other online sources instead
- Not a course on ethical, legal, or economic issues
  - We will touch on ethical issues, but the topic is huge
- Not a course on how to “hack” or “crack” systems
  - Yes, we will learn about attacks ... but the ultimate goal is to develop an understanding of attacks so that you can build more secure systems

What is Computer Security?

- Systems may fail for many reasons
- Reliability deals with accidental failures
- Usability deals with problems arising from operating mistakes made by users
- Security deals with intentional failures created by intelligent parties
  - Security is about computing in the presence of an adversary
  - But security, reliability, and usability are all related

What Drives the Attackers?

- Adversarial motivations:
  - Money, fame, malice, curiosity, politics, terror....
- Fake websites, identity theft, steal money
- Control victim’s machine, send spam, capture passwords
- Industrial espionage and international politics
- Access copy-protected movies and videos
- Attack on website, extort money
- Wreak havoc, achieve fame and glory

Security is a Big Problem

- Security very often on the front page of Slashdot and other media outlets

Challenges: What is “Security?”

- What does security mean?
  - Often the hardest part of building a secure system is figuring out what security means
  - What are the assets to protect?
  - What are the threats to those assets?
  - Who are the adversaries, and what are their resources?
  - What is the security policy?
- Perfect security does not exist!
  - Security is not a binary property
  - Security is about risk management

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Current events and security reviews are designed to exercise our thinking about these issues

From Policy to Implementation

- After you've figured out what security means to your application, there are still challenges
  - How is the security policy enforced?
  - Design bugs
    - Poor use of cryptography
    - Poor sources of randomness
    - ...
  - Implementation bugs
    - Buffer overflow attacks
    - ...
  - Is the system usable?

Don't forget the users! They are a critical component!

Many Participants

- Many parties involved
  - System developers
  - Companies deploying the system
  - The end users
  - The adversaries (possibly one of the above)
- Different parties have different goals
  - System developers and companies may wish to optimize cost
  - End users may desire security, privacy, and usability
  - But the relationship between these goals is quite complex (will customers choose not to buy the product if it is not secure?)

Other (Mutually-Related) Issues

- Do consumers actually care about security?
- Security is expensive to implement
- Plenty of legacy software
- Easier to write “insecure” code
- Some languages (like C) are unsafe

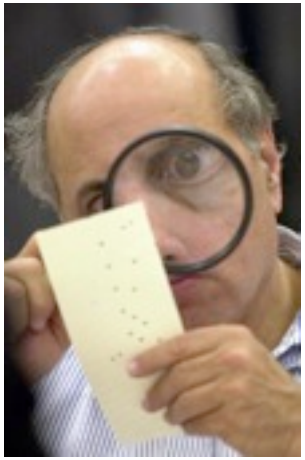
Approaches to Security

- Prevention
  - Stop an attack
- Detection
  - Detect an ongoing or past attack
- Response
  - Respond to attacks

- The threat of a response may be enough to deter some attackers

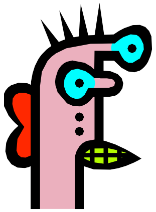
Example: Electronic Voting

- Popular replacement to traditional paper ballots



AP

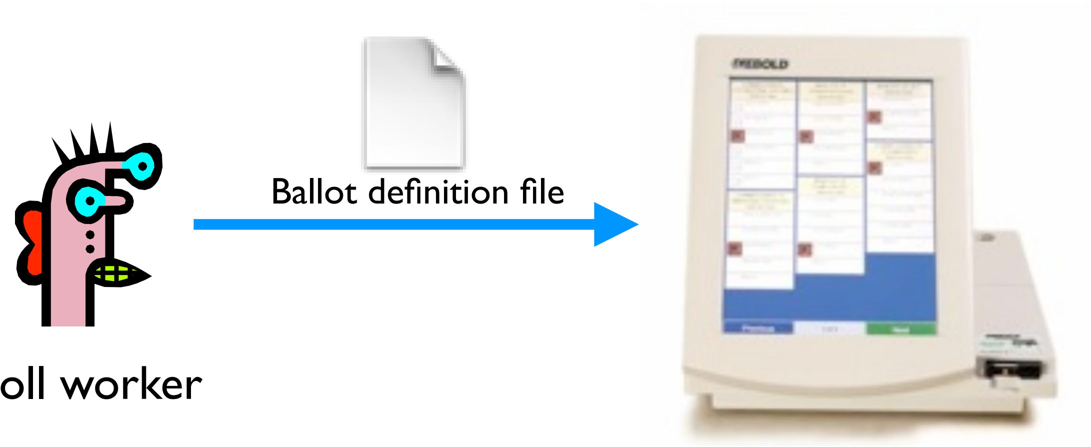
Pre-Election



Poll worker

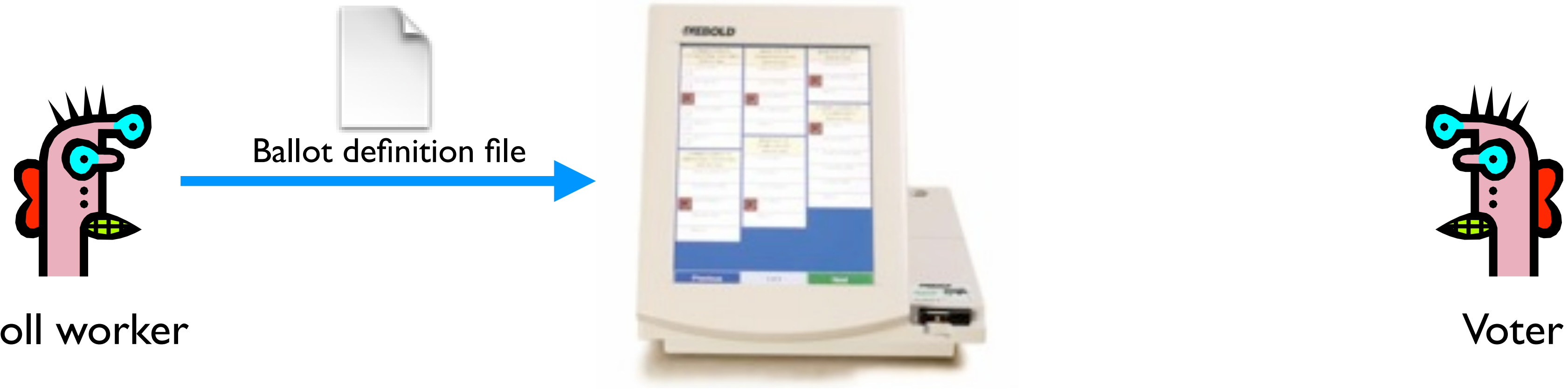
Pre-election: Poll workers load "ballot definition files" on voting machine.

Pre-Election



Pre-election: Poll workers load “ballot definition files” on voting machine.

Active Voting



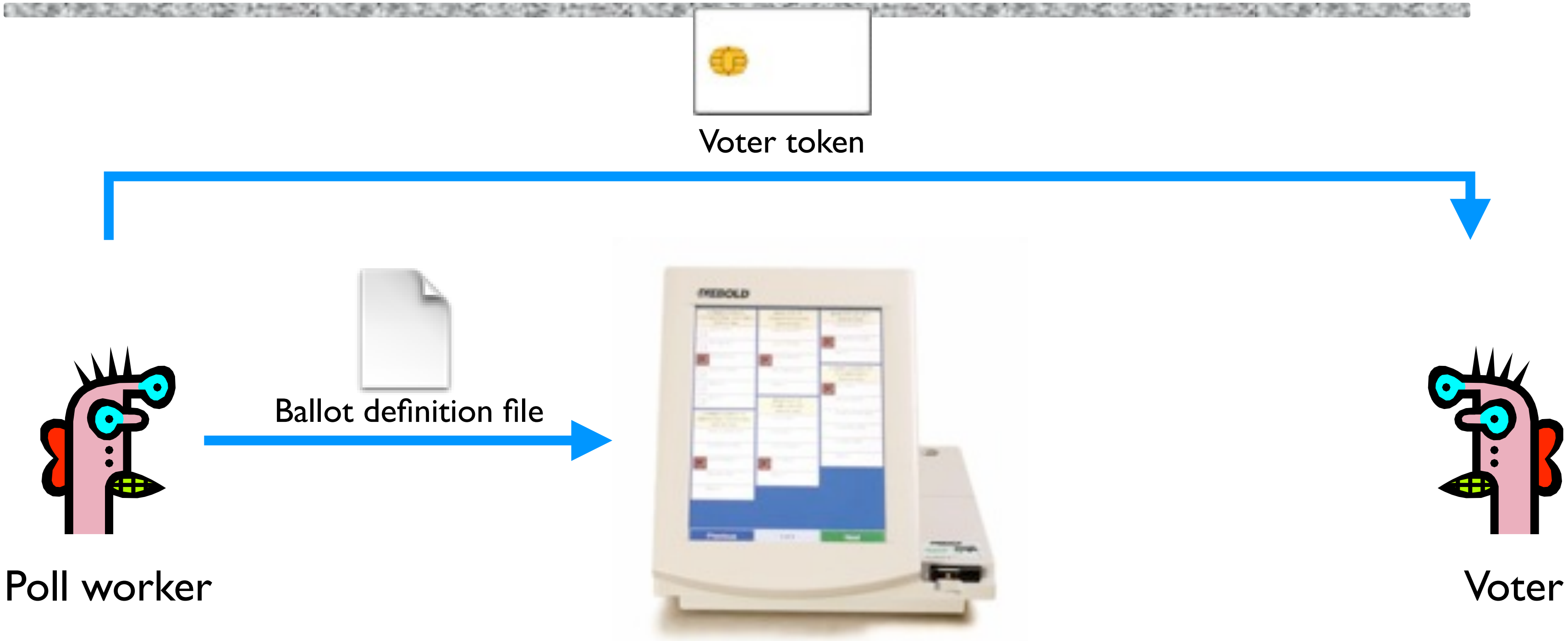
Ballot definition file

Poll worker

Voter

Active voting: Voters obtain single-use tokens from poll workers. Voters use tokens to active machines and vote.

Active Voting



Voter token

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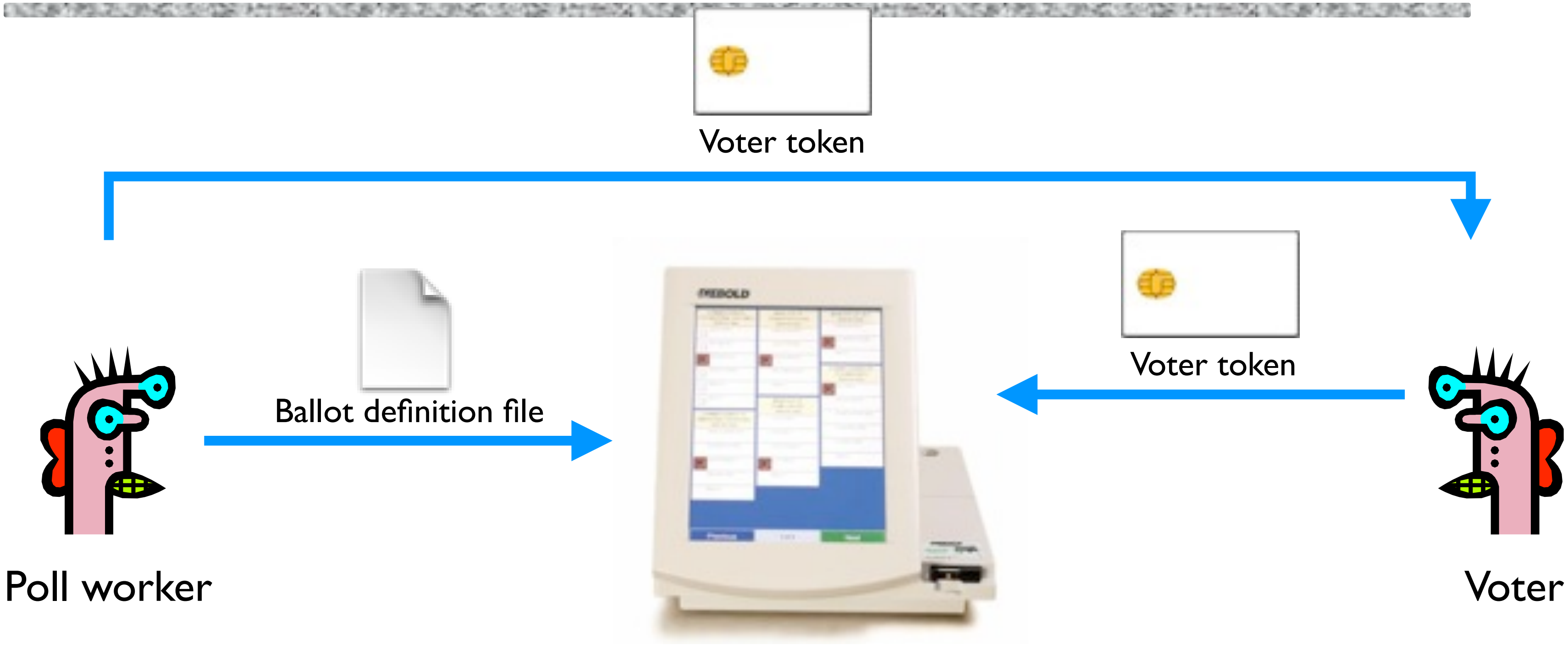

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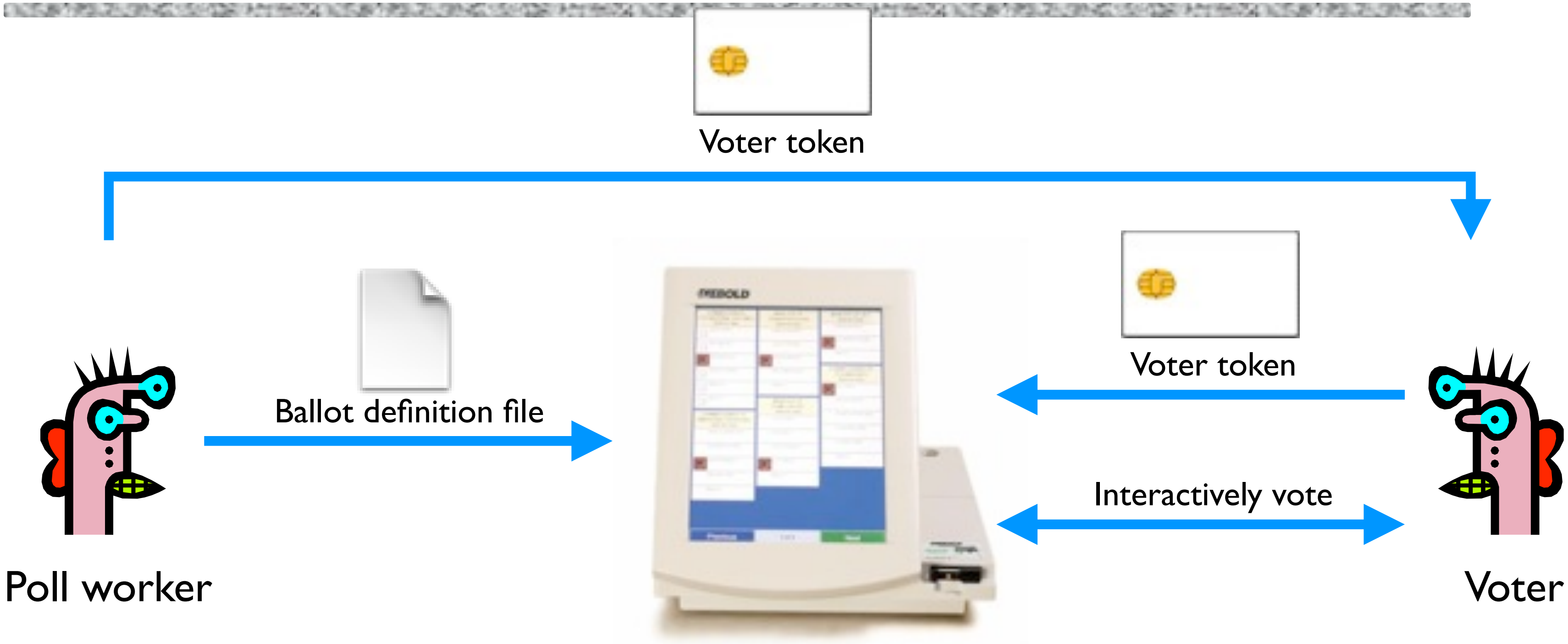

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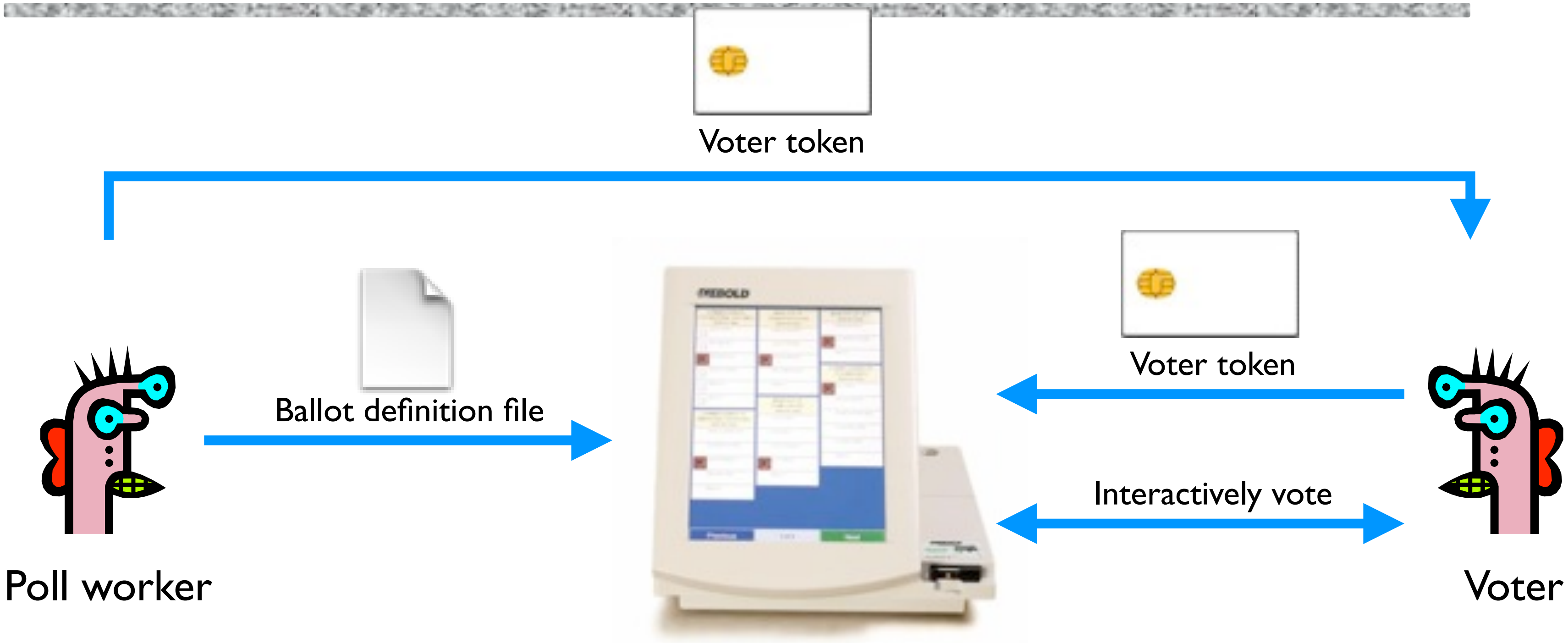


Voter token

Ballot definition file

Voter token

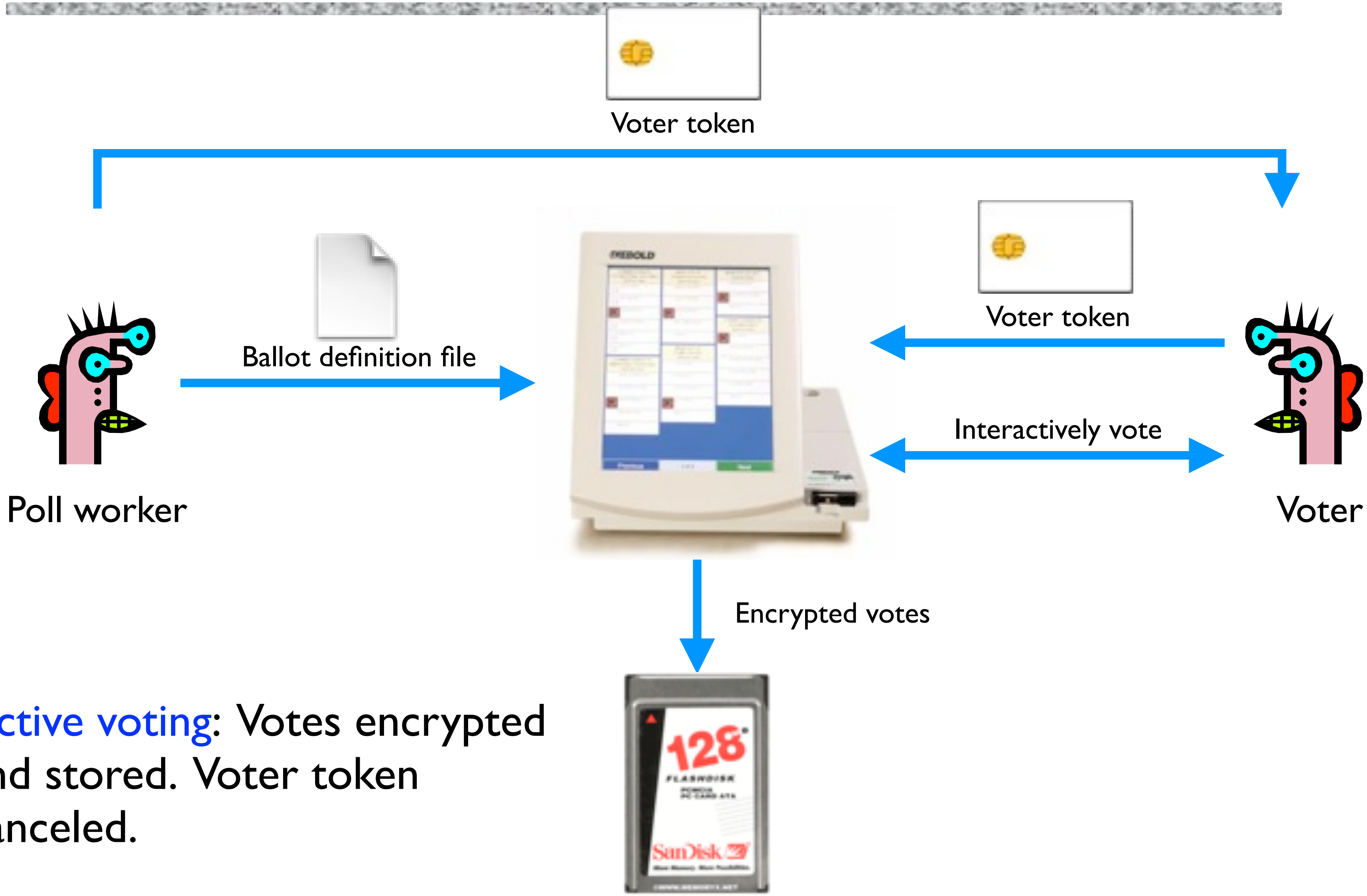
Interactively vote

Poll worker

Voter

Active voting: Votes encrypted and stored. Voter token canceled.

Active Voting



Voter token

Ballot definition file

Voter token

Interactively vote

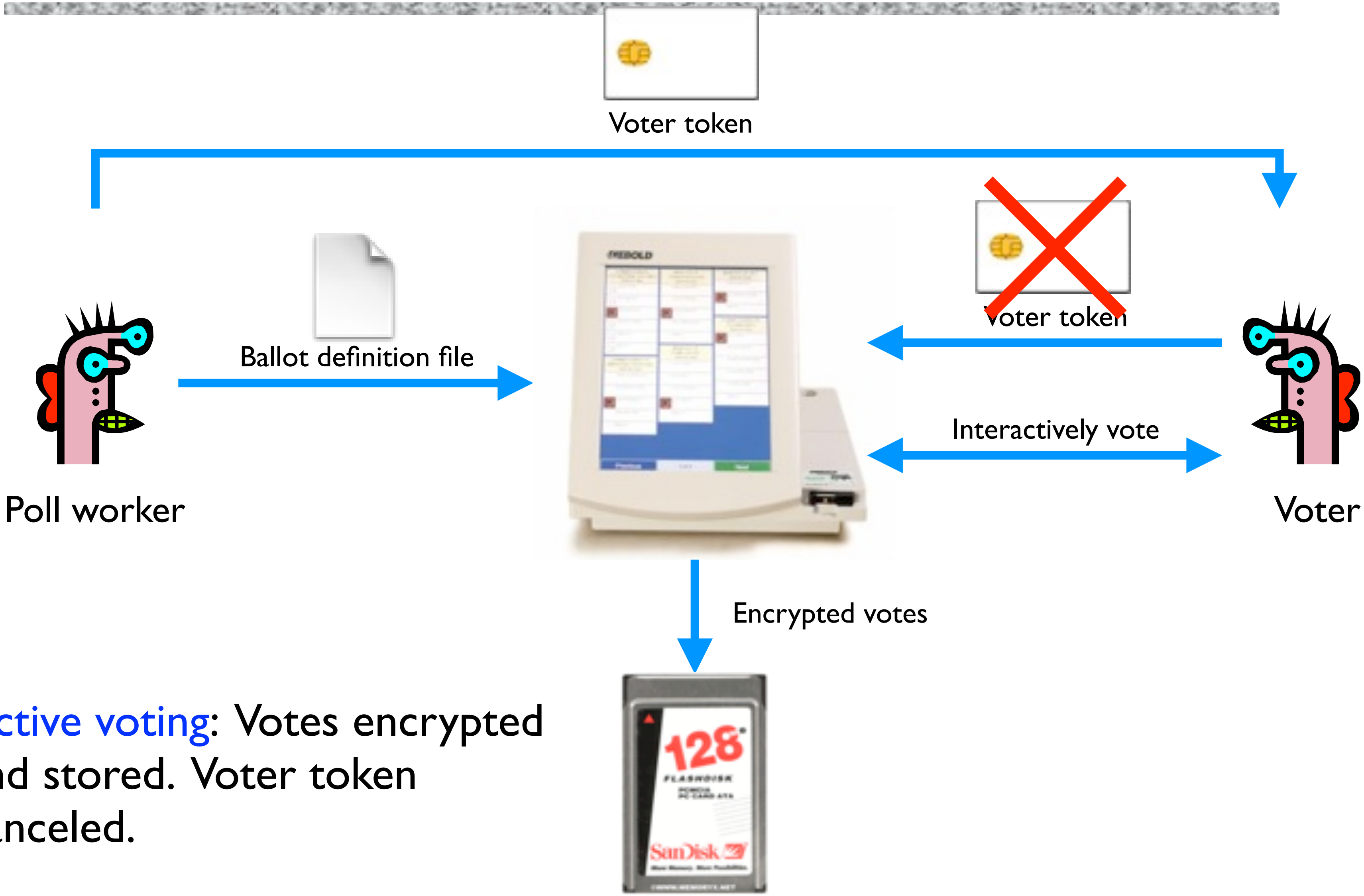
Poll worker

Voter

Encrypted votes

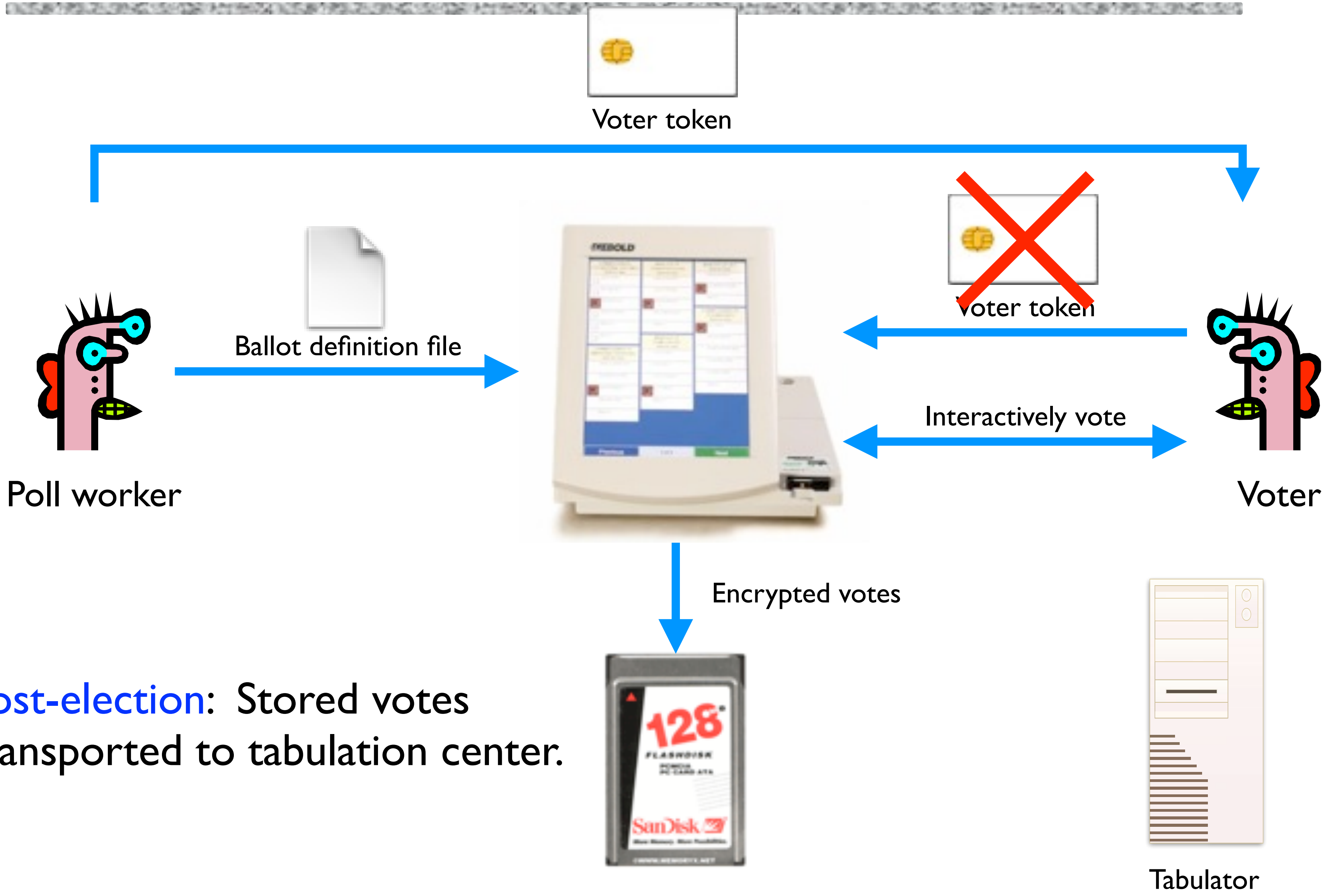
Active voting: Votes encrypted and stored. Voter token canceled.

Active Voting



Active voting: Votes encrypted and stored. Voter token canceled.

Post-Election



Voter token

Ballot definition file

Voter token

Interactively vote

Poll worker

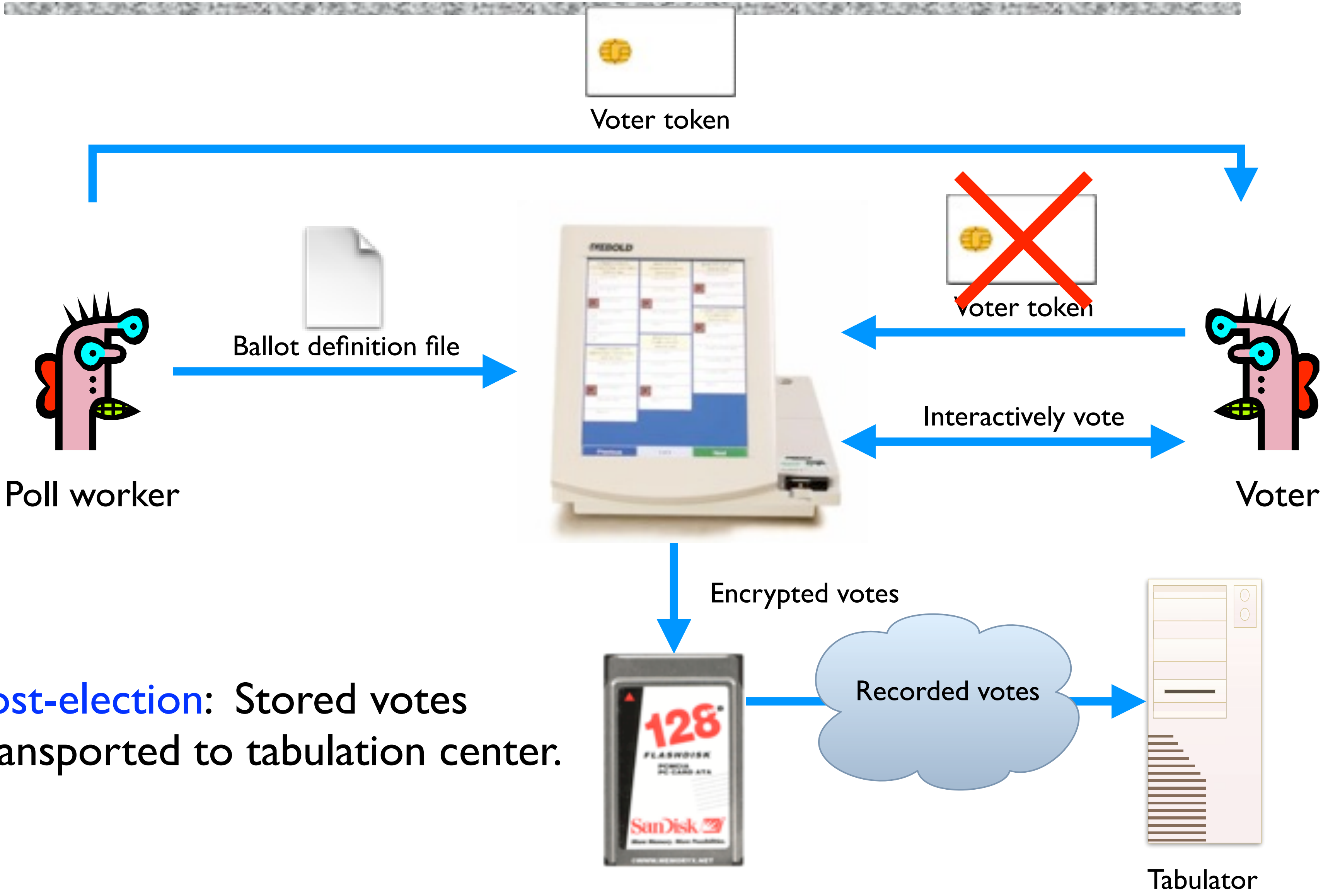
Voter

Encrypted votes

Tabulator

Post-election: Stored votes transported to tabulation center.

Post-Election



Post-election: Stored votes transported to tabulation center.