CSE 484 / CSE M 584: Computer Security and Privacy

Fall 2024

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Announcements

- Things Due:
  - Ethics Form: Due Monday
  - Homework #1: Due next Friday
    - Use the Ed discussion board to find groups
    - Will talk a little more about ethics on Monday
  - Research Readings (CSE M 584): Due next Thursday (and every Thursday thereafter)
- Will announce office hour schedule, to start next week, ASAP

Ethics

- To learn to defend systems, you will learn to attack them. You must use this knowledge ethically.

- In order to get a non-zero grade in this course, you must electronically sign the "Security and Privacy Code of Ethics" form by 11:59pm on Monday, September 30.

(Linked from the course schedule)

We will also repeatedly consider ethics (more generally) as part of our curriculum throughout the course (see HW1, for example).

Course Prerequisites

- Required: Data Abstractions (CSE 332)
- Required: Hardware/Software Interface (CSE 351)
- **Assume: Working knowledge of C and assembly**
  - **One of the labs will involve writing buffer overflow attacks in C**
  - **You must have (or develop) 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 JavaScript**
- **Assume: Ability to learn new programming languages / skills easily**

Discussion

- Everyone in this class deserves to be in this class!
- We are all coming to this course with different backgrounds and experiences
- There are no bad questions; never belittle a questioner or their question; always be supportive
- Instructors / staff aren't always aware of everything, so please call our attention to things as needed
  - E.g., someone might harm someone else with what they say without ever realizing that what they said is harmful; that harm still exists, regardless of whether there was an intent to harm

THREAT MODELING

Threat Modeling (Security Reviews)

- Assets: What are we trying to protect? How valuable are those assets?
- Adversaries: Who might try to attack, and why?
- Vulnerabilities: How might the system be weak?
- Threats: What actions might an adversary take to exploit vulnerabilities?
- Risk: How important are assets? How likely is exploit?
- Possible Defenses
- Not "traditional" threat modeling, but important:
  - Benefits: Who might the system benefit, and how?
  - Harms: Who might the system harm, and how?

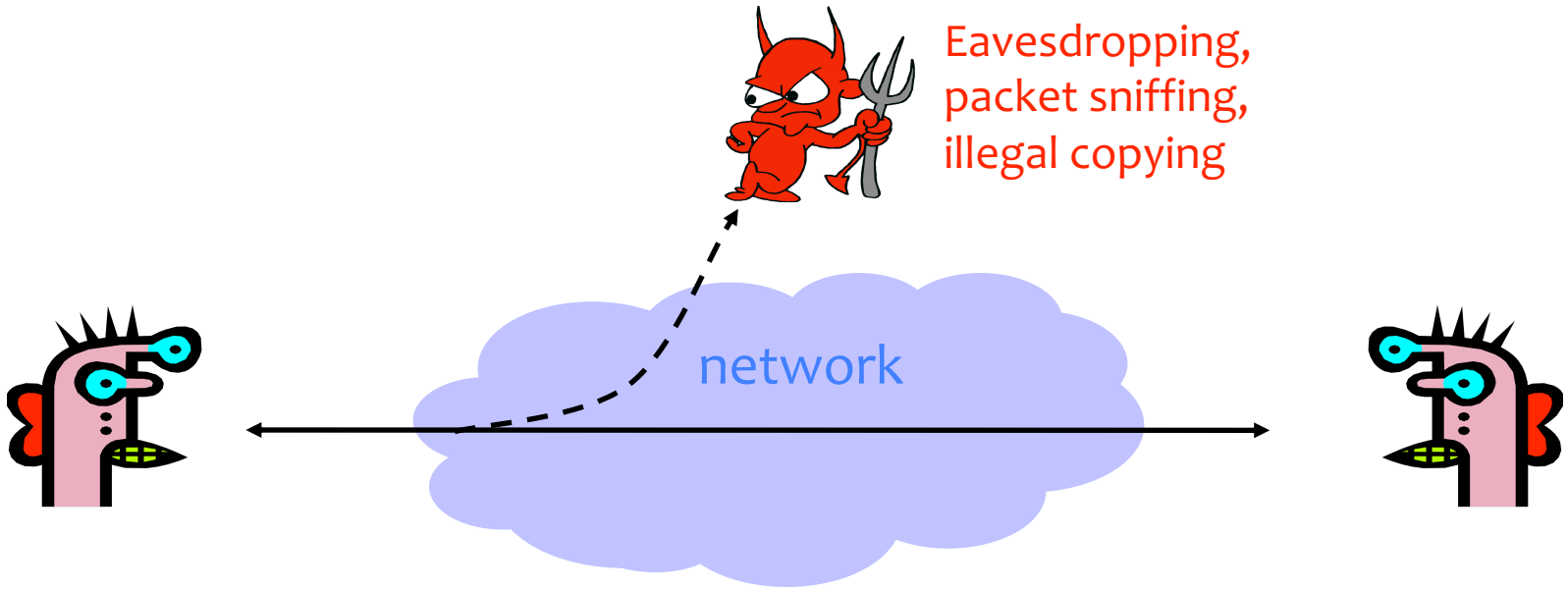
What's *Security*, Anyway?

- Common general security goals: "CIA"
  - Confidentiality
  - Integrity
  - Availability

- Or the extension: CPIAAU (Parkerian Hexad)
  - Confidentiality
  - Possession or Control
  - Integrity
  - Authenticity
  - Availability
  - Utility

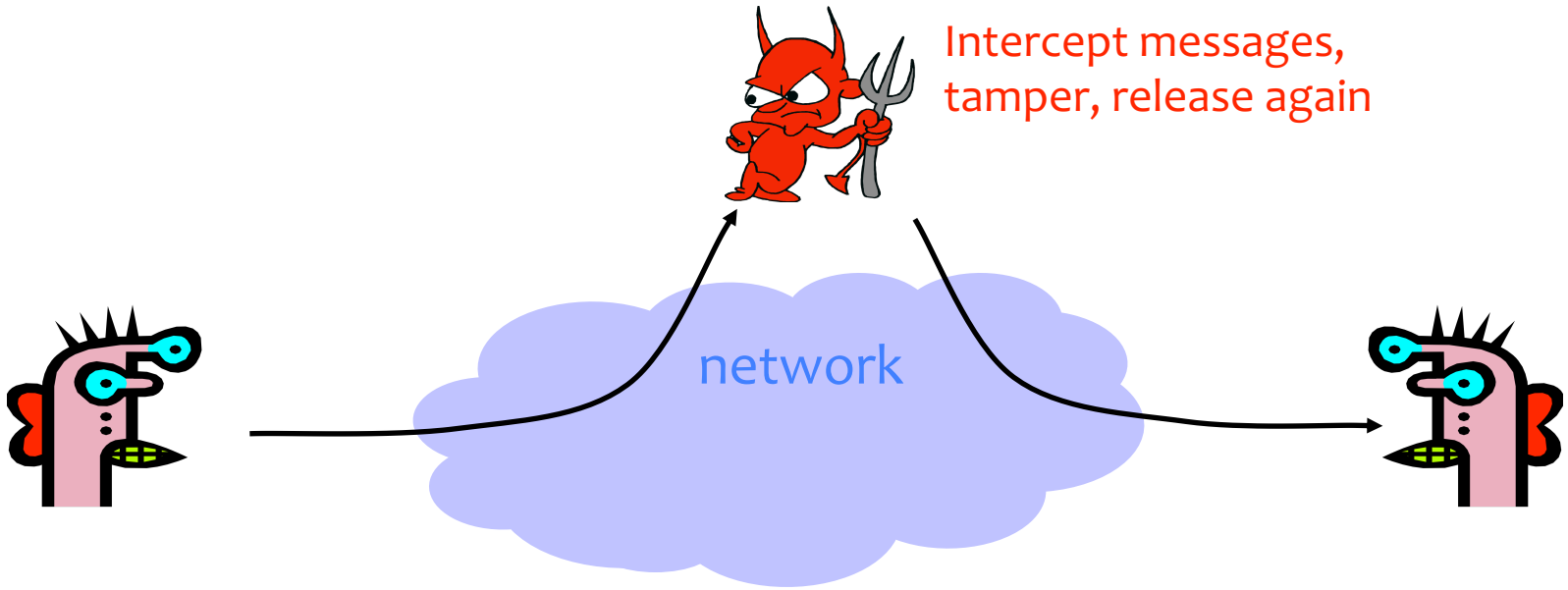
Confidentiality (Privacy)

- Confidentiality is concealment of information.



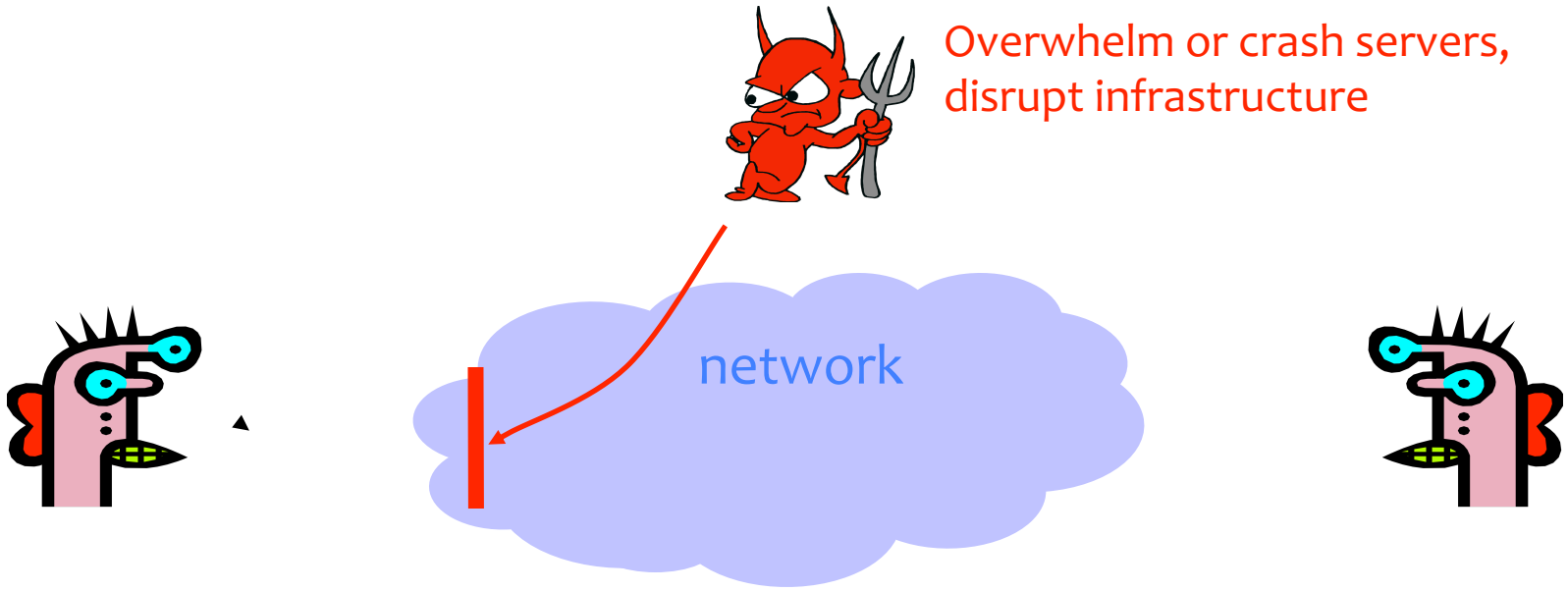
Integrity

- Integrity is prevention of unauthorized changes.



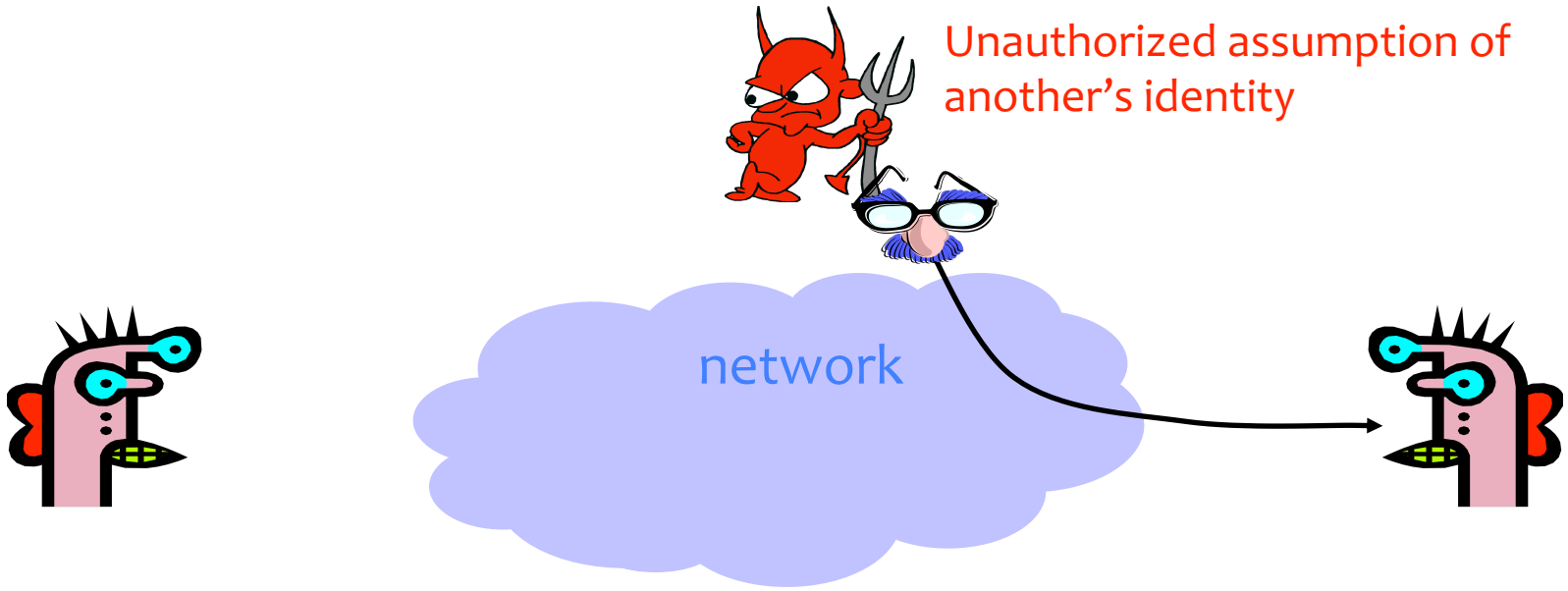
Availability

- Availability is ability to use information or resources.



Authenticity

- Authenticity is knowing who you're talking to.

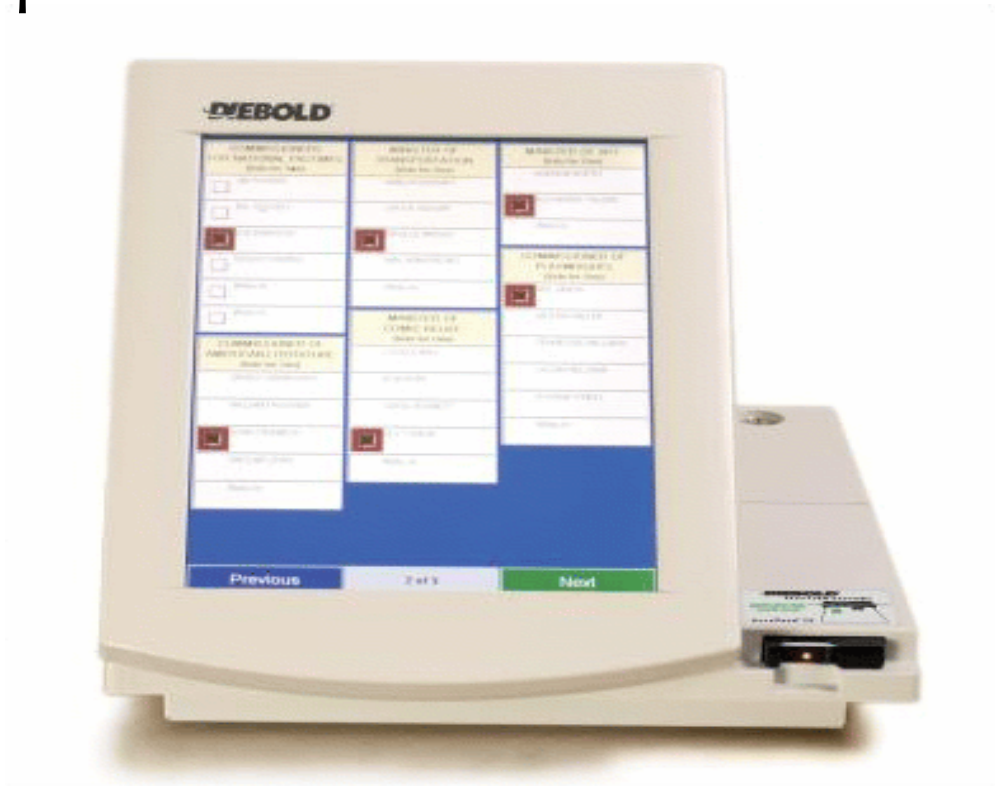


Threat Modeling

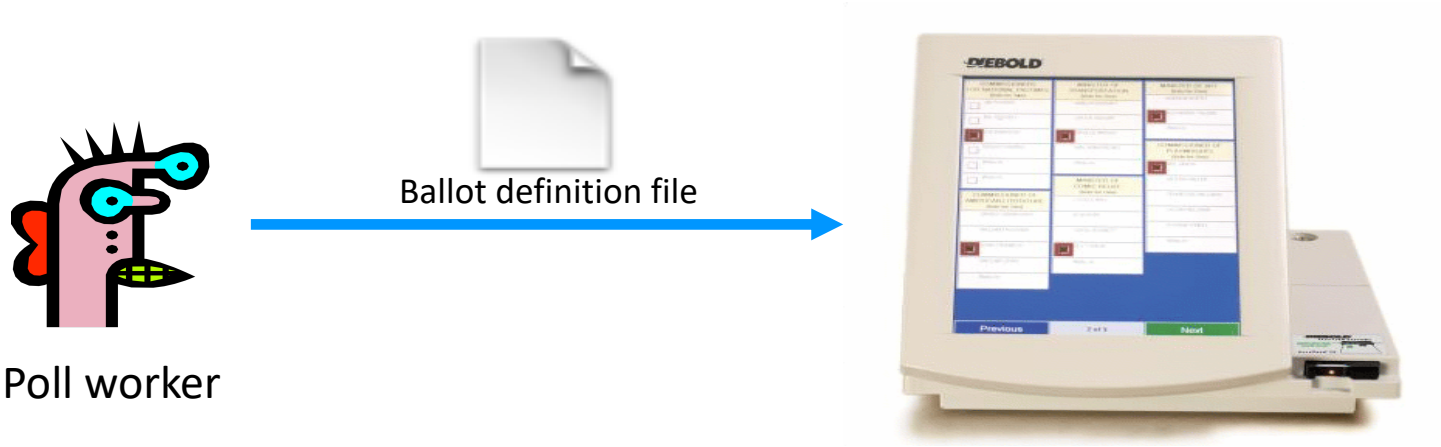
- There's no such thing as perfect security
  - But, attackers have limited resources
  - **Make them pay unacceptable costs / take on unacceptable risks to succeed!**
- Defining security per context: identify assets, adversaries, motivations, threats, vulnerabilities, risk, possible defenses

Threat Modeling Example: Electronic Voting

- Popular replacement to traditional paper ballots

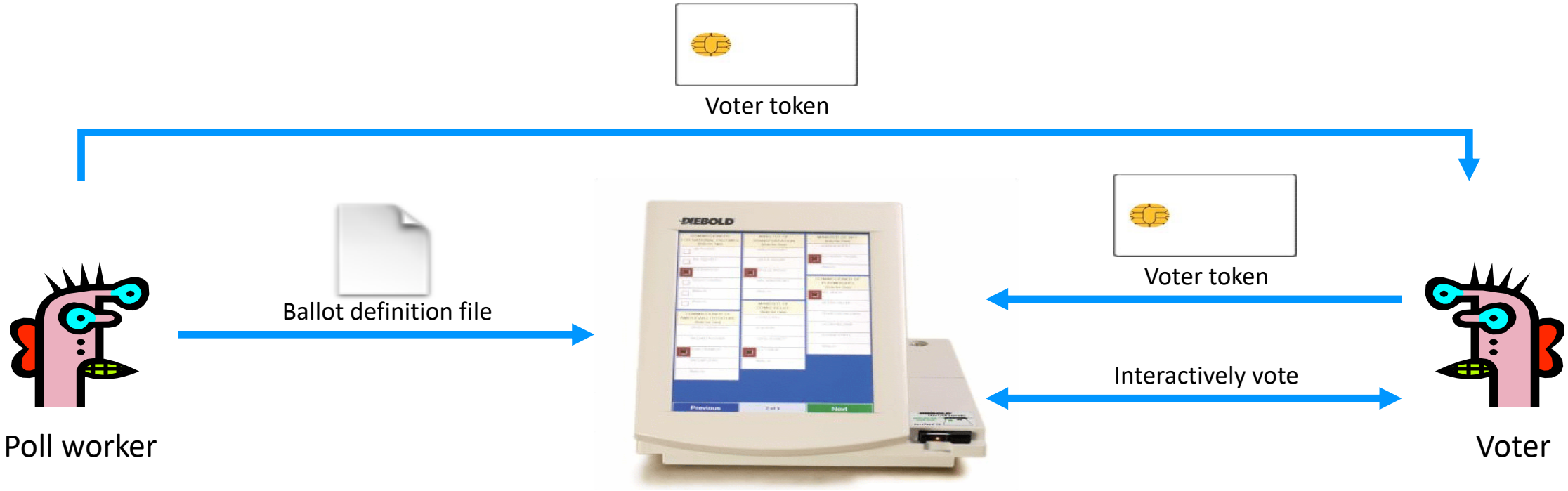


Pre-Election



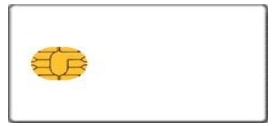
Pre-election: Poll workers load "ballot definition files" on voting machine.

Active Voting



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

Active Voting



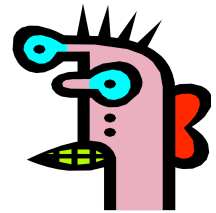
Voter token

Ballot definition file

Poll worker

Voter token

Interactively vote

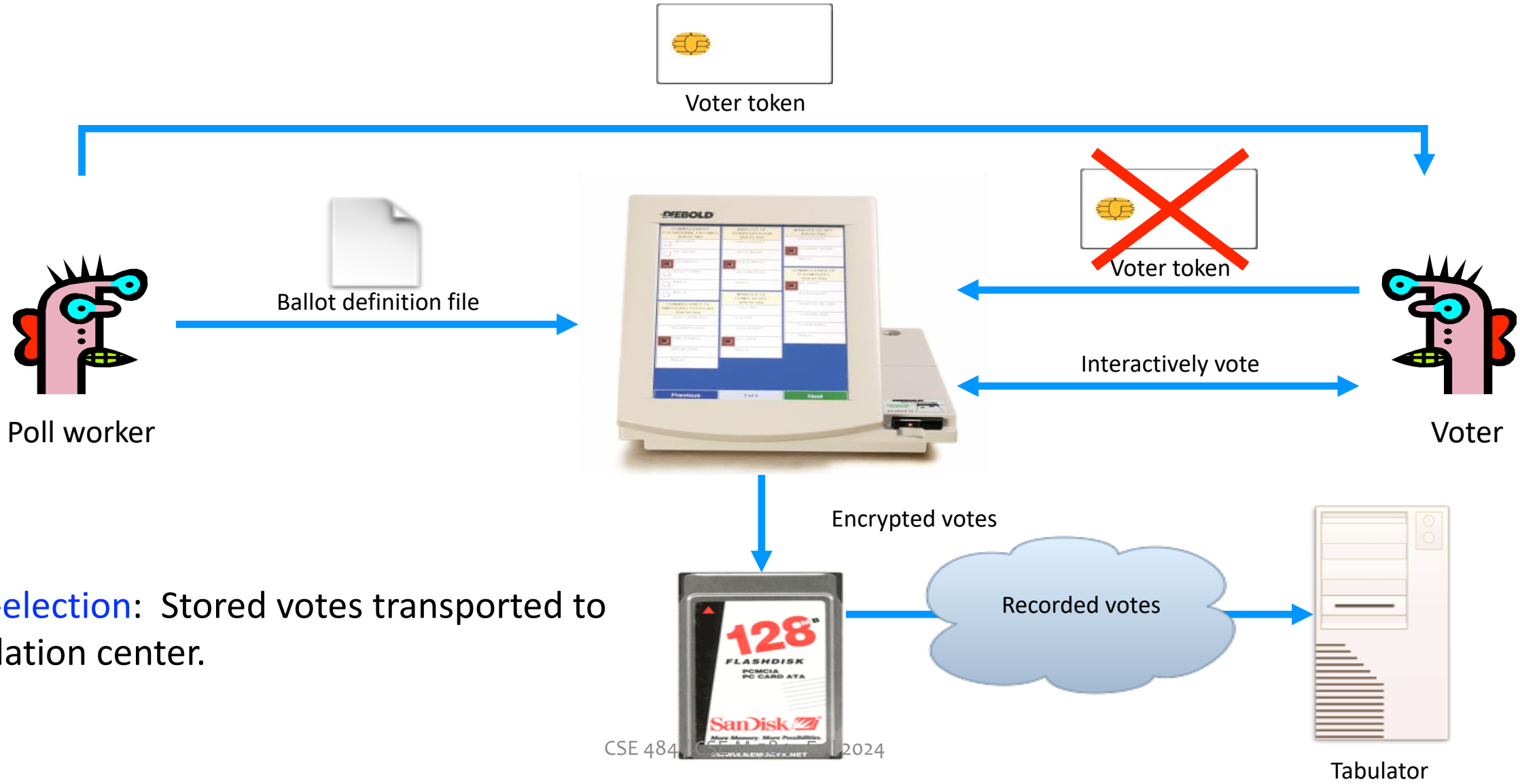


Voter

Encrypted votes

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

Post-Election



Post-election: Stored votes transported to tabulation center.

In-Class "Worksheet"

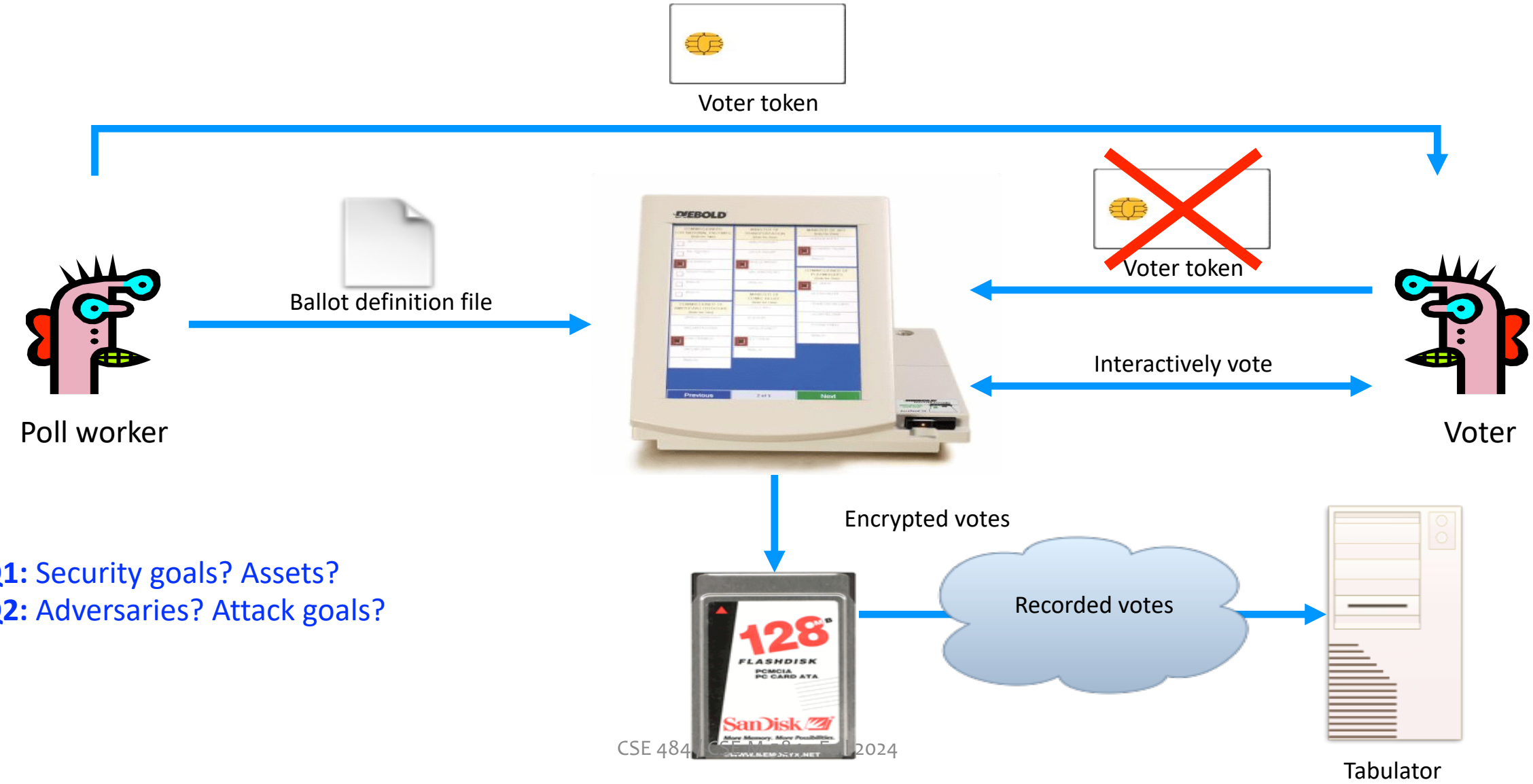
(not yet graded today, just practice)

- Go to **second** 484/584 Gradescope, look for 9/27 activity: https://www.gradescope.com/courses/881751/assignments/5050917
- Fill out the questions while discussing with your neighbor(s)
  - Everyone should submit their own
  - **No need for polish or complete sentences** – jot things down as you would on a piece of paper
- Q1: What do you think are the **security goals** of the electronic voting system described in class and shown above? What would be some of the **assets** that must be protected?
- Q2: Who are the **adversaries** who might try to attack this electronic voting system? What might be the **attacker's goals**? What potential **threats or vulnerabilities** do you see?

Security and E-Voting (Simplified)

- Functionality goals:
  - Easy to use, reduce mistakes/confusion, make voting more accessible
- Security goals?

Can You Spot Any Potential Issues?



Q1: Security goals? Assets?
Q2: Adversaries? Attack goals?

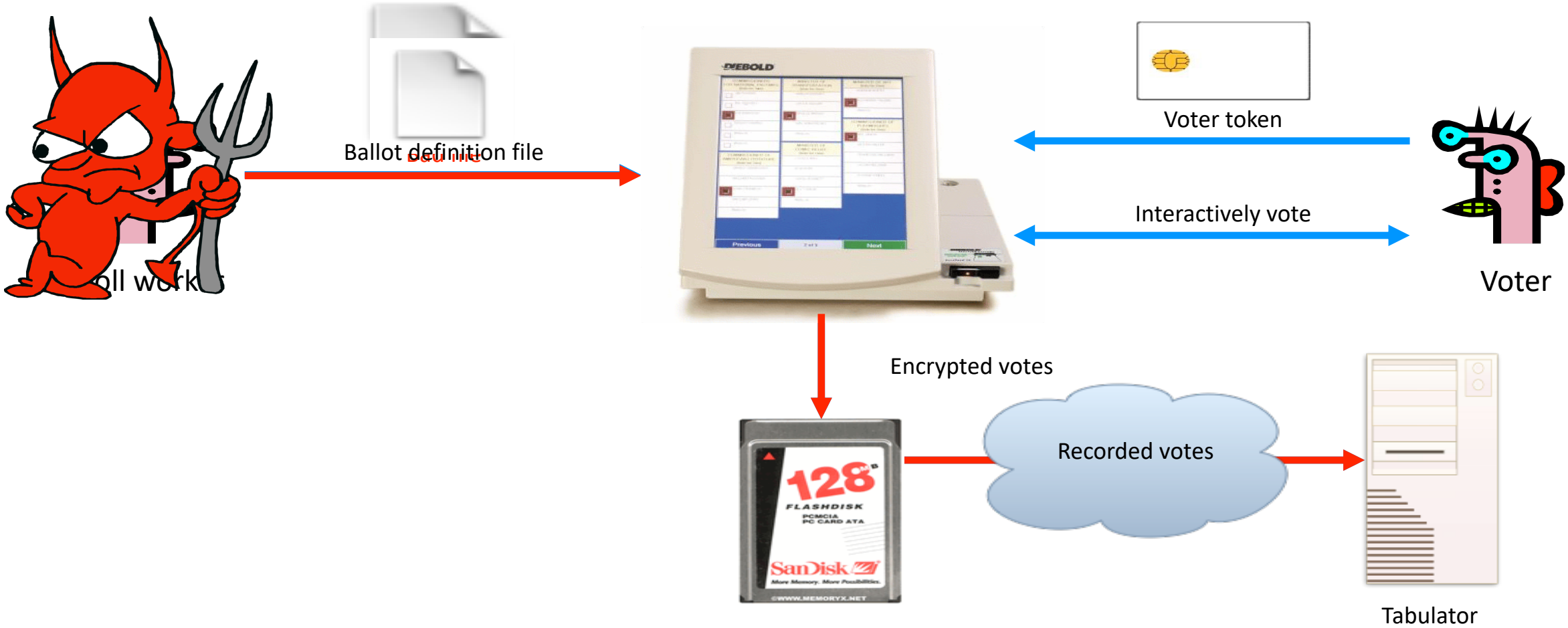
What Software is Running?

Problem: An adversary (e.g., a poll worker, software developer, or company representative) able to control the software or the underlying hardware could do whatever they wanted.


KEYS TO THE KINGDOM
Photo taken from Diebold's online store. The keys that open every Diebold touch-screen voting machine. Working copies have been made from the photo.

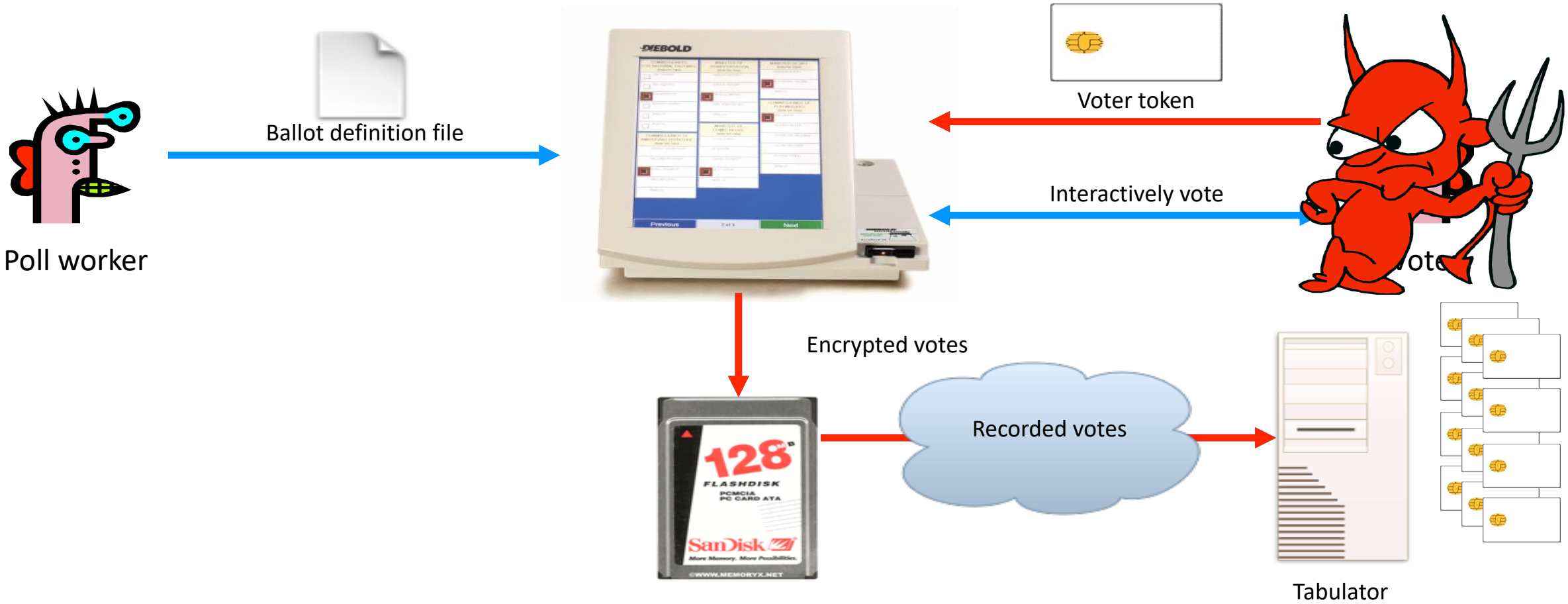
Problem: Ballot definition files are not authenticated.

Example attack: A malicious poll worker could modify ballot definition files so that votes cast for "Mickey Mouse" are recorded for "Donald Duck."



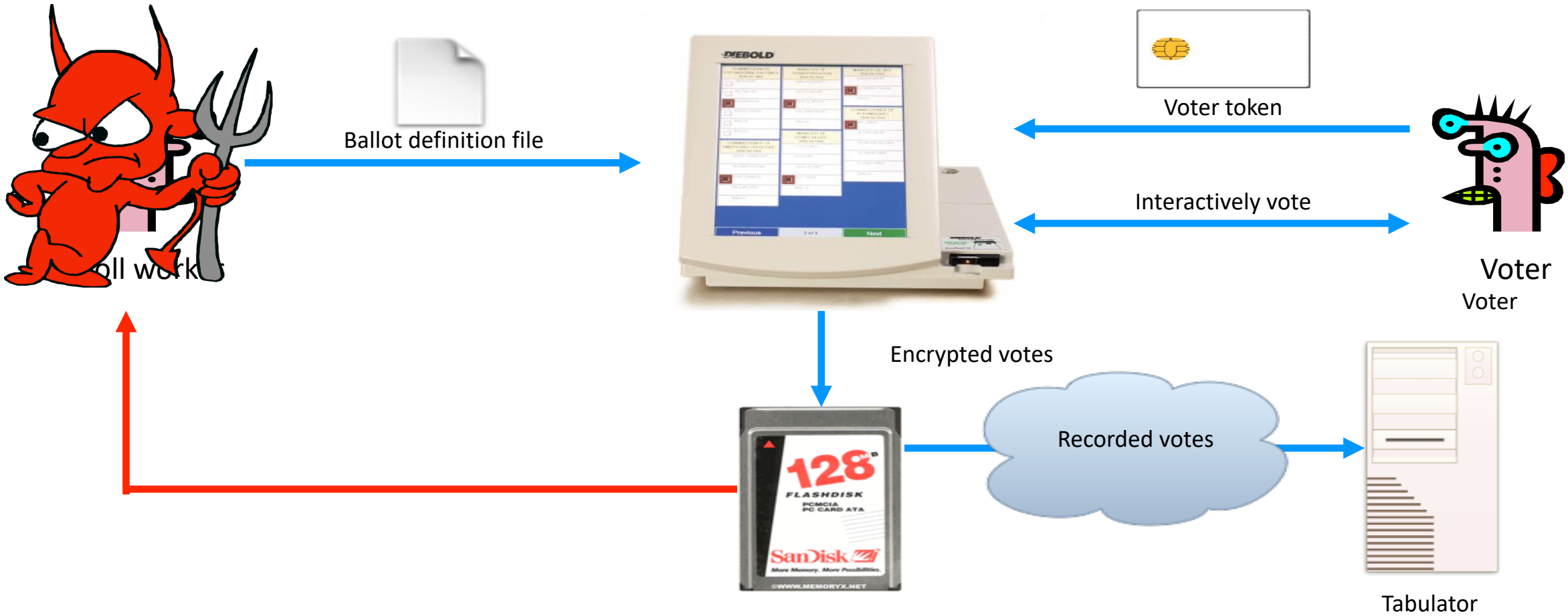
Problem: Smartcards can perform cryptographic operations. But there is no authentication from voter token to terminal.

Example attack: A regular voter could make their own voter token and vote multiple times.



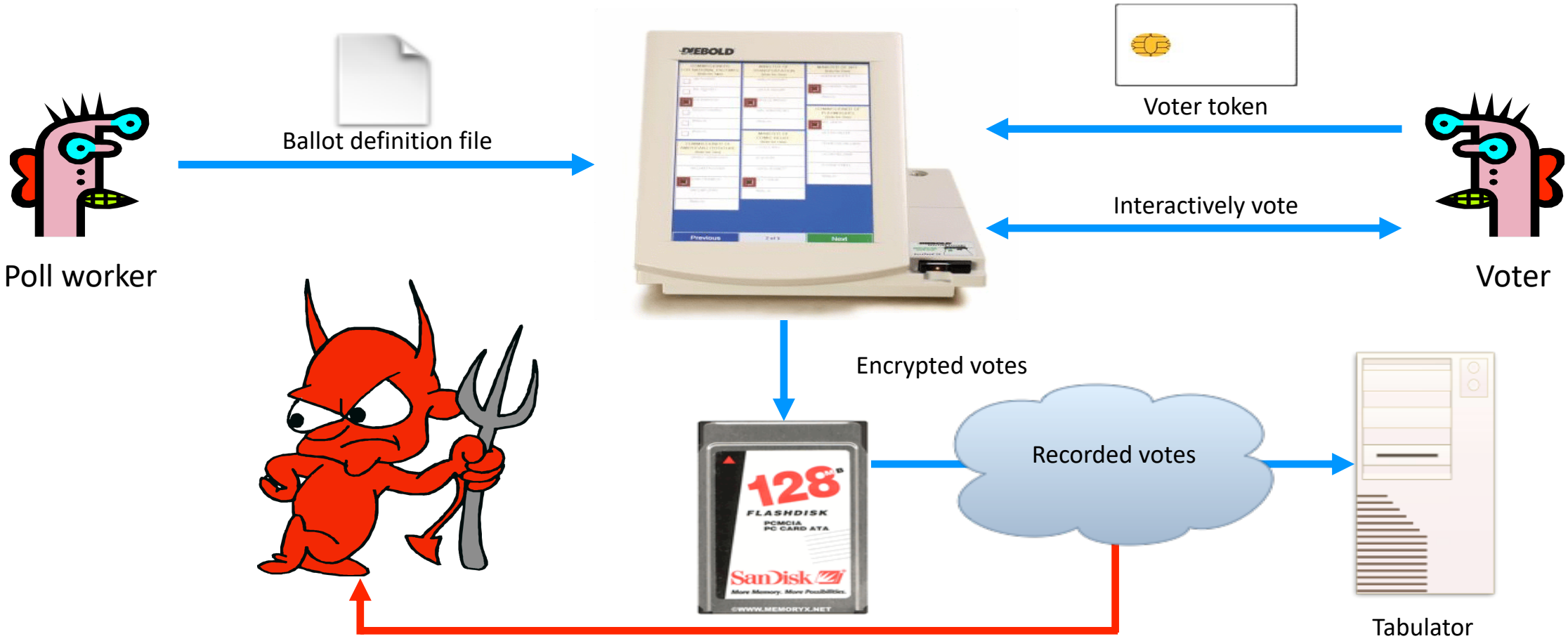
Problem: Encryption key ("F2654hD4") hard-coded into the software since (at least) 1998. Votes stored in the order cast.

Example attack: A poll worker could determine how voters vote.



Problem: When votes transmitted to tabulator over the Internet or a dialup connection, they are decrypted first; the cleartext results are sent the the tabulator.

Example attack: A sophisticated outsider could determine how voters vote.



TOWARDS DEFENSES

Approaches to Security

- Prevention
  - Stop an attack
- Detection
  - Detect an ongoing or past attack
- Response and Resilience
  - Respond to / recover from attacks

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

Whole System is Critical

- Securing a system involves a whole-system view
  - Cryptography
  - Implementation
  - People
  - Physical security
  - Everything in between

- This is because "security is only as strong as the weakest link," and security can fail in many places
  - No reason to attack the strongest part of a system if you can walk right around it.

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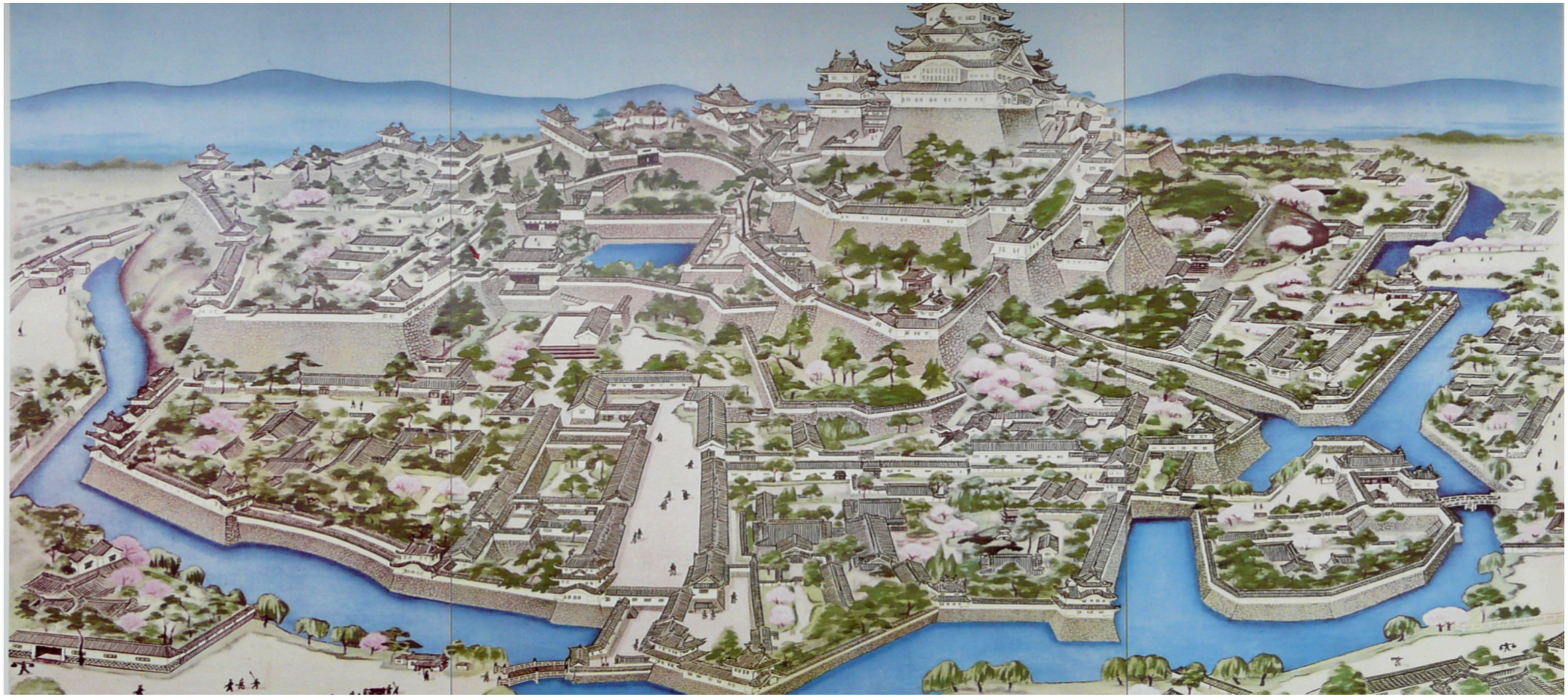
Attacker's Asymmetric Advantage



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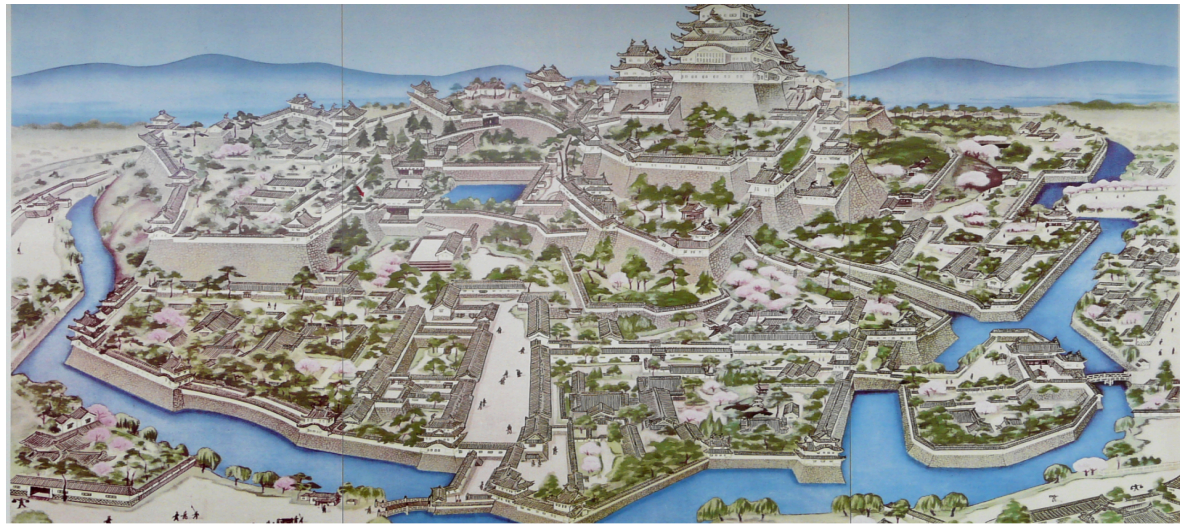

- Attacker only needs to win in one place
- Defender's response: Defense in depth

From Policy to Implementation

- After you've figured out what security means to your application, there are still challenges:
  - Requirements bugs and oversights
    - Incorrect or problematic goals
  - Design bugs and oversights
    - Poor use of cryptography
    - Poor sources of randomness
    - …
  - Implementation bugs and oversights
    - Buffer overflow attacks
    - …
  - Is the system **usable**?

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
    - Related question: Do system developers / companies really understand the needs and values of all their users? Or all stakeholders who might be impacted by the system?
  - But the relationship between these goals is quite complex (e.g., will customers choose features or security?)

Better News

- There are a lot of defense mechanisms
  - We'll study some, but by no means all, in this course
- It's important to understand their limitations
  - "If you think cryptography will solve your problem, then you don't understand cryptography… and you don't understand your problem" -- Bruce Schneier