CSE 484/M584: Computer Security (and Privacy)

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Admin

- Office hours are posted
  - They will start FRIDAY (none today or Thursday)
  - My office hours are Friday afternoons 230-330.
  - We have a LOT of office hours. Use them!
- Lab 1 will be posted tomorrow/tonight.
  - 1a will be due next Wednesday (Section should get you 90% of the way done)

Threat Modeling

Threat Modeling

- Assets: What are we trying to protect?
- 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: What mitigations do we have available?
- Not "traditional" threat modeling, but important (both in general, and to help better understand the system prior to threat modeling):
  - Benefits: Who might the system benefit, and how?
  - Harms: Who might the system harm, and how?

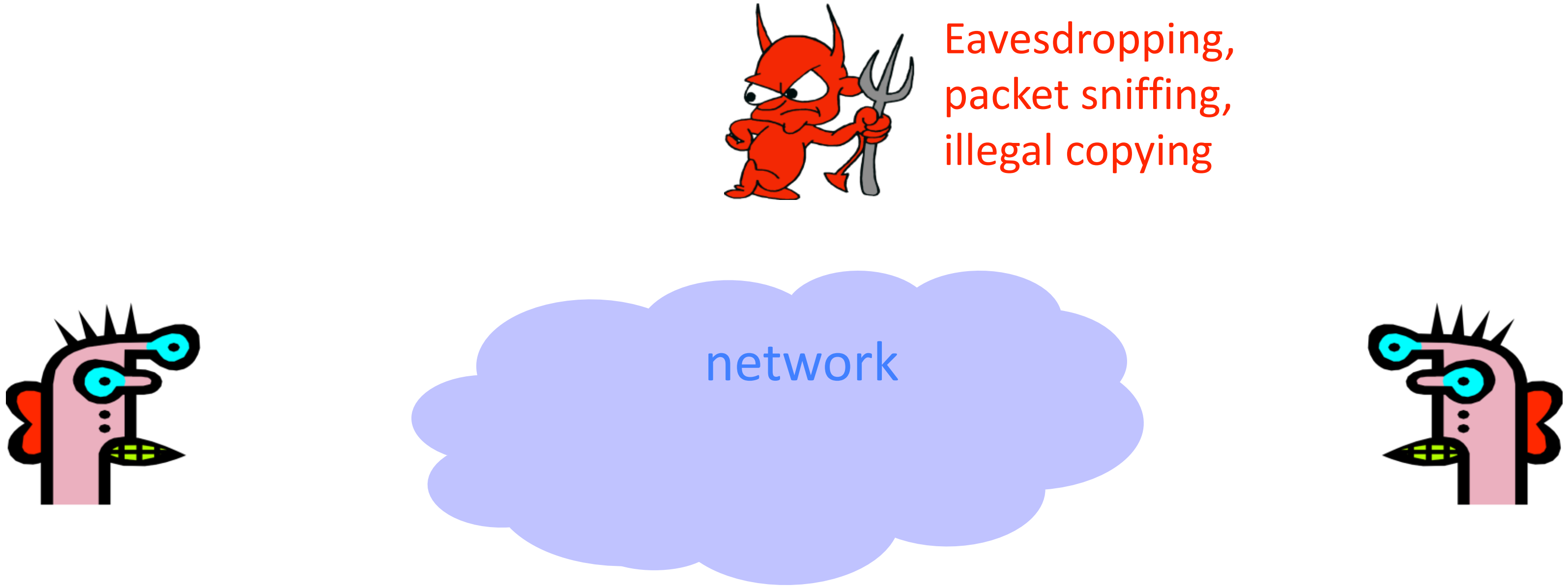
What's *Security*, Anyway?

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

- Or the extension: CPIAAU (Parkerian Hexad)
  - Control
  - Authenticity
  - Utility

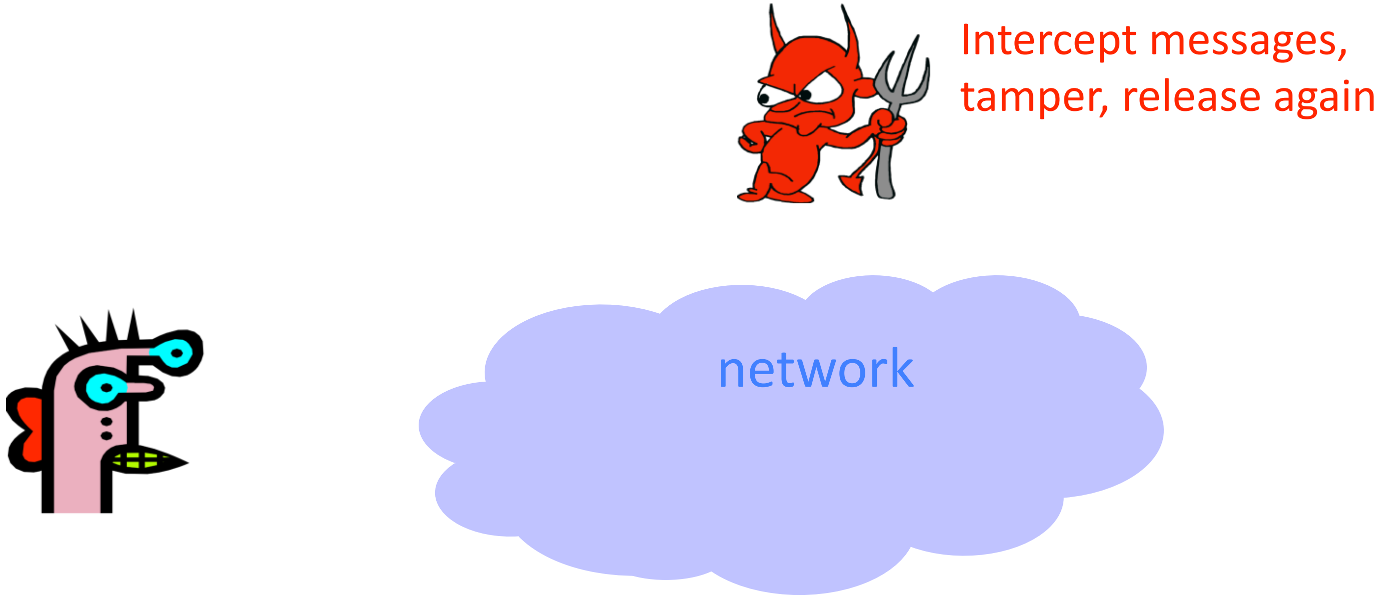
Confidentiality (Privacy)

- Confidentiality is concealment of information.



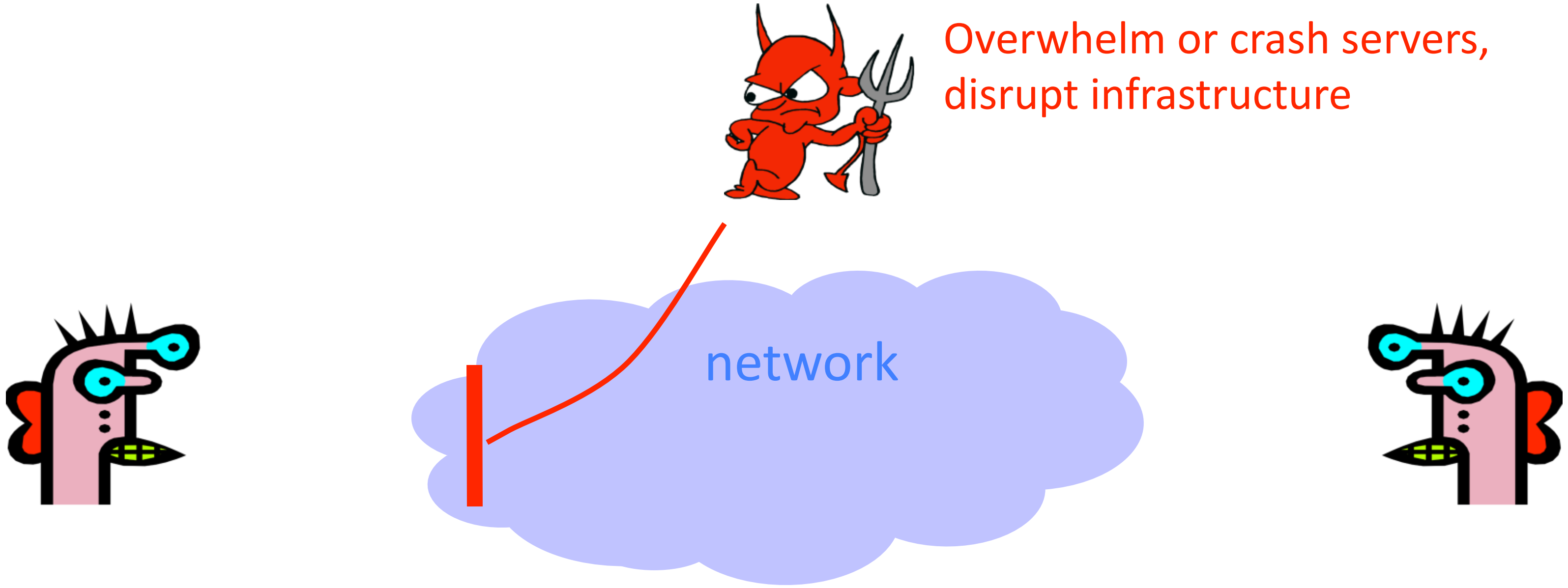
Integrity

- Integrity is prevention of unauthorized changes.



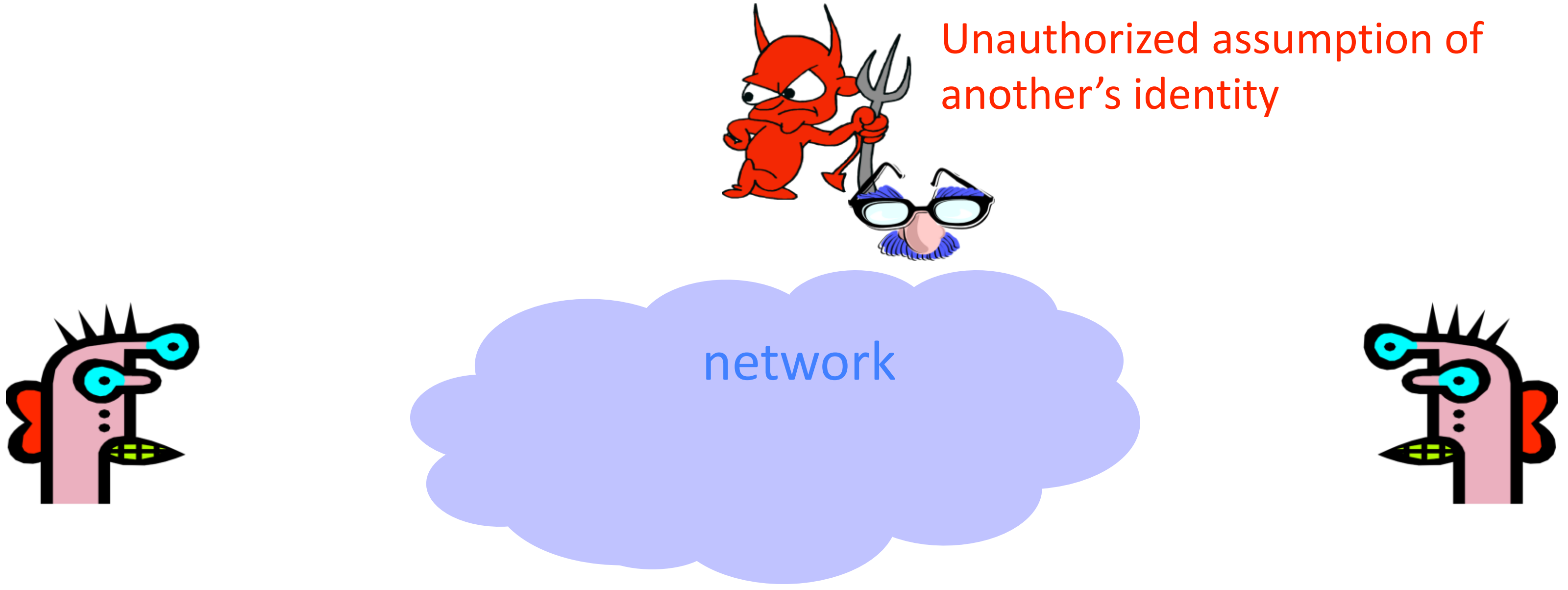
Availability

- Availability is ability to use information or resources.



Authenticity

- Authenticity is knowing who you're talking to.



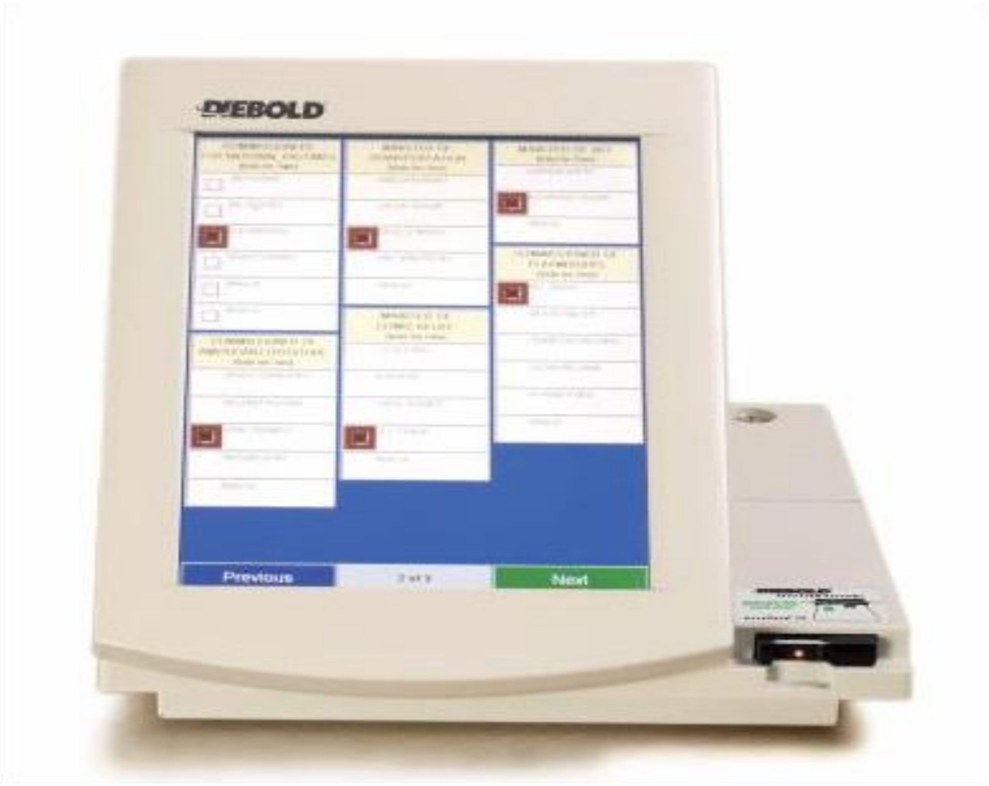
Threat Modeling

- 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

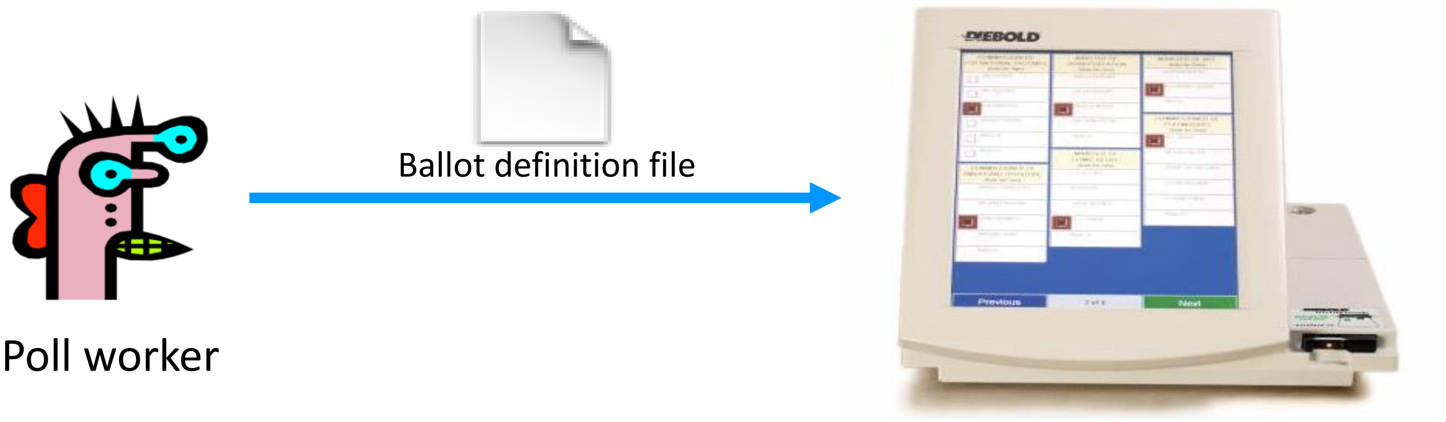


AP

Before we get into the system itself

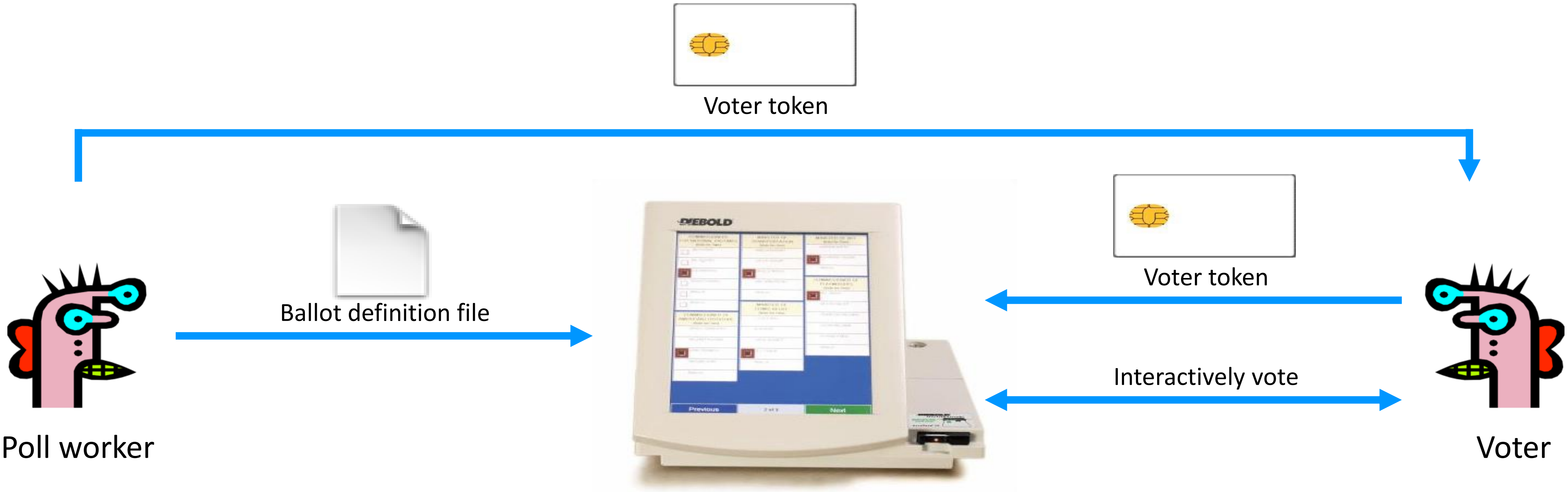
- Think about how in-person electronic voting must work
  - Machines
  - Votes
  - Voters
  - Etc.
- Lightning round threat modeling!
  - Assets?
  - Adversaries?
  - Risks (What might happen if assets are compromised?)
  - Defenses?

Pre-Election



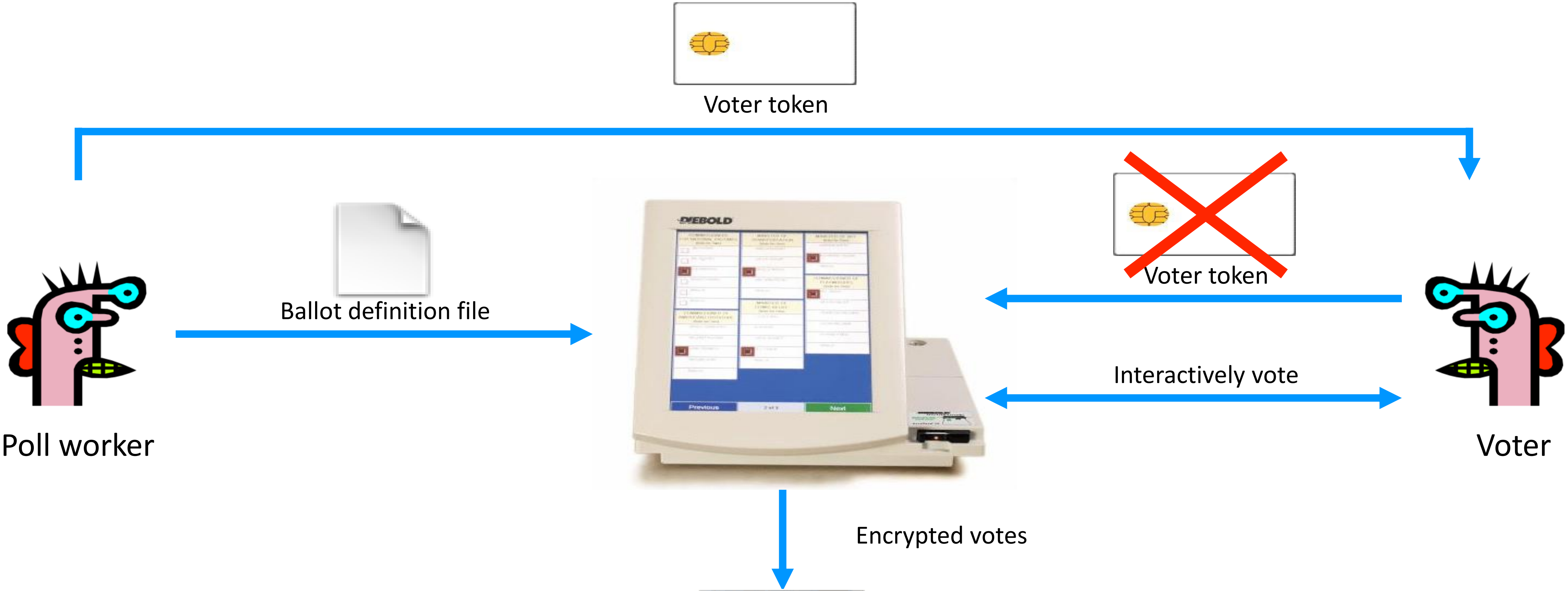
Pre-election: Poll workers load “ballot definition files” on voting machine.

Active Voting



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

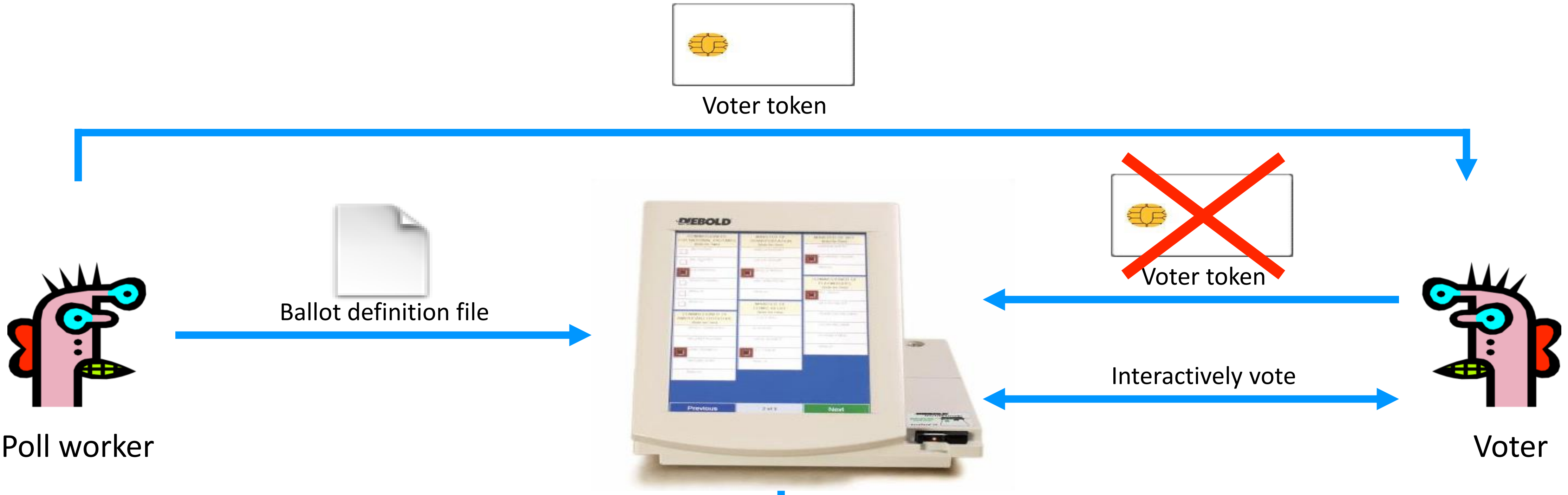
Active Voting

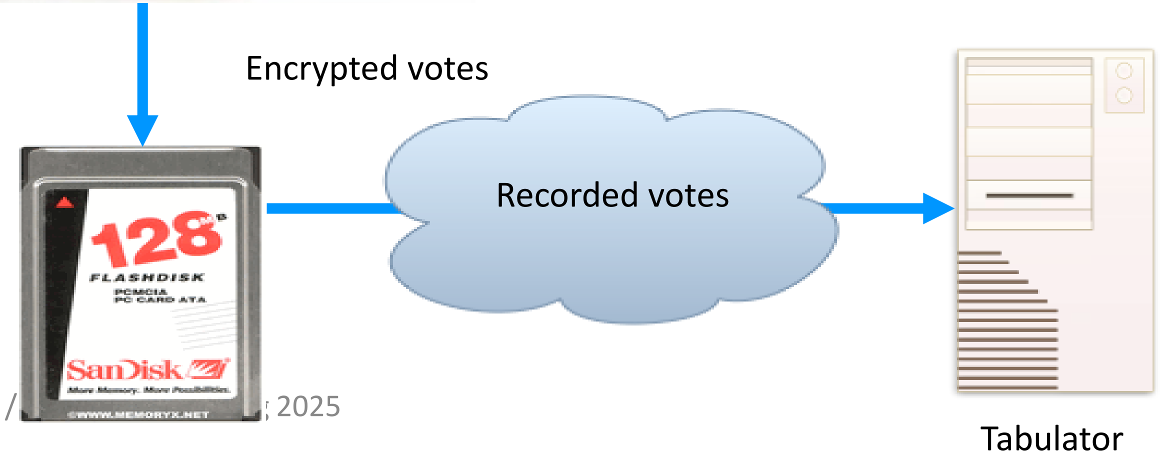


Active voting: Votes encrypted and stored.

Voter token canceled.

Post-Election



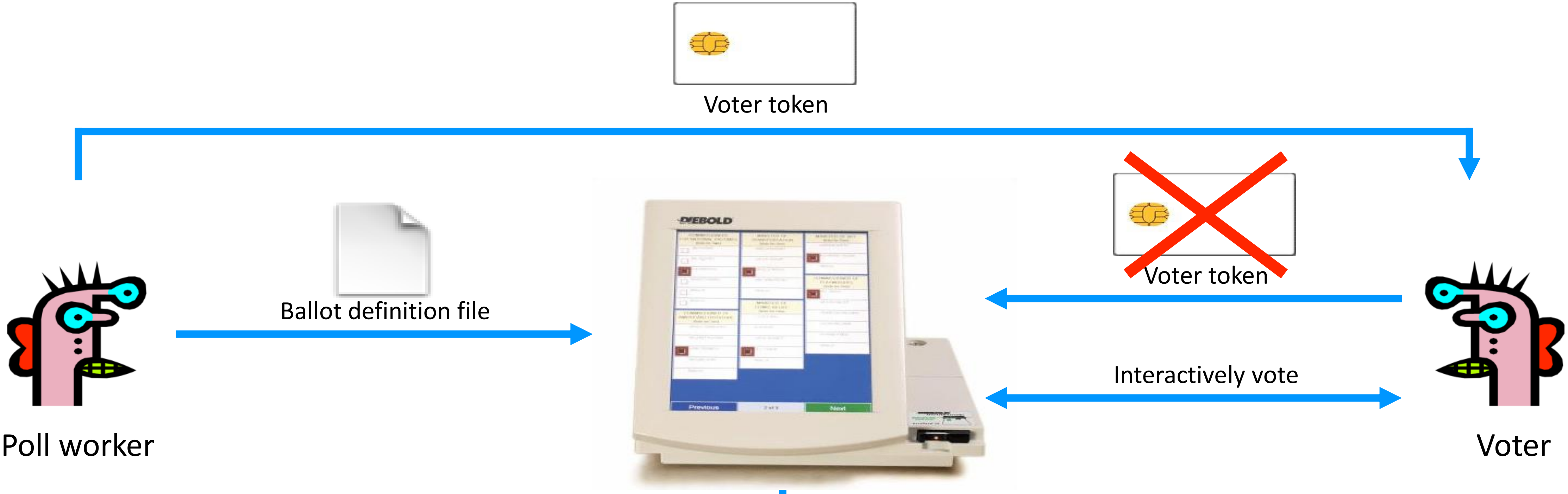


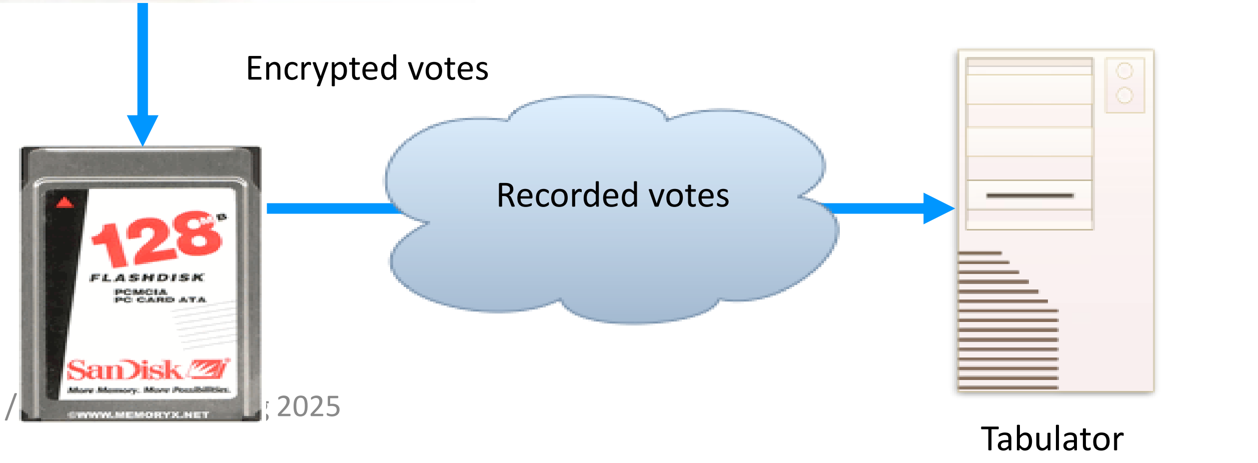
Post-election: Stored votes transported to tabulation center.

Threat modeling – In detail

- Gradescope
- Fill out the questions while discussing with your neighbors
  - Everyone should submit their own
  - **Polish not required, get down some good ideas!**

Post-Election





Post-election: Stored votes transported to tabulation center.


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.

The x86(_64)

First technical component of the course

- Understanding classic binary vulnerabilities and exploitation techniques
- We'll be doing everything on x86 (32 or 64bit)
- Code will be in C
  - Lab 1: very little C
  - FP: More C

Reminders

- Manual memory management
- Strings are ‘just’ arrays of bytes, *no length field*
  - Strings only end when there is a NUL(NULL) byte.
- Pointers/integers/etc are all just bytes

C strings

```
void main(int argc, char* argv[]){
    char string1[32];

    memset(string1, 'a', 32);
    string1[31] = 0x00; // or, '\0'

    printf("String1: %s\n", string1);

    memset(string1, 'a', 32);

    printf("String1, again: %s\n", string1);
}
```

Attacks on Memory Buffers

- Buffer is a pre-defined data storage area inside computer memory (stack or heap)
- Typical situation:
  - A function takes some input that it writes into a pre-allocated buffer.
  - The developer forgets to check that the size of the input isn't larger than the size of the buffer.
  - Uh oh.
    - "Normal" bad input: crash
    - "Adversarial" bad input : take control of execution

Stack Buffers

- Suppose Web server contains this function

```
void func(char *str) {
    char buf[126];
    ...
    strcpy(buf,str);
    ...
}
```

- No bounds checking on strcpy()
- If str is longer than 126 bytes
  - Program may crash
  - Attacker may change program behavior

Example: Changing Flags

- Suppose Web server contains this function

```
void func(char *str) {
        byte auth = 0;
    char buf[126];
    ...
    strcpy(buf,str);
    ...
}
```

- Authenticated variable non-zero when user has extra privileges
- Morris worm also overflowed a buffer to overwrite an authenticated flag in fingerd

Memory Layout

- Text region: Executable code of the program
- Heap: Dynamically allocated data
- Stack: Local variables, function return addresses; grows and shrinks as functions are called and return

Stack Buffers

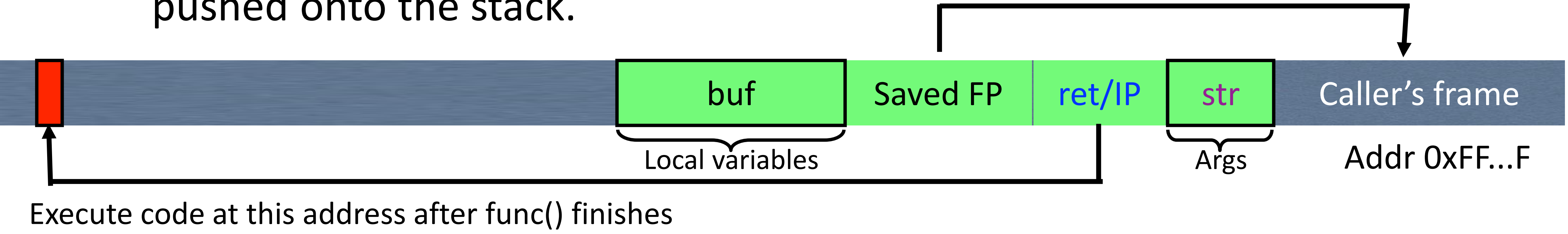
- Suppose Web server contains this function:

```
void func(char *str) {
        char buf[126];
        strcpy(buf,str);
}
```

Allocate local buffer (126 bytes reserved on stack)

Copy argument into local buffer

- When this function is invoked, a new frame (activation record) is pushed onto the stack.



What if Buffer is Overstuffed?

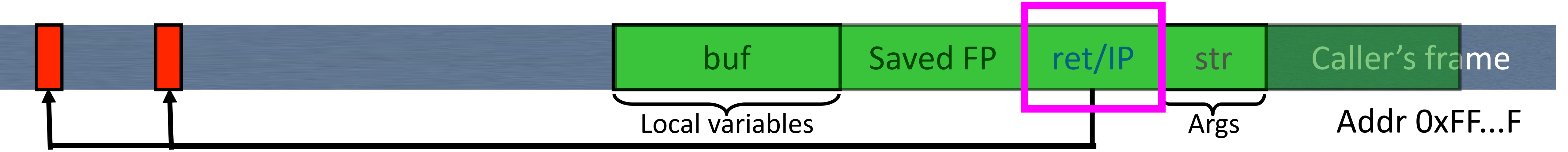
- Memory pointed to by str is copied onto stack…

```
void func(char *str) {
        char buf[126];
        strcpy(buf,str);
}
```

strcpy does NOT check whether the string at *str contains fewer than 126 characters

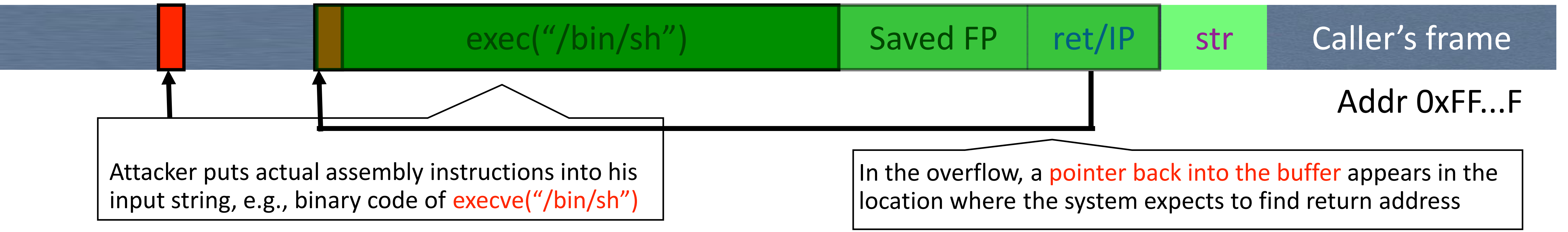
- If a string longer than 126 bytes is copied into buffer, it will overwrite adjacent stack locations.

This will be interpreted as return address!



Executing Attack Code

- Suppose buffer contains attacker-created string
  - For example, str points to a string received from the network as the URL



- When function exits, code in the buffer will be executed, giving attacker a shell **("shellcode")**
  - Root shell if the victim program is setuid root