ECE 471 – Embedded Systems
Lecture 22

Vince Weaver
http://www.eece.maine.edu/~vweaver
vincent.weaver@maine.edu

25 October 2017

Announcements

- Don't forget HW#7

Computer Security and why it matters for embedded systems

- Most effective security is being unconnected from the world and locked away in a box. Until recently most embedded systems matched that.
- Modern embedded systems are increasingly connected to networks, etc. Embedded code is not necessarily prepared for this.
- Internet of Things

The Problem

- Untrusted inputs from user can be hostile.
- Users with physical access can bypass most software security.

What can an attacker gain?

- Fun / Mischief
- Profit
- A network of servers that can be used for illicit purposes (SPAM, Warez, DDOS)
- Spying on others (companies, governments, etc)

Sources of Attack

- Untrusted user input
  Web page forms
  Keyboard Input

- USB Keys (CD-ROMs)
  Autorun/Autostart on Windows
  Scatter usb keys around parking lot, helpful people plug into machine.

- Network

cellphone modems
ethernet/internet
wireless/bluetooth

- Backdoors
  Debugging or Malicious, left in place

- Brute Force – trying all possible usernames/passwords

Types of Compromise

- Crash
  "ping of death"

- DoS (Denial of Service)

- User account compromise

- Root account compromise

- Privilege Escalation

- Rootkit
- Re-write firmware? VM? Above OS?

Unsanitized Inputs

- Using values from users directly can be a problem if passed directly to another process
- SQL injection attacks; escape characters can turn a command into two, letting user execute arbitrary SQL commands; xkcd `Robert '); DROP TABLE Students;--`
- If data (say from a web-form) directly passed to a UNIX shell script, then by including characters like `;` can issue arbitrary commands

Buffer Overflows

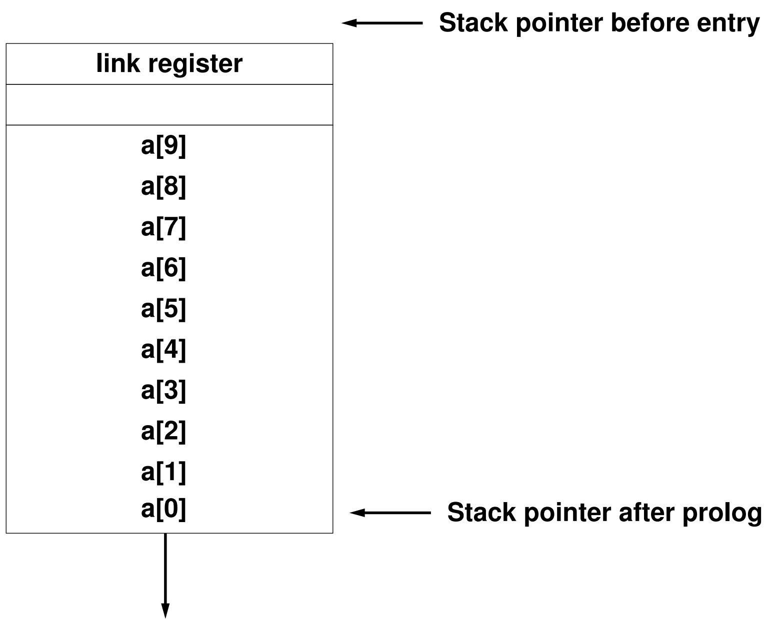
- User (accidentally or on purpose) copies too much data into a fixed sized buffer.
- Data outside expected area gets over-written. This can cause a crash (best case) or if user carefully constructs code, can lead to user taking over program.

Buffer Overflow Example

```
void function(int *values, int size) {
    int a[10];

    memcpy(a,values,size);

    return;
}
```

Maps to

```
    push    {lr}
    sub sp,#44

    memcpy

    add sp,#44
    pop {pc}
```



A value written to a[11] overwrites the saved link register. If you can put a pointer to a function of your choice there you can hijack the code execution, as it will be jumped to at function exit.

Mitigating Buffer Overflows

- Extra Bounds Checking / High-level Language (not C)
- Address Space Layout Randomization
- Putting lots of 0s in code (if strcpy is causing the problem)
- Running in a "sandbox"

Dangling Pointer / Null Pointer Dereference

- Typically a NULL pointer access generates a segfault
- If an un-initialized function pointer points there, and gets called, it will crash. But until recently Linux allowed users to mmap() code there, allowing exploits.
- Other dangling pointers (pointers to invalid addresses) can also cause problems. Both writes and executions can cause problems if the address pointed to can be mapped.

Privilege Escalation

- If you can get kernel or super-user (root) code to jump to your code, then you can raise privileges and have a "root exploit"
- If a kernel has a buffer-overrun or other type of error and branches to code you control, all bets are off. You can have what is called "shell code" generate a root shell.
- Some binaries are setuid. They run with root privilege but drop them. If you can make them run your code

before dropping privilege you can also have a root exploit. Tools such as ping (requires root to open raw socket), X11 (needs root to access graphics cards), web-server (needs root to open port 80).

Finding Bugs

- Source code inspection
- Watching mailing lists
- Static checkers (coverity, sparse)
- Dynamic checkers (Valgrind). Can be slow.
- Fuzzing