ECE 471 – Embedded Systems Lecture 14

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Announcements

- HW#6 is out
  reboot after using i2c (i.e. running hw5 code)
  how to set high an i2c bus
- HW#5 grades posted
  code comments?
- Project Overview
- Midterm review

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.

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

- 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.

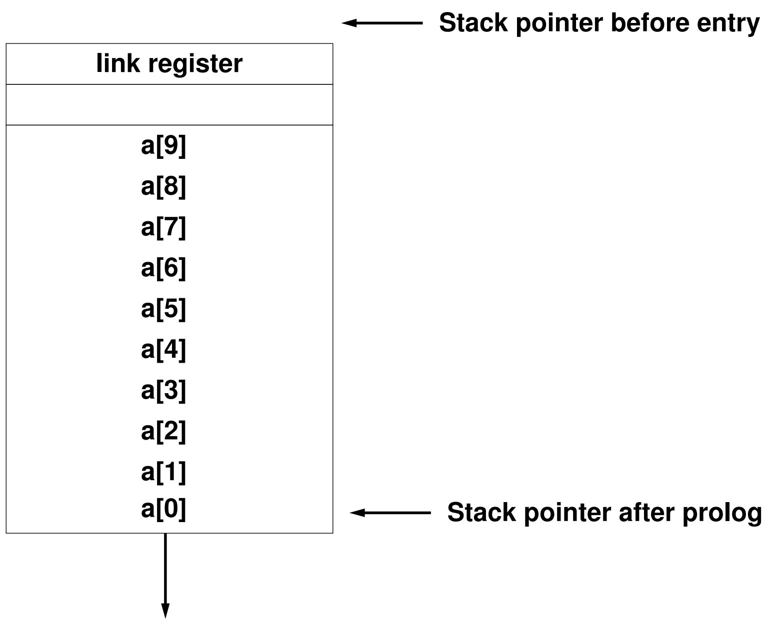
- Data outside expected area gets over-written. This can cause a crash (best case) or if user carefully constructs code, can lead to user taking over program.

Buffer Overflow Example

```c
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 be used to 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