

ECE 471 – Embedded Systems

Lecture 17

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Announcements

- HW#4 is out
- Project will be released soon



Low-Level C for Homework Review

- Can use high-level `fopen()`, `fscanf()`, and `fclose()` for this assignment
- Digression on how `sleep()` and `usleep()` work.
- Review how double/float work under C, and how to cast from `int` to `float`.



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.



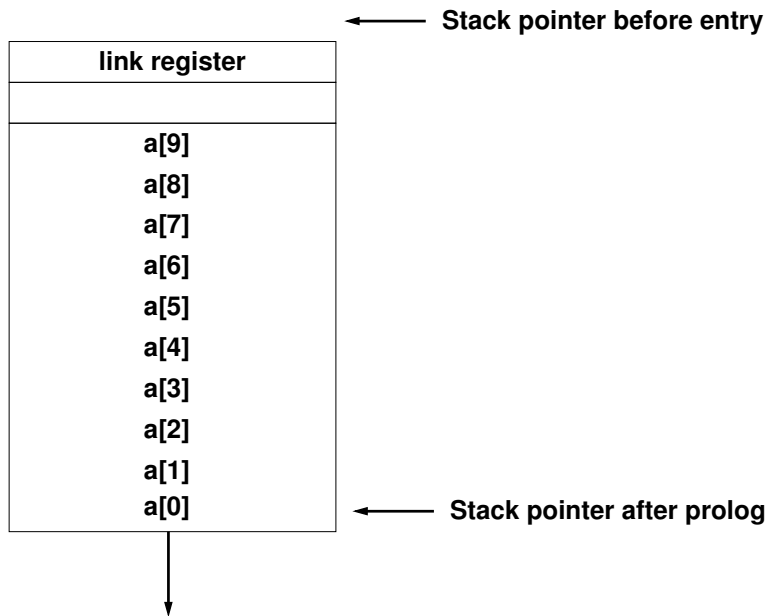
Buffer Overflow Example

```
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-overflow 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

