ECE 471 – Embedded Systems
Lecture 25

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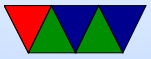
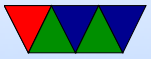
Announcements

- Don't forget HW#8
- Don't forget Project topics
- First 10 minutes of class is research presentation along with ECE100



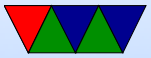
Types of Security Compromise

- Crash
  "ping of death"
- DoS (Denial of Service)
- User account compromise
- Root account compromise
- Privilege Escalation
- Rootkit
- Re-write firmware? VM? Above OS?



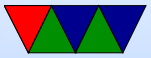
Unsanitized Inputs

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



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.

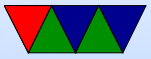


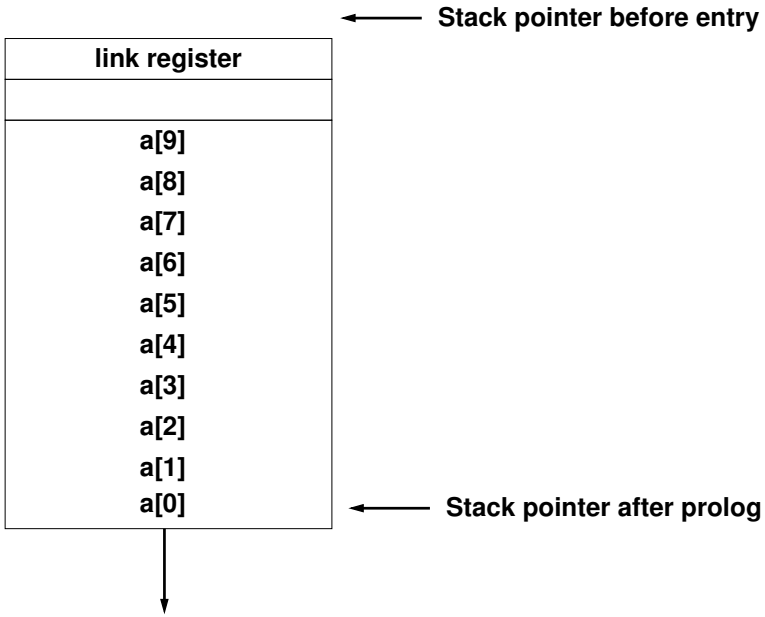
Buffer Overflow Example

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

    memcpy(a,values,size);

    return;
}
```

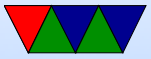
Maps to

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

    memcpy

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



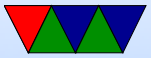


A value written to a[11] overwrites the saved link register. If you can put a pointer to a function of your choice there you can hijack the code execution, as it will be jumped to at function exit.



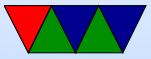
Mitigating Buffer Overflows

- 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”



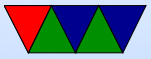
Dangling Pointer / Null Pointer Dereference

- 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.

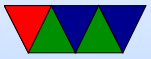


Privilege Escalation

- 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

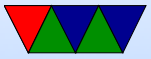


before dropping privilege you can also have a root exploit. Tools such as ping (requires root to open raw socket), X11 (needs root to access graphics cards), web-server (needs root to open port 80).



Information Leakage

- Can leak info through side-channels
- Detect encryption key by how long other processes take? Power supply fluctuations? RF noise?
- Timing attacks
- Meltdown and Spectre



Finding Bugs

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