# ECE 471 – Embedded Systems Lecture 13

Vince Weaver

http://web.eece.maine.edu/~vweaver

vincent.weaver@maine.edu

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# Announcements

- Don't forget homework #4

# Homework #3 – Exit

- Exit – value is an integer which goes into r0
- Note it is an integer, not ASCII
- Be sure to comment your code and fix any wrong comments

# Homework 3 – ARM32 vs THUMB2

- ARM32 – `0x1048C - 0x1041c = 0x70 = 112 bytes`
- Thumb2 – `0x10468 - 0x10414 = 0x54 = 84 bytes`
- Note it's bytes not bits. Also no need to divide by 4.
- Differences?
  - Thumb2 some instructions are 16-bit rather than 32-bit
  - Thumb2 different instructions (like movt/movw)

# Homework 3 – Code Density

- You need to run `strip` on this to see it. Why?
  Debug info, including extra thumb debug as well as the longer filename.
- You can use `readelf -a` and `readelf -s` to see the space the various segments take up.
  Look at executables, *not* the C source code.
- Sizes

| arch | unstripped | stripped |
|---|---|---|
| C arm32 | 11584 | 5544 |
| C thumb2 | 11580 | 5548 |
| asm arm32 | 1308 | 536 |
| C static | 493572 | 414820 |

- You would think THUMB2 would be much smaller, but the assembler makes some poor decisions about wide/narrow instructions.

- Reference my LL work

- C code is larger, but also remember to include the C

library:

```
ls -lart /lib/arm-linux-gnueabihf/libc-2.24.so
-rwxr-xr-x 1 root root 1234700 Jan 14  2018 /lib/arm-linux-gnueabihf/libc-2.24.so
```

- There are embedded C libraries, musl, newlib, uclibc, which are much smaller and often used in embedded systems.

# Homework 3 – gdb

- crashes!
- have to use awful gdb interface
- line 9 is the crash
- the assembly is `ldr r0,`

$$r3$$

- if you look at src code or info assem you can see it's dereferencing (following) a NULL (uninitialized) pointer, which is always a segfault on Linux

# Homework 3 – Something Cool

- How would you convert print_number to hexadecimal?
- Is it easier to divide by 16 than 10? Especially w/o a divide instruction?
- Yes, shift and masks. Trick part is to special case 10 to 15 to be A to F

# Homework 3 – Linux Tools

- cal missing days
- Julian to Gregorian calendar.
- People sad who paid weekly but paid rent monthly.
- George Washington's birthday
- Hunt for Red October
- Beware believing any page you google. Some urban legends / joke sites about this. If it were some sort of programmer bug it would have been fixed years ago.

# Operating Systems Types

- Monolithic kernel – everything in one big address space. Something goes wrong, lose it all. Faster

- Microkernel – separate parts that communicate by message passing. can restart independently. Slower.

- Microkernels were supposed to take over the world. Didn't happen. (GNU Hurd?)

- Famous Torvalds (Linux) vs Tannenbaum (Minix) flamewar

# Common Desktop/Server Operating Systems

- Windows
- OSX
- Linux
- FreeBSD / NetBSD / OpenBSD
- UNIX (Irix/Solaris/AIX/etc.)
- BeOS/Haiku

# Embedded Operating Systems

- Microsoft WinCE, Windows Mobile
- Linux / Android
- VXworks – realtime OS, used on many space probes
- Apple iOS
- QNX – realtime microkernel UNIX-like OS, owned by Blackberry now
- Cisco iOS
- ThreadX – found in Pi GPU

# Embedded Linux Distributions

- linaro – consortium that work on ARM software

- openwrt – small distro initially designed for wireless routers

- yocto – Linux Foundation sponsored embedded distro

- maemo – embedded distro originally by Nokia (obsolete)

- MeeGo – continuation of maemo, also obsolete

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- Tizen – Follow up on MeeGo, by Samsung and Intel

- Ängstrom – Merger of various projects

- And many others. It's very easy to put together a Linux distribution