ECE 471 – Embedded Systems Lecture 3

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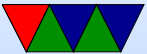
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Announcements

- HW#1 was posted, due Friday

- Reminder: The class notes are posted to the website.

The ARM Architecture

Brief ARM History

- **A**corn **R**ISC **M**achine. Acorn was a computer company in the UK in the 1980s
- Wanted a chip to succeed 6502. Decided to make one themselves. (Good idea, 65816 a pain and only 16-bit)
- 6502 was the chip in Commodore 64, Apple II, NES, Atari 2600
- Fun fact: 6502 co-designed by UMaine alum Chuck Peddle
- Bought by Softbank (Japan) in 2016

RISC / CISC Discussion

- Simple decode. Load/store. Fixed instruction width. 3-operand.
- MIPS is classic RISC
- x86 is classic CISC (with complex instructions)
  Though internally x86 executes uops, RISC
- ARM (predication, auto-increment, barrel shifter)
  Called RISC but has complex instructions

ARM Business Plan

- IP Licensing company. Does not fab own chips. License to other companies

- Other companies take the design, put on SoC, attach whatever other logic blocks are needed

- Relatively small company compared to Intel which not only deigns the chip, but fabs, etc.

- Can buy full core (Cortex-AX) or just rights to ISA and make your own (Apple A10)

AMBA Bus Protocol

Advanced Microcontroller Bus Architecture

- ARM System Bus (ASB), ARM Peripheral Bus (APB)

- ARM High Performance Bus (AHB)

- Common bus, various companies can provide logic blocks for it, can swap in and out ARM cores as needed.

ARM Architecture vs Family

- ARMv1 : ARM1
- ARMv2 : ARM2, ARM3 (26-bit, status in PC register)
- ARMv3 : ARM6, ARM7
- ARMv4 : StrongARM, ARM7TDMI, ARM9TDMI
- ARMv5 : ARM7EJ, ARM9E, ARM10E, XScale
- ARMv6 : ARM11, ARM Cortex-M0 (Raspberry Pi A/B)
- ARMv7 : Cortex A8, A9, A15, A7, Cortex-M3 (iPad, iPhone, Pandaboard, Beagleboard, Beaglebone, Pi2)
- ARMv8 : Cortex A50, A53, A57 (64-bit), Pi3

Various abbreviations in Model Names

- Modern Cortex Processors
  - "Application" ARM Cortex-A
  - "Real-time" ARM Cortex-R
  - "Micro-controller" ARM Cortex-M
- ARM7 Processors (example armv4 ARM7TDMI)
  - "E" means DSP instructions
  - "M" improved multiplier
  - "T" THUMB
  - "J" Jazelle (java bytecodes)

- ○ "D" Debug
- ○ "I" ICE (In-circuit Emulator)
- ○ "EE" ThumbExecutionEnvironment, Just-in-time
- ○ NEON – SIMD
- ARM11 Processors (Raspberry Pi is armv6 BCM2835 ARM1176JZF-S)
  - ○ (All have Thumb)
  - ○ S – Synthesizable
  - ○ J – Java Extension
  - ○ Z – TrustZone
  - ○ F – Vector Floating Point Coprocessor

STM32L476-Discovery

- Used in ECE 271
- 32-bit Cortex-M4, 80MHz
- FPU
- Thumb2 ISA
- Low-power (30nA shutdown, 120nA standby)
- Peripherals
  - LCD
  - Timers
  - 1MB Flash, 128k SRAM

○ USB/i2c/USART

Raspberry Pi

What is a Raspberry Pi?

- Raspberry Pi Foundation wanted small board to encourage CS in schools
- Easy to use and cheap enough that students can experiment without worrying too much about bricking it
- Back in the day small micro-computers encouraged hacking, modern Windows systems not so much
- There are other small embedded boards (BeagbleBone, etc.) but Pi is a nice combination of performance, cost, and available software

- Can run many operating systems. Even write your own (see ECE598) or bare metal. We'll be running Linux.

Raspberry Pi Models

- Model Names originally from BBC Micro
- All have more or less same SoC. VideoCore IV GPU runs show (VideoCore VI on pi4)
- First released in 2012

BCM2835/BCM2708 – ARM1176

- Model B – 700MHz ARM1176, 512MB RAM, SD, USB hub+USB Ethernet
- Model B+ – like B but micro-SD, composite video-out inside of audio jack, 4 USB ports, longer GPIO header, re-arranged outputs, more mounting holes, fewer LEDs, lower power
- Model A / Model A+ – less RAM (256MB/512MB), no Ethernet, no USB hub, cheaper, less power
- Zero – 1GHz, 512MB, smaller, cheaper, $5

- Zero W – 1GHz, has wireless, $10
- Compute Node – like B but on SO-DIMM backplane, eMMC

BCM2836/BCM2709 – ARM Cortex A7

- Model2 B – like B+ but with 1GB RAM, 900MHz Quad-core Cortex A7

BCM2837/BCM2710 – ARM Cortex A53

- Model3 B – 64-bit, 1.2GHz Cortex A53, wireless Ethernet, bluetooth
- Model2 B (v1.2) – like Model 2 but with the Cortex A53
- Compute 3
- Model3 B+ – better thermal, faster Ethernet (1GB but maxes at 300MB), power over Ethernet header. Still only 1GB (cost?)
- Model3 A+

BCM2711 – ARM Cortex A72

- Videocore VI at 500MHz
- 1, 2, or 4GB RAM
- USB3
- PCIe if you de-solder USB chip
- Real gigabit ethernet
- GPIO header has more i2c/spi etc options
- Model B