

ECE 471 – Embedded Systems

Lecture 2

Vince Weaver

`http://www.eece.maine.edu/~vweaver`

`vincent.weaver@maine.edu`

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Announcements

- HW#1 will be posted tomorrow (Friday), due next Thursday
- Working on getting the Raspberry Pis setup together.



The ARM Architecture



Brief ARM History

- **Acorn RISC Machine.** 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



RISC aside

- Simple decode. Load/store. Fixed instruction width. 3-operand.
- MIPS
- ARM (predication, auto-increment, barrel shifter)
- x86 (crazy)



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 designs the chip, but fabs, etc.



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.



Models – Confusing

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)
- ARMv7 : Cortex A8, A9, A15, A7, Cortex-M3 (iPad, iPhone, Pandaboard, Beagleboard, Beaglebone)



- ARMv8 : Cortex A50, A57 (64-bit)



Various abbreviations in Model Names

- Modern Cortex Processors
 - “Application” ARM Cortex-A
 - “Real-time” ARM Cortex-R
 - “Micro-controller” ARM Cortex-M
- ARM7 Processors
 - “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)
 - (All have Thumb)
 - S – Synthesizable
 - J – Java Extension
 - Z – TrustZone
 - F – Vector Floating Point Coprocessor



Cortex A9

- Pandaboard, iPad2, etc
- Up to 2GHz.
- Multi-core (1-4 cores)
- Also on-board Cortex-M codec decoders
- L1 cache 32kB i/d
- configurable L2 cache
- out-of-order super-scalar
- neon SIMD
- VFP3 floating point (optional)



STM32F4

- Used in Hummels Class
- ARM Cortex-M4F core, 180 MHz. F is for Floating point
- Static RAM, 64K core coupled memory (CCM), 4K battery-backed, 80B tamper-detect erase.
- Flash ROM: 512 - 2048 KB general purpose, 30 KB system boot
- Lots of busses: USB, CAN, SPI, I²S, I²C, UART, SDIO for SD/MMC, ADCs, DACs, GPIOs, DMA, RTC, CRC engine, RNG



- Some packages support external memory bus
- Instruction set: Thumb, Thumb-2, Saturating Math, DSP, FPU
- ARMv7E-M architecture
- 1-cycle 32-bit hardware multiply, 2-12 cycle 32-bit hardware divide, saturated math support
- DSP extension: Single cycle 16/32-bit MAC, single cycle dual 16-bit MAC, 8/16-bit SIMD arithmetic.
- Floating-Point extension (silicon option): Single-precision floating point unit, IEEE-754 compliant.
- 3-stage pipeline with branch speculation



- optional 8 region memory protection unit (MPU)



Cortex-M0

- Small core, optimized for small die size (cheaper!)
- ARMv6-M architecture[6]
- Thumb (most), missing CBZ, CBNZ, IT (predication)
- Thumb-2 (subset), only BL, DMB, DSB, ISB, MRS, MSR.
- 32-bit hardware multiply, 1-cycle or 32-cycles (silicon option)
- 3-stage pipeline (in-order)



Other Crazyyness

- BIG.little

