A Comparison of ARM Implementations

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Historical Overview

• Advanced Risc Machines (formerly Acorn Risc Machines)
• Originally conceived by Acorn Computers for business oriented computing in 1985
• Inspired by the Berkley Risc Project
Design Objectives

• Common Architecture
  – Fixed instruction length
  – Load/Store model
  – Pipelined architecture
• Reduced Cost
• Power Efficiency
• Well Rounded Performance
Low Level Implementation

• ARM 64-bit Instruction Set (AArch64)
  – 32-bit instructions
  – 32 128-bit registers
  – Supports 32 or 64-bit arguments

• Jazelle Instruction Set
  – 8-bit instructions
  – Uses Javabyte code execution
Low Level Implementation

• ARM Instruction Set
  – 32-bit instructions
  – Support load-store architecture
  – Execution uses a 3-address format
  – Example : ADDS r0,r1,#1
Low Level Implementation

• Thumb Instruction Set
  – 16-bit instructions, support load-store architecture,
  – Unconditional execution (branch instructions),
  – Uses a 2-address format
  – Example: ADD r1,#1

• Condition Codes
Rise to Popularity

• Initially became popular in Britain
• Dominated by the IBM PC
• Architecture didn’t make it to the commercial domain until 1987
• 1990 joint venture effort by Acorn Computers, Apple Inc. and VLSI Technology
• System-on-Chip approach
Rise to Popularity

• Designer Flexibility
  – Power Efficiency
  – Performance
  – Robust debugging tools

• Uncommon business model

• Manufacturing Flexibility
ARM Product Series

• “Classic” ARM: ARM7, ARM9, ARM11
  – Cheap, low power solutions
  – Cheaper, lower performance than Cortex Series
  – Lower-End devices, or devices that require simple controllers
ARM Product Series

• Cortex Embedded Processors
  – Cortex M Series
    • Low gate count
    • Low power consumption
    • Designed as microcontrollers
  – Cortex R Series
    • Higher Performance
    • Designed for Real-Time Applications
ARM Product Series

• Cortex Application Processor (A Series)
  – Emphasis on performance and power efficiency
  – Most Profitable Platform, fastest growing platform
  – Three Main Varieties:
    • A5  A8  A9
Application of ARM Processors

- Smartphones and Tablets
  - Cortex A Series
  - Combines Power Efficiency and performance
  - Primary Products: Cortex A5 and Cortex A9
  - Some manufactures like Qualcomm only use the ARMv7 ISA
Application of ARM Processors

- Networking
  - High Performance Applications Use Cortex A
    - Fiber to the Home Devices
  - Less demanding applications use Cortex R or M
    - Routers
  - Some also use Classic ARM9 or ARM11
Application of ARM Processors

• Embedded Processors
  – Cortex R, Cortex M, ARM9, ARM11
  – Largest Variety in products
    • Storage Controllers
    • Toys
    • Gadgets
    • Industrial
    • Home Automation
    • Sensors, signal processing
Application of ARM Processors

• Other Applications
  – Other Mobile Internet Devices
    • Smartbooks, netbooks, Ebook Readers, media players, mobile gaming systems
  – Entertainment Units
    • TVs
      • Network Media Players/DVD, Blu Ray Players
  – Micro controlled FPGAs (FPGA Core)
  – Enhanced Security Applications (SecuCore)
Current ARM Implementations

• General Features of Cortex A9
  – Currently most popular high-performance mobile processor
  – 64KB L1 Cache
    • 32KB Data, 32KB Instruction
  – 8-11 State Pipeline
  – Out of Order, Speculative, Dual Issue, Super Scalar
  – Can contain NEON vector processor, dedicated FPU
Current ARM Implementations

- nVidia Tegra (Generations 2 and 3)
  - Tegra 2: Dual Core Cortex A9 + ARM7 Low Power Processor
  - Tegra 3: Quad Core Cortex A9 + Cortex A9 Low Power Processor
  - Dedicated GeForce ULP GPU
  - Dedicated video/image processors
  - 1MB L2 Cache
Current ARM Implementations

• TI OMAP 4
  – Dual Core Cortex A9
  – Integrated Memory Controller
  – 45 nm Technology
  – Dedicated GPU
Current ARM Implementations

• Qualcomm Snapdragon S4 (Krait)
  – Dual Custom ARMv7 cores
  – 28 nm Technology
  – Proprietary Vector Processor
  – Integrated LTE Modem
  – Dedicated GPU
  – Can Power Off Unneeded CPU Cores
Future of ARM

• Cortex A7
  – Low power, cheaper processor
  – Meant to replace Cortex A5
  – Available in 2013/2014 in sub-$100 Smartphones
  – Integrated with A15 using big.LITTLE
Future of ARM

• Cortex A15
  – First Two Devices Launched in October
    • Samsung Chromebook, Galaxy Nexus 10
  – Very High Performance, low power consumption
  – Meant to replace Cortex A9
Future of ARM

• Cortex A50 Series and ARMv8 ISA
  – ARMv8: 64 Bit ISA, fully compatible with 32 bit ARM and THUMB ISAs
  – Cortex A50 series will be first to implement ARMv8
  – A53: Highly Efficient, Low Power Processor
  – A57: High Performance Processor
  – Will use big.LITTLE