Raspberry Pi Architecture

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Agenda

- Background Info
- Full Architecture Overview
- CPU Overview
- CPU Pipeline Stages
- Branch Prediction and Folding
- GPU Overview
- Applications
Background Info

- Created by Eben Upton, Rob Mullins, Jack Lang and Alan Mycroft at University of Cambridge
- They, in conjunction with Pete Lomas and David Braben, formed the Raspberry Pi Foundation
- The Model B was mass produced by Premier Farnell and RS Electronics in 2011
- Was created to provide inexpensive programming machines to today’s youth
Full Architecture Overview

- Two Models A & B, priced at $25 and $35 respectively
- Model A/B:
  - Broadcom BCM2835 (CPU & GPU)
  - 256/512MB SDRAM
  - 1/2 USB 2.0 Ports
  - None/Ethernet Port
  - HDMI
  - Audio
  - SD Card Slot
  - Micro USB for power
BCM2835: CPU Overview

- ARM11J6JZF-S (ARM11 Family)
- ARMv6 Architecture
- Single Core
- 32-Bit RISC
- 700 MHz Clock Rate
- 8 Pipeline Stages
- Branch Prediction
BCM2835: CPU Overview

- Core
- Load Store Unit
- Prefetch Unit
- Memory System
- Level One Mem. System
- Interrupt Handling
- System Control
- AMBA Interface
- Coprocessor Interface
- Debug
- Instruction cycle summary and interlocks
- Vector Floating-Point
CPU Pipeline Stages

Pipeline stages used by ARM1176JZF-S
CPU Pipeline Flow

Execution flow for ALU operations
CPU Pipeline Flow

Execution flow for Multiply Operations
Execution flow for Load/Store Operations
CPU Cache Organization

- Harvard Implementation (Simultaneous access for program memory and data memory)
- Write policy can be either write-back or write-through
- Replacement policy is either pseudo-random or round robin (controlled by RR bit)
BCM2835: Branch Prediction

- The Fetch stage can hold up to four instructions, allowing for prediction to occur on held instructions
- All predictions are resolved by the third execution stage
- Uses dynamic Prediction when there is a history associated with a branch
- Uses static prediction without history
  - backward branches being predicted as taken
  - forward branches as not taken.
- Two addresses are stored in the case of a failed prediction:
  - Recovery address if branch taken was predicted
  - Target address if branch not taken was predicted
 BCM2835: Branch Folding

Branch instructions are removed from the pipeline if the following conditions are met:

- The instruction is not a branch with a link (address is stored in a linked register)
- The instruction does not point to a code sequence that contains a branch in the first two instructions
- The instruction is not break-pointed
- The instruction is not aborted

This method can produce a CPI for branch instructions that is much lower than 1
BCM2835: GPU Overview

- Broadcom Videocore IV
- Uses OpenGL ES2.0
- Performance: 24 GFLOPS
- RPi can play 1080p Blu-Ray quality videos
- Graphical capabilities are similar to those of the original XBOX
Applications and Uses

- Robotics
- Game emulation
- Media Servers
- Education (Python is the primary language used)
- Powerful enough to be used as a personal computer
- Thousands of other projects (Often used in Senior Design)
64 Raspberry Pi Cluster

- 64 Raspberry Pi’s
- Total power usage ~192 watts
- Each Pi’s GPU provides ~24 gigaflops in graphical processing power

(S. Cox, 2012)
(Ars Technica, 2012)
Questions?
References

Raspberry Pi Foundation

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