Raspberry Pi
Architecture

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History of Raspberry Pi

- Created by the Raspberry Pi Foundation in the UK
- Released in 2012
- Currently sell four board configurations
- Created to help promote the teaching of basic computer science in schools
- As of October 2014, 3.8 million units have been sold
Why use one?

- Low cost, low power usage device
- Relatively simple to setup and use
- Small profile allows it to be used in various projects and not take up much space.
- Multiple Linux distributions have support for ARM Processors.
Specs

- HDMI output (1080p)
- RCA video output (576i, 480i)
- 3.5mm audio jack
- USB 2.0
- Ethernet (Fast-Ethernet)
- SD card reader
- 256 MB, 512 MB RAM
- Broadcom BCM2835 (SoC)
- ARM11 700 MHz processor
- VideoCore IV GPU
- GPIO Pins
- Micro USB powered
 Broadcom BCM2835

- Low Power ARM1176JZ-F Applications Processor
- Dual Core VideoCore IV Multimedia Co-Processor
  - Low Power, High Performance OpenGL, 1GP/s
- 1080p 30fps Full HD HP H.264 Video Encode/Decode
- Graphical capability near Xbox (Original) levels
- Advanced Image Sensor Pipeline
  - up to 20MP cameras operating at 220MP/s
ARM Processors

- ARM is a set of Instruction Set Architectures based on a Reduced Instruction Set Computing (RISC)
- Developed by British Company ARM Holdings
- Has become the most widely used ISA in terms of sheer production
- Used in Raspberry Pi because of its low price, low power usage and availability.
ARM11 Family

- ARM architecture 32-bit RISC microprocessor cores
- Uses ARM version 6
- Announced in April 2002
- Introduced new additions to previous ARM9 & ARM10
  - Single Instruction, Multiple Data
    - Double MPEG-4 & Audio DSP algorithm speeds
  - Multi-processor support
  - New cache architecture
    - Physically addressed cache
  - Redesigned pipeline
    - Out-of-order completion for some operations such as stores
    - Dynamic branch prediction
ARM1176 Structure Components

- Integer Core
  - FL coprocessor
- Memory Management Unit
  - Separate Instruct/Data cache
- Prefetch Unit
  - Branch Prediction
- Coprocessor Interface
  - Keeps pipeline in order
- Interrupt Controller
  - Allows faster interrupt entry
ARM11 Instruction Set

- Three Instruction Sets
  - 32-bit ARM instruction set
  - 16-bit Thumb instruction set
    - Condensed 32-bit code
    - Allows for fast interrupts and DSP algorithms
  - 8-bit Java bytecodes
    - Java compiled code
ARM11 Cache

- 4-way set associative
  - 4 blocks for each set
- Configurable 4 to 64KB
- Deliver 2 words per cycle
- Harvard Implementation
  - Different cache attributes
- Replacement Policy
  - Pseudo-Random
  - Round-Robin
ARM1176JZF-S Pipeline

Common decode pipeline

Fe1 | Fe2 | De | Iss
---|---|---|---
1st fetch stage | 2nd fetch stage | Instruction decode | Register read and instruction issue

Ex1 | Ex2 | Ex3
---|---|---
Sh | ALU | Sat
Shifter operation | Calculate writeback value | Saturation

MAC1 | MAC2 | MAC3
1st multiply stage | 2nd multiply stage | 3rd multiply stage

ADD | DC1 | DC2 | WBIs | WBex
Data address calculation | First stage of data cache access | Second stage of data cache access | Writeback from LSU | Base register writeback

ALU pipeline
Multiply pipeline
Load/store pipeline
Hit under miss
Load miss waits
Typical Pipeline Operations

- Fe1 - First stage of instruction fetch which issues address to memory and data returns from memory.
- Fe2 - Second stage of instruction fetch and branch prediction.
- De - Instruction decode
- Iss - Register read and instruction issue
- Sh - Shifter Stage
- ALU - Main integer operation calculation
- Sat - Pipeline stage for enabling saturation of integer results
- WBex - Write back of data from multiply or main execution pipelines
- MAC1/2/3 - First/Second/Third stage of multiply-accumulate pipeline.
- ADD - Address generation Stage
- DC1/2 - First and Second stage of data cache access.
- WBIs - Write back of data from Load Store Unit
Typical ALU Operation
Progression of a Load that misses
Programming On A Raspi

- The Raspberry Pi supports many official distributions of Linux.
- As quoted from the official Raspberry Pi site:
  - “The Raspberry Pi Foundation recommends Python as a language for learners.”
- Any language that compiles for ARMv6 can be used on the Raspi. Pre-installed default languages include Python, C, C++, Java, Scratch and Ruby
Example Projects

- Teaching programming to kids
- Clustered Super Computer
- Game Emulation
- Automatic Beer Brewing
- Home Security
- Control for Quadcopters

A 32-node Raspberry Pi Beowulf Cluster
Game Emulators
BrewPi
Raspberry Pi
Quadcopter Powered By Raspberry Pi
Raspberry Pi vs Beaglebone Black

**Raspberry Pi**
- $35
- I/O Pins: 8 Pins
- Power Draw: 260-350 mA
- CPU: ARM1176 @ 700 MHz
- Graphics: 1080p video streams through full sized HDMI
- Expandability: Capable of connecting Arduino Compatible shields

**BeagleBone Black**
- $45
- I/O Pins: 65 Pins
- Power Draw: 210-460 mA
- CPU: AM3359 Cortex A8 @ 1GHz
- Graphics: Does not support 1080p and only through micro-HDMI
- Expandability: Capes
Conclusion

★ Low cost
★ Great Graphics
★ Size of a Credit Card
★ Simple to setup and use
★ Great for educational purposes
Questions?
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