Designing Embedded Systems

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Basic Architectures

Control Unit

- Custom logic
- FPGAs (Field-Programmable Gate Arrays)
- Microcontrollers
- Microprocessors
- DSPs (Digital Signal Processors)
- ASIPs (Application Specific Instruction-set Processors)
- Multicore? (symmetric vs. asymmetric)
- Typical word size: 8/16/32-bit

Why Microprocessors?

- Microprocessors
  - ARM, MIPS, PowerPC, SuperH, Cell, Atom, …
  - Mostly less than 1 GHz
- Microprocessors are often very efficient:
  - Can use same logic to perform many different functions
- Microprocessors simplify the design of families of products

The Performance Paradox

- Microprocessors use much more logic to implement a function than does custom logic
- But microprocessors are often at least as fast:
  - Heavily pipelined
  - Large design teams
  - Aggressive VLSI technology, …

Power

- Custom logic uses less power, but CPUs have advantages:
  - Modern microprocessors offer features to help control power consumption
  - Software design techniques can help reduce power consumption
- Heterogeneous systems
  - Some custom logic for well-defined functions, CPUs + software for everything else

RAM

- SRAM
  - Easier to integrate on the same chip as processor
- DRAM
  - SDRAM (Synchronous DRAM): SDR/DDR/DDR2/DDR3
  - Mobile SDR/DDR SDRAM
  - RDRAM (Rambus DRAM)
- NVRAM (Non-Volatile RAM)
- Future NVRAMs: PRAM, MRAM, FeRAM
- Cache memory
- SPM (Scratch Pad Memory)

ROM

- Mask-programmed
  - Connections programmed at fabrication
- OTP (One-time programmable) ROM
  - Connections programmed after manufacture by user
- EPROM (Erasable programmable ROM)
- EEPROM (Electrically erasable programmable ROM)

Flash Memory

- NOR Flash
- NAND Flash
- Fusion memory: OneNAND Flash
- e-MMC: MoviNAND, iNAND
- Cards (MMC, SD, CF, …)

Interfacing

- ARM AMBA (Advanced Microcontroller Bus Architecture)
- ISA (Industry Standard Architecture)
- PCI (Peripheral Component Interconnect)

- I^2C (Inter-IC) bus
- USB

Common Peripheral Devices

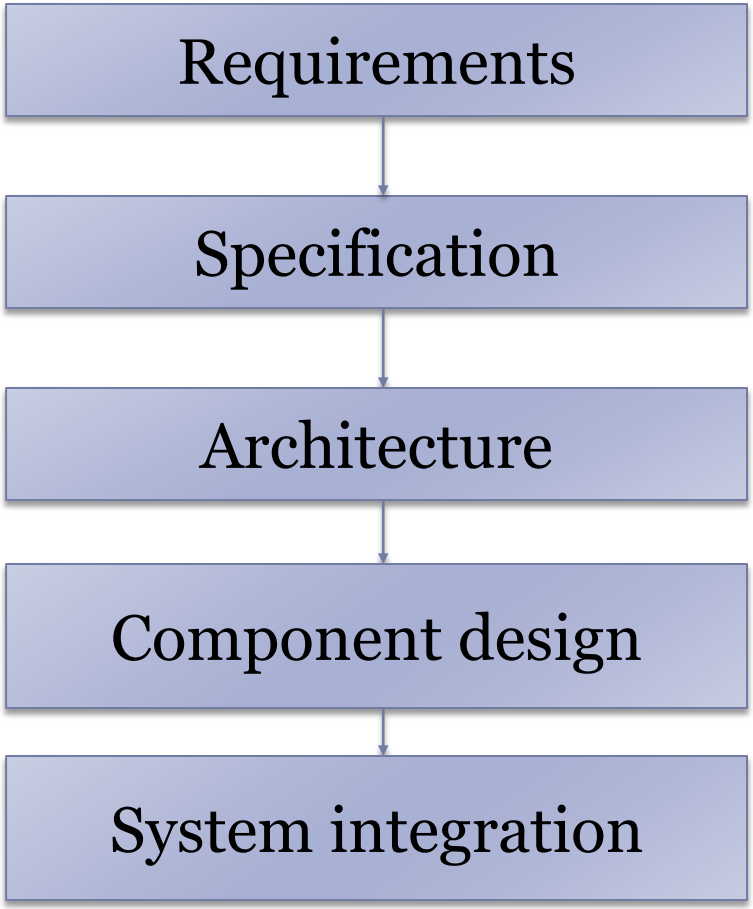
- Interrupt controller
- DMA controller
- Timer/Counter
- Real-time clock
- Watchdog timer
- UART (Universal Asynchronous Receiver Transmitter)
- IrDA (Infrared)
- Ethernet (wired/wireless)
- Bluetooth

Recent Trends

- Increasing computation demands
- Increasingly networked
- Increasing need for flexibility

- Getting complex
- Increasingly platform-based
  - Hardware architecture + associated software

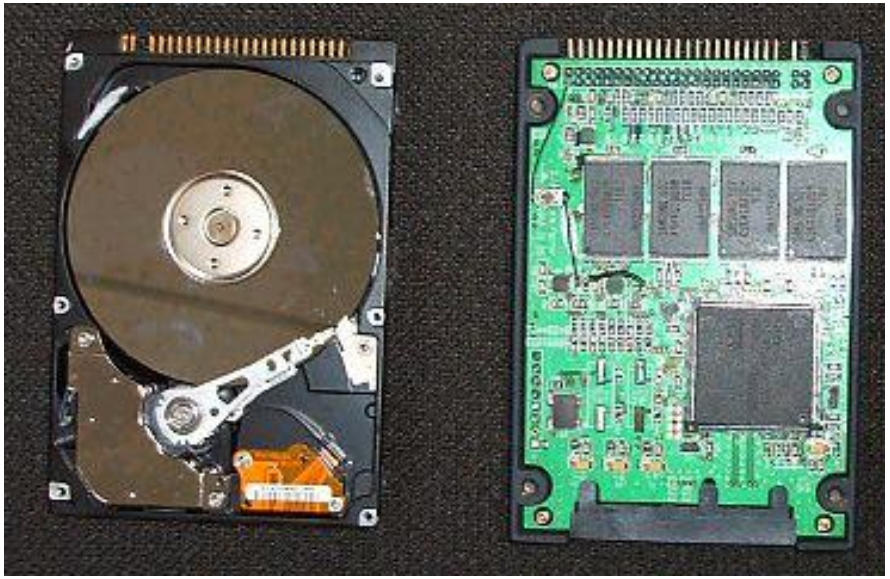
Design Process



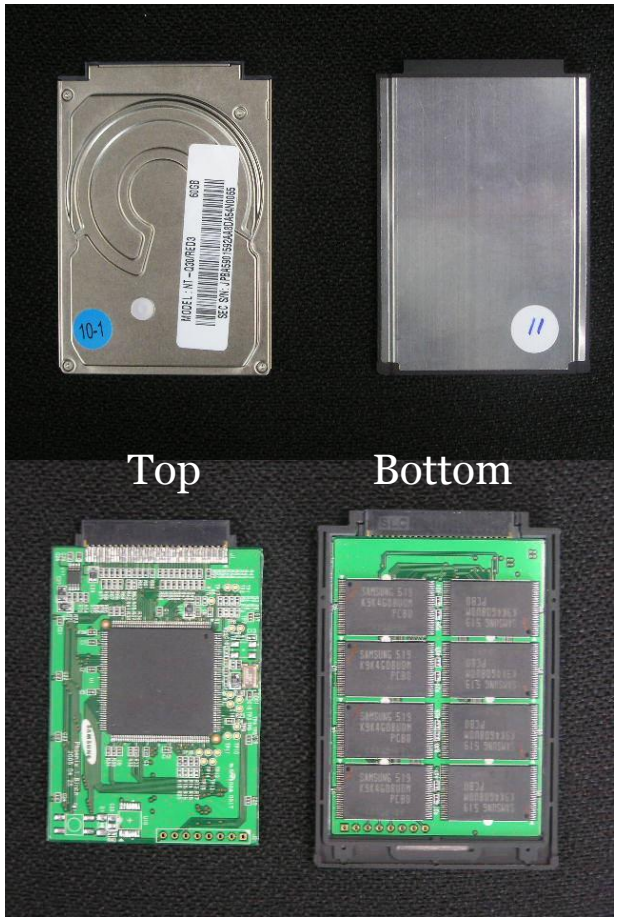
Solid State Drives (SSDs)

HDDs vs. SSDs (1)

2.5” HDD Flash SSD
(101x70x9.3mm)



1.8” HDD Flash SSD
(78.5x54x4.15mm)



HDDs vs. SSDs (2)

Feature	SSD (Samsung)	HDD (Seagate)
Model	MMDOE56G5MXP (PM800)	ST9500420AS (Momentus 7200.4)
Capacity	256GB (16Gb MLC x 128, 8 channels)	500GB (2 Discs, 4 Heads, 7200RPM)
Form factor	2.5” Weight: 84g	2.5” Weight: 110g
Host interface	Serial ATA-2 (3.0 Gbps) Host transfer rate: 300MB	Serial ATA-2 (3.0 Gbps) Host transfer rate: 300MB
Power consumption	Active: 0.26W Idle/Standby/Sleep: 0.15W	Active: 2.1W (Read), 2.2W (Write) Idle: 0.69W, Standby/Sleep: 0.2W
Performance	Sequential read: Up to 220 MB/s Sequential write: Up to 185 MB/s	Power-on to ready: 4.5 sec Average latency: 4.17 msec
Measured performance[1] (On MacBook Pro, 256KB for sequential, 4KB for random)	Sequential read: 176.73 MB/s Sequential write: 159.98 MB/s Random read: 10.56 MB/s Random write: 2.93 MB/s	Sequential read: 86.07 MB/s Sequential write: 84.64 MB/s Random read: 0.61 MB/s Random write: 1.28 MB/s
Price[2]	539,190 won	80,400 won

[1] Source: http://forums.macrumors.com/showthread.php?t=658571 [2] Source: http://www.danawa.com (As of Mar. 17, 2011)

1$-per-GB?

Source: http://www.gamemeca.com/hardware/news_view.html?seq=2109009&ymd=20120227 (Feb. 27, 2012)

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COMMENTS (1)

SSD Per-GB Cost to Fall Below $1 in Second Half of 2012 - Market Observers.

SSDs to Gain Considerable Market Share This Year, Says DRAMeXchange

[03/07/2012 08:53 PM]
by Anton Shilov

The $1-per-GB price has been for a long time considered as a holy grail for solid-state drives as it is widely believed that at such price points SSDs will start to be adopted by mainstream users. According to DRAMeXchange, a division of TrendForce market research firm, the price per GB will be even lower than $1 in the second half of the year, which will unleash growth potential for SSDs.

After SSDs based on NAND flash memory manufactured using the latest - 19nm, 20nm and similar - process technologies enter mass production in the second half of 2012, unit cost may fall below $1-per-GB, the pricing sweet spot the market has been anticipating. When this occurs, DRAMeXchange expects ultrabook/thin notebook makers will transition from adopting hybrid HDD solutions to pure SSD solutions, and mainstream capacity will increase to 128GB.

Source: http://www.xbitlabs.com/news/storage/display/20120307205305_SSD_Per_GB_Cost_to_Fall_Below_1_in_Second_Half_of_2012_Market_Observers.html

SSD Internals