

Multimedia production with embedded systems using openFrameworks

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Multimedia on embedded systems???

HD Video 1920x1080p @ 60fps @ 4bytes

→ $1920 \times 1080 \times 60 \times 4 = 497664000 \approx \mathbf{0.5\text{GBytes/s}}$

+ image processing + ... + ...

→ well in the GFLOPS domain for the processor

Multimedia on embedded systems???

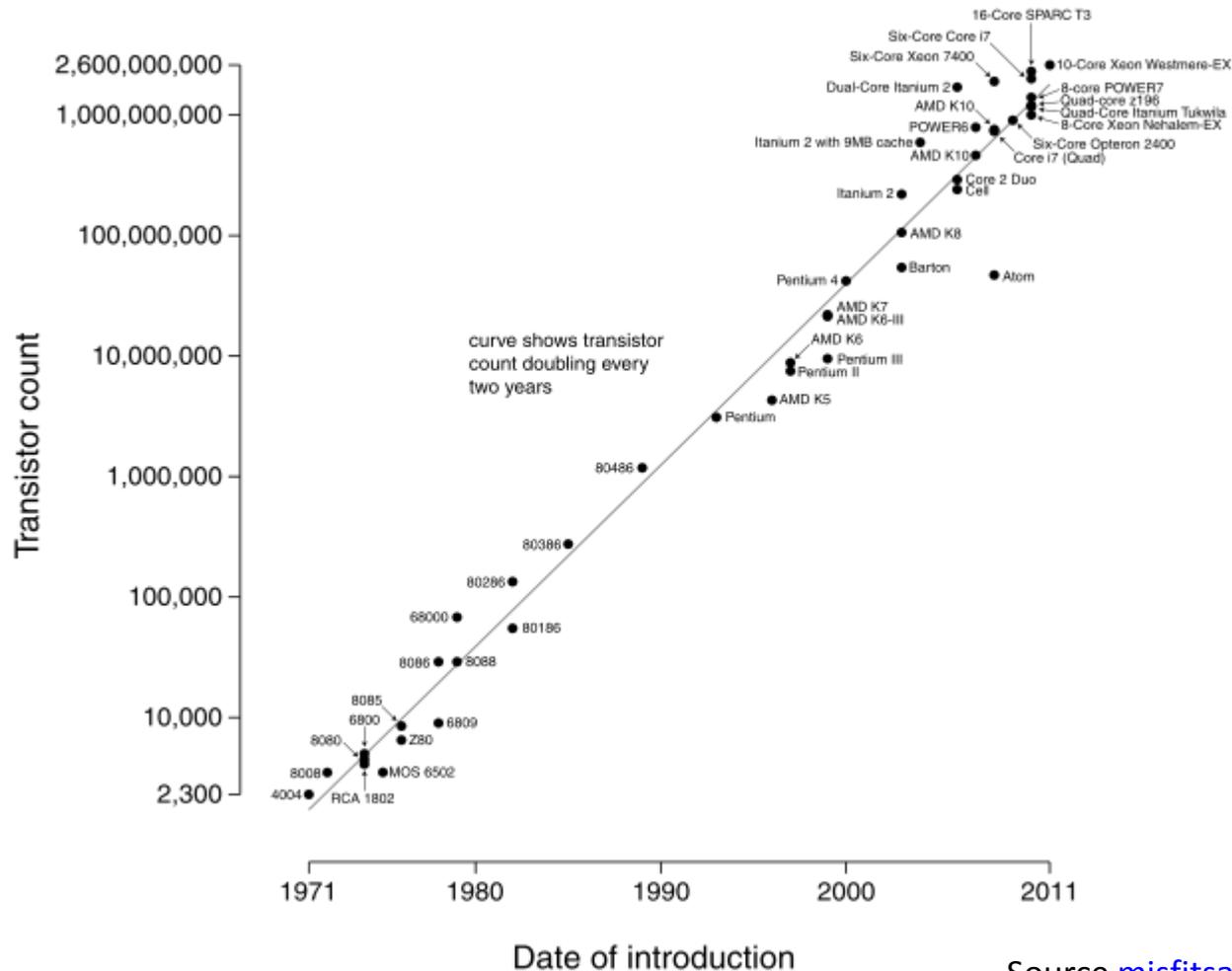


Source Arm

Number of transistors on a computer chip doubles approx. every two years

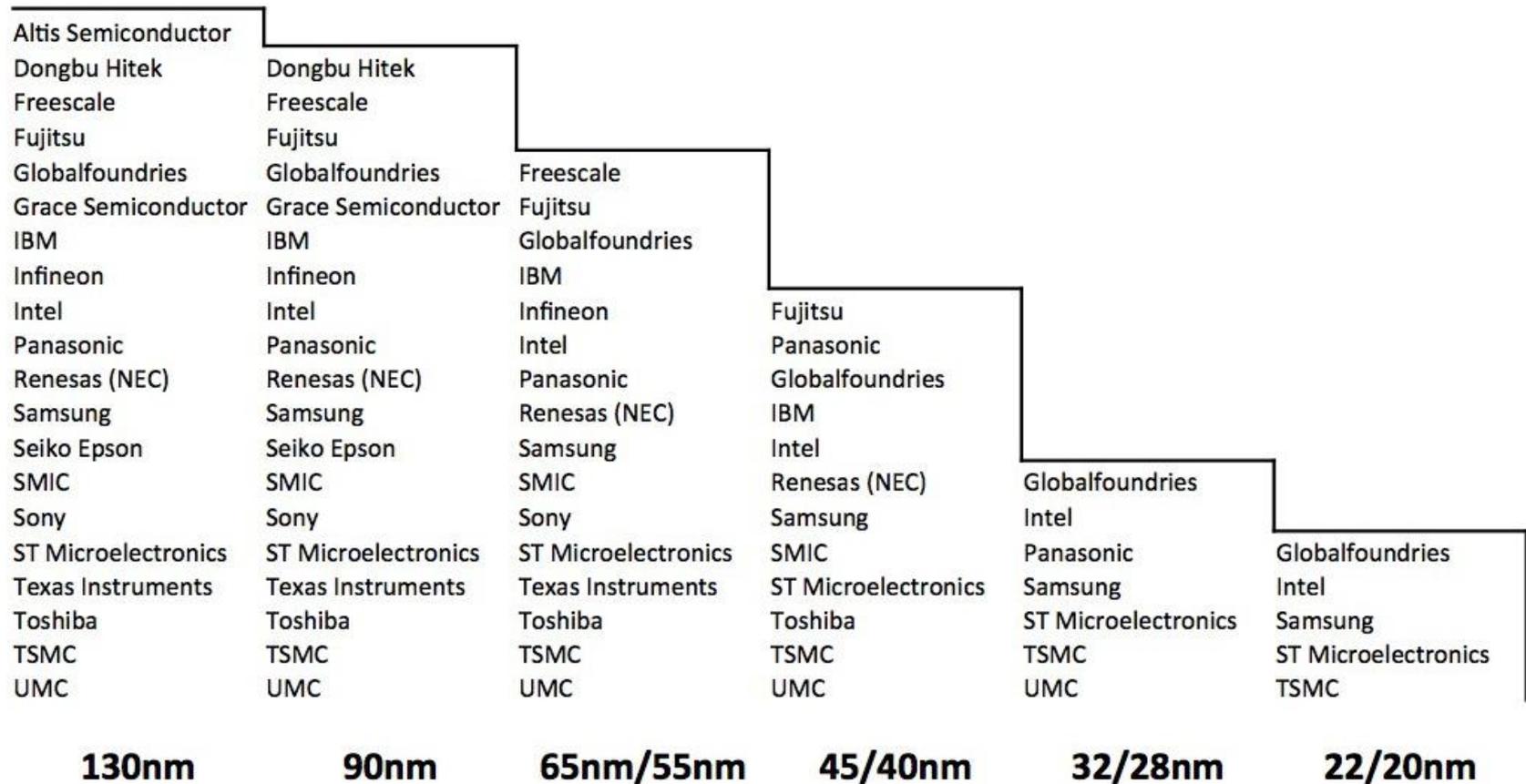
Moore's law

Microprocessor Transistor Counts 1971-2011 & Moore's Law



Source misfitsarchitecture.com

Fabs: not as popular as they used to be



Source: <http://www.theregister.co.uk>

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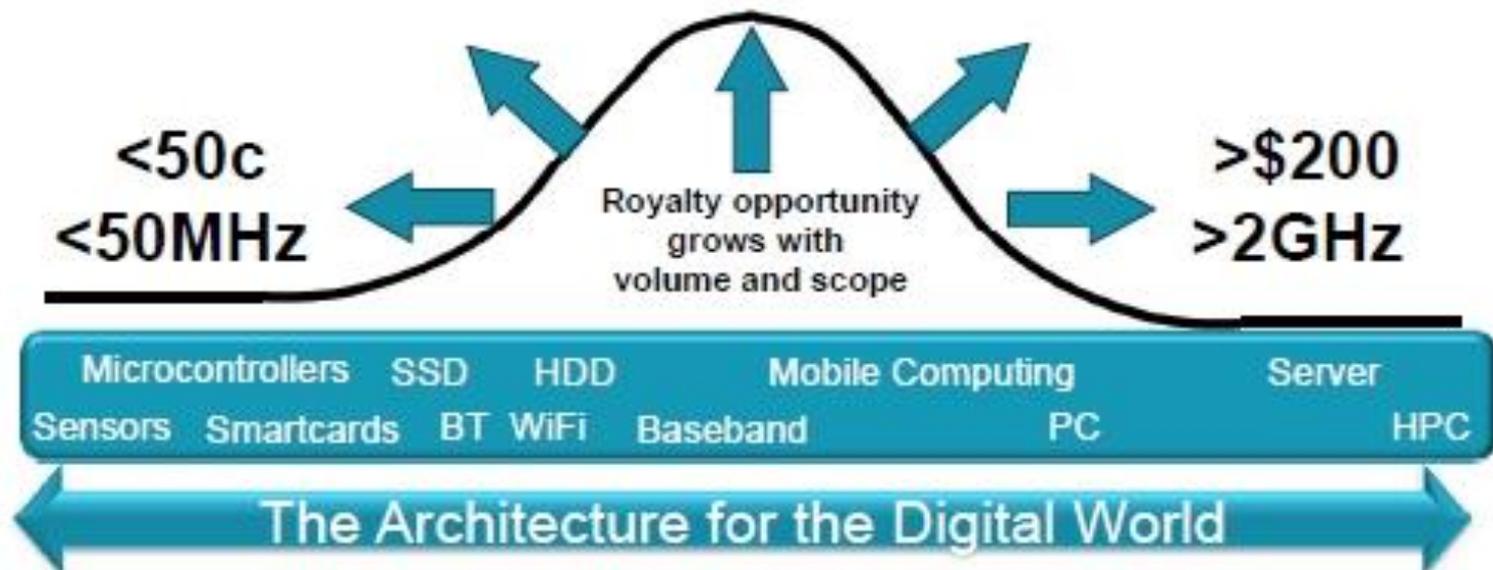
The Architecture for the Digital World®

ARM®

Embedded technology

ARM's 2020 Vision

- ARM is growing into new markets and product categories
 - From sensors to servers, from 50c to \$200, from <50MHz to >2GHz
- Today's processor licenses drive shipments beyond 2015
- Expect over 100 billion cumulative ARM based chips by 2020

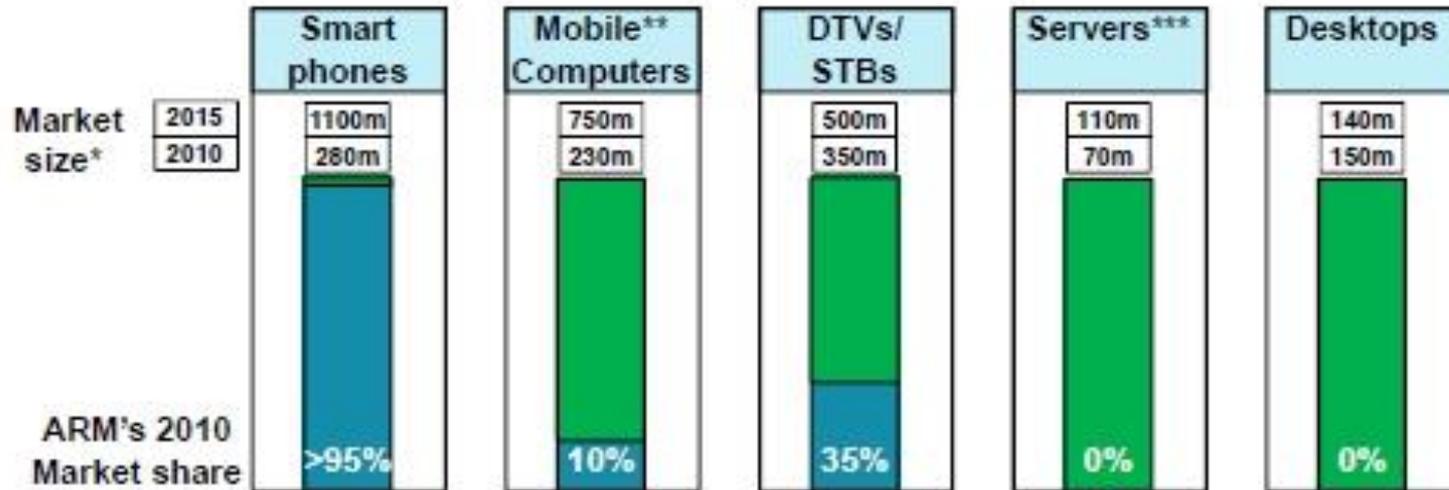


Source: <http://www.theregister.co.uk>

Embedded technology

ARM's High Performance Computing

- ARM Cortex-A family are used as applications processors in a wide range of computing products



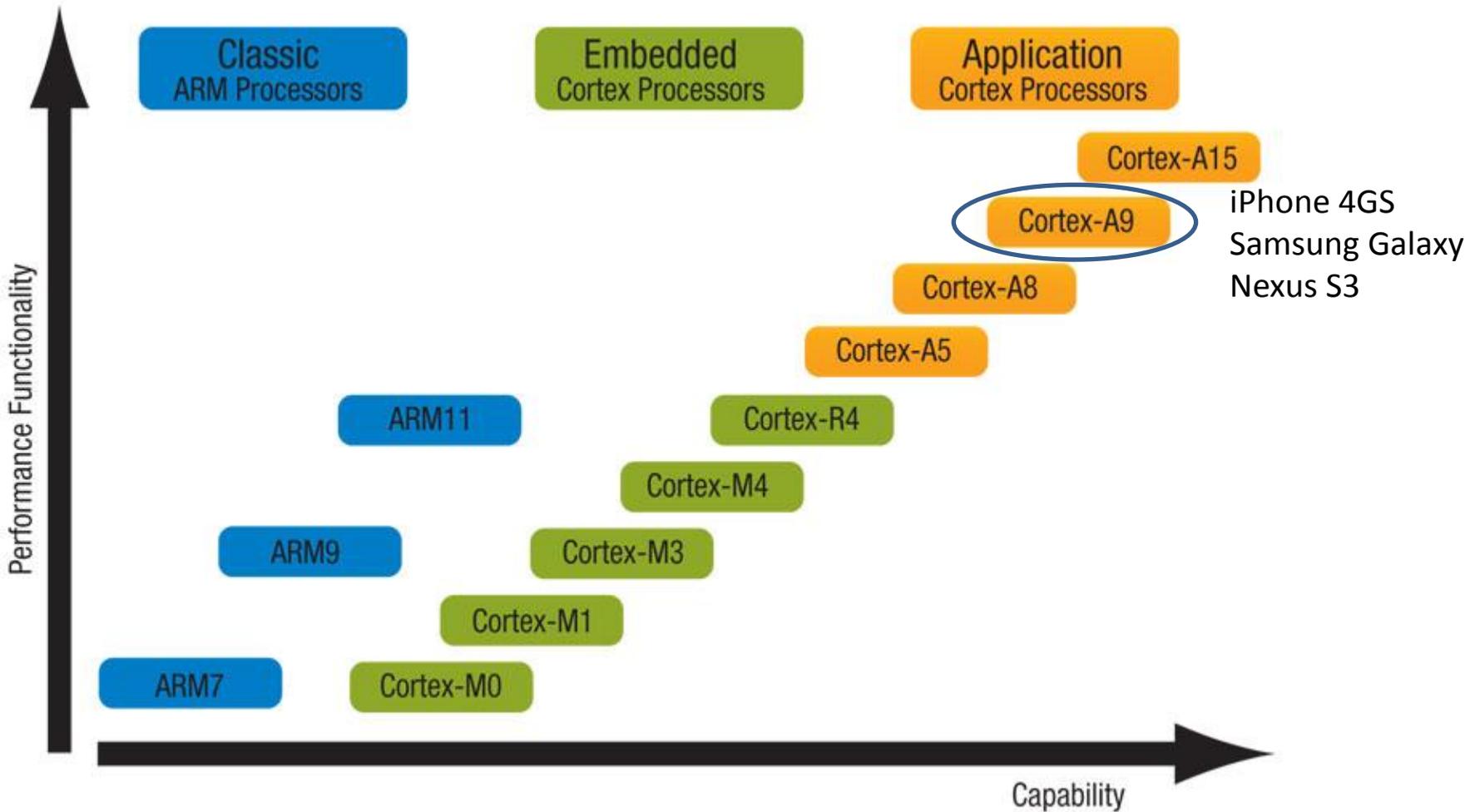
* Estimates based on forecasts from Gartner, SIA and ARM
** Includes tablet, netbooks and laptops
*** Opportunity for ARM-based application processors in server market

- Multiple semiconductor companies working on ARM-based server chips
- Chips based on clusters of **2.5GHz Cortex-A15** suitable for some server applications
- ARM is working with software/OEM ecosystem to enable products to get to market

Source: <http://www.theregister.co.uk>

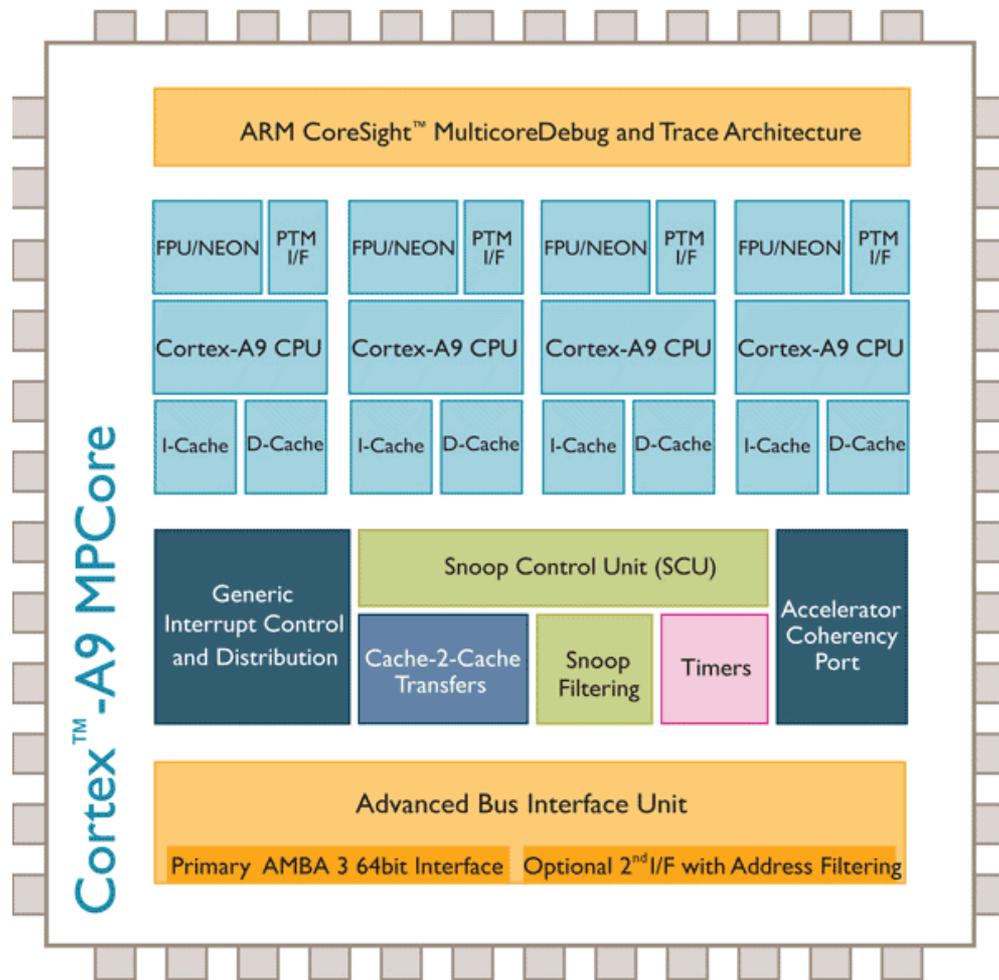
Embedded

ARM Processors



Ref.:
<http://www.arm.com/>

Embedded technology



Cortex-A9 Processor

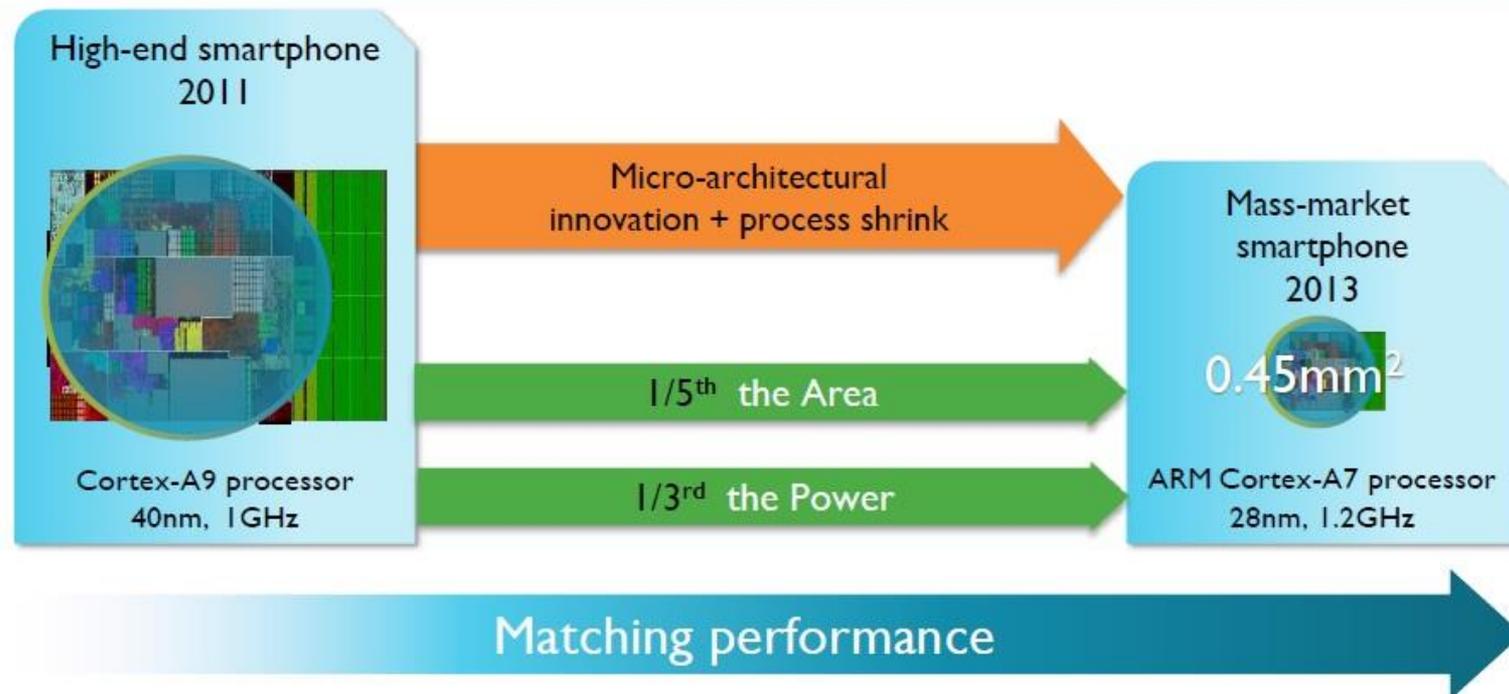
Available as either a single core or configurable multicore processor, with both synthesizable or hard-macro implementations available. This processor can scale across a wide variety of applications while enabling a consistent software investment across multiple markets.

Ref.: <http://www.arm.com/>

Embedded technology

Superphone to Mass-Market Smartphone in 2 Years

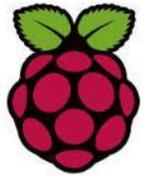
Outpacing Moore's Law with micro-architectural innovation



Not to be published without the consent of ARM

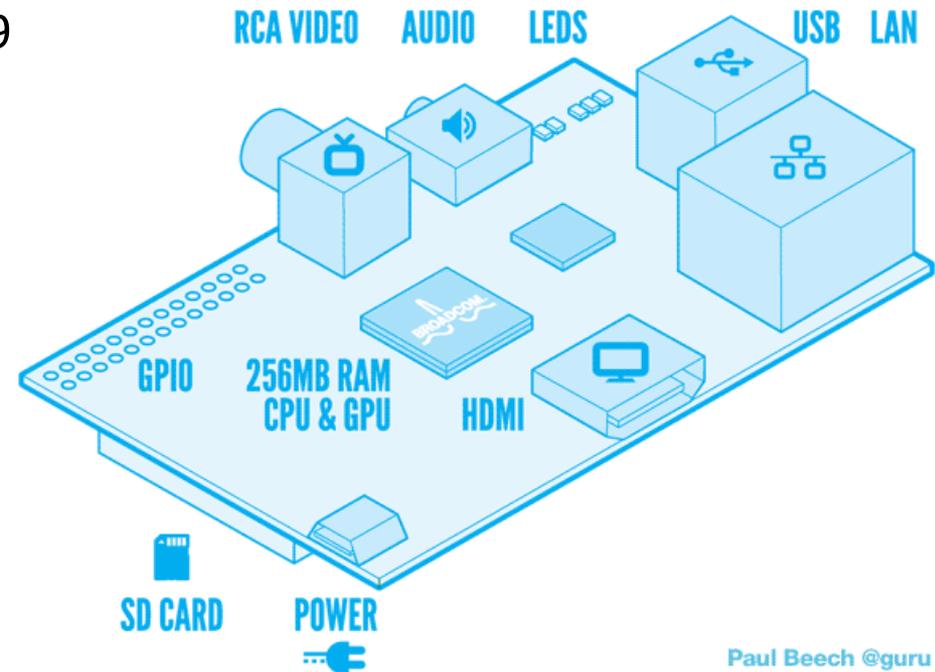
The Architecture for the Digital World® **ARM**

Source ARM



Raspberrypi.org

- Credit card-sized computer released 2012
- Charity foundation founded in 2009 to promote the study of basic computer science
- Keyboard, TV connector, HD Video
- Price tag \$25 to \$35
- Various OSs



Paul Beech @guru



Raspberrypi.org

	Model A	Model B
Target price: ^[7]	US\$ 25	US\$ 35 ^[73]
SoC: ^[7]	Broadcom BCM2835 (CPU, GPU, DSP, SDRAM, and single USB port) ^[3]	
CPU:	700 MHz ARM1176JZF-S core (ARM11 family, ARMv6 instruction set) ^[3]	
GPU:	Broadcom VideoCore IV @ 250 MHz ^{[74][75]} OpenGL ES 2.0 (24 GFLOPS) MPEG-2 and VC-1 (with license ^[71]), 1080p30 h.264/MPEG-4 AVC high-profile decoder and encoder ^[3]	
Memory (SDRAM):	256 MB (shared with GPU)	512 MB (shared with GPU) as of 15 October 2012
USB 2.0 ports: ^[14]	1 (direct from BCM2835 chip)	2 (via the built in integrated 3-port USB hub) ^[66]
Video input:	A CSI input connector allows for the connection of a RPF designed camera module ^[76]	
Video outputs: ^[7]	Composite RCA (PAL and NTSC), HDMI (rev 1.3 & 1.4), ^[77] raw LCD Panels via DS ^{[78][79]} 14 HDMI resolutions from 640×350 to 1920×1200 plus various PAL and NTSC standards. ^[80]	
Audio outputs: ^[7]	3.5 mm jack, HDMI, and, as of revision 2 boards, I ² S audio ^[81] (also potentially for audio input)	
Onboard storage: ^[14]	SD / MMC / SDIO card slot (3,3V card power support only)	
Onboard network: ^{[7][14]}	None	10/100 Ethernet (8P8C) USB adapter on the third port of the USB hub ^[66]
Low-level peripherals:	8 × GPIO, ^[82] UART, I ² C bus, SPI bus with two chip selects, I ² S audio ^[83] +3.3 V, +5 V, ground ^{[74][84]}	
Power ratings:	300 mA (1.5 W) ^[85]	700 mA (3.5 W)
Power source: ^[7]	5 volt via MicroUSB or GPIO header	
Size:	85.60 mm × 53.98 mm (3.370 in × 2.125 in) ^[86]	
Weight:	45 g (1.6 oz) ^[87]	
Operating systems:	Arch Linux ARM, ^[2] Debian GNU/Linux, Fedora, FreeBSD, NetBSD, Plan 9, Raspbian OS, RISC OS, ^[30] Slackware Linux ^[88]	

REL: WIKI

FLOPS

Date	Approximate cost per GFLOPS	Approximate cost per GFLOPS inflation adjusted to 2012 dollars ^[45]	Least expensive platform able to achieve 1 GFLOPS
1961	US \$1,100,000,000,000 (\$1.1 trillion)	US \$8.3 trillion	About 17 million IBM 1620 units costing \$64,000 each
1984	\$15,000,000	\$33,000,000	Cray X-MP
1997	\$30,000	\$42,000	Two 16-processor Beowulf clusters with Pentium Pro microprocessors ^[47]
April 2000	\$1,000	\$1,300	Bunyip Beowulf cluster
May 2000	\$640	\$836	KLAT2
August 2003	\$82	\$100	KASY0 ↗
August 2007	\$48	\$52	Microwulf ↗
March 2011	\$1.80	\$1.80	HPU4Science ↗
August 2012	\$0.75	\$0.73	Quad AMD7970 GHz System ↗
June 2013	\$0.22	\$0.22	Sony Playstation 4 ↗

@24GFLOPS=k\$31.2

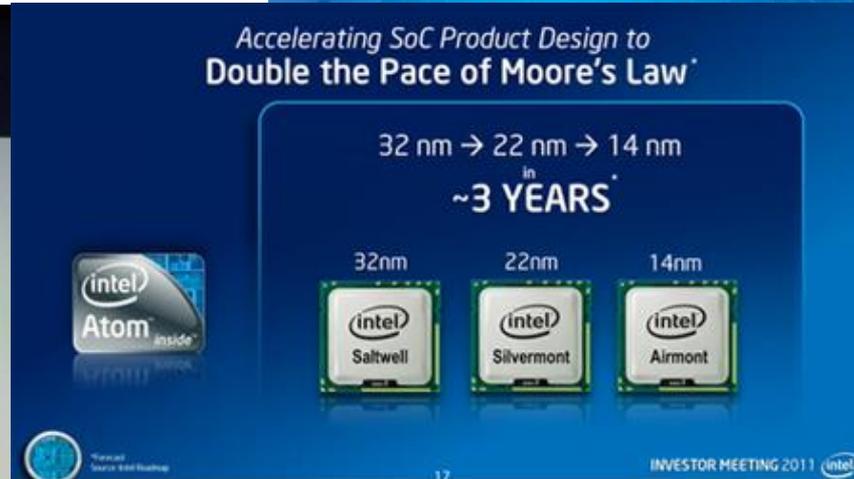
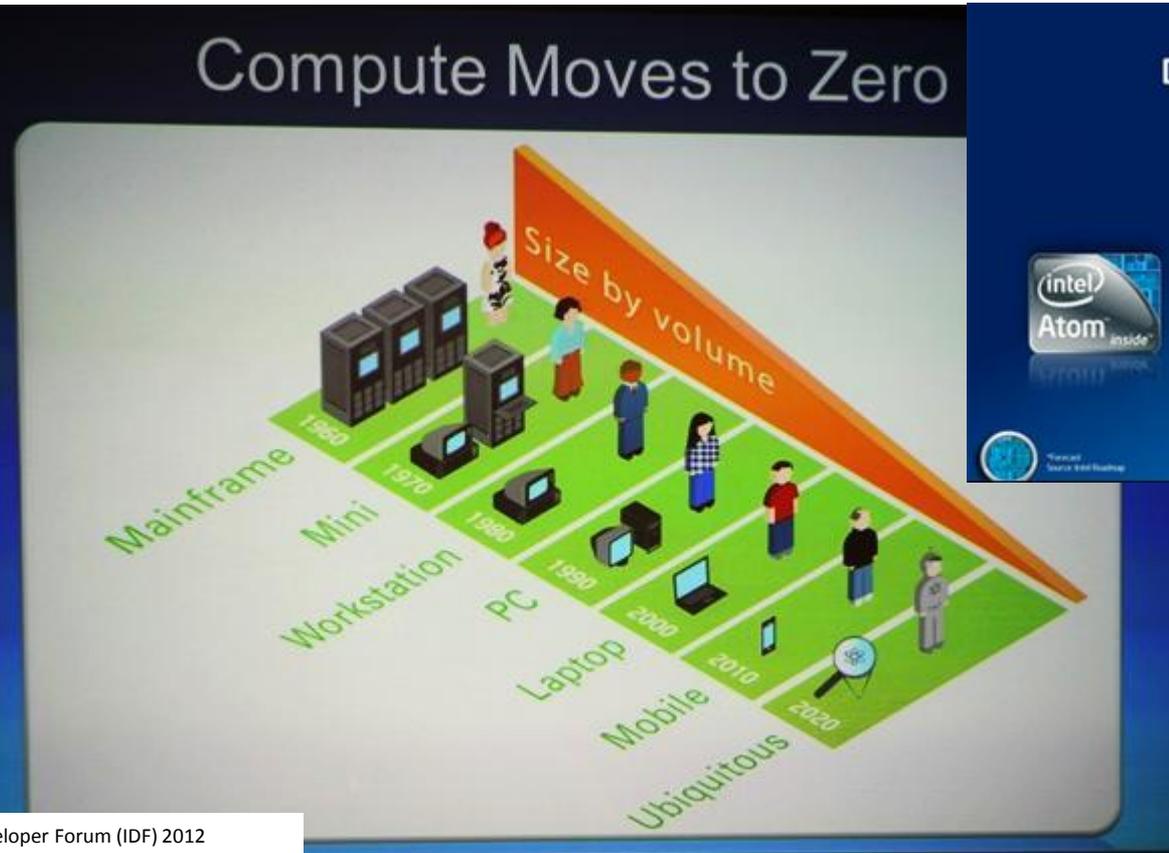
@24GFLOPS=\$43

@24GFLOPS=\$17.50

@24GFLOPS=\$5.30

<http://en.wikipedia.org/wiki/FLOPS>

Recent Intel statement



Intel expects that size of "meaningful compute" approaches zero.
 Size of Silicon is proportional to cost.
 Silicon with high level of complexity will reach point of low single digit costs.
 Impact to markets will be huge.

Source Intel

openFrameworks

- openFrameworks is an open source C++ toolkit
- Designed to assist the creative process
- Driven by a "do it with others" (DIWO) philosophy
- Providing a simple and intuitive framework for experimentation
- Wraps together several commonly used libraries
 - OpenGL, GLUT, ...
 - rtAudio, OpenAL, Kiss FFT, ...
 - FreeType, FreeImage, ...
 - OpenCV, Kinect, OpenNI, LeapMotion, ...
- Massively cross-platform
- [MIT License](#) (Commercial use is o.k.)

OSX

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linux

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mobile

openFrameworks for mobile platforms supports the same features as the desktop versions plus mobile specific features like accelerometer, compass, gps...

ios

osx only
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android

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linux arm

*openFrameworks for arm boards running linux like Raspberry Pi, Beaglebone (black), Pandaboard, BeagleBoard and others.
We have setup guides for some of the most common boards but it should work on any armv6 and armv7 board.*

linux armv6

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setup guide
[raspberry pi](#)

linux armv7

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setup guide
[pandaboard](#)
[generic armv7](#)

openFrameworks

- [Documentation](#)

openFrameworks

- Example projects
 - Base class methods example, UDP broadcast sender
 - UDP receiver example with [Box2d](#) and [TrueTypeFont](#) (triangulation) rendering