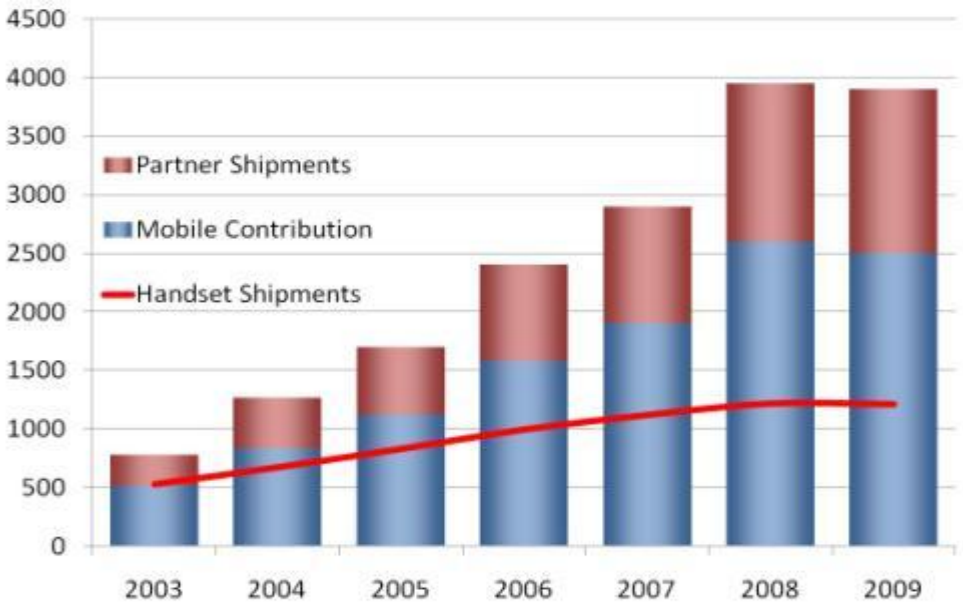
Google GTUG Beijing

典型ARM平台的硬件系统分析

华清远见：蒙洋

ARM Powers the Mobile World

- >12 Billion ARM Powered® chips in mobile devices
- 2.5 Billion ARM Powered chips shipped in 2009
- Average phone has > 2.0 ARM chips
- Scalable performance from ULCH to PC
- CAGR ~ 40% of smartphone predicted until 2013



Industry units (ex-memory) down ~20%
ARM FY09: 3.9bn units (down ~2%)

ARM7 ARM9 ARM11 Xscale ARM11

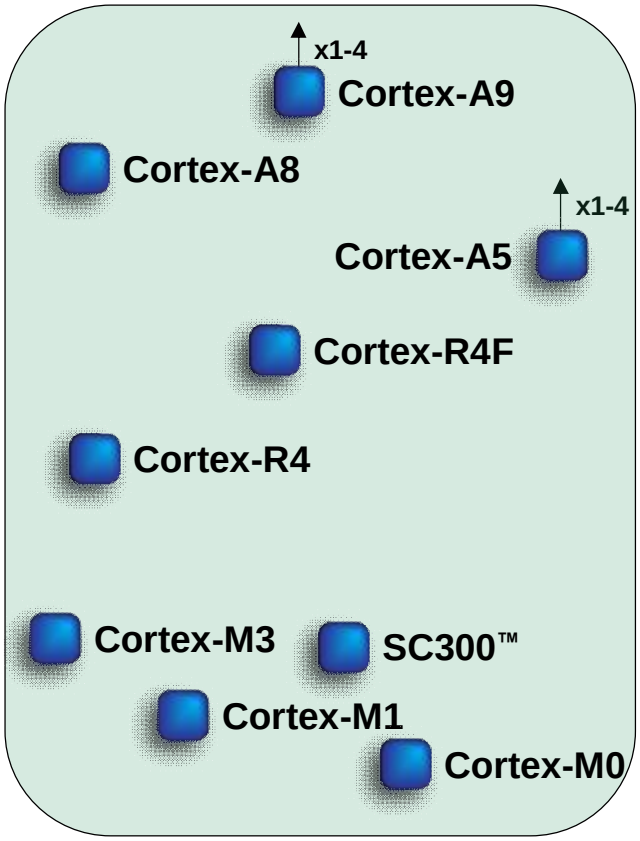
Cortex-A8

ARMv7

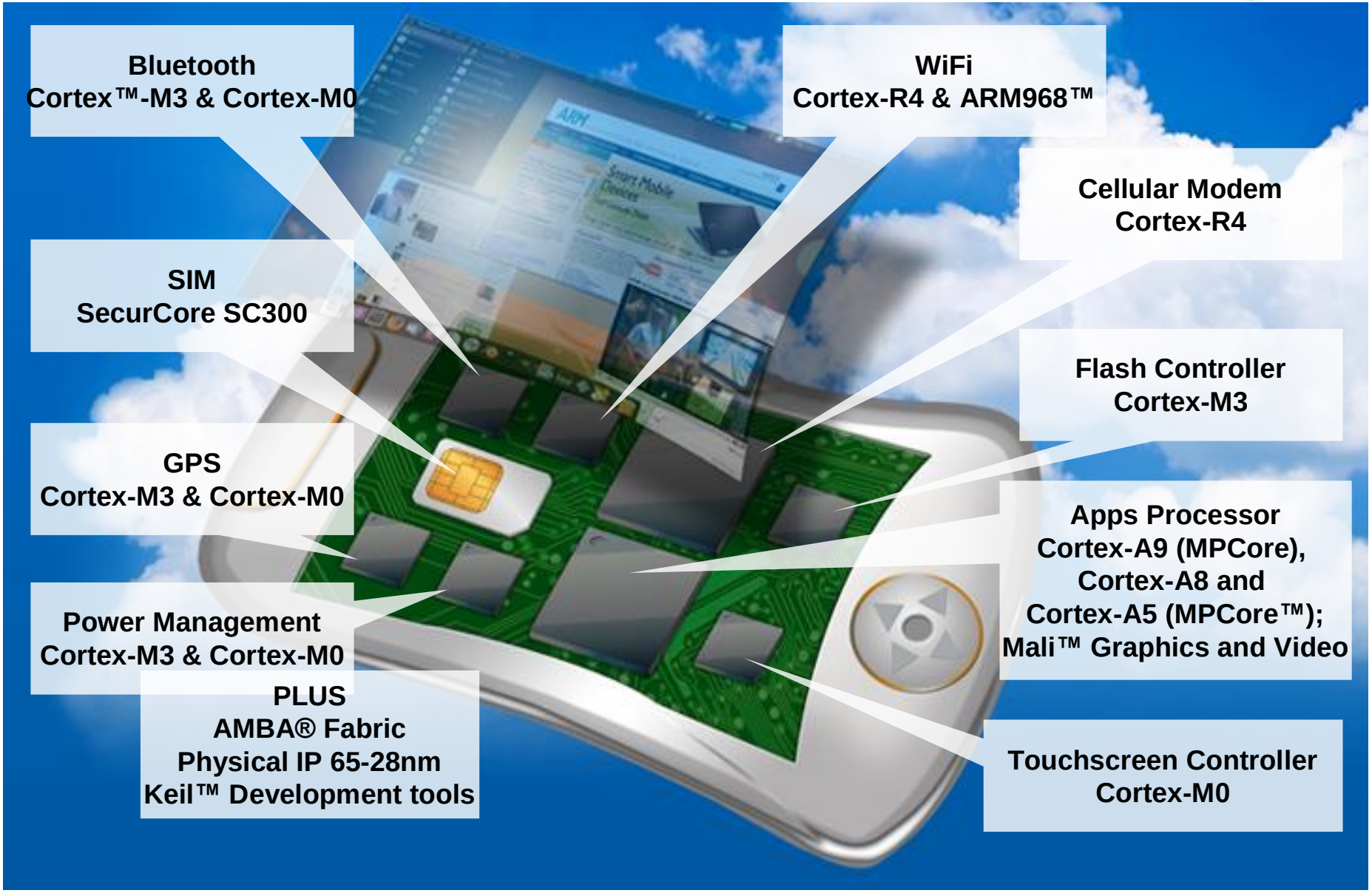
ARM Cortex Family of Processors

Bringing the benefits of architectural innovation across the computing spectrum

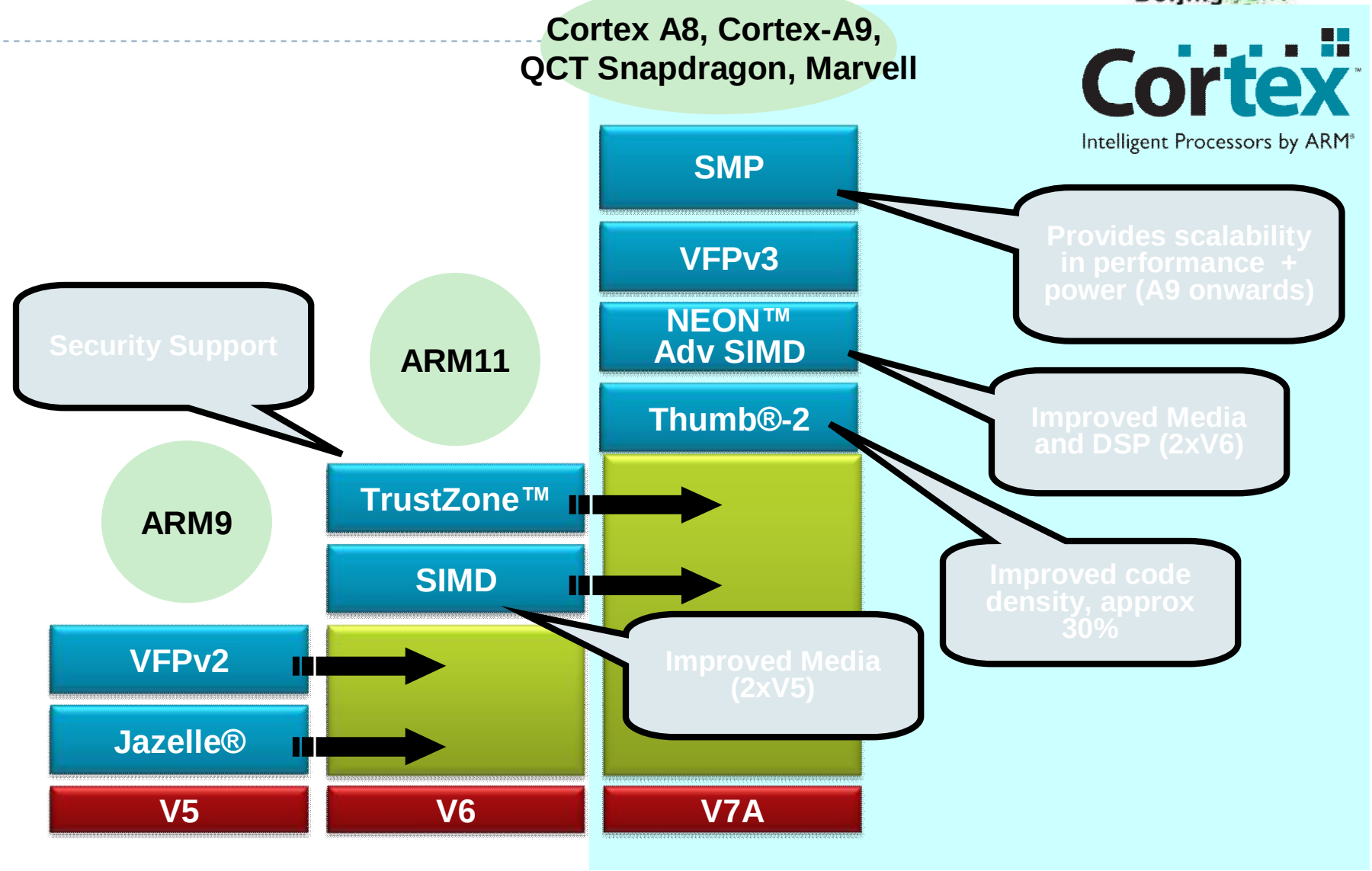
- ARM Cortex™-**A** Series:
  - Applications processors for complex OS
    and user applications
- ARM Cortex-**R** Series:
  - Embedded processors for real-time signal processing and control applications



ARM Powered Smartphone



Architecture Evolution on ARM



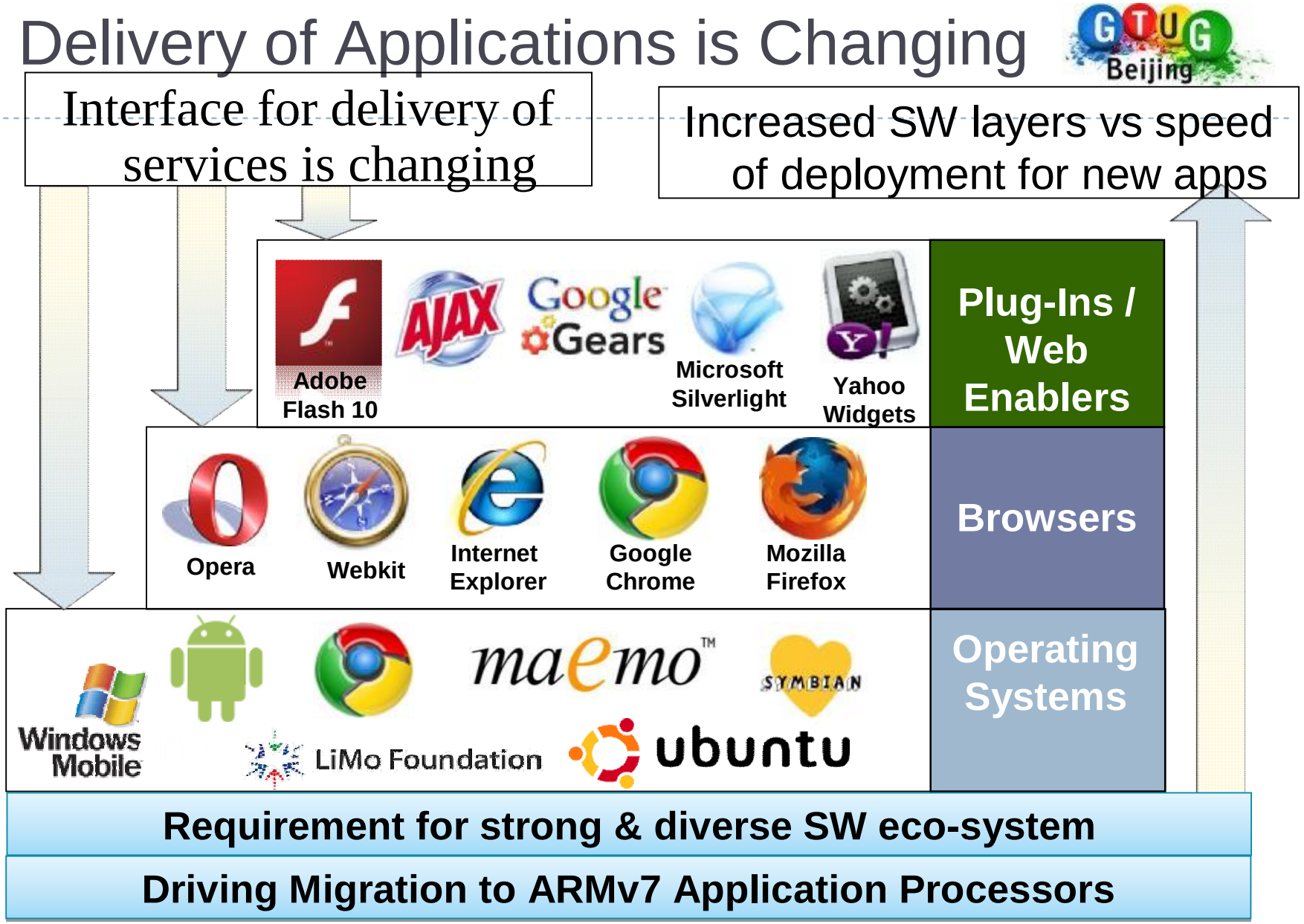
Expect a Wider Smartphone Portfolio

Just some of the Cortex-A class mobile devices announced

Today's advanced handsets are becoming mobile computers

- Only been 12 months since first ARMv7 handset was announced
- All the top5 OEMs now have introduced ARMv7 products
- 2010 smartphone features trickle down to 2013 low-end handset

Delivery of Applications is Changing



Redefining “Mobile”

- ARM Cortex devices are defining new categories of mobile products
  - Chipset variety and multiple operating systems enable product diversity
- First ARM technology-based mobile computing devices announced by leading OEMs
  - Mobile computing market expected to grow to 500m units by 2014*

Some of the New ARM-based Products Recently Announced

More Announcements Expected Through 2010

Rapid Evolution of Devices

ARM

Innovate
Differentiate
Competition

Results in rich selection of devices

Always Connected
Smart Mobile Devices

Tablet

Is this the breakout year?

smartbook

Lenovo launched at CES

Tablet

Clam

eReader

New must have device, major innovation

Netbook

2 yrs since introduction

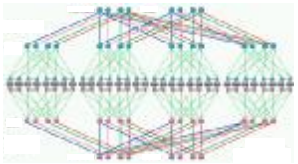
On-Demand Connected

Right-Size Computing

- **CPUs** -- High-performance / low-power CPUs are critical; you don't need high-end level PC processor performance

- **GPUs** -- Critical and are more important for the success of these devices then the CPU. A good GPU can make or break the device.

- **Video –** It is about HD, you can't do it, you can't play. 720p today moving quickly to 1080p

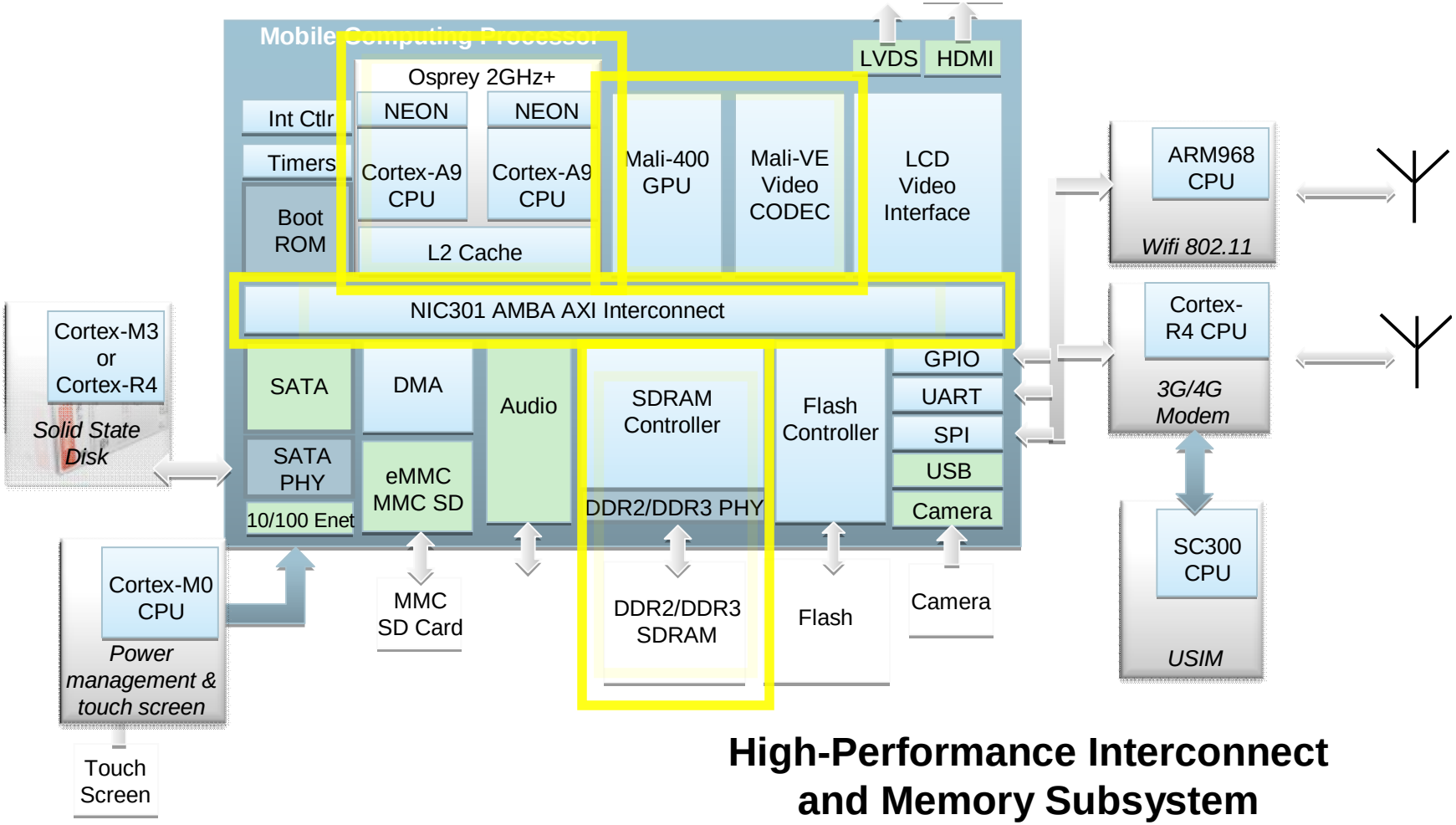


- **Fabric** -- High-performance and efficient SoC design … memory performance makes or breaks the design

Key System Components

ARM v7 Architecture Processor Complex with at least 256K L2

3D Graphics and HD Video Acceleration Blocks



High-Performance Interconnect and Memory Subsystem

Leading Mobile Solutions 2010

New NVIDIA® Tegra™ Mobile Web Processor

- Dual-core ARM® Cortex-A9 MPCore processor, up to 1.0 GHz
- Ultra low power NVIDIA graphics supporting OpenGL ES 2.0
- Adobe® Flash® 10.1 acceleration
- Full HD multimedia including 1080p encode and decode
- Delivers up to 140 hours of audio and up to 16 hours of HD video playback
- 12 megapixel camera support

ARM POWERED

NVIDIA

Qualcomm QSD8672

- Custom DualV7A CPUs, up to 1.5 GHz for faster response and processing
- Low-power 45nm process technology for higher integration and performance
- Higher-resolution WSXGA (1440 x 900) display support
- High-definition (1080p) video recording and playback
- Support for HSPA+ networks – 28 Mbps downloads and 11 Mbps uploads
- Supports CDMA2000 1X, 1xEV-DO Rel 0/A/B networks
- Improved 3D graphics – up to 80M triangles/sec and 500M+ 3D pixels/sec

ARM POWERED

QUALCOMM

ST-Ericsson U8500

- Dual-core ARM® Cortex™- A9 MPCore™ processor
- ARM Mali™ 400 GPU and NEON™ CPU extensions
- Full HD 1080p camcorder, multiple codecs supported (H264 HP,VC-1, MPEG-4)
- Simultaneous dual display support
- High-performance 3D graphics, support for OpenVG 1.1 and OpenGL ES 2.0
- State-of-the-art HSPA (High-Speed Packet Access) with selected HSPA+ features

ARM POWERED

ST ERICSSON

TI OMAP 4430 Processor

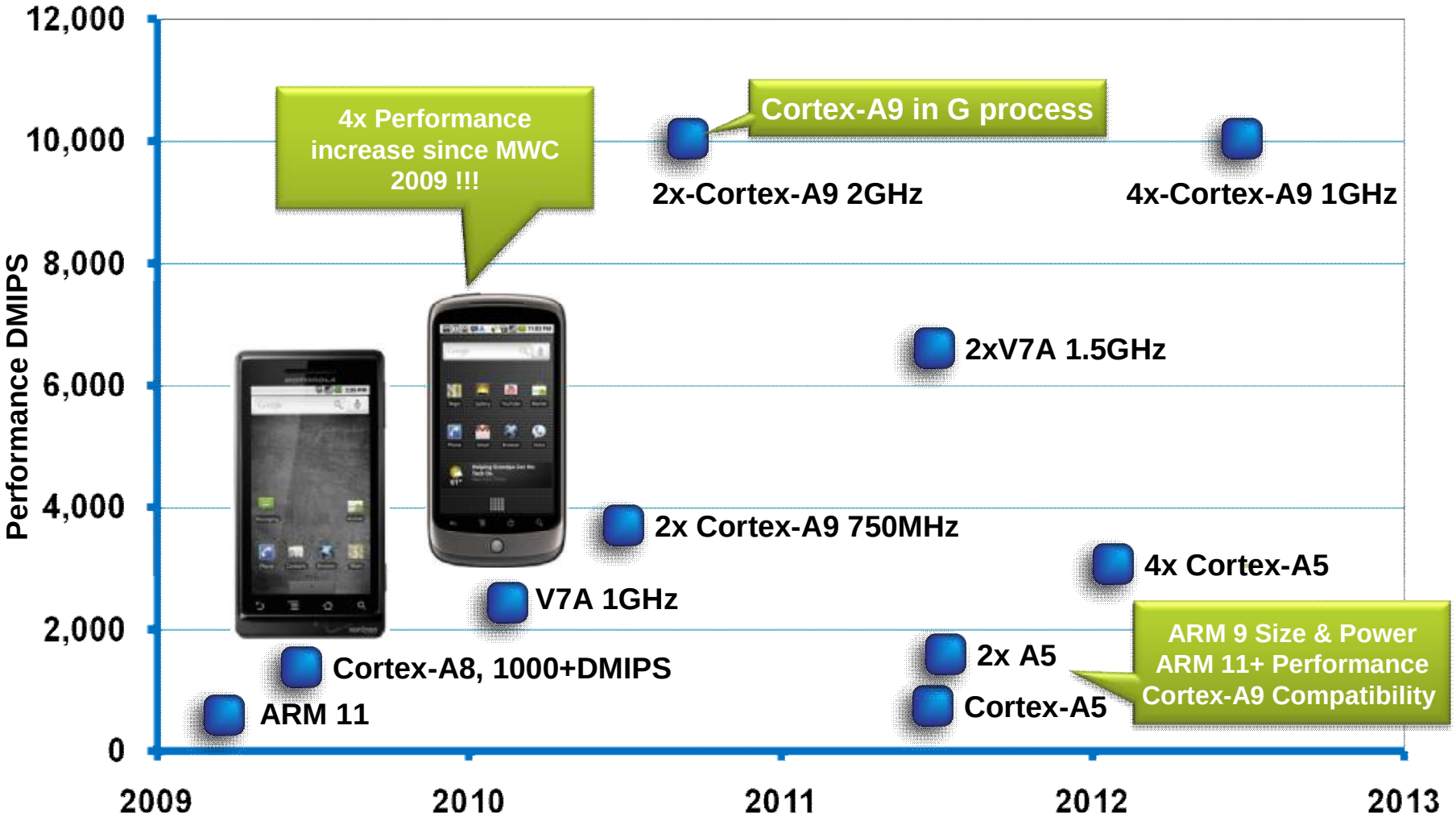
- Dual-core ARM® Cortex™-A9 MPCore™ processor at 1+ GHz with ARM NEON™ technology
- IVA3 multimedia accelerator – enables full 1080p HD video playback and record, running 30fps
- M-Shield™ mobile security technology enhanced with ARM TrustZone® support
- Supports OpenGL® ES v2.0, OpenGL ES v1.1, OpenVG v1.1 and EGL v1.3
- SmartReflex™ 2 technology – Advanced power reduction with dynamic voltage and frequency scaling (DVFS)
- Provides up to 140+ hours of CD-quality audio playback
- Delivers 10+ hours of 1080p HD video playback, 4+ hours of 1080p HD record

ARM POWERED

TEXAS INSTRUMENTS

Increasing Performance in Your Phone

Scalable Performance, Scalable Solutions, Scalable Power



Mobile Client of 2013

Device trends

- Evolve to become personal compute platform
- Console quality gaming
- Navigation with augmented reality
- Advanced video capability
- More web interaction
  - Content & applications delivered using HTML5 & FP10
- Fast broadband
  - Enterprise applications
  - Advanced multi-processing drives new consumer paradigms and uses
- Fast battery charge

Apps processor

- Multicore, GHz solutions
- No change to 300mW power budget
- New generation MP with greater dynamic range of performance
- 22nm
- New generation GPU
- Isolation of applications & secure payment

Modem

- LTE 100Mbps
- New-generation processor to handle high data rates

Best Software Solution for Mobile?

PC Legacy on x86

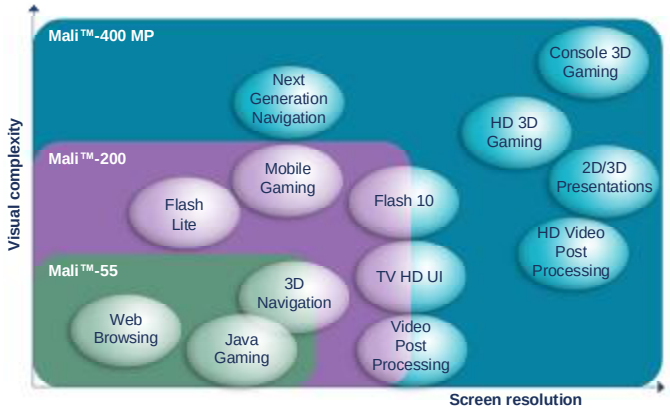
- Software designed for PCs
  - Windows focused
  - PC form factor focused
  - Designed for Core2 Duo+
  - Non optimised for power
- Only one mobile O/S
  - Moblin
  - Still not shipped on a mobile phone
- Moblin Garage App Store
  - Trying to bridge Atom performance gap
  - <100 applications on Moblin Garage
- Embracing QT
  - Hoping to build upon ARM ecosystem momentum

Innovation on ARM

- Software designed for mobile
  - 15+ years of power optimized software
  - Software designed for mobile experience
  - Utilizing location, camera, always on, always connected …
- Multiple mobile O/Ss
  - Driving innovation and diversity
  - Many now open source
  - Production proven
- Vibrant application stores
  - Hundreds of thousands of mobile phone applications on multiple operating systems and store fronts

Choosing the right architecture?

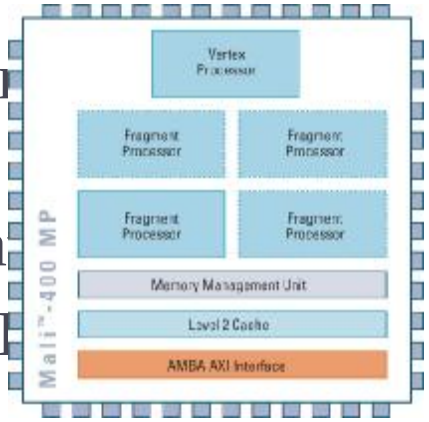
- Designing for OpenGL ES 2.0 and OpenVG 1.1
  - Geometry load constant, pixel processing scales with screen resolution
  - No additional geometry overhead when scaling pixel performance
- Separate Mali geometry & pixel processors



ling - optimum configuration for

on through independent clock ga

an “unified” shader for OpenGL E



Future Technology Directions

- Energy efficiency and high performance
  - Focus on memory bandwidth usage
- Area efficiency and flexibility/re-use
  - Multicore designs for scalable performance solutions
  - General Purpose computing on Graphics Processing Units (GPGPU)
  - Embedded application: image post-processing
- Composition software will be key
  - How to mix Audio, Video, 2-D graphics, 3-D graphics, UI, etc.
- 2012 graphics architecture changes will be driven by new functionality
  - E.g. 2nd generation GPGPU, OpenCL and geometry shader
  - Note: none of this is supported in current OpenGL ES standards
  - OpenGL ES 3.x specification will not complete until 2012

Porting Premium Games on Mali

Airplay is a unique technology from Ideaworks3D, delivering console-quality gaming to any ARM and Mali based platform.

ARM recently announced investment in Ideaworks3D

- Ideaworks3D Store Front on Mali
- Project Gotham Racing
- Resident Evil
- Fishlabs – Powerboat challenge iPhone game

Mali200 platforms (OpenGL ES 2.0) deliver an experience comparable to current-generation consoles.

Next-generation 2D and 3D Navigation

- **Working with TomTom and other middleware providers for next generation PNDs**

- Acceleration of navigation elements through Mali OpenGL ES
  - Textured roads
  - Digital terrain modelling, fogs effects
  - Elevated roads on landscapes, road intersection
  - 3D birds-eye view, realistic road signs

- Joint project with TomTom on Mali-55 and Mali-400 based platforms:
  - OpenGL ES 1.1 for map rendering
  - OpenVG for font rendering and Webkit
  - OpenGL ES 2.0 for 3D junction view

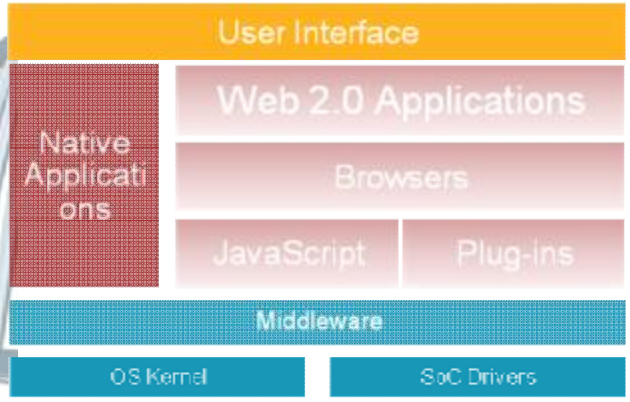
Browser Acceleration

- **Working with Opera ar[illegible] OPERA software [illegible]nable rich browsing experiences**

mozilla

- Key activities
  - Benchmarking browser experience on Mali
  - Optimisation suggestions for usage with hardware acceleration
  - Implementing use-cases and benchmark tests

ARM Software Ecosystem



Priority Enablement Projects

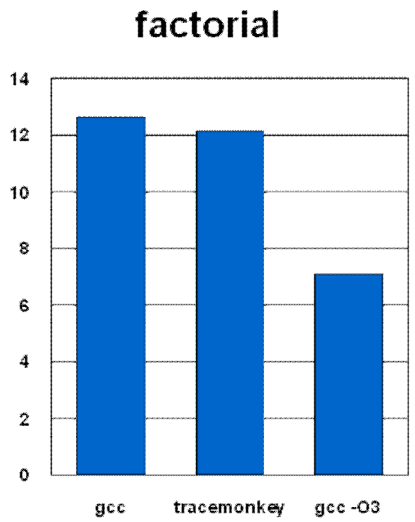
- Many ongoing engagements
  - Linux Kernel, GCC, etc…

- Priority projects for update
  - Java and JavaScript
  - Browsers
  - Android/ChromeOS
  - Flash 10

JavaScript Acceleration

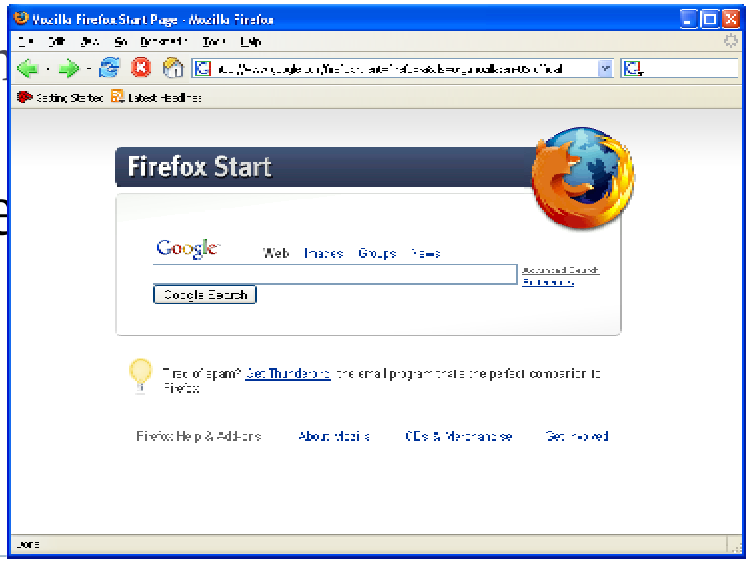
- 2009 was the year that JavaScript performance ***accelerated***
- 4 Key Open Source Projects to accele
  - "TraceMonkey" – Mozilla Foundation
  - "Tamarin"- Adobe
  - "Squirrel Fish (Extreme)"- WebKit
  - "V-8"- Google

- All accelerate JavaScript by compiling it to native code (JIT)
- Some yield up to 5X+ performance improvement
  - Example: Factorial is faster than non-optimized C



Mozilla Firefox and Fennec Browsers

- Targets Smartbooks, Smartphones, DTV's…
  - ARM created enhanced "Tamarin" nano JIT code gene
  - ARM optimized Cairo graphics for NEON
  - ARM is working with Mozilla to add OpenGLES 2.0
- Firefox 3.5 up to 2x faster* than Firefox 3.0
  - 7x JavaScript improvement between
- Release schedule parity with Inte
  - Firefox 3.6 Dec 2009
  - Fennec duled for Nov 2009



* Sunspider benchmark

Webkit - Advanced Browser Framework

- Webkit forms the basis for >6 browsers on ARM
- Webkit framework has 2 parts
  - WebCore – supports different graphics libraries
  - JavaScriptCore – supports different JavaScript Engines
- ARM is optimizing key libraries and engines

Squirrel Fish Javascript Engine

Cairo 2D Graphics

Google V8 Javascript Engine

skia 2D Graphics

Squirrel Fish Nitro *Extreme* Javascript Engine

Symbian S60 Browser

QT Browser Framework

Midori Browser

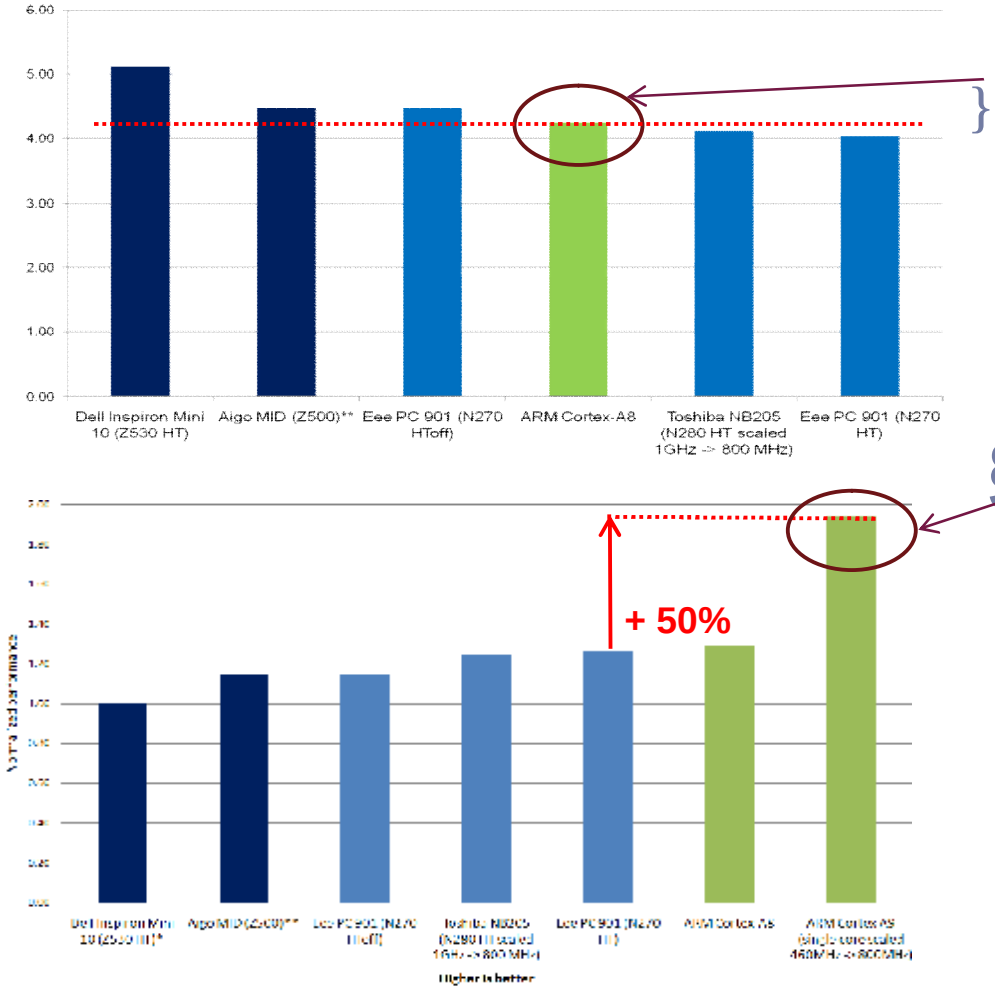
Browser

Chrome Browser

Safari Browser

Browsing on ARM Surpassing Intel

Cortex Web Page Rendering vs. Atom



Average web page load times (Bbench Suite)

- Cortex-A8 delivers similar performance of Atom at much lower power
- Cortex-A9 is 50% better than Atom at same MHz

Test platform: ARM Cortex A8-based SoC, gcc 4.3.3
Intel Atom-based netbooks running Linux
Benchmark: Bbench browser workload, Firefox 3.5

ARM Innovating with Google

- Android and Chrome OS target ARM from the

- Google, ARM and other OHA Partners deliver more ARM optimizations with each Android and Chrome OS release
- Staying with the mainline allows access to the latest features

ARM Architecture is the Only One That Will Ship On Android & Chrome

Android and ARM Inseparable

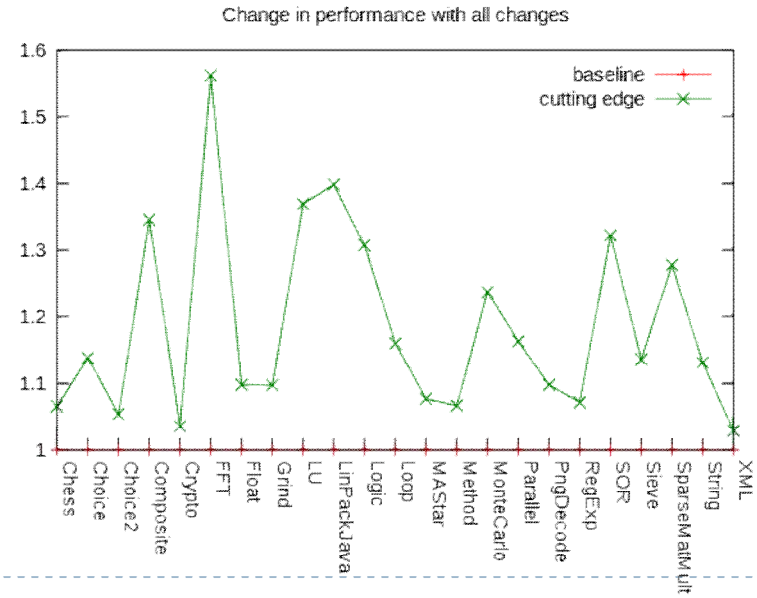
- Android was developed for and shipping exclusively on ARM
  - From the Android prototype to the Motorola Droid and Nexus One

- Android is optimized for ARM
  - 1,200 files of assembler code.
  - 20,000 or 28% of Bionic libraries are ARM assembler
  - 6,300 C & 4,900 C++ files many with ARM optimizations
- There are 268 companies and entities contributing code to the ARM Android codebase.

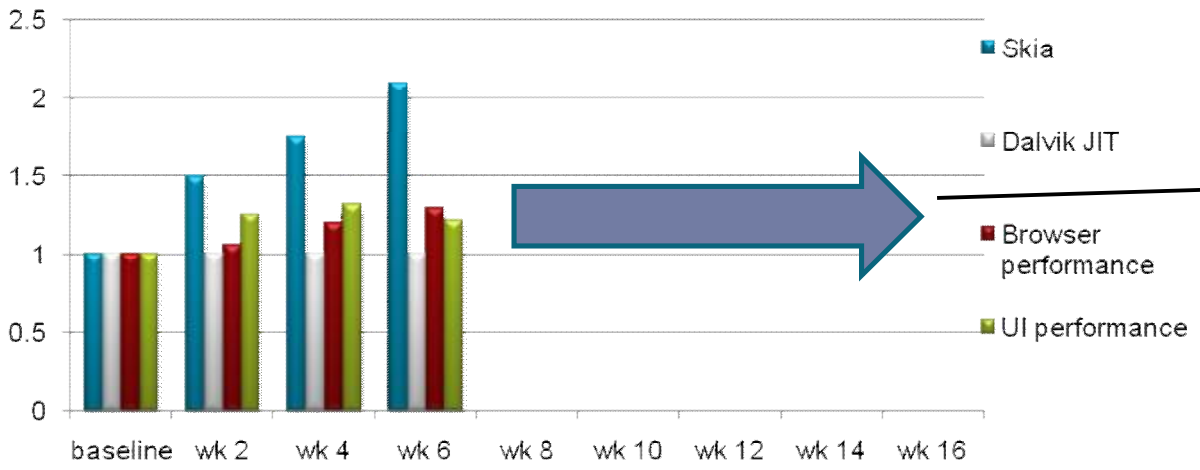
Google Dalvik Java VM Optimizations

- Dalvik JIT announced publically at Google-IO May '09
- Google has partnered with ARM on Dalvik open source project
  - Initially work on interpreter improvements yield ***>10% Uplift***
  - ARM working on JIT contributions to code generation
    - ARMv7 Thumb2 and Thumb-2 EE (as appropriate)

Cumulative improvement
ARMv7T interpreter over ARMv5T
EEMBC Grinderbench



Cumulative Android Neon Optimization Impact



Optimization and Benchmarking work Continues to improve Performance

- In Android and Chrome, Skia 2D graphics lib and Dalvik JIT are critical
  - Some Skia routines see as much as 500% lift from Neon
  - Overall performance improvement of 30% in UI, 10~30% in browser use cases due to Neon optimized Skia
    - Benefit increases at higher screen resolution

Notes: Test platform: Cortex A9, PL310 L2, 4:1 memory system, Android OS, gcc 4.3.3

Benchmark: Skia graphics lib, Bbench browser workload, Dalvik JIT

Adobe Flash Player Technology

The worlds most popular web Rich Content delivery vehicle

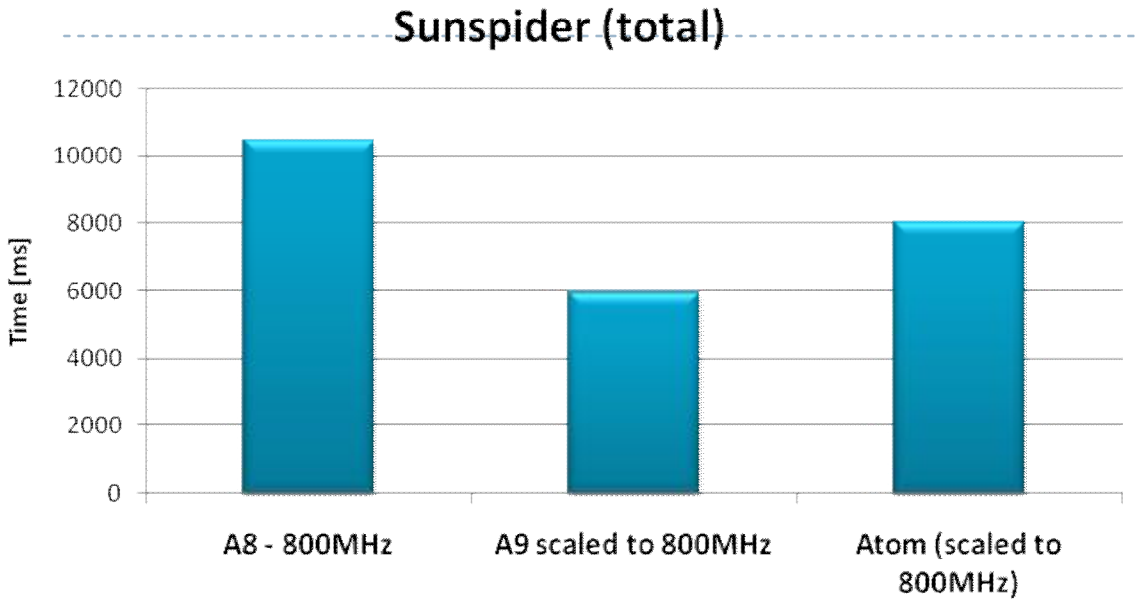
Vector & raster graphics rendering via software and hardware engines

Bi-directional audio & video streaming via Audio and Video codecs

Execution of ActionScript programs via Tamarin Central Virtual Machine

- Three core technology threads as part of Flash

Flash Player 10 – ActionScript 3.0



- 50%+ speedup from original NanoJIT to current version
  - Applies to both A8 and A9

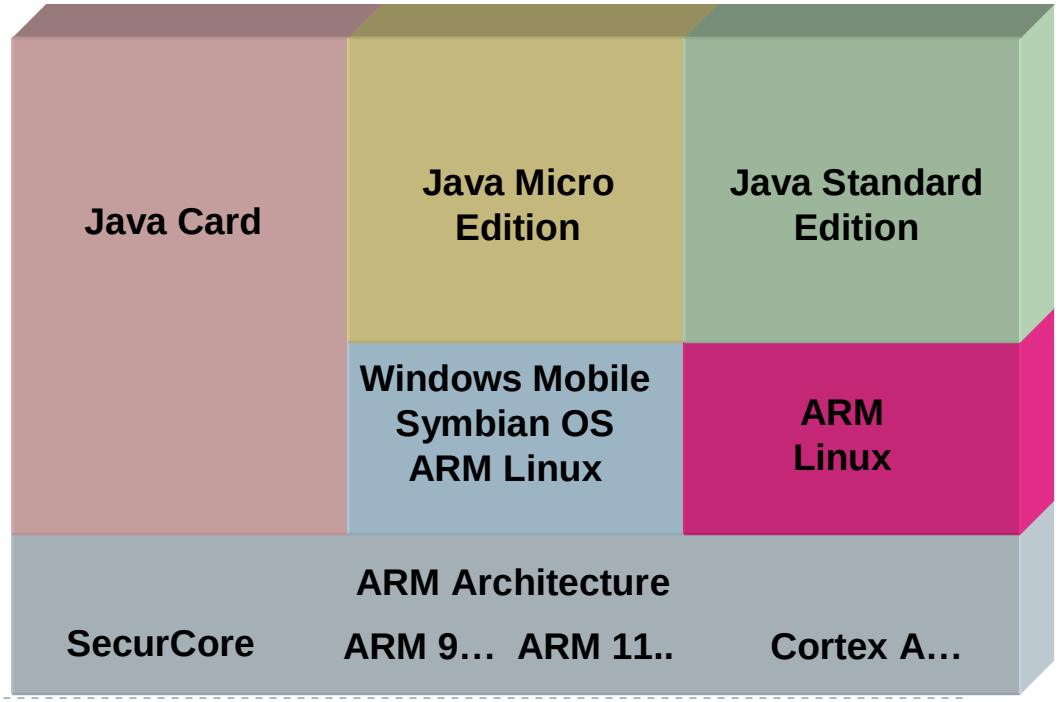
- A9 36% faster than Atom at same speed
- A9 76% faster than Cortex-A8

Test platform: ARM Cortex-A8 based SoC at 800MHz, ARM Cortex-A9 test chip dev platform at 460MHz (scaled to 800MHz for comparison), ARM Linux, gcc 4.4.3

Benchmark: Actionscript running Sunspider

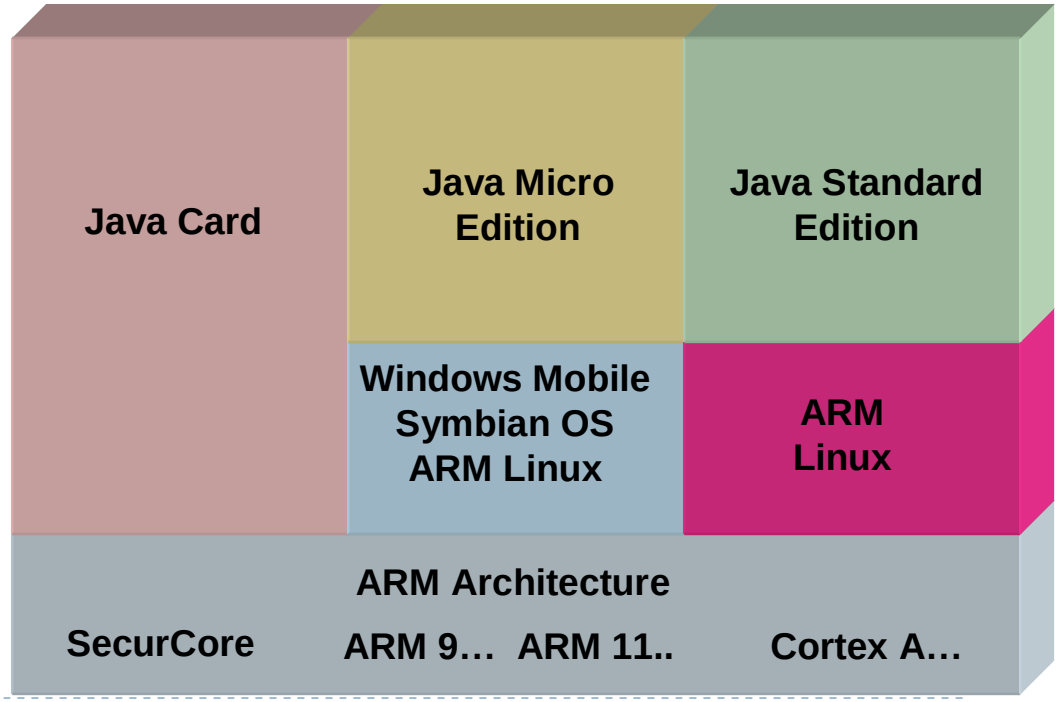
Java Standard Edition on ARM

- Java Standard Edition v6.10 (ARM) available from Sun since Q1 2009
  - For ARM Linux 2.6.22 and above
- Full Desktop Java for ARM
  - Includes C1 Client Hotspot JIT
  - Powers Java Applets in browser
  - Powers many desktop apps
  - Popular in Enterprise front-ends



OpenJDK (IcedTea) on ARM

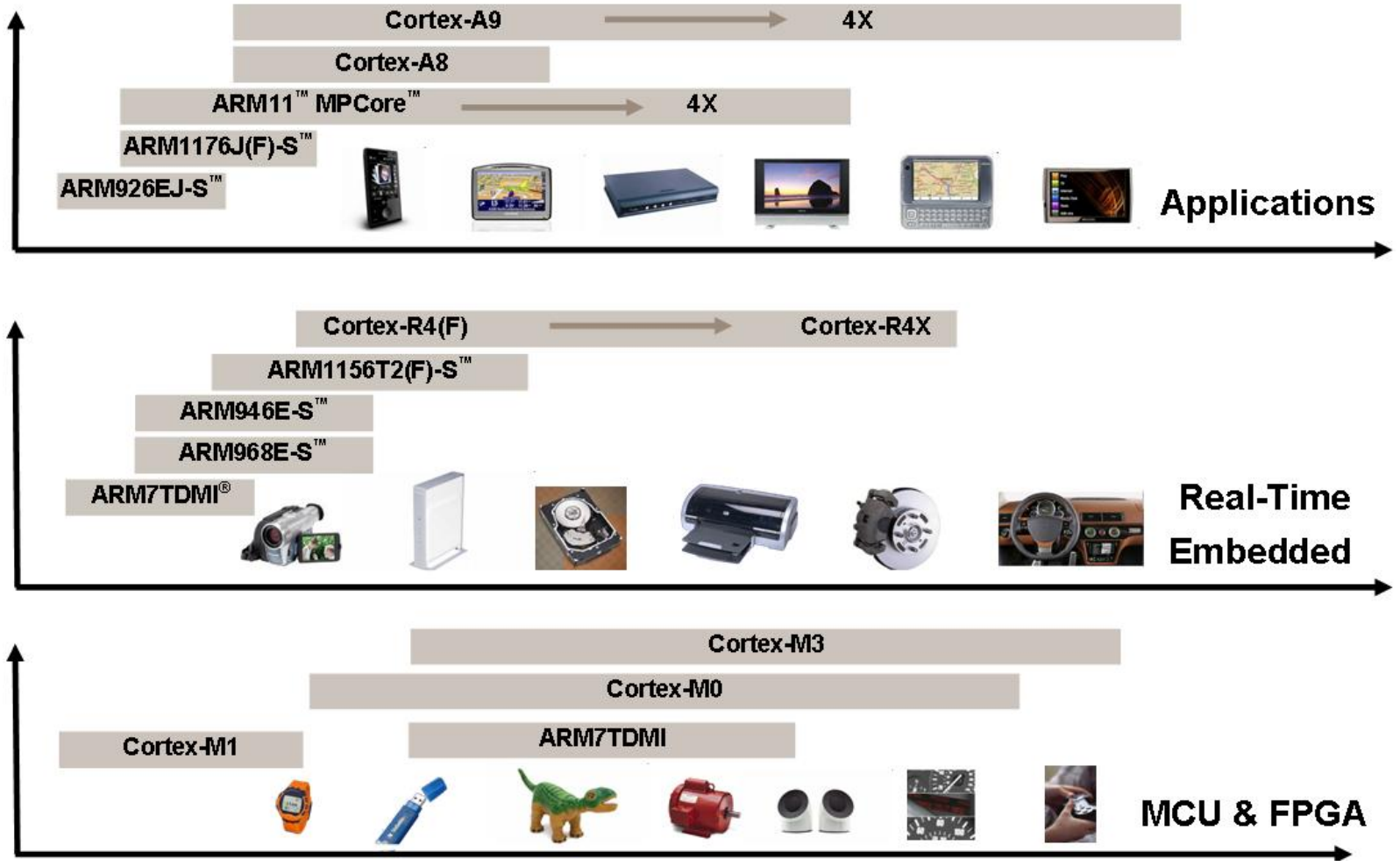
- ARM is driving optimization via Ubuntu
  - Added optimized ARM Assembly interpreter for Ubuntu – 4x speedup
- OpenJDK optimizations in Karmic
  - Accepted by Canonical
  - Pushed upstream to IcedTea
- ***Free*** Open Source Java
  - Complete implementation
  - Java TCK compliant



议题

1. ARM处理器概述
2. ARM平台硬件结构分析
3. ARM linux系统典型应用案例

ARM处理器的应用


Cortex-A9
4X
Cortex-A8
ARM11™ MPCore™
4X
ARM1176J(F)-S™
ARM926EJ-S™
Applications
Cortex-R4(F)
Cortex-R4X
ARM1156T2(F)-S™
ARM946E-S™
ARM968E-S™
ARM7TDMI®
Real-Time
Embedded
Cortex-M3
Cortex-M0
Cortex-M1
ARM7TDMI
MCU & FPGA

ARM体系结构的发展

Halfword and signed halfword / byte support

System mode

Thumb instruction set

Improved ARM/Thumb Interworking

CLZ

Saturated arithmetic

DSP multiply-accumulate instructions

Extensions:

Jazelle (5TEJ)

SIMD Instructions

Multi-processing

v6 Memory architecture

Unaligned data support

Extensions:

Thumb-2 (6T2)

TrustZone (6Z)

Multicore (6K)

Thumb only (6-M)

Thumb-2

NEON

TrustZone

Architecture Profiles:

7-A (Applications) : NEON

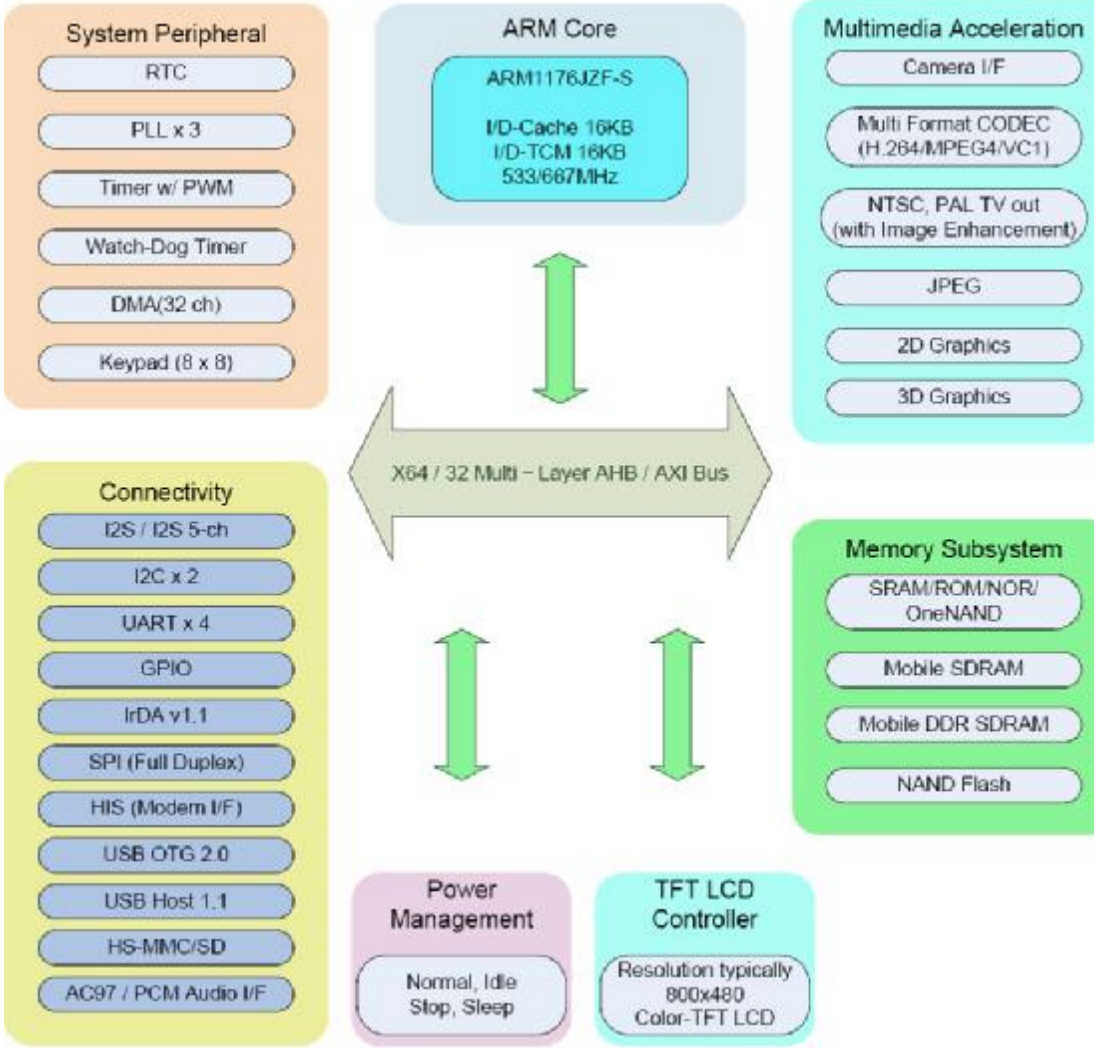
7-R (Real-time): Hardware divide

7-M (Microcontroller): Hardware divide, Thumb-2 only

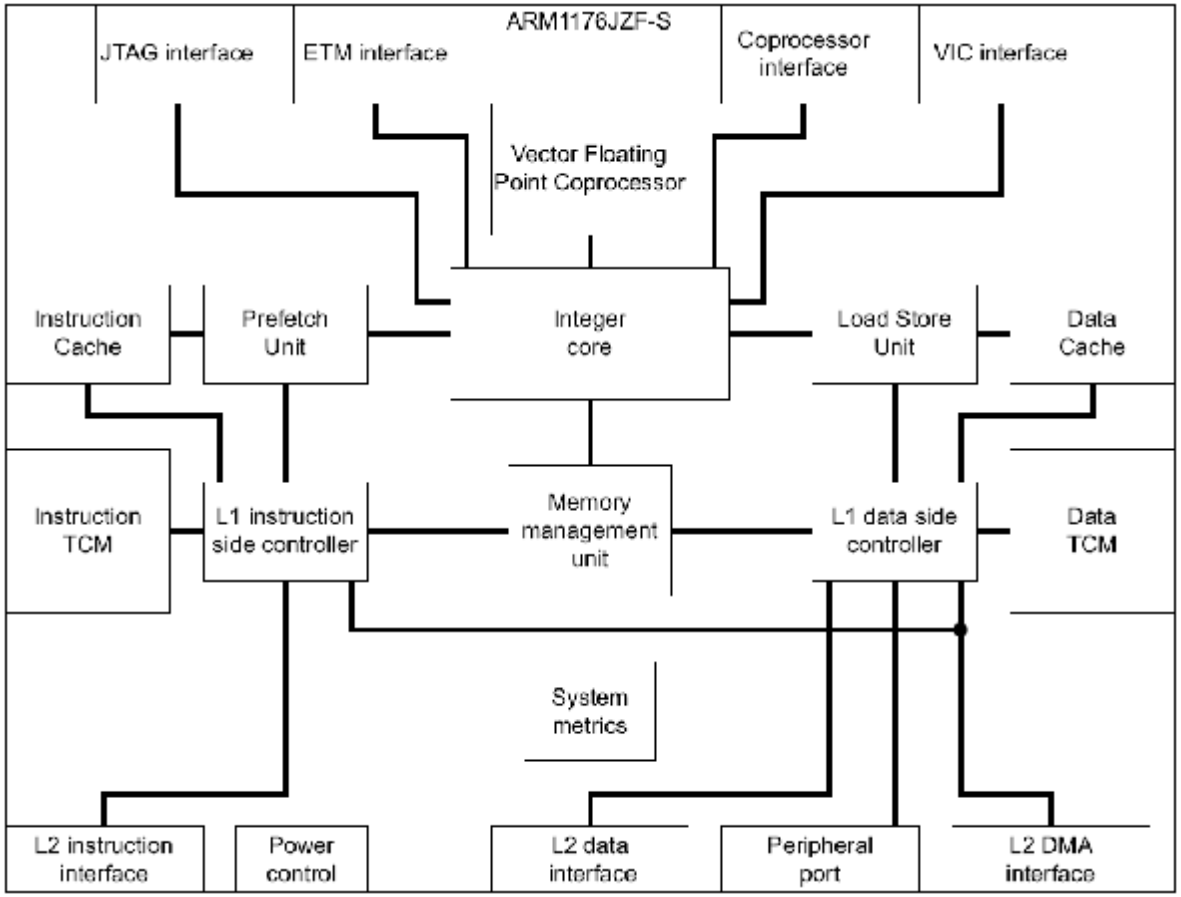
全新TOP6410单板机接口设计

- 基于S3C6410处理器
  - ARM1176JZF-S内核
  - ARM V6指令集

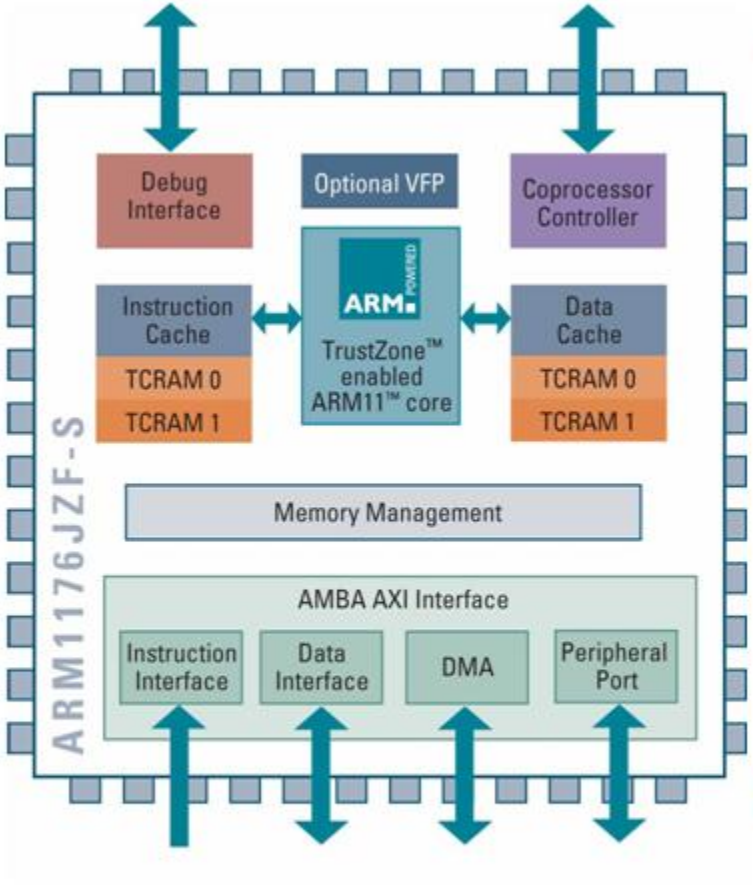
S3C6410内部结构图



ARM1176JZF-S 处理器框图



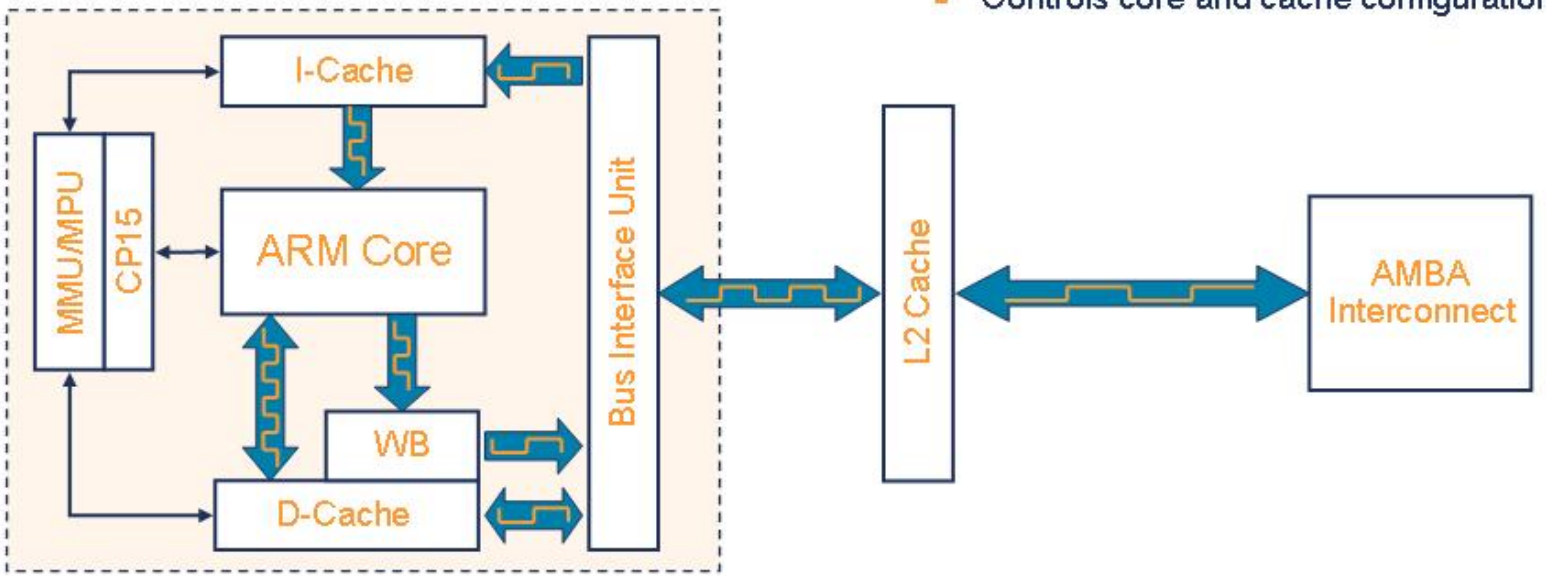
ARM1176JZF-S特性



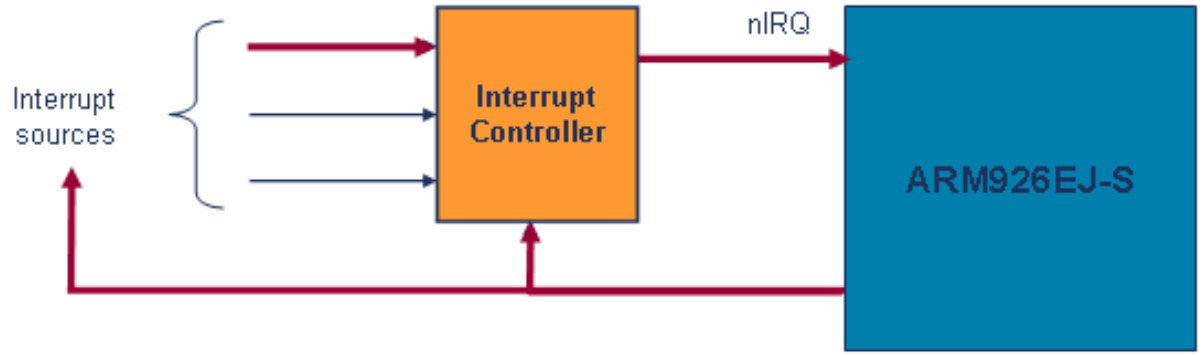
- **ARM1176JZ(F)-S**
  - Architecture v6Z - TrustZone
  - 8-stage pipeline
    - Load/Store Unit separate from ALU
    - Static and dynamic branch prediction
  - Physically-tagged 4-64k caches
  - Dual configurable TCMs
  - Memory management unit
  - Four AXI memory ports
  - Jazelle-DBX support
  - Intelligent Energy Management (IEM)
  - Optional integrated VFP coprocessor
- **ARM1136J(F)-S (not shown here)**
  - AHB memory interface
  - No TrustZone support
  - Single TCMs

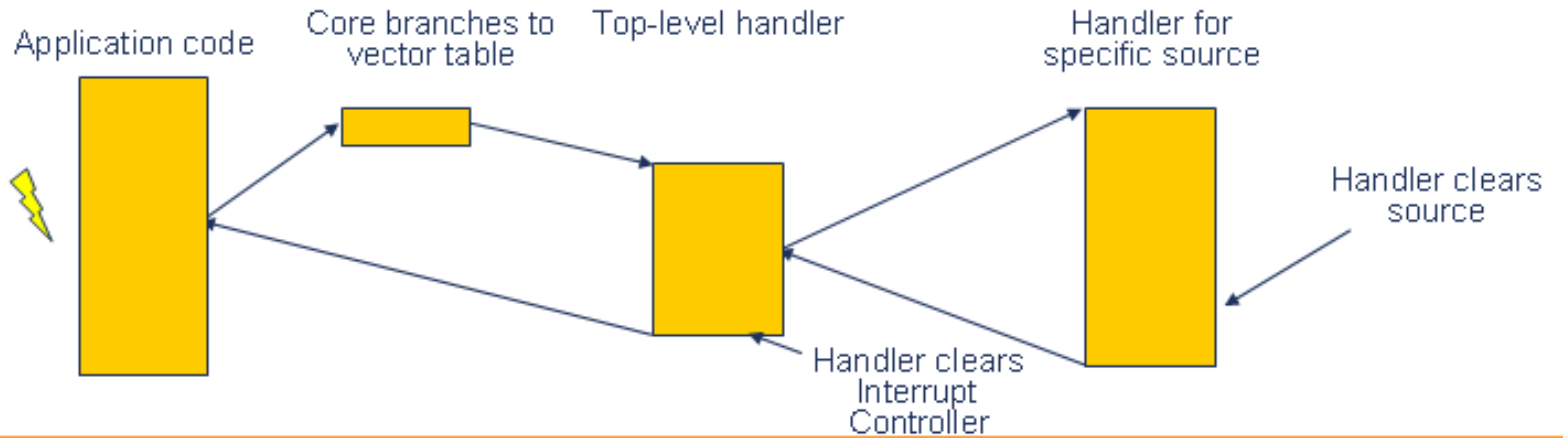
ARM核存储系统

- **MPU – Memory Protection Unit**
  - Controls memory access permissions
  - Controls cacheable and bufferable attributes for memory regions
- **MMU – Memory Management Unit**
  - Has all the features of an MPU
  - Also provides Virtual to Physical address translation
- **Cache**
  - Fast local memory
  - Holds copies of recently accessed memory locations
- **Write buffer**
  - Decouples writes to cache and external memory
- **CP15 - System Control Coprocessor**
  - Controls core and cache configurations

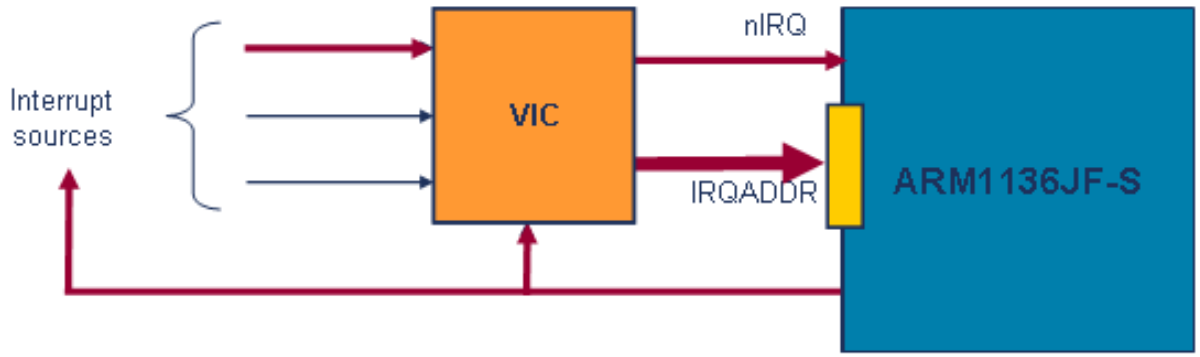


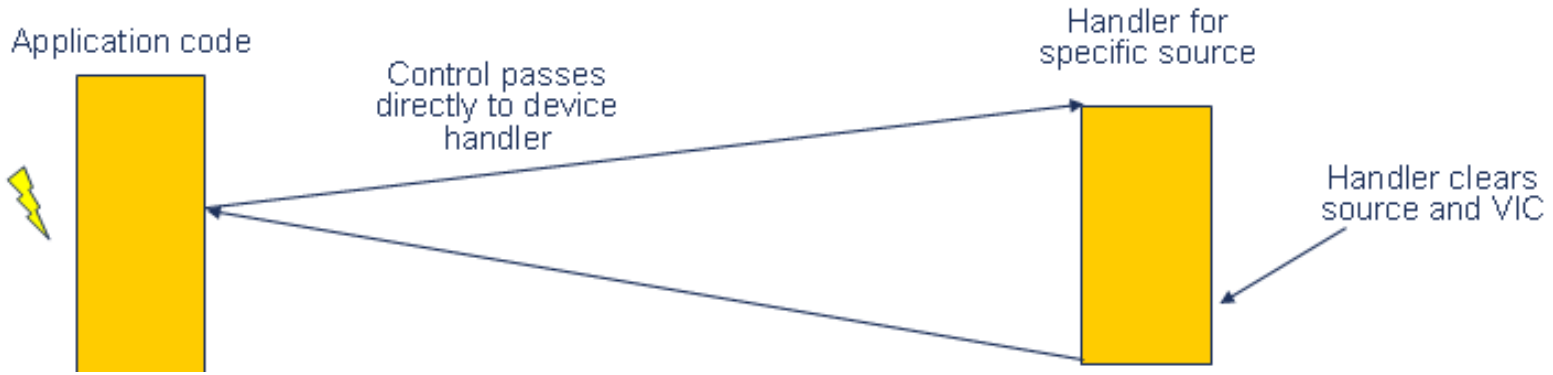
传统中断控制系统


Interrupt sources
Interrupt Controller
nIRQ
ARM926EJ-S


Application code
Core branches to vector table
Top-level handler
Handler for specific source
Handler clears source
Handler clears Interrupt Controller

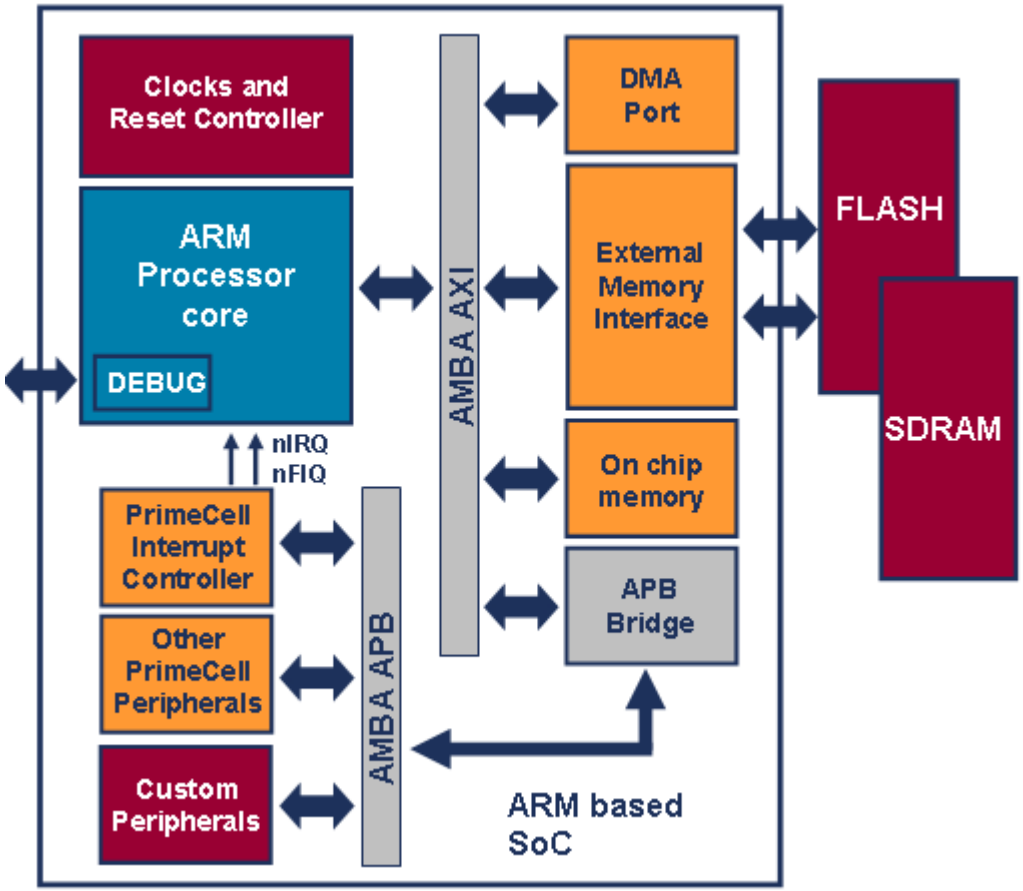
向量中断控制系统


Interrupt
sources
VIC
nIRQ
IRQADDR
ARM1136JF-S


Application code
Control passes
directly to device
handler
Handler for
specific source
Handler clears
source and VIC

ARM基础系统

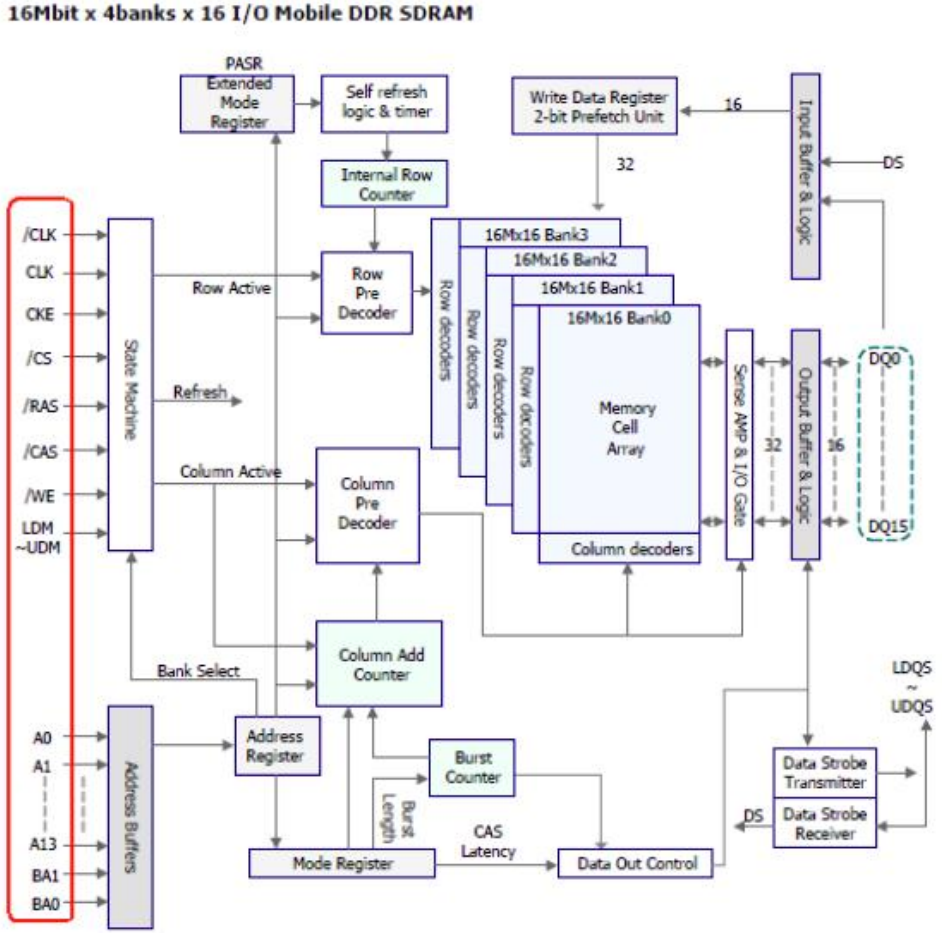
}


Clocks and Reset Controller
ARM Processor core
DEBUG
nIRQ
nFIQ
PrimeCell Interrupt Controller
Other PrimeCell Peripherals
Custom Peripherals
AMBA APB
AMBA AXI
DMA Port
External Memory Interface
On chip memory
APB Bridge
ARM based SoC
FLASH
SDRAM

TOP6410单板机内存设计-1

- TOP6410采用256M Byte mobile DDR，由两片16位的mobile DDR组成32位宽的256M Byte。
- 6410支持Mobile DDR、SDRAM、DDRI。考虑到速度和功耗的原因，由于Mobile DDR（mDDR）有如下特点，故选用其做为开发板的设计。
  - 低功耗，是常规DDRI的一代
  - 低电压，1.8V
  - 支持SLEEP功能
  - BGA封装，有效降低PCB面积
  - 一般不需要串端电阻和上拉电阻，设计方便

TOP6410单板机内存设计-2



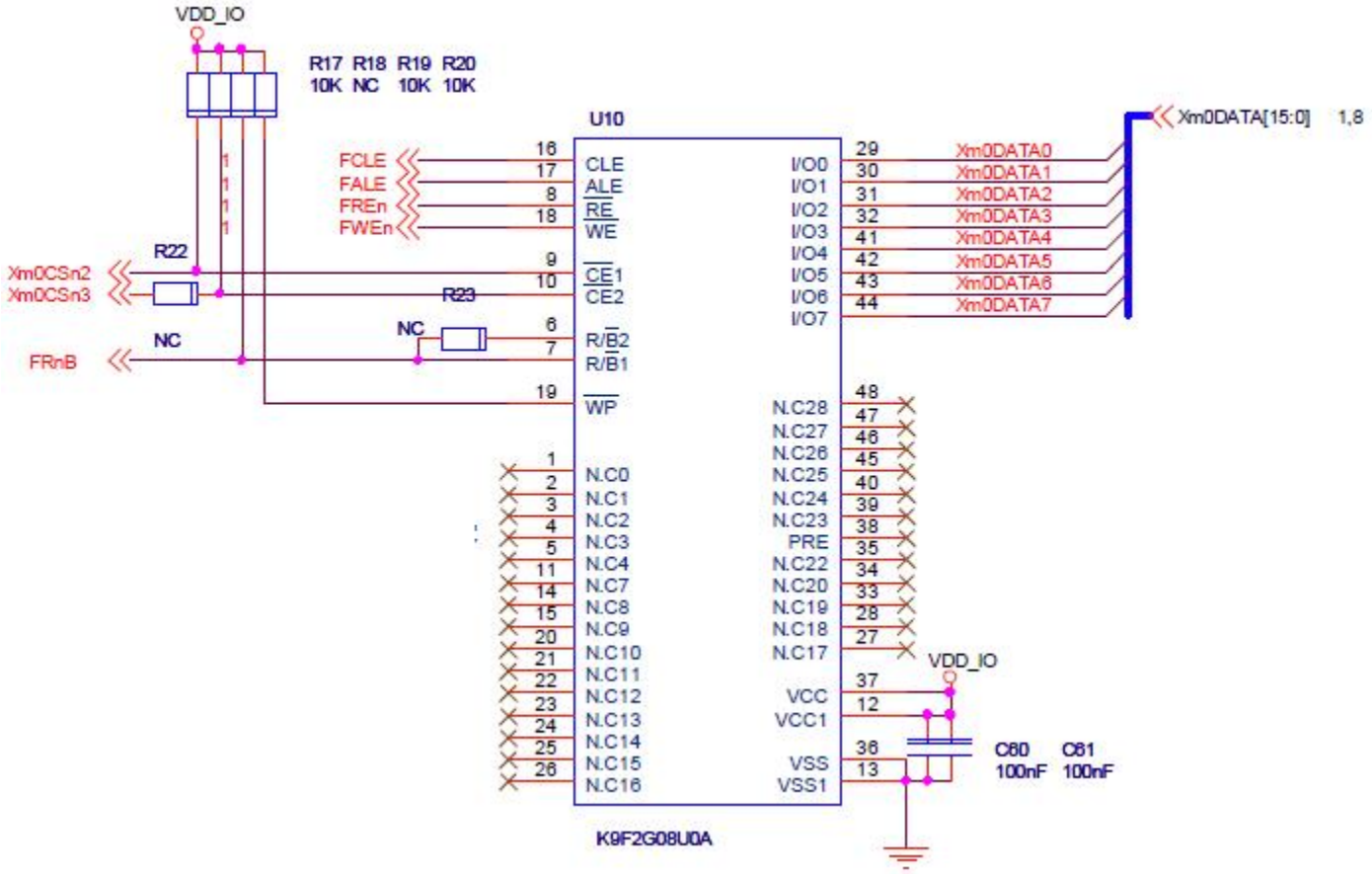
如上红框所示为所需的引脚，而 6410 提供的引脚能满足以上要求，

NAND Flash 和NOR Flash

- NOR的读速度比NAND稍快一些。
- NAND的写入速度比NOR快很多。
- NAND的4ms擦除速度远比NOR的5s快。
- 大多数写入操作需要先进行擦除操作。
- NAND的擦除单元更小，相应的擦除电路更少。

NAND FLASH电路设计分析

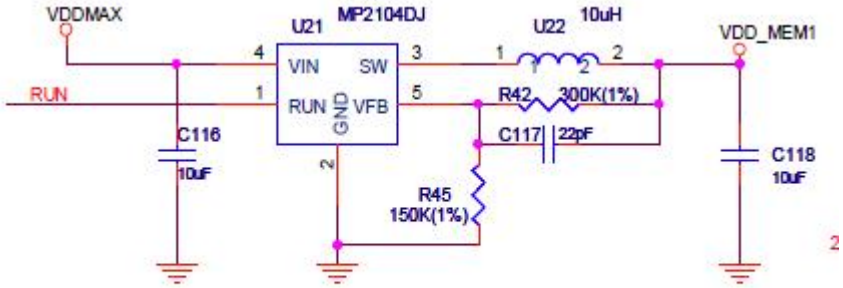
- S3C6410支持MLC和SLC型 NAND FLASH



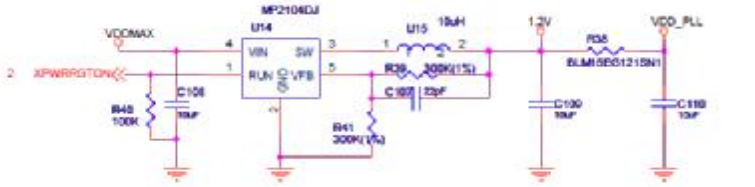
电源管理单元的实现

- 其中需要产生如下电压
- 1、VDDIO 3.3V 不受控
- 2、VDDARM 1.2V 受控
- 3、VDDINT 1.2V 受控
- 4、VDDPLL 1.2V 受控
- 5、VDDMEM1 1.8V 不受控
- 6、VDDALIVE 1.2V 不受控
- 7、VDDOTG 3.3V 受控
- 8、VDDOTI 1.2V 受控
- 9、VDDADC 3.3V 不受控

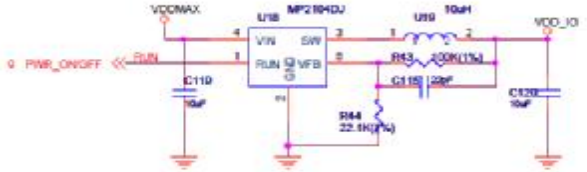
电源电路原理图



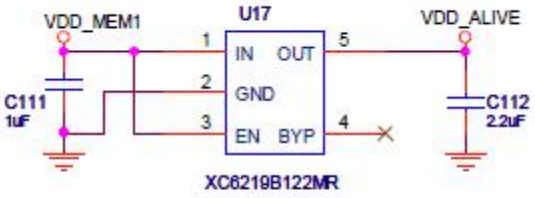
1.8V for mobile DDR



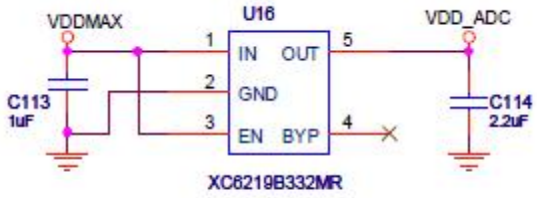
1.2V for PLL INT ARM and OTGI



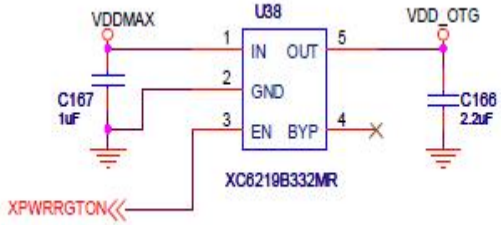
3.3V FOR SYSTEM



1.2V for ALIVE



3.3V FOR ADC or DAC

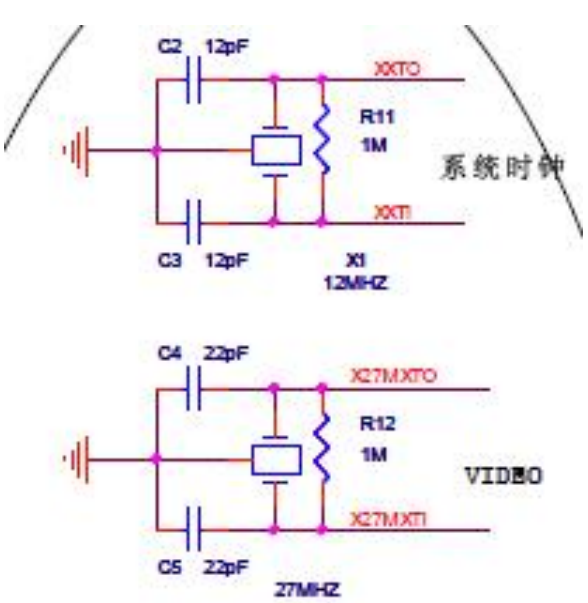


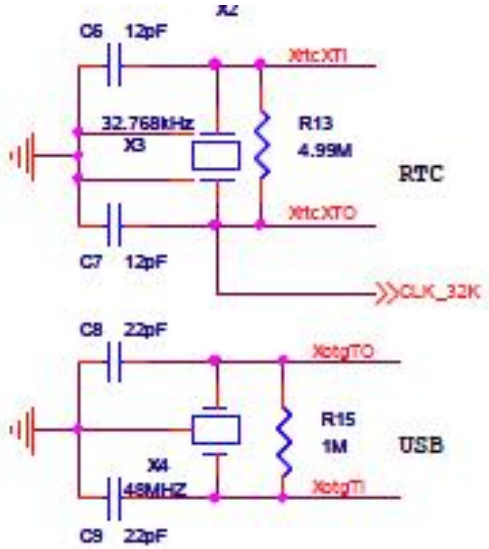
时钟信号设计

- 6410需要四路时钟信号，分别如下
  - 主时钟，12MHZ
  - Video时钟信号 27HZ，用于显示模块，如MFC LCD TV模块提供时钟信号
  - USB时钟，48MHZ，用于USB SD卡 SDIO提供时钟信号
  - RTC时钟，32.768KHZ，用于实时时钟模块提供时钟信号

其是1 2 3可以选择用有源晶振还是无源晶振，除主时钟外，2和3都需要做CPU寄存器的配置才能产生相应的时钟，即选择无源还是有源的。而主时钟用的是有源的还是无源的，由OM0引脚来配置，当OM0拉高时，使用无源晶振，当置低时，使用有源晶振，当使用无源晶振时，XEXTCLK引脚需要拉高。

时钟设计原理图

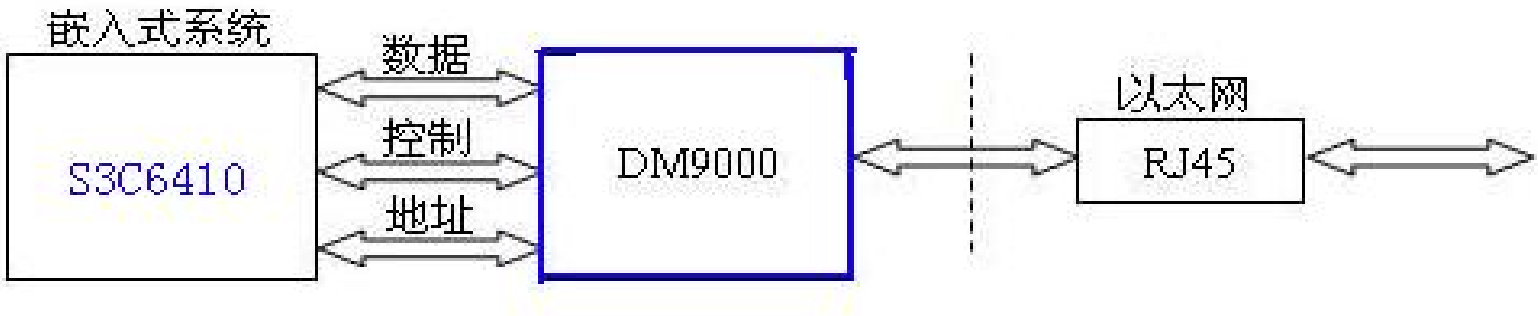




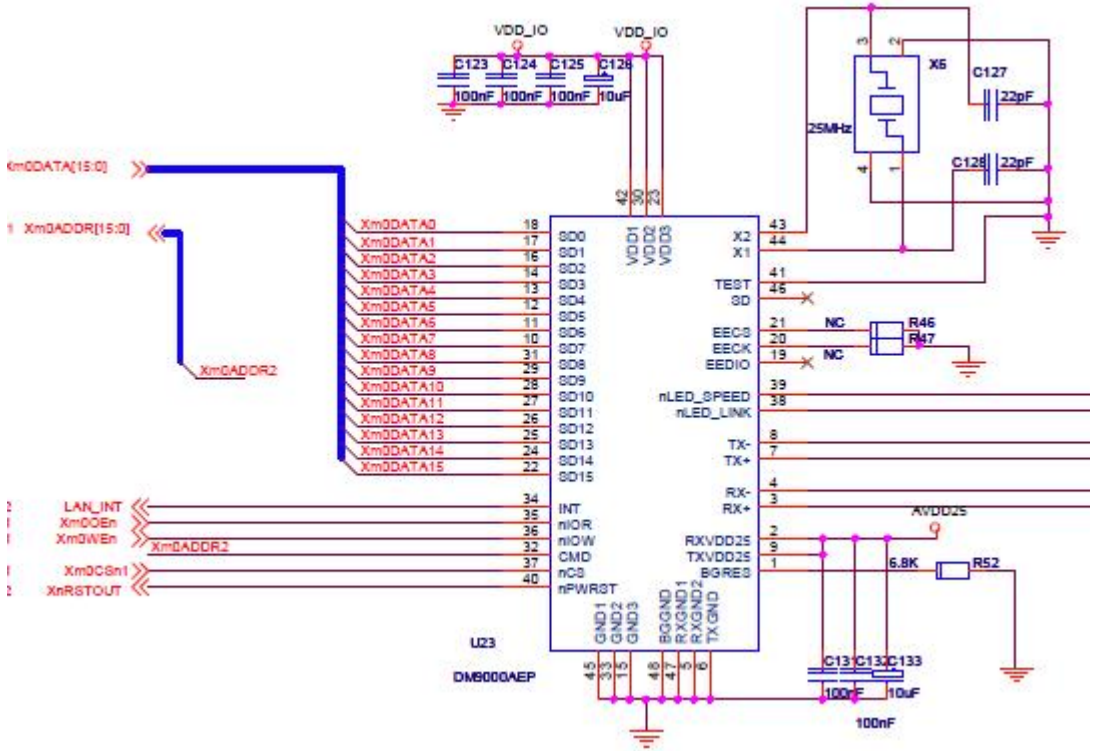
从成本考虑我们选择了无源晶振

网络设计

- DM9000——DAVICOM公司的10/100Mb/s自适应以太网芯片。其特点是：支持8位、16位、32位数据总线宽度；寄存器操作简单有效，有成熟的Linux驱动程序支持；3.3V接口电平；成本相当低廉；

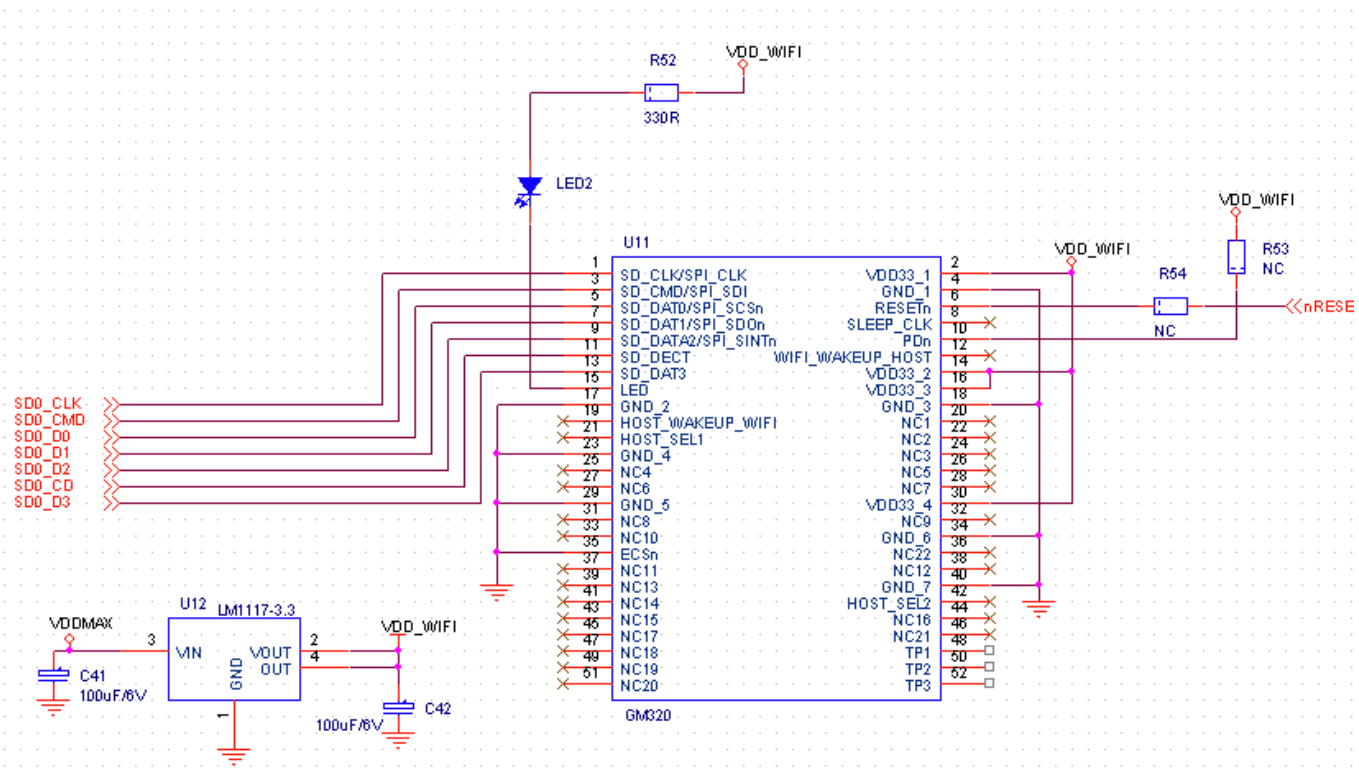


DM9000原理图设计



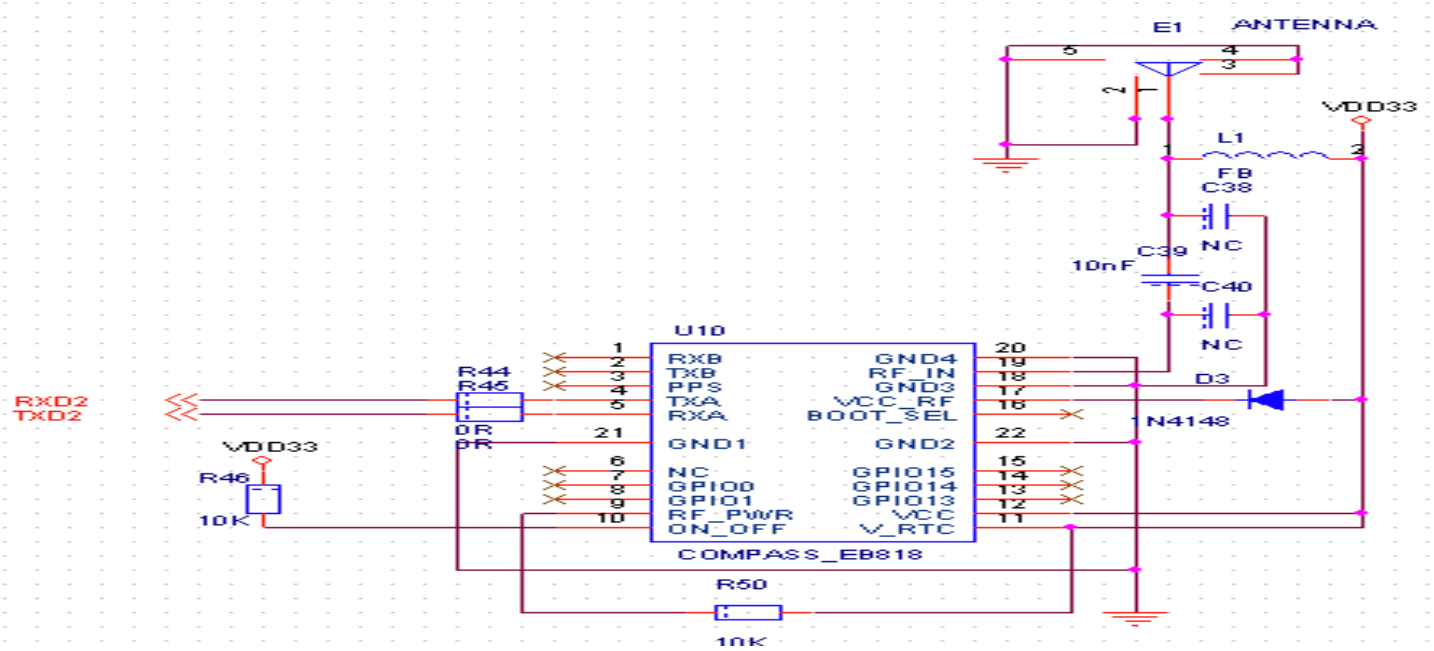
DM9000的总线是16位的，接在6410的Xm0的总线上。

WiFi电路设计



模块要求3.3V供电，我们采用LDO LM1117-3.3为WIFI模块供电。SD通道0接至WIFI模块的SD接口， 图中LED2为连接指示灯，当连接时，LED2会闪烁，连接成功后，LED2灯常亮。 由于模块是默认是SD卡接口连接，所以接口选择可以不接。 模块的RESET引脚可以接至CPU的复位引脚，也可以不接。 PDn引脚是上电使能引脚，模块默认拉高，低电平关闭模块供电。 SD0通道0也接在iNAND上，两者不能同时使用SD0，所以当使用iNAND时，不能使用WIFI模块，反之亦然。

GPS模块电路设计



GPS模块连接在CPU的串口UART2上，GPS的ON_OFF引脚是模块的电源使能引脚，高电平打开供电，低电平反之。模块的天线设计部分加多了电阻电容，以便天线灵敏的调节。

PCB布线分析之差分走线规则

- 1、时钟和差分信号线应该尽量短。
- 2、 高速走线尽量不要有过孔，并且要用45度或圆形的拐角。
- 3、 不要在晶体，晶振，电感，磁珠以及集成电路下面走线。
- 4、 信号线要保证在完整的电源和地平面上。
- 5、 时钟信号与其它走线之间的距离要保持在50mil以上。
- 6、 关于信号线的宽度和间距见图1。
- 7、 差分信号线的长度差应该控制在150mil以内。

DDR布线要求及规范

- **电源和GND的走线规则**

一、地层必须紧挨信号层，以提供良好的返回路径。

二、地层必须无割裂现象。

三、接地管脚的处理：

- 过孔必须尽量靠近管脚；
- 旁路电容的接地管脚尽量靠近CPU相应接地管脚；
- 将靠近的接地管脚用走线连接在一起。

四、电源管脚的处理：

- 旁路电容的电源管脚尽量靠近CPU相应电源管脚；
- 过孔必须尽量靠近管脚。

在PCB面积允许的条件下，尽可能多的放置旁路电容。

- **数据信号走线规则**
  - 数据信号包括DQ，DQM，DQS信号，共分了四个组。
  - 同一小组的信号的长度匹配必须在1.5mm（约60mil）以内，并且尽量在一个信号层内走线，如果同一组的信号在不同的信号层内走线，必须进行PCB的层的阻抗匹配。
- **时钟信号SCLKn和SCLK走线规则**
  - 时钟信号SCLK和SCLKn必须按差分走线方式，时钟信号的长度要比数据信号和地址控制信号都要长。长度关系是：
  - 数据信号 < 地址控制信号 < 时钟信号
  - 以上三组信号的组间长度差控制在10mm（390mil）以内。
  - 对于DDR部分的阻抗最好控制在50-60欧姆之内

Q&A

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欢迎进行技术交流！