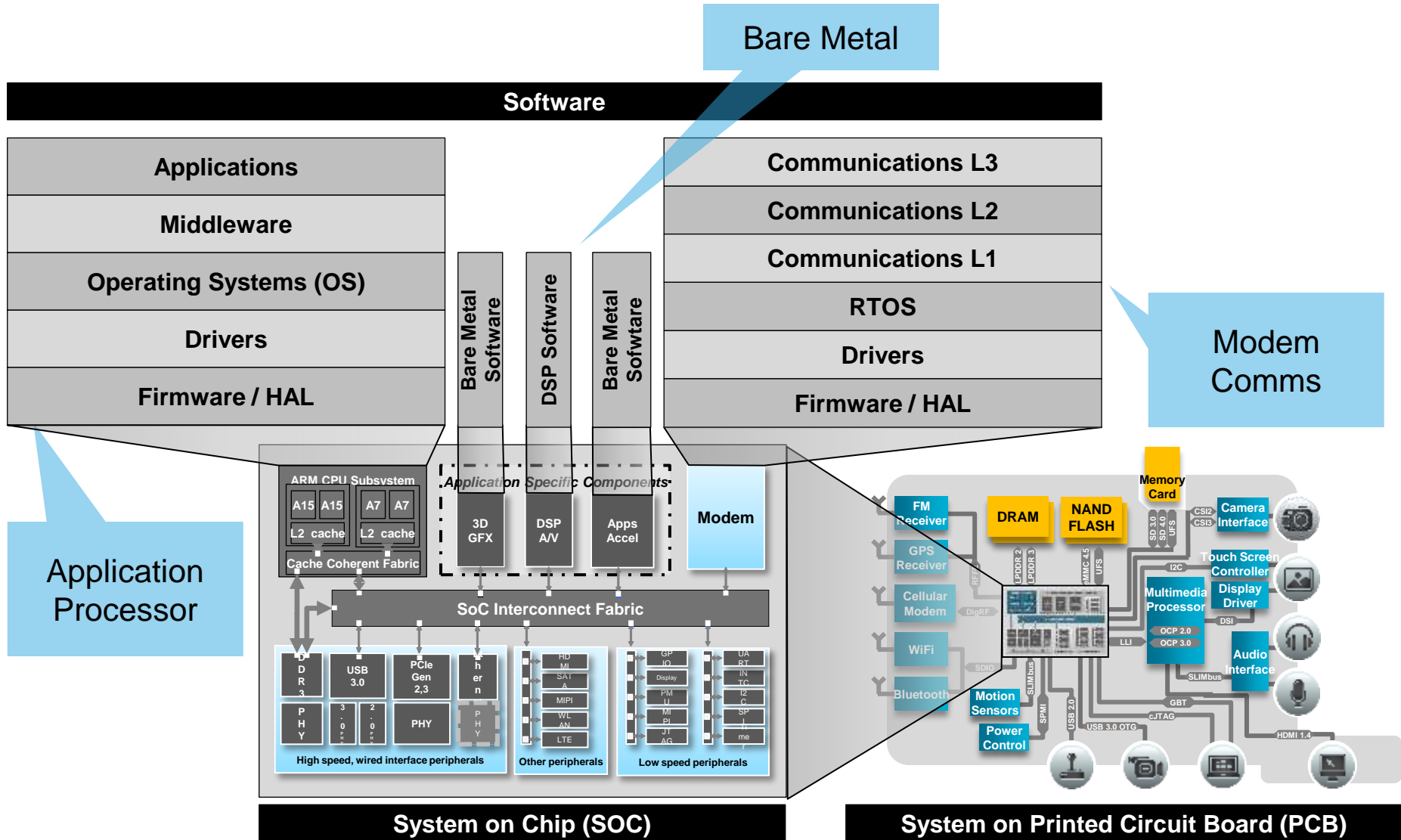# Embedded HW/SW Co-Development
It May be Driven by the Hardware Stupid!
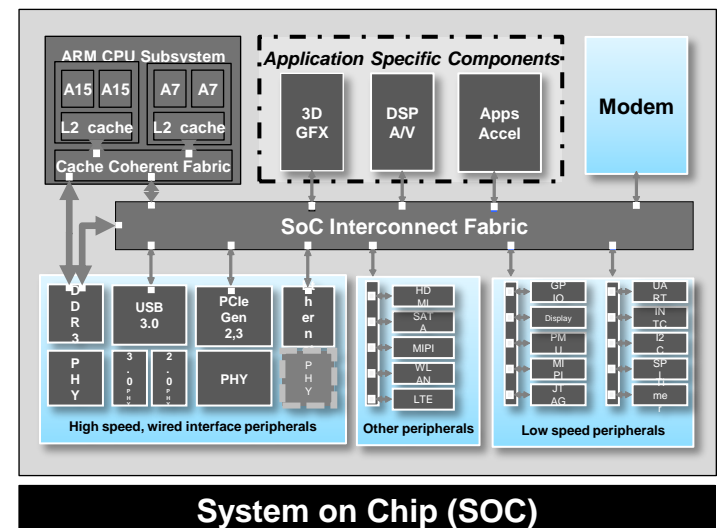
Frank Schirrmeister
EDPS 2013
Monterey
April 18th

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2013 System Example: Handset & Board

Bare Metal

Software

| Applications |
| Middleware |
| Operating Systems (OS) |
| Drivers |
| Firmware / HAL |

Bare Metal Software

DSP Software

Bare Metal Software

| Communications L3 |
| Communications L2 |
| Communications L1 |
| RTOS |
| Drivers |
| Firmware / HAL |

Modem Comms

Application Processor

ARM CPU Subsystem

A15 A15   A7 A7

L2 cache   L2 cache

Cache Coherent Fabric

Application Specific Components

3D GFX

DSP A/V

Apps Accel

Modem

SoC Interconnect Fabric

DDR3
PHY

USB 3.0
3.0 PHY 2.0 PHY

PCIe Gen 2,3
PHY

her n
PHY

High speed, wired interface peripherals

HD MI
SAT A
MIPI
WL AN
LTE

Other peripherals

GP IO
Display
PM MI PI
JT AG

UA RT
IN TC
I2 C
SP I
me

Low speed peripherals

System on Chip (SOC)

FM Receiver

GPS Receiver

Cellular Modem

WiFi

Bluetooth

Memory Card

DRAM

NAND FLASH

SD 3.0 / SD 4.0 / UFS

LPDDR 2 / LPDDR 3

eMMC 4.5 / UFS

CSI2 CSI3

Camera Interface

Touch Screen Controller

Multimedia Processor

OCP 2.0

OCP 3.0

Display Driver

Audio Interface

Motion Sensors

Power Control

RF

DigRF

LLI

SDIO

SLIMbus

SLIMbus

SPMI

USB 2.0

USB 3.0 OTG

cJTAG

I2C

DSI

GBT

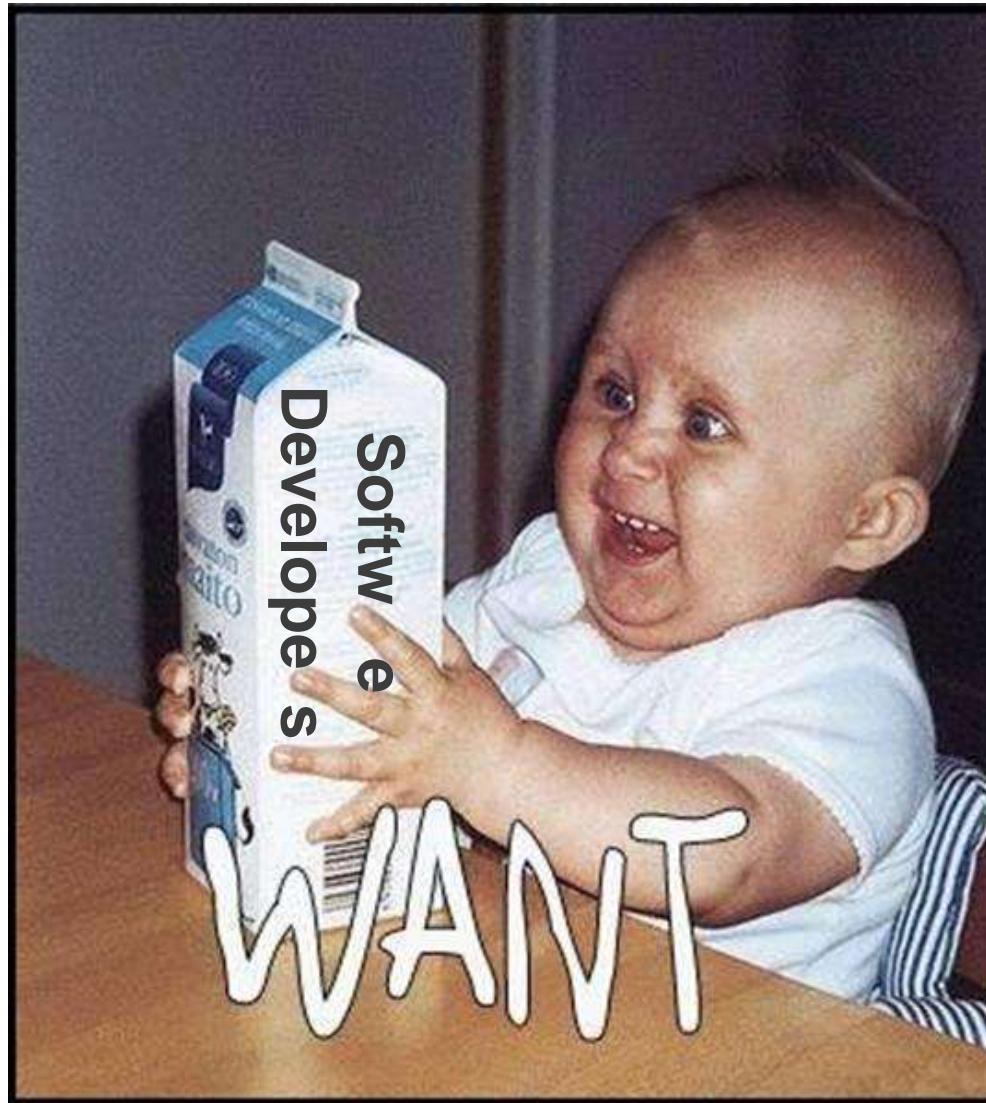HDMI 1.4

System on Printed Circuit Board (PCB)

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How a Chip in 2015 may look …

- More complex designs, more at <90nm, overall less starts
- More than 110 IP Blocks
- More than 70% re-use
- More than 60% of effort in software
- Multi-core
- Software distributed across cores
- Low power issues
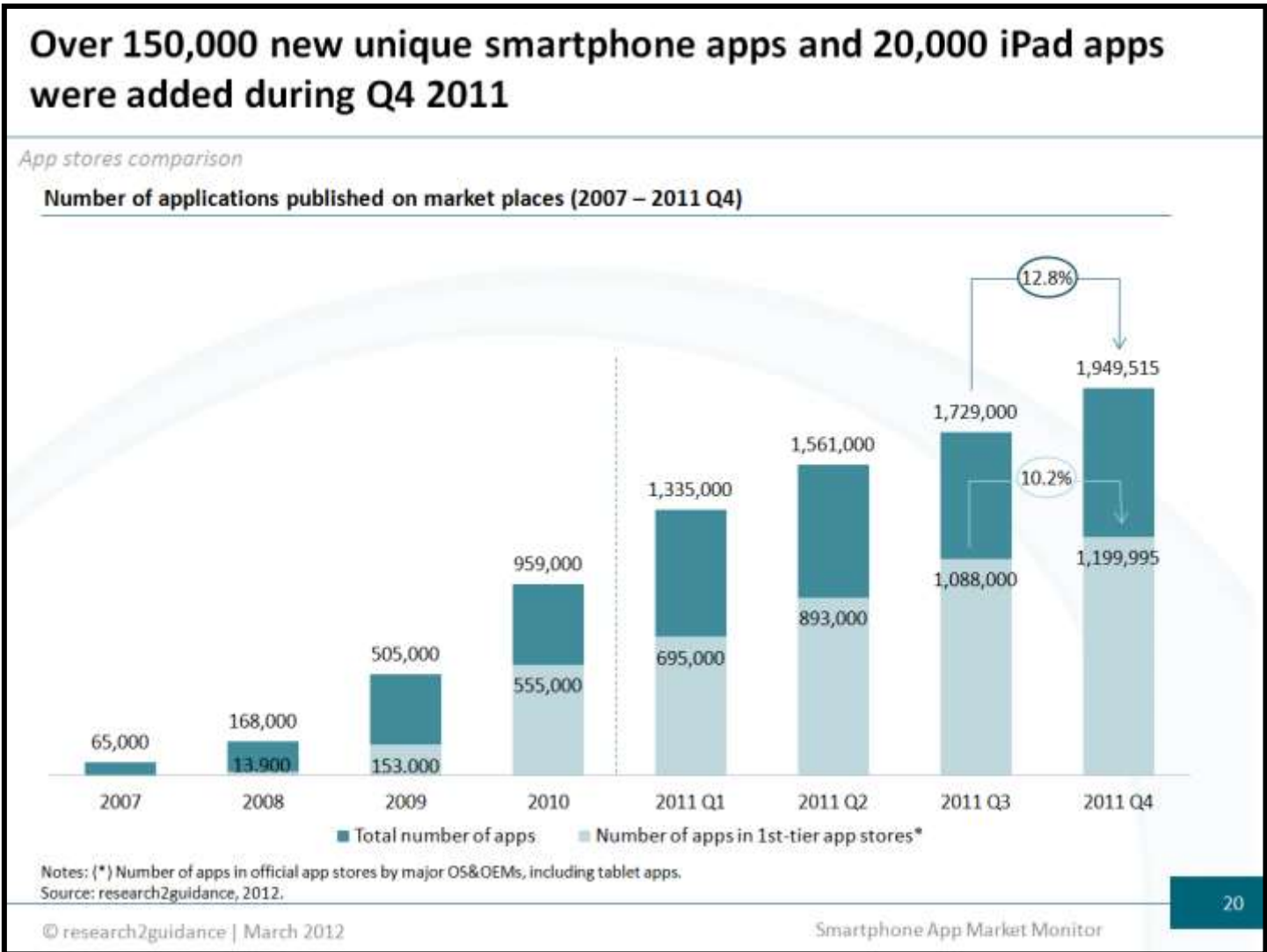- Application specific issues
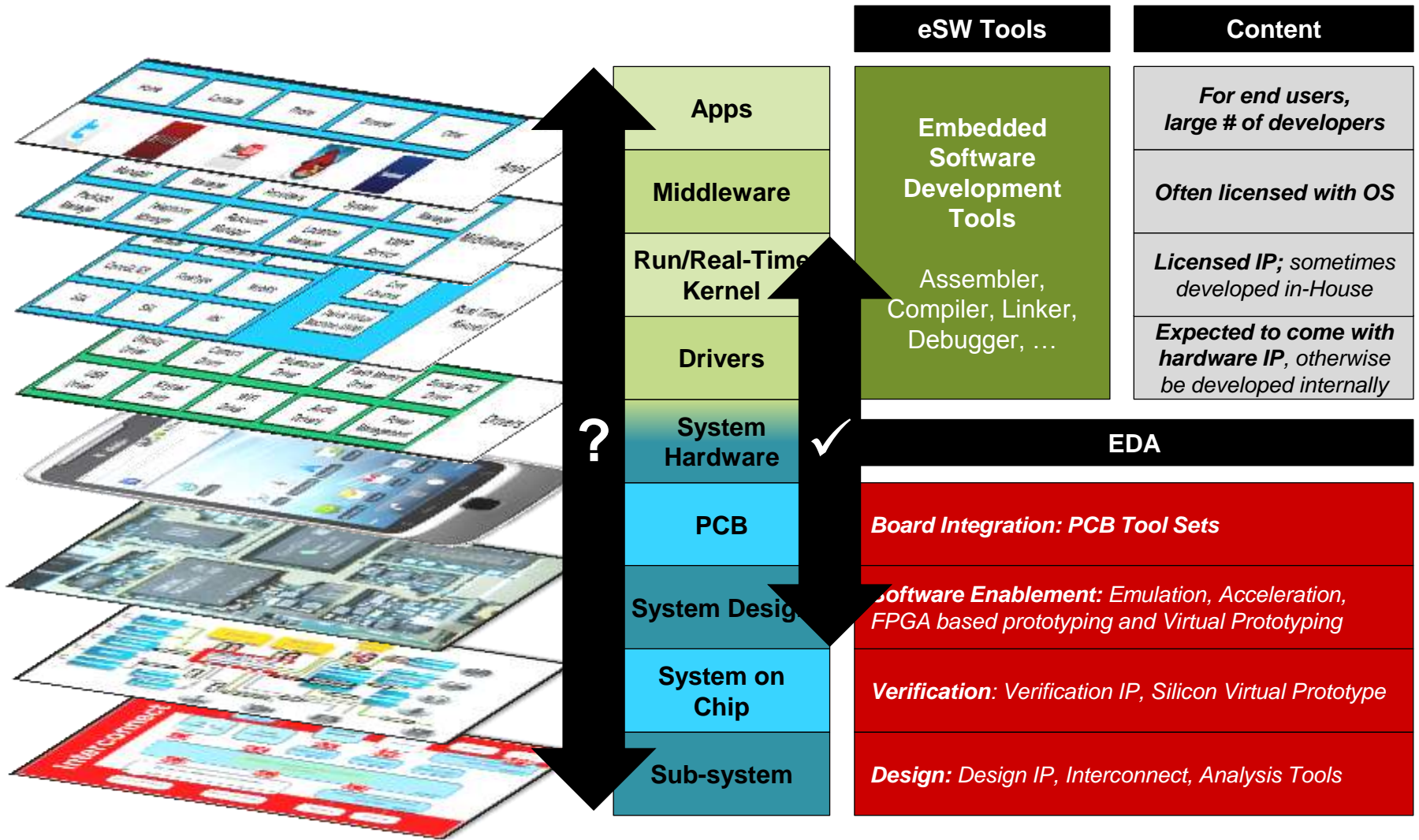- High analog mixed signal content

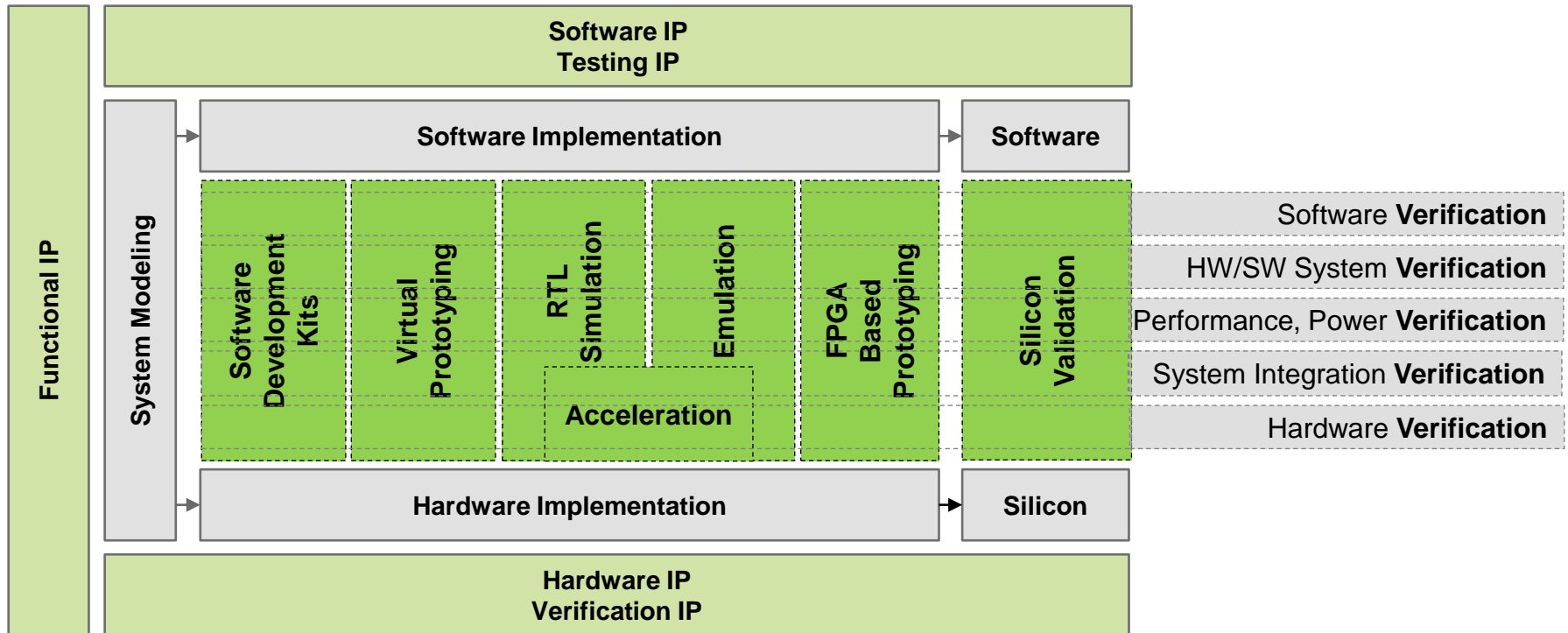**System on Chip (SOC)**

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Why is EDA so excited?

Source: http://bitsandpieces1.blogspot.in/

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Why is EDA so excited?

Source: research2guidance – (Permission at DAC 2012)

Over 150,000 new unique smartphone apps and 20,000 iPad apps were added during Q4 2011

App stores comparison

Number of applications published on market places (2007 – 2011 Q4)

- 2007: 65,000 (13,900)
- 2008: 168,000 (13,900)
- 2009: 505,000 (153,000)
- 2010: 959,000 (555,000)
- 2011 Q1: 1,335,000 (695,000)
- 2011 Q2: 1,561,000 (893,000)
- 2011 Q3: 1,729,000 (1,088,000) — 12.8%, 10.2%
- 2011 Q4: 1,949,515 (1,199,995)

■ Total number of apps   ■ Number of apps in 1st-tier app stores*

Notes: (*) Number of apps in official app stores by major OS&OEMs, including tablet apps.
Source: research2guidance, 2012.

© research2guidance | March 2012   Smartphone App Market Monitor

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Where do HW and SW meet, actually?

Stack Layers	eSW Tools	Content
Apps	**Embedded Software Development Tools** Assembler, Compiler, Linker, Debugger, …	*For end users, large # of developers*
Middleware		*Often licensed with OS*
Run/Real-Time Kernel		*Licensed IP; sometimes developed in-House*
Drivers		*Expected to come with hardware IP, otherwise be developed internally*
System Hardware	**EDA**	
PCB	*Board Integration: PCB Tool Sets*	
System Design	*Software Enablement: Emulation, Acceleration, FPGA based prototyping and Virtual Prototyping*	
System on Chip	*Verification: Verification IP, Silicon Virtual Prototype*	
Sub-system	*Design: Design IP, Interconnect, Analysis Tools*	

? ✓

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A System Development Flow

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Choosing the right Engine for the Task!
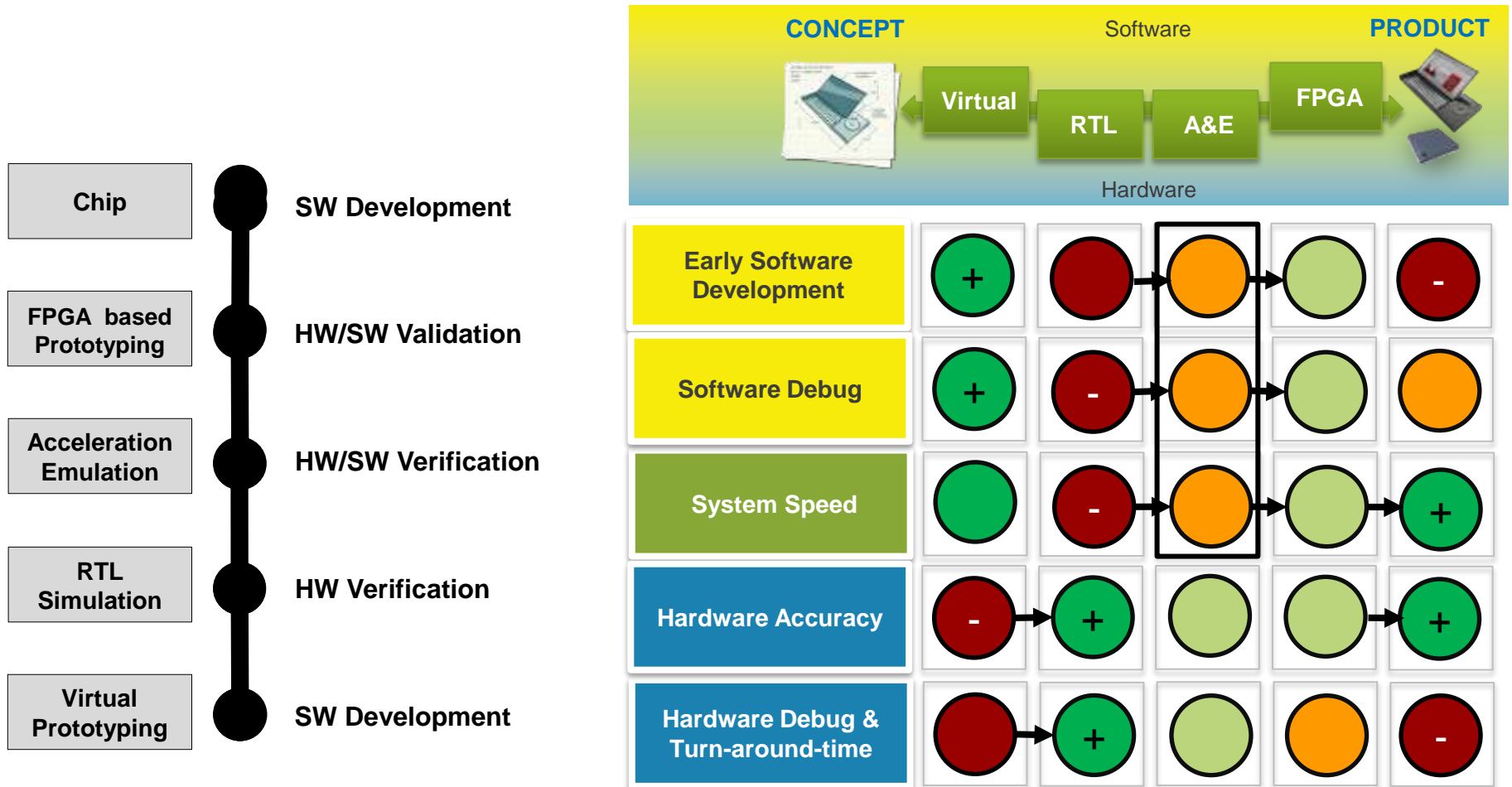
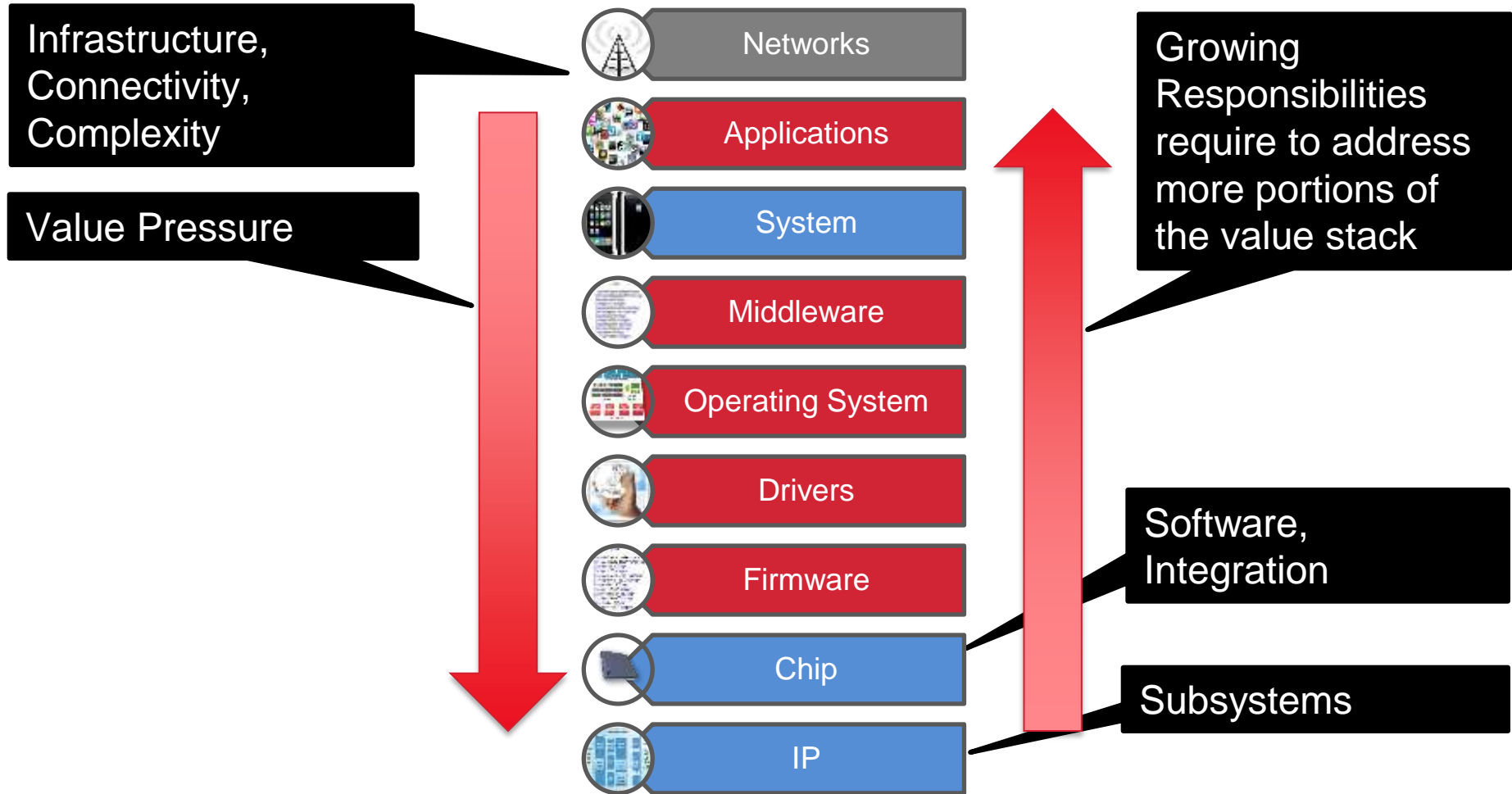# Who is doing what in a Changing World?

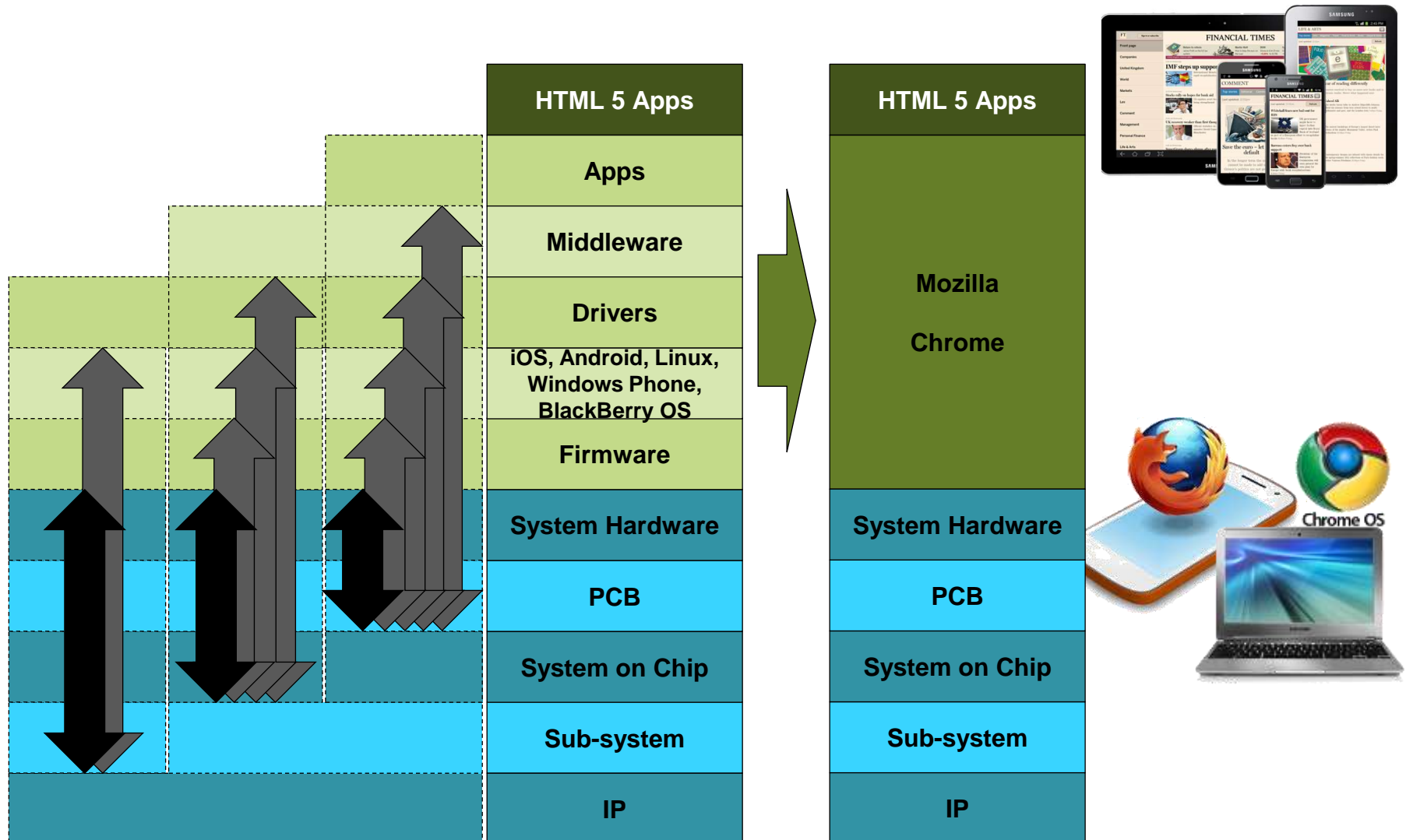|	2000	2004	2007	2008	2008	2008	2010	2011
Networks	Operators	Operators	AT&T	Operators	AT&T, Verizon	Operators	Operators	Operators
Applications	Nokia Ericsson	Nokia, Palm	Apple	OVI	Apple	Google	HP	Google
System				Nokia and Symbian		System Houses	HP	Google Motorola
Middleware			Apple		Apple			
Operating System	Symbian, Palm OS	Symbian, Palm OS				Google	Palm	
Drivers	Nokia							
Firmware	TI, Qualcomm, Motorola	TI, Qualcomm, Freescale	TI, Qualcomm, Motorola	TI, Qualcomm		All Semis	TI Qualcomm	All Semis
Chip								
IP	Processor Peripherals	Processor Peripherals	Processor Peripherals	Processor Peripherals	Processor Peripherals	Processor Peripherals	Processor Peripherals	Processor Peripherals

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Decisions in Product Creation?

Infrastructure, Connectivity, Complexity

Value Pressure

Growing Responsibilities require to address more portions of the value stack

Software, Integration

Subsystems

| Networks |
| Applications |
| System |
| Middleware |
| Operating System |
| Drivers |
| Firmware |
| Chip |
| IP |

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What's in an iPhone SDK?
The key to be independent of HW …

Cocoa Touch	Multi-touch events, Multi-touch controls, Acceleromter, View Hierarchy, Localization, Alerts, Web View, People Picker, Image Picker, Camera
Media	Core Audio, OpenAL, Audio Mixing, Audio Recording, Video Playback, JPG, PNG, TIFF, PDS Quartz, Core Animation, Embedded OpenGL
Core Services	Collections, Address Book, Networking, File access, SQLite, Core Location, Net Services Threading, Preferences, URL utilities
Core OS	OS X Kernel, BSD TCP/IP, Sockets, Power Management, Keychain, Certificates, File System, Lib System, Security, Bonjour

Increasing HW Dependence

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SW Developers Increasing the Distance to HW

| HTML 5 Apps |
| Apps |
| Middleware |
| Drivers |
| iOS, Android, Linux, Windows Phone, BlackBerry OS |
| Firmware |
| System Hardware |
| PCB |
| System on Chip |
| Sub-system |
| IP |

| HTML 5 Apps |
| Mozilla
Chrome |
| System Hardware |
| PCB |
| System on Chip |
| Sub-system |
| IP |

Chrome OS

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HTML5 – Next Generation Programming

Financial Times Landing Page

- *"The FT web app […] is available via your Safari browser at app.ft.com rather than from an app store.*

- *The web app is our most complete app to date and we regularly add new features and sections to it.*

- *These are available instantly, without the need to download a new version. […] The web app replaces our apps that were available in the App Store."*

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Meanwhile, On the Hardware Side …
… From IP to Sub-Systems

- Because they're optimized for the power, performance, and area requirements, DPUs deliver 10-100x more performance than standard CPUs and DSPs. Other benefits include:

- **Easy customization** with automated tools.

- **Product differentiation** – each DPU can be unique, making it almost impossible to copy.

- **Reduced time to market** – dramatically less verification time.

- **Flexibility** – Because it's programmable you can make changes after tape-out.
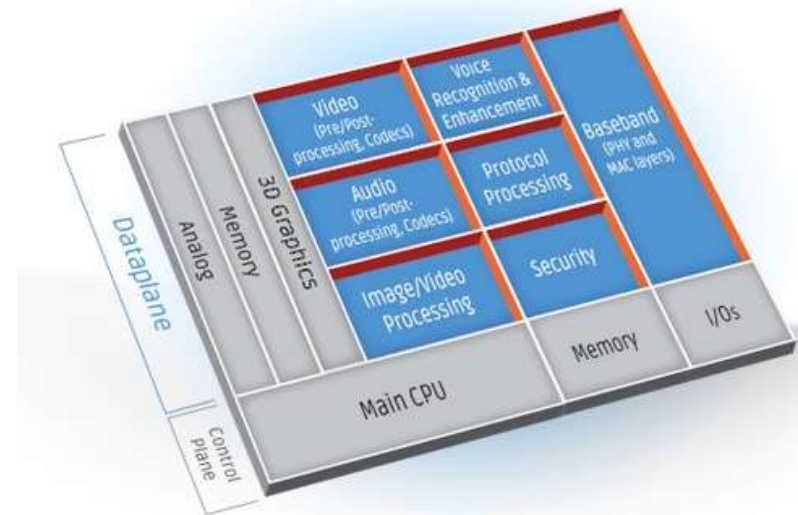
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Meanwhile, On the Hardware Side …
… Programmability Rules!

- Zynq-7000 processor-centric architecture
  - ARM® dual-core Cortex™-A9 MPCore™ processing system
  - Xilinx 28nm unified programmable logic
- Extensible Virtual Platform
  - Enables software developers to immediately begin OS, driver and app development
  - High performance TLM models of hardware accelerators extend the base platform

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Endless HW Abstractions
Where do we go from here?

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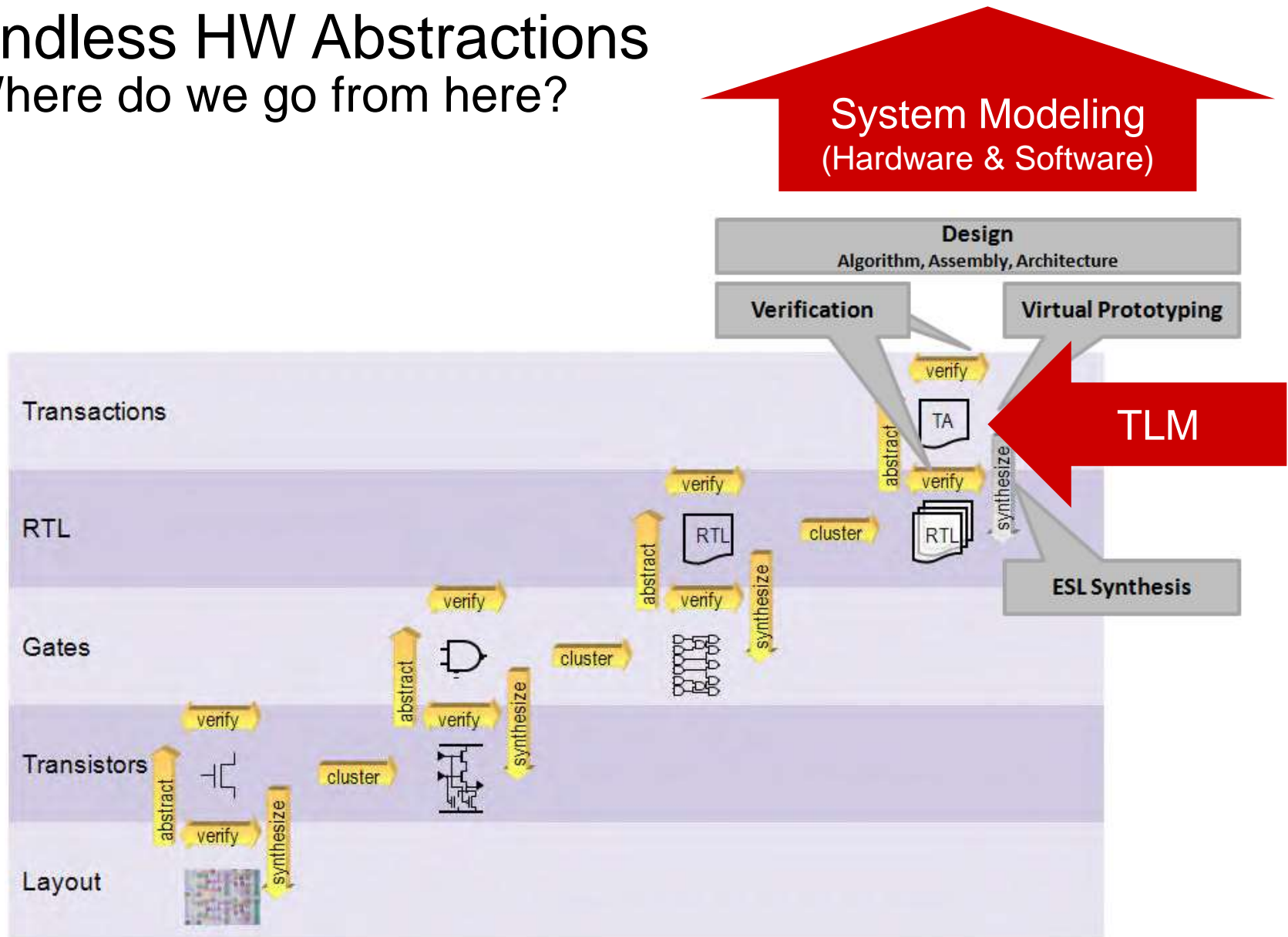
Summary

- ## Where do we go from here
  - Application drive design impacts system level
  - Hardware dependencies drive HW/SW Co-Development
  - A lot of software can be developed without hardware knowledge

- ## HW/SW Development
  - Today remains in the lower levels – Drivers, OS, Middleware
  - Delivery often done with the Hardware
  - Software development is done on more and more abstract engines representing the hardware

- ## What's next
  - True system-level modeling (HW/SW independent) some time away
  - Focus on SW development on programmable HW and sub-systems

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