Silicon IP for Low Cost Smartphones

Executive Summary

Smartphones are the personal computers of the 21st century. The performance and functionality of the device, the performance and capacity of cloud-based servers, and the bandwidth of 4G cellular networks have created a $100B market in the developed world. Smartphone shipments are expected to grow 32.7% year over year in 2013 reaching 958.8 million units. The market for high-end phones, dominated by Apple and Samsung, will continue to grow at ~8% CAGR, but the next surge in growth will come from mid-range phones ($200 to $400), and low-end phones priced below $200. These segments are expected to experience ~15% CAGR according to analysts.

Smartphones enabled a completely new computing experience supported by millions of apps conveying personal, commercial, educational, and social benefits. And you can still talk to a person or your personal assistant, e.g. Siri. The benefits are universally compelling but the >$500 price (unsubsidized) of a high-end smartphone restricts wide-spread adoption in low income segments and emerging markets.

Feature phones in developing countries play a vital role in communication. Smartphones will enable access to new resources (market prices, weather, services), education, and rich media social features. Photosharing is rapidly becoming the lingua franca of the planet.

A large number of sub $100 smartphones are launching this year in China, India, Southeast Asia, the Middle East, South America and Africa. China is aggressively pursuing this market in design, development and consumption. The leading Silicon suppliers are Qualcomm, Samsung, MediaTek, with many established and new entrants taping out application processors on low cost process nodes (e.g. 40nm).

Application processors utilize a number of interface standards from JEDEC (e.g. eMMC) and the MIPI® Alliance (e.g. CSI, DSI, D-PHY) and rely on IP providers like Arasan Chip Systems to provide validated total solutions that ensure specification compliance and compatibility with a range of external devices.

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Smartphones in emerging markets

The market for high-end phones, dominated by Apple and Samsung will grow at ~8% CAGR, but the next surge in growth will come from mid-range phones in the $200 to $400 range, and low-end phones priced below $200. These segments are expected experience ~15% CAGR according to analysts. IDC June 2013, ABI Research Q2 2013.

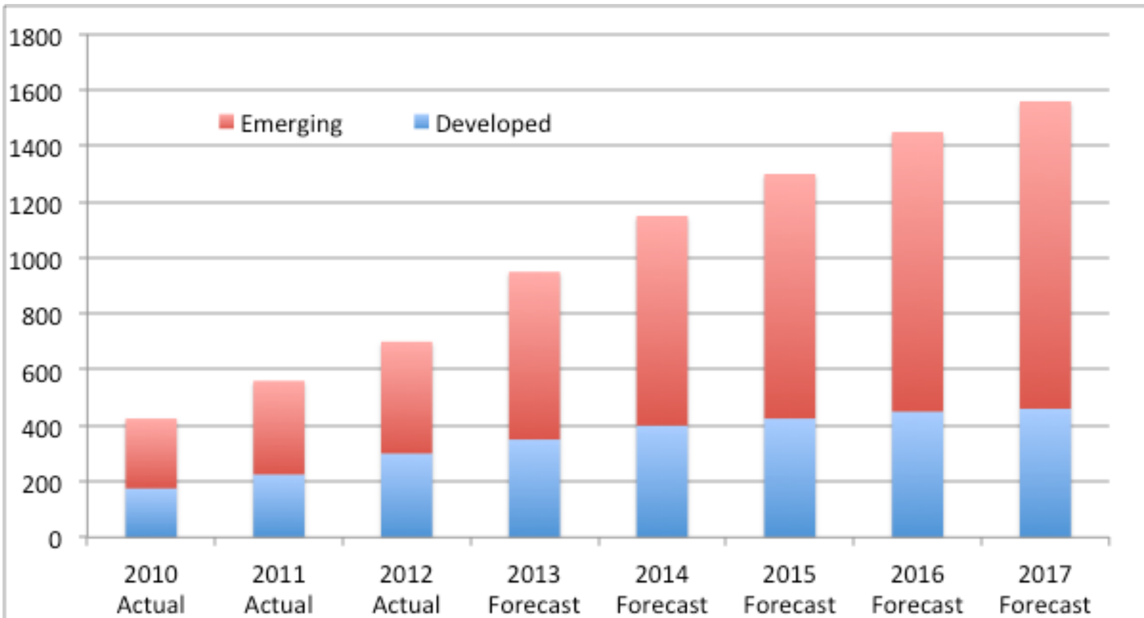

Figure 1. Smartphone Shipments by Economic Designation – IDC June 2013

Mid-range smartphones

Several mid-range smartphones have been introduced in China from Huawei, Lenovo, ZTE, Coolpad, Oppo, and Xiaomi. Xiaomi and Huawei are expanding outside of China into Europe and Asia with mid-range and high-end smartphones.

The Indian smartphone market grew 75% (Q1 2013 vs. Q1 2012) with new brands entering the market (e.g. Micromax Canvas SD) and low-end models from market leaders (e.g. Samsung Galaxy Star).

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Low-end segment smartphones

Examples include the Goophone and Mogu S2 (China), Huawei Ascend Y300 (India), Motosmart XT305 (Brazil), HTC Desire (Middle East), and the Yolo (Kenya).

Figure 2. Low-end phones introduced in 2013

Typical Features

Processor	1GHz Dual Core
Display	HVGA 320 x 480
RAM	< 1GB
Storage	4GB embedded + SD Slot
Camera	5MP Rear
Cellular	UMTS / HSPA / GSM
WiFi	802.11 b/g/n

Table 1. Typical Low-End Smartphone Features

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The Silicon Perspective

Overview

Yesterday's high-end smartphone application processor (AP) typically was design with dual or quad core ARM CortexA9 processors. The current crop of low-end and mid-range smartphones are built around single and dual core ARM Cortex A5, A7 or A9 cores with ARM Mali or Imagination Tech PowerVR graphic co-processors.

Interface IP Components

Application processors contain a range of standard interface IP components connecting interfaces (camera, display, etc.) and co-processing ICs (modems, power management, etc.) The Medfield processor from Intel shown in Figure 2. is representative of the most frequently used interfaces. Note, the high costs of design and fabrication lead many IC suppliers to design multi-purpose or multi-application chips. An AP may contain interfaces that may not be supported in the specific end products, e.g. HDMI outputs for a media player vs. a smartphone.

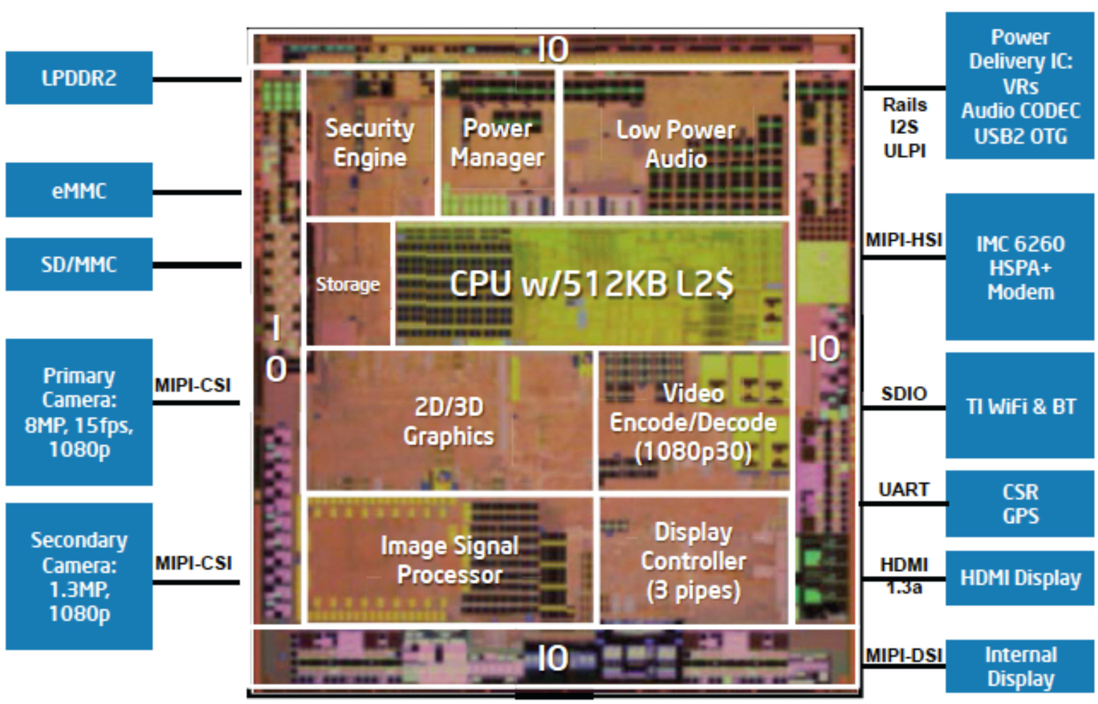

Figure 3. Medfield Processor and System Interface Diagram [IEEE Micro 2013]

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Standards

- Smartphone interface standards are defined by independent organizations like MIPI, JEDEC, SDA, and USB-IF.
- The MIPI Alliance, is a standards setting body focused on mobile interface standards e.g. Camera, Display, Chip to Chip.
- JEDEC develops open standards for all memory interfaces including eMMC and UFS for Flash Memory.
- The SD Association sets standards for memory cards (SD, miniSD and microSD).
- The USB-IF (USB implementers forum) provides compliance certification and promotion for USB products.

Camera and Display

The camera subsystem based on CSI (Camera Serial Interface), and the display interface based on DSI (Display Serial Interface), utilize D-PHY as the physical layer. For CSI-2 and DSI, MIPI defines a separate clock lane, and up to 4 data lanes connected with a differential signal pair. The maximum serial data rate for HS data transfers is 1.5 Gbps per data lane.

D-PHY allows power efficient, EMI reduced, serial communication between a CSI-2 or DSI host/device pair. Both Camera and Display can utilize multiple D-PHY connections (lanes) as shown in Table X, allowing scalability to the highest display resolution available in today's smartphones and tablets, e.g. Apple Retina Display.

Video Format	Size	Bandwidth Mbps	IP
HVGA	480 x 320	2200 @30fps	DSI 1 lane
WVGA	800 x 480	550	DSI 1 lane
SVGA	1280 x 768	700	DSI 1 lane
UVGA	1280 x 960	1,800	DSI 2 lanes
HD	1920 x 1080	2,880 @60fps	DSI 4 lanes
HD Slow-Mo	1920 x 1080	5,700 @120fps	[?]

Table 2. D-PHY Transfer and Format Support

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Embedded Storage

Embedded storage is non-volatile memory (e.g. NAND Flash) attached to the system printed circuit board. Embedded storage can be used for application and user data, including media files and temporary storage for applications when main memory space is unavailable. And it serves as the boot device upon power-up. The eMMC format is a JEDEC. eMMC supports a high data rate with up to 8 data bits. The standard continues to evolve to provide higher data rates and commands extensions.

Features	eMMC 4.4	eMMC 4.5	eMMC 5.0
Introduction	2009	2011	2013
Data Rate	832 Mbps	1.6 Gbps	3.2 Gbps
Data Lines	4 or 8 bit	4 or 8 bit	1, 4 or 8 bit
IO Voltage	1.8v / 3V	1.8V / 3V	1.8V / 3V
Interface	DDR-52	SDR 200	DDR 400

Table 3. eMMC Roadmap

External Storage

Low end smartphones typically have a relatively small embedded memory (4GB) for to reduce cost. Additional memory up to 32GB can be added by with MicroSD cards.

Network

The SDIO interface is capable of a maximum bandwidth of 100Mbps but practical throughput is 30 - 40Mbps range, which is adequate for the interface to network ICs for WiFi and Bluetooth. USB 2.0 is the standard interface for device charging and file transfer. OTG and Host support are often provided to enable accessory connection. Mobile applications require a low power PHY. Value priced phones may include the UBS 2.0 HSIC for interface to high speed radio modem IC.

Audio

At the low-end segment, an I^2S interface to an audio IC will provide microphone, speaker, headset, audio in, and vibrator interfaces.

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Features are the Future

Smartphones enabled a new personal computing experience supported by millions of apps conveying commercial, educational, entertainment, and social benefits. The benefits are universally compelling but the >$500 price (unsubsidized) of a high-end smartphone restricts wide-spread adoption in low income segments and emerging markets.

In the developed world, smartphones have become media consumption devices, with larger screens and HD quality video. Feature phones were rapidly adopted in the third world to provide basic communications. Smartphones will enable access to utilities that can literally improve the lifestyle and economic conditions of people in the third world.

- Local farmers can check market prices, eliminating inefficiencies and fraud.
- People in remote villages can bank, making online payments and money transfers.
- Adults and children with limited school access will have powerful learning aides
- People gain knowledge about the world, news, weather, politics
- The social benefits of sharing with disconnected friends and family are universal human desires. Since low-end smartphones will be introduced at prices near the manufacturing cost of mature components, the opportunity to compete on cost alone will diminish. As competition in isolated markets increases, features will become most important to both new and repeat customers.

Physical features (colors, size, weight, and thickness) are manufacturing dependent, while performance features depend on the Silicon components – the application processor, the graphics subsystem, the interface IP and interface components.

- camera quality – camera subsystem and IP interface
- audio quality – audio subsystem and IP interface
- display resolution – LCD and IP interface
- application responsiveness and multitasking – processor architecture and OS
- case color, weight, thickness, etc.
- attached accessories – Bluetooth headset

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IP Standards meet evolving needs

Cameras will provide improved image quality with features that rival digital cameras such as multi-shot burst shooting, richer colors, high-speed video, lower power consumption and sophisticated image processing. These features will be enabled by the new MIPI CSI-3 standard that contains MIPI UniPro^{SM} and the low power, high-speed M-PHY for physical layer transmission.

Display resolution will continue to improve with features like slow motion video, enabled by 120fps video. Implementation solutions beyond the limits of 4-lane DSI include DisplayPort and VESA-compliant image compression.

The storage demands for high resolution images and video will be met by the JEDEC UFS standard, which combines the MIPI Unipro controller and M-PHY with the powerful SCSI command set. Embedded storage performance will improve application performance and multitasking. External storage density devices with >1000GB and data rates approaching 1.5GB/s will emerge.

Network interfaces (e.g. USB 3.0 SSIC) will enable Gbps WiFi provided by 802.11ac. Near field communication (NFC) is growing in many markets and is another candidate for the SDIO interface. The MIPI SLIMbus enables a richer audio experience and simplifies system design support for multiple audio datastreams.

The Importance of Standards-Based IP

High-end and mid-range smartphones will differentiate on media quality, cellular data rate, wearable accessories, etc. Complexity demands will be met by IP sub-systems, comprised of digital logic, analog circuitry and software stacks. Over time features will migrate from higher priced phones to lower priced phones. Standards-based IP plays an essential role in enabling Silicon feature migration. A new interface not only has to work with the latest generation of external components but maintain compatibility with components designed for previous versions of the standard. Arasan's active participation in the critical standard-setting bodies for mobile enables this level of quality assurance and future-proofing. The goal of Arasan's Total IP Solution is to provide standards-compliant IP components with validation systems to support device and SoC implementers.

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