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The Smart (phone) Choice? Discrete *vs.* Integrated Processors

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ABSTRACT

Smartphones are poised to be the fastest growing handset segment in the coming years, rising from 14% of global handset shipments in 2008 to a projected 32% in 2010. With multiple choices in smartphone operating systems and diverse advanced communication standards to support, the handset designer is confronted with a daunting choice – the use of a discrete applications processor in conjunction with a discrete baseband processor versus an integrated SoC that combines an applications processor with a baseband processor in a single chip.

Neither is a silver bullet. Both have a rightful place and will jostle with each other to dominate this growing segment.

The choice however can have significant implications on product and business competitiveness via such dimensions as system cost, time-to-market, power consumption, flexibility to spin out devices for different communication standards, performance maximization, harmonization of user experience, device form factor (via PCB size & component count) and component supply chain management.

This whitepaper evaluates the key factors to help make an informed decision.

INTRODUCTION

The wireless revolution has had a tremendous impact on society and people worldwide. In 2008, over 1.2B handsets[1] were shipped worldwide, fueled by rapid growth in emerging markets. Smartphones are poised to be the fastest growing handset segment in the coming years, rising from 14% of global handset shipments in 2008 to a projected 32% in 2010[2].

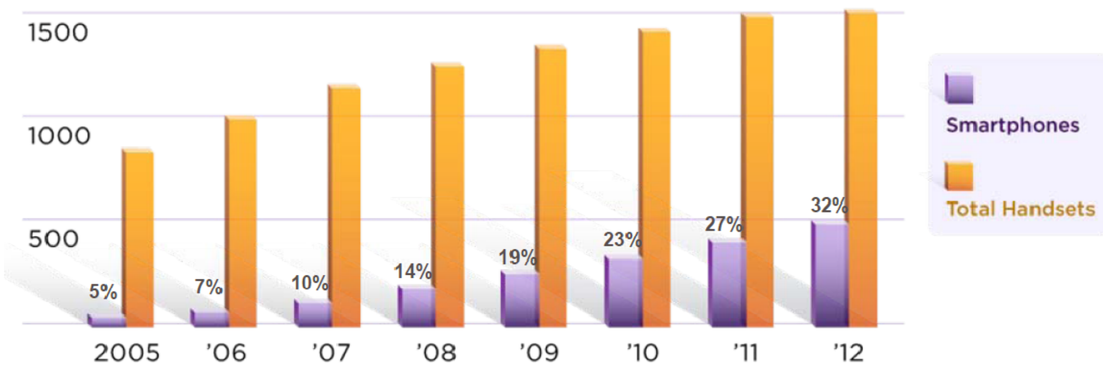

Figure 1: Smartphone shipments as a percentage of total global handset shipments[3]

The growth of these devices is driven largely by a confluence of several factors including:

1. Demand for mobile email
2. Browsing and data services such as applications, location services, multi-media
3. Handset technology advancements such as innovative form factors, display size, multi-touch display interface, high-performance processor for accelerated multimedia and graphics, battery life etc.
4. Device convergence (GPS, music, camera, game console, media player, etc)
5. Faster 3G data speeds
6. Compelling user experience (e.g. Google Maps, Facebook, YouTube, etc.)
7. Increasing business mobility applications (enterprise email, CRM, mobile/desktop integration, tracking and telematics, mobile commerce, etc.)
8. Mobile application platforms and third party mobile applications ecosystem
9. Increasing ARPU from 3G data services for Operators
10. New revenue opportunities for handset OEMs (e.g. Application store-fronts)
11. A shift in consumer interests from voice/SMS-only phones to user-friendly, media-centric, customizable (application) handsets accelerating a global replacement market

Further, smartphones command higher ASPs (average selling price) on the order of US$350 (2008)[4] signaling higher revenue and profitability potential for handset OEMs.

This has heightened the intensity of competition among handset makers, putting a downward pressure on smartphone ASPs and pushing them down from the high-end tiers into the mass market tiers.

The application-centric smartphones generally evolved with an architecture based on a discrete applications processor that is coupled to a discrete modem communication processor. This is unlike the traditional evolution of the classic voice/SMS-centric feature phones which evolved as 'fat modems' where applications processing was done on the baseband processor itself.

The two worlds are set to collide. The handset designer is now confronted with a daunting choice – the use of a discrete applications processor in conjunction with a discrete baseband processor versus an integrated SoC that combines an applications processor with a baseband processor in a single chip.

CRITICAL FACTORS – DISCRETE *vs.* INTEGRATED PROCESSORS

There is no one right answer. Both a discrete APE processor and an integrated (APE + BB) have a rightful place and will jostle with each other to dominate this growing segment.

The choice can nevertheless have significant implications on product and business competitiveness. Product management and handset designers need to evaluate the trade-offs in reaching an appropriate decision. Here are some key factors that influence the decision process:

1. ***Flexibility to spin out multiple devices***
   In view of applications and software integration complexity, a discrete applications processor can provide an OEM the flexibility to support multiple communication standards (HSDPA vs. HSPA vs. CDMA-EVDO vs. WiMAX/LTE) by simply replacing the modem processor as appropriate.

2. ***Performance Maximization***
   With increasing 3G/4G data rates, and an increasing emphasis on performance centric applications such as full browsing and multimedia applications & services, a discrete applications processor allows maximization of performance via dedicated resources (memory and bus) without power constraints imposed by modem

3. ***Uniform User Experience across multiple communication standards***
   With increasing revenue from applications & services and increasing numbers of OEM and Operator deployed application storefronts, a critical care-about is maintaining a uniform user experience across devices. A discrete applications

processor allows an OEM to introduce smartphones for different modem communication standards while maintaining the same user experience across the devices. The application ecosystem is thus leveraged across all the devices.

4. ***System eBoM/Cost Savings***
   In mass market applications where cost has to be balanced with features, an integrated (applications + baseband) SoC can offer eBoM/cost savings via
   a. Memory savings from shared memory
   b. Power management savings from shared PMU
   c. CPU/DSP core savings
   d. Peripherals savings
   e. Package cost savings
   However, recent advances in shared memory technology (one DRAM[5], oneNAND[6]) when coupled with PoP (package-on-package) techniques[7], can mitigate some of the cost disadvantages of an architecture based on a discrete applications processor.

5. **SoC Integration complexity**
   This is more a careabout for the chipset vendor. The more complex the application processor and the modem, the more technical challenges we face in integrating the two. There are several single-chip integration techniques:
   i. Single-chip SoC – Highest complexity but greatest eBoM savings
   ii. Die-on-die SoC – Intermediate cost savings but offers valuable flexibility and space savings compared

6. ***Target market segment** and **Volume Potential***
   With increasing software integration complexity and the desire to differentiate (esp. in very-high and high-tier segments), the OEM may find a discrete applications processor more attractive to leverage their sw investment with the same applications/ software foundation. An example is Apple's iPod (music player) and an iPhone (smartphone). When volumes reach a threshold where differentiation is largely based on cost, an integrated (applications + baseband SoC) can be more attractive especially in the mid-tier market segments.

   Typical segmentation scenarios today are:
   a. Very-High Tier – Discrete APE – E.g. TI's OMAP3430[8]
   b. High-Tier – A mix of
      i. Discrete APE – E.g. TI's OMAP3430, ST's Nomadik[9]
      ii. Integrated (stacked APE and BB) – E.g. ST's U380[10]
      iii. Integrated (single-die) – E.g. QCOM's Snapdragon QSD8x50[11]

c. Mid-Tier – Integrated (single-die) - E.g. QCOM's MSM7201[12], BRCM's BCM2153[13]
d. Low-Tier – Integrated (single-die)

7. ***Time-to-Market (TTM) advantage***
Integrated (Apps + Modem) processor potentially reduces OEM SW integration level of effort especially in regards to the development and integration of the telephony software layer that interfaces the OS with the protocol stack.

Further, the integrated device is usually coupled with power management and RF in a chipset that is delivered as a complete system solution with a pre-tested and pre-validated hardware and software reference design, undergoing many of the tests an actual phone is put through before being approved for commercial release including FTA (full type approval) IOT (Interoperability testing), conformance testing, robustness testing, SW reliability testing, and operator field testing. Major hardware and software issues can be resolved during this phase thereby reducing the overall handset development cycle time for the OEM.

However, when going across multiple communication standards, a discrete applications processor can provide a TTM advantage leveraging the same applications processor across all of the standards.

8. ***Platform (SW) System Integration Complexity*** is higher if
a. If Apps & modem are from different parties, HW and SW integration can be burdensome esp. if proprietary interfaces are used. One must also develop and integrate the software telephony layer that allows the applications processor and the modem to communicate effectively. Design, integration and debugging of the hardware and software components can lengthen overall system development.
b. Integrating the applications processor and modem in a single chip can simplify system design and shorten time-to-market. It eliminates the need to develop and integrate the telephony software layer that interfaces the OS with the protocol stack. The chipset vendor can develop and validate the telephony software for efficient inter-processor communications..
c. On SoC (Applications + baseband) chips, if a single CPU core (e.g. an ARM core) is used to drive both Apps and Modem (Layer 2 and 3 of the protocol stack) while a separate DSP handles Layer 1, the SW system integration can be more complex versus a scenario where the modem is de-coupled from the Apps (e.g. with its own CPU core). For example, a powerful ARM processor, which might be complemented with dedicated

hardware accelerators, can manage the applications functions while a second (ARM + DSP) addresses the modem functions.

9. ***PCB footprint savings***
   An integrated (Applications + Baseband) SoC can enable smaller and creative form factors via fewer components (memory, PMU, and external active & passive components). This enhances flexibility to provide additional functionality (Wi-Fi, GPS, BTH, mDTV, NFC etc.) within form factor constraints. However, recent advances in shared memory technology (oneDRAM, oneNAND) when coupled with PoP (package-on-package) techniques, can mitigate some of the disadvantages of an architecture based on a discrete applications processor

10. ***Lower PCB component count***
    An integrated (Applications + Baseband) SoC enables fewer components that can translate to
    a. Improved reliability
    b. Reduced sourcing burden
    c. Reduced system eBoM

11. **Reduced Power Consumption**
    With appropriate SoC design techniques, the chipset vendor can reduce the system power consumption via
    a. Fewer components (memory, PMU, and complementary external active & passive components)
    b. Proximity of the baseband and applications processors
    c. Optimized system software

12. ***Process Technology node** and corresponding **die size***
    This is again a careabout for the chipset vendor. While an integrated solution can be expected to be cheaper, the result of combining an applications processor and a baseband processor is a much larger die whose size is influenced by the process technology node. A larger die can have an impact on yield especially on an advanced technology node that is just ramping up. This can erode the cost savings from the single-die integration in the early phase of the volume ramp.

Table 1: Tradeoffs between discrete and integrated smartphone processors

CAREABOUT	DISCRETE APE and BB	INTEGRATED (APE + BB)
Target Market Segment	Hi-end Smartphones & Mobile Internet Devices (Lower Volumes)	Value Smartphones (Higher Volumes)
Flexibility to spin out multiple devices	✓	≈
Performance maximization	✓	≈
Uniform User Experience across standards	✓	≈
System eBoM/Cost savings	≈	✓
Platform System SW Integration Ease	≈	✓
TTM Advantage for single handset	≈	✓
TTM Advantage for multiple handsets across standards	✓	≈
PCB Footprint Savings	≈	✓
PCB Component Count Savings	≈	✓
Reduced Power Consumption	≈	✓

SUMMARY

Application & data-centric smartphones are poised to be the fastest growing segment in the wireless market. Further, wireless is beginning to foray into new application centric consumer devices beyond handsets such as ultramobile netbooks, E-book readers, and gaming devices. While data speed does impact user experience, application and related services offer many dimensions to differentiate personalization and user experience, thus leading to higher ARPU over voice centric services.

Historically, handsets have evolved more as 'fat modems' where application processing and modem communication were all handled on the same chip. On the other hand, application centric devices such as PCs, gaming devices etc. evolved as standalone devices based on discrete applications processors. Connectivity was added on via discrete connectivity modules.

The two worlds are set to collide to create converged devices with vast possibilities. It also means non-traditional wireless players whose core competency is more on the applications side will enter the fray.

While there is not one clear path, both discrete processors and integrated components will jostle with each other to dominate the growing smartphone segment and new consumer wireless broadband markets.

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[1] iSuppli: Handset Shipments Return to Growth (July, 2009) http://www.businessweek.com/the_thread/techbeat/archives/2009/07/isuppli_handset.html
[2] ABI Research – Smartphone and OS markets (Q1-2008) http://abiworld.com/research/1000998-Smartphone_and_OS_Markets
[3] Qualcomm- Evolving Wireless Services (Jan, 2009) http://www.atis.org/LTE/documents/Evolving%20Wireless%20Services%20for%20the%20Future.pdf
[4] RBC Capital Markets, Sizing the Smartphone Global Market (Nov, 2008) http://www.scribd.com/doc/17361921/Global-Smartphone-Market-Sizing
[5] Samsung oneDRAM http://www.samsung.com/global/business/semiconductor/products/fusionmemory/Products_OneDRAM.html
[6] Samsung oneNAND http://www.samsung.com/global/business/semiconductor/products/fusionmemory/Products_OneNAND.html
[7] PoP package-on-Package http://en.wikipedia.org/wiki/Package_on_package
[8] TI's OMAP3430 Platform http://focus.ti.com/general/docs/wtbu/wtbuproductcontent.tsp?contentId=14649&navigationId=12643&templateId=6123
[9] ST's Nomadik Platform http://www.stericsson.com/platforms/nomadik.jsp
[10] ST's U380 Platform http://edageek.com/2008/02/08/mobile-open-os-ti/
[11] Qualcomm's Snapdragon Platform http://www.qctconnect.com/products/snapdragon.html#
[12] Qualcomm's MSM7201 Platform http://www.qctconnect.com/products/msm_7201.html
[13] Broadcom's BCM2153 Platform http://www.broadcom.com/products/Cellular/3G-Baseband-Processors#tab=products-tab

ABOUT THE AUTHOR

Sunil Hattangady is the President of Emblaze Consulting LLC, a company dedicated to helping technology businesses define and implement strategies for business competitiveness, new market penetration & customer acquisition, product innovation, creative marketing & communications, and strategic alliances & acquisitions.

Sunil is a marketing and business leader with multi-disciplinary achievements, international experience, and a track record in achieving revenue generation via market analysis and competitive product positioning, driving new product & business initiatives, building efficient cross-functional teams & alliances, and managing effective & persuasive communications

In his 14 years at Texas Instruments, Sunil has had a track record of innovation and product delivery in diverse roles such as Strategic Marketing Manager for TI's 2.5G/3G/4G Wireless Products, OMAP Software Product Line Manager, OMAP Wireless Security Program Manager, and Technology Development Leader.

His major accomplishments include driving product management and competitive strategy for TI's 2.5G/3G/4G smartphone, featurephone, and MID (Mobile Internet Device) products; managing TI's OMAP Security Applications program from concept to first implementation; driving strategic alliances with smartphone OS partners that led to revenue-generating joint products; leading a miniaturization initiative that culminated in the smallest 'phone-in-a-chip' GSM module; and pioneering an advanced semiconductor technology now an industry standard and adopted worldwide.

Sunil is currently working on strategic opportunities and business development for growing companies with a focus on next-generation communication technologies, consumer devices, wireless M2M (machine-to-machine communications), and medical devices.

Sunil has an MBA from University of Texas at Austin, and a Ph.D. in Engineering from North Carolina State University, and holds over 20 US patents.

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