ARM and Intel Battle over the Mobile Chip's Future

Brad Smith

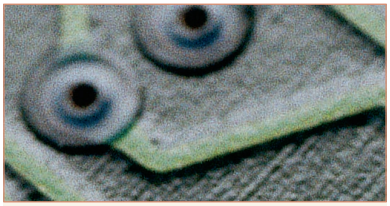
During the past few years, the lines between traditional computers and mobile devices have been blurring. Users work with products such as Apple's iPhone and Research in Motion's BlackBerry to access the Web, send and receive e-mail, compose documents, shoot and view video, and download applications, not just make calls.

Meanwhile, wireless consumer-electronics products such as personal-navigation and gaming devices are increasingly accessing the Internet for various tasks, such as retrieving mapping information and participating in multiplayer games.

Thus, mobile devices are performing many more computing-related tasks than in the past, which places additional demands on the chips that run them. While doing this work requires mobile processors that provide high performance, they also must manage and conserve power so that they won't quickly drain devices' batteries.

ARM Ltd. has dominated the mobile-chip market for about 10 years. The company doesn't make processors but instead designs cores, CPUs, and microprocessor architectures and licenses them to manufacturers.

As vendors have given mobile devices more functionality, the chip makers' approach has been to surround an ARM core with a series of specialized chips that either accelerate functions such as video rendering or handle specialized tasks like memory caching.



Now, Intel, which rules the PC- and laptop-chip worlds, plans to challenge ARM, in recognition that mobile devices have become an attractive market, far outselling PCs and laptops.

Unlike ARM, Intel is putting most functionality on a single chip, as it does with PC and laptop chips, rather than using separate pieces of silicon to enhance a core's capabilities.

This approach reflects Intel's approach of trying to give mobile devices the power of small PCs, according to Pankaj Kedia, director of global ecosystem programs for Intel's Ultra Mobility Group.

ARM, on the other hand, is trying to keep mobile devices working in ways that people like now, while adding functionality but not sacrificing battery life, said Bob Morris, the company's director of mobile computing.

In essence, ARM and its partners are trying to build more powerful handheld computing devices, while Intel is trying to make a handheld PC based on the company's x86 architecture.

This has set up a battle between two market leaders and their different ways of looking at the new world of smart mobile devices.

A TALE OF TWO APPROACHES

The key to designing chips for today's smart mobile devices is providing high performance, multifunctionality, and low power consumption. This applies not only to smart phones but also to the relatively new ultramobile PCs (UMPCs) and soon-to-be-released, somewhat smaller mobile Internet devices (MIDs).

There are two main approaches to accomplishing these goals.

ARM's model

The leading mobile-chip makers include Freescale Semiconductor, Qualcomm, Samsung Semiconductor, STMicroelectronics, and Texas Instruments (TI). Each licenses ARM's chip architecture and builds its own processors, adding radios for communications, coprocessors, and some circuitry of its own design.

At its most basic, the ARM architecture is a 32-bit, reduced-instruction-set-computing CPU design. The devices in today's high-end smart phones use the ARM version 5 or 6 instruction set and have clock rates from 400 MHz to 1 GHz, compared to typical new laptop chips' minimum 2.1 GHz. They consume a maximum of about 300 milliwatts, while laptops use 15 to 35 watts just in idle mode.

Popularity. Last year, about 3 billion ARM-based chips shipped worldwide. Will Strauss, chief analyst for market-research firm Forward Concepts, estimated that 99 percent of the world's smart phones, and all new ones, use ARM-based technology. He said the other 1 percent use an Infineon Technologies core. ARM chips are also widely

used in consumer electronics such as personal media players, he said.

New functionality. As smart phones have added capabilities, chip makers have had to include dedicated circuitry to provide the necessary functionality with the required performance. The circuitry can be on separate pieces of silicon or on chips that surround the ARM core on the same piece of silicon.

Either way, manufacturers must build them to work with the ARM core. In some cases, the circuitry accelerates performance for various functions, such as video, without burdening the CPU. In others, it handles, for example, memory, power management, interchip connectivity, and wireless communications such as Wi-Fi. ARM now designs some of the companion chips' architectures, including 3D graphics engines, said the company's Morris.

The ARM core's instruction set recognizes tasks and offloads them when appropriate to the correct piece of companion or integrated circuitry.

If an application requires processing by another piece of circuitry, the ARM core sends it the instructions and then saves power by going into sleep mode. In addition, power-management features turn off the host device's display, reduce screen brightness, or shut off peripheral devices or radios when not in use.

Using multiple chips also minimizes power consumption because they aren't running all the time.

The CPU could run software to perform functions now handled by the other chips, but this uses more processing and power than dedicated hardware and is not as fast, Morris said.

Up and coming. Later this year, the Marvell Technology Group plans to ship an ARM-based XScale processor that runs at 1.0 to 1.5 GHz, said Shyam Krishnamurthy, director of strategy for the company's Mobile Business Group. Marvell's current devices and smart phones from manufacturers such as Motorola and Samsung, runs at 624 MHz and includes applications and communications processors.

Given the new trends in smart wireless devices, ARM is designing chip cores—the Cortex A8 and A9—for smart phones, as well as for UMPCs and MIDs, which have bigger screens, more capabilities, and full Internet browsers. ARM designed the Cortex cores to support a richer set of features and provide more capabilities, such as higher clock rates and new power-management techniques.

Mobile devices are performing more computing-related tasks than in the past.

ARM has licensed the A8 to several companies, which will begin releasing products with it by the end of this year, Morris said. The A9 will appear in devices in three to five years and will have four cores to provide more or less power as necessary, he added.

Qualcomm will use the A8 license in its new Snapdragon chipset—for smart phones, gaming and portable-entertainment devices, and mini-computers. The company has been testing Snapdragon since November 2007 and plans to release it later this year, noted Manjit Gill, director of product management for the Qualcomm's Chip Business Unit.

TI will use the A8 in its latest smart-phone chipsets, which the company has been testing and expects to appear in products late this year or in early 2009. To the A8 core, the 800-MHz OMAP3430 multimedia chipset, which Figure 1 shows, adds a 2D/3D graphics accelerator, a high-performance video and audio accelerator, and an imaging signal processor for a device's camstrategic marketing in TI's wireless terminal business unit.

Intel's model

The cellular-phone market has grown rapidly. In 2007, vendors sold about 1.12 billion mobile phones, compared to 432.7 million in 2002, according to IMS Research, a market-analysis firm.

This is many more than the 271.2 million PCs and laptops sold last year, according to market-research firm Gartner Inc. Thus, mobile devices represent an increasingly attractive market for chip manufacturers.

Meanwhile, sales are growing faster for smart phones than for cell phones in general. In fact, ABI Research says smart phones, which comprised 10 percent of the handset market in 2007, will represent nearly 33 percent by 2013.

Said ARM's Morris, "The real market for computing is going to be mobile devices." This has attracted Intel, the world's biggest maker of PC and laptop chips.

New chip. Intel has targeted smart phones before, developing the ARM-based, XScale processor platform several years ago. XScale chips were moderately successful, but Intel sold the platform to Marvell in 2006.

Now, Intel is trying again with new chips marketed as one of the company's Centrino processors, which laptops currently use. The Centrino Atom processor, which includes the Intel Atom chip and a controller hub designed to provide PC-like functionality, is due to ship in MIDs this summer.

Vendors could also use Atom in consumer-electronics products such as portable media players and personal navigation devices with Internet access, which could provide services like real-time traffic updates, noted Intel's Kedia.

Atom will be smaller, consume less power, and offer more cellular capabilities than laptop and PC chips.

Atom supports video, audio,

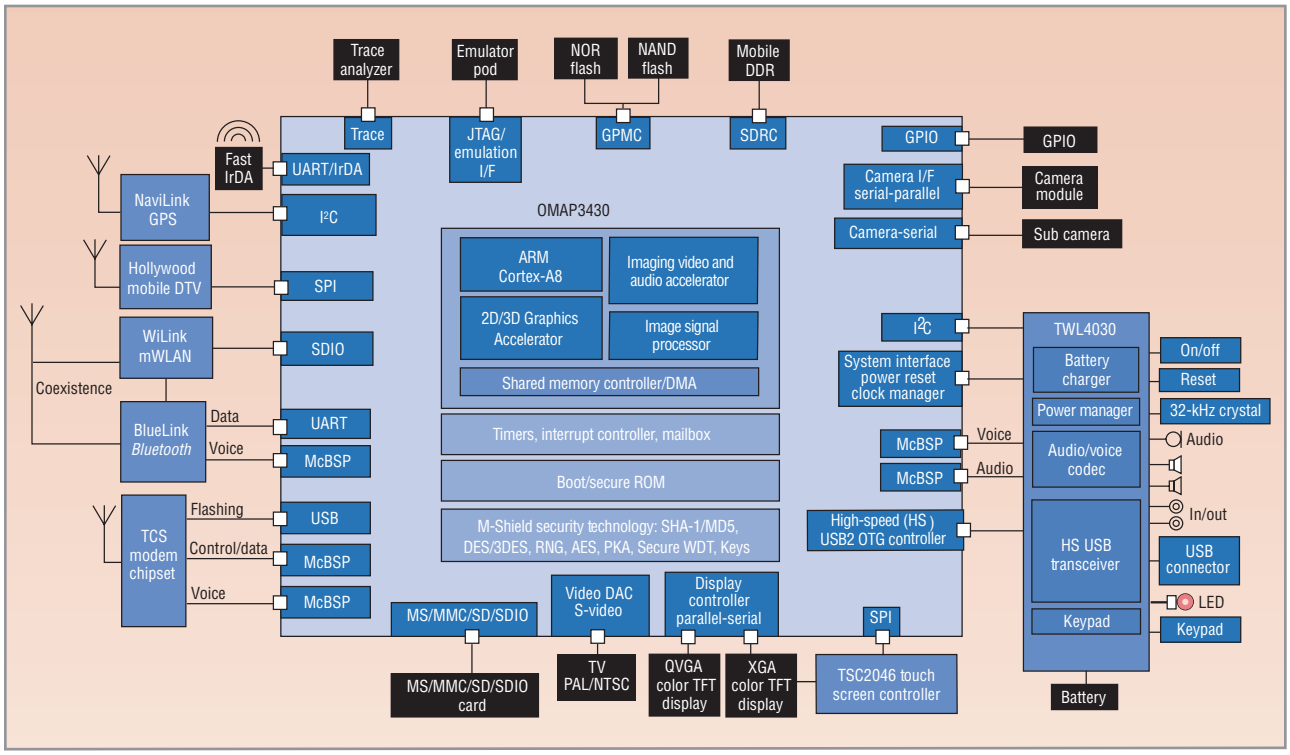


Figure 1. Texas Instruments' OMAP3430 multimedia chipset for mobile devices adds circuitry to handle numerous functions—including graphics and video acceleration and image signal processing—to the new Cortex A8 core that ARM Ltd. designed. This reflects the basic approach for ARM-based mobile chips. Rather than using one chip to handle all tasks, manufacturers add separate circuitry to the cores that ARM designs to handle and accelerate specialized functions.

SpeedStep technology, which dynamically adjusts processor voltage and core frequency to meet applications' needs, thereby decreasing overall power consumption. Some variants also support hyperthreading for improved parallelization.

Intel's approach. Rather than requiring separate chips for many different tasks, Intel has kept most of the functions on the Atom itself, which has a burst mode that lets it run at higher-than-normal clock rates for short time periods.

Intel is used to integrating as many functions as possible into its PC and laptop chips. The company wants to do the same with its mobile chips but must avoid excessive power usage in the process.

Intel has thus integrated most of the functionality into Atom, but still uses its controller hub to handle some tasks, such as graphics, memory, and wireless communication," said Kedia. According to Intel, Atom offers more performance than ARM chips due the higher clock speed and because it keeps most processing on the CPU.

The company says that the role of accelerators should be limited and that it is best to use an x86-based processor as much as possible. This would let mobile devices use the same x86-based software that personal computers run, thereby providing a desktop-like experience and enabling users to work with the same applications they're accustomed to from their PCs.

Inside Atom. Intel uses several mechanisms to manage Atom's power usage, including *clock gating*, which activates the clocks in a logic block only when they have work to do.

Atom contains 47 million transistors and is the smallest processor Intel has ever made, measuring 25 square millimeters, compared to the 107 square millimeters of the Intel Core 2 Duo for laptops and PCs.

"We can have up to 1.86-GHz performance in a device that has a 5-inch display and can deliver four to

Atom consumes 2 watts of power at top speed, 100 milliwatts at low speed, and an average of 200 milliwatts running a range of applications. Intel's Core 2 Duo uses 35 watts.

Atom is fully x86-compatible, which means it works with applications—including browsers and games—written for the x86 chips in PCs, said Kedia. Vendors wouldn't have to rewrite these applications, which would be required for devices that use other types of chips, he added.

According to Intel, users will want PC-like experiences from future mobile devices and that it thus designed the Centrino Atom to support Linux, Microsoft Windows Vista, and Windows XP, but not

THE BATTLE PLAYS OUT

ARM and Intel are coming at the mobile-device-chip market from different perspectives, said Gary Koerper, vice president of platform planning and systems architecture for Motorola's Handset Unit.

"ARM is coming up from the smart-phone space and trying to work into a mini-PC world, while Intel is coming down from the laptop [and PC]," he noted.

This explains the different approaches they have taken with their mobile chips.

According to Koerper, ARM's strength in mobile devices is its low-cost, low-power core, and its design flexibility.

The ARM Cortex A8 consumes less than 50 milliwatts of power in active mode, compared to Atom's higher usage rates of up to two watts.

Intel, though, has the advantage of working with many computer manufacturers who want to begin selling mobile devices, noted Forward Concepts' Strauss.

ARM's designs are licensed by companies that might implement them differently and add their own technologies, Kedia said. He maintained this could lead to incompatibilities in the way the chips use third-party software.

However, Morris said that ARM's licensees work to ensure this doesn't happen.

Analysts generally agree that Intel has made significant strides in mobile-chip technology with the Centrino Atom. Also, the company can offer a rich ecosystem of vendors and developers from the PC industry, and its chips can be used in many consumer products, said Jim McGregor, research director and principal analyst for the In-Stat market-research firm.

Energy consumption will be a critical factor. For example, noted Forward Concepts' Strauss, "Nokia has specified they don't want anything running more than 3 watts because [the heat that would generate] would be uncomfortable for your ear." Although Atom's central processor may use up to 2 watts, he said, peripherals such as modems or application processors could push power usage over 3 watts.

However, noted Intel's Kedia, Intel's next-generation mobile chipset, code-named Moorestown, will use one-tenth as much power as the first generation of Centrino Atom chipsets, while maintaining the same performance.

This would be much more competitive, according to Strauss.

Of course, McGregor said, ARM won't be standing still either and is already working on its Cortex A9 processor.

ARM has the advantage of experience designing mobile chips, cores with low power consumption, as well as a large installed base. And makers of ARM-based chips have achieved economies of scale in manufacturing.

Intel has considerable resources, x86 compatibility, and PC-like performance.

McGregor said manufacturers will have to consider these factors as they decide which chips to put in their future smart mobile devices.

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