Reed Electronics Group

MICROPROCESSOR REPORT

www.MPRonline.com

THE INSIDER'S GUIDE TO MICROPROCESSOR HARDWARE

Intel Defends x86 Strategy

Desktop PCs Are Still Important, but Mobile Computing Is Crucial

By Tom R. Halfhill {8/24/09-01}

As personal computing migrates from desktops to pockets, Intel knows it must push the x86 architecture into ever-smaller, lower-power, lower-cost systems. But investors and financial analysts are watching the lower prices of Intel processors and worry that Atom will cannibalize Intel's most lucrative line of business.

Their worries aren't entirely unfounded. Never has the price difference between Intel's low-end and high-end PC processors been so wide and the performance difference so narrow.

Intel's top-of-the-line PC processor is the Core i7-975 Extreme Edition—a quad-core, 3.33GHz chip listed at $999 (bulk pricing for 1,000 units). Intel's bottom-of-the-line PC processor is the Atom 230—a single-core, 1.6GHz chip listed at $29 (same bulk pricing). Both support Hyper-Threading and 64-bit x86 extensions, and Intel manufactures both chips in its current 45nm high-*k* metal-gate process. Both can run Windows Vista and the installed base of PC software.

Yet the difference between their list prices is a staggering 3,400%. And industry sources say Intel is aggressively discounting Atom list prices. In particular, Nvidia says Intel is offering some Atom processors *with system chipsets* for $25—or $45 for the Atom CPU alone. (That's not a misprint. Nvidia accuses Intel of trying to discourage customers from pairing Atom with Nvidia's Ion system chip.)

Let's put these prices into historical perspective. Intel's first x86 processor (the 8086) debuted in 1978 for $360. Adjusted for inflation, that's $1,279 in current dollars—not out of line with today's $999 Core i7-975 Extreme Edition. However, the $29 list price for a low-end Atom would be a trifling $8 in 1978 dollars. (On the other hand, In-Stat estimates that an Atom chip costs Intel less than $10 to make, so it's still profitable.)

In late July, Intel summoned industry analysts to a "technology summit" in San Francisco. The PowerPoint presentations contained little technology. Instead, Intel executives mounted a spirited defense of the company's grand strategy to move the x86 into new low-priced PCs, embedded systems, smartphones, and other consumer electronics. The overall message: these markets offer tremendous opportunities for growth, so Intel must pursue them, even at the risk of price erosion. Intel says it can still maintain a market for higher-priced PCs and processors.

Intel made a good case, and *Microprocessor Report* agrees with most of Intel's strategy. Mobility, affordability, and ubiquitous communications are redefining personal computing. Intel can't ignore these trends, and the x86 must adapt to changing times. However, we also recognize that price erosion threatens the foundation of Intel's successful business model. Without substantial revenues and profits, Intel can't afford to sustain its leads in fabrication technology and manufacturing volume. Intel is charting a necessary but risky course.

Different Laws for Rich and Poor

Microprocessors are Intel's primary business, but manufacturing is the key to Intel's success. Since the 1990s, Intel has consistently been the first semiconductor company to move the latest fabrication technology into high-volume production for microprocessors.

IBM scores some advances in fabrication technology and claims some advantages for its Power Architecture server

processors, but nobody matches Intel's one-two punch of technology and volume. Intel's lead in manufacturing is a crucial edge that helps compensate for occasional stumbles, such as the company's overcommitment to the power-hungry NetBurst microarchitecture and late adoption of 64-bit x86 extensions.

Maintaining the lead in manufacturing is very expensive, both in research-and-development and fab-construction costs. Progress also depends on the pace of Moore's law, the defining principle of Intel's business model. Lately, we've seen another spate of press reports warning of an impending demise of the industry's most famous law.

At the San Francisco technology summit, Intel engineers assured everyone—once again—that Moore's law is very much alive. Intel anticipates steady progress in fabrication technology through the 22nm node. That's two generations ahead, which is always as far forward as Intel can see.

But there's a joke going around the semiconductor industry: Although Moore's law remains in effect, only Intel can afford it. For poorer companies, Moore is less.

Intel Goes It Alone

As with most jokes, there's a vein of truth. Intel is the last microprocessor vendor building state-of-the-art fabs and developing state-of-the-art fabrication technology without the help of major partners or joint ventures. Even large competitors like AMD, Freescale Semiconductor, IBM, Samsung, and Texas Instruments are spinning off fabs, participating in consortiums, or shifting production to independent foundries.

Intel expects the mobile-PC market to 'trifurcate' into three segments: notebooks, netbooks, and ultrathins.

Intel is starting 32nm production at two fabs in Oregon this year and is claiming higher yields and better performance than ever. Intel says its 32nm transistors are 22% faster and leak only 10% as much current as its 45nm transistors—remarkable achievements. In addition, Intel will start 32nm production at two more fabs in Arizona and New Mexico next year. The company is spending $7 billion in 2009–2010 to deploy this technology.

To sustain these massive capital expenditures, Intel must generate big revenues and profits, and that's harder to do with microprocessors costing only $29 (with correspondingly lower-priced system chipsets). On the one hand, an Atom die is only 10% the size of a Core i7 die—so if an Atom costs only 10% as much, Intel would seem to be reaping the same amount of revenue per wafer. And if the market wants more Atom processors, Intel can save money by running fewer wafers.

On the other hand, the additional test and packaging costs of producing ten times as many chips per wafer eats into the profits. Intel says profit margins on Atom processors are good, but margins don't tell the whole story. Intel needs big profits, not just good margins, to sustain the capital investments in its fabs and manufacturing technology. A lower margin on an expensive processor can make much more money than a higher margin on an inexpensive processor.

Meanwhile, retail prices for PCs keep sliding. Since 2008, the hottest market segment has been netbooks, which usually cost less than $400 and sometimes less than $300. In July, market researchers at NPD reported that the average selling price of a Windows PC (including desktops and laptops) is only $515. NPD also reported that Apple gets 91% of the revenue for PCs priced over $1,000, suggesting that Windows PCs above that threshold have almost vanished. NPD's numbers exclude mail-order sales, so corporate purchases might push the average price higher. Other sources peg the average price of a PC closer to $800. In any case, the historical trend is toward cheaper PCs.

Intel is contributing to this slide. Intel is primarily responsible for starting the netbook trend (by introducing the Atom processor) and for labeling it (by popularizing the term "netbook"). Netbooks have been a rare bright spot in this recession, selling faster than Nintendo's Wii and Apple's iPhone.

However, Intel says only 3% of netbooks are the user's primary PC, so they aren't cannibalizing the market. Independent market research and anecdotal evidence tend to support this conclusion. Netbooks are almost always supplemental PCs, and many are purchased by people who already own a conventional notebook PC. Intel says netbooks are whetting the public's appetite for smaller PCs delivering competitive performance.

Next Big Thing: Ultrathins

Over the next few years, Intel expects the mobile-PC market to "trifurcate" into three segments: traditional notebooks, netbooks, and ultrathin notebooks. Ultrathins are the latest thing. Essentially, they are imitations of Apple's popular MacBook Air. When Apple CEO Steve Jobs dramatically unveiled the world's thinnest notebook computer at Macworld Expo in January 2008, critics dismissed it as another Apple gimmick. As usual, the gimmick soon became an object of envy.

Today, the MacBook Air starts at $1,400, leaving plenty of room for Asian OEMs to build a lower-priced ultrathin PC with Windows. Although these computers will be much thinner than traditional notebooks, they will have larger keyboards and screens and faster processors than netbooks. Therefore, ultrathins will command higher retail prices, generating bigger revenues and profits.

To enforce the boundary between netbooks and ultrathins, Intel requires OEMs to limit the screens of Atom-based netbooks to 10.1 inches. (This limit also keeps Atom from displacing Intel's higher-end processors in conventional notebooks.) Intel says most ultrathins will have 13.3-inch screens, and most regular notebooks will have

15.6-inch screens. Ultrathins will have faster processors than netbooks—probably a Core 2 Duo or Core i7 processor instead of an Atom. If, as Intel expects, a few million buyers pass up the cramped netbooks for more luxurious ultrathins, the new category will lift Intel's average selling prices, counteracting the deflationary force of netbooks.

One potential snag is another emerging category of mininotebooks, sometimes called smartbooks. Basically, these are netbooks without x86 processors or Windows. Most smartbooks will have an ARM processor and Linux. Qualcomm is leading this charge with its ARM-compatible SnapDragon chip. Freescale Semiconductor is another contender, also with an ARM-based SoC. Smartbooks will cost even less than netbooks, especially when sold with a service contract for cellular Internet access. Indeed, the smartbook may be "free."

MPR is preparing an analysis of the netbook/smartbook market and the technology behind it. Until then, we note that previous attempts to sell Linux netbooks have largely failed, with some sales channels reporting a 20% return rate.

The problem is that when a system resembles a traditional notebook PC, users expect it to run traditional PC software—in other words, Windows software. Open-source alternatives like Mozilla Firefox and OpenOffice run well on Linux, but when users try to install something different (like iTunes), they are disappointed. To succeed, smartbooks must clearly position themselves as mobile devices for web browsing, email, social networking, and other (mostly cloud-based) applications that don't require a Wintel PC.

Intel predicts that PCs will follow the same trend as telephones: first, one per house; then one per room; then one per person.

Nettops: Another Opportunity

Intel defends its nettop strategy, too. Nettops are the desktop counterparts to netbooks—small, low-cost PCs often powered by Atom processors. An example is the $349 Eee Box from Asus, the Taiwanese company whose diminutive Eee PC ignited the netbook rage. Dell and other major vendors offer similarly priced small PCs, including some with more-powerful Intel or AMD processors.

Nettops, like netbooks, tend to deflate retail prices and leave less headroom for profit. They are becoming especially popular as media-center PCs in living rooms, thanks to their compact dimensions and decorator colors. Therein lies the central thread of Intel's argument—nettops, like netbooks, will be supplemental PCs, not replacements for primary PCs.

At the San Francisco summit, this case was made by Mooly Eden, general manager of Intel's Mobile Platforms Group. (Longtime *MPR* readers will also remember Eden as the project leader for the Pentium M processor, which saved Intel from a worse fate after the NetBurst meltdown in 2002.) Eden illustrated his case with a Japanese newspaper advertisement for vacuum cleaners. The advert's message was that a handheld vac is no substitute for a full-size machine—a refined household needs both.

Eden predicts that PCs will follow the same trend as telephones. First there was one per house, then one per room, then one per person. Nettops, netbooks, and ultrathins are sufficient for smaller computing tasks, especially on the go. However, users still need a more capable desktop PC for tackling the big jobs. Eden rejects the notion that PC performance is becoming irrelevant. He predicts that today's PCs won't be fast enough to run much of the software written five years from now. "The hardware-software spiral is alive and kicking," he said.

Unfortunately for Intel, Microsoft might be shirking its duty as the largest gravitational force causing that spiral. Beta testers say Windows 7 is actually a little faster than Vista. Then, too, the most compute-intensive software written five years from now will probably run on GPUs, not CPUs. Massively parallel GPUs programmed for general-purpose computing will be especially valuable in media-center PCs that transcode digital-video formats and stream high-definition video. Nevertheless, Intel will gladly sell processors for any PC, no matter what its price or which room of the house it occupies. Consequently, Intel sees supplemental PCs as an opportunity, not a threat.

Intel's strategy makes sense. It dovetails with our long-held view that the dominance of traditional desktop PCs is waning as personal computing goes mobile and wireless Internet access becomes universal. However, as PCs in all forms continue spiraling downward in price, Intel is bound to make less money per processor.

One consolation is that Intel will claim the lion's share of that volume and revenue. AMD has no microprocessors competitive with Atom and is fighting for survival after spinning off its fabs to Global Foundries. (See *MPR 11/24/08-01*, "AMD's Fresh Start.") With Transmeta gone, the only other x86 vendor is VIA Technologies. VIA's Centaur subsidiary is clinging to 1% or 2% market share, despite pioneering the concept of small x86 processors for low-cost PCs and embedded systems. (See *MPR 3/10/08-01*, "VIA's Speedy Isaiah.")

Opportunities Beyond PCs

Declining prices of PCs won't necessarily undermine Intel's manufacturing-centric business model if the company can make up the money elsewhere. And that's exactly what Intel intends to do. Another leg of the strategy is to drive up demand for server processors and x86 embedded processors.

As notebook PCs, desktop PCs, wireless phones, and other personal-computing devices get cheaper, more of them are sold. Because almost all these systems will eventually connect to the Internet, they boost demand for web servers, mail servers, storage servers, application servers, and search-engine data centers. As the largest vendor of server

processors, Intel stands to gain substantial new business—perhaps enough to offset the price declines in clients.

Another growth market is embedded processors, particularly for deeply embedded applications—those in which the microprocessor is largely invisible to users. Examples are smart sensors and point-of-sale terminals. Intel predicts that 15 billion embedded devices will connect to the Internet by 2015, and most will engage in machine-to-machine communications, with little or no user participation. For instance, thermostats distributed throughout a building can communicate with a control center at another location, allowing remote monitoring and regulation of environmental systems. Another example is the "smart grid" envisioned by utility companies.

Intel says the market for deeply embedded processors is worth $11 billion annually, already dwarfing the $3.6 billion PC-server market. The green campaign to improve energy efficiency is expected to create more demand. Intel says a medium-size chain of retail stores might have 50,000 point-of-sale terminals, most of which are powered 24 hours a day, even when the stores are closed—because employees don't bother to shut them off. Each year, inactive terminals in the U.S. consume as much power as Hoover Dam generates in four days. Remotely powering down the terminals could cut power consumption by 75%, Intel estimates.

To storm the embedded market, Intel is building 14 new Atom-based SoCs in 32nm technology.

Today, ARM rules the handset market, and MIPS and the Power Architecture are strong in networking and consumer electronics. Intel hopes to break in with the x86. Although Atom was a good first step, future x86 processors must consume even less power to win designs for the smartphones and deeply embedded systems that Intel craves.

Right now, the market is pulling Atom in two directions. To stay competitive in small PCs, Atom needs more throughput. To become more competitive in embedded systems, Atom needs lower power. In addition, Intel must make a persuasive argument that the x86 is the best architecture for embedded applications. (See *MPR 4/7/08-01*, "Intel's Tiny Atom.")

One of Intel's arguments is that fourth-generation (4G) cellular telephony equipment will use about ten different microprocessor architectures, which complicates software development and support. Presumably, the x86 is the savior that will bring order to the chaos. However, Intel is counting baseband processors among those architectures. So far, Intel hasn't made a case that the x86 is an efficient substitute for DSPs.

More x86 SoCs Are Coming

To storm other segments of the embedded market, Intel is building 14 new Atom-based SoCs in 32nm technology. The chip packages are being trimmed down, too, and will range from 0.8mm to 2mm thick. (Multichip packages will be thicker.) These chips will supersede Intel's first-generation SoCs for communications and consumer electronics, most of which use the older Pentium M "Dothan" core. (See *MPR 8/18/08-01*, "Intel's New SoCs.")

Sunit Rikhi, Intel's vice president for technology and manufacturing, says his SoC technology is running about six months behind his CPU technology. That is, CPUs are tested and certified for manufacturing in a new fabrication process first, then SoCs are tested and certified about six months later. SoCs are more difficult to fabricate, largely because of their analog/digital mixed-signal elements. Intel certified SoC production at 32nm in 1Q09 and is now refining the process. One refinement is the fabrication of multiple SoC designs with mixed-signal features on a single wafer.

More evidence of Intel's determination to penetrate the embedded market came in June with the acquisition of Wind River Systems. (See *MPR 6/29/09-02*, "Tough Times Bring Change.") Naturally, Wind River's customers have been concerned about this turn of events. Doug Davis, general manager of Intel's Embedded and Communications Group, told analysts at the summit that Wind River will continue operating as a wholly owned subsidiary and will continue supporting non-Intel CPUs. In other words, Intel says it won't use Wind River to thin the herd of embedded-processor architectures.

Perhaps Intel's most interesting gambit in the embedded market is its Digital Health Group. Led by general manager Louis J. Burns, this group is designing and selling end-user systems, not embedded processors. The first product is the Intel Health Guide, a keyboardless tabletop computer that helps patients monitor their condition, regulate treatment, and obtain professional advice by videophone. It has been approved by the Food and Drug Administration (FDA) for sale in the U.S. and is also certified in Australia, Canada, Ireland, and the U.K.

Intel says it entered this uncharacteristic line of business partly because of the huge growth potential (aging populations, rising health-care costs, increasing emphasis on home care). Another reason is that selling chips and offering the usual reference designs proved inadequate. To get FDA approval in the U.S. and the equivalent in other countries, Intel had to undertake a major research project and mastermind the product design. Most of the PC OEMs that are Intel's regular customers couldn't tackle the job. (See *MPR 8/24/09-01*, "Intel, M.D.")

More Upside Than Downside

As we noted at the beginning of this report, our impression of Intel's Technology Summit was that it was actually a marketing effort to explain Intel's x86-everywhere strategy. By some accounts, that strategy seems to be eroding prices and threatening Intel's livelihood. Although netbooks and nettops are having that effect, at least initially, we think Intel's long-term strategy is sound. Clearly, the action is

shifting away from traditional desktop and laptop PCs, so Intel must follow.

On August 17, Dell announced that it will enter the smartphone market by partnering with China Mobile Ltd., one of the world's largest manufacturers of mobile handsets. Dell is following other major PC vendors. Acer, Asustek, and Hewlett-Packard have also launched cellphones. So far, none of their phones uses an x86 processor.

Whether Intel can successfully push the x86 into markets now dominated by the ARM, MIPS, Power, and other embedded-processor architectures is the big question. Power consumption is only one obstacle. Outside the PC realm, the x86 loses some of its advantages in software. And, as *MPR* has noted before, Intel's reluctance to broadly license the x86 is a handicap when competing against ARM and other companies that license embedded-processor cores for custom chips. Intel's recent SoC collaboration with TSMC addresses some, but not all, of those concerns. (See *MPR 3/30/09-01*, "Intel Will Customize Atom.")

All things considered, *MPR* believes that Intel's x86-everywhere strategy has more upside potential than downside potential. The hazards of inaction and inertia look worse than the risks Intel must take.

For More Information

All but one of the PowerPoint presentations from Intel's Technology Summit in San Francisco are available in the pressroom section of Intel's website. (The missing presentation is Mooly Eden's.)
www.intel.com/pressroom/kits/innovation/summit09/index.htm?iid=pr1_marqsub_summit09