

Last week's Intel Developer Forum, the 18th to be held in the US since the first 1997 event where Gordon Moore delivered the keynote, marked several turning points with regard to Intel's role in the electronics industry:

- It marked the end of the Howard High era. Howard has been the face of Intel's PR department since as far back as we can remember, but last week he announced his retirement from Intel. He will be missed, although his departure hardly merits a press release.¹
- It marked the end of the NetBurst microarchitecture era. NetBurst, the technology behind Intel's Pentium 4 and Xeon lines for the last five years, burst onto the scene in November 2000. The original 1.5GHz model barely outperformed the 1.0GHz Pentium III it superseded. Follow-on versions at ever higher frequencies tended to deliver more heat than performance. NetBurst, more than any other Intel technology, created the competitive opportunity that allowed AMD to claim performance and performance/watt leadership for the first time in its history. We expect neither a press release nor an obituary noting the passing of NetBurst to issue from Intel's PR department.
- It marked the end of the Pentium[®] era. Intel launched its first Pentium 13 years ago, after a court ruled it could not trademark simple numbers like "486" and "586." Although Intel substantially changed Pentium's underlying architecture three times, and shrunk the size of its transistors from 800nm to 65nm, each new version proudly bore some variation of the Pentium name. Now Intel believes the Pentium brand has become too closely aligned with Megahertz for Megahertz's sake. Intel retagged its mobile processors with the new "Core™" brand earlier this year, and plans to extend that brand to desktops with the Q3 launch of chips based on its new Core™ microarchitecture. R.I.P. Pentium[®], but don't look for a press release.
- It marked the end of Intel's x86 microprocessor monopoly era. Of course, Intel never referred to itself as a monopolist; if pressed, the company might agree it had "a dominant" segment share. Intel always maintained that it remained vulnerable to competitive challenges. The past year has demonstrated it was correct in its characterization of the market; AMD challenged and Intel was vulnerable. Perhaps Intel's legal department will want to issue a press release.

At IDF Intel showed that it's ready to put its massive engine back on the track. Now that AMD has had a chance to sip from the fountain of technology leadership, will Intel's new products restore the *status quo ante*? Will AMD willingly resume its traditional role as a provider of low cost, low performance processors for personal computers aimed at value-oriented buyers? We suspect not. In the remainder of this note, we outline the reasoning behind our conclusion.

A Brief History of the x86 Processor Market

From 1980, when Intel crushed its competition (Motorola) to win the microprocessor socket in the original IBM PC until very recently, Intel took no prisoners in its relentless campaign to gain market leadership.² The company out-marketed, out-designed and out-manufactured all its so-called competitors. Those competitors demonstrated incredible inventiveness in finding new ways to mess up their own businesses. They under-invested, over-promised and under-delivered; even when they (rarely) achieved a performance advantage, they proved unable to maintain that advantage for more than a quarter or two. The results were about as predictable as a football game between the Pittsburgh Steelers and your local high school team.

¹ The PR department will need to designate a replacement who can utter the phrase "OK guys, you know the drill. Raise your hands and wait for the mike runner to come to you," with the same aplomb as Howard.

² Intel dubbed the internal effort to win IBM's PC business "Operation Crush."

Over the past decade, one Intel competitor, AMD, slowly began to get its act together. It assembled a team of expert CPU designers and gave them the time they needed to create an extremely competitive product. It partnered with leading suppliers (first Motorola, later IBM) to augment its manufacturing process technology, and put in place the capacity to supply 20 percent of the processors the market would need. It made a few astute technology bets that worked out in its favor, including SOI process technology, on-board memory controllers and multi-core technology as the path to increased system performance. It has executed with nary a hiccup for almost five years. When Intel's NetBurst problems began to manifest themselves in 2003 and 2004, AMD was well positioned to capitalize on Intel's misery and seize the mantle of technology leadership.

Back to the Present

At last week's IDF show, Intel took the wraps off the next-generation design it has dubbed "Core™ Microarchitecture." By any measure, the architects in Intel's Israeli Design Center (IDC) have created a superb design that puts Intel back on the competitive landscape. It's likely that in desktop and notebook segments, Intel may leap ahead of AMD, at least by a skosh, with regard to performance and power consumption. In two-way servers, the Q3 launch of Woodcrest should allow Intel to achieve parity with AMD on thermal and power metrics; at that point each company will win some benchmarks and lose some, based on the behavior of specific programs. It will take longer for Intel to find its way out of its four-way server morass, given that it cannot shed its NetBurst legacy in this segment until late in 2007.

While Intel has busied itself retooling its roadmap and realigning its architecture to fit with advancing semiconductor process technology, AMD has been building its reputation, one chip at a time. It has now emerged as a credible alternative to Intel in the markets both companies serve. The market has shifted from a monopoly with one credible supplier and one wannabe to a duopoly with two credible suppliers. This should hardly come as a surprise. Most markets with high entry barriers eventually evolve into oligopolistic configurations; Intel's ability to maintain its dominant position for as long as it has demonstrates just how high the barriers to entry are in the markets it serves.³ But now that the walls have been breached, we see little likelihood that the market will revert to its former arrangement. Customers (i.e., system OEMs) prefer a choice of suppliers, be it in regards to graphics (ATI and Nvidia), LAN interfaces (Broadcom, Intel and Marvell), wireless adapters (Atheros, Broadcom and Intel), and a variety of other components. These products, unlike DRAM modules or disk drives, cannot be freely substituted for one another, but they provide similar functions. OEMs choose one or another supplier for a variety of reasons that don't always devolve to "highest performance" or "lowest price." We anticipate that each company will at times pull ahead of the other, only to see the other pull ahead at a later date. This strikes us as the way markets are supposed to operate. The New England Patriots did not make it to Super Bowl XXXX, but they may very well end up as a contender in Super Bowl XXXXI.

Price War? We Don't Think So

Although both Intel and AMD lower prices periodically to make room in their product line-ups for new, faster processors, one or two Wall Street analysts always seem to interpret these moves as signs of an impending price war. The fab capacity Intel and AMD plan to add this year buttresses that scenario. We beg to differ. In markets with perfect competition (i.e., few barriers to entry or exit, and many competitors) prices tend to track the marginal cost of production. Add in a few barriers to exit, and prices can even fall below marginal cost, as happens from time to time in the DRAM industry. The competition in the x86 processor segment is far from perfect in this regard. The segment has high barriers to entry and exit, and only two suppliers. Duopolies often end up in a Nash Equilibrium, a state first described by John Nash, the Nobel Laureate portrayed in "A Beautiful Mind." Nash observed that firms in duopolistic markets typically set production levels that maximize their own profits. Each firm understands its competitor's strategy and adapts its own accordingly. The end result is that the combined output of both producers is greater than the output of a single monopolistic producer, but less than a large number of producers operating independently would deliver. Conversely, the overall price level in a duopoly is lower than a monopolist would charge, but higher than the prices determined by a perfectly competitive market. Thus the combined profit for duopolists will be less than that of a monopolistic supplier, and some of the profit a monopolist would have obtained gets redistributed to the customers of the duopolists. This may account for the somewhat lopsided distribution of profits in the PC industry to date. Historically, Intel and Microsoft have done very well in that environment, while PC supplier margins have varied between thin and non-existent. We view the increasing profitability of HP's PC business as a sign this redistribution may already have begun.

³ AMD alleges that other factors may be at work, but that's a subject for a different note.