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Itanium 2 = PA-RISC 2?

Research Note

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Itanium[1] was a flop. Its Explicitly Parallel Instruction Computing (EPIC) architecture was supposed to be a "breakthrough in microprocessor technology, enabling industry-leading performance, compatibility, and scalability,"[2] according to Intel and co-developer Hewlett-Packard. But the chip's integer performance was trailing edge. Only a few thousand systems based on this "breakthrough" technology ever sold—a market penetration that was, shall we say, limited. HP was the biggest seller of Itanium-based systems, but critics charged that almost all of HP's Itaniata actually shipped not to real customers but to Intel and Microsoft. The best counterclaim HP could make to that was to say Itanium workstations had actually shipped to "dozens of companies." Dozens of companies—wow!

Now Itanium 2 (a.k.a. "McKinley") is hitting the street, but no one seems to care much. Even Itanium 2's surprisingly strong performance compared to both Itanium and its RISC-based competition has caused scarcely a ripple in the industry. In fact, Intel itself seems nervous about being seen as publicly pushing Itanium 2 too hard. Even at its own Developers' Forum back in February Intel highlighted traditionally lower-profile I/O technologies such as InfiniBand, somewhat to the exclusion of Itanium 2.

But HP does care. It cares a lot. And, more than Intel or any other vendor, it is pulling out all the stops on the Itanium 2 release. HP is announcing new systems, running benchmarks, and generally evangelizing the debut of the second generation of a chip architecture it has been talking up since it began joint development with Intel in 1994.

HP's enthusiasm about Itanium 2 is not surprising. It has made a huge bet on the future of the IPF architecture, and its acquisition of Compaq makes the wager that much more serious by hitching the former Compaq's future to IPF as well. But this enthusiasm—combined with the ambivalence vendors such as Dell are showing toward Itanium 2—means that HP is, effectively, the

1. Itanium was the first processor in the Itanium Processor Family (IPF). It was originally code named Merced.
2. Intel press release at the 1997 Microprocessor Forum when details of the new architecture's instruction set were formally unveiled.

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only stalwart IPF supporter among first-tier system suppliers. This is partly because of HP's existing commitment, but mostly because other vendors (and their customers) are largely satisfied with the mix of proprietary RISC and x86 chips that are already available. This lack of OEM demand means that Itanium 2 will be most relevant to systems from, and customers of, HP—making it more the next-generation of HP's PA-RISC and Alpha than a general-purpose chip for the rest of us.

The Vendor Landscape Has Shifted

The first Itanium chip failed partly because the industry failed it. It launched into one of the biggest industry retrenchments in high-tech history, following the meltdown of the dot-coms and the subsequent deflation of the IT vendors who had come to depend on their profligate spending on technology. In a sudden IT-spending drought, it took more to make a new processor successful than an Intel label and vague promises of a 64-bit revolution.

But Itanium 1 also failed on its own merits. It was slow, for example. And the supporting ecosystem of hardware and software was excruciatingly thin, especially for commercial applications.

Itanium 2, in direct contrast, is not slow. The architecture's performance has been pumped up by tweaks virtually everywhere: in chip frequency, the speed of the system bus, the number of execution units, the tight integration of the L3 cache, *et cetera*. Integer processor performance as measured by the SPECint2000 benchmarks edges even IBM's 1.3 GHz POWER4, the previous speed champion among RISC processors.

Even floating-point performance, one of the few bright spots for the original Itanium, has been approximately doubled in Itanium 2. Intel and HP have also released some highly competitive multiprocessor numbers, albeit scaled only to a modest four-way server. These impressive numbers show that the underlying IPF architecture has no fundamental performance-limiting flaws, and that it can compete with the best RISC has to offer.

HP Stands (Virtually) Alone

Processors need to perform well to succeed, but simply performing well isn't enough. Plenty of CPUs have briefly grabbed headlines with winning benchmark numbers only to fade away when significant hardware or software support failed to materialize.[3] Processors also need to be widely adopted and endorsed by major system vendors. It is in this respect that Itanium 2's prospects are mixed.

3. Anyone remember the Motorola 88000, the Intergraph Clipper, or the Zilog Z-8000 and Z-80000?

Comparing the Itanium and Itanium 2 Processors

	Itanium	Itanium 2
Max core frequency	800 MHz	1 GHz
Max L3 cache	4 MB (on-board)	3 MB (on-die)
System bus	2.1 GB/sec (266 MHz/64-bits)	6.4 GB/sec (400 MHz/128-bits)
Execution units	13 (4 integer, 3 branch, 2 floating point, 2 SIMD, 2 load or store)	16 (6 integer, 3 branch, 2 floating point, 1 SIMD, 2 load or store)
Volume chipsets	Intel 460GX	Intel 870, HP zx1, IBM EXA
Other chipsets	Hitachi CF-1, NEC AzusA, Unisys ES7000	Bull (870-based), Hitachi CF-2, Unisys (870-based), NEC

For example, Dell, which lives to sell systems efficiently and in high volume, is sitting out the Itanium 2 launch. This doesn't reflect any philosophical opposition to IPF on Dell's part; the company will be happy to sell IPF systems as soon as people are willing to buy a lot of them. But the snub very publicly affirms Dell's opinion that IPF won't sell in volume for quite a while; and Dell's opinions about volume sales have to be taken very seriously.

Or take IBM, which is well positioned to offer medium- to large-scale Itanium 2 machines using the Enterprise X-Architecture. Its "Summit" chipset was designed from the outset to support both Itanium 2 and Xeon MP processors.[4] IBM was all set at one point to bring its AIX version of Unix over to IPF, just as HP has done with HP-UX. But that effort was quietly curtailed, then formally cancelled.[5] Much of the reason was certainly lack of interest from customers and ISVs, and the growing importance of Linux on Intel-architecture platforms. But IBM's redoubled focus on integrating technology it controls—including POWER4 and AIX 5L—into its most strategic "scale up" server platforms, must also have played an important role in the decision. While IBM will certainly offer systems for both commercial and technical markets based on the Itanium 2 and its successors, IPF is just one small element of the company's variegated server strategy and far from the most strategic.

Of course, IPF is attracting some attention and commitments from a variety of smaller vendors, who will either assemble small- to medium-sized systems from standard components or design Big Iron around it.

Groupe Bull, Hitachi, and NEC have all publicly stated that they plan to release high-end Itanium 2 systems—but there is little reason to believe that these new systems will help any of these companies break out of their current trailing market positions, which are largely constrained to narrow geographic areas or vertical markets.

Among the second-tier vendors, only Unisys, which has pioneered the idea of the "Windows mainframe," really stands to get a major boost from the release. A solid-performing 64-bit processor that can run Windows creates opportunity for Unisys. But it also creates a huge risk, not only from new high-end Wintel architectures like IBM's Summit, but from potential customers and investors who increasingly want to see concrete evidence Unisys can succeed with a high-end Windows server strategy.

Thus, it is HP that is left to fill the role of great IPF promoter. HP's entire strategy revolves around the new architecture. The company will phase out its own PA-RISC and Alpha architectures and offer what has grown to be a multitude of OSs: various versions of Windows, Linux, HP-UX, OpenVMS, and NSK. Although HP will keep PA-RISC and Alpha around through a couple more chip upgrade cycles, and IA-32 will remain a component of lower-end servers, desktops, and notebooks for the foreseeable future, IPF is the heart of HP's server strategy. HP is even playing a large role in chipset design. And not just at the high-end where IPF will find its way into Superdome and other HP Big Iron. HP has also designed the most volume-oriented of the Itanium 2 chipsets, zx1, targeted at small high-performance servers and workstations—a space usually supported by products from Intel and other chip companies.[6]

What's more, Compaq, though it had committed even before the acquisition to migrate its Alpha base to IPF, was not a particularly vocal IPF promoter. Its ProLiant (Intel-based) side of the house was slow in developing IPF-based products, and lax in proselytizing IPF to customers and partners—certainly more so than its then competitors at HP, anyway. Now, HP's commitment is Compaq's commitment.

4. See Illuminata Research Notes, "The Odd Couple: Windows Meets Big Iron" (January 2002) and "Race to the Top", (December 2001).
5. AIX on IPF was originally known as Project Monterey, the last in a series of unsuccessful efforts led by the former Santa Cruz Operation (SCO) to create a standard datacenter-ready Unix for Intel platforms.
6. See Illuminata Research Note, "zx1: Chipset for Nimble McKinleys", (February 2002).

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x86 Refuses to be Displaced

Intel once promoted IPF as just about the only processor that the general-purpose computing world would ever need. Its roadmaps predicted IPF would rapidly replace its own 32-bit server chips and strike a mortal blow against RISC—forcing the system vendors that used those chips to switch to IPF or perish. Indeed, in addition to Compaq, HP, and IBM, even Sun once had a Solaris for IA-64 project.[7] Every major RISC vendor considered covering its processor bet at some point.

As time went by, Intel and its partners started to take a more nuanced view of IPF adoption—recognizing its fit with some classes and uses of systems and its lack of near-term or mid-term fit with others. It is now clear that IPF, whatever its eventual growth path, will not supplant x86-based systems any time soon, let alone the entire RISC universe.

IBM and Sun remain firmly committed to their RISC processors—especially for high-end systems. And the way both Intel and AMD have successfully cranked up the clock of 32-bit processors to dizzying multi-gigahertz speeds will help to ensure that those processors stay around for the many desktops and low-end servers that don't need 64-bit memory addressability or blazing floating-point performance. And, indeed, nowhere on Intel's current processor roadmap does IA-32 come to the end of its road.

There's also a wild card in the processor architecture game: 64-bit extensions to the x86 architecture—an approach that AMD is aggressively championing in the form of its coming Opteron processor (code named "Hammer").

The approach has its drawbacks. A clean slate like IPF lets designers make major changes, many of which lead to great gains. But it's certainly simpler to extend the x86 architecture to 64 bits than it is to design a new instruction set and processor architecture from the ground-up. The Opteron approach would also let 32-bit x86 binary code run at full native speed, even on a 64-bit system, meaning the impact on existing software would be minimal. In contrast, running 32-bit binaries on IPF processors in what amounts to a 32-bit emulation mode comes with huge performance penalties.[8] Opteron's ability to mix attributes of 32-bit and 64-bit chips would allow for the gradual introduction of 64-bit apps alongside 32-bit apps, if the chips and extensions work as advertised.

Of course there's also a downside to Opteron's quick-and-dirty approach to 64-biterization. All the old x86 cruft—the kludges and compromises of its long development, remain. It will still have a limited and specialized register set, weak floating-point performance, and a complex morass of processor instructions, for example, lying just beneath the new 64-bit exterior. Such evolutionary changes are never really transparent. Taking advantage of Opteron's 64-bitness will require new versions of operating systems[9] and applications. Without updates, the software won't be able to use the extensions, leaving Opteron as just a 32-bit processor with dreams of 64-bitness.

But in spite of its technical limitations, Opteron has the potential to gobble up a noticeable chunk of the desktop and entry server market, or at least keep Itanium 2 from doing so. These low-end systems are not primary targets for Itanium 2, but they do represent the volume mainstream of the server market as a whole. If AMD successfully brings Opteron to market—and scores OEM wins from major desktop and server vendors—it could score big. Expanding to 64-bit computing with little additional charge and with little of the pain of software migration, but with a clear path to the day when 64-bit applications will be available, is an attractive prospect.

If AMD's Opteron—or even Intel's own "Yamhill" skunkworks project, which is based on a similar technology approach[10]—begins to siphon off a large

7. As the IPF architecture was then known.

8. The penalty varies but is typically well over 50 percent. Any remotely performance-sensitive code must, at a minimum, be recompiled for IPF.

9. Linux and Microsoft Windows support are in the works.

10. In deference to its more strategic IPF, Intel will not even publicly acknowledge the existence of Yamhill, which is effectively a backup plan in case AMD's approach starts to gain market traction.

share of the overall 64-bit pie, IPF will be left to compete only for lower-volume/high-margin performance-oriented commercial and technical applications.

IPF could well end up competing primarily with RISC processors while most of the market volume continues to use IA-32 or 64-bit extended versions of IA-32 for more modest computing needs. And, under this scenario, it is HP that will inevitably be the primary purveyor of IPF processors because the other two major system vendors are committed to their own chips. Sure, as IPF matures, IBM will use it within the xSeries and Dell will build it into a few high-performance servers and workstations, but HP will make or break IPF just as IPF will make or break HP's computer business.

HP's Double-Edged Sword

That said, Itanium 2's surprisingly good benchmark numbers and comparatively widespread support will give it a significantly broader ecosystem in which to play than any other RISC processor. It is the only processor architecture supported by Linux, Windows, and a commercial-grade Unix, for example. This breadth of OS support—as well as hardware coming from vendors in addition to HP—will help to drive at least some of the volume economics that have led to the ubiquity of IA-32. This will all benefit HP as the primary IPF system supplier.

HP will pay for this relative popularity with a loss of control over some of the technology it needs to service its high-end customer base. As primary purveyor of IPF, HP's will be the main voice Intel will hear on matters relating to IPF. This will further enhance its influence with Intel, which was already significant, but vastly expanded when it acquired Compaq.[11] This influence will be important in melding the designs of future IPF processors and HP systems.

But, fundamentally, however heavy was HP's involvement in Itanium's initial architectural design, IPF processors are Intel's to bring to market. HP has thus ceded some control over its highest-end market to Intel. That will make it much harder for HP to persuade Intel to adapt designs or make other changes that are to HP's unique benefit, rather than that of third parties who may eventually ship important numbers of IPF-based systems. As Itanium becomes more widely installed and attracts more third parties, this problem will only get worse. For HP, this is a potential disadvantage compared to RISC vendors who control their entire hardware environment, and much of their software.

The Future of HP and Itanium 2

HP was always the system vendor most singularly committed to IPF. Its acquisition of Compaq has only served to consolidate further its status as the vendor—together with Intel—at the center of the IPF universe. Indeed, we would argue that IPF is ultimately more critical to HP's future success than it is to Intel's. Other vendors both large and small will also offer systems built around Itanium 2 and its successors, but HP will likely sell more than all other companies put together—which in turn will cause competitors such as IBM to further de-emphasize IPF in their product portfolios.

IPF won't solely serve HP's performance-oriented commercial and technical computing needs, but that will be its focus and, consequently, that which drives its roadmap and future development. A high-end 64-bit processor primarily found in HP systems. Think of it as PA-RISC 2 (and Alpha 2) rolled together and sprinkled with Intel's "volume economics" mantra.

11. See Illuminata Quick Note, "HP(q) Servers: Quick Start to New Journey", (May 2002).

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