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## Is There a 64-Bit x86 in Intel's Future?

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In recent weeks there has been much speculation regarding whether Intel's forthcoming Pentium 4, code-named Prescott, includes 64-bit extensions similar to those AMD added last year to its Athlon 64 and Opteron lines. Intel has been notably silent on this topic, both on and off the record, leaving pundits and financial analysts to ponder the issue unassisted by any hints or nudges from the company. Some have concluded that these features will appear sooner, rather than later, maybe even as early as this quarter. Insight 64 believes these extensions are unlikely to appear before the mid-2005. Several factors constrain Intel's actions this year; we believe further that Intel wouldn't want to move sooner, even if it could. But before we examine the Intel-specific issues, we need to explore why 64-bit technology has attracted so much attention over the past two years.

All 64-bit architectures, be they RISC, CISC, or EPIC, differ from 32-bit architectures in one key regard – the amount of memory that can be directly addressed via the processor's registers and memory-based pointers. Programs use pointers to access data structures, so pointer size directly impacts the maximum amount of memory a program can use. Intel's 32-bit Pentium and Xeon processors can directly address up to 4,294,967,296 bytes of main memory, commonly referred to as 4GB. 64-bit processors like Intel's Itanium and AMD's Opteron can address four billion times more memory, up to 18,446,744,073,709,551,616 bytes or 16 exabytes (EB). When the first Pentiums appeared in 1993, a 4GB memory bank sold for more than \$100,000, so the 4GB addressing constraint was rarely encountered in practice. Today, users can buy a 4GB memory bank for less than \$500, but even if users can afford more, their programs cannot take advantage of DRAM in excess of 4GB. In short, 32-bit processors limit how much memory a processor can effectively utilize and 64-bit processors provide a straightforward solution to this problem.

In the mid-1990's, virtually all general-purpose processor suppliers correctly anticipated that 32-bit addressing would constrain advanced software, and created 64-bit roadmaps to eliminate this problem. Sun and IBM added 64-bit features to their 32-bit lines and provided systems that could handle legacy 32-bit software along with newer 64-bit programs. Intel, a company that had successfully and compatibly extended its 8-bit 8085 architecture to a 16-bit 8086 architecture in 1978, and to a 32-bit x86 architecture in 1985, concluded that a compatible 64-bit x86 extension would not be able to match the performance of the RISC processors that were just hitting their stride in the mid-90's. Instead, Intel (along with its partner HP) developed an entirely new 64-bit architecture now known as Itanium. It started this effort in 1994, and the program is only now, after ten years and over a billion dollars of investment, beginning to bear fruit. Like still waters than run deep, it has been difficult for Intel to demonstrate that Itanium has attained any marketplace momentum. They hope to communicate this message during 2004 through the steady drip-drip of press releases that announce this or that major organization has installed Itanium-based systems as a key part of its computing infrastructure. Unless and until Intel cements Itanium's image as a successful product line within its intended high-end markets, any action that calls attention to alternate Intel 64-bit strategies could be harmful to Itanium's long-term prospects. Insight 64 believes this phenomenon alone will push an Intel 64-bit x86 into 2005 at best, but there are other considerations as well that reinforce this conclusion.

Software programs (both applications and operating systems) must be specifically adapted to take advantage of any 64-bit architecture. While this is clearly the case for software that runs on Intel's Itanium processors, it applies equally to software that runs on AMD's Opteron and Athlon 64 CPUs. (32-bit software running on these processors sees them as very fast 32-bit x86 processors, but cannot access their 64-bit features.) Insight 64 believes that one key software developer – Microsoft – was reluctant to support multiple variants of 64-bit x86 systems, and settled on the AMD64 extensions as its target for 64-bit x86 systems from both AMD and Intel. Although Microsoft's 64-bit Windows adaptation for Itanium is labeled "Windows Server 2003 for 64-Bit Itanium-based Systems," its 64-bit adaptation for Opteron has the more generic title "Windows Server 2003 for 64-bit Extended Systems." It seems unlikely that any 64-bit extensions within Prescott's circuitry could be compatible with the x86-64 extensions now known as "AMD64," since Intel needed to finalize its Prescott design long before AMD released the details of its instruction-set extensions in the fall of 2002. It seems far more likely that products based on Intel's next-generation "Tejas" design, rumored to be hitting the streets in 2005, will provide the compatibility needed for Intel's chips to run software debugged on AMD systems. Even so, Microsoft does not plan to release its "64-bit Extended Systems" until the second half of 2004, so there would be little pressure on Intel to launch its own 64-bit x86 products until late this year.

Finally, even if Intel could launch a 64-bit x86 processor without impact to its 64-bit Itanium strategies, it cannot ignore the marketing benefit that would accrue to AMD should Intel pursue a strategy that AMD championed for almost four years. Intel's Itanium strategy short-changed x86 performance in the interests of high-end system performance and scalability, while AMD followed a path that limited high-end potential, but formed a better bridge with the existing 32-bit x86 world. The introduction of a 64-bit Pentium can only be interpreted as a tacit endorsement that AMD's approach has some merit. In the interests of damage control, Intel will want to delay this move as long as it can. Thus we conclude that whether one views the situation from the standpoint of hardware, software or market position, Intel is unlikely to launch a 64-bit x86 design during 2004.