

The AMD64 Computing Platform:

Your Link to the Future of Computing

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"True innovation is innovation that makes the greatest possible technology available to the widest possible audience. True innovation is not just a factor of bigger and better, but innovation measured by its availability and relevancy to end users."

Hector Ruiz, President and CEO
Advanced Micro Devices, Inc.

Executive Summary

AMD64 is a new computing platform that extends the ubiquitous x86 architecture to accommodate 64-bit processing. Formerly known as x86-64, AMD's enhancements to the x86 architecture allow users of laptops, desktops, workstations, and servers operating within a 32-bit architecture to migrate seamlessly to the superior performance of 64-bit technology. This approach defines a new class of computing by combining full x86 compatibility, a high-performance 64-bit architecture, and the economics of an industry-standard processor. This new class of computing allows the technology industry to build solutions focused on customer needs while removing barriers to future innovation. The AMD Opteron™ and upcoming AMD Athlon™ 64 processors are AMD's first milestones in building this new class of computing. Companies such as Microsoft®, SuSE, IBM, NVIDIA, VIA, GIGABYTE, MSI, SIS, and others have announced their intention to provide solutions for these processors and the AMD64 platform. Investments in x86 applications are preserved, as they can run out their normal lifecycles on AMD64 platforms. Over time, more capable applications can be phased in, allowing customers to control development costs and migrate gradually and according to business needs.

Evolutionary Technology Leaves No One Behind

Increasing demand for performance, capability, and addressable memory have driven the evolution of computing architectures. The AMD64 platform has evolved from preceding architectures to maintain compatibility while extending capability. Since the introduction of the IBM PC in 1979, there has only been one major architecture shift for x86 processors: the introduction of the first 32-bit processor and, seven years later, the introduction of Windows NT[®], the first mainstream 32-bit client operating system. The proven lifespan of 16- and 32-bit architectures indicates that the AMD64 platform should provide stability and longevity. However, the industry has matured since the introduction of 32-bit computing. The AMD64 platform is designed to enable a much faster transition from 32- to 64-bit computing than the previous transition from 16- to 32-bit computing.

Nathan Brookwood, principal analyst at Insight64, remarks that “transitions of this nature can take 5 to 10 years to accomplish, and during this interval, users need to accommodate a mix of 32-bit and 64-bit applications. Other 64-bit architectures use a variety of hardware and software emulation techniques to accommodate 32-bit x86 software, if they accommodate such software at all. [The] AMD64 [platform] is unique in its approach to delivering 64-bit capabilities along with highly competitive 32-bit performance.”

Months prior to the launch of the first AMD64 processor, major OS vendors including Red Hat, SuSE, and Microsoft announced support, provided development tools, and collaborated with AMD on operating systems during the pre-production phase. Today the industry is prepared to deliver full-featured 64-bit solutions and applications, as well as operating systems with native backward compatibility with software written for x86 applications. This combination of compatibility and longevity makes the AMD64 platform a superior vehicle to transition from the present to the future.

True Performance, True Innovation

The AMD64 Instruction Set Architecture (ISA) extends the existing x86 ISA and natively executes 32-bit code with no "emulation mode" to degrade performance. For 32-bit software that does not require immediate 64-bit implementations, AMD64 processor-based systems will be able to provide full application performance that should continue to improve with AMD64 platform performance enhancements. As noted in the February 2003 issue of *Fortune Magazine*:

"Jim Allchin, the man in charge of Microsoft's operating systems, calls the performance of software on the AMD [processor-based] machines 'pretty amazing'." Microsoft took applications written for today's 32-bit chips and ran them on an [AMD] Opteron [processor-based] server loaded with the new Windows[®] 64-bit operating system. The programs performed considerably better than the same ones using 32-bit Windows. Microsoft's new operating system allows any application to reach deeper into memory. "We can give any 32-bit application an additional gigabyte of memory, and you don't have to write a single byte of code," says Allchin. Programs written especially for 64 bits get further 'dramatic performance advantages,' he says."¹

Many applications, however, encounter architectural barriers that prevent efficient performance scaling. The AMD64 ISA is designed to allow continued performance scaling for applications that demand multiprocessor scalability, larger addressable memory, better multimedia performance, or improvements in computational accuracy.

Applications that do not immediately benefit from a port to 64 bits do not need to be ported, and will run at full performance in AMD64 processor-driven environments. A large number of applications and usage scenarios, however, are likely to benefit from a native AMD64 environment over a legacy x86 environment. The kind of applications most likely to benefit may include those that:

¹ Kirkpatrick, David. *Chip Battle*. *Fortune* (February 3, 2003) at <http://www.fortune.com/fortune/technology/articles/0,15114,418480,00.html>.

- Need large memory addressing and push total system memory requirements above 4GB, such as those with large datasets (financial and scientific modeling applications), and host-based desktop applications (to run multiple instances simultaneously without reducing performance);
- Must manage a large number of concurrent users or application threads, such as large scale thin-client solutions, large databases, and data warehouse applications for solutions in customer relationship management (CRM), supply chain management (SCM), enterprise resource planning (ERP), and digital rights management (DRM) systems;
- Require real-time encryption and decryption for enhanced security, including e-commerce and protection of private or classified data;
- Require mathematical precision and floating-point performance including modeling, simulation, statistics and financial analysis, imaging/video/signal processing, physics, medical research, telecommunications, encryption, and compression;
- Require large, high-power database performance including decision support, searching and indexing, document and content management, and voice recognition;
- Require the x86 compatibility or the economies of scale of x86, but the large memory addressing capabilities of 64-bit computing, including many high performance computing (HPC) cluster applications;
- Provide digital content creation capabilities such as computer-aided design, manufacturing and engineering (CAD, CAM, and CAE), digital music production and video editing, and real-time media streaming solutions;
- Require maximum performance for realistic and cinematic consumer experiences including computer games, digital video, and real-time collaboration; and
- Migrate capabilities previously available on 64-bit workstations to the business, consumer, and hobbyist desktop, including 3D modeling, rendering, animation, simulation, and software development.

Scalability and Flexibility

AMD, along with industry partners, plans to make AMD64 technology available for laptops, desktops, workstations, and servers. For the first time, 64-bit solutions with full x86 compatibility and uncompromised 32-bit performance will be available in a wide variety of configurations for a diverse range of implementations. This flexibility is designed to allow IT professionals to choose the appropriate form-factor and level of performance for their 64-bit applications.

The evolution of microprocessor architectures has played a fundamental role in increasing the capabilities and usefulness of computers. AMD64 processors are designed to maintain full compatibility with x86 while providing the architectural enhancements that provide world-class 64-bit performance. With the AMD64 ISA, relevant instructions and encodings have evolved to support 64-bits, increasing the resources available to the hardware and software. Major enhancements over legacy x86 include:

- Sixteen 64-bit general-purpose integer registers that quadruple the general purpose register space available to applications and device drivers as compared to x86 systems.
- Sixteen 128-bit XMM registers for enhanced multimedia performance to double the register space of any current SSE/SSE2 implementation.
- A full 64-bit virtual address space with 52 bits of physical memory addressing that can support systems with up to 4 petabytes of physical memory—more than one million times the amount of RAM supported by 32-bit x86 systems².
- 64-bit operating systems to provide full, transparent, and simultaneous 32-bit and 64-bit platform application multitasking.

² AMD Athlon 64 processors and AMD Opteron processors will initially support 48-bit virtual memory addresses and 40-bit physical memory addresses. Modern x86 processors support Physical Addressing Extensions (PAE), which supports applications addressing beyond 4GB of memory space. However, PAE is rarely used by applications, as it is limited to addressing 64GB, difficult to program, difficult to optimize performance, and is not portable to other processor architectures.

AMD64 processors support HyperTransport™ technology and are designed for flexibility and scalability. HyperTransport technology provides “glueless” multiprocessing, simplifying the design of multiprocessor workstations and servers. Compatibility with x86 makes the AMD64 computing platform the first 64-bit platform designed to be compatible with mainstream PC applications while offering world-class performance, making it suitable for solutions ranging from the consumer client PC to the High Performance Cluster. The combination of flexibility and scalability reconciles the broad range of capability and performance requirements IT professionals face today.

The first major design win for the AMD64 platform demonstrates its performance and scalability. In October 2002, Sandia National Laboratories selected the AMD Opteron processor to power its upcoming massively parallel processing supercomputer, Red Storm. Red Storm is expected to use in excess of 10,000 AMD Opteron processors to achieve 40 trillion calculations per second. According to James L. Tomkins, a Distinguished Member of Technical Staff at Sandia, a primary objective for Red Storm is “excellent performance per dollar,” while another is scalability to “20,000 processors.” Red Storm demonstrates the ability of customers to take AMD64 platform scalability to new heights, making truly world-class performance possible. When the system goes online in 2004, this supercomputer is expected to be the fastest in the U.S. and one of the fastest in the world.

Compatibility Preserves Investment; Simplifies Technical Transitions

The AMD64 platform can reduce the cost and complexity normally associated with maintaining vastly different systems and platforms in enterprise computing centers. At the enterprise level, system administrators will have an easier time ensuring interoperability of operating systems, peripheral hardware, device drivers, and applications in AMD64 environments. System administrators can continue to operate their existing 32-bit applications while testing and phasing in applications ported to AMD64 processors as needed, diminishing the chances of downtime or interruption of service. This approach provides a smooth transition—perhaps more appropriately called evolution instead of migration—to a more consolidated enterprise-computing environment.

A recent report from Giga Information Group notes the likelihood of competitive total cost of ownership and significant savings for large enterprise-class customers that use servers based on the AMD64 platform:

“Based on Giga’s research, an organization should consider a server replenishment strategy that includes deploying AMD Opteron processors prior to the need to migrate to 64-bit applications. With this strategy, AMD Opteron processor-based servers will be able to run existing 32-bit applications while being available to adopt 64-bit applications at the organization’s own pace, as hardware, ISV software support and developers’ time become available. This migration strategy and binary feature would likely reduce future server costs for an organization adopting AMD’s x86-64 technology, as these AMD Opteron processor-based servers would not have to be discarded and replaced with a 64-bit upgrade.”³

³ Reprinted with the permission of Giga Information Group. The above has been extracted from its original context. To gain access to the original printed material as issued, view the entire report at http://www.amd.com/us-en/assets/content_type/DownloadableAssets/TEI_for_AMD_Opteron_FINAL.PDF or contact Giga Information Group.

Similarly, software developers can port applications to AMD64 environments with a minimum of investment and the potential to expand their applications' capabilities. As noted in the online article "*From DB2 to Opteron: A simple 64-bit migration path*" posted on ZDNet.com on August 21, 2002, "it took only two days, for example for IBM to port DB2, an enterprise database software suite, to the AMD Opteron [processor]."⁴ New code development is done using familiar tools and development environments from leading vendors including Microsoft and SuSE. This means developers can quickly modify, extend, rewrite, compile, test, and debug code. Furthermore, application developers who have traditionally been limited to serving the server or 64-bit market are enticed by being able to target a platform with mainstream economies of scale. In fact, major software vendors have already quickly and successfully migrated applications from x86 to the AMD64 platform.

Major operating systems such as Windows and Linux are expected to migrate to the AMD64 platform from their x86 legacy. This means that this new class of computing will empower corporate IT managers by allowing them to grow into 64-bit computing while continuing to leverage their already existing investments in x86 human capital, existing knowledge base, as well as hardware and software infrastructure. For many enterprise users, this continuity is likely to have a favorable impact on software costs. Professional multiprocessor workstations running on AMD64 processor-powered operating systems, for example, will be able to offer 64-bit capabilities while leveraging existing x86 software titles at current price points. IT managers can now also deploy servers that provide full performance on existing x86 applications, but provide the addressability, scalability, and performance of a 64-bit platform.

⁴ From "DB2 for Opteron: A simple 64-bit migration path" August 21, 2002 ZDNet <http://techupdate.zdnet.com/techupdate/stories/main/0,14179,2877957,00.html>

Conclusion

The AMD64 platform benefits customers by providing investment protection while removing barriers to the next level of computing. AMD64 processors provide full application performance with native execution of 32- and 64-bit code. Customers can employ AMD64 processors in an entirely 32-bit environment, in a mixed environment such as a 64-bit operating system and a mix of 32- and 64-bit applications, or in homogeneous 64-bit environments. With the AMD64 platform, users can enjoy the technical superiority of 64-bit computing without sacrificing legacy x86 application compatibility or performance. The first AMD64 processors; the AMD Opteron processor for the workstation and server space, and the upcoming AMD Athlon 64 processor for the mainstream desktop and notebook markets, will offer all the benefits of the AMD64 platform. AMD64 software will not only be compatible with these processors, but is expected to remain compatible with future AMD64 processors, enabling an even larger installed base and "horizontal" solutions spanning the client and server. AMD will continue to provide customers with technology that is useful today and deliver cumulative benefits in the future. By protecting customer investments, simplifying platform migration, and removing barriers to future innovation, AMD64 technology clears a path for the future of computing.

AMD Overview

Founded in 1969 and based in Sunnyvale, California, AMD (NYSE: AMD) is a global supplier of integrated circuits for the personal and networked computer and communications markets with manufacturing facilities in the United States, Europe, Japan, and Asia. AMD, a Standard & Poor's 500 company, produces microprocessors, Flash memory devices, and silicon-based solutions for communications and networking applications.

Cautionary Statement

This White Paper includes forward-looking statements that are made pursuant to the safe harbor provisions of the Private Securities Litigation Reform Act of 1995. Forward-looking statements are generally preceded by words such as “expects,” “plans,” “believes,” “anticipates,” or “intends.” Investors are cautioned that all forward-looking statements in this white paper involve risks and uncertainties that could cause actual results to differ from current expectations. Forward-looking statements in this white paper about the AMD Opteron processor and AMD Athlon processor involve the risk that AMD will not be able to produce the processor in the volume required by customers on a timely basis; that AMD may not be successful in developing an infrastructure to support the processor; that third parties may not provide infrastructure solutions to support the processor; that the processor will not achieve customer and market acceptance; and that software applications will not be optimized for use with the processor. We urge investors to review in detail the risk and uncertainties in the company’s Securities and Exchange Commission filings, including the most recently filed Form-10K.

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