Alpha AXP and Its 64-bit Architecture

Power for Today's Applications, The Foundation for Tomorrow's Applications

Alpha AXP RISC enables the affordable use of new technology such as multi-media, including full-motion video, voice recognition/translation and imaging

Advances in communication technologies such as fax machines, cellular telephones, and voice messaging systems have significantly changed the way we communicate, helping to make our work both easier and more productive. Now, a similar revolution is occurring in the way we use computers. New technologies such as multimedia, voice recognition/translation, and virtual reality will enable people to work and to be entertained in ways completely different from today.

Imagine a future when a executive will simply instruct his desktop system to, "show me the profitability for this product across both a geographic and business cut" and can see the information immediately. A future where the power of a virtual reality application will let you walk through a simulation of a house before it's built. Or a future where your desktop system automatically searches massive databases each morning to provide you with a news summary that includes audio and video clips and is specifically tailored to your tastes and interests.

That future is not far away. Computer applications are experiencing the same leap in power that led from the mainframes and 16-bit minicomputers of the early '70s to the 32-bit microprocessors of the mid-'80s. That increase in power began the age of desktop computing, moving computers to the desks of individuals and creating whole new ways of working that didn't exist prior to the availability of 32-bit systems.

Unlimited Growth into the 21st Century

Now, an advanced Super64 RISC architecture that provides for unlimited growth into the 21st century is stimulating the next generation of high-powered applications. Like its 32-bit predecessor, the 64-bit architecture will create whole new types of businesses, as well as new ways of doing business.

What does a 64-bit architecture mean to you? Applications that once would have required the power and precision of a supercomputer will become common on your desktop system. The 64-bit architecture will enable and enhance such technologies as multimedia, imaging, artificial intelligence, object-oriented programming, voice recognition/translation, and computer-aided design, engineering, and manufacturing. In turn, these technologies will allow us to use computers in ways undreamed of now. For example, new 64-bit desktop systems will allow desktop production of video presentations to become as easy and as common as desktop publishing is today. In the not-too-distant future, a salesperson may film a new product in action with his camcorder, capture the video in digital form on his desktop system, and then easily produce a professional-class customized videotape sales presentation within a few hours.

Alpha AXP and its 64-bit architecture will fundamentally change three major areas in our every day life:
The way we:
- communicate
- use information
- are entertained

If you have children, you're probably aware of the transition from 8-bit to 16-bit video games. The newer 16-bit video games, such as the Nintendo Super NES and Sega Genesis systems, offer superior graphics and animation in comparison to the older 8-bit systems. In a similar fashion, 64-bit technology will allow application developers to create new business applications clearly superior to applications based on the older 32-bit technology.

These 64-bit systems will run applications faster and will allow applications to work with larger files and databases better than ever before. The power of Super64 RISC will allow applications to present information in ways much easier for people to understand and work with. Sound, video, voice recognition capabilities, and sophisticated 3-D graphics will become common in all types of applications. In business, 64-bit technology will enable sophisticated business modeling applications to provide executives with decision support through "what-if" simulations for changes in personnel, economic conditions, material supply, or competitive pressures.

Office systems will become richer for all levels of users, providing a complete working environment with universal access to far more of an organization's information. Eventually, with the power a 64-bit system offers, applications will go far beyond document management, workflow and conferencing groupware, to simulating redesign of the business and a much greater understanding of competitive situations and risks. The additional computing capacity and speed inherent in the 64-bit architecture will meet business computing needs for the next 25 years as new applications and systems become available.

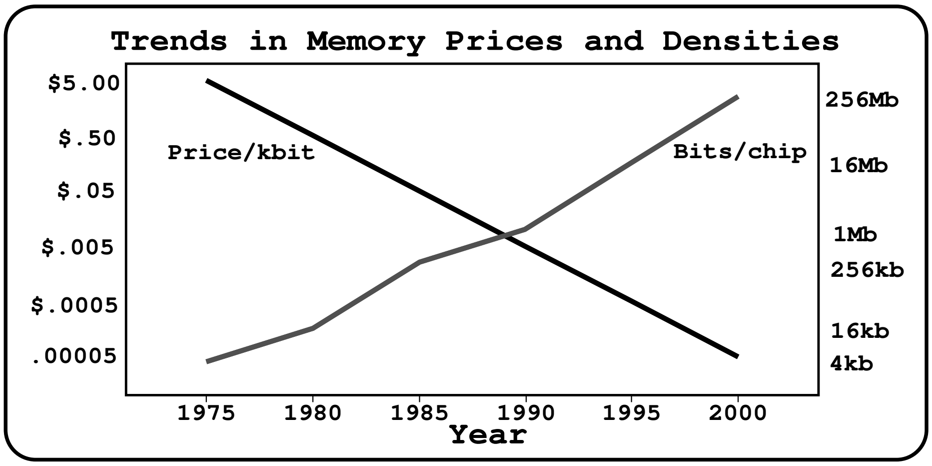
Increasing the Power of Today's Applications

The move toward 64-bits is not only a promise for tomorrow, but also a means for software developers to increase the power and performance of end-user applications today. As the performance of computer systems continues to grow each year, end-users are already placing increasing demands on applications to handle complex data and problems -- demands that force applications to push the capabilities of 32-bit computing to the maximum. Some analysts have suggested that leading industry applications have already reached the limit of 32-bit computing, and that many more will have reached the limit within the next two years.

By 1995 the average server will have 16 Gigabytes of real memory, 4 tiimes the addressing of 32-bit systems

The price of memory continues to drop with each passing year (See Figure 1), while memory capacity continues to increase. NEC is expecting to produce over one million 16 Mb chips per month by mid-1993 and all Japanese chip manufacturers are preparing to produce 16 Mb chips. Fujitsu, in fact, has announced plans to sell 256 Mb chips by 1996. Clearly, the cost of memory will drop dramatically in the years ahead. By 1995, the average mainframe and server system will have 16 GB (four times the addressing limit of 32-bit systems) of real memory, while workstations and desktop systems will have 2 GB of real memory.

Figure 1



Every major manufacturer of microprocessors (See Table 1) has plans to move to a Super64 RISC architecture and operating system to capitalize on new powerful systems with huge memory capacities. But while some companies are just beginning to catch up with this trend, only Digital Equipment Corporation has implemented a Super64 RISC architecture complete with operating system, product family, and software -- the Alpha AXP architecture.

Only the Alpha AXP architecture has all the components of a 64-bit system

Table 1

Architecture	Sponsor	Introduced	First System Ship(ped)	64-bit OS Support	First Available Applications
Alpha AXP	**Digital**	**1992**	**1992**	**Available Now (OSF)**	**Available Now**
R4000	SGI/MIPS	1992	1992	late 1995	1995
Sparc	SUN/HAL	1993	1993(HAL)	1995	1996
Power	IBM	1994	1995	1996	1996
PA-RISC	HP	1994	1995	1996	1996
P7 Pentium	Intel	1995	1996	1997	1997

(Source: International Data Corporation, 1992)

Digital already is providing both the 64-bit architecture and the operating system needed to support it. Digital's Super64 RISC architecture is fully implemented, including such features as 64-bit integer and floating-point registers. These two features enhance the performance of a system's integer and floating point calculations -- increasing performance to up to two or more times faster than a 32-bit systems. Without the 64-bit addressing features incorporated into a 64-bit architecture, software developers would have to employ such workarounds as segmentation, overlays, and indirect addressing to have their applications access data beyond 32-bits (4 GB). This proves very complicated, costly and difficult to port to alternative platforms. In order for an architecture to be considered 64-bits it requires that the integer, addressing data paths and registers be 64-bit, not just the floating point operations.

Table 2

CPU	Year Released	Referred to as *	Integer register size (Instruction Set Architecture)	Generated User address size (Instruction Set Architecture)	Physical address size (Hardware Implementation)	Data bus size (Hardware Implementation)	64-bit O/S support ***
DEC VAX-11/780	1978	32	32	31	32	64	No
IBM ESA/370	1988	32	32	32**	32	128	No
IBM AS/400	1988	48	48	48	48	64	No
HP Precision Arch.	1988	32	32	32**	32	32-64	No
Sun SPARC	1987	32	32	32	36	32-64	No
MIPS R4000	1990	64	64	40-62	36	64	No
Motorola 68040	1990	32	32	32	32	32	No
IBM POWER	1990	32	32	32**	32	64-128	No
Intel 486SX	1991	32	32	32**	32	32	No
DEC AXP 21064	**1992**	**64**	**64**	**43**	**34**	**64-128**	**Yes**

* Processors are usually referred to by their integer register size.
** These processors use some form of segmentation to obtain more bits of address space.
***Added by Digital Equipment

Source: Gartner Group, 12/92

*Corporate data bases are growing at a rate of 20-30% per year with conventional data. With the addition of **new** data types such as voice, video and images, data bases will grow exponentially*

Digital's Alpha AXP architecture is the industry's first to combine the speed and enormous addressing capability required to run the next generation of high-powered applications. With Digital's Alpha AXP architecture, users will be able to run applications faster, with increased detail, and at a reduced cost. The Alpha AXP technology will allow applications to handle larger databases, larger files, and larger problems, even as databases in the future grow exponentially to incorporate voice, video, imaging, and object-oriented elements.

In fact, The Gartner Group noted in November 1992 that two Alpha AXP platforms, the DEC 7000 AXP and DEC 10000 AXP systems, appear to be significantly more powerful than the IBM ES/9000 520 class series of water cooled mainframe computers. The Gartner Research Note stated, "...the two (Digital) systems are mainframes in both processor performance and I/O capability. There is a 0.7 probability that the AXP 10000 will turn out to be faster than both this year's IBM 47 MIPS ES/9000 uniprocessor (model 520) and next year's 56 MIPS version. We estimate that an AXP 10000 single-processor system will run between 200 tpsA and 250 tpsA on the TPC-A benchmark, potentially placing it in the 48-60 MIPS range."

Table 3

	Digital 21064	MIPS R4000	HP HP7100	IBM RS/6000	SUN Supersparc
SPECmark 89	183	70	136	126	N/A
SPECint 92	106	58	80	62	58
SPECft 92	200	62	150	133	71
Chip speed MHz	200	100*	99	62.5	45

*R4400 150 MHz results not available

Alpha AXP Technology Acknowledged as the Best

Leading industry trade magazines recognize Alpha AXP technology as the best

Leading computer trade magazine editors throughout the world have recognized the Alpha AXP microprocessor and systems as among the best technologies introduced in 1992. In January 1993, BYTE magazine recognized the Alpha AXP chip with an "Award of Excellence" for being "one of the best products, technologies, and standards [representing] the most significant developments in innovation, performance, and price." BYTE reported that "workstations keep getting faster and faster, and DEC's scalable Alpha AXP CPU will help ensure this rising performance curve for the foreseeable future."

DIGITAL NEWS AND REVIEW agrees. The Alpha AXP architecture received an "Editor's Select Award" in December 1992 for "fundamentally improving the way in which computers can be applied to solve strategic applications problems." And CORPORATE COMPUTING noted that, "The real cymbal crash for the Alpha AXP architecture is for its openness ... DEC's Alpha AXP machines run more operating systems than any other workstation ... the Alpha AXP architecture could boost enterprise computing to new levels."

The high speed and addressing capabilities of the Alpha AXP family provide not only the power to solve today's problems fast, but also to solve complex problems faster. Most currently available applications will run faster simply by taking advantage of the 64-bit manipulation capabilities of the Alpha AXP architecture. For example, the processing power of the Alpha AXP architecture may allow breakthroughs in scientists' understanding of complex chemical reactions, such as the effect of drugs on nerve receptor sites. Currently, models of chemical reactions using quantum mechanic calculations can take days to process, even on the fastest 32-bit processors. With the Alpha AXP architecture, the same reaction can be modeled in a quarter of the time and viewed with greater clarity. By speeding up these computations, the Alpha AXP architecture will allow scientists to model larger molecules and gain more meaningful information on their behavior.

Extremely large databases stored in memory will dramatically improve application performance

The Alpha AXP family will also dramatically improve the search for information in all types of businesses. By allowing volumes of information to be brought on-line and even directly into memory, the Alpha AXP architecture will make the search for information much easier and much more efficient. In fact Oracle Corporation says that access to data in data bases contained wholly in memory can be up to 500,000 faster than data stored on disk. The addressing capability of the Alpha AXP architecture allows a system's physical memory to approach 281 billion bytes, meaning that extremely large databases -- billions of bytes of information -- can be loaded into main memory.

Table 4

Data Location	Access Path	Access Time (ns)
Registers	-	5
On-chip Cache	-	10
Main Memory	System Backplane	50-100
Disk	I/O Backplane	25,000,000

Source: Oracle Corporation

Longevity Protects Your Investment

A key difference between the Alpha AXP architecture and first-generation 32-bit RISC architectures is longevity. For a computer architecture, longevity is based on three requirements: addressability, "openness" (that is, support for multiple operating systems), and scalable performance. Digital's Alpha AXP is the only technology that fulfills all three requirements.

Super64 RISC systems can address 4 billion times the information of its 32-bit predecessors. Digital's open business practices and architecture promote the sale or license of the architecture, chips, boards, systems and software. And, Digital has compatible Alpha AXP systems from the PC to the data center all capable of running OpenVMS, DEC OSF/1, or Microsoft Windows NT.

Power for Today, Capacity for the Future

AXP systems are capable of running the operating system of your choice:
DEC OSF/1
OpenVMS
Microsoft Windows NT

As noted earlier, the 64-bit Alpha AXP architecture will provide the data and addressing capacity -- 4 billion times the capacity of 32 bits -- needed for the applications of tomorrow. To put the capacity of 64-bit technology into perspective, consider this analogy: in comparison to 64 bits, 8 bits is the area of a business card; 16 bits is the area of a desktop; 32 bits is the area of a city block -- while 64 bits would be an area that would be almost twice as large as the total land surface of the Earth, or an area ten times the size of North America.

Current applications have already begun to exhaust the capacities of 32-bit architectures. This trend will only become worse for those first-generation architectures as end-user demand for applications that incorporate sound, video, high-quality rendering of graphics and images and access to enormous databases continues to grow. For instance, 45 seconds of quality, full-motion video requires as much as 4 gigabytes of storage, the maximum allowed for 32-bit systems. Clearly, multimedia applications of the future will require significant database storage.

The Universal Platform Opens Doors for Current and Future Operating Systems

The Alpha AXP family members are not point products developed for any single technology platform, but rather an architecture -- a blueprint for a de facto standard. The Alpha AXP architecture was specifically designed with multiple software environments in mind. Today, the Alpha AXP family supports DEC OSF/1, OpenVMS, and Microsoft Windows NT. The tens of millions of people who currently use DOS and Windows-based applications will be able to move to 64-bit systems, running their applications faster than today's fastest PCs. It's expected that other operating systems will be added during the coming years. With the Alpha AXP family of products, you'll choose the operating system that best meets your application needs, without compromise.

Digital is committed to offering the deepest and broadest portfolio of Alpha AXP applications. Over 1,100 software vendors have already committed to making more than 2,000 applications available on 64-bit Alpha AXP systems. Plus, to ensure the wide availability of Alpha AXP hardware and software, Digital is licensing the Alpha AXP architecture and selling Alpha AXP chips, boards, and systems -- making it easy for vendors to incorporate the benefits of the Alpha AXP architecture into their products.

64-Bit Performance Saves Time and Money

The Alpha AXP architecture was developed to provide platform scalability from the desktop system to the data center machine. Just as with the VAX architecture, the Alpha AXP architecture is designed so that every Alpha AXP system -- from smallest to largest -- will run the same applications and operating systems both now and in the future. Just as with VAX VMS systems, applications developed for the Alpha AXP architecture will only need to be ported once -- eliminating costly conversions and providing end-users with unlimited growth into the future.

High performance will obviously always be in demand for computer systems, and that's why the Alpha AXP architecture was designed with performance as a primary goal. The first-generation 64-bit microprocessor, the DECchip 21064, runs at up to 200 MHz making it the fastest chip available (in fact, the DECchip 21064 microprocessor is currently acknowledged in The Guinness Book of Records as the world's fastest chip). In the future, the performance of Alpha AXP-based systems is expected to increase by a factor of 1,000. This will be accomplished through the use of superscalar and superpipeline techniques and memory management designed for the use in massively parallel processing systems. In addition, the Alpha AXP architecture can be implemented in many semiconductor technologies and is not restricted to CMOS.

Summary

There are limits to the capabilities of any type of technology, including computer technology. Current applications are already approaching the boundaries imposed by the limits of 32-bit architectures, while market demand is increasing its push for the incorporation of such things as video, audio, speech recognition, object-oriented tools, and intelligent agents into the applications of the future. But as both applications and databases continue to grow in size and capabilities, they will also need to match user requirements for speed, performance, and usability.

Every major manufacturer of microprocessors is moving to the next stage of computing -- 64-bit technology. But 64-bit technology isn't simply a promise on the horizon, it's a concrete, viable means for software developers to increase the current capabilities of their applications as well as to enhance their future applications. Super64 RISC technology means current applications will increase their performance, while enhancing their capabilities to handle larger databases, files, and problems.

Digital is leading the way in the market's transition from 32 to 64-bit computing with the first deployment of a full 64-bit RISC architecture -- the Alpha AXP architecture. Digital's initial implementation of the Alpha AXP architecture offers the best price/performance available today and supports the broadest range of systems and software in the market.

The Alpha AXP architecture was designed with the future of open systems in mind. Multiple software environments are already supported by the Alpha AXP architecture, with support for future operating systems equally assured. Alpha AXP technology offers unlimited growth into the 21st century for both software developers and end users who will benefit from the new, powerful applications of the future.

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