64-Bit Computing and the HP-UX 11.00 Operating Environment

June 1999
Table of Contents

Abstract.................................................................................................................................................. 3
The Market for 64-Bit computing........................................................................................................... 3
Fundamentals: What does 64-Bit Computing Entail?........................................................................... 4
Benefits of 64-Bit Computing: Increased Scalability and Performance.................................................. 5
Caveat: Not All Applications Need 64-Bits ......................................................................................... 6
What Customers Want with 64-Bit Computing.................................................................................... 6
HP’s 64-Bit Operating Environment: HP-UX 11.................................................................................. 7
Investment Protection of 32-Bit Applications........................................................................................ 7
Why HP-UX Is Available in 32-Bit and 64-Bit Versions........................................................................ 8
When Applications Should Remain 32-Bit............................................................................................ 8
Important Considerations Before Moving to a 64-Bit Computing Environment................................. 8
64-Bit Standards.................................................................................................................................... 8
HP-UX 11 Software Transition Kit Web Page....................................................................................... 9
Enhancements to HP-UX 11 Beyond 64-Bits....................................................................................... 9
Summary.................................................................................................................................................. 10
For More Information.............................................................................................................................. 11
Glossary................................................................................................................................................... 12
Abstract
In September 1997, Hewlett-Packard introduced its first 64-bit implementation of HP-UX, with version 11.00. The chief benefits of 64-bit computing lie in much greater scalability and potentially faster performance, compared with a 32-bit environment.

This paper describes the current market for 64-bit computing, tells what 64-bit computing entails, details customer requirements for 64-bit computing, and covers the major benefits of HP-UX 11.

For several years Hewlett-Packard has been implementing a number of hardware and software strategies that met customer requirements in the emerging 64-bit computing market. In 1996, HP introduced the 64-bit PA-8000 processor to lay the foundation for its 64-bit hardware architecture. HP gradually incorporated 64-bit functionality into successive versions of HP-UX, culminating with the introduction of the full 64-bit version, HP-UX 11, in September 1997. Consistent with its leadership in developing and implementing UNIXR standards, HP-UX 11 conforms to 64-bit UNIX standards.

HP recognized the 64-bit trend to increased system performance and capacity while also noting that customers want to make transitions to new technology with as little effort as possible. HP has invested to ensure that customers moving to HP-UX 11 experience a smooth upgrade path, highlighted by the ability to run existing applications on HP-UX 11 without requiring any recoding or recompiling.

With a long list of other enterprise computing features, HP-UX 11 lays the foundation for meeting customer computing needs well into the next millennium.

The Market for 64-Bit Computing
Demand for 64-bit computing is in its early stages of market acceptance. The key market drivers for 64-bit computing are users who require high-performance, resource-intensive applications and applications such as databases and OLTP that need to access 64-bit capabilities. Today’s use of 64 bits is found in high-end database and compute-intensive scientific modeling applications. In the database arena, the major database vendors have introduced Very Large Memory (VLM) products that take explicit advantage of 64-bit architecture scalability to achieve increases in performance, especially for very large decision support and OLTP applications.

As corporate and government computing needs increase, and with it their need to handle larger amounts of data, so too will demand rise for 64-bit computing. Other applications that will likely take advantage of 64-bit computing include:

- Internet-based commerce and large Web servers.
- Multimedia applications, including video/audio servers and 3D animation.
- Technical applications, such as ECAD/MCAD, and fluid dynamics.

---

1 Eddie Berin and John Verrochi are Product Managers, HP-UX, in HP’s High-Performance Systems Division.
2 For easier readability, hereafter we refer to HP-UX 11.
**Fundamentals: What Does 64-Bit Computing Entail?**

The phrase “64-bit computing” refers to the total system environment’s ability to process 64-bit data, instructions, and addressing. A true 64-bit environment contains a 64-bit CPU with 64-bit registers and data paths, 64-bit memory addressing, 64-bit Direct Memory Access, and a 64-bit kernel as the heart of the operating system. A 64-bit environment has significantly higher scalability than its 32-bit counterpart and higher performance for many kinds of applications. Note that not all operating systems that claim to be 64-bit actually are true 64-bit environments, lacking key elements such as a full 64-bit kernel.

Memory addressing is one of the most important system elements that benefits from the scalability of 64 bits. Whereas a 32-bit operating system provides flat addressing of up to \(2^{32}\) 32-bit words, or 4 GB of memory, a 64-bit operating system provides flat addressing for \(2^{64}\) 64-bit words, or 18 billion GB (18 exabytes) of memory\(^3\). As shown in the table on page 6, scalability increases associated with 64 bits are dramatic and can be illustrated by the following example.

```
<table>
<thead>
<tr>
<th>Word Length</th>
<th>Mathematical Expression</th>
<th>Relative Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-bit</td>
<td>(2^8 = 256)</td>
<td>Business card</td>
</tr>
<tr>
<td>16-bit</td>
<td>(2^{16} = 65,536)</td>
<td>Desktop</td>
</tr>
<tr>
<td>32-bit</td>
<td>(2^{32} = 4.29E+09)</td>
<td>City block</td>
</tr>
<tr>
<td>64-bit</td>
<td>(2^{64} = 1.84E+19)</td>
<td>Surface of the earth (!)</td>
</tr>
</tbody>
</table>

64-bit computing has 4 billion times the capacity of 32-bit
```

The advantages of 64-bit computing are not limited just to memory—they span both hardware and software. In *hardware*, 64-bit computing applies to the processor, memory, and disk. In *software*, 64-bit computing allows very large files and file systems, large physical memory (>4 GB), large virtual memory, and large addressing, in addition to the use of 64-bit integer and floating-point registers. The use of 64-bit databases allows much larger amounts of data to be held in memory for faster processing and also increases the number of users who can access that data. Moreover, 64-bit technical applications enable the modeling and simulation of complex data, such as fluid dynamics.

\(^3\) Note this is the theoretical figure for 64-bit addressing. At current RAM prices, 18 EB would cost approximately US$400 billion.
Benefits of 64-Bit Computing: Increased Scalability and Performance

Any application that is outgrowing a 32-bit computing environment will suffer performance degradation. A true 64-bit environment provides a significant number of benefits, concentrated in the two major areas of scalability and performance. 64-bit computing provides increased scalability and performance across the operating environment. Every critical resource capacity from memory, storage, and program addressability is increased by several magnitudes. This enormous capacity increase translates to raw high performance when harnessed to its fullest potential.

A very large memory capacity allows a greater number of in-memory processes. The in-memory nature alone is extremely fast. Memory is accessed about 10,000 times faster than disk drives (~80 nanoseconds versus 8 milliseconds for a disk). For large applications that swap to disk frequently, simply moving to a 64-bit operating environment with generous RAM would increase performance dramatically. A 32-bit system is limited to 4 GB of memory ($2^{32}$ bits); and as application size, data set size, and number of applications per system increases, total addressable system memory becomes the bottleneck. A 64-bit environment will have huge system memory capacity to support the largest applications today and in the foreseeable future.

For example, the large database vendors enhance the scalability and performance of their products by exploiting 64-bit capabilities. This allows them to get a higher percentage of data into memory and assures that full indexes reside in memory. By reducing swapping to disk, search and access performance significantly increases. For example, a transaction-oriented lab test at HP yielded a 34 percent reduction in I/O operations per transaction when changing from a 32-bit environment to a 64-bit environment.
The complementary increase in file sizes and file system sizes further enhances performance when moving to a 64-bit environment. Depending on the application, the use of one large file versus a large number of smaller files results in decreased system overhead. The overhead efficiency inherent in a 64-bit environment comes from the use of fewer file descriptors and provides a side benefit of easier system manageability by requiring maintenance of only one file versus several files.

The table below summarizes the sources of increased performance and scalability associated with 64-bit computing by type of application.

<table>
<thead>
<tr>
<th>Example</th>
<th>Sources of performance and scalability gains</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large database</td>
<td>• Reduced swapping</td>
</tr>
<tr>
<td></td>
<td>• Larger memory allocation per user</td>
</tr>
<tr>
<td></td>
<td>• Many more users</td>
</tr>
<tr>
<td></td>
<td>• Large file implementations</td>
</tr>
<tr>
<td>Decision support</td>
<td>• Reduced swapping</td>
</tr>
<tr>
<td></td>
<td>• Direct addressing</td>
</tr>
<tr>
<td></td>
<td>• Large file implementations</td>
</tr>
<tr>
<td>Technical applications</td>
<td>• Large process data space</td>
</tr>
<tr>
<td></td>
<td>• More available shared memory segments</td>
</tr>
<tr>
<td></td>
<td>• Reduced swapping</td>
</tr>
<tr>
<td></td>
<td>• High-precision arithmetic</td>
</tr>
</tbody>
</table>
**Caveat: Not All Applications Need 64 Bits**

With all the advantages of 64-bit computing, it should be noted that it is not necessary for all of today’s applications. Many applications fit comfortably within the limitations of a 32-bit environment. It is important to put this new technology in perspective and to make use of 64-bit computing only in those environments where it provides clear benefit.

**What Customers Want with 64-Bit Computing**

Hewlett-Packard’s analysis of its customer base has shown that IT managers and end users are most concerned with three main issues in adopting 64-bit computing.

- **Performance increase and greater scalability**—When customers consider moving to 64-bit computing, performance increases/parity and greater scalability are viewed as important “must-haves.” If they cannot be ensured, then there is little reason to move from a 32-bit environment.

- **Investment protection**—Customers want to be assured that their investment in 32-bit applications and data is protected. Data compatibility allows use of persistent files (such as `/etc/password`) without modification on newer HP-UX releases. HP’s long-standing commitment to binary compatibility in HP-UX provides support for fully-linked, well-behaved applications (those that use only published interfaces and sound programming practices) to move forward to the latest version of HP-UX. Customers want to be assured that their 32-bit applications can run in a 64-bit environment with no modification. Recoding and recompiling to take explicit advantage of the 64-bit environment must be an optional activity. Coexistence and interoperability between 64-bit and 32-bit applications running on the same platform is also important. This would allow, for example, a 32-bit application to take advantage of a 64-bit database running on the same server.

- **Standards conformance**—Customers want to retain the flexibility in platform choice that open enterprise computing affords through industry standards.
HP’s 64-Bit Operating Environment: HP-UX 11

Consistent with its objective of extending its position as the premier vendor of open systems to customers in the UNIX server market, Hewlett-Packard introduced HP-UX 11. This version delivers the benefits of 64-bit computing as well as a long list of other features while preserving customers’ investments in existing 32-bit applications. The 64-bit features of HP-UX 11 include the following:

- True 64-bit computing environment
- 32-GB physical memory (multi-terabyte enabled)
- Large shared memory (4-TB) for increased support of a number of processes sharing memory and general capacity increase for individual applications
- Addressability up to 16-TB virtual memory to allow very large memory (VLM) access for resource-intensive applications
- 1-TB memory-mapped files
- Large (1-TB) networked files and local files to match the increased resource requirements generated by 64-bit computing environments
- 64-bit Veritas VxFS (Journaled File System)
- Full 64-bit integer capability for superior numerical analysis and high precision in complex calculations
- Investment Protection of 32-Bit Applications

HP-UX 11 continues HP’s long-standing commitment to investment protection through binary compatibility, which allows fully-linked, well-behaved HP-UX 9.x and 10.x applications to run on HP-UX 11. The 64-bit version of HP-UX 11 will support both 32- and 64-bit applications that can communicate using all standard inter-process communication methods such as IPC, pipes, and shared memory. This will also allow 32-bit applications to directly benefit from the performance of 64-bit databases. HP has implemented a program to ensure that a wide range of applications are available on HP-UX 11, including VLM versions of databases from Informix, Oracle®, and Sybase.
Why HP-UX 11 Is available in 32-Bit and 64-Bit Versions

In today’s computing environment, both 64-bit and 32-bit computing have their respective places. 64-bit computing is essential for applications that must make use of the increased scalability and performance of a 64-bit operating system. However, many computing needs are met with 32-bit applications on a 32-bit operating system. HP provides both 32-bit and 64-bit versions of HP-UX 11, so users can choose the operating environment that best meets their needs. Since both 32-bit and 64-bit versions of HP-UX 11 run on HP’s 64-bit PA-8x00 processors, users can upgrade from 32-bit HP-UX to 64-bit HP-UX at their own pace, when requirements change. This will also allow end users with 32-bit PA-7x00-based servers to take advantage of the many other features of HP-UX 11.

When Application Should Remain 32-Bit

Applications that do not require 64-bit features should remain as 32-bit. These 32-bit applications can run on both the 32-bit and 64-bit versions of HP-UX 11, saving the costs associated with supporting multiple versions of the application. Some vendors’ 64-bit operating systems do not support 32-bit applications and force the customer to port to 64-bit, regardless of true need. If an application does not utilize the 64-bit capabilities, there is little advantage to recompiling it into a 64-bit application.

Important Considerations Before Moving to a 64-Bit Computing Environment

Users should consider these factors before moving to the 64-bit version of HP-UX 11:

- Both system and software must effectively use 64-bit capabilities
- New or upgraded hardware may be needed; currently HP 9000 K-, T-, and V-Class systems based on PA-8x00 processors can run 64-bit HP-UX 11

64-Bit Standards
The establishment and use of standards are an important reason for the success UNIX has enjoyed during the past 20 years. Standards are integral to the concept of open systems computing. They benefit end users, who gain flexibility in platform selection, and ISVs, who may find porting to different UNIX variants less problematic. The Open Group, established in February 1996 as a result of the merger of X/Open and Open Software Foundation, is the primary promulgator of UNIX standards.

In August 1995, a group of leading UNIX system suppliers led by Hewlett-Packard and Intel announced their intention to develop 64-bit standards to facilitate the development of high-performance applications that would run on multiple 64-bit UNIX-based platforms.

(continued on next page)
• 64-bit computing may not be required everywhere in an environment. For example, in a three-tier configuration, the back-end database server could be 64-bit, but application servers and desktops might remain 32-bit.

• A 32-bit system can create and compile 64-bit applications. Note that 64-bit applications can be created and compiled on a 32-bit system; however, running and debugging the applications requires a true 64-bit system.

**HP-UX 11 Software Transition Kit Web Page**

To assist customers, HP created the HP-UX 11 Software Transition Kit Web page, accessible at: [http://www.software.hp.com/STK](http://www.software.hp.com/STK). This Web page contains the latest information and tools to use when upgrading to the HP-UX 11 environment. There are documents describing performance and portability considerations, 64-bit feature usage, HP-UX 11–specific features (not necessarily tied to 64-bit), and many other topics. There are several tools that are available for analyzing source code for issues with native 64-bit coding and related documentation. Please consult the above URL for the latest HP-UX 11 developer information.

**Enhancements to HP-UX 11 Beyond 64-Bits**

HP-UX 11 is a major new release for HP platforms and contains a long list of features beyond the 64-bit environment described in this paper. For example, several features in HP-UX 11 have been added to provide additional performance. The Performance Optimized Page Sizing (POPS) allows PA–8x00-based systems to tailor the system page size per application for optimal performance. For Very Large Memory configurations, the Dynamic Memory Resilience (DMR) automatically detects failed memory blocks and automatically deallocates the failed memory without interrupting applications or rebooting the system.

For reduced total cost of ownership (TCO), features such as HP Ignite/UX allow the creation of golden system

---

**64-Bit Standards (cont.)**

The resulting so-called Aspen initiative had the objective of reducing multi-platform application and system software development cost and complexity, protecting customers’ software investments, and simplifying the decision process for IT managers as they deploy 64-bit solutions.

In February 1996, the working group participants agreed on a 64-bit draft definition for UNIX application environments that builds on X/Open’s Single UNIX Specification (or SUS, previously known as SPEC 1170) for 32-bit UNIX. The participants in this announcement included Digital Equipment Corporation, Hewlett-Packard, IBM, Intel, NCR, Novell, Santa Cruz Operation, and SunSoft.

(continued on next page)
images that can be used to remotely deploy new servers quickly and cost-effectively using the corporate intranet.

Another tool, HP Software Distributor/UX, provides an industry-standard tool for easy distribution of applications across the intranet with push or pull capabilities.

For more information on these and many other new features contained in HP-UX 11, please consult the product brief at: http://www.hp.com/go/hp-ux

Summary
By virtue of its commitment to meeting customers’ expectations for 64-bit computing—smooth upgrade path and investment protection, performance and scalability increases, and standards compliance—and its collaboration with leading industry partners, Hewlett-Packard best meets customers’ current 32-bit and 64-bit computing needs.

Hewlett-Packard’s 64-bit HP-UX 11 provides:

- Broad performance gains without end-user applications requiring recompilation. End users will experience performance gains dominated by 64-bit aspects of HP-UX, database, and other ISV applications, and will recompile their applications to take advantage of 64-bits.
- Investment protection is ensured through forward binary compatibility, in which 32-bit applications can run unmodified in a 64-bit environment. Concerns over migration can be dismissed because 64-bit HP-UX will not require recoding or recompiling of 32-bit applications.
- Openness and platform flexibility needed by customers will be ensured by HP-UX’s continued embrace of UNIX standards.
- A wide range of other features for performance, resilience, integration, security, and manageability.

64-Bit Standards (cont.)
They further agreed to remove data size dependencies in application programming interfaces (APIs) by adopting the LP64 data model as the standard for 64-bit UNIX.

Today, HP-UX 10.10 and 10.20 have the X/Open UNIX 95 brand, which signifies compliance with the X/Open Single UNIX Specification. HP has submitted HP-UX 11 to X/Open for UNIX 95 certification. This branding indicates that the operating system supports common application programming interfaces (APIs) that allow greater application portability among UNIX 95-branded UNIX systems. This portability provides customers with increased investment protection.

X/Open, the standards body now part of The Open Group, has a Web page that covers UNIX 95 and other standards at: http://www.xopen.org
For More Information

- Information on HP-UX is located at http://www.hp.com/go/hp-ux.
- Information on HP-UX strategy and future directions is located at http://www.hp.com/go/unix
- For those with access to HP’s Electronic Sales Partner (ESP), this paper may be accessed at keyword 64bitWP.
Glossary

API
Application programming interface. A set of rules and functions specified by ISVs and operating system vendors that allow interaction among programs

byte
8 bits

CPU
Central processing unit. Processor that functions as the “brain” of a computer

ECAD/MCAD
Electronic/mechanical computer-aided design

exabyte
$2^{64}$ bytes or 16 exabytes (EB)

GB
Gigabyte (GB) or 1024 megabytes or 2^32 bytes

ISV
Independent software vendor, or an application written by such a vendor

LP64
64-bit long and pointer data type

MB
Megabyte (MB) or 1024 kilobytes

OLTP
Online transaction processing

PA-RISC
Precision Architecture Reduced Instruction Set Computing, Hewlett-Packard’s proprietary processor architecture, and/or the applications that run on this processor

physical memory
See real memory
process address space
The largest amount of virtual memory that can be used by a single UNIX process.

RAM
Random access memory. See real memory.

real memory
Amount of physical memory (or RAM) that can be addressed by software on the system.

shared memory
Memory that can be shared between several UNIX processes.

SUS
Single UNIX Specification, as specified by X/Open, part of The Open Group.
Succeeded SPEC 1170.

TB
Terabyte (TB) or 1024 GB or 241 bytes.

URL
Universal Resource Locator.

virtual memory
An operating system feature which that applications to access more memory than is actually physically installed as RAM, by moving (paging) data in RAM to and from a reserved part of the disk known as the swap file or swap partition.
We use this designation to represent the PA-8x00 family of 64-bit PA-8000, PA-8200, and the forthcoming PA-8500 processors.

For more information, contact any of our worldwide sales offices or HP Channel Partners (in the U.S. call 1 800 637 7740).

For the location of the nearest sales office call:

**United States of America:** +1 800 637 7740

**Canada:**
Hewlett-Packard Ltd.
5150 Spectrum Way
Mississauga, Ontario L4W 5G1
+1 905 206 4725

**Japan:**
Hewlett-Packard Japan, Ltd.
Japan Country H.Q.
3-29-21, Takaido-Higashi, Suginami-ku,
Tokyo, 160-8585 Japan
+81 3 3331 6111

**Latin America:**
Hewlett-Packard
Latin American Region Headquarters
Waterford Building, 9th Floor
5200 Blue Lagoon Drive
Miami, Florida 33126 USA
+1 305 267 4220

Refer to country phone numbers

**Australia/New Zealand:**
Hewlett-Packard Australia Ltd.
31-41 Joseph Street
Blackburn, Victoria 3130
Australia (A.C.N. 004 394 763)
+61 3 9272 2895

**Asia Pacific:**
Hewlett-Packard Asia Pacific Ltd.
17-21/F, Shell Tower
Times Square
1 Matheson Street
Causeway Bay
Hong Kong
+8522 599 7777

**Europe/Africa/Middle East:**
Hewlett-Packard S.A.
150, Route du Nant-d’Avril
CH-1217 Meyrin 2
Geneva, Switzerland
+41 22 780 81 11

European Multicountry: +41 22 780 81 11
Middle East and Africa: +41 22 780 71 11
European Headquarters: +41 22 780 81 81

Refer to country phone numbers

For direct country contact call:

**Argentina:** +541 787 7145

**Austria:** +43 1 25 000 0

**Belgium and Luxembourg:** +32 2 778 31 11

**Brazil:** +5511 7296 8000

**Chile:** +56 2 797 7233

**Colombia:** +571 629 5030

**Denmark:** +46 45 99 10 00

**East Central Europe, CIS, and Yugoslavia:** +43 1 25 000 0

**Finland:** +358 9 887 21

**France:** +33 1 69 82 60 60

**Germany:** +49 7031 140

**Greece:** +30 1 689 644

**Hungary:** +36 1 252 7300

**Iceland:** High Performance Systems hf.
+354 1 67 10 00

**Ireland:** +353 12 88 33 99

**Israel:** Computation and Measurement Systems (CMS) Ltd.
+972 3 5380 333

**Italy:** +39 2 92122770

**Mexico:** +525 326 4600

**Netherlands:** +31 20 547 6911

**Norway:** +47 22 7356 00

**Poland:** +48 22 608 77 00

**Portugal:** +351 1301 7343

**Russia and the CIS, excl. Ukraine:** +7 095 923 5001

**Slovenia:** +38 61 55 84 72

**Spain:** +34 1 631 1600

**Sweden:** +46 8 444 2000

**Switzerland:** +41 1 735 7111

**South Africa:** Hewlett-Packard South Africa (Pty) Ltd.
+27 11 806 1000

**Turkey:** +90 212 224 5925

**United Kingdom:** +44 1344 369231

**Venezuela:** +582 239 4133

SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc. in the USA and other countries.

UNIX is a registered trademark of The Open Group.

The information contained in this document is subject to change without notice.

© Copyright Hewlett-Packard Company and SAS Institute Inc. 1999

All Rights Reserved. Reproduction, adaptation, or translation without prior written permission is prohibited except as allowed under the copyright laws.

M0699