The Intel® Extended Server Memory Architecture

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Intel® Extended Server Memory Architecture

1.0 Overview

The Intel Extended Server Memory Architecture refers to a collection of technologies that transcend the 4 Gigabyte (32-bit) memory barrier for enterprise applications. Server platforms using Intel's Pentium® II Xeon™ processor can provide the first, complete support for this architecture. The Intel Extended Server Memory Architecture includes technologies that provide full 36-bit addressing support from the processor, level one and two cache, and chip set. Together, they provide a non-intrusive, evolutionary path for enterprise applications to exploit >4 Gigabytes of memory to achieve unsurpassed performance, cost/performance and scalability on Intel Architecture servers. Information technology managers will realize greater competitiveness for their business-critical applications and solutions - database management systems (DBMS), on-line transaction processing (OLTP), data warehousing, decision support systems (DSS) and other end-to-end business solutions. The Intel Extended Server Memory Architecture is or will be supported by the majority of industry standard operating systems and enterprise applications available today. In addition, this architecture with operating support provides a clear path to Intel's IA-64 product line that will maintain full application compatibility with the technologies described herein.

2.0 Benefits of the Intel® Extended Server Memory Architecture

The Intel Extended Server Memory Architecture provides a fundamental performance and system throughput benefit to enterprise applications - the ability to hold all or a larger portion of a customer's enterprise database in main memory (DRAM) as opposed to consistently moving that data to and from the disk subsystem. The performance and throughput benefits arise from the fact that disk transfers are several orders of magnitude slower than data transfers between the processor and main memory - Megabytes/sec vs. Gigabytes/sec respectively. This benefit applies to many medium-size enterprise databases in the Gigabyte range as well as to very large databases (VLDB) in the hundreds of Gigabytes to Terabyte range. The Intel Extended Server Memory Architecture allows enterprise applications to exploit this performance and throughput benefit by using the memory above 4 Gigabytes as an application-managed buffer cache.

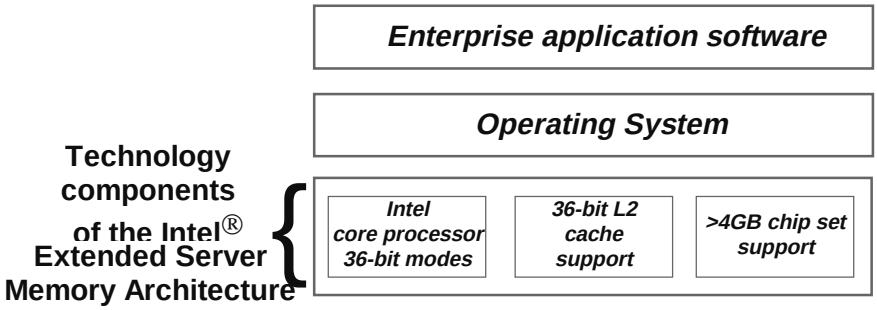
DBMS (database management system) engines that are designed to take advantage of the Intel Extended Server Memory Architecture will realize the performance and throughput gains described above. This delivers end-user benefits to the many business solutions built upon these DBMS engines. For example, on-line transaction processing (OLTP) applications achieve greater throughput and the ability to complete business transactions more quickly. Early testing indicates gains of 10-14% on industry-standard TP (transaction processing) benchmarks when memory size is increased from 4 to 8 Gigabytes (everything else being equal). The exact speedup realized by an application will vary depending on the size of the customer's database, system configuration and the

characteristics of the application. Another example is in enterprise decision support systems (DSS) - the added performance of the underlying DBMS engine on large databases will result in faster queries - critical for enterprises where speed of data analysis and decisions is a very real concern in today's fast-paced, global, 24x7 business climate. Other examples of business-critical applications where this architecture will deliver greater throughput and faster response time on large enterprise databases are line-of-business (LOB) solutions and data warehousing applications.

The following lists some of the vendors and products that will support the Intel Extended Server Memory Architecture: Microsoft's SQL Server*, Oracle's Oracle8* database technology, SAS Institute's suite of data warehousing and decision support software and Informix database technology.

3.0 Technology Elements of the Intel® Extended Server Memory Architecture

The Intel Extended Server Memory Architecture includes core processor, cache, and chip set technologies that enable > 4 Gigabyte of memory. These are shown in the figure below and described in the next three sections.



4.0 Core Processor 36-bit Modes

The Intel Extended Server Memory Architecture is defined to include two 36-bit addressing modes in the core processor: PAE-36 and PSE-36. These two modes offer alternative means to achieve >4 Gigabyte physical memory addressability - the exact mode used depends on the operating system in use. The combination of these two modes as part of the architecture enables support by the majority of the industry's operating systems (described below). PAE-36 stands for 36-bit Page Address Extension and was introduced with the Pentium Pro processor in 1995; the Pentium II Xeon processor maintains compatibility with PAE-36. PSE-36 is an acronym for 36-bit Page Size Extension and is a new feature of the Pentium II Xeon processor.

	PAE-36	PSE-36	Intel Extended Server Memory Architecture support
Pentium® Pro processor	✓		Subset support
Pentium® II Xeon™ processor	✓	✓	Full support
Future Intel processors	✓	✓	

PAE-36 and PSE-36 both provide mechanisms for accessing physical memory above 4 Gigabytes - they offer different processor addressing schemes depending on the exact operating system in use. Full technical descriptions of these 36-bit addressing modes can be found at http://developer.intel.com/design/PentiumII/manuals/243690.htm.

Both modes allow operating systems to support up to 36-bits or 64 Gigabytes of main memory (DRAM) and therefore provide significant headroom for enterprise applications. Via these 36-bit processor addressing modes, the Intel Extended Server Memory Architecture will be supported by Microsoft's Windows NT Server*, Enterprise Edition 4.0 and 5.0 (via PSE-36), an upcoming release of Sun's Solaris* operating system (PAE-36), UnixWare® from SCO® (PAE-36), plus other OEM-versions of Unix such as the Virtually Windowed Shared Memory feature of Sequent's Dynix/ptx (PAE-36).

4.1 Low-level Software

Intel has developed a PSE-36 low-level software driver for the PSE-36 addressing mode for use in Microsoft's Windows NT Server, Enterprise Edition. This driver interfaces directly to the PSE-36 addressing mode of the processor and manages the use of memory above 4 Gigabytes. It allows enterprise applications to use this memory as an application-managed cache. By caching all or a large portion of the database in memory, less time is spent moving data to and from the disk subsystem (several orders of magnitude slower than accessing the database in memory).

Microsoft will be supplying and supporting this driver as part of Microsoft's Windows NT Server, Enterprise Edition 5.0. For Microsoft's Windows NT Server, Enterprise Edition 4.0, Intel is supplying and supporting this driver via server OEMs. In this case, server OEMs integrate this driver into their Pentium® II Xeon™ processor server platforms and deliver the complete solution to end-users and system integrators. For early developers, the driver and software developers kit (SDK) will also be available directly from Intel. Please refer to developer.intel.com for further details.

5.0 Cache Support

To support > 4 Gigabytes of memory, the Intel Extended Server Memory Architecture is defined to include high-performance level 2 (L2) processor caches with full support for 36-bit (64 Gigabyte) memory addressability. Since caches are designed to hold frequently used data close to the processor, they must also store the 36-bit address of the data being cached. Note that the memory addressability of the cache is not to be confused with the size of the cache (how much data can be held in the cache). As shown below, both Pentium Pro and Pentium II Xeon processors include L2 caches with 36-bit memory addressability and hence are processors that support the Intel Extended Server Memory Architecture.

	L2 Addressability	L2 Size
Pentium® Pro processor	64 Gigabytes (36-bits)	512 KB, 1 MB
Pentium® II processor	4 Gigabytes (32-bit)	512 KB
Pentium® II Xeon™ processor	64 Gigabytes (36-bits)	512 KB, 1 MB, 2M (available in 2H'98)

6.0 Chip Set Support

The Intel Extended Server Memory Architecture includes chip sets that support >4 Gigabytes of memory. These chip sets allow OEMs to design systems that can be fully configured with > 4 Gigabytes of DRAM. Along these lines, the Intel 450NX chip set - complementary to the Pentium II Xeon processor - supports up to 8 Gigabytes of DRAM. Given the 64 Gigabyte headroom of the Intel Extended Server Memory Architecture, the amount of DRAM supported by future, high-end chip sets is expected to grow beyond 8 Gigabytes over time. Applications supporting the Intel Extended Server Memory Architecture will obtain transparent benefits from these increases in memory over time.

7.0 Summary

The Intel Extended Server Memory Architecture describes technologies that transcend the 4 Gigabyte (32-bit) memory barrier for enterprise applications. Server platforms using Intel's Pentium® II Xeon™ processor can provide the first, complete support for this architecture. Enterprise applications will benefit from increased performance and throughput on large enterprise databases. For more up-to-date information on which applications will be supporting the Intel Extended Server Memory Architecture, please refer to the Intel website at http://www.intel.com/procs/servers/index.htm.

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