Ideal Platform for Enterprise Systems Demanding High Availability, Proven Performance, and Reliability

NEC Servers with the Intel® Xeon® processor E7 v2 family provide a major boost to the performance of enterprise systems and large-scale BI (business intelligence) processing

"In testing parallel processing to its limits, we demonstrated how the high performance of the Intel® Xeon® processor E7 v2 family with Intel® HT Technology has raised the bar for multiprocessing."

– Yukio Kumazawa
Technical Advisor
Application Platform Products Department
Server Platform Business Division
Microsoft Japan

Servers with the Intel® Xeon® processor E7 v2 family in a four-CPU configuration can deliver up to twice the processing performance, three times the memory capacity, and four times the I/O bandwidth of previous models. Together with their excellent transaction processing performance, these servers provide a high level of availability essential to enterprise systems via advanced RAS functions that guarantee the integrity of important data while also reducing costs and the frequency of server downtime.

This white paper describes benchmark tests conducted jointly by Intel and three other companies using an NEC Express5800/A2040b enterprise server with the Intel® Xeon® processor E7 v2 family in a four-CPU configuration (60 physical cores). The tests demonstrated that the server, with only three-quarters of the number of cores, could deliver equivalent performance to an eight-CPU (80 physical cores) server running the previous Intel® Xeon® processor E7 family. It also demonstrated the similar processing capabilities to a physical server when operated in a Hyper-V* virtualized environment. These results prove that the NEC Express5800/A2040b is the ideal platform for high-volume transaction processing that is essential to mission-critical business in the era of big data requiring very high-volume and complex data processing, as well as fitting into the virtualized environment.

Superior Performance and Reliable Operation by NEC Enterprise Server with Intel® Xeon® processor E7 v2 family CPUs

This white paper describes benchmark tests conducted jointly by Intel, NEC Corporation, SCSK Corporation, and Microsoft Japan using a performance benchmarking tool which is similar to popular OLTP performance benchmarking test kits used in the industry. The tool simulates various forms of transactions processed in customer management system of a wholesaler and measures the OLTP performance. The test kit enables reliable evaluation of processing power for mission-critical applications such as demanding enterprise OLTP applications and big data analysis for business intelligence.

The testing was conducted using an NEC Express5800/A2040b enterprise server with four Intel® Xeon® processor E7-4890 v2 (15-core, 2.80 GHz) CPUs and a Violin 6000 series flash memory array supplied by SCSK.

Tester

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NEC Corporation

SCSK Corporation

Server	**NEC Express5800/A2040b**
Memory	1TB
No. of sockets (cores)	4 CPUs/60 physical cores (Code name: Ivy Bridge-EX architecture)
Processor	Intel® Xeon® processor E7-4890 v2 (2.80 GHz)
Storage	**Violin flash memory array V-6606-HA24-8xFC 6TB**
Logical capacity	3.37TB
LUNs for physical server	3.17TB
LUNs for Hyper-V* Guest	50GB × 4
Software	
Server OS	Windows Server* 2012 Data Center
Database platform	SQL Server* 2012 Enterprise Edition SP1 x64 Edition

Table 1. Hardware and Software Configuration for the Benchmark Tests

The Intel® Xeon® processor E7 v2 family is the latest model in the Intel® Xeon® processor product line. It provides enterprise systems with high levels of availability and reliability, while also delivering the high processing performance for in-memory analysis needed for analyzing big data.

The NEC Express5800/A2040b can have up to four Intel® Xeon® processor E7 v2 family CPUs, and improves the system-level availability through NEC's own proprietary RAS technology. As an enterprise server with availability equivalent to RISC-based platforms, the NEC Express5800/A2040b is the best fit for mission-critical applications, such as enterprise OLTP systems, information management or co-ordination among organizations, and big data analysis for business intelligence.

The Violin 6000 series flash memory array from SCSK is the ideal storage system for core mission-critical business applications, high-volume data analysis in real time, and scale-out virtualization infrastructure.

The software used in the tests consisted of Microsoft* Windows Server* 2012 Datacenter and Microsoft* SQL Server* 2012 Enterprise Edition SP1 x64 Edition, a combination suitable for large mission-critical systems.

The testing can be broadly divided into two parts. The first part ran performance comparison between the new system and a server with the older Intel® Xeon® processor E7-8870 (2.40 GHz, 8 CPUs, 80 physical cores) to see the improvement in processing performance by the new system. The testing also included the validation of the CPU performance limits with Intel® Hyper-Threading Technology (Intel® HT technology)1 turned on and turned off. For this testing, the database size was set very small so that it could be saved entirely within cache memory.

In recognition of the growing use of virtualization in enterprise systems, the second part of testing looked at database processing performance under a virtualization environment. Windows Server* 2012 includes a virtual non-uniform memory access (V-NUMA) function that can utilize the non-uniform memory access (NUMA) function of the Intel® Xeon® processor E7 v2 family from Hyper-V*, and provides a major performance boost to SQL Server*.

As achieving the high levels of availability demanded by enterprise business applications was a prerequisite for both parts of testing, the integrated memory controller was operated in lock-step mode to prioritize availability.

Intel® HT Technology Boosts Processing Performance by 15% Under Heavy Loads

Yukio Kumazawa, a technical advisor at Microsoft Japan, describes the purpose of the benchmark tests as follows:

"In addition to CPU and memory partitioning, the Intel® Xeon® processor E7 v2 family allows for full partitioning down to the I/O level, below the level of the hypervisor. Partitioning all layers of a virtualization environment in this way makes it possible to implement full virtualization. The NEC Express5800/A2040b server further extends the functions of this new Intel® Xeon® processor to provide numerous enhancements to aspects such as availability. Here, combining the Violin 6000 series flash memory array providing high availability and advantages in data-intensive applications, we conducted these benchmark tests to prove the excellent performance gain and how well this works in a virtualization environment."

The initial testing verified the performance of Microsoft* SQL Server* 2012 for parallel execution of multiple transactions. The transaction mix consisted of 20% inserts and 10% updates, with the remainder being queries with a diverse range of sizes. These transactions were used for two cases with Intel® HT Technology turned on or off. As the Intel® Xeon® processor E7-4890 v2 CPU used for the testing has 15 CPU cores, the upper limit for parallel execution was also set to 15, equal to the number of physical cores (15).

The results indicated that the upper limit for concurrent users when Intel® HT Technology was turned off was 2,300 threads.

When Intel® HT Technology was turned on and the NUMA architecture was enabled, this limit increased to 2,500 threads. While not a notable difference, it demonstrated that turning on Intel® HT Technology under heavy load conditions achieves an approximate 15% performance boost.

Stable Performance under Practical Conditions for Parallel Processing of Up to 2,000 Threads

Continuing with the tests, Figure 1 shows the performance at five second intervals for five minutes period of parallel execution under seven different cases in which Intel® HT Technology was turned on or off while varying the number of threads.

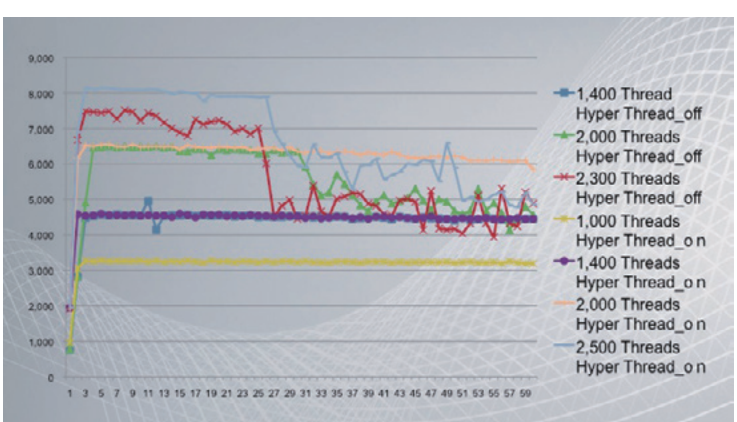

Fig. 1. Parallel Processing Performance for Different Numbers of Threads with Intel® HT On or Off

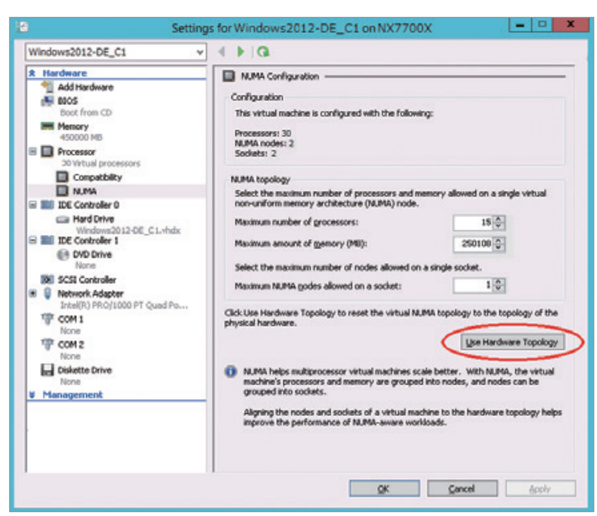

Fig. 2. Hyper-V* Manager V-NUMA Setting Screen

The vertical axis represents the number of transactions per second and the horizontal scale represents five-second increments. Starting from the case with the fewest transactions, the results under very low load are close to a straight line, indicating stable performance. When a heavier load is applied, the performance initially remains largely constant until about the two minute mark, after which the performance progressively declines as waiting queues start to overflow. This type of phenomenon has been observed in many performance benchmark experiments in the past.

The performance benchmark is done by converting the number of transactions processed over a five-minute period to transactions per second value. The results indicate that when Intel® HT Technology is turned on, very stable processing performance can be achieved up to about 2,000 threads. Likewise, when Intel® HT Technology is turned off, it was estimated that processing performance was most stable at a slightly lower level of around 1,800 threads.

Operating with 100% load as conducted in this test is unlikely to be seen on a real-world online transaction processing system, and it would be a common recognition to operate with 70 to 80% of sizing as the load range at which performance is likely to be at its most stable. Accordingly, 2,000 threads when Intel® HT Technology is turned on, and 1,800 threads when turned off, can be considered a very reasonable and realistic guideline for stable operation on this particular hardware. These results also indicate that Intel® HT Technology is a useful option to ensure performance, especially under such situations as high loads not anticipated at the design stage.

Stable Performance Maintained when Using Virtualization to Run Multiple Databases

Next was a benchmark test under a virtualization environment using the NUMA architecture. The main objective of this testing was to verify the ability of the V-NUMA function of Windows Server* 2012 Hyper-V* to deliver high performance in a virtualization environment utilizing SQL Server* 2012 and the NUMA function of the Intel® Xeon® processor E7 v2 family. Another objective was to verify the ability of the system to run multiple databases independently using virtualization, such that if one of the databases is overloaded (close to 100% load), it does not impact other virtualization environments in any way. To this end, the Hyper-V* manager was used to configure two guest environments on the Hyper-V* environment.

There are two particular points to note regarding the settings used to configure the test system. Figure 2 shows Hyper-V* manager's V-NUMA settings for a virtual machine. V-NUMA is enabled by clicking the "Use hardware topology" button at the bottom right of the screen when configuring the system.

Next, deselect the "Allocate memory that spans physical NUMA nodes to virtual machines" checkbox in the settings for memory allocation spanning NUMA nodes in the V-NUMA settings screen for the Hyper-V host. Without these settings, SQL Server* 2012 would detect the server as an SMP machine and be unable to use the NUMA architecture.

NUMA Architecture Boosts Server Performance

Non-uniform memory access (NUMA) is a memory access architecture for multi-processor configurations. Its major feature is that each CPU has its own local memory, which improves server processing performance by eliminating delays caused by memory access conflicts of the sort that occur in SMP.

• NUMA support in SQL Server*

SQL Server* has been supporting NUMA since SQL Server* 2000 SP4, improving performance in applications such as large databases or online transaction processing by taking advantage of the NUMA architecture built into CPUs such as the Intel® Xeon® processor.

• V-NUMA incorporating support for virtualization

Virtual non-uniform memory access (V-NUMA) is a function for implementing NUMA on virtualization environments that has been available since Windows Server* 2012 Hyper-V* 3.0. Because it makes the NUMA function available to the guest OS running on top of Hyper-V*, it can provide major performance improvements to applications on Hyper-V* such as SQL Server* 2012.

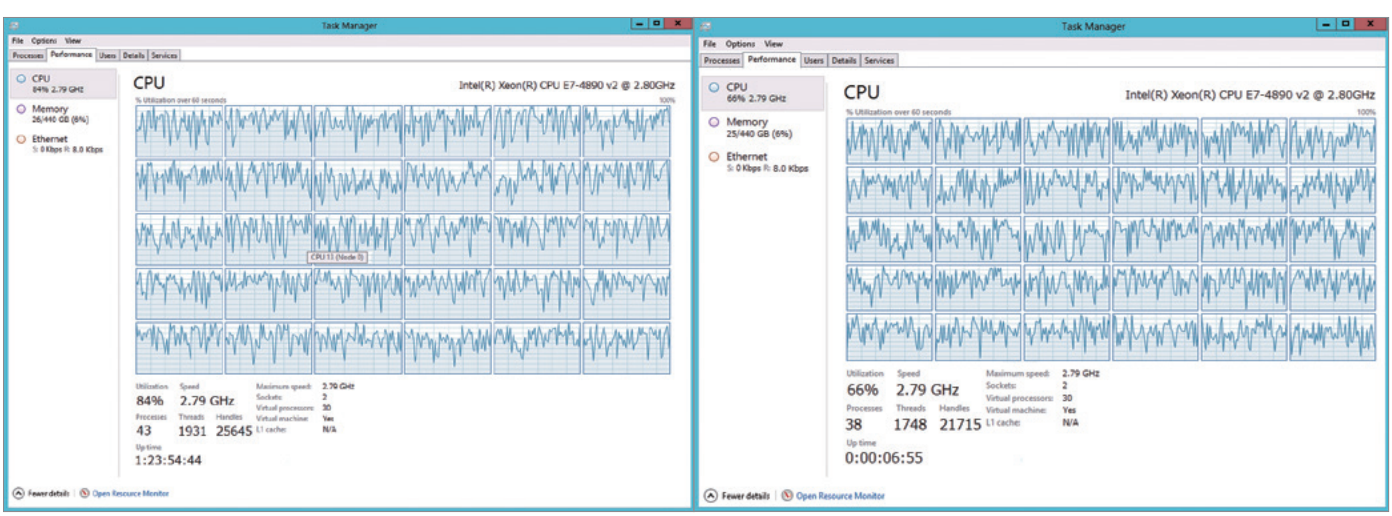

Fig. 3. Independence of Databases Under Virtualization Using V-NUMA

This test validated the behavior of V-NUMA, using Hyper-V* to partition a server with four CPUs and 60 physical cores into two systems with two CPUs and 30 cores each. As the NEC Express5800/A2040b server has four CPUs, it can have four NUMA nodes. SQL Server* 2012 has a function called the affinity mask option that assigns threads to processors. This function can be used to specify a configuration, for example, by having an instance run using node 0 and node 1 only, the system appears to be a two socket server for the user. As the setting is equivalent to a machine with a native configuration of two CPUs and 30 physical cores, it allows comparative benchmark testing to be performed with a two-socket/30-core virtual machine configured on V-NUMA.

The test results indicated about 850 threads was a maximum when a load was applied to a normal NUMA node which is to be comparable with conventional NUMA. When a load was applied to the two-socket/30-core virtual machine configured on V-NUMA, the result was 830 threads at maximum, only 20 threads fewer. This indicates an overhead of only a few percent.

Next was the test to verify the independence of multiple databases running in a virtualization environment. Figure 3 shows no interference between the databases when a load of 830 threads was applied simultaneously from the two guests.

Figure 4 shows a graph comparing the execution of 830 threads under three different configurations, where the blue line represents virtual machine 1 configured using V-NUMA, green represents virtual machine 2 configured using V-NUMA, and red represents the machine that does not use V-NUMA. Intel® HT Technology was turned off in all cases. These results demonstrate that roughly the same processing capacity can be obtained regardless of whether V-NUMA is used.

Intel® HT Technology Boosts Processing Performance by 15% under High Load Platform with the Proven Superior Performance and Reliable Operation Required for Mission-Critical Systems

This benchmark test demonstrated that the NEC Express5800/A2040b with Intel® Xeon® processor E7 v2 family CPUs can satisfy the requirement for high performance in mission-critical applications.

When compared to the older SQL Server* 2008 R2 running on servers with the Intel® Xeon® processor E7-8870 (2.40 GHz, 8 CPUs, 80 physical cores), tests demonstrated that SQL Server* 2012 SP1 running on a four-CPU configuration (60 physical cores) can achieve equivalent performance using only three-quarters as many cores (1.02 times when Intel® HT Technology is off, 0.99 times when Intel® HT Technology is on).

"The testing clearly proved the fact that the overall system is faster, including all interconnect speeds as well as PCI and memory access, and the clock speed. Regarding the benefits of Intel® HT Technology, while these may not be evident at low loads, we demonstrated an improvement in processing performance under high loads of about 15% over the previous system." (Kumazawa)

The NEC Express5800/A2040b enterprise server with Intel® Xeon® processor E7 v2 family CPUs provides a platform that delivers excellent reliability and performance in enterprise systems and in applications such as business intelligence that involve processing of large quantities of data in real time. In addition, with up to 16 of the latest PCI-Express 3.0 I/O slots available, the server allows for partitioning of virtual machines all the way from CPU level to the I/O level. This contributes to reliable and stable performance in virtualized environment too.

For more information on the Intel® Xeon® processor E7 v2 family, visit **http://www.intel.co.jp/content/www/jp/ja/processors/xeon/xeon-processor-e7-family.html**

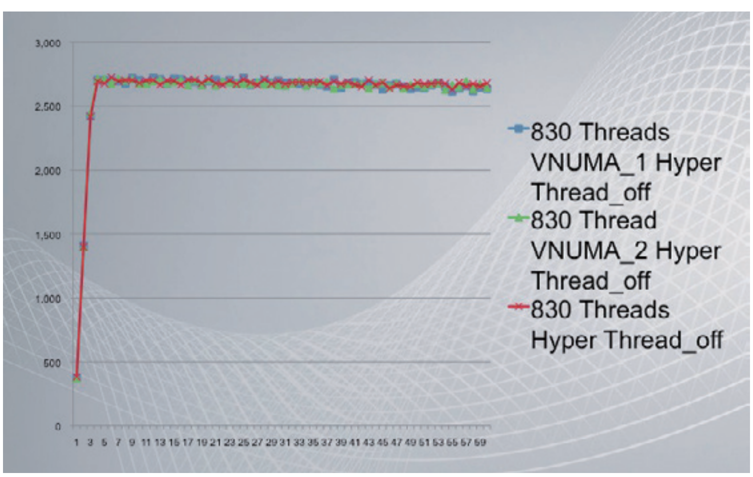

Fig. 4. Parallel Processing of 830 Threads Using V-NUMA

[1] Available on select Intel® processors. Requires an Intel® HT Technology-enabled system. Consult your PC manufacturer for details. Performance will vary depending on the specific hardware and software used. For more information, including details on which processors support HT Technology, visit http://www.intel.co.jp/jp/products/ht/hyperthreading_more.htm.

Source: Results of benchmark testing conducted jointly by Intel Corporation, Microsoft Japan, NEC Corporation, and SCSK Corporation (May 2014)

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