

# 64 bit Dual-Core Intel Xeon Processors & VMware ESX Server: A Powerful Combination for Systems Consolidation

Mark F. Ewert, VMware Certified Professional  
Foedus

April 2006

The modern datacenter is typified by a high percentage of underutilized systems. Organizations grappling with rising physical and environmental costs need a solution to consolidate these underutilized systems on fewer physical servers.

This whitepaper explores how VMware ESX Server, running on 64 bit Dual-Core Intel Xeon processors, provides a powerful solution for systems consolidation; and demonstrates the tremendous virtual processing capacity of Intel's new Dual-Core processors over traditional single core.

In tests measuring virtual CPU capacity using CPUs running at the same frequency with the same cache size, 64 bit Dual-Core Intel Xeon processors provided 81% more processing power for virtual machines than single core.

## CONTENTS

Executive Summary . . . . .	4
Consolidating x86-class Servers using VMware ESX Server. . . . .	4
Intel Dual-Core Processor Architecture . . . . .	5
VMware ESX Server Processor Scheduling . . . . .	5
Virtual Processing Scalability: Single Core vs. Dual-Core . . . . .	6
Conclusion. . . . .	8
References. . . . .	8

## EXECUTIVE SUMMARY

Faced with growing power, environmental and hardware management costs, organizations are increasingly looking for solutions to consolidate their underutilized systems on fewer physical computers.

Systems virtualization provided by VMware ESX Server enables organizations to consolidate these underutilized systems as virtual computers running on a smaller number of physical ESX server computers. Each physical ESX Server can run several virtual computers limited only by the capabilities of its underlying physical hardware<sup>1</sup>.

64 bit Intel Dual-Core Xeon processors provide a tremendous increase in computing performance over traditional single core processors while consuming the same physical space and power.

The combination of VMware ESX Server and Intel Dual-Core Processors provide organizations a powerful platform for systems consolidation. In scalability tests using Intel 64 bit Xeon 7000 Sequence MP Processors, Intel Dual-Core provided an 81% increase in virtual processing capacity over single core.

Furthermore, while this test focused only on the benefits of dual-core technology for virtualization, Intel offers several other innovations ideal for enterprise consolidation. These advancements include unique industry-leading reliability features, larger processor cache and the industry's first x86 hardware assisted virtualization.

## CONSOLIDATING X86-CLASS SYSTEMS USING VMWARE ESX SERVER

Computers and computer software have revolutionized modern business; but years of increasing demand for new applications have resulted in the typical datacenter being congested with a high percentage of underutilized servers. Consolidating applications on common x86-class operating systems such as Windows and Linux is typically not feasible due to concerns of system instability and other common barriers such as the need to keep applications separated for regulatory compliance. VMware ESX Server enables organizations to avoid these obstacles and consolidate their underutilized x86-class systems using technology once limited to the mainframe.

VMware ESX Server is a systems virtualization platform. Systems virtualization enables powerful physical computers to host multiple, virtual computers. Each virtual computer shares the physical host computer's resources yet remains an individual functional system. Each virtual computer has its own memory, hard disk, processor and network interface just like a physical computer; and runs off-the-shelf versions of all major x86 operating systems including Windows Server, Linux and Novell NetWare. Since VMware ESX Server virtualizes the entire computer, including operating system and applications, it does not require integration of previously separated applications to achieve consolidation gains.

Acting as an interface between the physical hardware and these virtual machines, VMware ESX Server efficiently coordinates requests for physical computing resources by the virtual computers. Using VMware ESX Server, organizations are able to more efficiently leverage the computing power in modern server computers by sharing them amongst multiple, underutilized virtual systems.

By consolidating underutilized physical systems as virtual machines on a smaller number of VMware ESX Servers, organizations are able to reduce their physical computing costs and datacenter congestion.

---

<sup>1</sup> Up to a total of 80 virtual CPUs

## INTEL DUAL-CORE PROCESSOR ARCHITECTURE

Perhaps the greatest recent innovation in microprocessor design, Dual-Core processors essentially provide two CPUs within the same sized chip as traditional single core processors. By combining two processing cores on the same chip die, the processors provide two logical CPUs to multiprocessing aware operating systems and applications while using only one physical CPU socket. This theoretically doubles the processing power within the same physical footprint as traditional single core systems: making two-way single core servers into logical four-ways using two Dual-Core CPUs.

Furthermore, since the Dual-Core processors run within the same physical chip they consume far less power than two physical single core CPUs. This increase in processing power without substantial increase in power consumption or physical server space is a tremendous benefit to datacenter managers struggling to maintain costs.

In addition to having two cores, Dual-Core Intel Xeon processors are 64 bit enabled with Intel's EM64T technology and support hyperthreading. With hyper-threading, each processor core features a second logical processor capable of handling a separate processing thread. With two cores and two hyper-threads, the 64 bit Dual-Core Intel Xeon processor provides four logical processors per physical socket to handle thread intensive multiprocessing application load.

For multiprocessing aware computing environments, Intel Dual- Core processors provide a tremendous boost in processing capability within the same physical space as servers configured with traditional single core Xeon processors.

## VMWARE ESX SERVER PROCESSOR SCHEDULING

One of the many powerful features of VMware ESX Server is its unique ability to efficiently tap the power of multiprocessor systems by dynamically scheduling virtual machine processor load across multiple processors, cores and hyper-threads.

ESX Server identifies processor cores and their associated hyperthreads as individual logical processors, each capable of handling virtual machine processing demands. Figure 1 shows how ESX separates the individual cores and hyper-threads in a Dual-Core processor into logical CPUs.

Processor Component	Logical ESX CPU
1st core	CPU0
1st core's hyper-thread	CPU1
2nd core	CPU2
2nd core's hyper-thread	CPU3

*Figure 1: Dual-Core Processor VMware ESX Server Logical CPU Assignment*

As ESX Server utilizes each core and Hyper-Thread as individual logical processors, it is able to allocate virtual machine processor load across each far more efficiently than if it combined the cores and threads into black holes of processing power. Furthermore, with Intel Dual-Core CPUs, VMware ESX Server has two additional logical processors per processor socket than single core; providing a substantial increase in virtual processing power in the same physical footprint.

Each physical 64 bit Dual-Core Intel Xeon CPU with hyper-threading provides ESX Server four logical processors for efficient CPU process scheduling. A standard dual socket, Dual-Core server provides eight logical ESX Server CPUs; and a four socket, Dual-Core system enables ESX Server to schedule virtual processing load across 16 logical processors.

## VIRTUAL PROCESSING SCALABILITY: SINGLE CORE VS. DUAL-CORE

To demonstrate the substantial gain in VMware ESX Server virtual processing power using Dual-Core processors, analysts determined how many identical virtual machines under individual processing load could be run simultaneously at 70% aggregate ESX Server CPU utilization on a Dual-Core Intel 64 bit Xeon based server configured to use both cores per processor vs. the same system limited to a single active core per physical CPU.

VMware ESX Server v2.5.2 build 16390 was installed on an Intel Server with four 64 bit Dual-Core Intel Xeon 7040 MP processors and 16Gigabytes of RAM running on the Intel E8500 mainboard chipset. The VMware ESX Server system was installed on an internal 15,000 RPM 73GB SCSI3 hard drive. The virtual disk files for each virtual machine were stored on a 400GB LUN on an HP MSA1000 Storage Area Network (SAN) connected to the Intel test server with a QLogic Fiber Channel Host Bus Adapter (HBA).

VMware ESX Server was configured with 800MB of RAM allocated to the ESX Server Service Console with the remaining 15.2GB's of RAM available for virtual machines. VMware VirtualCenter 1.3 running on a separate physical computer was used to manage the virtual environment and create the test virtual machines via cloning.

Guest OS:	<b>Windows 2000 Server</b>
IP Address:	<b>0.0.0.0</b>
DNS Name:	
VMware Tools:	<b>Installed</b>
Devices	
Device	Summary
Memory	384 MB
Hard Disk 1 (SCSI 0:0)	4000 MB
CD-ROM 1 (IDE 1:0)	Using drive /dev/cdrom
Floppy 1	Using drive /dev/fd0
NIC 1	TESTING(internal)
Virtual CPUs	1
SCSI Controller 0	BusLogic

Figure 2: Test Virtual Machine Specifications

Each test virtual machine was an identical clone of a reference virtual Windows 2000 SP4 Server with one virtual CPU, 384MB of RAM, a BusLogic SCSI adapter and a 4GB virtual SCSI disk drive (see figure 2).

CommLinx Solutions CPU Load Simulator was installed in each virtual test machine and used to generate virtual CPU load. Aggregate VMware ESX Server CPU load was monitored using the ESX Server Management User Interface (MUI) and esxtop command-line tool.

To evaluate VMware ESX Server CPU scalability on Dual-Core vs. single core processors, identical virtual test machines under individual CPU load were started in increasing numbers until the ESX Server system reached 70% aggregate CPU utilization. 70% is considered the max healthy production ESX Server system load.

Two rounds of tests were conducted with the virtual test servers running at 6% and 25% virtual CPU load respectively; representative average loads of underutilized corporate servers.

In each round, the test virtual servers were first configured to leverage Dual-Core, utilizing all four physical 64 bit Dual-core Intel Xeon MP Processors, their eight corresponding cores and eight associated hyper-threads for a total of sixteen (16) logical ESX processors. After it was determined how many virtual machines running at the respective test load it took to reach 70% aggregate ESX Server CPU utilization; the test was repeated with the virtual machines configured to use only single core. In the single core configuration, the virtual machines were limited to each of the four processors' primary cores and associated hyper-threads for a total of eight (8) logical ESX CPUs. In all tests, the ESX Server virtualization system was limited to CPU0, the default configuration.

## RESULTS

In the first round of tests using virtual machines with 6% virtual CPU load, analysts were able to run fortythree (43) virtual Windows 2000 servers simultaneously at 70% aggregate ESX Server single core processor utilization. Against Dual-Core, ESX Server was able to reach its maximum supported eighty (80) running virtual machines at only 65% aggregate ESX Server processor load. Remarkably, in previous single core tests running virtual machines at 6% CPU load, only servers with eight physical CPUs were able to reach the 80 virtual machine ESX Server limit.

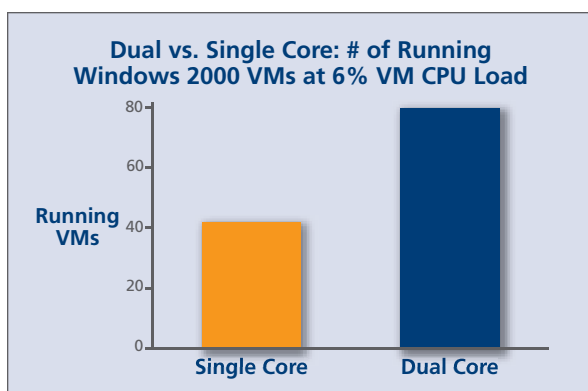


Figure 3: Dual vs. Single Core at 6% VM CPU Load

In the second round of tests using virtual machines at 25% virtual CPU load, VMware ESX Server was able to run twenty-one (21) virtual Windows 2000 Servers using single core; and thirty-eight (38) against Dual-Core, an 81% increase in virtual CPU capacity.

When analyzing these results it is important to understand that by design, the test protocol was narrowly focused on demonstrating the processing scalability benefits of two cores per physical CPU vs. one. As only CPU processing scalability, and not overall system performance was to be ascertained, system load was limited by necessity to only the CPU. By using identically configured virtual machines each generating only 6% CPU load (no active memory, network or disk I/O), analysts were able to create an artificial test environment that isolated and demonstrated just the CPU processing benefits of two cores per physical processor over one.

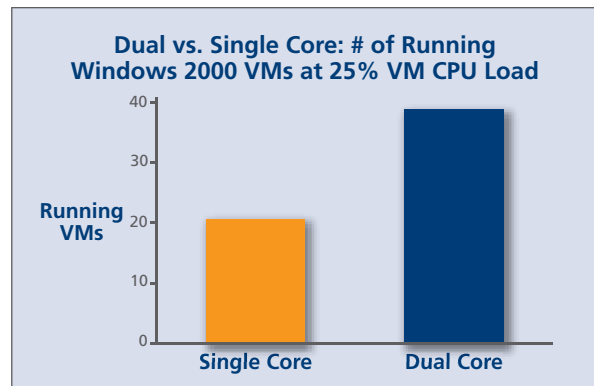


Figure 4: Dual vs. Single Core at 25% VM CPU Load

Furthermore, analysts used VMware ESX Server's Processor Affinity, and not different physical servers or even Intel Xeon CPUs, to isolate load to single or Dual-Cores. By utilizing the same physical server with the same 64 bit Dual-Core Intel Xeon 7040 MP processors, chipset, front side bus, memory and disk I/O in each test, analysts were able to further isolate gains in virtual CPU scalability to just the difference in number of cores per physical processor.

Therefore, it is important to understand the results demonstrate only the benefit of 64 bit Dual-Core Intel Xeon processor cores. By design the tests did not demonstrate the additional scalability benefits of other advances in Intel architecture such as increased front side bus speed and differences in layer 2 cache design. These advances, combined with Intel Dual-Core technology theoretically offer even greater aggregate virtual infrastructure scalability than the 81% attributable to just the differences in number of cores.

Combined, the technical advances featured in the 64 bit Dual-Core Intel Xeon Platform provide a tremendous increase in virtual infrastructure scalability over systems featuring the single core technology of the past.

## CONCLUSION

VMware ESX Server running on 64 bit Dual-Core Intel Xeon processors provides organizations an extremely powerful platform for systems consolidation. With a tremendous increase in virtual processing capacity, Intel 64 bit Dual-Core Xeon processors enable VMware ESX Server to host more virtual machines than traditional single core, without increasing power consumption or consuming additional datacenter space. VMware ESX Server is able to fully leverage the multiprocessing power of 64 bit Dual-Core Intel Xeon processors enabling a higher density of virtual to physical machines. By moving to virtual computers running on VMware ESX Servers powered by 64 bit Dual-core Intel Xeon processors, organizations are able to significantly reduce their physical computing costs while more efficiently leveraging their investments in computing resources.

## REFERENCES

### VMware ESX Server

[www.vmware.com/products/esx/](http://www.vmware.com/products/esx/)

### VMware Virtual Center

[www.vmware.com/products/vc/](http://www.vmware.com/products/vc/)

### Dual-Core Intel Xeon Processors

[www.intel.com/business/bss/products/server/dual-core-xeon.htm](http://www.intel.com/business/bss/products/server/dual-core-xeon.htm)

### Intel 7000 Sequence Xeon Processors

<ftp://download.intel.com/products/processor/xeon/dcprodbrief.pdf>

### Foedus Virtual Infrastructure Solutions

[www.foedus.com](http://www.foedus.com)



### Foedus

30 International Drive  
Portsmouth, NH 03801  
877-2-foedus tel  
603-431-2662 fax  
[www.foedus.com](http://www.foedus.com)