# Performance brief for IBM WebSphere Application Server 7.0 with VMware ESX 4.0 on HP ProLiant DL380 G6 server

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# Executive summary

By virtualizing the server environment, you can improve server utilization and consolidate servers onto high capacity virtual machines. This allows you to reduce the cost to maintain and manage your server infrastructure. Virtualization also allows you to migrate data and applications among servers more quickly and efficiently.

The VMware® ESX™ 4.0 server takes maximum advantage of available cache and memory locality as in 2 and 4 core virtual machine scenarios. The performance delta between the physical and virtual configuration is significantly reduced with the latest Intel® Xeon® X5570 (Nehalem) processor over previous tests with IBM WebSphere Application Server and the Apache DayTrader application. In many cases by increasing the number of WebSphere instances and CPUs allocated to the virtual machines VMware ESX 4.0 outperforms the physical environment. You will find more details regarding the comparison in the following sections.

This paper compares the performance of virtual and physical servers running IBM WebSphere Application Server (WAS) on HP ProLiant DL380 G6 server and VMware ESX 4.0 with Red Hat Enterprise Linux (RHEL) 5.3 server.

**Target audience:** This paper provides assistance to solution architects for configuring IBM WebSphere Application Server on VMware ESX 4.0. Prior knowledge of WebSphere Application Server, VMware ESX 4.0, Red Hat Enterprise Linux and SUSE Linux Enterprise Server is assumed.

This white paper describes testing performed in Sep 2009.

# WebSphere test configuration

In order to compare the performance and scalability of WebSphere Application Server on a single physical server running the OS natively to the performance on VMware virtual machines, multiple instances of WebSphere Application Server were created both in the native and virtual configurations. The DayTrader performance benchmark application was installed and configured in all WebSphere instances.

Tests were performed, and the performance throughputs were calculated, with varying numbers of WebSphere instances and core allocations to the operating system on the physical and virtual environments. The paper refers to CPU cores as CPUs in the native environment. In the virtual environment a physical core corresponds to a virtual core or a virtual CPU.

Figure 1 show the hardware configuration, which consists of ProLiant DL380 G6 servers used as application servers. Separate servers were used for HP LoadRunner to simulate the load for the DayTrader benchmark and for the Oracle® 11*g* database server. The HP StorageWorks 8400 Enterprise Virtual Array (EVA8400) was used for storage. The operating system RHEL 5.3 and VMware ESX 4.0 were installed on the internal storage. The virtual machines were stored on EVA8400 SAN storage.

Hyper-threading was disabled in the BIOS of the servers running the physical and virtual environments.

**Figure 1.** ProLiant DL380 G6 test server configuration

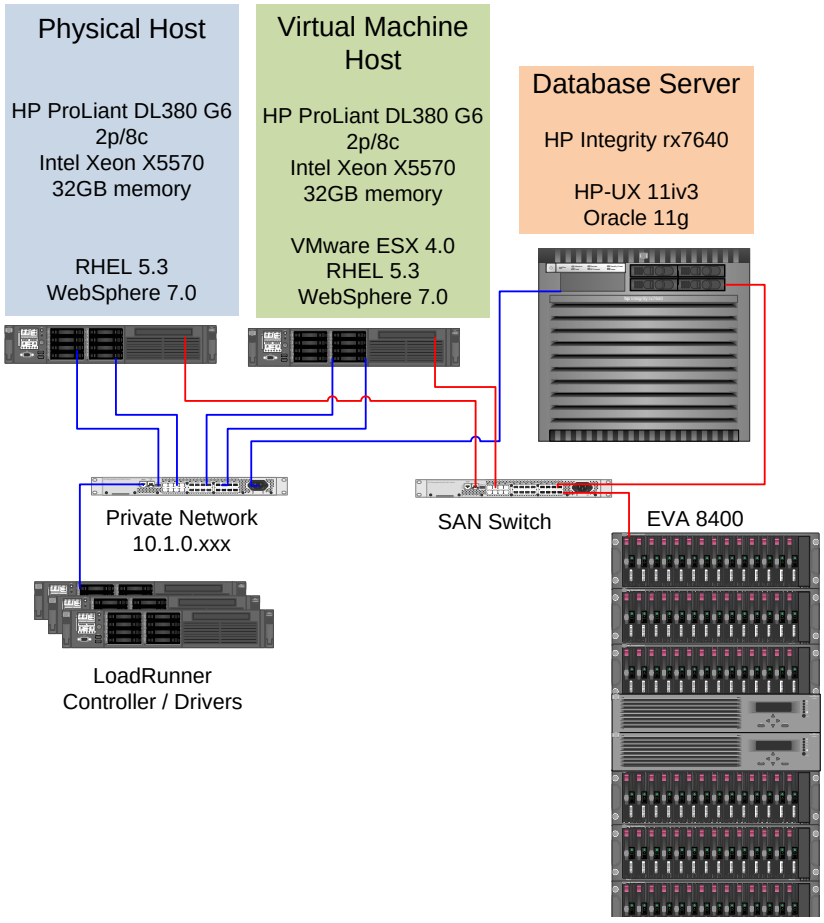



Figure 1 shows the physical and virtual server configuration using HP ProLiant DL380 G6 server. The physical server was running RHEL 5.3 and WebSphere Application Server 7.0; the DayTrader application was configured on this server. The number of CPUs and the amount of memory allocated on the physical environment were controlled using 'maxcpus' and 'mem' parameters in /boot/grub/grub.conf configuration file.

Figure 2 shows a logical representation of the physical server configuration.

**Figure 2.** Physical server configuration

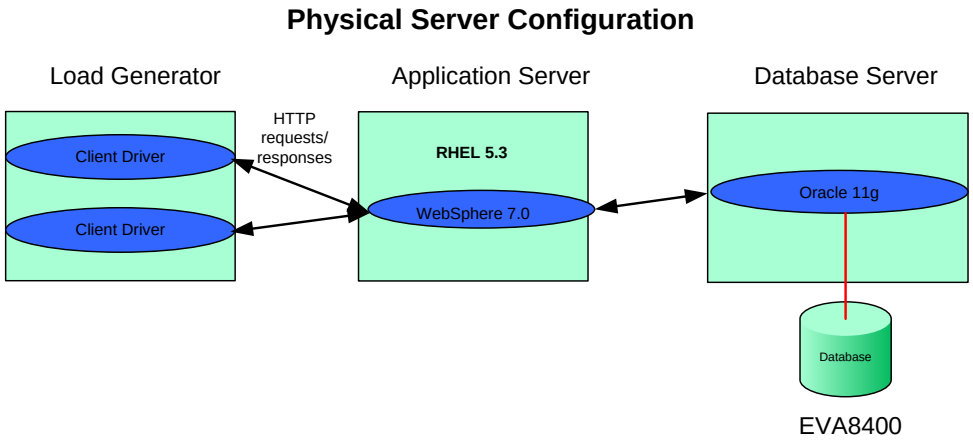
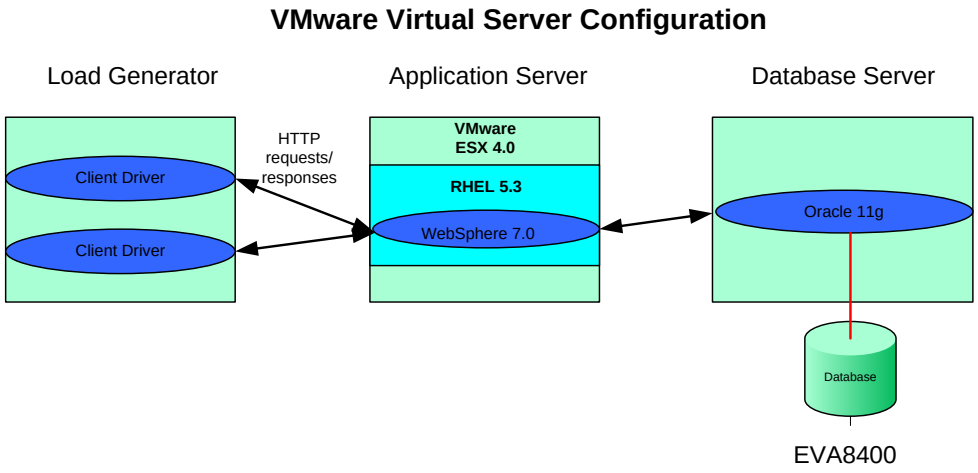



Figure 3 shows a logical representation of the virtual server configuration. In the virtual server configuration VMware ESX 4.0 was installed. Virtual machines with RHEL 5.3 and WebSphere Application Server 7.0 were installed with 4 GB of memory. The DayTrader application was configured on these virtual machines.

**Figure 3.** VMware virtual server configuration




The operating system and WebSphere configurations were identical in both physical and virtual environments.

## Server information

The following is the test server configuration

**Virtual: VMware ESX 4.0 (build 164009)**
**Machine: HP ProLiant DL380 G6**
**CPU:  2 Quad-Core Intel® Xeon® CPU X5570 @ 2.93GHz**
**Memory: 32 GB**
**Guest OS: Red Hat Enterprise Linux Server 5.3**
**Application Server: IBM WebSphere Application Server 7.0.0.5**
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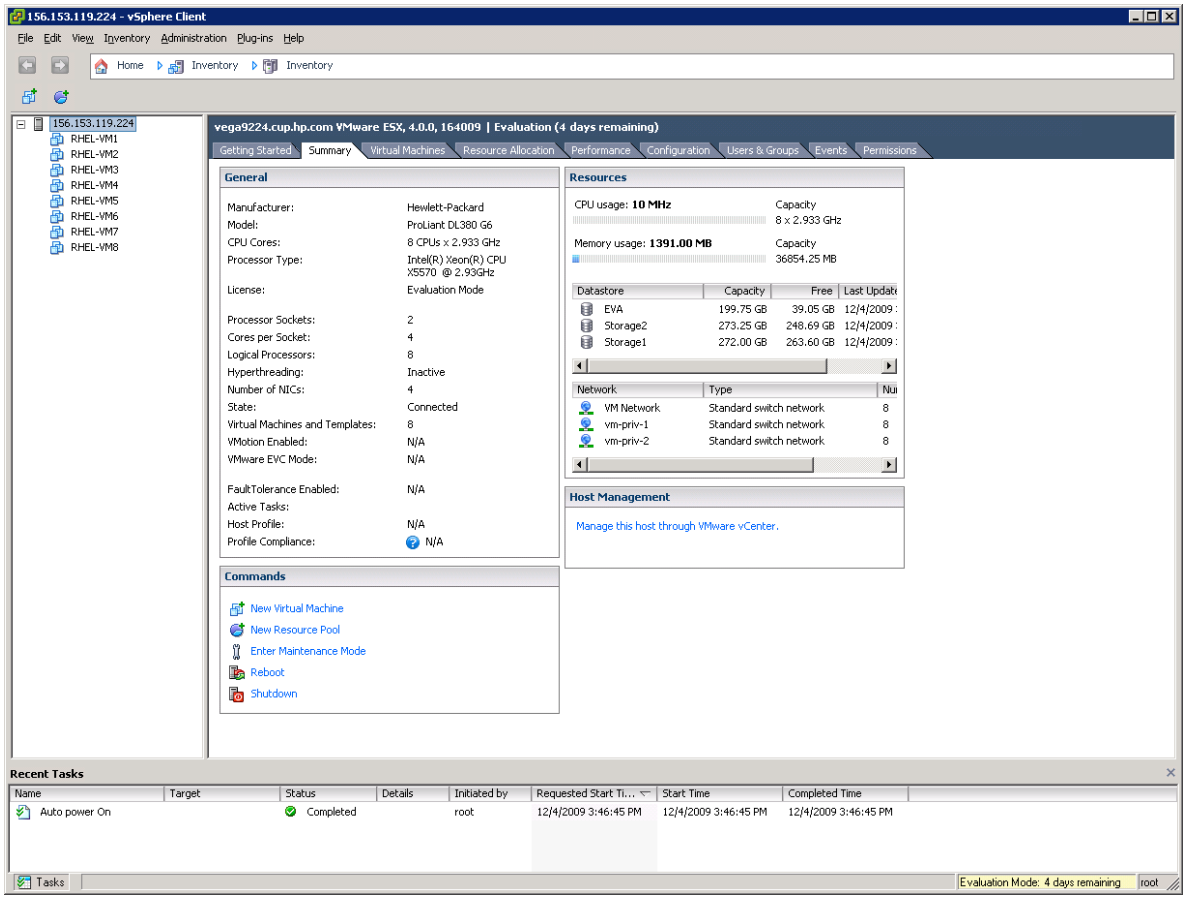
**Physical: Red Hat Enterprise Linux Server 5.3**
**Machine: HP ProLiant DL380 G6**
**CPU: 2 Quad-Core Intel Xeon CPU X5570 @ 2.93GHz**
**Memory: 32 GB**
**OS: Red Hat Enterprise Linux Server 5.3**
**Application Server: IBM WebSphere Application Server 7.0.0.5**

Figure 4 is the screenshot from VMware vSphere™ 4 Client showing the virtual machine configuration.

**Figure 4.** VMware vSphere client application




# WebSphere and OS tuning

Below is a list of tuning modifications:

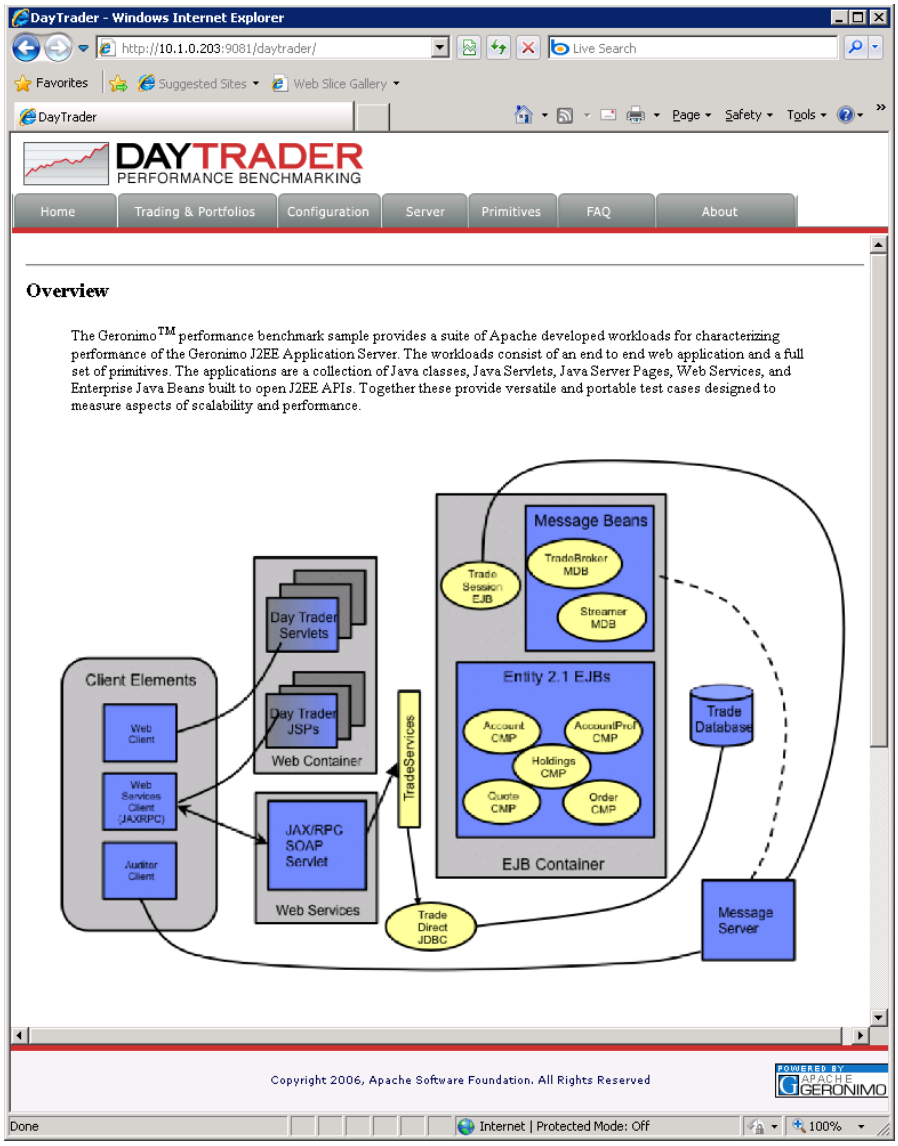
- Enabled hugepages on both virtual and physical servers.
  - vm.nr_hugepages = 512
- Used separate vmxnet2 network interfaces for web server and database traffic.
- Allocated memory to the virtual machine so that the operating system does not use swapping.
- Set the minimum and maximum heap size for Java™ to 1024M
  - '-Xms1024m -Xmx1024m' to reduce garbage collection from the JVM.
- Enable large memory pages for the JVM with '–Xlp' option.
- WebSphere thread and connection pools were modified for best performance.

Tests were performed with the default e1000 network adapter. We noticed a **performance improvement of additional ~2% with vmxnet2 network adapter**. The results in the paper are with the vmxnet2 network adapter.

# DayTrader benchmark

DayTrader is an end-to-end benchmark and performance sample application built around an online stock trading system. The application allows users to login, view their portfolio, lookup stock quotes, and buy or sell stock shares. This benchmark implements J2EE 1.4 including the new EJB 2.1 component architecture, Message Driven beans, transactions (1-phase, 2-phase commit) and Web Services (SOAP, WSDL). Figure 5 shows the home page of the DayTrader 2.0 application. This DayTrader application represents 3-tier architecture involving the client, application server and backend database. Thus closely simulates real-world customer scenarios.

**Figure 5.** DayTrader Benchmark



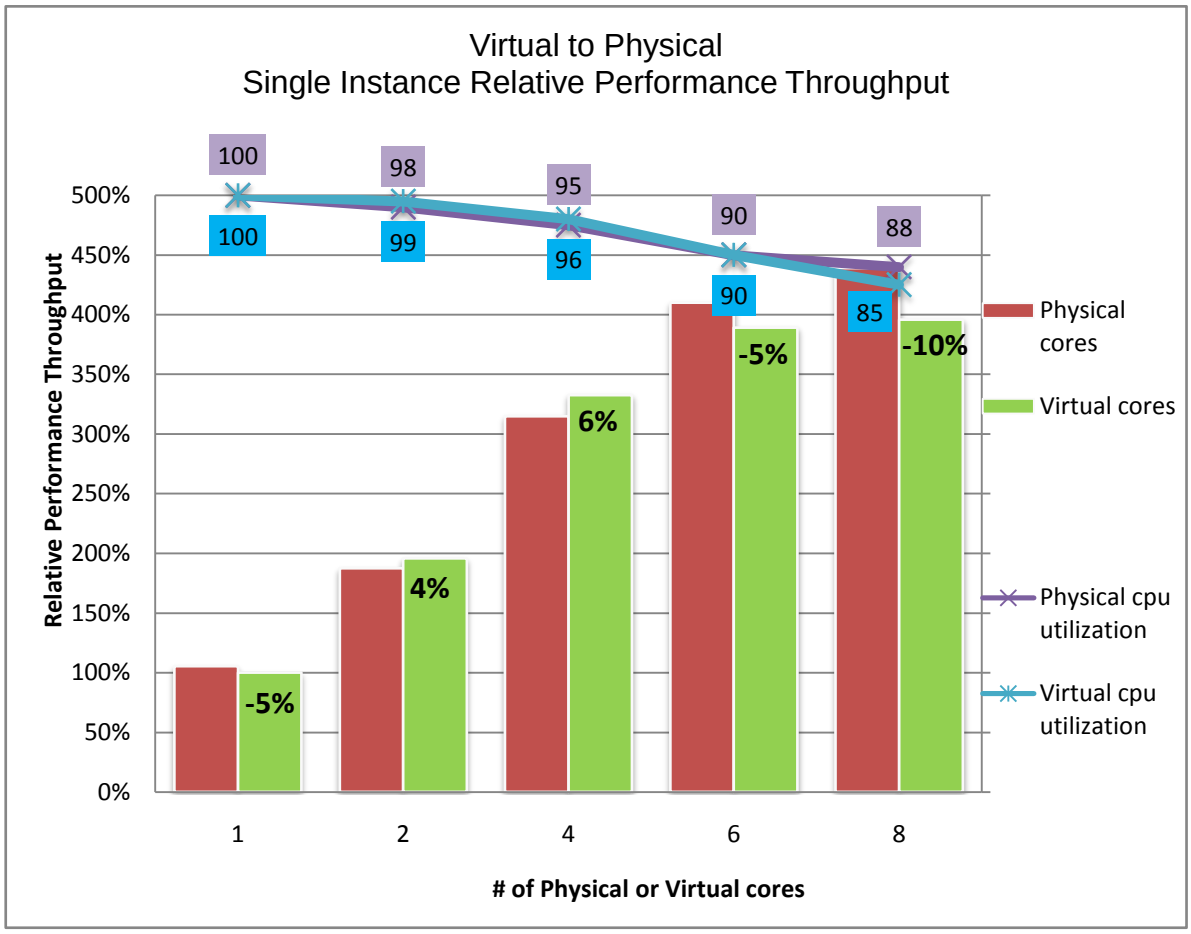

The operating system and WebSphere configurations were identical in both physical and virtual server environments.

LoadRunner was used to generate the load and the number of transactions processed by the application servers was calculated for comparison.

## WebSphere with single instance

Figure 6 compares the relative performance of the physical and virtual server environments when running the DayTrader benchmark on a single instance of WebSphere Application Server with varying core or virtual CPU allocations.

**Figure 6.** Single instance physical and virtual comparison

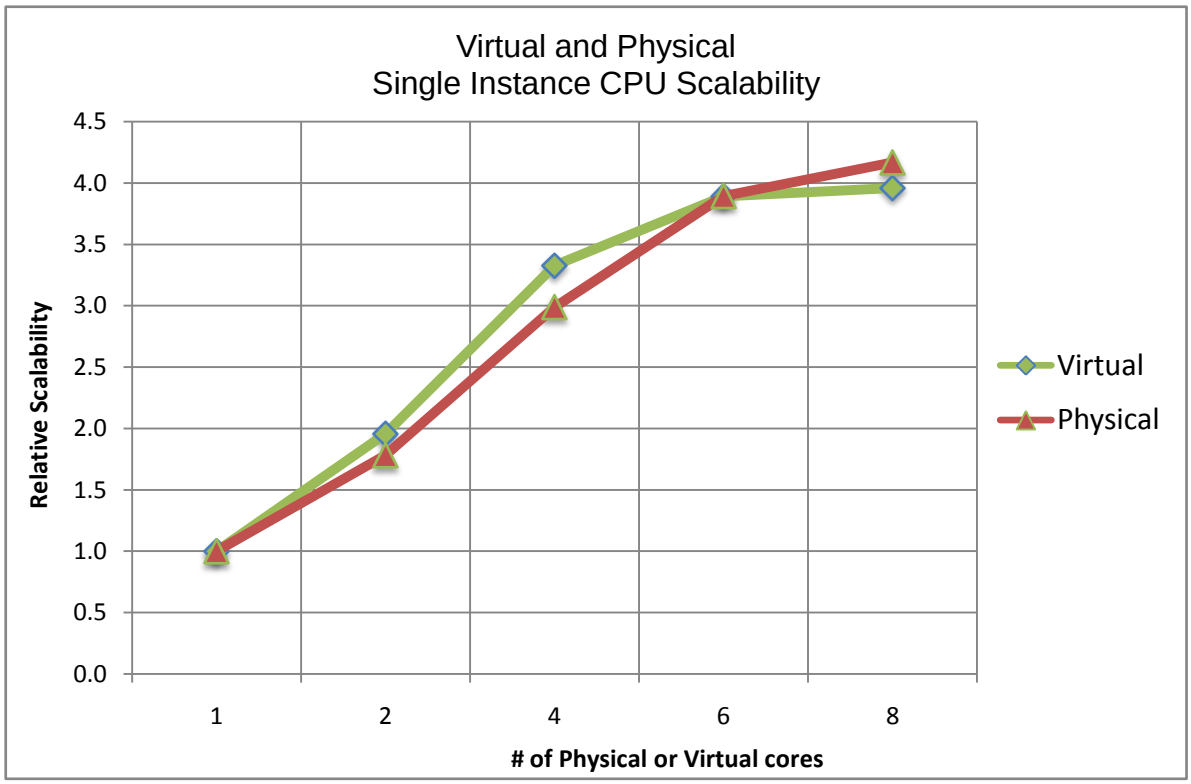



Depending on the number of cores or virtual CPU's allocated, the VMware ESX 4.0 virtual environment in some cases exceeds the performance of physical environment, as shown in 2 cores and 4 cores configuration of about 4% and 6% respectively. The virtual operating system takes maximum advantage of available cache and memory locality as shown in case of 2 and 4 cores performance data. The performance delta between the physical and virtual configuration is significantly reduced with the latest Intel Xeon X5570 processor over previous tests with WebSphere and the DayTrader application. The performance degradation in virtual environment with 1 core, 6 cores and 8 cores case is about 5%, 5% and 10% respectively. The percentage throughput difference is calculated in relation to 1 core virtual machine performance. Due to an unidentified bottleneck the tests were unable to saturate the CPU on 6 and 8 cores.

## Physical and virtual CPU scalability

Figure 7 shows the scalability characteristics for virtual and physical environments are similar as the number of active cores increase from one, to two, four and six. As shown in the graph below, the scalability data indicates that both environments can achieve proportionally equivalent throughput gains with additional CPU cores and associated caches.

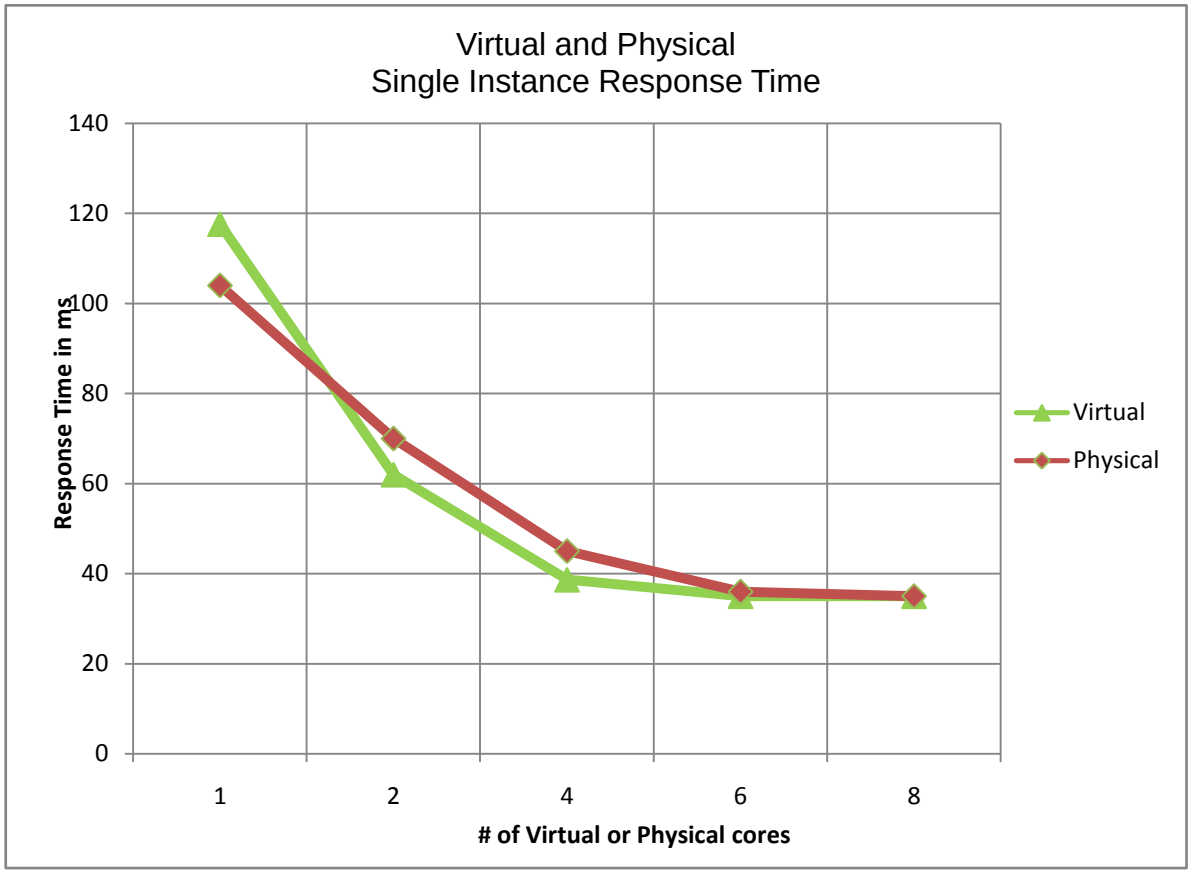
**Figure 7.** Scalability of virtual and physical CPUs




## Response times

The amount of time it takes to complete one transaction decreases as the number of CPUs increase. The response time in the virtual environment decreases from 118ms with 1 CPU to 62ms with 2 CPUs. Figure 8 shows the response times with various physical and virtual CPU allocations. Depending on your response time requirements, the number of CPUs can be increased to match the specific requirements.

**Figure 8.** Comparing response times




# WebSphere with multiple instances

The following section evaluates the performance results for various multi-instance and multi-VM scenarios. The VMware ESX 4.0 configurations include virtual machines with two, four and eight virtual CPUs.

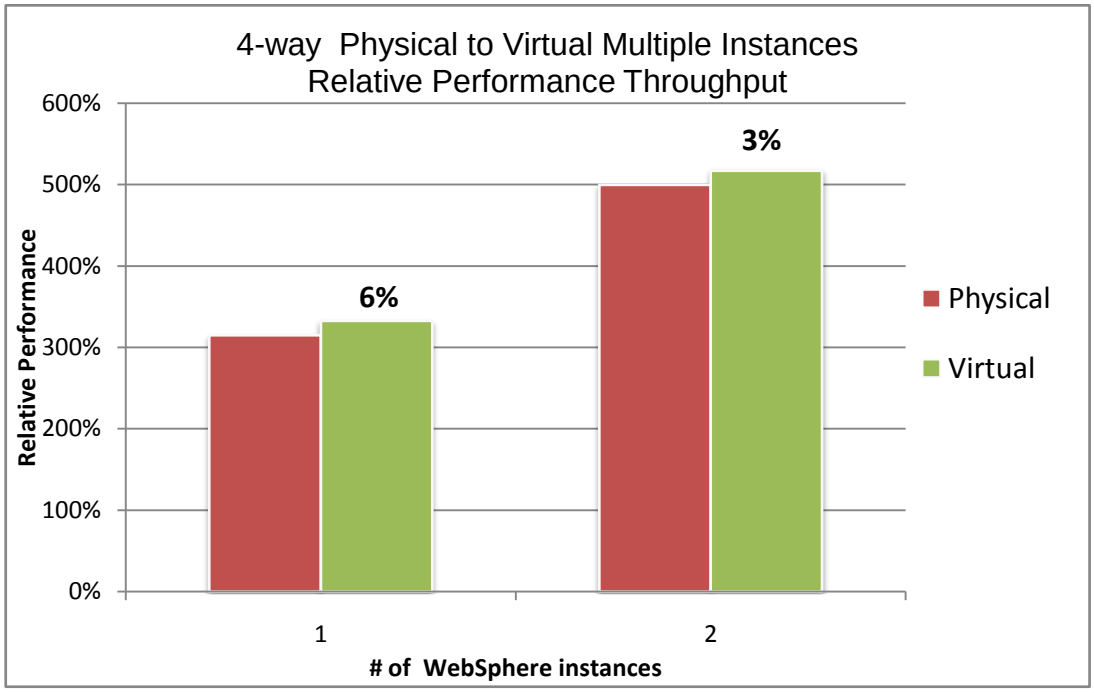
Each VM has a single instance of WebSphere Application Server. The operating system and WebSphere configuration are the same in both virtual and physical environments.

## 4-way physical and virtual comparison

This section compares the physical and virtual performance with four CPUs per WebSphere instance. Figure 9 shows the relative throughput in these cases. With one WebSphere instance, the physical configuration used 4 cores, while the virtual configuration used one VM with 4 vCPUs. With two WebSphere instances, the physical configuration used 8 cores, while the virtual configuration used two VMs with 4 vCPUs each.

When running with one instance, the virtual configuration outperformed the physical by 6%. With two instances, which used all eight cores available on the server, the virtual configuration outperformed the physical by 3%.

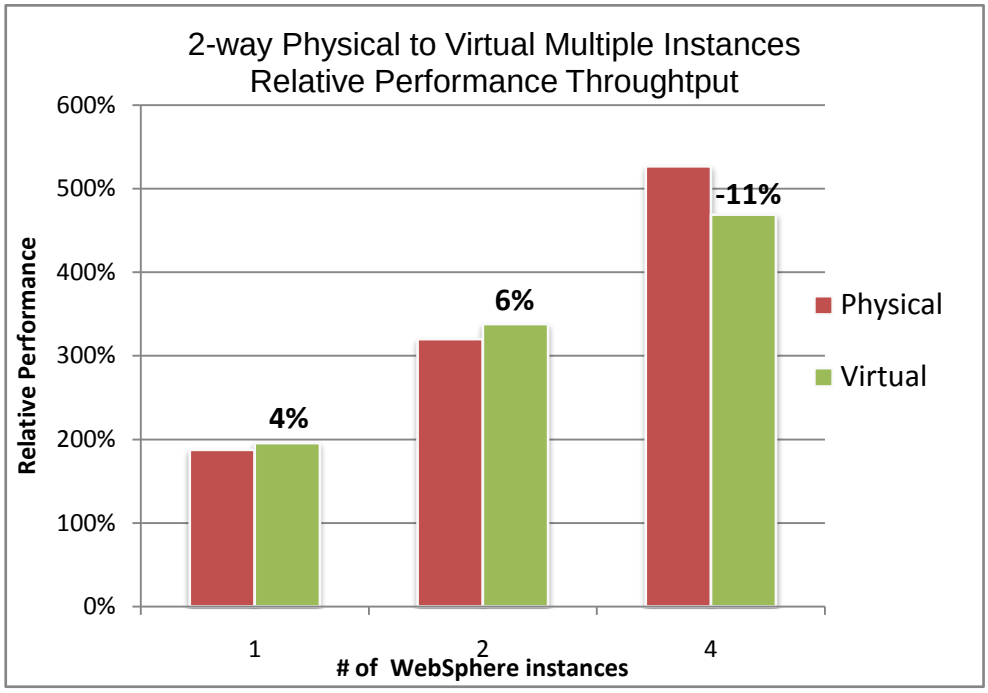
**Figure 9.** 4 core physical to virtual relative throughput comparison




## 2-way physical and virtual comparison

This section compares the physical and virtual performance with two CPUs per WebSphere instance. Figure 10 shows the relative throughput in these cases. With one WebSphere instance, the physical configuration used 2 cores, while the virtual configuration used one VM with 2 vCPUs. With two WebSphere instances, the physical configuration used 4 cores, while the virtual configuration used two VMs with 2 vCPUs each. With four WebSphere instances, the physical configuration used all eight cores, while the virtual configuration used four VMs with 2 vCPUs each. When running with one instance, the virtual configuration outperformed the physical by 4%. With two instances the virtual configuration outperformed the physical by 6%. With four instances, which used all eight cores available on the server, the physical configuration outperformed the virtual by 11%.

**Figure 10.** 2 core physical to virtual relative throughput comparison



# Summary

Virtualization is an excellent way to increase server utilization. However, care should be taken on how the CPU and memory resources are allocated to the virtual machines. Performance might degrade with improper allocation of resources.

The system resources should be monitored to check if swapping is taking place on the virtual machine. If so, increase the memory allocation for the virtual machine. Over committing the memory on the virtual machines will degrade the performance considerably. Using the vmxnet2 network adapter for the virtual machines will provide better performance than the default e1000 network adapter.

As seen in the tests, VMware ESX 4.0 performance is at most 11% less than the physical server. In many cases VMware ESX 4.0 outperforms the physical environment. The gap between the environments can be reduced by increasing the number of instances and CPUs allocated to the virtual machines. Both virtual and physical environments provide incremental performance gains as the number of active CPUs are increased.

# For more information

HP ProLiant servers, http://www.hp.com/go/proliant

IBM WebSphere, http://www.ibm.com/websphere

Red Hat Enterprise Linux, http://www.redhat.com/rhel

SUSE Linux Enterprise, http://www.novell.com/linux

VMware ESX server, http://www.vmware.com/esx

Apache DayTrader 2.0 Benchmark Sample, http://cwiki.apache.org/GMOxDOC20/daytrader.html

To help us improve our documents, please provide feedback at http://h20219.www2.hp.com/ActiveAnswers/us/en/solutions/technical_tools_feedback.html.

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