Virtualization

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The combination of powerful multi-core processors and virtualization technology has enabled organizations to significantly increase the efficiency of their data centers—helping them consolidate physical servers onto multiple virtual machines (VMs) to support increased utilization of hardware resources while still maintaining high levels of performance. Over the past several years, increasing the number of cores in a processor has almost completely replaced increasing clock speed as the primary way to boost processor performance. New six-core Intel Xeon 7400 series processors are an example of this trend, providing higher performance than previous quad-core processors with approximately the same clock speed.

To evaluate these new six-core processors in virtualized environments, in September 2008 the Dell Enterprise Technology Center (Dell TechCenter) team ran a series of tests comparing performance and power consumption on three server configurations running the Microsoft Windows Server® 2008 Hyper-V virtualization platform at 80 percent processor utilization: a Dell PowerEdge R900 server with six-core Intel Xeon processors, the same server with quad-core Intel Xeon processors, and an HP ProLiant DL585 G2 server with quad-core AMD Opteron™ processors. As the results demonstrate, simply upgrading the PowerEdge R900 to six-core Intel Xeon processors helped both increase performance and reduce power consumption, while the PowerEdge R900 with six-core processors provided increased performance and performance per watt over the HP ProLiant DL585 G2.

TEST ENVIRONMENT

The test environment was based on a Dell PowerEdge R900 server and an HP ProLiant DL585 G2 server connected to four Dell EqualLogic™ PS5000XV Internet SCSI (iSCSI) storage area network (SAN) arrays. Each server ran the Microsoft Windows Server 2008 Hyper-V virtualization platform.

Hardware configuration

Figure 1 shows the server configuration used in the test environment. The Dell PowerEdge R900 is a four-socket server that supports Intel Xeon 7300 and Intel Xeon 7400 series processors. In the first round of tests, the Dell TechCenter team configured this server with four quad-core Intel Xeon X7350 processors at 2.93 GHz, for a total of 16 cores; in the second round, the team upgraded the server to four six-core Intel Xeon E7450 processors at 2.4 GHz, for a total of 24 cores. The six-core processors use both level 2 (L2) and L3 cache, providing a high-performance server processor well suited for running many VMs (see Figure 2). The upgrade required only a BIOS update and installation of the new processors; otherwise, the

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system configuration remained the same for all tests: 128 GB of RAM, one additional Intel Gigabit Ethernet network interface card (NIC), and the on-board Dell PowerEdge Expandable RAID Controller (PERC) 6/i for local storage.

The HP ProLiant DL585 G2 is a four-socket server that supports AMD Opteron 8000 series processors. The test team configured this server with four quad-core AMD Opteron 8358 SE processors at 2.4 GHz and 128 GB of RAM. Each processor is coupled with RAM and interconnected through a 1 GHz HyperTransport™ bus. The direct connection of this design keeps the memory close to the processors and can provide faster access than other processor designs.

Figure 3 summarizes the storage configuration used in the test environment. The test team connected each server to a dedicated Ethernet-based iSCSI SAN with a dual-port Intel Gigabit Ethernet PCI Express (PCIe) NIC. Storage consisted of four Dell EqualLogic PS5000XV arrays, each with sixteen 146 GB, 15,000 rpm Serial Attached SCSI (SAS) drives, for a total of 64 disks. The iSCSI SAN used Dell PowerConnect™ 5448 Gigabit Ethernet switches and was configured to route iSCSI traffic through the iSCSI subnet and NICs only, using the remote configuration feature of the EqualLogic Host Integration Tools. The iSCSI software initiator included with Microsoft Windows Server 2008 was used to connect through two NIC ports to the EqualLogic storage.

The test team configured a RAID-10 storage pool with all four EqualLogic PS5000XV arrays and then created eight 200 GB logical units (LUNs) in this pool. EqualLogic storage arrays are designed...
to automatically spread their volumes across the member arrays to help optimize performance; for these tests, the eight volumes were the only active volumes, so they were spread evenly across the member arrays. The test team assigned four volumes to each server, then created VMs and evenly divided them across the volumes.

Software configuration

Each server ran the Microsoft Windows Server 2008 Hyper-V virtualization platform—an optional server role in 64-bit Windows Server 2008 operating systems designed to run on any system with processors that support virtualization. The test team first installed Windows Server 2008 Enterprise x64 Edition on each test server, then added the Hyper-V role to enable the hypervisor. Because a beta version of Hyper-V shipped with the OS, the test team next upgraded to the latest version by applying the Hyper-V update for Windows Server 2008 from the Microsoft Web site.

To compare the performance of each server configuration, the test team created a set of Windows Server 2008 VMs. They first created and installed an initial VM configured with one virtual processor, one virtual NIC, 2 GB of memory, and 18 GB of disk space running the 64-bit versions of the Microsoft Windows Server 2008 OS and the Microsoft SQL Server database platform, with Service Pack 2, then added the Hyper-V integration services to this initial VM. These services include drivers that are optimized for Hyper-V VMs.

To complete the setup, the test team loaded the open source Dell DVD Store test application, which simulates an online e-commerce application as users log in to a store; search for DVDs by actor, title, or category; and purchase DVDs. The software includes database creation and indexing scripts, stored procedures, data loading scripts, and client simulation driver programs. For these tests, the team loaded the medium-size version of the DVD Store database—approximately 1 GB of data—using the scripts included with the DVD Store kit.

The test team replicated the initial VM by using sysprep to first prepare the virtual hard disk for replication and then perform a simple file copy. The virtual disks were evenly distributed across the LUNs assigned to each server on the Dell EqualLogic arrays. To complete the VM replication, the test team created and configured new VMs to use the new virtual disks.

Figure 3. Storage configuration in the test environment

<table>
<thead>
<tr>
<th></th>
<th>Dell EqualLogic PS5000XV</th>
</tr>
</thead>
<tbody>
<tr>
<td>iSCSI connections</td>
<td>Three 1 Gbps connections per array</td>
</tr>
<tr>
<td>Disks</td>
<td>Sixteen 146 GB, 15,000 rpm SAS drives per array</td>
</tr>
<tr>
<td>Storage pool</td>
<td>RAID-10 with all four arrays as members</td>
</tr>
<tr>
<td>LUNs</td>
<td>Eight 200 GB LUNs, with four assigned to each server</td>
</tr>
</tbody>
</table>

TEST RESULTS: PERFORMANCE AND POWER CONSUMPTION

The performance of a virtualized server can be measured in two components: sizing or capacity, which indicates the number of VMs that a server can support, and the aggregate performance that those VMs can achieve. In addition to performance, however, organizations should also consider power consumption when evaluating a server. Power consumption depends on multiple factors, including amount of RAM, number of PCI adapters, number of internal disks, and load level.

The Dell TechCenter team used the ds2sqlserverdriver.exe program included with the DVD Store software to run the workload against multiple VMs simultaneously. This driver program connects directly to the database server and simulates user activity.

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to the SQL Server database and simulates the load that an application server would create against the database when users log in, browse, and purchase items from an online store. For these tests, each VM was driven by an instance of the driver program with 10 threads and a delay time of 0.2 seconds.

To simulate the way enterprises typically run applications on VMs in a production environment, the test team increased the number of VMs through successive rounds of testing until processor utilization for the entire physical server was approximately 80 percent—a reasonably high level of usage that still allowed for workload spikes. The team calculated the utilization by averaging the values from the Hypervisor Logical Processor % Total Run Time performance counter during each test. A power meter attached to the servers measured power consumption during the tests.

Figure 4 summarizes the results, including the number of VMs supported by each server configuration, total performance of all VMs in orders per minute (OPM), average power consumption, and performance per watt. These results demonstrate that the Dell PowerEdge R900 with six-core Intel Xeon processors offered up to 27 percent performance advantage over the HP ProLiant DL585 G2 with quad-core AMD Opteron processors and up to a 6 percent advantage in performance per watt. In contrast, although the PowerEdge R900 with quad-core processors outperformed the HP ProLiant DL585 G2, that increase came with up to a 20 percent disadvantage in performance per watt.

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### Efficient, High-Performance Virtualization

The combination of high performance and efficiency provided by the Dell PowerEdge R900 server makes it well suited for Microsoft Hyper-V virtualization. However, as the Dell TechCenter tests demonstrate, the type of multi-core processors can also play a key role in overall evaluation: the Dell PowerEdge R900 with six-core Intel Xeon processors provided a significant boost in performance while reducing power consumption compared with the same server with quad-core Intel Xeon processors, and provided higher performance and higher performance per watt compared with an HP ProLiant DL585 G2 server with quad-core AMD Opteron processors. For organizations considering upgrading to six-core processors, these results can provide an idea of the potential advantages they can offer in Hyper-V virtualized environments.

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**Figure 4.** Workload performance results for each server in the test environment at 80 percent processor utilization

<table>
<thead>
<tr>
<th></th>
<th>Number of VMs</th>
<th>Performance</th>
<th>Performance advantage compared with HP server</th>
<th>Average power consumption</th>
<th>Performance per watt</th>
<th>Performance-per-watt advantage compared with HP server</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP ProLiant DL585 G2</td>
<td>26</td>
<td>58,355 OPM</td>
<td>—</td>
<td>720 W</td>
<td>81.0 OPM/W</td>
<td>—</td>
</tr>
<tr>
<td>Dell PowerEdge R900 with quad-core processors</td>
<td>30</td>
<td>62,983 OPM</td>
<td>8%</td>
<td>971 W</td>
<td>64.9 OPM/W</td>
<td>-20%</td>
</tr>
<tr>
<td>Dell PowerEdge R900 with six-core processors</td>
<td>40</td>
<td>74,084 OPM</td>
<td>27%</td>
<td>864 W</td>
<td>85.7 OPM/W</td>
<td>6%</td>
</tr>
</tbody>
</table>