Competitive Power Savings with VMware Consolidation on the Dell PowerEdge 2950

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Section 1

Executive Summary

By consolidating servers coming off lease or near end of life, companies can save over 2 kilowatts by migrating to VMware Virtual Infrastructure 3 running on a Dell PowerEdge 2950 server.

The Dell Enterprise Technology Center measured workloads and power consumption on three older generation servers; a Dell PowerEdge 2650, an HP DL380 G3, and an IBM x345. These servers were then migrated using VMware Converter 3 to see how many of the workloads could be consolidated onto a VMware Infrastructure 3 environment on a Dell PowerEdge 2950 server utilizing Intel Xeon x5355 Quad core processors.

The testing shows that 8 of these workloads can be consolidated, resulting in over 500% power savings while achieving an equivalent amount of performance as the 8 physical servers.

A comparison of consolidating from older HP server hardware to the Dell PowerEdge 2950 using VMware Virtual Infrastructure 3 indicates an average cost savings in power of $5,732.55 over three years.

Section 2

Introduction

Server consolidation is one of the reasons many customers choose to implement virtualization technologies. There are many studies showing the value of consolidating older applications onto a virtualized infrastructure. Many of these studies show comparisons to applications running on Pentium III class servers. While interesting studies, the Pentium III processor is nearing a decade old. A more practical study would be one which looks at servers that are nearing end of life or end of lease.

The testing in this paper focuses on consolidating approximately 3 year old Dell, HP, or IBM servers onto the current Dell PowerEdge 2950 running VMware ESX server virtualization software. The older systems all utilize the Intel Xeon DP processor and the new PowerEdge 2950 uses the quad-core Xeon x5355. This scenario is designed to be representative of servers that are nearing the end of their lifecycle and how their existing workloads can be easily and more efficiently migrated onto a new Dell PowerEdge server.

Each server was tested using the Dell DVD Store test application (available at http://www.delltechcenter.com/page/DVD+Store). The workload on each server was increased until the CPU utilization was approximately 30% to simulate a typical utilization level of servers. Performance was then recorded in terms of orders per minute (OPM) and average system power consumption was measured using an Extech 380803 Power Datalogger.

The physical machines were then migrated, a physical to virtual (P to V) migration, using VMware Converter 3. This ensured that the VM software images were identical to the physical servers.

The VMs were then cloned and powered on one at a time with the DVD Store application running to produce the same number of OPM as observed on the physical server. The number of VMs was increased until the average CPU utilization, as measured on the ESX server, was approximately 80%.

The number of VMs achieved was then recorded and compared to the physical machines by multiplying the corresponding OPM and power measurements by the number of VMs.

Using this test, the Dell Enterprise Technology Center was able to show consolidation of 8 physical servers. The solution achieved approximately the same number of OPMs with a power savings of over 500%, or 2 kilowatts for the entire solution.

Section 3

Testing Methodology

Hardware Configuration

Each of the three older servers were configured as similarly as possible. Table 1 shows the hardware configuration used for each server. Hyperthreading was disabled on all of the servers. The latest version of firmware and drivers available on the respective vendors websites for all systems and components were downloaded and installed on each server. All drives for each server were configured in a RAID-5 array with no hot spare.

The server used for consolidation was the Dell PowerEdge 2950. This is a dual-socket server that supports Intel® Xeon® 5000, 5100, and 5300 series processors. The Dell test team configured the PowerEdge 2950 with two quad-core Intel Xeon X5355 processors at 2.66 GHz. The quad-core Intel Xeon X5355 has a total of 8 MB L2 cache, with 4MB shared by two cores. The Xeon X5355 has a frontside bus speed of 1333MHz.

	Dell PowerEdge 2650	IBM x345	HP DL380 G3	Dell PowerEdge 2950
Processors	Two Intel Xeon DP	Two Intel Xeon DP	Two Intel Xeon DP	Two Intel Xeon x5355 Quad Core
Processor Speed	3.06 GHz	3.06 GHz	3.06 GHz	2.66 GHz
Processor Cache Size	1 MB	1 MB	1 MB	8 MB
Front Side Bus	533 MHz	533 MHz	533 MHz	1,333 MHz
Memory	4 x 512MB PC2100 DIMMs	4 x 512MB PC2100 DIMMs	4 x 512MB PC2100 DIMMs	6 x 2GB PC5300 DIMMs
RAID	PERC 3/Di	ServeRAID 5i	HP Smart Array 5i+	PERC 5/i
Disk Drives	3 x 73 GB 10K RPM SCSI 3.5”	3 x 73 GB 10K RPM SCSI 3.5”	3 x 73 GB 10K RPM SCSI 3.5”	5 x 73GB 10K RPM 2.5” SAS
Power Supplies	Dual Redundant	Dual Redundant	Dual Redundant	Dual Redundant

Table 1 - Server Hardware Configurations

Software Configuration

Each of the physical servers was installed with Windows 2000 Server SP4. The database used to run the DVD Store application was SQL Server 2000 Enterprise Edition SP4.

Dell DVD Store Test Application

To help evaluate the performance and scalability of Dell PowerEdge servers, Dell engineers created the DVD Store Version 2 (DS2) e-commerce test application, which has been featured in various Dell studies and demonstrations. The DS2 workload may be used as a database test or as a stress tool. This application includes a back-end database component, a Web application layer, and driver programs. DS2 was designed with a database component as well as the mid-tier application and includes advanced database features such as transactions, stored procedures, triggers, and referential integrity.

For more information on the DVD Store, or to download, please visit this URL, http://www.delltechcenter.com/page/DVD+Store

VMware Converter 3

To ensure that the software stack remained consistent between the physical and virtual servers, the Dell Test team used VMware Converter 3 to migrate the physical machines to VM images on the ESX Server.

VMware Converter can be run on a wide variety of hardware and supports most commonly used versions of the Microsoft Windows operating systems. With this robust, enterprise class migration tool it is possible to:

- Convert local and remote physical machines into virtual machines.
- Complete multiple conversions simultaneously with a centralized management console and conversion wizard.
- Convert other virtual machine formats such as Microsoft Virtual PC and Microsoft Virtual Server or backup images of physical machines such as Symantec Backup Exec LiveState Recovery or Ghost 9 to VMware virtual machines.
- Restore VMware Consolidated Backup (VCB) images of virtual machines to running virtual machines.
- Clone and backup physical machines to virtual machines as part of a disaster recovery plan.

During the migration process, the Dell test team did a screen capture and turned it into a demonstration of the VMware Converter 3 product. To view this demo please visit this URL, http://www.delltechcenter.com/page/Demonstrations

Section 4

Test Results

Physical Servers

Using the DVD Store, the workload on each server was increased until the CPU utilization was approximately 30%. The parameters were then compared for the runs on each server, and one set was chosen to use for all servers.

The parameters for DVD Store that yielded the closest CPU Utilization for all servers were 2 threads and a think time of .015. The DVD Store was then run 3 times for one hour each on each physical server and the results averaged. The power was also recorded for each run.

The following chart shows the results for the physical servers

	DS2 Score (OPM)	Power Draw (Watts)	Avg CPU Util (%)
Dell PE 2650	3041.33	290.67	30.82
HP DL380 G3	2858.00	346.00	33.20
IBM x345	2450.67	278.67	28.91
Average	2783.33	305.11	30.98

Table 2 - Results for Physical Servers

Even though the purpose of this paper is not to compare the physical servers, it is interesting to note that the Dell machine had the best performance, and the HP machine had the highest power consumption.

The following graph shows an example from the Dell PowerEdge 2650 of the CPU utilization measured on the server

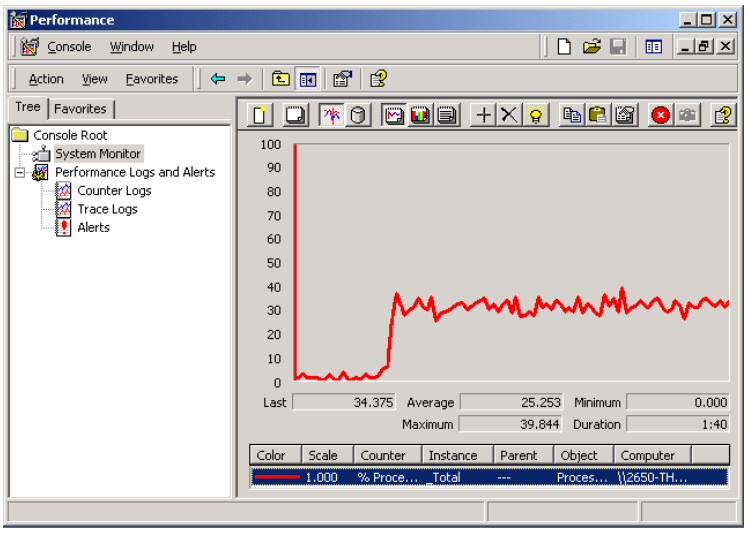

Figure 1 - Performance Monitor on Dell PE 2650

Virtualized Servers

Each physical server was then migrated to a VM on the Dell PE 2950 using VMware Converter 3. Testing was then performed on each VM to see what DVD Store parameters would yield approximately the same OPM score on the VM as was achieved on the physical platform. After being migrated to VMs, any performance differences due to hardware was eliminated. This was observed by the fact that running the DVD Store on any of the VMs that were migrated from the different physical servers yielded the same OPM.

The average OPM across the three physical servers of 2,814 was used as the baseline performance number that the VMs had to achieve in the consolidation test. Through a few rounds of testing it was then determined that using DVD Store parameters of n_threads=2 and think_time=0, yielded an approximate OPM of 2,800 for the VMs.

The number of these VMs running on the Dell PE 2950 was then increased until the CPU Utilization measured on the ESX Server was approximately 80%. The figure below shows a screenshot of the CPU utilization measured on the Dell PE 2950 taken during the tests.

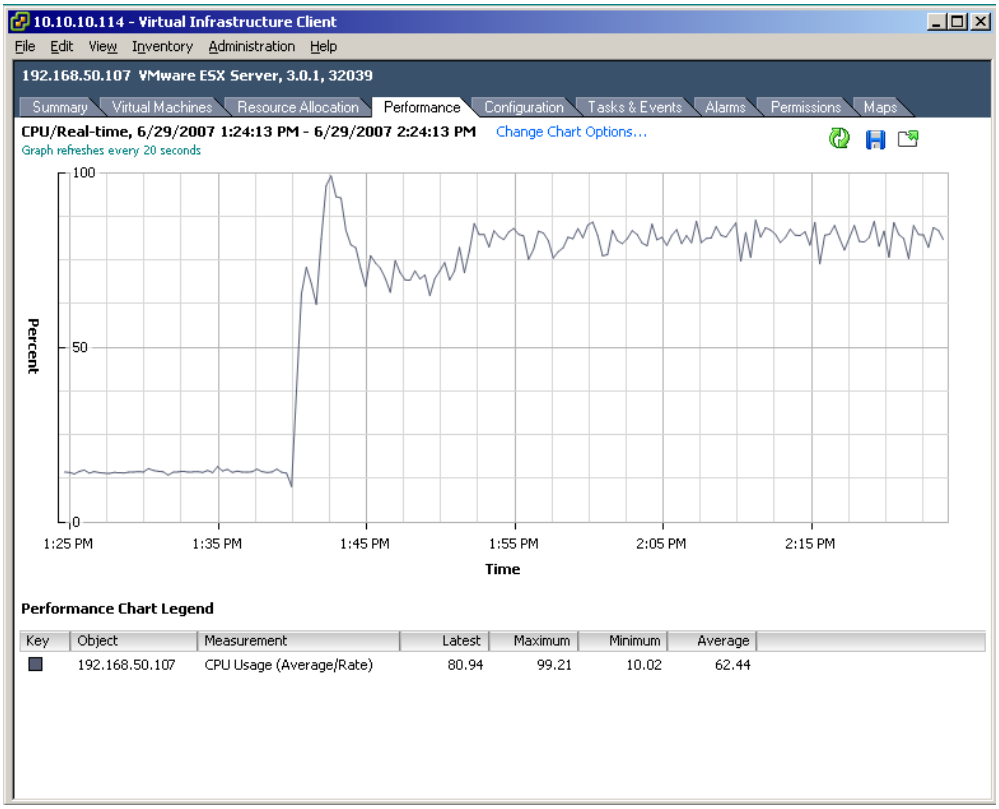

Figure 2 - CPU Utilization on the Dell PE 2950

Using this methodology, the Dell test team was able to consolidate 8 workloads to VMs on the single Dell PE 2950. Extrapolating the results from the physical servers shows that 8 physical servers would achieve an OPM of 22,508. The 8 VMs achieved an OPM of 22,065, which is within 2% of the performance of the physical platform.

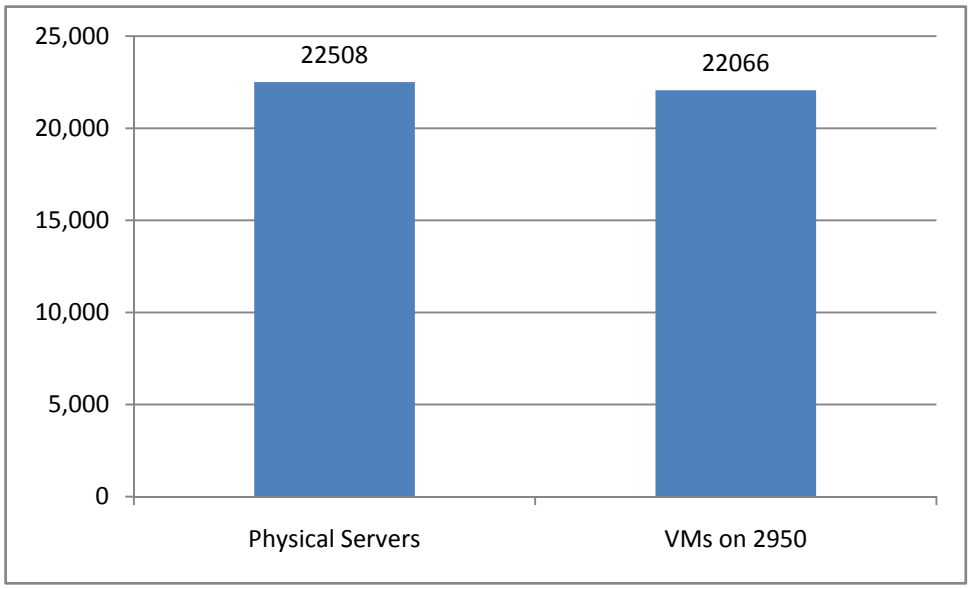

Figure 3 - OPM Measurement

On average, the extrapolation of the physical servers had a combined power draw of 2,460 watts. The power draw of the virtualized environment with the Dell PE 2950 was 440 watts. This represents a savings of over 2 kilowatts or 5.6 times more energy efficient than the physical servers.

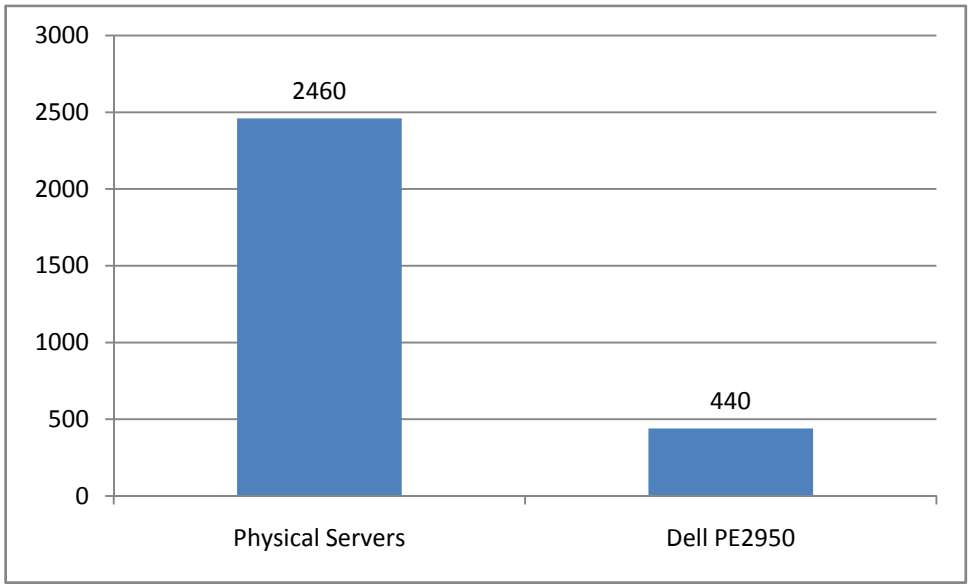

Figure 4 - Wattage measurement

If we compare the HP DL380 G3 to the Dell PE 2950, the power savings is 6.3X. The HP DL380 G3 measured 2,768 watts during the test, compared to the 440 watts measured on the Dell PE 2950.

Calculation of Energy and Money Saved

Using the HP DL380 G3 as an example comparison, the savings is 2,328 watts as compared to the same solution virtualized on the Dell PowerEdge 2950. Power is sold by the kilo watt hour (kWh). Assuming that this solution will exist for an average 3 year life of a server, the total kWh can be calculated.

2.328 kilowatts X 3 years X 365 days/year X 24 hours/day = 61179.84 kWh

Using the latest average price for commercial electricity from the US Department of Energy [1], which is 9.37 cents per kWh as of April 2007, the total costs saved from using this solution can be calculated.

61,179.84 kWh X $0.0937 per kWh = $5,732.55

This is the average cost of electricity across the entire US. Using the information from the government website, cost savings for different regions of the country can be determined.

[1] DOE Average pricing data for electricity in the US - http://www.eia.doe.gov/cneaf/electricity/epm/table5_6_a.html

Section 5

Conclusion

By consolidating servers coming off lease or near end of life, companies can save over 2 kilowatts by consolidating eight typical three-year old servers to VMware Virtual Infrastructure 3 running on a Dell PowerEdge 2950 server.

The average costs in power savings is over $5,700 when compared to a consolidation from the HP DL380 G3. This savings is achieved while still maintaining an equivalent level of performance as the existing solution.

Using VMware Converter 3, it is simple and easy to migrate a server to a VM without disrupting the existing environment. This VM can then be tested using the same methodology in this paper to see the results.