

Red Hat® Enterprise Virtualization 3

Study finds substantial increase in middleware performance when migrating from previous-generation bare metal to virtualized environments.

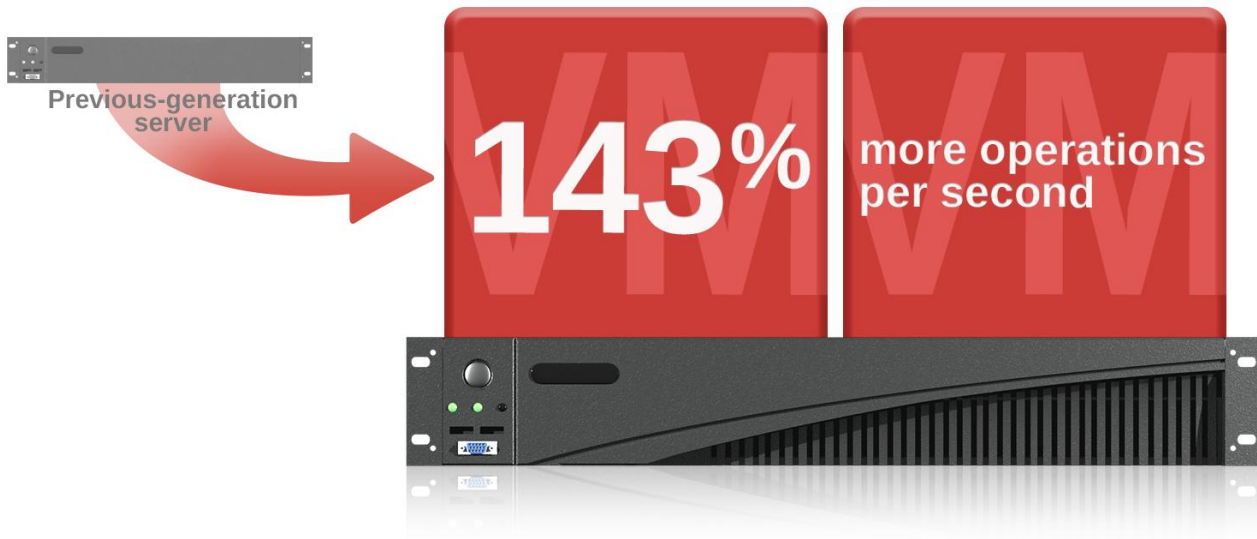


Consolidating older servers to newer Intel® Xeon® processor-based platforms that employ power-saving capabilities and faster processors with more cores can be an excellent strategy for reducing data center costs. However, to realize these cost savings, application owners must limit the retuning and testing costs of porting applications. Consolidating to a virtualized environment that supports virtual machines (VMs) running the original operating system can be an ideal and easy-to-implement solution.

In our labs, we virtualized a middleware application running on Red Hat® Enterprise Linux® hosted on a previous-generation bare-metal server onto a Red Hat Enterprise Virtualization VM on a two-socket server powered by Intel® Xeon® processors E5-2690. The migration caused minimal disruption and the single VM increased performance over the previous-generation server by 90.3 percent, with headroom to host additional applications.

When we added a second VM to take advantage of the headroom, each VM still outperformed the previous-generation server, indicating that moving previous-generation servers to VMs backed by Intel® Xeon® processors E5-2690 can significantly improve overall Java performance while providing the benefits of both virtualization and new server technologies.

To exploit the spare headroom, a second VM was added that performed the same work. Both VMs outperformed the previous-generation server.



MIGRATE MIDDLEWARE ONTO RED HAT ENTERPRISE VIRTUALIZATION 3.1 VIRTUAL MACHINES POWERED BY THE INTEL® XEON® PROCESSOR E5-2690

CIOs look to save money. Current-generation servers using Intel® Xeon® processor E5-2600 products can replace several older servers while offering greater performance. Application owners, however, may be reluctant to consolidate several applications currently running on several independent servers. One concern is whether applications would be able to run side by side without reconfiguration, and another is that a single runaway application could take down or affect the other applications. The Red Hat Enterprise Virtualization environment addresses these risks by allowing you to migrate each application to its own independent virtual machine.

WHAT WE FOUND

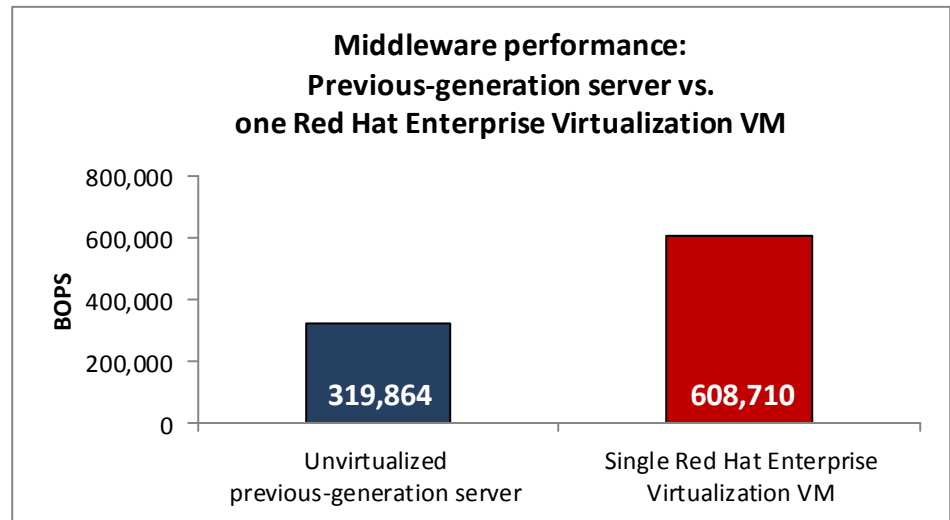
We compared the performance of a middleware application running unvirtualized on an older Intel® Xeon® processor E5500 series platform with the same application and workload running on a similarly sized Red Hat Enterprise Virtualization VM on a newer Intel® Xeon® processor E5-2600 series platform. We used a middleware benchmark tool that measures the number of business operations per second (BOPS) an application delivers under various workloads.

Migrating the middleware application and its workload from the original physical server to the Red Hat Enterprise Virtualization VMs was straightforward: we installed the original OS, Red Hat Enterprise Linux 5.8, on the VM, and copied the

application and its workload configuration to the new virtual host. It ran well without any configuration changes or retuning.

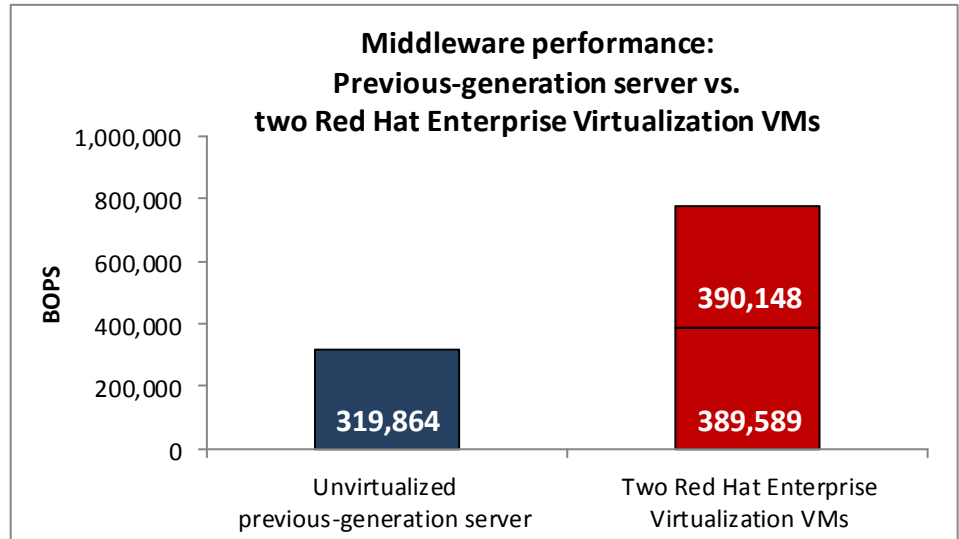
As Figure 1 shows, the Red Hat Enterprise Virtualization VM backed by the new Intel® Xeon® processor E5-2690 delivered 90.3 percent greater application performance than the bare-metal previous-generation server. Furthermore, that performance boost occurred while using less than one-half of the CPU and RAM resources of the new, more powerful server. In contrast, the same application running on the older server consumed the entire CPU resource.

Figure 1: Business operations per second that two identical middleware applications achieved when using all available server/VM resources (each server and VM had 16 cores and 24 GB of RAM). The application running on the Red Hat Enterprise Virtualization VM outperformed the one on the physical server by 90.3 percent.



Next, we investigated how effectively Red Hat Enterprise Virtualization could use the excess CPU capacity, or headroom, by adding a second identical but independent middleware VM. As Figure 2 shows, each of the two simultaneous applications in Red Hat Enterprise Virtualization VMs delivered an average of 21.9 percent greater performance than the original application, and combined to deliver 143.8 percent greater performance than the original application.

Figure 2: Business operations per second achieved by one instance of a middleware application on a previous-generation server and two instances in Red Hat Enterprise Virtualization VMs. Each application in the Red Hat Enterprise Virtualization VM outperformed the one on the physical server by an average of 21.9 percent, and the pair’s total performance was 143.8 percent greater.



For system configuration information, see [Appendix A](#). For step-by-step details on how we tested, see [Appendix B](#).

RESULTS IN DETAIL

We started with a white-box, bare-metal server as our previous-generation system. The system had two quad-core, hyper-threaded Intel® Xeon® processors E5540 with 24 GB of RAM. The Red Hat Enterprise Virtualization Hypervisor 3.1 system was a white-box server with two eight-core hyper-threaded Intel® Xeon® processors E5-2690 with 64 GB of RAM. Each Red Hat Enterprise Virtualization VM, like the previous-generation system, had 16 virtual cores and 24 GB of RAM.

The middleware workload used two JVM SPECjbb2005 instances (see the next section for more on SPECjbb2005). A higher SPECjbb2005 score indicates the server is able to handle more Java requests and thus deliver greater middleware throughput and computations.

Figure 3 shows the Java middleware performance for the unvirtualized previous-generation server and for one and two VMs running on the server with the Intel® Xeon® processors E5-2690.

Middleware system	Unvirtualized previous-generation server	1 Red Hat Enterprise Virtualization VM	2 Red Hat Enterprise Virtualization VMs
SPECjbb2005 score (BOPS)	319,864	608,710	389,589
			390,148
Total system performance	319,864	608,710	779,737

Figure 3: SPECjbb2005 scores for the three middleware configurations we tested. Higher scores are better.

WHAT WE TESTED

Middleware workload

SPECjbb2005 is an industry-standard benchmark created by the Standard Performance Evaluation Corp. (SPEC®) to measure a server's Java performance. (Note: SPEC and the SPECjbb2005 are trademarks of the Standard Performance Evaluation Corporation.) SPEC modeled SPECjbb2005 on the three-tier client/server architecture, with the middle layer as the primary focus. According to SPEC, "Random input selection represents the first (user) tier. SPECjbb2005 fully implements the middle-tier business logic. The third tier is represented by tables of objects, implemented by Java Collections, rather than a separate database."¹

SPECjbb2005 utilizes multiple special data groups and multiple threads as it runs. Each data unit is a "warehouse," a roughly 25MB collection of data objects. Each thread represents an active user posting transaction requests within a warehouse. The benchmark run begins with one warehouse and then increases the number of warehouses; its goal is to saturate the server's processor capacity. As the number of warehouses increases, so does the number of threads. The benchmark's metric portrays the server's throughput in business operations per second or SPECjbb2005 BOPS. A higher number of SPECjbb2005 BOPS is better. (For more information on SPECjbb2005, go to <http://www.spec.org>.)

About Intel® Xeon® processor E5-2600 series

According to Intel, the Intel® Xeon® processor E5-2600 product family delivers leadership performance, excellent data center performance per watt, and breakthrough I/O innovation and trusted hardware security features to enable IT to scale. These processors power not only servers and workstations, but also storage and communication systems.

Supporting up to eight cores per processor and up to 768 GB of system memory, the Intel® Xeon® processor E5-2600 product family increases performance by up to 80 percent compared to the previous generation Intel® Xeon® processor 5600 series.

Like all recent Intel® Xeon® processors, the Intel® Xeon® processor E5-2600 product family features Intel® Virtualization Technologies (VT). Intel® VT provides hardware assists, which increase performance and scalability and reduce CPU overhead.

Learn more about Intel® Xeon® processor E5-2600 series at http://download.intel.com/newsroom/kits/xeon/e5/pdfs/Intel_Xeon_E5_Factsheet.pdf

¹ <http://www.spec.org/jbb2005/docs/UserGuide.htm>

About Red Hat Enterprise Virtualization 3 for Servers

Red Hat Enterprise Virtualization is a complete virtualization management solution for server and desktop virtualization and the first enterprise-ready, fully open-source virtualization platform. It is based on the Kernel-based Virtual Machine (KVM) hypervisor and the oVirt open virtualization management platform, and is designed to run enterprise-grade workloads – whether the virtual machines are running Red Hat Enterprise Linux or Microsoft® Windows®. Red Hat Enterprise Virtualization fully supports Intel® VT, and allows high VM density per physical machine.

Red Hat Enterprise Virtualization features support for high-availability scenarios, live migration, live snapshots, live storage migration and management, network management, and scheduling of system tasks.

IN CONCLUSION

Consolidating to a virtualized environment that supports VMs running the original operating systems can help you save on data center costs and eliminate retuning and testing costs that can be necessary when porting applications. You can reinstall the operating systems, such as Red Hat Enterprise Linux 5.8, on VMs and copy the application software and configuration to them. Selecting a virtual environment that optimizes performance and improves price/performance can lead to significant savings in the data center. You can get better performance and greater efficiency by replacing several older servers with newer ones powered by Intel® Xeon® processors running Red Hat Enterprise Virtualization, reducing the number of servers you need to run and maintain.

In our tests, we easily and successfully migrated a middleware application running on Red Hat Enterprise Linux on a two- to three-year-old bare-metal server to virtual machines on Red Hat Enterprise Virtualization 3 Hypervisor using Intel® Xeon® processors E5-2690.

Not only was there minimal disruption of the workload, but performance increased dramatically—by 90.3 percent when we ran one VM and by 143.8 percent when we ran two VMs.

These findings demonstrate that moving older servers to Red Hat Enterprise Virtualization VMs with newer Intel® Xeon® processors can provide all of the benefits of virtualization while significantly improving application performance.

APPENDIX A – SERVER CONFIGURATION INFORMATION

Figure 4 provides detailed configuration information for the test servers.

System	White box	Previous-generation white box
General		
Number of processor packages	2	2
Number of cores per processor	8	4
Number of hardware threads per core	2	2
CPU		
Vendor	Intel	Intel
Name	Xeon	Xeon
Model number	E5-2690	E5540
Stepping	C1	C0
Socket type	LGA2011	LGA1366
Core frequency (GHz)	2.90	2.53
Bus frequency	8.0 GT/s	5.86 GT/s
L1 cache	32 KB + 32KB (per core)	32 KB + 32KB (per core)
L2 cache	256 KB (per core)	256 KB (per core)
L3 cache (MB)	20	8
Platform		
Vendor and model number	Intel Server Board	Intel Server Board
Motherboard model number	S2600GZ	S5520HC
BIOS name and version	SE5C600.86B.01.02.0003	S5500.86B.01.00.0061
BIOS settings	Default	Default
Memory module(s)		
Total RAM in system (GB)	64	24
Vendor and model number	Samsung M393B1K70BH1-CH9	Kingston KVR1333D3E9S-4GI
Type	PC3-10600R	PC3-10600R
Speed (MHz)	1,333	1,333
Speed running in the system (MHz)	1,333	1,333
Timing/Latency (tCL-tRCD-tRP-tRASmin)	9-9-9-36	9-9-9-36
Size (GB)	8	4
Number of RAM module(s)	8	6
Chip organization	Double-sided	Double-sided
Operating system		
Name	Red Hat Enterprise Virtualization Hypervisor 6.3	Red Hat Enterprise Linux 5.8
Kernel	2.6.32-279.51.el6.x86_64	2.6.18-308.el5 x86_64
File system	ext4	ext3
Language	English	English
RAID controller		
Vendor and model number	Intel Onboard RSTe iastor	Intel Embedded Server RAID II
Firmware version	N/A	A1002251631I

System	White box	Previous-generation white box
Driver version	RHEV 6.3 default	RHEL 5.8 default
Cache size	None	None
Hard drive 1		
Vendor and model number	Intel SSD 710 Series	Western Digital WD160ABYS
Number of drives	1	1
Size (GB)	100	160
RPM	N/A	7,200
Type	SAS	SATA
Ethernet adapter		
First Ethernet adapter		
Vendor and model number	Intel I350 Quad-Port Gigabit Ethernet Controller	Intel on-board NIC S50
Type	Integrated	Integrated
Second Ethernet adapter		
Vendor and model number	Intel Ethernet Server Adapter X520-SR1	Intel Ethernet Server Adapter X520-SR1
Type	PCI-E	PCI-E
Power supplies		
Total number	1	1
Vendor and model number	Intel DPS-750XB A REV:S4F	Delta DPS-1000 HBA
Wattage of each (W)	750	1,000
Cooling fans		
Total number	5	2
Vendor and model number	Nidec UltraFlo V60E12BS1B5-07A014	Dynatron G555
Dimensions (h x w) of each	2-1/2" x 2-1/2"	2-1/2" x 2-1/2"
Volts	12	12
Amps	1.60	0.75
Optical drive		
Vendor and model number	TEAC DV-28S-W	None

Figure 4: System configuration information for the test servers.

APPENDIX B - HOW WE TESTED

We performed SPECjbb2005 tests in three scenarios: the previous-generation white box server (16 cores, 24GB); one Red Hat Enterprise Virtualization VM (16 cores, 24 GB) on the second white box with two Intel® Xeon® processors E5-2690, and simultaneously workloads on two Red Hat Enterprise Virtualization VMs (each with 16 cores, 24 GB) on the second white box.

Installing Red Hat Enterprise Virtualization Hypervisor on the second white box with Intel® Xeon® processor E5-2690

We performed the following steps to install Red Hat Enterprise Virtualization Hypervisor 3.1 on our system under test. For further information, refer to the Red Hat Enterprise Virtualization install documentation located on the installation media.

1. Boot to the Red Hat Enterprise Virtualization Hypervisor standalone installation disk.
2. Allow the installation to automatically boot to begin the installation process.
3. Once the installer loads, select Install Hypervisor.
4. Select the proper disk to install Red Hat Enterprise Virtualization on, and click Continue.
5. Select the disk again, and click Continue.
6. Enter and confirm a new password, and click Install.
7. Once the installation is completed, click Reboot.
8. Log onto the Red Hat Enterprise Virtualization 3 Hypervisor console as admin.
9. Select the Network screen, and enter the server's name.
10. On the Network screen, enter the IP address for the DNS and NTP servers. Often they will both point to the Red Hat Enterprise Virtualization Manager server via the management network (see the next step).
11. On the Network screen, select the network interface for the management network (able to access the Red Hat Enterprise Virtualization Manager server).
12. On the NIC configuration screen, select static IP address and enter the IP address, netmask, and gateway for the hypervisor.
13. Select Apply, and press Enter to save the configuration.
14. Select the Security screen, and select Enable SSH Password Authentication.
15. Select Apply, and press Enter to save the configuration.
16. On the Red Hat Enterprise Virtualization Manager screen, enter the IP address for the Red Hat Enterprise Virtualization Manager (assumed to be on and connected to the hypervisor via the management network).
17. On the same screen, select Verify RHEVM certificate.
18. On the same screen, enter a password (for root access to the hypervisor) in the Password and Confirm Password boxes.
19. Select Apply, and press Enter to save the configuration.
20. On the Status screen, select Logout, and press Enter.
21. At the login prompt, login in as root using the password entered in Step 17.
22. Start the nomad service with the following commands:

```
chkconfig numad on
service numad start
```
23. Log off the server.

Creating Red Hat Enterprise Linux 5.8 guests

Comments on managing the Red Hat Enterprise Virtualization 3.1 Hypervisor from Red Hat Enterprise Virtualization Manager

We assume that Red Hat Enterprise Virtualization Manager has been configured for the hypervisor; that is, within Red Hat Enterprise Virtualization Manager the following tasks have been performed:

1. One local-storage datacenter and cluster has been created.
2. The management network has been associated with the cluster
3. The Red Hat Enterprise Virtualization 3 Hypervisor server has been accepted as a host in this datacenter.
4. The installation DVD image for Red Hat Enterprise Linux 5.8 has been uploaded to an ISO storage domain.

Creating the Red Hat Enterprise Virtualization guests

1. Log into Red Hat Enterprise Virtualization Manager.
2. In the Hosts tab, select New Server.
3. In the New Server Virtual Machine window, name your VM, select the Blank template, enter 24 GB for RAM, select 16 cores as 16 one-CPU sockets, select Red Hat Enterprise Linux 5.8 x86_64 as the operating system, and click OK.
4. A New Virtual Machine – Guide Me window will appear. Click Configure Network Interfaces.
5. In the New Network Interface window, name the NIC, select the VM or management network, select the Red Hat VirtIO type, and click OK.
6. Back at the New Virtual Machine – Guide Me window, select Configure Virtual Disks.
7. In the New Virtual Disk window, enter 40 GB, keep the defaults, and click OK.
8. From the main VM window, right-click on the VM, and select Run Once.
9. On the Run Once Window, attach the Red Hat Enterprise Linux 5.8 x86_64 ISO image to the VM's CD device, and click Run.
10. From the main VM window, select the VM and open its console window.
11. Install and configure Red Hat Enterprise Linux 5.8 following the instructions in section Installing Red Hat Enterprise Linux 5.8 on the previous-generation white box server, below.
12. Repeat steps 2 through 11 for each additional VM.

Installing Red Hat Enterprise Linux 5.8 on the previous-generation white box server or guests

1. Insert the Red Hat Enterprise Linux 5.8 x86_64 install DVD, and boot the server.
2. On the CD Found screen, select Skip, and press Enter.
3. On the first RED HAT ENTERPRISE LINUX 5 screen, click Next.
4. On the Installation Language screen, select English, and click Next.
5. On the Installation keyboard screen, select U.S → English, and click Next
6. On the Installation Number pop-up screen, either enter your subscription number or select skip, then press OK.
7. On the Warning pop-up screen, click Yes to initialize the boot disk.
8. On the disk-partitioning screen, verify that the correct drive is checked, and click Next.
9. On the Warning pop-up screen, click Yes to remove any previous Linux partitions and data on the installation drive.
10. On the Network Devices screen, click Edit to configure the NICs.
11. On the Edit Interface pop-up screen, select IPv4 and Manual configuration, enter the server's IP address and Prefix, and click OK.
12. Back on the Network Devices screen, enter the server's hostname and the IP addresses for its Gateway and DNS server. Click Next.
13. On the Time zone screen, select your time zone, and click Next.
14. On the Administrator Password screen, enter the root password twice, and click Next.
15. On the software-package screen, keep the defaults, and click Next.

16. On the next screen, click Next to partition the drive and begin OS installation.
17. When the install completes, click Reboot.
18. On the Welcome screen, click Forward.
19. On the License Agreement screen, select Yes, and click Forward.
20. On the Firewall screen, select Disabled, and click Forward.
21. On the Warning pop-up screen, click Yes.
22. On the SELinux screen, select Disabled, and click Forward.
23. On the Warning pop-up screen, click Yes.
24. On the Kdump screen, keep the defaults and click Forward.
25. On the Date and Time screen, check the defaults, and click Forward.
26. On the Software Updates screen, choose the option for your subscription status, and click Forward.
27. On the Create User screen, enter the user id, password, and name, and click Forward.
28. On the Sound Card screen, click Forward.
29. On the Additional CDs screen, click Finish to reboot the server.
30. Log into the server as root
31. Configure the server so that the middleware application can use up to 21GB in huge pages (q.v., the memory specification for the JVMs in the `runSPECjbb.sh` script, below):
 - a. Append the following line to the file `/etc/security/limits`.


```
*                - memlock                22020096
```
 - b. Append the following lines to the file `/etc/sysctl.conf`.


```
## allocate approximately 21GB for huge pages, and
## allow the admin group to access them.
vm.nr_hugepages = 10951
vm.hugetlb_shm_group = 0
```
 - c. Activate huge pages by executing the following command.


```
sysctl -p
```
 - d. Log out of this account so that the new resource limit can take affect.

Installing the Middleware application, SPECjbb2005, on the previous-generation server

1. Log onto the previous-generation server with the userid of the application, and go to its top-level directory.
2. Copy the archive to the server and unpack it


```
tar xf SPECjbb2005_v1.07.tar
```
3. Create the shell script `runSPECjbb.sh` (see section Running the Middleware workload, below) into the top-level SPECjbb2005 directory.

Migrating the Middleware application from the previous-generation server to the VMs

We created a tar archive of the SPECjbb directory on the previous-generation server and copied the archive to each VM.

1. Log onto the previous-generation server with the userid of the application, and go to the top-level SPECjbb2005 directory.
2. Create an archive of the middleware application:


```
cd ..
tar czf /tmp/SPECjbb2005_v1.07.tgz SPECjbb2005_v1.07
```
3. Copy the archive to the first VM with scp:


```
scp /tmp/SPECjbb2005_v1.07.tgz <IP Address of VM 1>:/tmp
```
4. Log off the previous-generation server and log onto the first VM with the userid of the application.
5. Change directory to the location of the middleware application.
6. Unpack the archive:


```
tar xzf /tmp/SPECjbb2005_v1.07.tgz
```
7. Repeat steps 3 through 6 for the second VM.

Running the middleware workload

We ran the following script to run the SPECjbb2005 workload on each VM, and on the previous-generation server. The script also collects server performance and resource usage on the VM and hypervisor.

runSPECjbb.sh

```
#!/bin/bash
## Install and run this script in the top-level SPECjbb2005 directory.

## Run two instances of SPECjbb2005

export CLASSPATH=./jbb.jar:./check.jar:$CLASSPATH

# print JVM version information
date
echo JVM classpath = $CLASSPATH
java -version
echo

##### JVM options (Open JDK)
## memory:
jvm_opts1="-Xms10g -Xmx10g -Xmn9g"

## garbage-collection:
jvm_opts2="-XX:+UseParallelOldGC -XX:ParallelGCThreads=8 -XX:+AlwaysPreTouch"

## other:

jvm_opts3="-XX:+AggressiveOpts -XX:+UseBiasedLocking -XX:+UseLargePages \
-XX:LargePageSizeInBytes=2m -XX:+UseCompressedOops -XX:AllocatePrefetchDistance=192 \
-XX:AllocatePrefetchLines=4 -XX:SurvivorRatio=68 -XX:TargetSurvivorRatio=90 \
-XX:LoopUnrollLimit=45"
#####
jvm_opts="$jvm_opts1 $jvm_opts2 $jvm_opts3"
#####

## Gather resource usage every 5 seconds from this server, and the RHEV-H. server.
ssh rhevh3 "vmstat -n 5" > vmstat_rhevh.out &
vmstat -n 5 > vmstat.out &

echo "Starting SPECbb Controller"
java -cp jbb.jar:check.jar -Xms32m -Xmx32m spec.jbb.Controller -propfile SPECjbb.props
&
sleep 5

taskset -c 0-7 java $jvm_opts spec.jbb.JBBmain -propfile SPECjbb.props -id 1 | \
tee multi.1 | egrep "warehouses|throughput" &
taskset -c 8-15 java $jvm_opts spec.jbb.JBBmain -propfile SPECjbb.props -id 2 | \
tee multi.2 | egrep "warehouses|throughput"

pkill -f vmstat; jobs; wait

echo "Run completed"; date
## end of file
```

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