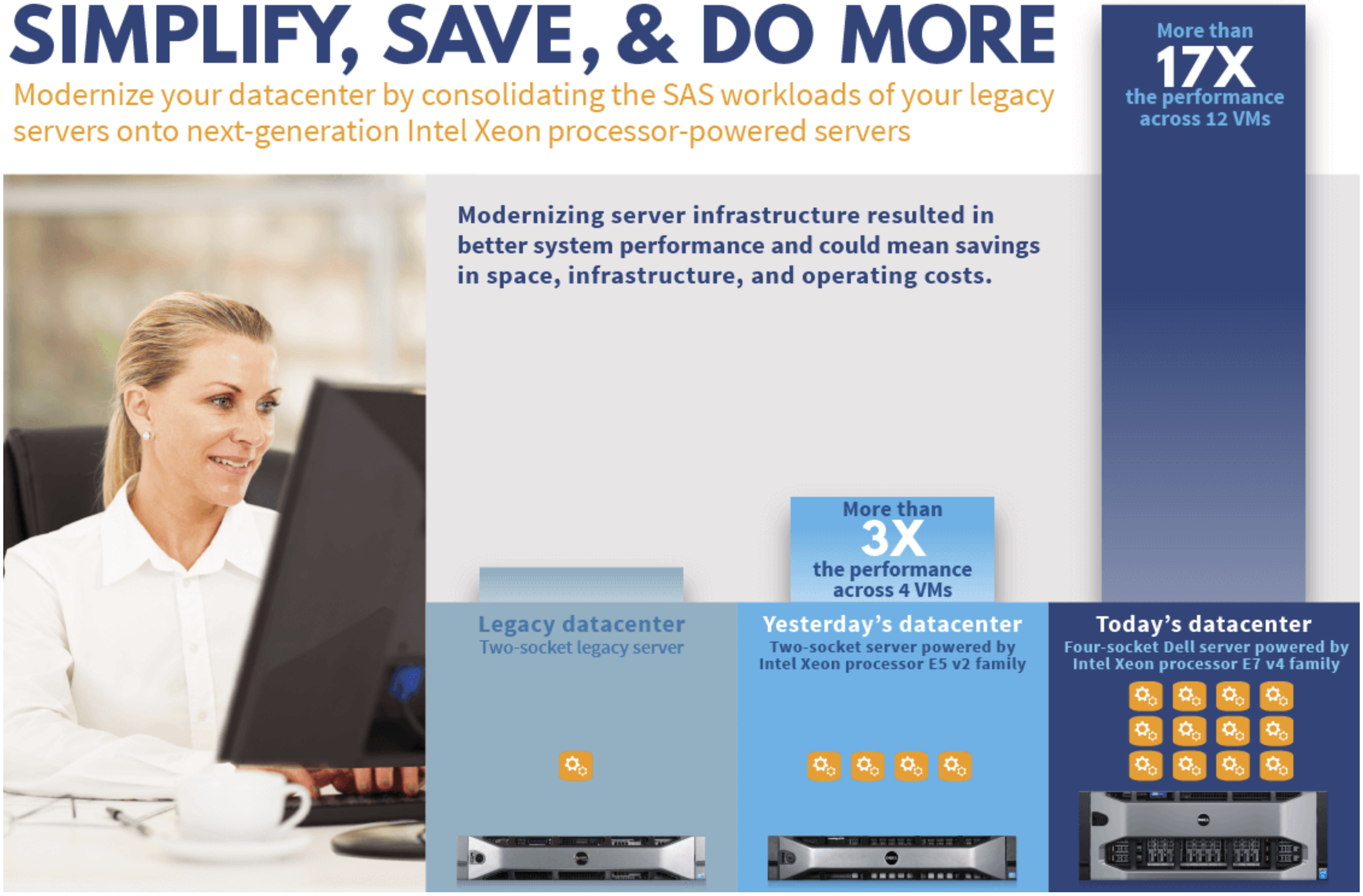
COMPLETE MORE SAS® 9.4 WORKLOADS FASTER WITH SERVERS POWERED BY THE INTEL® XEON® E7 V4 PROCESSOR FAMILY AND THE INTEL® SSD DATACENTER FAMILY

SIMPLIFY, SAVE, & DO MORE

Modernize your datacenter by consolidating the SAS workloads of your legacy servers onto next-generation Intel Xeon processor-powered servers



Is an outdated data center holding back your business? It might be time to modernize and simplify your infrastructure with new systems that can do the work of many older servers. This can translate to savings in space and operating costs.

For businesses running SAS Analytics software, this means virtualizing bare-metal legacy servers onto a newer platform, such as servers powered by the Intel Xeon E7 v4 Processor Family. In the Principled Technologies datacenter, we found that a server powered by Intel Xeon E5-2680 v2 processors with Intel Solid-State Drives (SSD) DC S3710 Series did more than three times the SAS work of a six-year-old legacy server. Powered by Intel Xeon E7-8890 v4 processors, a newer server with Intel SSD DC P3700 Series for PCIe® did more than 17 times the SAS work of the legacy server.[1] What's more, the average run time of each VM on the server powered by Intel Xeon E7 v4 processors completed the SAS multi-user scenario workload in 30 percent less time.

[1] For more information on the SAS 9.4 workload and jobs, see The SAS workload section on page 3 and Appendix A.

JUNE 2016
A PRINCIPLED TECHNOLOGIES TEST REPORT
Commissioned by SAS

SAVING WITH MODERNIZATION

One approach to datacenter modernization combines consolidating resources through virtualization with upgrading to new hardware technology. These improvements can lead to reduced complexities throughout the technology stack, and potentially reduce operational expenses (OPEX). Specifically, consolidating physical hardware in the datacenter typically provides these advantages:

- Reduced power and cooling requirements
- Smaller physical footprints, such as reduced number of racks and servers, which reduces space-related costs
- Lower management costs due to fewer physical servers to manage
- Fewer resources wasted as a result of underutilized hardware

Newer systems generally support substantially more RAM and storage, sometimes in the form of faster SSDs. These technologies are ideal for in-memory data processing and advanced analytics, such as SAS 9.4. The additional RAM and high-performance SSDs work with Intel Xeon E5 v2 and E7 v4 processor technology, and are designed by Intel to deliver fast performance for analytics workloads while increasing datacenter efficiencies.

Moving workloads from legacy servers onto newer servers powered by Intel Xeon E7-8890 v4 processors and Intel SSDs DC P3700 running SAS 9.4, can help in consolidation efforts, contributing to your modernization initiatives. By running more SAS instances and at a faster rate, one newer four-socket server powered by Intel Xeon E7-8890 v4 processors delivered substantially more performance than a single legacy server (see Figure 1). The modernized datacenter lets your business run more data analytics and develop more insightful business intelligence faster.

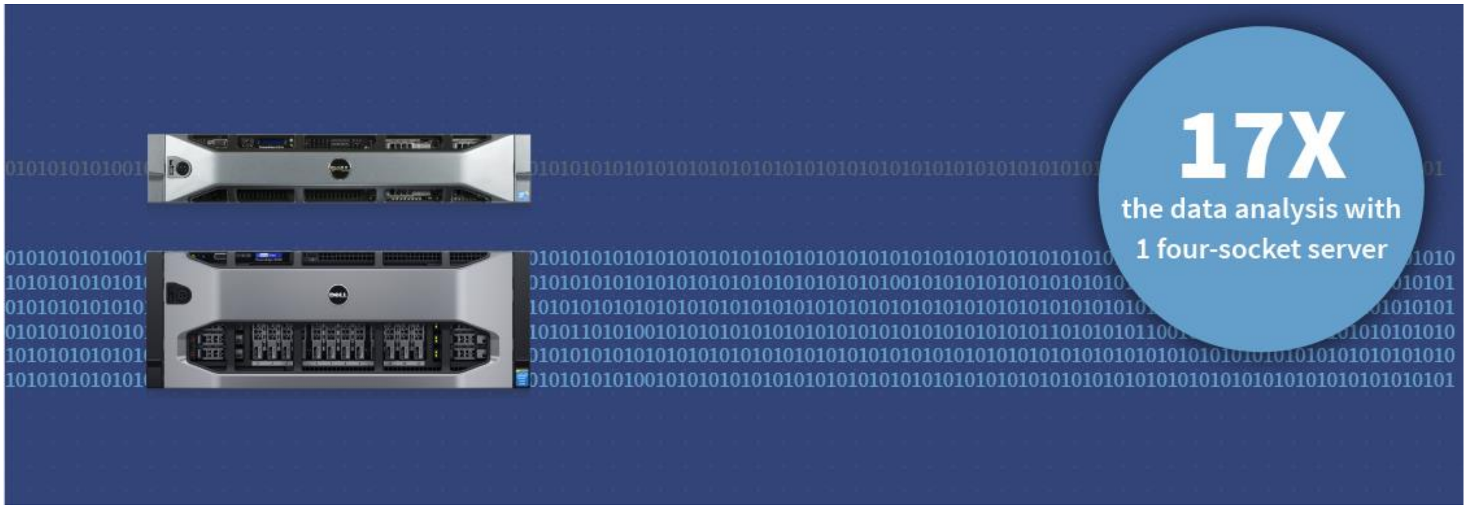


Figure 1: Consolidating workloads is a key to modernization.

THE RIGHT COMBINATION WITH INTEL + SAS

Deployments of SAS 9.4, an environment designed by SAS for business and advanced complex data analytics, can benefit from servers powered by the Intel Xeon E7 v4 Processor Family as processing, data storage, and analysis requirements increase over time. The updated Intel technology in four-socket servers make them well suited to support large-volume, complex data analytics software such as those from SAS.

A server that contains four Intel Xeon E7 v4 processors, provides up to 96 cores and 192 threads, and supports up to 12TB of DDR4 RAM can improve performance and help speed up your SAS workloads. Newer servers can also support increased RAM and faster SSD storage.

In our testing, we took advantage of these RAM and SSD improvements. The servers powered by Intel Xeon E5-2680 v2 processors had 384 GB RAM with 16 DC S3710 SATA SSDs and the servers powered by Intel Xeon E7-8890 v4 processors had 3,072 GB RAM with twelve DC P3700 PCIe SSDs.

For the modern datacenter, servers based on the Intel Xeon E7 v4 processor family also provide new and significant reliability, security, virtualization, and orchestration features. According to Intel, new features of Intel® Run Sure Technology are designed to offer stronger diagnostics and boost system uptime. Intel notes that Intel® Resource Director Technology also provides new features, including Cache Monitoring and Allocation Technologies (CMT, CAT) and Memory Bandwidth Monitoring Technology (MBM).

For more information on components used in our testing, see Appendix A. For detailed hardware configuration information, see Appendix B.

The SAS workload

For our hands-on testing, SAS created and provided us with a multiuser workload to simulate the work of a typical SAS foundation environment consisting of 102 different data analysis tasks. The test scenario was a self-contained SAS 9.4 workload that simulated 30 simultaneous users performing computation-focused jobs, as well as I/O-focused jobs. The data analysis jobs varied from small and lightweight (e.g., simple reporting), to more complex analytics (e.g., regression), to heavy data manipulations (e.g., joins, sorts).

For more information on SAS 9.4, see Appendix A. Appendix C shows how we performed our tests. See Appendix D for VM configuration files.

WHAT WE FOUND

More jobs in less time

Virtualizing meant more work in less physical space—up to 17 times the amount of analytics work was performed simultaneously on one four-socket server powered by Intel Xeon E7-8890 v4 processors as compared to the legacy server.

Running twelve virtual SAS 9.4 instances on the server powered by Intel Xeon E7-8890 v4 processors and PCIe SSDs provided a number of benefits. First, we found that simply virtualizing the SAS workloads increased the amount of jobs that both the two-socket server powered by the Intel Xeon E5-2680 v2 processors and the four-socket server powered by the Intel Xeon E7-8890 v4 processors could perform simultaneously. Simply put, virtualizing meant more work in less physical space, which creates an opportunity to consolidate legacy two-socket servers in your datacenter.

Second, the two-socket server powered by Intel Xeon E5-2680 v2 processors provided over three times the relative performance of the two-socket legacy server, while the four-socket server powered by Intel Xeon E7-8890 v4 processors provided more than 17 times the relative performance. This performance calculation uses the average time to complete the workload to compare the work of each VM. Figure 2 shows the relative performance for our three solutions.

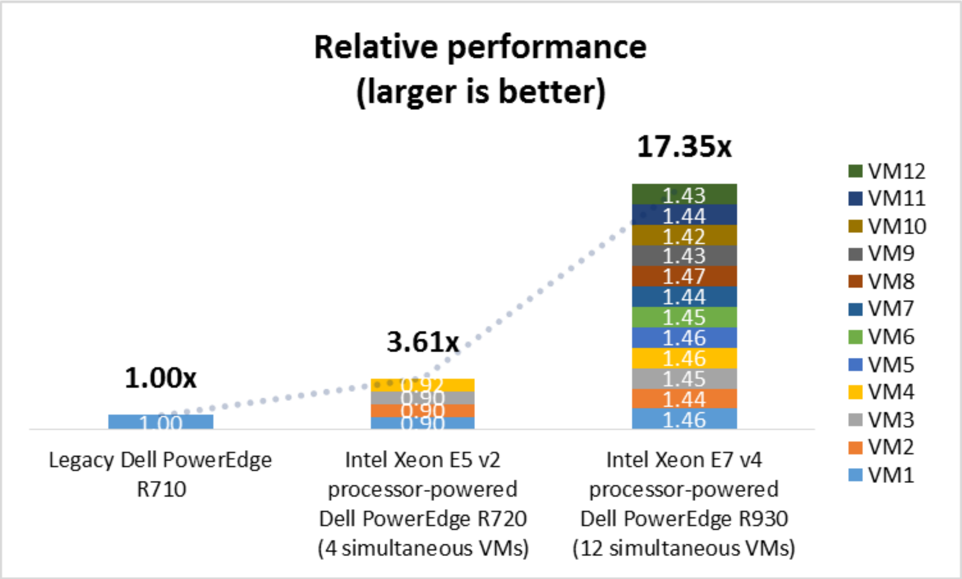


Figure 2: The relative performance of each solution.

The VMs on four-socket server with Intel Xeon E7-8890 v4 processors completed the SAS workload in **30 percent less time**, on average, than the legacy server did.

Keeping those two previous points in mind, the four-socket server powered by Intel Xeon E7-8890 v4 processors provided more than 17 times the relative performance of the legacy server in 30 percent less time. The VMs on the server completed, on average, the concurrent mix of SAS jobs in 114 combined workload hours, compared to 164 combined workload hours on the bare-metal legacy server. The four Intel Xeon E7-8890 v4 processors and the improved I/O performance offered by the Intel DC P3700

PCIe SSDs drove the shorter average time to complete the workload. Improved technology simply meant less time to complete the work.

Figure 3 shows the average time each solution took to complete the SAS multi-user scenario workload. We summed the total elapsed run time for each of the jobs in the workload to get our aggregate time to complete a SAS multi-user scenario.

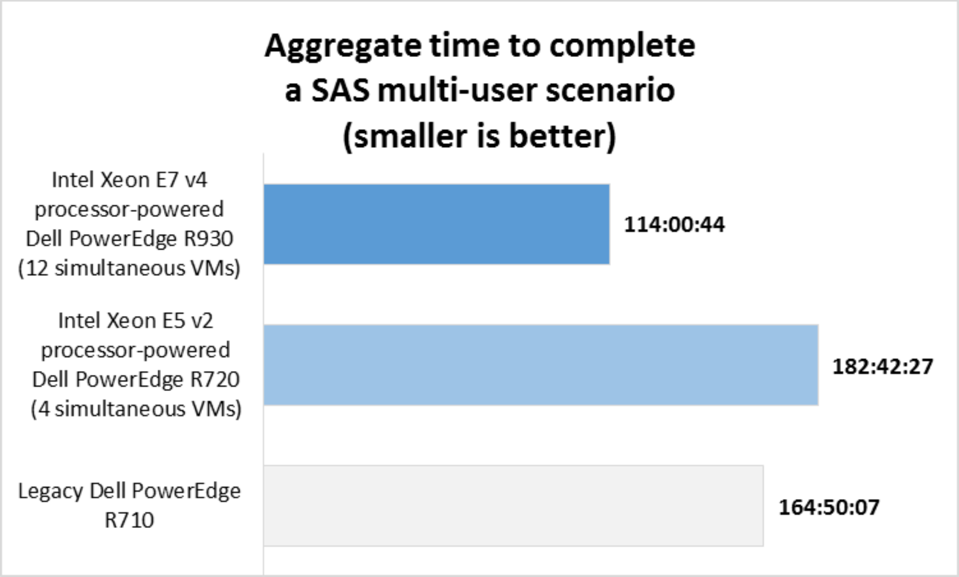
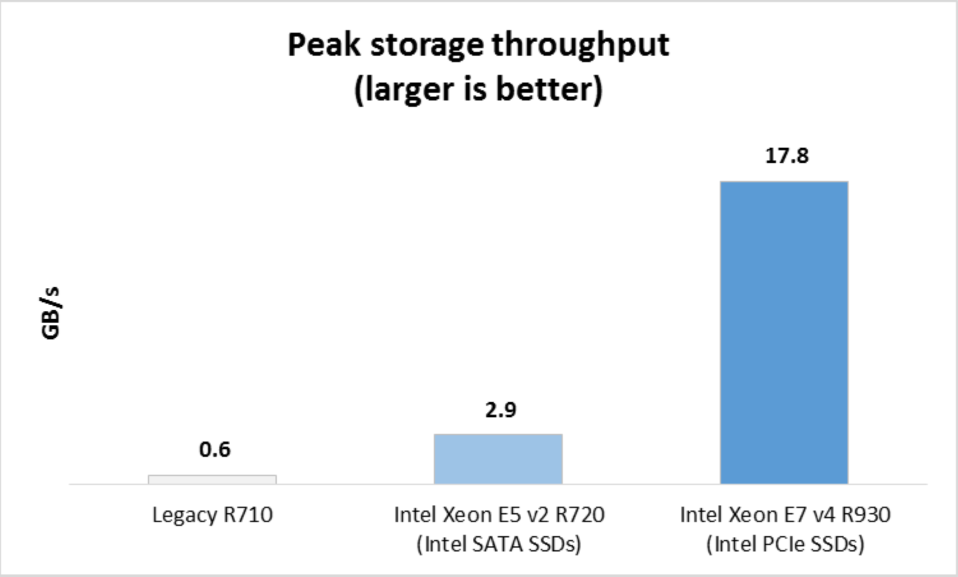


Figure 3: The average aggregate time it took each solution to complete one SAS multi-user scenario in hours:minutes:seconds.

Supporting processor performance with Intel SSD storage

Running SAS 9.4 software on a server without improved storage performance could place limitations on the workloads, leave the processor underutilized, and limit the speed of your SAS jobs. Combining the Intel Xeon E7 v4 processors with the Intel DC P3700 PCIe SSDs allowed us to increase the workload density and get more from our storage subsystem. A higher workload density meant the newer server completed more jobs simultaneously and averaged more jobs per hour. Using the Intel DC P3700 PCIe SSDs improved the outputs from the disk subsystem. Figure 4 shows the peak storage throughput that each solution achieved.

Figure 4: The peak storage throughput in GB per second for each solution.



Your business could see a number of potential benefits by upgrading your legacy servers with hard-disk drives (HDDs) to newer servers with PCIe SSDs:

- Get SAS data sooner and have more time to analyze the data
- Save on management time by having fewer servers to maintain
- Reduce waste by utilizing processor and memory resources more effectively

CONCLUSION

A key to modernizing your datacenter is to consolidate your legacy workloads through virtualization, which can help reduce complexity for your business. Fewer servers require fewer physical resources, such as power, cabling, and switches, and reduce the burden on IT for ongoing management tasks such as updates. In addition, integrating newer hardware technology into your datacenter can provide new features that strengthen your infrastructure, such as RAS features on the processor and storage performance improvements. Finally, using SAS 9.4 ensures that you have the latest features and toolsets that SAS can offer.

Compared to a legacy server, we found that a modern four-socket server powered by Intel Xeon E7-8890 v4 processors with Intel SSD DC P3700 Series provided more SAS instances, more than 17 times the relative performance, and a shorter average time to complete the SAS workload. Consolidating your SAS workloads from legacy servers onto servers powered by Intel Xeon E7 v4 processors and SAS 9.4 can provide your business with the latest hardware and software features, reduce complexity in your datacenter, and potentially reduce costs for your business.

APPENDIX A – ABOUT THE COMPONENTS

About the new Intel Xeon E7 v4 processor family

Intel designed the new Intel Xeon E7 v4 processor family to support demanding enterprise workloads—particularly analytics workloads—by featuring up to 24 cores and 48 threads per socket to offer strong performance and scalability. The Intel Xeon E7 v4 processor family supports up to 24TB DDR4 3DS LRDIMM memory per eight-socket server, which, according to Intel, can provide flexibility and room to grow.

The Intel Xeon E7 v4 processor family supports all the previous reliability, availability, and serviceability features of previous processor releases to support critical workloads. This processor family also includes a new version of Intel® Run Sure Technology with more features, as well as other new security, virtualization, and orchestration features. For more information about the Intel Xeon E7 v4 processor product family, visit www.intel.com.

About the new Intel SSD DC P3700 Series

According to Intel, "[t]he Intel® Solid-State Drive Data Center Family for PCIe brings extreme data throughput directly to Intel Xeon processors with up to six times faster data transfer speed than 6 Gbps SAS/SATA SSDs. The performance of a single drive from the Intel SSD Data Center Family for PCIe, specifically the Intel Solid-State Drive Data Center P3700 Series (460K IOPS), can replace the performance of seven SATA SSDs aggregated through a host bus adapter (HBA) (approximately 500K IOPS)." For more information on the Intel SSD PC P3700 Series, visit www.intel.com/content/www/us/en/solid-state-drives/solid-state-drives-dc-p3700-series.html.

About SAS 9.4

SAS 9.4, the latest release of SAS®9 architecture, uses multicore technologies[2] to deliver processing capabilities through in-database and in-memory analytics. According to SAS, this results "in greater insights more quickly from big data and streaming data." SAS upgraded the architecture with features that meet the needs of traditional on-site SAS deployments and of private and public cloud deployments:

- Choose from many deployment options, including hosted and managed cloud options with SAS Solutions OnDemand
- Use potentially highly scalable environments for testing and development with six new products
- Integrate SAS into your business processes with new APIs, including mobile delivery options for popular smartphones and tablets
- Get monitoring and management capabilities with the new Web-based SAS Environment Manager
- Monitor data according to your schedule (daily, weekly, or monthly) with the new SAS Environment Manager
- Receive alerts, notifications, and data from your servers in the customizable SAS Environment Manager dashboard

[2] We did not fully leverage multi-core/threading technologies with the workload we used in this study, but you could do so with newer SAS 9.4 capabilities, such as in-memory and high-performance analytics.

The second maintenance release, SAS® 9.4 TS1M3 (9.4M3), offers new features and enhancements for products such as SAS/STAT®, SAS® Enterprise Miner™, and SAS/ETS®. For more information on SAS 9.4, visit sas.com/en_us/software/sas9.html.

About the SAS workload

Test details

This benchmark represents a common mixed-analytics scenario consisting of 102 jobs running in a multiuser fashion. SAS designed the workload to simulate real-world SAS batch users and SAS interactive users where an average of 30 simultaneous jobs are executing at any point in time. The only exception is during initial ramp up and ramp down periods at the beginning and end of execution.

Control scripts launch jobs over a set interval (typically one to four minutes), simulating a multiuser environment where users enter and exit from the system. Some periods are heavier than others are during execution, which simulates a typical work environment when some periods are batch-only jobs and other periods consist of batch and interactive jobs consecutively. This ultimately simulates a real-world workload environment with peaks and valleys in system resource utilization.

The analytic workload encompasses a mix of CPU-intensive and I/O-intensive procedures that simulate a large workgroup of 30 simultaneous sessions. Each session runs a combination of the following SAS procedures: Logistic (PROC LOGISTIC), Regression (PROC REG), Generalized Linear Model (PROC GLM), SORT (PROC SORT), MEANS (PROC MEANS), MIXED (PROC MIXED), SUMMARY (PROC SUMMARY), DATA steps, and SQL (PROC SQL).

The benchmark executes 19 different SAS programs with 102 different jobs, each executing one or more times. The benchmark uses different input data for all jobs. Please note that output data volumes were three to four times the input data volumes, as SAS programs typically read and write data in parallel depending on function or analytical procedure invokes.

Data

Characteristics of test data includes the following:

- Individual file sizes up to 146 GB
- File types: text, sas7bdat, binary
- Row counts up to 200 million
- Variable and or column counts up to 12,179
- Binary file usage with EBCDIC and binary data from a mainframe (MVS)
- 500 GB input data

In our testing, we created and ran scripts that ran scripts from SAS, dropped caches, and cleaned up old test results. Then, we initiated performance-monitoring tools on the VMs and the KVM host through our scripts. We started the SAS workload on every VM on the system under test simultaneously.

For the PowerEdge R710, we ran the scripts on the host. We waited for the SAS workload scripts to finish running, and then we stopped all performance monitoring. We then transferred those results and parsed the data.

About the Dell PowerEdge R930

As applications grow more powerful and complex, businesses may seek high-performance servers to take full advantage of those applications. According to Dell, the Dell PowerEdge R930 is designed to handle innovative, high-value enterprise workloads and applications. It offers up to 96 processing cores, up to 96 DIMM slots and space for up to eight 2.5-inch PCIe SSDs and six internal AIC PCIe SSDs. Dell calls the PowerEdge R930 its “most powerful server” and notes that it is “built for scalability and speed” for demanding, mission-critical applications.

For more information on the Dell PowerEdge R930, visit www.dell.com/us/business/p/poweredge-r930/pd.

APPENDIX B – SYSTEM CONFIGURATION INFORMATION

Figure 5 provides detailed configuration information for the test systems.

System	Dell PowerEdge R710	Dell PowerEdge R720	Dell PowerEdge R930
General			
Number of processor packages	2	2	4
Number of cores per processor	4	10	24
Number of hardware threads per core	2	2	2
System power management policy	Maximum performance	Performance	Performance
CPU			
Vendor	Intel	Intel	Intel
Name	Xeon	Xeon	Xeon
Model number	X5570	E5-2680 v2	E7-8890 v4
Platform			
Vendor and model number	Dell PowerEdge R710	Dell PowerEdge R720	Dell PowerEdge R930
Motherboard model number	0YDJK3	0M1GCRX04	0Y4CNCA01
BIOS name and version	6.4.0	2.5.4	2.0.1
BIOS settings	Performance	Default	Default
Memory module(s)			
Total RAM in system (GB)	96	384	3,072
Vendor and model number	Hynix HMT31GR7BFR4A-H9	Hynix HMT42GR7MFR4C-PB	Samsung M386A4G40DM0-CPB
Operating system			
Name	CentOS 7	CentOS 7	CentOS 7
Kernel Version	3.10.0-327.18.2.el7.x86_64	3.10.0-327.18.2.el7.x86_64	3.10.0-327.18.2.el7.x86_64
File system	xfs	xfs	xfs
RAID controller			
Vendor and model number	Dell PERC 6/i	Dell PERC H710P Mini	Dell PERC H730P
Firmware version	6.3.3.0002	21.3.2-0005	25.4.0.0017
Driver version	06.807.10.00-rh1 (megaraid_sas)	06.807.10.00-rh1 (megaraid_sas)	06.807.10.00-rh1 (megaraid_sas)
Cache size (MB)	256	1,024	2,048

System	Dell PowerEdge R710	Dell PowerEdge R720	Dell PowerEdge R930
Solid-state drives #1			
Vendor and model number	N/A	Intel SSD DC S3710	Intel SSD DC P3700
Number of drives	N/A	8 8	4 12
Size	N/A	800 GB 400 GB	2.0 TB
Type	N/A	2.5" SATA 6Gb/s	1/2 Height PCIe 3.0 2.5" PCIe 3.0
Solid-state drives #2			
Vendor and model number	N/A	N/A	Intel SSD DC S3700
Number of drives	N/A	N/A	12
Size	N/A	N/A	400 GB
Type	N/A	N/A	2.5in SATA 6Gb/s
Hard drives			
Vendor and model number	8 × Toshiba® MBF2600RC	N/A	2 × Toshiba AL13SEB900
Number of drives	8	N/A	2
Size (GB)	600	N/A	900
RPM	10K	N/A	10K
Type	SAS 6Gb/s	N/A	SAS 6Gb/s

Figure 5: System configuration information for the test systems.

APPENDIX C – HOW WE TESTED

Installing CentOS 7

1. Connect the installation media to the server. We used the virtual optical drive available on both servers' out-of-band management consoles.
2. Boot to the installation media.
3. At the splash screen, select Install CentOS 7 and press Enter.
4. For language, choose your desired language, and click Continue. We chose English (United States).
5. At the Installation Summary screen, configure the Date & Time to match your time zone.
6. Set software-selection to Minimal Install (R710, R720 VM, R930 VM) or Virtual Host (R720, R930).
7. Set the Installation Destination to Automatic partitioning.
8. Configure the Network & Hostname for your testing network.
9. Click Begin Installation.
10. During the installation process, set the Root Password. We elected not to create another user during installation.
11. Once the installation is completed, disconnect the installation media and click Reboot.

Configuring the Dell R710 (bare-metal)

Run the following commands for each process.

Installing updates and additional packages

```
yum install -y epel-release
yum update -y
yum install -y chrony nmon time xfsprogs tuned numactl wget vim nfs-utils
openssh-clients man unzip numactl ipmitool OpenIPMI sysstat pigz
```

Disabling SELINUX

```
setenforce 0
sed -i 's/SELINUX=enforcing/SELINUX=disabled/' /etc/selinux/config
```

Disabling the firewall

```
systemctl stop firewalld
systemctl disable firewalld
```

Editing /etc/fstab

Change the following:

```
/dev/mapper/centos-root / xfs defaults 0 0
```

To the following:

```
/dev/mapper/centos-root / xfs defaults,nobarrier,noatime,nodiratime 0 0
```

Synching the time

```
sed -i '/server .*/d' /etc/chrony.conf
echo 'server 10.41.0.5 iburst prefer' >> /etc/chrony.conf
systemctl restart chronyd
systemctl enable chronyd
```

Creating and formatting volumes (assumes RAID10)

```
VG_NAME=centos
DISKS=8
STRIPE=256
lvcreate ${VG_NAME} -r 16384 -l 100%FREE -n sasdata

mkfs.xfs -d su=${STRIPE}k,sw=$(($DISKS / 2)) /dev/${VG_NAME}/sasdata

mkdir -p /data
echo -e "/dev/${VG_NAME}/sasdata  /data  xfs
defaults,nobarrier,noatime,nodiratime,inode64  0 0" >> /etc/fstab
mount -v /data
```

Creating and applying a tuned profile

```
cp -rp /usr/lib/tuned/throughput-performance /usr/lib/tuned/sas-performance
cat <<EOF > /usr/lib/tuned/sas-performance/tuned.conf
# Additional Tuning for SAS
[main]
include=throughput-performance

[cpu]
force_latency=1
governor=performance
energy_perf_bias=performance
min_perf_pct=100

[vm]
transparent_hugepages=never

[disk]
devices=!dm-*
EOF

tuned-adm profile sas-performance
reboot
```

Creating users

```
groupadd -g 500 sas
useradd -u 500 -g 500 sasdemo
useradd -u 400 -g 500 sas
echo 'export PATH=$PATH:/usr/local/SASHome/SASFoundation/9.4' >>
/home/sasdemo/.bashrc
echo 'export ASUITE=/data/asuite' >> /home/sasdemo/.bashrc
echo 'export PATH=$PATH:/usr/local/SASHome/SASFoundation/9.4' >> /root/.bashrc
echo 'export ASUITE=/data/asuite' >> /root/.bashrc
echo "sasdemo ALL=(root) NOPASSWD:ALL" | tee -a /etc/sudoers.d/sasdemo
chmod 0440 /etc/sudoers.d/sasdemo

passwd sasdemo
passwd sas
```

Extracting SAS workload files

```
cd / ; pigz -d -c sasdata.tar.gz | tar -xhf- ; sync
cd / ; tar -zxf sas.tar.gz ; sync
```

Configuring the R720 (Virtual Host)

Run the following commands for each process.

Installing updates and additional packages

```
yum install -y epel-release
yum update -y
yum install -y chrony nmon time xfsprogs tuned numactl wget vim nfs-utils
openssh-clients man unzip numactl ipmitool OpenIPMI sysstat pigz
```

Disabling SELINUX

```
setenforce 0
sed -i 's/SELINUX=enforcing/SELINUX=disabled/' /etc/selinux/config
```

Disabling the firewall

```
systemctl stop firewalld
systemctl disable firewalld
```

Editing /etc/fstab

1. Change the following:

```
/dev/mapper/centos-root / xfs defaults 0 0
```

To the following:

```
/dev/mapper/centos-root / xfs defaults,nobarrier,noatime,nodiratime 0 0
```

2. Add the following:

```
hugetlbfs  /dev/hugepages  hugetlbfs  mode=1770,gid=107  0 0
```

Editing /etc/libvirt/qemu.conf

```
hugetlbfs_mount = "/dev/hugepages"
```

Editing /etc/sysctl.d/10-qemu.conf

```
vm.hugetlb_shm_group = 107
vm.nr_hugepages = 190720
```

Synching the time

```
sed -i '/server .*/d' /etc/chrony.conf
echo 'server 10.41.0.5 iburst prefer' >> /etc/chrony.conf
systemctl restart chronyd
systemctl enable chronyd
```

Creating and formatting volumes (assumes 8xRAID5 and 8xRAID5)

```
VG_NAME=sas
STRIPE=256
DISKS=8
SAS_DEV=/dev/sda
```

```
pvcreate --dataalignment $(((${DISKS} - 1) * ${STRIPE} * 4))K $SAS_DEV

vgcreate -s $(((${DISKS} - 1) * ${STRIPE} * 4))k $VG_NAME $SAS_DEV

lvcreate -n work1 -L 1334361m -C y -r 16384 $VG_NAME
lvcreate -n work2 -L 1334361m -C y -r 16384 $VG_NAME
lvcreate -n work3 -L 1334361m -C y -r 16384 $VG_NAME
lvcreate -n work4 -L 1334361m -C y -r 16384 $VG_NAME

lvcreate -n os1 -L 40g -C y -r 16384 centos
lvcreate -n os2 -L 40g -C y -r 16384 centos
lvcreate -n os3 -L 40g -C y -r 16384 centos
lvcreate -n os4 -L 40g -C y -r 16384 centos

lvcreate -n data1 -L 597g -C y -r 16384 centos
lvcreate -n data2 -L 597g -C y -r 16384 centos
lvcreate -n data3 -L 597g -C y -r 16384 centos
lvcreate -n data4 -L 597g -C y -r 16384 centos

virsh pool-define-as --name $VG_NAME --type logical --target /dev/$VG_NAME
virsh pool-start --pool $VG_NAME
virsh pool-autostart --pool $VG_NAME

virsh pool-define-as --name centos --type logical --target /dev/centos
virsh pool-start --pool centos
virsh pool-autostart --pool centos
```

Creating and applying a tuned profile

```
cp -rp /usr/lib/tuned/virtual-host /usr/lib/tuned/sas-virtual-host
cat <<EOF > /usr/lib/tuned/sas-virtual-host/tuned.conf
# Additional Tuning for SAS
[main]
include=virtual-host

[cpu]
force_latency=1
governor=performance
energy_perf_bias=performance
min_perf_pct=100

[disk]
devices=!dm-*
EOF

tuned-adm profile sas-virtual-host
reboot
```

Configure the R930 (Virtual Host)

Run the following commands for each process.

Installing updates and additional packages

```
yum install -y epel-release
yum update -y
yum install -y chrony nmon time xfsprogs tuned numactl wget vim nfs-utils
openssh-clients man unzip numactl ipmitool OpenIPMI sysstat pigz
```

Disabling SELINUX

```
setenforce 0
sed -i 's/SELINUX=enforcing/SELINUX=disabled/' /etc/selinux/config
```

Disabling the firewall

```
systemctl stop firewalld
systemctl disable firewalld
```

Editing /etc/fstab

1. Change the following:

```
/dev/mapper/centos-root / xfs defaults 0 0
```

To the following:

```
/dev/mapper/centos-root / xfs defaults,nobarrier,noatime,nodiratime 0 0
```

2. Add the following:

```
hugetlbfs  /dev/hugepages  hugetlbfs  mode=1770,gid=107  0 0
```

Editing /etc/libvirt/qemu.conf

```
hugetlbfs_mount = "/dev/hugepages"
```

Editing /etc/sysctl.d/10-qemu.conf

```
vm.hugetlb_shm_group = 107
vm.nr_hugepages = 1475328
```

Synching the time

```
sed -i '/server .*/d' /etc/chrony.conf
echo 'server 10.41.0.5 iburst prefer' >> /etc/chrony.conf
systemctl restart chronyd
systemctl enable chronyd
```

Creating and formatting volumes (assumes 12xRAID10)

```
STRIPE=256
VMCOUNT=12
POOL_NAME[0]=vmpool
POOL_DEVS[0]="/dev/sdb"
POOL_DISKS[0]=12
POOL_HWRAID[0]=true
POOL_VOLNAME[0]=os
POOL_VOLSIZE[0]=40

POOL_NAME[1]=vmpool
POOL_DEVS[1]="/dev/sdb"
POOL_DISKS[1]=12
```

```
POOL_HWRAID[1]=true
POOL_VOLNAME[1]=cdata
POOL_VOLSIZE[1]=50

for (( i=0; i<${#POOL_NAME[@]}; i++ ));
do
  NAME=${POOL_NAME[$i]}
  DEVS=${POOL_DEVS[$i]}
  DISKS=${POOL_DISKS[$i]}
  HWRAID=${POOL_HWRAID[$i]}
  VOLNAME=${POOL_VOLNAME[$i]}
  VOLSIZE=${POOL_VOLSIZE[$i]}

  vgremove -f $NAME
  pvremove $DEVS
  for dev in $DEVS; do
    dd if=/dev/zero of=${dev} bs=1M count=10 oflag=direct
  done

  if $HWRAID; then
    pvcreate --dataalignment $((${DISKS} * ${STRIPE}))K $DEVS
  else
    pvcreate $DEVS
  fi

  vgcreate -s $((${DISKS} * ${STRIPE}))k $NAME $DEVS

  for vm in `seq 1 $VMCOUNT`;
  do
    if $HWRAID; then
      lvcreate -n ${VOLNAME}${vm} -l ${VOLSIZE} -C y $NAME
    else
      if [ ${DISKS} -lt 4 ]; then
        lvcreate --type raid1 -m 1 -n ${VOLNAME}${vm} -l ${VOLSIZE} -C y $NAME
      else
        lvcreate --type raid10 -i $((${DISKS} / 2)) -I ${STRIPE} -m 1 -n
${VOLNAME}${vm} -l ${VOLSIZE} -C y $NAME
      fi
    fi
  done

  virsh pool-define-as --name $NAME --type logical --target /dev/$NAME
  virsh pool-start --pool $NAME
  virsh pool-autostart --pool $NAME
  sync
done
```

Creating and applying a tuned profile

```
cp -rp /usr/lib/tuned/virtual-host /usr/lib/tuned/sas-virtual-host
cat <<EOF > /usr/lib/tuned/sas-virtual-host/tuned.conf
# Additional Tuning for SAS
```

```
[main]
include=virtual-host

[cpu]
force_latency=1
governor=performance
energy_perf_bias=performance
min_perf_pct=100

[disk]
devices=!dm-*
EOF

tuned-adm profile sas-virtual-host
reboot
```

Configuring the R720 Virtual Machines

Installing updates and additional packages

```
yum install -y epel-release
yum update -y
yum install -y chrony nmon time xfsprogs tuned wget vim nfs-utils openssh-clients
man unzip sysstat numactl pigz
```

Disabling SELINUX

```
setenforce 0
sed -i 's/SELINUX=enforcing/SELINUX=disabled/' /etc/selinux/config
```

Disabling the firewall

```
systemctl stop firewalld
systemctl disable firewalld
```

Editing /etc/fstab

Change the following:

```
/dev/mapper/centos-root / xfs defaults 0 0
```

To the following:

```
/dev/mapper/centos-root / xfs defaults,nobarrier,noatime,nodiratime 0 0
```

Synching the time

```
sed -i '/server .*/d' /etc/chrony.conf
echo 'server 10.41.0.5 iburst prefer' >> /etc/chrony.conf
systemctl restart chronyd
systemctl enable chronyd
```

Creating users

```
groupadd -g 500 sas
useradd -u 500 -g 500 sasdemo
useradd -u 400 -g 500 sas
echo 'export PATH=$PATH:/usr/local/SASHome/SASFoundation/9.4' >>
/home/sasdemo/.bashrc
```

```
echo 'export ASUITE=/data/asuite' >> /home/sasdemo/.bashrc
echo 'export PATH=$PATH:/usr/local/SASHome/SASFoundation/9.4' >> /root/.bashrc
echo 'export ASUITE=/data/asuite' >> /root/.bashrc
echo "sasdemo ALL=(root) NOPASSWD:ALL" | tee -a /etc/sudoers.d/sasdemo
chmod 0440 /etc/sudoers.d/sasdemo

passwd sasdemo
passwd sas
```

Creating and applying a tuned profile

```
cp -rp /usr/lib/tuned/virtual-guest /usr/lib/tuned/sas-virtual-guest
cat <<EOF > /usr/lib/tuned/sas-virtual-guest/tuned.conf
# Additional Tuning for SAS
[main]
include=virtual-guest

[vm]
transparent_hugepages=never

[disk]
readahead=>8192
EOF

tuned-adm profile sas-virtual-guest
reboot
```

Creating and formatting volumes (assumes RAID5)

```
STRIPE=256
DATA_DISKS=8
WORK_DISKS=8
DATA_DEV=/dev/sdb
WORK_DEV=/dev/sdc

mkfs.xfs -f -d su=${STRIPE}k,sw=$((${DATA_DISKS} - 1)) ${DATA_DEV}
mkfs.xfs -f -d su=${STRIPE}k,sw=$((${WORK_DISKS} - 1)) ${WORK_DEV}

mkdir -p /data
mkdir -p /work

echo -e "`blkid ${DATA_DEV} | cut -d\" \" -
f2`\t/data\txfs\tdefaults,nobarrier,noatime,nodiratime,inode64\t0 0" >>
/etc/fstab
echo -e "`blkid ${WORK_DEV} | cut -d\" \" -
f2`\t/work\txfs\tdefaults,nobarrier,noatime,nodiratime,inode64\t0 0" >>
/etc/fstab

mount -v /data
mount -v /work

rm -rf /data/*
mkdir -p /data/asuite
cd /data/asuite
mkdir -p /work/output
ln -s /work/output
mkdir -p /work/saswork
ln -s /work/saswork
mkdir -p /work/utilloc
ln -s /work/utilloc
```

Extracting SAS workload files

```
cd / ; pigz -d -c sasdata.tar.gz | tar -xhf- ; sync
cd / ; tar -zxf sas.tar.gz ; sync
```

Configuring the R930 Virtual Machines

Installing updates and additional packages

```
yum install -y epel-release
yum update -y
yum install -y chrony nmon time xfsprogs tuned wget vim nfs-utils openssh-clients
man unzip sysstat numactl pigz
```

Disabling SELINUX

```
setenforce 0
sed -i 's/SELINUX=enforcing/SELINUX=disabled/' /etc/selinux/config
```

Disabling the firewall

```
systemctl stop firewalld
systemctl disable firewalld
```

Editing /etc/fstab

Change the following:

```
/dev/mapper/centos-root / xfs defaults 0 0
```

To the following:

```
/dev/mapper/centos-root / xfs defaults,nobarrier,noatime,nodiratime 0 0
```

Synching the time

```
sed -i '/server .*/d' /etc/chrony.conf
echo 'server 10.41.0.5 iburst prefer' >> /etc/chrony.conf
systemctl restart chronyd
systemctl enable chronyd
```

Creating users

```
groupadd -g 500 sas
useradd -u 500 -g 500 sasdemo
useradd -u 400 -g 500 sas
echo 'export PATH=$PATH:/usr/local/SASHome/SASFoundation/9.4' >>
/home/sasdemo/.bashrc
echo 'export ASUITE=/data/asuite' >> /home/sasdemo/.bashrc
echo 'export PATH=$PATH:/usr/local/SASHome/SASFoundation/9.4' >> /root/.bashrc
echo 'export ASUITE=/data/asuite' >> /root/.bashrc
echo "sasdemo ALL=(root) NOPASSWD:ALL" | tee -a /etc/sudoers.d/sasdemo
chmod 0440 /etc/sudoers.d/sasdemo

passwd sasdemo
passwd sas
```

Creating and applying a tuned profile

```
cp -rp /usr/lib/tuned/virtual-guest /usr/lib/tuned/sas-virtual-guest
cat <<EOF > /usr/lib/tuned/sas-virtual-guest/tuned.conf
# Additional Tuning for SAS
[main]
include=virtual-guest

[vm]
transparent_hugepages=never

[disk]
readahead=>8192
EOF

tuned-adm profile sas-virtual-guest
reboot
```

Creating and formatting volumes (assumes SATA is RAID10 and PCIe is NORAID)

```
STRIPE=256
SATA_DISKS=8
```

```
PCIE_DISKS=1
SATA_DEV=/dev/sdb
PCIE_DEV=/dev/sdc

mkfs.xfs -f -d su=${STRIPE}k,sw=$((${SATA_DISKS} / 2)) ${SATA_DEV}
mkfs.xfs -f -d su=${STRIPE}k,sw=${PCIE_DISKS} ${PCIE_DEV}

mkdir -p /sata
mkdir -p /pcie

echo -e "`blkid ${SATA_DEV} | cut -d\" \" -
f2`\t/sata\txfs\tdefaults,nobarrier,noatime,nodiratime,inode64\t0 0" >>
/etc/fstab
echo -e "`blkid ${PCIE_DEV} | cut -d\" \" -
f2`\t/pcie\txfs\tdefaults,nobarrier,noatime,nodiratime,inode64\t0 0" >>
/etc/fstab

mount -v /sata
mount -v /pcie

mkdir -p /data/asuite
cd /data/asuite
mkdir -p /sata/cdata
ln -s /sata/cdata
mkdir -p /pcie/input
ln -s /pcie/input
mkdir -p /pcie/output
ln -s /pcie/output
mkdir -p /pcie/saswork
ln -s /pcie/saswork
mkdir -p /pcie/utilloc
ln -s /pcie/utilloc
```

Extracting SAS workload files

```
cd / ; pigz -d -c sasdata.tar.gz | tar -xhf- ; sync
cd / ; tar -zxf sas.tar.gz ; sync
```

APPENDIX D – CONFIGURATION FILES

R720-vm1.xml

```
<domain type='kvm' id='2'>
  <name>r720-vm1</name>
  <uuid>42c3a63a-c8f8-4657-8e16-11d1ae4a2604</uuid>
  <memory unit='KiB'>97517568</memory>
  <currentMemory unit='KiB'>97517568</currentMemory>
  <memoryBacking>
    <hugepages/>
    <nosharepages/>
  </memoryBacking>
  <vcpu placement='static' cpuset='0,2,4,6,8,20,22,24,26,28'>10</vcpu>
  <resource>
    <partition>/machine</partition>
  </resource>
  <os>
    <type arch='x86_64' machine='pc-i440fx-rhel7.0.0'>hvm</type>
    <boot dev='hd'/>
  </os>
  <features>
    <acpi/>
    <apic/>
  </features>
  <cpu mode='host-passthrough'>
    <topology sockets='1' cores='5' threads='2'/>
  </cpu>
  <clock offset='utc'/>
  <on_poweroff>destroy</on_poweroff>
  <on_reboot>restart</on_reboot>
  <on_crash>restart</on_crash>
  <devices>
    <emulator>/usr/libexec/qemu-kvm</emulator>
    <disk type='block' device='disk'>
      <driver name='qemu' type='raw' cache='none' io='native'/>
      <source dev='/dev/centos/os1'/>
      <backingStore/>
      <target dev='sda' bus='scsi'/>
      <alias name='scsi0-0-0-0'/>
      <address type='drive' controller='0' bus='0' target='0' unit='0'/>
    </disk>
    <disk type='block' device='disk'>
      <driver name='qemu' type='raw' cache='none' io='native'/>
      <source dev='/dev/sas/work1'/>
      <backingStore/>
      <target dev='sdb' bus='scsi'/>
      <alias name='scsi0-0-0-1'/>
      <address type='drive' controller='0' bus='0' target='0' unit='1'/>
    </disk>
    <disk type='block' device='disk'>
      <driver name='qemu' type='raw' cache='none' io='native'/>
      <source dev='/dev/centos/data1'/>
      <backingStore/>
      <target dev='sdc' bus='scsi'/>
      <alias name='scsi0-0-0-2'/>
      <address type='drive' controller='0' bus='0' target='0' unit='2'/>
    </disk>
    <controller type='scsi' index='0' model='virtio-scsi'>
      <alias name='scsi0'/>
      <address type='pci' domain='0x0000' bus='0x00' slot='0x04' function='0x0'/>
    </controller>
    <controller type='virtio-serial' index='0'>
      <alias name='virtio-serial0'/>
      <address type='pci' domain='0x0000' bus='0x00' slot='0x05' function='0x0'/>
    </controller>
    <controller type='usb' index='0'>
      <alias name='usb'/>
      <address type='pci' domain='0x0000' bus='0x00' slot='0x01' function='0x2'/>
    </controller>
    <controller type='pci' index='0' model='pci-root'>
      <alias name='pci.0'/>
    </controller>
    <interface type='bridge'>
      <mac address='52:54:00:22:95:79'/>
      <source bridge='br1'/>
      <target dev='vnet0'/>
      <model type='virtio'/>
      <alias name='net0'/>
      <address type='pci' domain='0x0000' bus='0x00' slot='0x03' function='0x0'/>
    </interface>
    <channel type='unix'>
      <source mode='bind' path='/var/lib/libvirt/qemu/channel/target/domain-r720-vm1/org.qemu.guest_agent.0'/>
      <target type='virtio' name='org.qemu.guest_agent.0' state='disconnected'/>
      <alias name='channel0'/>
      <address type='virtio-serial' controller='0' bus='0' port='1'/>
    </channel>
    <channel type='spicevmc'>
      <target type='virtio' name='com.redhat.spice.0' state='disconnected'/>
      <alias name='channel1'/>
      <address type='virtio-serial' controller='0' bus='0' port='2'/>
    </channel>
    <input type='mouse' bus='ps2'/>
    <input type='keyboard' bus='ps2'/>
    <graphics type='spice' port='5900' autoport='yes' listen='127.0.0.1'>
      <listen type='address' address='127.0.0.1'/>
    </graphics>
    <video>
      <model type='qxl' ram='65536' vram='65536' vgamem='16384' heads='1'/>
      <alias name='video0'/>
      <address type='pci' domain='0x0000' bus='0x00' slot='0x02' function='0x0'/>
    </video>
    <memballoon model='virtio'>
      <alias name='balloon0'/>
      <address type='pci' domain='0x0000' bus='0x00' slot='0x06' function='0x0'/>
    </memballoon>
  </devices>
</domain>
```

R930-vm1.xml

```
<domain type='kvm' id='2'>
  <name>r930-vm1</name>
  <uuid>3526a529-8d53-409d-8f1b-8dc8626295a1</uuid>
  <memory unit='KiB'>251658240</memory>
  <currentMemory unit='KiB'>251658240</currentMemory>
  <memoryBacking>
    <hugepages/>
    <nosharepages/>
  </memoryBacking>
  <vcpu placement='static' cpuset='0,4,8,12,16,20,24,28,96,100,104,108,112,116,120,124'>16</vcpu>
  <resource>
    <partition>/machine</partition>
  </resource>
  <os>
    <type arch='x86_64' machine='pc-i440fx-rhel7.0.0'>hvm</type>
    <boot dev='hd'/>
  </os>
  <features>
    <acpi/>
    <apic/>
  </features>
  <cpu mode='host-passthrough'>
    <topology sockets='1' cores='8' threads='2'/>
  </cpu>
  <clock offset='utc'/>
  <on_poweroff>destroy</on_poweroff>
  <on_reboot>restart</on_reboot>
  <on_crash>restart</on_crash>
  <devices>
    <emulator>/usr/libexec/qemu-kvm</emulator>
    <disk type='block' device='disk'>
      <driver name='qemu' type='raw' cache='none' io='native'/>
      <source dev='/dev/vmpool/os1'/>
      <backingStore/>
      <target dev='sda' bus='scsi'/>
      <alias name='scsi0-0-0-0'/>
      <address type='drive' controller='0' bus='0' target='0' unit='0'/>
    </disk>
    <disk type='block' device='disk'>
      <driver name='qemu' type='raw' cache='none' io='native'/>
      <source dev='/dev/nvme0n1'/>
      <backingStore/>
      <target dev='sdb' bus='scsi'/>
      <alias name='scsi0-0-0-1'/>
      <address type='drive' controller='0' bus='0' target='0' unit='1'/>
    </disk>
    <disk type='block' device='disk'>
      <driver name='qemu' type='raw' cache='none' io='native'/>
      <source dev='/dev/vmpool/cdata1'/>
      <backingStore/>
      <target dev='sdc' bus='scsi'/>
      <alias name='scsi0-0-0-2'/>
      <address type='drive' controller='0' bus='0' target='0' unit='2'/>
    </disk>
    <controller type='scsi' index='0' model='virtio-scsi'>
      <alias name='scsi0'/>
      <address type='pci' domain='0x0000' bus='0x00' slot='0x04' function='0x0'/>
    </controller>
    <controller type='virtio-serial' index='0'>
      <alias name='virtio-serial0'/>
      <address type='pci' domain='0x0000' bus='0x00' slot='0x05' function='0x0'/>
    </controller>
    <controller type='usb' index='0'>
      <alias name='usb'/>
      <address type='pci' domain='0x0000' bus='0x00' slot='0x01' function='0x2'/>
    </controller>
    <controller type='pci' index='0' model='pci-root'>
      <alias name='pci.0'/>
    </controller>
    <interface type='bridge'>
      <mac address='52:54:00:9f:b9:15'/>
      <source bridge='br1'/>
      <target dev='vnet0'/>
      <model type='virtio'/>
      <alias name='net0'/>
      <address type='pci' domain='0x0000' bus='0x00' slot='0x03' function='0x0'/>
    </interface>
    <channel type='unix'>
      <source mode='bind' path='/var/lib/libvirt/qemu/channel/target/domain-r930-vm1/org.qemu.guest_agent.0'/>
      <target type='virtio' name='org.qemu.guest_agent.0' state='disconnected'/>
      <alias name='channel0'/>
      <address type='virtio-serial' controller='0' bus='0' port='1'/>
    </channel>
    <channel type='spicevmc'>
      <target type='virtio' name='com.redhat.spice.0' state='disconnected'/>
      <alias name='channel1'/>
      <address type='virtio-serial' controller='0' bus='0' port='2'/>
    </channel>
    <input type='mouse' bus='ps2'/>
    <input type='keyboard' bus='ps2'/>
    <graphics type='spice' port='5900' autoport='yes' listen='127.0.0.1'>
      <listen type='address' address='127.0.0.1'/>
    </graphics>
    <video>
      <model type='qxl' ram='65536' vram='65536' vgamem='16384' heads='1'/>
      <alias name='video0'/>
      <address type='pci' domain='0x0000' bus='0x00' slot='0x02' function='0x0'/>
    </video>
    <memballoon model='virtio'>
      <alias name='balloon0'/>
      <address type='pci' domain='0x0000' bus='0x00' slot='0x06' function='0x0'/>
    </memballoon>
  </devices>
</domain>
```

ABOUT PRINCIPLED TECHNOLOGIES

Principled Technologies, Inc.
1007 Slater Road, Suite 300
Durham, NC, 27703
www.principledtechnologies.com

We provide industry-leading technology assessment and fact-based marketing services. We bring to every assignment extensive experience with and expertise in all aspects of technology testing and analysis, from researching new technologies, to developing new methodologies, to testing with existing and new tools.

When the assessment is complete, we know how to present the results to a broad range of target audiences. We provide our clients with the materials they need, from market-focused data to use in their own collateral to custom sales aids, such as test reports, performance assessments, and white papers. Every document reflects the results of our trusted independent analysis.

We provide customized services that focus on our clients' individual requirements. Whether the technology involves hardware, software, Web sites, or services, we offer the experience, expertise, and tools to help our clients assess how it will fare against its competition, its performance, its market readiness, and its quality and reliability.

Our founders, Mark L. Van Name and Bill Catchings, have worked together in technology assessment for over 20 years. As journalists, they published over a thousand articles on a wide array of technology subjects. They created and led the Ziff-Davis Benchmark Operation, which developed such industry-standard benchmarks as Ziff Davis Media's Winstone and WebBench. They founded and led eTesting Labs, and after the acquisition of that company by Lionbridge Technologies were the head and CTO of VeriTest.

Disclaimer of Warranties; Limitation of Liability:
PRINCIPLED TECHNOLOGIES, INC. HAS MADE REASONABLE EFFORTS TO ENSURE THE ACCURACY AND VALIDITY OF ITS TESTING, HOWEVER, PRINCIPLED TECHNOLOGIES, INC. SPECIFICALLY DISCLAIMS ANY WARRANTY, EXPRESSED OR IMPLIED, RELATING TO THE TEST RESULTS AND ANALYSIS, THEIR ACCURACY, COMPLETENESS OR QUALITY, INCLUDING ANY IMPLIED WARRANTY OF FITNESS FOR ANY PARTICULAR PURPOSE. ALL PERSONS OR ENTITIES RELYING ON THE RESULTS OF ANY TESTING DO SO AT THEIR OWN RISK, AND AGREE THAT PRINCIPLED TECHNOLOGIES, INC., ITS EMPLOYEES AND ITS SUBCONTRACTORS SHALL HAVE NO LIABILITY WHATSOEVER FROM ANY CLAIM OF LOSS OR DAMAGE ON ACCOUNT OF ANY ALLEGED ERROR OR DEFECT IN ANY TESTING PROCEDURE OR RESULT.

IN NO EVENT SHALL PRINCIPLED TECHNOLOGIES, INC. BE LIABLE FOR INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES IN CONNECTION WITH ITS TESTING, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. IN NO EVENT SHALL PRINCIPLED TECHNOLOGIES, INC.'S LIABILITY, INCLUDING FOR DIRECT DAMAGES, EXCEED THE AMOUNTS PAID IN CONNECTION WITH PRINCIPLED TECHNOLOGIES, INC.'S TESTING. CUSTOMER'S SOLE AND EXCLUSIVE REMEDIES ARE AS SET FORTH HEREIN.