

Live Migration with Xen Virtualization Software

Virtualization is an emerging trend in enterprise data centers. Using virtualization software, system administrators can run multiple operating systems on a single server, therefore exploiting most of the server's resources. This article outlines an evaluation deployment of a LAMP (Linux®, Apache, MySQL, and PHP) application stack for a live migration setup on a virtual machine using Xen open source software. This article can serve as a guide for those enterprises wishing to evaluate Xen in their environment.

BY DAVID SCHMIDT AND PUNEET DHAWAN

Related Categories:

Linux

Virtualization

Xen virtualization

Visit www.dell.com/powersolutions
for the complete category index.

Virtualization is one of the fastest-growing trends within enterprise data centers. It allows multiple operating systems—in virtual machines—to execute concurrently on the same computer system. Virtual machines execute within special boundaries called partitions, which have different levels of access to various hardware components. Partitions can be provided with virtualized hardware, share a piece of physical hardware among themselves, or be the sole “owner” of a particular hardware component. A special-purpose virtual machine provides management functionality and is sufficiently privileged to create and manipulate other virtual machines. The software that allows the multiplexing of virtual machines on a single physical machine is called the virtual machine monitor (VMM), or *hypervisor*.

Because it creates a standard virtual hardware platform regardless of the underlying physical system,

virtualization technology further enables the migration of virtual machines from one physical system to another. When migrations can be performed without interrupting the execution of the guest OS on the virtual machine, they are referred to as live migrations. The benefits of live migrations are considerable: Being able to dynamically relocate operating systems in response to performance needs, systems management events, or data center scale-out requirements could change the way data centers are designed and used.

This article provides instructions for setting up a live-migration environment with Xen hypervisor software and the Linux OS. The application stack is the DVD Store e-commerce application, a Dell-developed open source application that simulates an e-commerce environment using MySQL and Apache.¹ The DVD Store e-commerce application includes Microsoft® Windows®

¹ For more information about the DVD Store e-commerce test application, visit linux.dell.com/dvdstore.

and Linux driver utilities. The guidelines provided in this article may be used by system administrators who wish to evaluate the capabilities of the Xen hypervisor for consideration in future virtualization deployments.

Virtualization and Xen

The Xen hypervisor is an open source software package that creates and manages partitions for multiple virtual machines. Partitions in a Xen environment are known as domains, with the management domain referred to as Domain0. Xen uses a virtualization architecture called para-virtualization, in which the guest operating systems are “aware”—that is, designed to take advantage of the fact—that they are running in a virtualized environment. With para-virtualization, the guest OS is modified to make special calls (hypercalls) to the hypervisor for privileged operations, instead of the regular system calls in a traditional unmodified OS. The applications in the guest OS’s domain, however, remain unmodified.

Hardware and software requirements

The example scenario presented in this article assumes the use of Dell™ PowerEdge™ 2850 servers with local SCSI storage for Xen and shared Network File System (NFS) storage for virtual machines (see Figure 1). Other Dell servers can work with Xen; however, this article does not provide specific guidelines for other Dell PowerEdge systems.

The Xen version used for the example scenario was the Xen 3.0.1 from prebuilt installation tarballs. Xen requires a base Linux installation over which the Xen kernel can be installed. The example scenario presented in this article assumes the use of the Red Hat® Enterprise Linux 4.1 distribution; however, other Linux distributions have been used successfully with Xen.

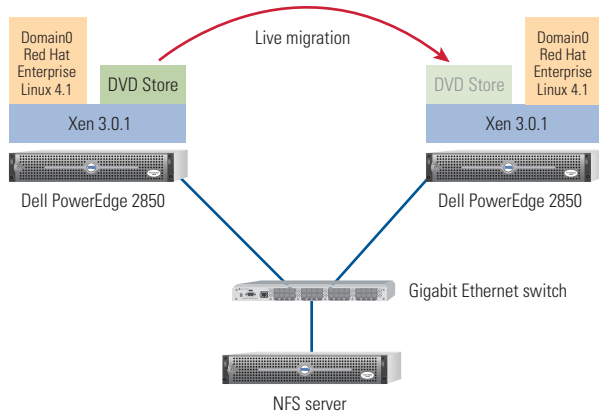


Figure 1. Xen configuration for live migration

Xen installation and configuration

To perform live migration of virtual machines among physical systems, administrators must install Xen on each of the participating physical systems. The physical systems should have access to the same shared file system like that provided by an NFS server and should be on the same switched network.

For a Xen live migration setup, Dell recommends that administrators have the same Linux and Xen installation on each of the physical hosts. Xen can be installed either through the binaries provided by the Xen open source community (well suited for a generic installation) or through a compilation of the Xen and Linux kernel sources (if customization is required). This section describes how to use the prebuilt binaries to install Xen.

Installation prerequisites

With a little planning during the Linux installation phase, even a fundamental Linux installation should satisfy most Xen installation prerequisites; however, administrators should check that the Linux bridge utilities and firewall are installed and functioning normally.

Linux bridge utilities. The bridge utilities can be installed from the installation media with the following command:

```
$ rpm -Uvh bridge-utils-0.9.6-1.i386.rpm
```

Firewall. When installing Red Hat Enterprise Linux 4.1, administrators should either disable the firewall feature or open Xen-specific ports. On a Xen host, ports used by Xen can be configured in the file `/etc/xen/xend-config.sxp`. Dell best practices recommend placing Domain0 for Xen hosts on a separate network to help prevent unauthorized access to these management domains.

Installation using prebuilt binaries

To install Xen using the prebuilt binaries provided by Xen developers, administrators should follow these steps:

1. Download the Xen 3.0.1 prebuilt tarball (`xen-3.0.1-install-x86_32.tgz`) from www.xensource.com/xen/downloads.
2. Unpack the Xen installation files from the tar archive:

```
$ tar -zxvf xen-3.0.1-install-x86_32.tgz
```

3. Install GNU C libraries. Administrators can choose to install Xen-friendly GNU C library (glibc) libraries and the modified Naming Service Caching daemon. This improves Xen performance compared to using standard glibc libraries. The glibc libraries are included in the Xen 3.0 Red Hat Package Manager (RPM™) files for Red Hat Enterprise Linux 4.1 (`xen-3.0-x86_32-rhel4.1.bin.tar`), which is available at www.xensource.com/xen/downloads:

```
$ tar -xvf xen-3.0-x86_32-rhel4.1.bin.tar
$ cd xen-3.0-x86_32-rhel4.1.bin
$ rpm -Fvh glibc*
$ rpm -Fvh nsd*
$ cd
```

If administrators choose not to update the glibc libraries, they must take special steps to disable thread local storage. Administrators can disable thread local storage by issuing the following command:

```
$ mv /lib/tls /lib/tls.disabled
```

Although RPMs for Xen are available in this package, Dell engineers chose not to use RPMs to install Xen because of configuration differences between the Xen kernel provided by RPMs and the tar archive.

4. Install Xen using the following commands:

```
$ cd xen-3.0.1-install
$ ./install.sh
```

5. Create the initial ramdisk for Xen. Red Hat Enterprise Linux 4 employs the udev program² to create device nodes. Nodes for /dev/console and /dev/null are required to start udev; otherwise, the boot process stops and issues the message “Warning: unable to open an initial console.” To prevent this, generate an initrd image using the following commands:

```
$ depmod 2.6.12.6-xen0
$ mkinitrd /boot/initrd-2.6-xen.img 2.6.12.6-xen0
```

If the `mkinitrd` command replies that it cannot find certain modules, and those modules are known to exist in the Domain0 kernel,³ use the `builtin` option to exclude them. For example, the `mptbase` and `mptscsih` modules can be excluded using the following command:

```
$ mkinitrd --builtin=mptbase --builtin=mptscsih
/boot/initrd-2.6-xen.img 2.6.12.6-xen0
```

Xen boot process

Administrators can configure the `grub.conf` file so that the boot loader lists the Xen kernel as a bootable option.

Edit grub.conf

The GRand Unified Bootloader (GRUB) is the default boot loader used in the Red Hat Enterprise Linux 4 distribution, and the `grub.conf` file must be modified to allow Xen to boot. To do so, administrators should add the following lines at the end of `/boot/grub.conf`:

```
title Xen 3.0.1
root (hd0,0)
kernel /xen-3.gz dom0_mem=262144
module /vmlinuz-2.6-xen0 root=/dev/VolGroup00/
    LogVol100 ro maxcpus=1 console=tty0 nouseb
module /initrd-2.6-xen.img
```

The kernel line tells GRUB where to find the Xen hypervisor and what boot parameters should be passed to it—in this case, allocating 262,144 KB of memory to Domain0. The first module line describes the location of the Xen Linux kernel for Domain0 that Xen should start and the parameters that should be passed to it. The second module line describes the location of the initial RAM disk. Administrators should change the root parameters and provide the correct relative paths in GRUB according to their setup.

Dell best practices recommend that the other menu options remain unmodified in the `grub.conf` file; otherwise, the system may not boot to the normal (non-Xen) Linux kernels later. The Xen kernel can be tagged as the default kernel to boot by setting the `default` parameter in the `grub.conf` file according to the position of the Xen kernel in the `grub.conf` file.

As with any relatively new and somewhat experimental software, Xen may exhibit unintended performance under certain conditions. For example, Xen systems have been observed to become unresponsive to user input when intensive I/O activity is present and USB support is enabled in Xen. For the configuration described in this article, USB support should be disabled in Domain0 by adding the `nouseb` parameter in GRUB:

```
module /vmlinuz-2.6-xen root=LABEL=/ ro maxcpus=1
    console=tty0 nouseb
```

Start Xen

The final step in enabling the Xen kernel to be a bootable option is for administrators to reboot the system and select the Xen option when the GRUB menu appears. The system should then boot the Xen hypervisor and start Domain0.

²For more information, see “udev—A Userspace Implementation of devfs” by Greg Kroah-Hartman, *Proceedings of the Linux Symposium*, July 23–26, 2003; www.kroah.com/linux/talks/ols_2003_udev_paper/Reprint-Kroah-Hartman-OLS2003.pdf.

³A list of drivers included in the Linux kernel can be found in the configuration file `/boot/config-2.6.12-xen0`.

Configuration for the DVD Store domain

In a Xen environment, Domain0 is the management domain responsible for creating and managing other guest domains. Guest domains are numbered sequentially, but they are commonly referred to collectively as DomainU in documentation. This section covers the steps for setting up the DVD Store application's guest domain in Xen.⁴

Setting up the base OS for DVD Store and shared storage

Because no method currently exists for booting an OS installation CD within a para-virtualized Xen guest domain, the root file system for a domain must be installed and configured manually. To do so, administrators can install the base OS for the DVD Store application on a physical server and then copy the partitions to a shared storage location—in this case, an NFS server. Of course, this requires a second physical system, which may not be feasible.

Because an NFS server is required for the Xen live-migration environment, the NFS server can be used as the source for the DVD Store's base OS. To configure such an environment, administrators can take the following steps:

1. Set up the base Linux OS for the NFS server. This should also be the desired base OS for the DVD Store domain. Make sure to provide enough space to hold the file system for the dvdstore guest domain.
2. Create a directory on the NFS server named dvdstore. This will be the shared storage directory that contains the DVD Store root file system.
3. Copy the file system of the NFS server to the dvdstore directory and create other required files with the following commands:

```
$ cd /
$ cp -ax {root,var,etc,usr,bin,sbin,lib}/dvdstore
$ mkdir /dvdstore/{proc,sys,home,tmp,dev}
$ for i in console null zero; do MAKEDEV
  -d /dvdstore/dev -x $i; done
```

4. Edit the /dvdstore/etc/fstab file to use /dev/sda1 as the root file system. The fstab file for the dvdstore guest domain should contain the following lines:

```
/dev/sda1 /          ext3    defaults      1 1
None      /dev/pts  devpts  gid=5,mode=620 0 0
None      /proc     Proc    defaults      0 0
None      /dev/shm  Tmpfs   defaults      0 0
```

5. Edit the /etc/exports file of the NFS server to include the following line, and make sure that the IP address glob corresponds to the correct network:

```
/dvdstore 192.168.*.*(rw,async,no_root_squash)
```

6. Export the directory with the following command:

```
$ exportfs -a
```

7. Start the NFS service:

```
$ service nfs start
```

The NFS server should then be ready, and the OS files for the DVD Store domain should be present in the /dvdstore NFS share. Administrators can then create the domain inside the Xen systems, boot the domain, and complete the setup of the DVD Store application.

If administrators do not wish to use the NFS server's OS as the base OS for the DVD Store's guest domain, they should take the following steps:

1. Configure an additional server with the DVD Store guest's intended OS.
2. Configure the /etc/exports file of the NFS server to allow write access to this additional server (see step 5, above).
3. Mount the /dvdstore directory on this additional server.
4. Follow steps 3 and 4, at left.

Creating the domain configuration file

Xen uses configuration files for defining domains. Example configuration files can be found on the Xen host at /etc/xen/xmexample1 or /etc/xen/xmexample2. The files use a "name = value" format—and lines starting with the # symbol are comment lines. Administrators can take the following steps to create a configuration file for the DVD Store domain:

1. Copy the /etc/xen/xmexample1 file to the /etc/xen/dvdstore.cfg file and open it for editing.
2. Edit the below-listed variables in the configuration file so that they correspond to the following values (use appropriate values for the ip, netmask, and nfs_server variables):

```
kernel = "/boot/vmlinuz-2.6-xenU"
memory = 512
```

⁴ The DVD Store application stack can be configured according to the directions provided in "LAMP Quickstart for Red Hat Enterprise Linux 4" by Dave Jaffe, Ph.D., Dell Inc., December 2005; www.dell.com/downloads/global/solutions/lamp_quickstart_rhel4.pdf. The instructions provided in that article should be used in conjunction with those provided in this article to correctly set up the DVD Store application stack inside a guest domain using Xen.

```

name = "NFS-DVDStore"
vif = [ 'mac=00:16:3e:00:00:11, bridge=xenbr0' ]
#vif = [ ' ' ]
#disk = [ 'phy:hda1,hda1,w' ]
ip="XXX.XXX.XXX.XXX"
netmask="XXX.XXX.XXX.XXX"
#root = "/dev/sda1 ro"
root = "/dev/nfs"
nfs_server = '192.168.1.1'
nfs_root = '/dvdstore'

```

Starting the DVD Store domain

Xen guest domains are created and managed by the xend daemon. By default, the xend daemon does not start during boot. To start it automatically, administrators can issue the following command:

```
$ chkconfig xend on
```

Then, they can take the following steps:

1. Start the xend daemon with the following command:

```
$ service xend start
```

2. Make sure the service is running by checking the current domains. Only Domain0 should be running at this point. The output should look like the text below:

```

$ xm list
Name      Id   Mem(MiB) VCPUs   State   Time(s)
Domain-0  0    256       1       r----   100.8

```

3. Start the DVD Store domain with the following command:

```
$ xm create -c -f /etc/xen/dvdstore.cfg
```

The `-c` option immediately connects the console to the DVD Store domain, allowing the guest OS boot process to be monitored.

Note: Depending on the distribution, Linux firewall services may be automatically enabled. Administrators may need to disable the Linux firewall to connect with the NFS server.

Installing the DVD Store application stack

After the DVD Store domain is booted, administrators can exit the console by pressing Ctrl + J. To reconnect to the guest domain, use the following command:

```
$ xm console <guest domain id/name>
```

When the DVD Store application boots, the next step is to set up the DVD Store application stack. For information about setting up the MySQL database and HTTP server stack and running test loads against the store using the driver utilities, see “Three Approaches to MySQL Applications on Dell PowerEdge Servers” by Dave Jaffe, Ph.D., and Todd Muirhead at www.dell.com/downloads/global/solutions/mysql_apps.pdf. Administrators may also visit the “Index of /dvdstore” Web site at linux.dell.com/dvdstore.

Live migration of the DVD Store domain

After the DVD Store application stack is running, live migration of the dvdstore guest can be performed to examine the stability and flexibility of Xen. Administrators can take the following steps to migrate the DVD Store domain:

1. Create a second Xen server to act as the target system using the steps described in the “Xen installation and configuration” section in this article. Make sure the target server has access to the NFS server and to the source Xen server currently hosting the DVD Store.
2. Open a Secure Shell connection to the source server.
3. Using the steps described in the “Installing the DVD Store application stack” section in this article, start the DVD Store driver utility on a client system. Wait for the connection to stabilize.
4. At the Domain0 command prompt of the source Xen server, enter the command `xm list` to see a listing of resident domains. The DVD Store domain should be present. To begin migrating the DVD Store from the source Xen server to the target Xen server, enter the following command (use the appropriate IP address for the target Xen server):


```
$ xm migrate --live NFS-DVDStore 192.168.0.2
```
5. Upon completion of the `migrate` command, issue the `xm list` command. The DVD Store domain should not be listed. Connect to a Domain0 command prompt on the target Xen server and issue the `xm list` command to verify that the DVD Store domain now resides on the target server.

Troubleshooting information

Administrators may encounter common problems such as the following when installing, configuring, and operating Xen.

System hangs while booting Xen with the following error message: “Warning: unable to open an initial console.” This message occurs when `udev` requires the presence of `/dev/console`

and `/dev/null` before starting. For more information, refer to the “Installation using prebuilt binaries” section in this article.

Guest domain with root NFS and Dynamic Host Configuration Protocol (DHCP) assignment for its virtual interface device fails to boot. Support for DHCP must be enabled in the DomainU kernel to allow NFS root configurations; however, DHCP is not enabled in the default DomainU kernel provided with the distributed Xen binaries. Administrators should either assign a static IP address in the DomainU configuration file or recompile the DomainU kernel with additional support using the Xen kernel sources.

Guest domain fails to boot with the following error message: “Enforcing mode requested but no policy loaded. Halting now.” This message will appear if the SELinux security policy is enforced in the DomainU file system. Disable SELinux by editing the `/etc/selinux/config` file for the DVD Store domain file system by changing the `SELINUX` option to `SELINUX = disabled`.

Guest domain fails to migrate with the following error message: “Received invalid response from Xend, twice.” Edit the `/etc/xen/xend-config.sxp` file. Change the `xend-relocation-hosts-allow` parameter to allow any or selected hosts to migrate a domain. Uncomment the `xend-relocation-port` parameter. Restart the xend service after saving the changes to the file.

Additional troubleshooting resources. For more troubleshooting assistance, administrators can refer to the Xen FAQ at wiki.xensource.com/xenwiki/XenFAQ.

Potential of Xen virtualization technology

As Xen continues to mature, its popularity and influence in the virtualization community will likely grow. Features such as live

migration, combined with the near-native performance of the Xen hypervisor layer, can create a compelling alternative to other virtualization tools. The configuration described in this article is just one of many ways administrators can configure Xen, and—as with any open source software—administrators have the power to adapt Xen to their own unique environment. ➔

Acknowledgments

The authors wish to thank Dave Jaffe and Todd Muirhead for their work on the DVD Store application.

David Schmidt is a systems engineer on the Enterprise Solutions Engineering team within the Dell Product Group, where he develops solutions for the scalable enterprise. Previously, David worked in the systems management group developing the Dell OpenManage™ Deployment Toolkit. David has a B.S. in Computer Engineering from Texas A&M University.

Puneet Dhawan is a systems engineer on the Scalable Enterprise Team at Dell. Puneet has a bachelor’s degree in Electrical Engineering from The Punjab Engineering College (PEC) in Chandigarh, India, and a master’s degree in Computer Engineering from Texas A&M University.

FOR MORE INFORMATION

Xen open source community:

www.xensource.com/xen