

# Virtualization in the Data Center

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# Virtualization: The New Data Center Paradigm, Again

**SUSE Linux Enterprise 10, the flagship Linux platform from Novell, continues to lead the way in data center virtualization, with support for both x86-based processors and mainframes.**

Virtualization is almost as old as enterprise computing itself. First introduced in the 1960s to allow partitioning of mainframe hardware, it has been a mainstay of high-end proprietary server environments ever since. Today, virtualization is once again a hot topic of conversation in the data center because emerging technologies have the potential to remedy issues relating to resource utilization, efficiency, scalability and manageability. Armed with virtual machines on commodity hardware, data center administrators hope to create new levels of flexibility and agility in their environments at a lower total cost of ownership.

Virtualization can drive up resource utilization on individual servers, thus increasing the total return on those investments. Moreover, it can integrate distributed systems, transforming disparate racks of compute and storage servers into a bona fide enterprise IT platform.

Two new major developments will have a dramatic effect on virtualization technology adoption. On the hardware side, x86 architecture-based microprocessor manufacturers have released a new generation of chips that support virtualization natively. On the software side, the emergence of the open-source Xen\* hypervisor virtual machine technology has eliminated much of the performance impact associated with the mediation layer that accompanies full virtualization and software emulation. The introduction of Xen also drives down the overall cost of virtualization.

These developments could completely decouple software from the underlying physical implementation. The result would be

impressive new levels of resource utilization and improvements in availability, manageability, scalability, performance, application security and much more.

But virtualization is not a panacea. Without the right infrastructure and management tools, virtualization may do very little to stem the tide of complexity and inefficiency that has overwhelmed even administrators' best plans. Thus, when selecting a vendor to help you virtualize your data center, you should choose one with the management tools and experience to help make your implementation a successful one.

Novell® sees virtualization as a tremendous opportunity for its data center customers. Novell envisions virtualization-enabled data centers in which there is highly sophisticated integration of components that are largely isolated today. It's an environment in which Novell expertise and technologies will play prominent roles. SUSE® Linux Enterprise 10, the flagship Linux\* platform from Novell, continues to lead the way in data center virtualization, with support for both x86-based processors and mainframes.

## Virtualization Defined

Virtualization is an abstract concept that encompasses several definitions related to IT resource consolidation and management. Virtualization refers to the pooling of IT resources in a way that masks the physical nature and boundaries of those resources from resource users. In more concrete terms, virtualization is the decoupling of software from hardware. It is the abstracting of the software from the underlying implementation.

Virtualization can take place at various points in a server architecture—between the application and operating system (e.g., middleware clustering or containers) or between the operating system and hardware (e.g., virtual machines). This document concentrates on the latter.

Three key virtualization technologies in the data center are developing the fastest:

- **Hypervisor Virtual Machine**—*This technology enables the deployment and operation of multiple operating system instances on a single physical server concurrently, without using a general-purpose host operating system for primary access to the hardware. However, it does allow hardware resources to be allocated on a fractionalized basis. By 2008, hypervisors are likely to account for 90 percent of virtual machine deployments on Linux.*
- **Aggregated Virtualization**—*This technology enables distributed computing resources (servers/processors, memory, input/output processors) to be aggregated for use by a single instance of an operating system.*
- **Shared Operating System Virtualization**—*This technology enables the operation of multiple applications using a single instance of an operating system and to dynamically allocate appropriate resources to each without affecting the operations of the applications.*

## Full Virtualization vs. Paravirtualization

Two types of virtual machines (VMs) have gained credibility in data center environments. Virtual machines based on *full virtualization* feature a virtualization layer that mediates access to hardware resources and permits multiple operating-system instances—and even incompatible operating systems—to coexist on a single server. It does not require modification of guest operating systems.

However, this mediating layer model requires the virtual machine to trap and emulate all privileged instructions, and performance can be negatively affected by as much as 50 percent. In addition, full virtualization doesn't allow for cooperative resource-sharing when running two VMs on the same box at the same time. For example, two Web-server VMs running on the same server hardware can't share Web pages they may not be using at that moment; consequently, partitioning is still course-grained between them. Moreover, with full virtualization, the host operating system on which the VM runs can be single point of failure. Licensing complexity and scalability limitations are also persistent concerns.

VMware\* (a Novell partner) servers are the most popular full virtualization-based virtual machines.

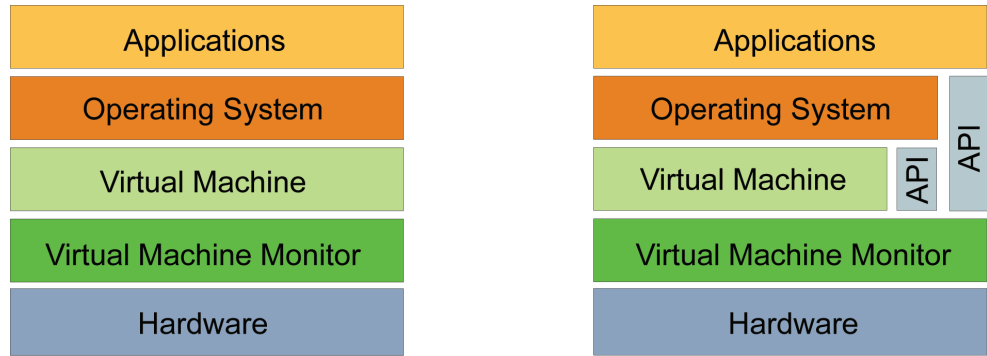
Virtual machines based on *paravirtualization* differ from full virtualization in that their para- (or partially) virtualized operating-system instances are modified to become aware of the virtualization layer. This helps the hypervisor avoid hard-to-virtualize processor instructions by replacing them with a procedure call providing that functionality. The result is better performance than that of full-virtualization VMs. Virtualization based on the paravirtualization model is an emerging trend because it exacts better performance out of existing chips while offering powerful advantages with the next generation of virtualization-enabled x86 chips. It also allows for cooperative memory-sharing between machines without modifying the host operating system. And it holds the promise of VMs that are finely tuned to the host Linux operating system.

Leading vendors offering paravirtualization management solutions include Virtual Iron and XenSource. Both vendors are Novell partners.

**Fast-developing key virtualization technologies in the data center include:**

- Hypervisor Virtual Machine
- Aggregated Virtualization
- Shared Operating System Virtualization

Xen is the industry's fastest and most secure infrastructure virtualization software technology and has been endorsed and adopted by more than 20 of the industry's major vendors, including Novell.



**Figure 1.** Full virtualization versus paravirtualization architecture. Note that in both cases, there is a software layer called the virtual machine monitor (VMM) that includes a virtual machine scheduler and provides for coarse-grained memory management and I/O virtualization. The paravirtualization model includes APIs that assist the VM in some instances.

## Xen: The Open Source Hypervisor

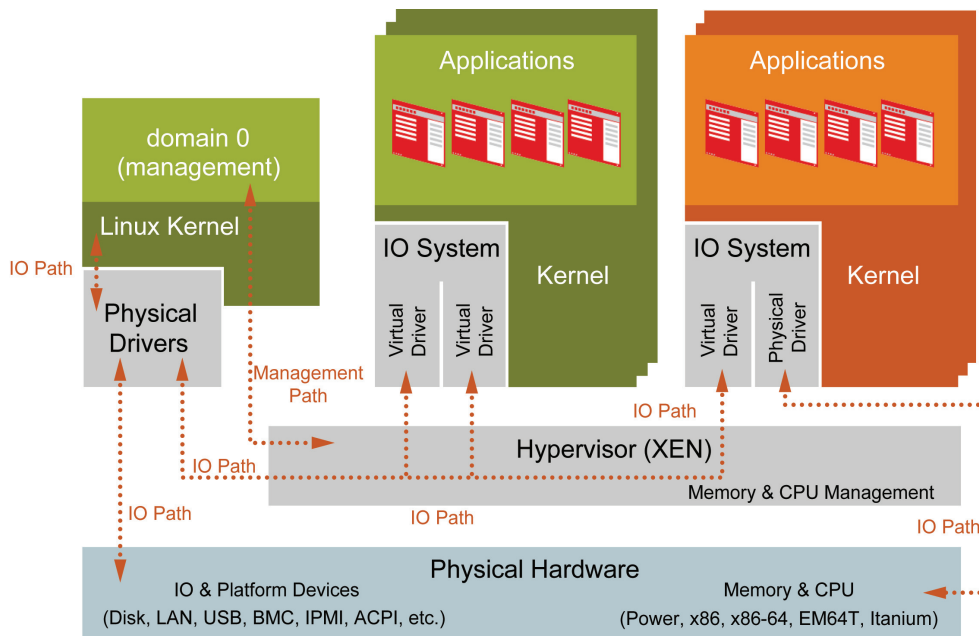
The hottest technical trend in virtualization is the Xen hypervisor, which is open source virtualization technology. Xen provides the platform for running multiple operating systems in virtual machines on a single physical box of hardware by enabling the multiple operating systems to talk to the hardware as if each operating system were the only one on the server. In order for an operating system to realize its best performance on Xen, the operating system must be modified to make it aware of the hypervisor. Because Xen enables guest operating systems to be tuned and optimized for virtual machines, it also allows administrators to securely run several virtual machines on a single physical system with performance comparable to native code.

To run an unmodified operating system using Xen, you must deploy Xen on top of the latest chips available from AMD and Intel. The AMD\* Virtualization and Intel\* VT chips work with Xen to enable users to run unmodified operating systems on top of Xen. This feature enables a data center adminis-

trator to virtualize Windows\* on top of Linux. However, you will also see better performance from a modified operating system on top of Xen than you will see from an unmodified operating system on top of Xen and a virtualization-aware chip.

Xen is the industry's fastest and most secure infrastructure virtualization software technology and has been endorsed and adopted by more than 20 of the industry's major vendors, including AMD, Dell, Egenera, Hewlett-Packard, IBM, Intel, Mellanox Technologies, Network Appliance, Novell, Red Hat, Sun Microsystems, TopSpin, Unisys and Valtire. Xen is licensed under the General Public License (GPL) and is available for free download. You can also obtain the Xen code by subscribing to an enterprise Linux distribution such as SUSE Linux Enterprise 10, which includes the Xen code and management tools as part of the distribution.

While the Xen technology is an open source project that provides the foundation for virtualization, many companies are building commercial toolsets for Xen virtual-machine management.



**Figure 2.** The Xen architecture enables paravirtualized operating systems to talk directly to the hardware with minimal impact to performance.

Xen is currently the best-performing hypervisor in the industry and typically has 10 times less overhead than competitive proprietary offerings. Xen's unique performance benefits result from its use of paravirtualization, which allows hosted virtual servers to collaborate with the hypervisor to achieve the best performance for enterprise applications. Other vendors (such as Microsoft) are now rushing to implement their own hypervisors, but they are at least three years behind the Xen project. Xen also leverages the hardware virtualization capabilities of Intel's VT and AMD Virtualization processors.

## Why Virtualization Is the Next Big Thing

Three disruptive trends are converging to make virtualization a logical, practical investment for data centers. The first is the rise of the commodity-based server environment. Linux and x86 architecture-based servers have made scaling out the norm in enterprises today. SANs are also growing in the commodity realm. However, as the processing power of servers increases dramatically,

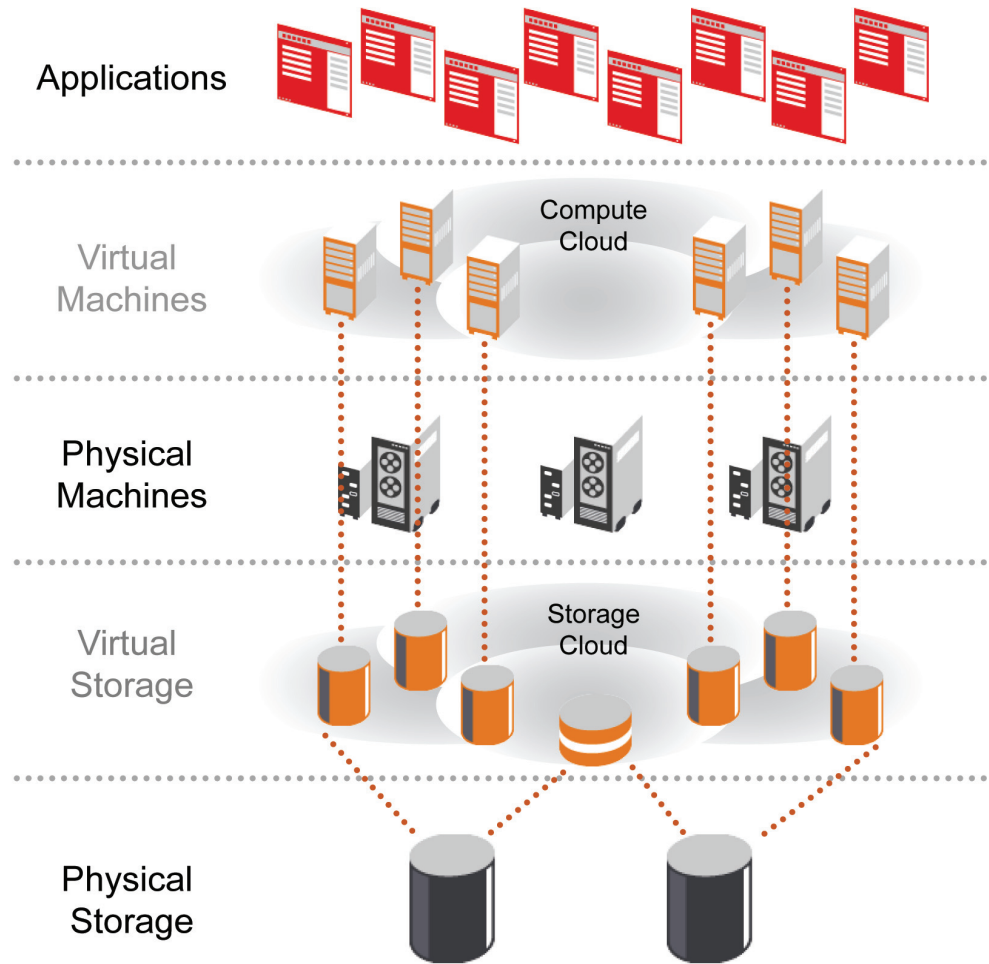
one- application/one-server configurations make less sense with every passing year. Most individual applications simply don't require anywhere near the compute capacity that server microprocessors now provide.

The second trend is that people are migrating to more modular deployments that feature multiple-server, high-availability clustering and failover solutions as well as Web services. In these complex environments where scalability is essential, data center managers don't want the capacity of their applications to be capped by the servers on which they are running. And they don't want CPU cycles or storage to be limited that way, either. What they *do* want are virtualization technologies similar to (or better than) those they had in their old UNIX\* environments. And they want to implement chargeback models and better automation of service-level agreement compliance. Virtualization can make these new commoditized environments as efficient as possible and usher in a new era of utility computing.

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The average workload of servers in enterprise environments is between five and 40 percent, leaving more than 60 percent of the available capacity unused.

<sup>1</sup> Research conducted by Novell Technical Specialists, consolidated from interviews with customers in October 2005.



**Figure 3.** A virtualized environment enables flexible, efficient and scalable utilization of resources.

The third disruptive trend is being driven by leading x86-chip manufacturers who are integrating virtualization technologies into x86 chip architecture. Both the AMD Virtualization and Intel Virtualization Technology (VT) will help make software virtualization products more efficient, robust, secure and flexible to use. VT will enable the creation of boundaries around virtual machines or around different partitions. It will also enable the creation of partitioned application spaces running on a single operating system, similar to Solaris containers on servers. Both companies are shipping virtualization-enabled microprocessors today.

Given this level of commitment from Intel and AMD, as well as the strides the Linux community is making, virtualization is now a full-fledged component of the operating system. The days of proprietary virtualization platforms are quickly coming to an end.

### Why Virtualization Matters to Your Business

According to recent research, the average workload of servers in enterprise environments is between five and 40 percent, leaving more than 60 percent of the available capacity unused.<sup>1</sup> One of the primary reasons

Henry Ford was a genius in that he understood better than anyone how to maximize utilization of resources (human and otherwise) in his factories. Can you imagine if Henry Ford ran his production line at 40-percent capacity on a good day? He would have gone broke within a week! Yet in most data centers, servers typically operate at a fraction of their total capacity.

In today's data center, deploying a server-based application is a laborious, thankless task. The administrator has to find the hardware, install an operating system, change control, tune parameters, figure out how much memory is required, find some disk space and then, finally, perform the install. After all that effort, the server is, for all intents and purposes, welded to the application.

The majority of today's data centers still run one application stack on one server, thus driving ever-growing server sprawl, which in turn means more money spent on hardware and resources to manage it. With virtualization, you can reduce the number of servers by running multiple applications on a single server.

By putting applications and operating systems in virtual machines, data center managers can harness more of that unused compute power and bring CPU, memory and peripheral (LAN or disk) channel capacity utilization up to 80 percent. They can extract up to eight times more real work from the same amount of resources. And they can provision applications and systems dynamically—moving VMs from one server to another (and one customer to another) as needed.

Physical hardware resources consumed during the day for one workload can be re-purposed during the night for another—automatically. Applications and services can be prestaged or “incubated” in test environments and then quickly and easily deployed

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and redeployed into production. With virtualization technologies in place, it is the VM image that is managed and updated as opposed to the actual running server, allowing for effective, non-disruptive testing of patches and updates. The result is that applications and services can now be managed in a life-cycle instead of on an *ad hoc* basis. What's more, the data center can be better equipped to handle increased workloads, whether temporary or permanent. When you add in server and storage consolidation and couple it with centralized management, you can significantly lower the total cost of ownership for your entire data center.

### **Benefits of Virtualization**

The benefits of virtualization include the following:

- **Decreased Hardware Costs**—*With virtualization, you can lower costs by reducing the number of physical servers maintained. Reduce your physical space and power requirements by consolidating servers while still retaining the scalability to accommodate additional projects.*
- **Increased Server Utilization**—*By allowing multiple applications to co-exist on one physical server, virtualization enables the use of resources more efficiently and harnesses more of each server's capacity, increasing server utilization. Virtualization can allow for the deployment of 12 or more virtual machines on each physical server for a 12:1 consolidation ratio. In addition, CPU utilization will increase by up to 30 percent.*

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## With the release of SUSE Linux Enterprise 10 from Novell, organizations now have virtualization technology built into their enterprise operating systems.

Novell will be the first enterprise Linux vendor to ship Xen as part of its distribution. Aside from providing the basis for optimizing resource utilization in the data center, SUSE Linux Enterprise 10 will offer the first set of integrated management tools for Xen through its YaST module.

- **Reduced Server Provisioning Time**—*Virtualization reduces server provisioning time by up to 90 percent, enabling organizations to be much more responsive to customer needs. Traditional server deployment can take more than six hours, even if an appropriate physical server is available onsite. It takes significantly less time to deploy a virtual machine residing on an existing physical server. The savings are even greater when you factor in the additional time to obtain a physical server; the procurement process typically takes six to eight weeks.*
- **Remote Management of VM Instances**—*Troubleshooting servers can be done anytime, anywhere on the network, eliminating the need for an organization's technicians to physically be in front of the machine. As a result, IT can support VM instances throughout the world from a central location without the need for "smart hands" to be dispatched to the physical servers' locations.*
- **Increased Flexibility and Scalability**—*Due to the ease of deploying new virtual machines, an IT team can respond more rapidly and flexibly to business requirements for new IT resources.*
- **Increased Productivity**—*Being able to run multiple operating systems on a single computer allows an organization to do more in-depth development and testing and take on additional projects.*
- **High Availability and Nonstop Maintenance**—*A virtual machine and its applications can be easily relocated to an alternative location or remote data center. The ability to migrate virtual servers and the hosted applications enables planned hardware and software maintenance with zero application downtime.*

- **Tighter Application Security**—*Vulnerabilities are isolated and minimized by creating a virtual machine for each application. Protection can extend to the application, libraries, services and operating system.*
- **More Control Over Configuration Change Management**—*Unapproved changes made to a running application in production are protected through the ability to rollback a servers to a warehoused image.*
- **Scalability on Demand**—*Virtual-machine images can automatically be deployed on existing hardware to add more processing power at peak demand times. Compute resources can be allocated to other activities when the spike subsides.*

### Virtualization Built into SUSE Linux Enterprise

With the release of SUSE Linux Enterprise 10 from Novell, organizations now have virtualization technology built into their enterprise operating systems. Novell will be the first enterprise Linux vendor to ship Xen as part of its distribution. Aside from providing the basis for optimizing resource utilization in the data center, SUSE Linux Enterprise 10 will offer the first set of integrated management tools for Xen through its YaST module.

With this graphic-based tool, users will be able to create, start, stop and migrate Xen virtual machines running on SUSE Linux Enterprise Server. They'll also have the ability to migrate a paravirtualized guest virtual machine from one physical machine to another in a high-availability cluster without interruptions. The whole operating system and application state in the VM is maintained when migrated. Administrators will therefore be able to perform hardware maintenance on live applications during production hours.

### The Novell Storage Foundation

The Novell Storage Foundation is included in SUSE Linux Enterprise 10 and represents another important part of the Novell approach

to virtualization. The Novell Storage Foundation is an integrated combination of the Oracle\* Cluster File System 2 (OCFS2), Heartbeat2 and the Enterprise Volume Management System 2 (EVMS2). The Novell Storage Foundation enables virtual machine images to be accessed by all nodes in a cluster.

Oracle Cluster File System 2 (OCFS2) is a general-purpose journaling file system that is fully integrated into the SUSE Linux Enterprise kernel. OCFS2 allows you to store application binary files, data files and databases on devices in a SAN. All nodes in a cluster have concurrent read and write access to the file system. A distributed lock manager helps prevent file access conflicts. OCFS2 supports up to 32,000 subdirectories and millions of files in each directory. The O2CB cluster service (a driver) runs on each node to manage the cluster.

Heartbeat2 is an open source software package that monitors all the nodes used in a cluster. Heartbeat2 exchanges “heartbeats” on the network interfaces of the members of the cluster to find out which nodes in the cluster are active. If a node fails, it does not emit a signal. In this case, Heartbeat2 ensures that another node takes over the relevant tasks and identity and makes the failover known within the network. This means that the cluster remains consistent. Heartbeat2 has been tested to 16 nodes, although theoretically there is no limit to the number of nodes that can be supported in a cluster. New for Heartbeat2 is the additional support for the new Open Cluster Framework (OCF)-based system resource monitors. These allow custom resource monitoring to be built into the Heartbeat2 high-availability system so that if a resource (application or service) is not behaving properly—even if it appears to be running—it can be restarted on the same or other node. In addition, Heartbeat2 includes powerful resource-dependency graphs, which allow relationships between modules to be created. This is an important feature for applications and services based on service-oriented architecture.

The Enterprise Volume Management System 2 (EVMS2) is a rich, extensible volume manager with built-in cluster awareness. Its plug-in framework allows plug-ins to add functionality for support and knowledge of any partition type. Being cluster-aware, EVMS2 guarantees that managed devices are named identically on each node in the cluster for easier management.

The combination of these three software module forms the basis of the Novell Storage Foundation, which, when combined with Xen virtualization software, offers customers a complete automated virtual machine failover solution as part of the total SUSE Linux Enterprise solution.

## How to Get Started Today

There is a lot of excitement at Novell these days regarding virtualization technologies and the launch of SUSE Linux Enterprise 10. Support for virtualization within the next generation of x86-based servers, coupled with integration of Xen virtualization technology into the SUSE Linux Enterprise distribution, is likely to have a dramatic impact on data center management.

If you are looking to get started with virtualization today, the easiest thing to do is to download an evaluation copy of SUSE Linux Enterprise Server 10 from Novell. The Xen hypervisor code is included as part of the distribution, and the YaST management tool provides the basic management tools to start. You can find detailed instructions for configuring Xen virtual machines on the Xen Technology Preview Web site, located at <http://forge.novell.com/modules/xfmod/project/?xenpreview> or in the SUSE Linux Enterprise administrator’s manual.

Once you have downloaded the code, you’ll probably want to start by building some basic virtual machines using Xen on a single machine. If you have three machines available, you can test out virtual machine migration.

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Using the iSCSI target initiation tools included in SUSE Linux Enterprise Server 10, you can configure a small cluster of two machines that share storage on a third machine. You can then migrate the virtual machine between the two physical machines to simulate a failover. Novell recommends that you start with a simple workload, like Apache, or that you test out a custom application that you may want to virtualize. You may want to consider some of the following workloads for virtualization:

### **Server Consolidation**

Take a few servers that are used for similar purposes and consolidate them on a single box using virtualization. Combining similar workloads on a single box may also help you consolidate administrative burden. Start with non-production boxes, and when you're comfortable with managing virtual servers, move to noncritical production areas.

### **Development Servers**

If your organization often repurposes servers for the development of custom applications, why not provision virtual servers for development environments instead of physical servers? Moving to virtual servers may also provide consolidation benefits and reduce the time required to create additional development server resources. Start by creating a primary server image for your development

servers, and then whenever you need a new server for your developers, simply create a new virtual machine and install your primary development server image.

### **Test Servers**

This scenario is exactly the same as the development servers, except you have a different primary-server image. Because you are using Xen paravirtualization, you will not lose performance on these test servers, and you may actually be able reduce the time needed to establish environments where your applications can be tested and validated.

If you would like a more detailed evaluation of virtualization or assistance setting up a more detailed proof of concept, Novell has the exceptional knowledge, tools and support that can help you develop a successful management and automation strategy that makes the most of today's virtualization opportunities. Novell account teams are happy to talk with you in more depth about what virtualization on Linux can do for your business and why Novell is the partner of choice for deploying mission-critical applications on Linux in your data center.

Contact a sales representative for more information, or visit [www.novell.com/datacenter](http://www.novell.com/datacenter) to learn more about Novell Data Center solutions.



Contact your local Novell Solutions Provider, or call Novell at:

1 888 321 4272 U.S./Canada  
1 801 861 4272 Worldwide  
1 801 861 8473 Facsimile

### **Novell, Inc.**

404 Wyman Street  
Waltham, MA 02451 USA