A White Paper by Stratus Technologies
June 2008

Best Practices for Server Virtualization in Mission-Critical Healthcare IT

Stratus Technologies

Abstract

Server virtualization is beginning to be deployed in healthcare information technology (IT), and holds great potential for containing IT costs and addressing application lifecycle management issues. Along with these substantial advantages come challenges and risks. This paper provides an introduction to server virtualization for hospitals and healthcare delivery organizations. It also offers best practices you can use to benefit from virtualization, while avoiding missteps that could affect the availability and performance of mission-critical healthcare IT.

IT Growth and Server Virtualization

In the U.S., larger hospitals and healthcare delivery organizations are leading the way to dramatically increased use of IT, for reasons that include improving the quality of care and patient safety.[1] Cost continues to be a hurdle to IT deployment, however, including for high-priority clinical applications such as electronic medical records and computerized practitioner order entry (CPOE).[2]

Server virtualization is getting attention as hospitals and other healthcare delivery organizations increase IT usage while seeking ways to accommodate its cost. Among many other advantages, virtualization allows healthcare delivery organizations to save money by consolidating a number of applications on the same physical server.

Server virtualization can be defined as the practice of using a software layer to let one physical computing server run multiple virtual machines that support multiple applications. A time-honored approach in the mainframe world, virtualization today involves Windows® and Linux® computer servers.

Healthcare is Mission-Critical

The surge of server virtualization now underway in business enterprises began with applications deemed less critical, characterized by lower processing requirements and tolerant of limited service outages. Advanced clinical applications can gain advantages from server virtualization that go beyond those seen in typical enterprise software applications — although special concerns apply as well.

Virtualization that supports patient care applications puts the technology into the mission-critical realm. Here, service interruptions are unacceptable. A server/application outage of only a few minutes can be devastating when a clinician requires immediate access to the electronic health record (EHR) of a critically ill patient, for example.

While consolidating applications on fewer computer servers has significant benefits, risks exist when the underlying platform (including hardware, virtualization software layer and drivers) is not sufficiently robust. A problem that affects the platform could cause downtime or performance issues for all the applications on that platform. The incident could then be followed by a long recovery time.

Using server clustering to provide a robust platform presents another challenge. Running a single application clustered on multiple servers in a non-virtualized environment is difficult enough. With virtualization, IT personnel have to deal with the complexity of configuring, testing and maintaining multiple applications that are clustered on the same platform.

---

[1] *Healthcare IT News*, "IT adoption grows -- for large, urban hospitals," March 1, 2007
[2] *18th Annual HIMSS Leadership Survey,* April 10, 2007

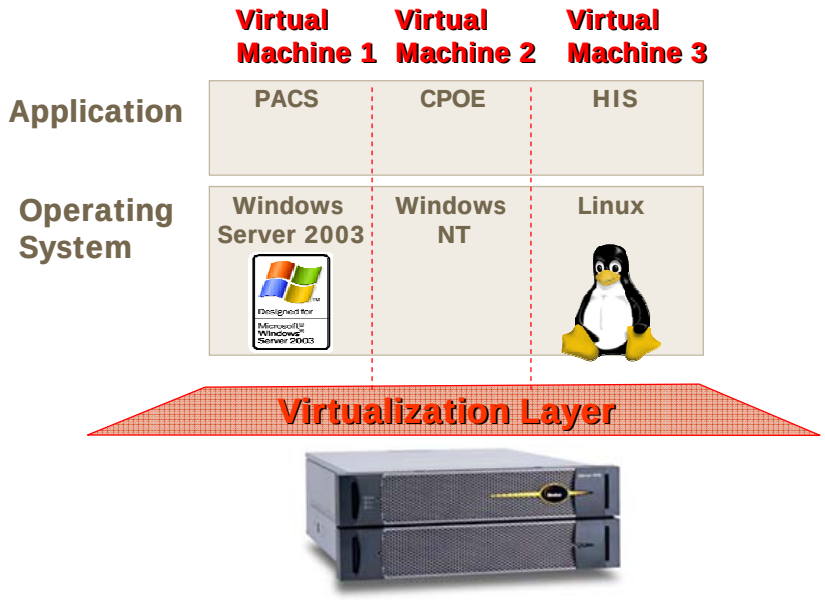
Therefore, evaluating and addressing an application's availability requirements is important when considering a move to a virtual environment. Before exploring these and other concerns in more depth, let's first review the basic concepts of server virtualization.

Server Virtualization Basics

In a virtualized environment, each virtual machine on a physical server exists within its own container or partition. While implementations differ, generally speaking each partition contains an application (or applications) and an instance of an operating system known as a guest operating system (OS).

A number of these partitions sit on a software layer called a hypervisor. The hypervisor is the thin, low-overhead layer that manages the basic services necessary to host the applications and their guest operating systems.

Figure 1: A View of Virtualization



PACS: Picture Archiving and Communication System
CPOE: Computerized Practitioner Order Entry System
HIS: Hospital Information System

Each virtual machine runs a separate instance of an operating system and application(s), and has access to a portion of the server's resources.

The virtual machines on a server may use the same flavor of operating system, use different releases of the OS or use entirely different types (e.g., Windows and Linux) of operating systems.

Some approaches use a host operating system below the hypervisor, but these impose system overhead. More recent solutions promote "bare metal" performance, which becomes possible when the hypervisor is implemented directly on the server hardware.

The market offers a number of commercially available software-based server virtualization products. The trend is to support virtualization that includes both Windows and Linux operating systems. VMware holds the largest market share. XenSource has introduced the concept of open-source virtualization. Microsoft likewise provides solutions for the Windows OS, and is working to extend support to the Linux OS. In addition, these vendors have announced initiatives that would allow their virtualization solutions to work together, which holds promise for standardization.

Why Virtualize?

Reducing the number of physical servers tends to be the initial reason behind a decision to virtualize. Server consolidation is only the first of many potential advantages, especially considering the distinct characteristics of healthcare IT.

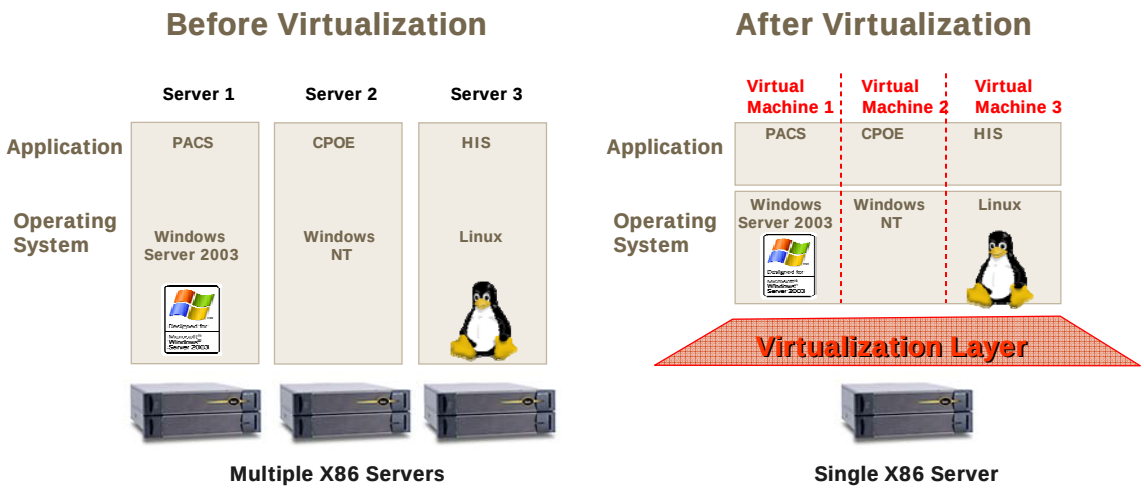
Server Consolidation

Many applications in the enterprise require as little as 5-10 percent of a server's capacity. Business enterprises that have implemented virtualization are opting to consolidate a number of these applications on a single physical server, while planning capacity for growth in the total workload.

According to a 2007 report by Yankee Group, 85% of virtualization software acquired by enterprises goes to server consolidation projects. The report also states that businesses have been able to better their server utilization from 10% to 80% in certain instances. [3]

Consolidating servers by running multiple instances of the OS and multiple applications on a single server has a large impact on the total cost of ownership (TCO) through the life of the server. Not only does consolidation reduce hardware expense, but also reductions in power, cooling, and floor space requirements by up to 50%-70% can be obtained, all while increasing service levels to the business.

Figure 2: Server Consolidation Example



More efficient use of resources through server consolidation can bring savings in hardware-related costs and reduce environmental expenses as well: space, power and cooling.

[3] Yankee Group, *Server Consolidation Creates New Opportunities for Fault-Tolerant Servers*, January 22, 2007

At healthcare facilities, patient care areas take precedence so space for IT systems may be more limited than in other business settings. Consolidating applications onto fewer physical servers can save precious square footage in addition to allowing new applications to be deployed.

Application Lifecycle Management

Compared with typical enterprise applications, healthcare IT applications are distinguished by the need for long lifecycles — possibly a decade or more. After the IT solution is in production, healthcare delivery organizations want to ensure stability and reduce risk by avoiding changes to the software application itself, as well as the operating system and the server hardware.

Achieving this objective becomes challenging because vendors often do not support the original operating system version throughout your desired application lifecycle. This means you have to seek out extended support and pay a premium. Moreover, most server hardware is obsolete after three or four years.

Virtualization allows you to abstract the application and OS away from the server hardware. You can effectively extend the lifecycle of your application as a result. The ability of a hypervisor to support older guest operating systems allows you to upgrade the hardware platform without affecting applications or their operating systems. A related benefit is that the ability to upgrade server hardware eliminates the need to stock hard-to-obtain components required to maintain older computer servers.

Capabilities that virtualization can enable over the extended lifecycles of healthcare IT applications include:

- **Speed and ease of provisioning.** Server virtualization allows you to create a standard virtual machine — consisting of software files that include the application and an operating system — that can be copied onto a server in a matter of minutes when additional capacity is required. The virtual machine can be qualified and tested in advance to ensure it will work as expected.
- **Hardware and capacity upgrades.** When more processing power or storage capacity is needed, virtualization can similarly let you move the virtual machine to newer hardware with no change to the application or operating system. You are not locked into older hardware.
- **Failover and disaster recovery (DR).** A virtual machine's image — including configuration state, disk state and so on — residing on one physical server can also be periodically replicated to another physical server for backup or fast restart. Healthcare delivery organizations can use this capability to support DR. Not only is it prudent to provide for recovering electronically stored health data, but also The Health Insurance Portability and Accountability Act (HIPAA) requires a DR plan to do so.

  Some virtualization software also allows for point-in-time rollbacks. Useful when data corruption has occurred, rollback lets an administrator revert the virtual machine to an earlier known good state.

- **Upgrades without downtime.** A capability known as live migration allows for planned hardware and operating system upgrades (in cases where the operating system is not visible to the application) with virtually no interruption to the application and little perceived impact by users. Note that the operating system that can be upgraded is at the host OS/hypervisor layer; guest operating systems cannot be upgraded online.

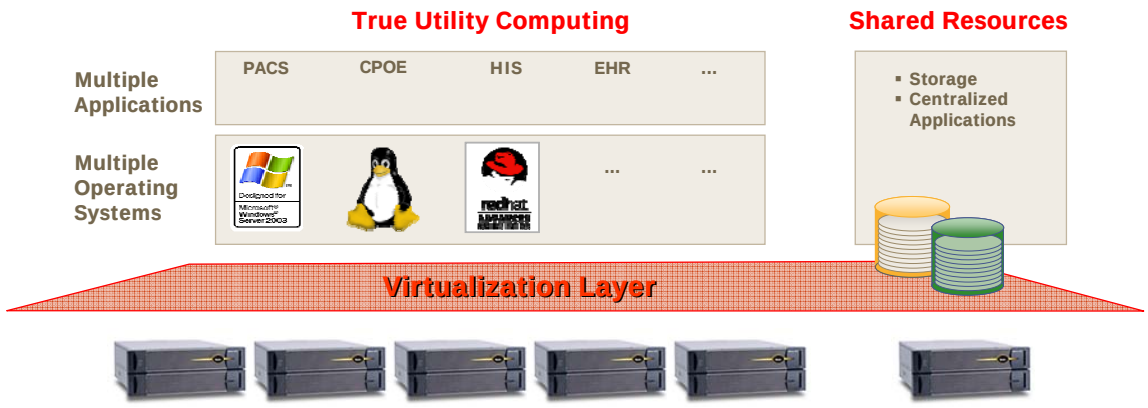
  Live migration works by copying the system state iteratively while the application continues to run. Shortly before a final copy of the virtual machine is ready for migration, only a brief application blackout (perhaps milliseconds) is necessary to synchronize the second virtual machine with the original.

Ahead: True Utility Computing

As virtualization technology advances, users as well as vendors envision utility computing as the goal. People want pools of servers that not only run multiple applications, but also enable dynamic and fluid use of resources. In the future, automated management capabilities — such as application-sensitive monitoring and intelligent policy making — will be necessary to bring this flexibility to the mainstream.

Such utility computing will feature the self-management and policy making necessary to reduce requirements for IT labor and expertise, in addition to reducing the chance of operator error that industry experts cite as a leading cause of downtime.

Figure 3: Utility Computing Scenario



True utility computing enables resource sharing and dynamic resource allocation based on user-specified criteria, such as time of day and incremental capacity needs.

Figure 4: From Server Virtualization to Utility Computing

Today	Tomorrow

• Server virtualization is the focus
• Requirement for IT expertise
• Management and monitoring still developing
  - Ongoing IT administration is required
  - Policy making is not automated
• Vendors have not implemented virtualization standards
• Exposure to single point of failure at virtualization code layer and the server hardware
	• Utility computing is the focus
	• Simpler deployment, use will make benefits more broadly accessible
	• Management and monitoring come of age
	  - Self-management
	  - Policy making can be automated
	• Virtualization standards will increase ease of deployment, reduce risk
	• Single point of failure at virtualization layer is overcome by deploying in a fault-tolerant environment
	• Robust fault-tolerant hardware eliminates single points of failure on the virtualization server platform

Today taking advantage of everything that virtualization has to offer still requires the knowledge of, and management by, skilled IT professionals. And "putting all your eggs in one basket" can be a significant concern unless the underlying platform technology has the necessary robustness.

Best Practices for Mission-Critical Healthcare

The risk and cost of service interruptions become higher as applications become more integral to patient care, more interoperable and interdependent, and relied upon by more clinicians and administrative personnel. Employing best practices can help you achieve the advantages you seek from virtualization, without compromising the availability and performance of mission-critical healthcare IT applications.

Start Small and Controlled

Starting with a pilot project is wise; administrative or financial applications that have leeway for some downtime may be a good place to get experience. Even then, the server on which you are consolidating becomes more essential when it drives numerous applications. Make sure to conduct an appropriate risk assessment as well as testing before deployment.

Know Your Application

Begin by characterizing your software application and its workload correctly. Which resources does your application consume? How much? When? How much headroom do you need for peak times and temporary surges in demand? In the event of performance degradation, the application could become unavailable and provide poor response time to users or processes.

In addition, not every application is a good candidate for virtualization. Typical examples are I/O-heavy applications and performance-sensitive environments that are not easily characterized.

Confirm Compatibility

Establish that the application, server hardware, operating system and I/O devices and drivers are compatible, if not certified, with the virtualization technology you plan to use. The number of pre-qualified options should expand as server virtualization in healthcare gains ground.

Understand Tradeoffs

Because virtual servers are easy to set up and don't require the same management approval as hardware purchases, trade press articles report that some adopters are experiencing "virtual server sprawl."

Expect some performance penalty as well; how much depends on your application and the virtualization technology you use.

What's more, maximizing application availability and performance on a virtual machine requires considerable skill. And you need to understand how virtualization will affect your software license fees.

Seek Enterprise-Strength Technology

Remember that the virtualization layer has the potential to be a single point of failure for all of the virtual machines it supports. One rule of thumb: Software reliability increases as the amount of code and its complexity decrease.

Look for virtualization software that is small, compact and controlled — as appliance-like in nature as possible. Virtualization and availability solutions that are simple to configure and maintain provide crucial advantages not only by reducing operating cost, but also by significantly reducing your exposure to server/application downtime as a result of operational errors.

Plan for Business Continuity

Reliable availability and performance become more important the more that you depend on an IT resource, and the more that resource is integrated with other systems. To mitigate the risk of disruption, institute backup and disaster recovery measures for the physical servers that run your virtual machines.

Simplify with Robust Hardware

Virtualization subtracts physical complexity but adds equally real complexity in a virtual dimension. Without proper planning, this can be an issue because IT tends to be added faster than the technical staff necessary for ongoing management.

Clustering multiple servers is one technique for achieving greater availability of servers and applications. Implementing virtualization on a server cluster adds another layer to deploying and administering a cluster, on top of the ongoing attention from IT staff that is already necessary. For instance, a server must be running to migrate its workload to another member of the cluster. Therefore when a double-bit memory fault causes a server to crash, its workload cannot be transferred, data will probably be lost and a reboot will be necessary. And with clustering, you can expect to incur performance overhead in any case.

For simplicity's sake, consider a fault-tolerant server that automatically protects reliability and availability without requiring changes to your mission-critical application. This approach uses redundant components while appearing as a single server to virtualization and application software. Ideally, the emphasis should be on preventing downtime and data loss instead of simply on quick recovery.

Don’t Go It Alone

Virtualizing in a manner that promotes the availability and performance of mission-critical applications requires considerable expertise. Today, this goal is not realistic without a knowledgeable staff and/or a trusted professional services provider.

It is easy to make mistakes when doling out resources to virtual servers, for example. While allocating disk and memory among virtual machines is rather straightforward and fine-grained, CPU and network resources are another story. An incorrect assumption will quickly drag down a CPU- or network-intensive environment.

Conclusion

As server virtualization technology matures, it is becoming suitable for the uncompromising demands of mission-critical healthcare applications. Server virtualization can be a boon for managing the application lifecycles of healthcare IT — with a few cautions. You can gain new capabilities and reduce costs, as long as you choose appropriate technology and plan properly.

For more information, visit www.stratus.com.