

Virtualization in Education

Contents

- 2 Introduction**
- 3 What a virtual computer is**
- 3 Desktop virtualization**
- 4 Server virtualization**
- 6 The benefits of virtualization for education**
- 14 Real world examples**
- 17 Summary**
- 18 Learn more**

Introduction

For the past 25 years, education has enjoyed a technological rollercoaster ride as the personal computer has moved from being a rarity to a mainstay of classrooms around the world. While many positive effects have been observed, the fact remains that education expects more from technology than it frequently gets.

Fortunately, advances in both the technology and the methods employed to implement the technology may provide answers. While relatively new to schools, the concept of virtualization is proving itself in the business and consumer world as “the next big thing.”

Simply put, virtualization is a technique for hiding the physical characteristics of computing resources from the way in which other systems, applications or end users interact with those resources. As a practical matter, when you get a Google map on your cell phone or when you let your PC automatically shop for the lowest price, you are using virtualization. The concept of virtualization is very broad and can be applied to devices, servers, operating systems, applications and even networks.

While the details can be technical and abstract, virtualization can have a large impact on education technology. We’ll lump the impacts into two major areas. The first area is operational efficiency and related costs, and the second area is academic benefits. We’ll focus on applications and benefits that are generally unobtainable without virtualization.

What a virtual computer is

A virtual computer is a logical representation of a computer in software. By decoupling the physical hardware from the operating system, virtualization provides more operational flexibility and increases the utilization rate of the underlying physical hardware. Although virtualization is implemented primarily in software, many modern microprocessors now include hardware features explicitly designed to improve the efficiency of the virtualization process.

In a traditional physical computer, one instance of the operating system supports one or more application programs. In a virtualization environment, a single physical computer runs software that abstracts the physical computer's resources so that they may be shared between multiple "virtual computers." Each virtual computer may be running a different operating system from all of the other virtual machines on the physical machine. A crash or other program error on any of the virtual machines leaves all of the other virtual machines unaffected.

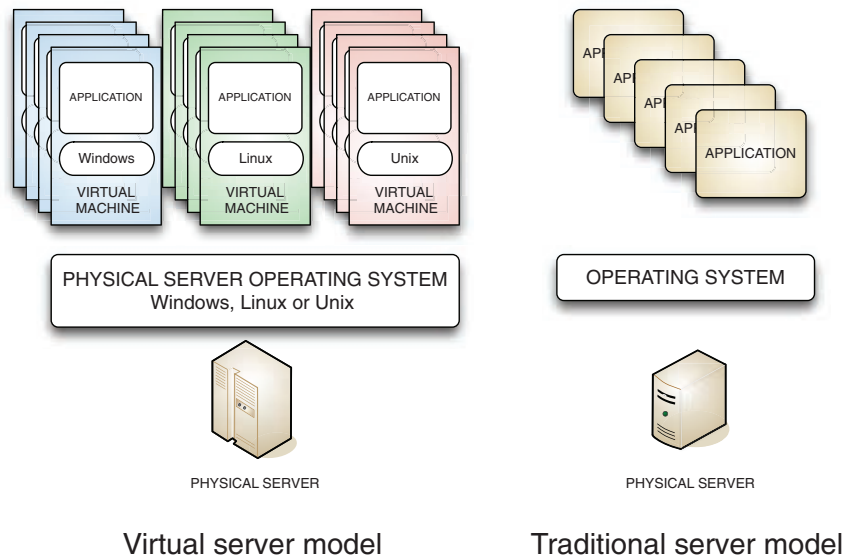
IBM's heritage in server virtualization reaches back over 40 years to the mainframe. Today, we offer solutions for Microsoft® Windows®, UNIX® and Linux® consolidation.

Desktop virtualization

Desktop virtualization moves the operating system and the applications it supports from the student desktop to a virtual computer running in a server. Each user can still customize the desktop environment (to the extent permitted by school policies). However, unlike working on a single assigned PC, when the student moves to a different location, such as from the classroom to a lab or library, the student's entire workspace appears on whichever workstation or device the student is currently using.

If workstation hardware should fail, the student's entire workspace is instantly available on any other workstation on the network. Software licenses for applications the student uses may be available for use by other students when the student's virtual desktop is not actually in use.

Figure 1: Server models



Server virtualization

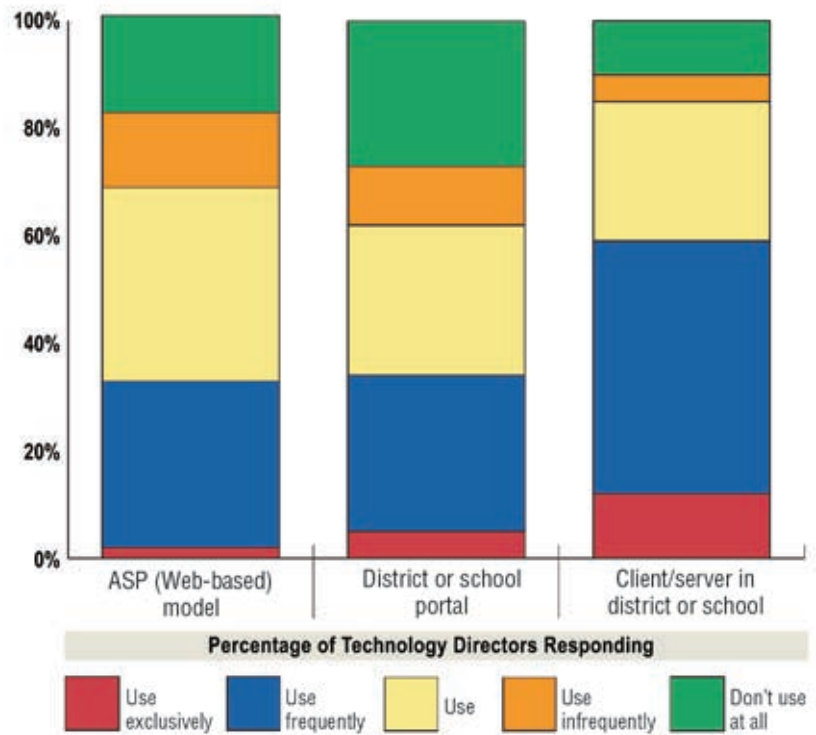
Server virtualization allows a physical server to be partitioned to run multiple secure virtual servers. This creates an opportunity to consolidate physical servers, thus helping to reduce hardware acquisition and management costs by eliminating “infrastructure sprawl” at the server level.

If the resource requirements of one of the server-based products running in a virtual server grows, because of increased usage for example, moving that virtual server to a different physical server with more available resources is as simple as copying a file.

This ease of replication of virtual servers also means that it’s simple to maintain snapshots of virtual servers as file back-ups and quickly restore complex systems to operation in the event of physical server hardware failures. This increased resilience results in more efficient use of existing physical server resources, lower operating costs, reduced power consumption and greater overall reliability.

In 2006, The Greaves Group and The Hayes Connection jointly conducted a survey of the 2,500 school districts in the United States with more than 4,000 students. Entitled *America's Digital Schools 2006 (ADS2006)*, the survey provides in-depth information about the use of technology, both actual and planned, in K-12 schools.

Figure 2: Hosting models



Source: *America's Digital Schools 2006*

The *ADS2006* survey asked technology directors about the hosting model for online instructional applications. The results show that the client/server model is used either exclusively or frequently by the majority of schools. Server virtualization gives district IT departments the tools to deliver secure, supportable application servers without software interaction problems.

Highlights

Furthermore, as new instructional products are deployed in one school, replicating the server for other schools in the district becomes a simple file copy operation. The lower support costs and higher hardware utilization rates made possible by virtualization enable districts to support more instructional applications at a lower cost.

The benefits of virtualization for education

Hardware refresh cycle savings

Most schools in the United States have acquired student workstation computers over an extended period. The typical school is faced with the dilemma of whether to spend scarce technology budget dollars to expand the number of student workstations toward one per student or to replace the oldest machines with newer models that will better support current operating systems and desktop applications.

Desktop virtualization is helping schools utilize older PCs and reduce the cost of new student workstations.

Desktop virtualization provides a way to increase the useful life of existing older PCs while at the same time reducing the cost-per-seat of new student workstations. This is done by running virtual desktop software on older PCs and purchasing less expensive thin client workstations rather than full desktop computers to add additional workstation seats to the school. Even older PCs that cannot run current versions of popular operating systems and desktop applications can do so when used as thin clients running virtualized desktop software.

Effective use of disparate hardware

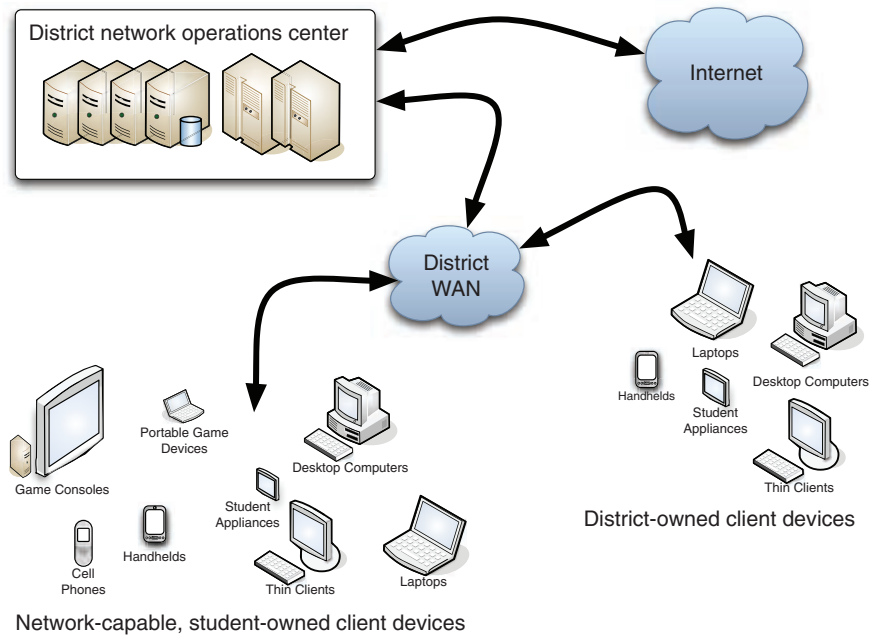
The *ADS2006* survey reported that more than a quarter of responding school districts with 4,000 or more students said they are implementing a 1:1 computing program in at least one grade of one school. To achieve one computer per student, districts must take full advantage of all of the available computing resources in the district.

Because the virtualization layer abstracts the resources of the underlying computer and presents them in a standardized way to the virtual machine's operating system and applications, any virtual machine can be run on any server in the data center. Older, smaller servers will support fewer virtual machines than newer, larger servers. However, the management interfaces to all of the virtual machines will be uniform and will result in lower administration costs.

For desktop workstations, virtualization provides a way to deliver a uniform student experience regardless of PC age. A lab equipped with PCs with different processors and memory will provide a uniform student user experience because the virtualized desktop environment exists on the network servers rather than individual PCs. The students' personalized workspaces will follow them from classroom to lab to library, and, where connectivity is available, the workspaces will even follow students home.

As connected devices become more ubiquitous, schools will be faced with the problem of supporting not only district-owned devices, but also a growing range of student-owned devices. More and more students now own personal network capable devices. Some, such as cell phones, smart phones, handhelds and portable game consoles already come to school with students in many districts. Others, such as game consoles and personal computers, could be used to extend the school day by providing access to curriculum content from home. Virtualization technologies provide a way to abstract the workspace environment in such a way as to be able to present educationally valid content on a broad range of devices.

Figure 3: Network infrastructure scenario



The additional network security provided by virtualization makes it possible for school networks to allow connection of student-owned devices to the school network without compromising the security, which is essential to maintain the reliability of the network.

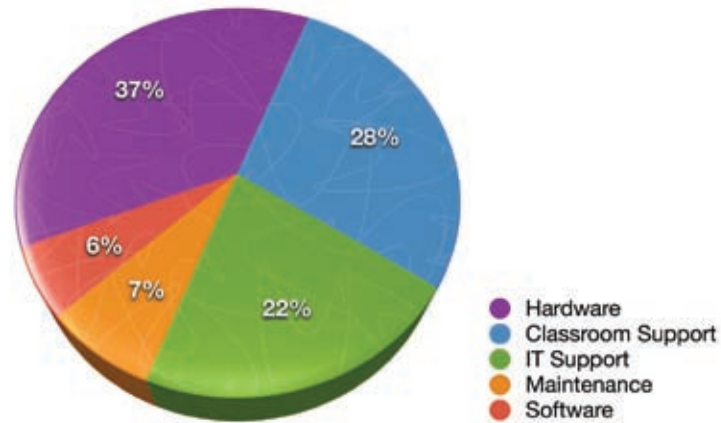
With client virtualization, you no longer care that all of the devices on the network are not similar. You can deliver curriculum content to students regardless of where they are or what sort of device they are using.

Lower total cost of ownership

Because the management of virtualized PC clients takes place mostly in the data center rather than in classrooms, administration is both simplified and standardized. Many system set-up and configuration operations that require access to physical computers in traditional computing environments become simple file copy operations in a virtualized desktop environment.

Analysis of data from *ADS2006* by The Greaves Group indicates that 50 percent of the total cost of ownership (TCO) of a PC is classroom support and IT support costs. Virtualized PC clients can help lower TCO by reducing cost of operations and both classroom and IT support.

Figure 4: Personal computer TCO components



Source: America's Digital Schools 2006 data analysis by The Greaves Group

Virtualization is green. As schools replace older desktop PCs with hardware specifically designed as thin clients, there are substantial savings derived from reduced power consumption. Let's take a look at the power savings for a school with 200 workstations that convert from traditional desktop computers to PC virtual clients on thin client hardware.

With 200 traditional desktop computers consuming an average of 150 watts per PC, we have a total power consumption of 30,000 watts. By replacing those machines with thin client hardware that consumes 20 watts per workstation (4,000 watts total) and adding an IBM BladeCenter[®] server to host the virtualization, which consumes an additional 4,000 watts, we have a total power consumption for the entire system of 8,000 watts.

Highlights

This means we're saving about 110 watts per desktop. If you're paying 10 cents per kilowatt hour for electricity, that's an estimated savings of more than \$20,000 per year. And do not forget, if you get your electricity from a coal-fired power plant, this means those 200 desktops contribute less than a third as much to the global warming problem as the 200 traditional PCs did.

In some states, utility companies are offering rebate programs for data centers that undertake virtualization programs. PG&E customers in northern and central California can earn financial incentives for virtualization projects. The incentives are based on the amount of energy savings achieved through data center consolidation. Qualifying customers can earn a maximum rebate amount of \$4 million per project site.

In addition to the rebate, customers can expect to save \$300 to \$600 in annual energy costs for each server that is removed. Those savings can almost double when reduced data center cooling costs are also taken into account.

Virtualization can provide companies significant energy savings and cost savings.

“Virtualization technology is helping our customers realize significant energy and cost savings while addressing critical data center capacity issues,” explains Helen Burt, senior vice president and chief customer officer for PG&E. “By providing financial support, we hope to increase adoption of this technology.”

In the *ADS2006* survey, 65 percent of responding superintendents said that “Low TCO” was “extremely important” in implementing a successful 1:1 computer program. Virtual client computing is one of the most powerful tools available in reducing student computing TCO.

Stretching software licensing dollars

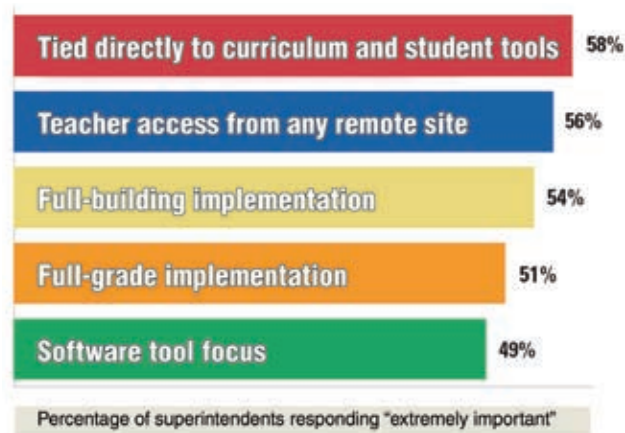
With virtual desktop workstations, you need only purchase software licenses for the peak instantaneous usage of any given product. Because licensed software runs in virtual PC clients on the server rather than on individual machines, it's easier to control. Limiting usage of a particular program to the number of licenses on hand becomes a manageable task. Just as virtual servers maximize utilization of physical server resources, virtual PC clients maximize utilization of software licenses.

Better data security

In a virtual desktop environment, software, data and most of the hardware elements that comprise the desktop workstation are in the data center and not on the desktop. This makes virtual PC clients inherently more secure since all of the data resides on servers in a secure data center rather than spread over desktops throughout the school.

The inherent security provided by virtualizing client machines lets you open the network to outside connections without compromising security. Teachers can use virtual clients running on district-owned notebooks or on their own personal PCs without the risk of insecure, virus-contaminated computers infecting the school network. In the *ADS2006* survey, more than half of the responding superintendents rated teacher access to the school network from any remote site "extremely important."

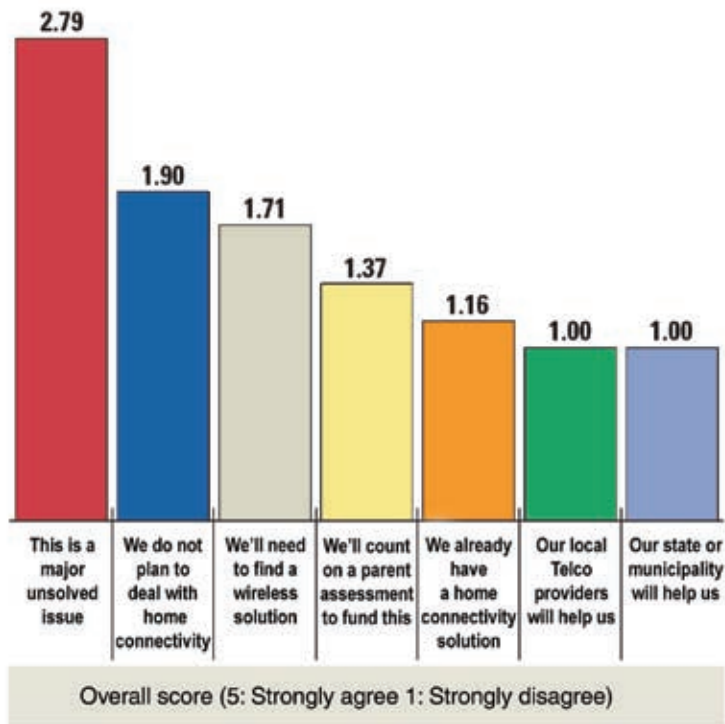
Figure 5: Desired features for ubiquitous computing



Source: *America's Digital Schools 2006*

Likewise, students using virtual client technology can connect to the school network using family-owned hardware without compromising the security of the network. Encouraging students to use curriculum resources on the school network effectively lengthens the school day and increases the network utilization. However, the issue of home connectivity is a thorny one for most school districts. The *ADS2006* survey asked the question “How has the home connectivity question been handled in your district?” The two most common responses from technology directors were “This is a major unsolved issue” and “We do not plan to deal with home connectivity.”

Figure 6: Home connectivity



Source: America's Digital Schools 2006

While everyone agrees that allowing students to connect from home has a beneficial effect on student performance, the network security issues and lack of standardized equipment in homes has made this difficult until now. Client virtualization addresses both issues. Students connecting to virtual PC clients on the school server can use a broad range of workstation devices ranging from game consoles to the family PC. The school network is protected because the virtual client connection interface is inherently secure and protects the school network from malicious content on the students' physical devices.

Higher equipment utilization

By isolating applications on dedicated virtual machines, the machine's available resources become the factor limiting the number of applications that can be supported, instead of the complexity of supporting multiple applications that share a single operating system environment.

Let's look at one way virtualization can result in higher server utilization in a school. When a new piece of server-based software (such as a learning management system) is deployed in a school district, the IT department must determine whether that system requires a dedicated server or if it can coexist with other systems on an existing server.

Because it simplifies product testing, the suppliers of server-based software almost always recommend running even small-to-medium-sized products on dedicated servers. Opting to recommend shared server operation is unattractive to software vendors because it forces them to take responsibility for undesirable software interactions that might actually be the fault, not of their software, but of one of the other systems running on the server. When school IT departments follow these recommendations, the result is improved server stability but at the cost of having a large number of woefully underutilized servers on the network.

Server virtualization allows each server-based product to run in its own virtual server free of interactions with other server-based products running in other virtual servers on the same physical server. Additional server-based products running in dedicated virtual servers can be added to the physical server until the resources of the physical server are fully utilized.

Real world examples

Clovis Unified School District

Located in Fresno County, California, the Clovis Unified School District has been using both server and client side virtualization for more than four years. The 42 schools in the district are connected with a Wide Area Network (WAN) that links every classroom, media center and office. Each secondary school site is connected to the district office via district-owned fiber providing up to 1 GB Ethernet speeds. The WAN is connected to the Internet with a DS3 ATM line to Pac Bell and a 20 megabit connection to the Fresno County Office of Education. The data network is protected by a Cisco PIX firewall. Over 300 Windows 2003 servers provide proxy, caching, filtration, VPN and other services to more than 7,200 workstations in the district.

The district operates approximately 950 seats of computer labs. Of these, the majority – more than 700 seats – are equipped with thin client devices running software that provides virtualized desktops for students. These are typically 35-seat labs in elementary and middle schools and range from 10 to 40 seats in the high school computer labs. While the bulk of the virtual clients run Microsoft Windows, the district does operate three labs running Linux thin client workstations. According to Chuck Phillips, the retiring chief technology officer for Clovis Unified School District, the switch to virtual client computing has yielded big savings in maintenance costs. “It’s been a real plus for us...we can tell that it’s working because of the growth, Phillips says. “Individual schools in the district decide what facilities they want, and they couldn’t have afforded this many seats if they implemented traditional PC-based computer labs.”

Highlights

As the district upgrades switches and network infrastructure in the schools, they are moving servers back to the district network operations center from the schools. This results in lower support costs as more of the support can be handled from a central location. Richard Kebo, the interim chief technology officer for the Clovis Unified School District, began using server virtualization about four years ago. Initially virtualization was used to provide secure sandbox environments for testing new applications and systems. But when budgets were tight, the district saw an economy of scale in running virtual server environments. According to Phillips, "Switching to virtual servers lowered the cost per server from about \$5,000 to \$3,000 per server. That's important in a district that's growing by more than 400 students per year." Kebo noted that virtualization has not reduced the number of servers because of the rapid growth of the network. "But it's the reason we've been able to keep up with the growth," he says.

Server virtualization increases system reliability and security.

Server virtualization has also increased system reliability. According to Phillips, "The schools would load up too many applications on one server and then wonder why things didn't work. Virtualization lets each application run in its own secure environment. It's been a real plus for us."

Cardiff University

Cardiff University in Wales is also implementing a server virtualization program. The university is currently running approximately 1,000 servers. “We have lots of servers running a single legacy application because of worries over software interaction,” says Simon Vaughan, assistant director for University Systems. Vaughan expects to see a 4-to-1 reduction in the number of servers as the virtualization program spreads. Cardiff uses VMware’s ESX server. “I would go with ESX every time. It’s just so easy,” says Vaughan. “It’s very low maintenance.”

But Cardiff uses other virtualization technologies as well. Their Cluster High Performance Computing project is using XEN server virtualization. The university also uses IBM’s Virtual Infrastructure Access Services and Citrix Metaframe servers to deliver virtual workstations to administrative staff. “That’s about 25 percent of our application delivery,” says Vaughan.

Cardiff University expects server virtualization to enable them to consolidate the 12 major server rooms they are now running into two network operations centers. “It will be a big space savings,” says Vaughan. “We’ll be able to turn back those rooms to the University for other uses.”

While Vaughan is enthusiastic about the lower support costs and the ease with which virtualization enables his department to deliver service improvements, he points out that, “power is a significant part of the overall savings. Not only a reduction in server power consumption, but a big reduction in cooling costs as well.” Vaughan estimates that the server virtualization program will yield an overall reduction in server TCO of 50 percent by the time the virtualization program is completed.

Summary

Virtualization is a powerful technology trend that is happening now. The trend is already underway and the outlook is that it will grow very rapidly. Educators owe it to themselves and their institutions to examine the opportunity very closely and see when and how they can start taking advantage of this exciting capability. Virtualization lets your IT staff deliver better service at lower cost and with greater security and reliability.

To find out if your network can benefit from virtualization, ask yourself the following questions:

- *Do you want to improve student performance by allowing student-owned devices to connect to the network?*
- *Do you want to extend the useful life of existing lab and classroom PCs?*
- *Does your IT staff spend a large portion of its time visiting school sites to perform maintenance on labs or classroom PCs?*
- *Do you want to reduce overall network power consumption and at the same time reduce server-room cooling costs?*
- *Do you need more room in your server rooms or network operations center?*
- *Does your IT staff routinely install or test new applications on a dedicated server to avoid unwanted software interactions?*
- *Do you want to enable a future of virtualized applications?*

If you answered “yes” to two or more of these questions, your district would benefit from greater use of virtualization technology.

Visit www.ibm.com/education today to arrange a visit from an IBM Global Education representative who can arrange for a site survey to give you a detailed analysis of the benefits of virtualization technologies for your organization.

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www.vmware.com/products/vi/esx/

Leostream Virtual Desktop Connection Broker

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IBM Systems Director: Virtualize More Manage Less
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