

Using IBM Virtualization to Manage Cost and Efficiency



Redguide for Business Leaders

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- See a dynamic infrastructure view of virtualization for business leaders
- Reduce costs, improve utilization, and speed provisioning of services
- View IBM hardware and software virtualization capabilities



Executive overview

Virtualization is part of the IBM® Dynamic Infrastructure® vision to build a smarter planet. IBM demonstrates leadership in virtualization and consolidation solutions that reduce cost, improve asset utilization, and speed provisioning of new services.

This IBM Redguide™ publication serves as both an introduction to the benefits that can be realized through virtualization and an overview of pertinent IBM hardware and software virtualization solutions to deliver that value.

This Redguide publication is organized into four main areas:

- ▶ An executive overview of the benefits and business drivers of virtualization (page 1)
- ▶ A quick look at consolidation using virtualization (page 5)
- ▶ An overview of IBM hardware and software virtualization technologies (page 9)
- ▶ The next steps to evaluating and deploying virtualization (page 35)

For more details about virtualization on various IBM platforms see *IBM Systems Virtualization: Servers, Storage, and Software*, REDP-4396, at:

<http://www.redbooks.ibm.com/abstracts/redp4396.html>

Also refer to “Other resources for more information” on page 36.

Business and IT management professionals seek to deliver new and enhanced business services in less time and with greater agility. The goal of providing rapid near real-time response to customer requirements is in part being achieved by taking advantage of virtualization. Virtualization provides many benefits, including improved physical resource utilization, improved hardware efficiency, and reduced power and cooling expenses.

Management of this new virtualized environment should be considered carefully to help reduce the burden of the operations team. IT management is embracing virtualization to deliver greater value to the business. Virtualization of the environment delivers benefits that enable IT management to do more with less.

Consolidation of resources obtained through virtualization offers compelling return on investments for the business. Most businesses are moving forward with server or storage

virtualization projects, or both, and are realizing the financial benefits. Virtualization should be a key initiative for many reasons, including:

▶ Environmental concerns

Many customers face similar issues. The organic growth of application environments has caused servers to proliferate from one or two servers to dozens or even hundreds of servers and beyond. This proliferation creates a real challenge in the data center when dealing with power, cooling, and physical space. Virtualization allows for consolidation and a more effective use of resources.

▶ Infrastructure simplification

Server sprawl can create an unwieldy environment. Virtualization enables you to simplify your physical infrastructure. Virtualizing enables you to get more use out of existing assets by sharing assets that were previously dedicated, and utilizing previously wasted white space. This makes them more effective and easier to manage. For example, being able to share I/O adapters between logical partitions on a server means that you need fewer adapters, which means that you need fewer cables, which also means that you need fewer ports on your switches. Virtualization allows you to consolidate your existing environment and also to contain and manage future growth.

▶ Improved manageability

When implemented correctly, virtualization (recommended in conjunction with automation) can increase the manageability of your infrastructure. IBM has been developing cross-platform tools using IBM Systems Director and IBM Tivoli® software to help manage heterogeneous infrastructures with a common set of tools. The use of cross-platform tools begins the process of building a consolidated view of your environment.

▶ Improved responsiveness

Virtualization can enable you to improve business responsiveness and operational speed by re-allocating resources dynamically to applications as needed. This re-allocation helps better match changing business cycles or handle unexpected surge in demand. This is possible because you have decoupled the physical from the virtual, thus providing an abstraction layer and flexibility. Faster application deployments and flexibility can be seen as a business advantage where, for example, being first to market with a new service can be a key to success.

▶ Business resiliency

Virtualization can help you meet your business challenges through an available and resilient infrastructure—from mitigating planned or unplanned outages to full disaster recovery. Virtualization can help:

- Increase the availability of your applications and workloads.
- Insulate users from system failures.
- Lower the cost of disaster recovery.

▶ Lower total cost of ownership

Virtualization enables you to simplify IT infrastructure and management and help workloads become independent of hardware resources. This enables clients to make business-driven policies to deliver resources based on time, cost, and service-level requirements. Making better use of IT assets in support of business goals enables you to reduce total cost of ownership.

For a virtualization solution to be effective, it must be flexible, dynamic, and secure, and it must integrate easily within a heterogeneous infrastructure. An effective virtualization solution allows you to maximize the utilization of your hardware, reduce cost through shared resources, and deploy new instances quickly without necessarily requiring additional

hardware. IBM technologies excel at providing the most flexible, dynamic, and secure virtualization solutions for x86, UNIX®, mainframe, and storage infrastructures.

IBM recognized the importance of virtualization in the 1960s with the development of the System/360 Model 67 mainframe and has continued to innovate ever since. Where possible, IBM takes advantage of proven investments in advanced server technologies and skills. This strategy allows greater capability for across server lines without having to reinvent technologies and methods. By using the proven capabilities of other server families, IBM shortens development cycles, reduces development costs, and increases interoperability for your complex IT environments. When IBM designs a server, the goal is always to get as close as possible to a platform that maintains continuous operation.

The cost of managing the IT infrastructure has become the largest and fastest-growing component of overall IT spending for many organizations. Virtualization helps address this cost through the consolidation of physical resources. However, companies must be careful not to add complexity by sharply increasing the number of managed virtual resources.

IBM Systems Director helps address these needs by unifying its industry-leading server and storage management products under one family, IBM Systems Director and TotalStorage® Productivity Center. The IBM Systems Director family provides a modular, open standards-based set of solutions that can be tailored easily to fit the requirements of any size business and can be integrated seamlessly into enterprise management solutions from IBM Tivoli and others. With capabilities that include configuration, discovery, health and status monitoring, automated response, and power and virtualization management, the IBM Systems Director family gives IT professionals what they need to manage both physical and virtual systems throughout multiple IT environments. IBM Systems Director can work in partnership with software management solutions from IBM, provided through the IBM Tivoli suite of offerings.

IBM Tivoli Service Management enables clients to better manage their infrastructure, operations, and IT processes, and to deliver services aligned to business goals more effectively. IBM software addresses the management challenges of a virtualized IT environment to provide the ability to embrace virtualization and strive to meet your business' various service-level agreements (SLAs). Business service-level agreement breaches are minimized using IBM best practices and IBM Tivoli service management solutions designed to manage the complexities introduced by virtualization.

The IBM model not only simplifies the way an IT organization views resources, it also affects the way that resources are allocated and added in response to change. The ability to plan system resources in flexible, granular increments combined with the notion that capacity is a variable object that can be altered in real time rather than a fixed object changes how customers can respond to business needs.

IBM is uniquely positioned to offer both a breadth and depth of virtualization offerings. No other vendor can bring together the virtualization solutions (infrastructure simplification, rapid application deployment, and business resiliency); server, storage, and application virtualization; and cross-platform management in a heterogeneous environment. IBM virtualization balances the need for flexibility and isolation in a virtualized environment, while simplifying management so that customers can manage the ever-increasing server and storage requirements while maintaining or reducing current staff.

Virtualization benefits

Virtualization helps you take back control of your infrastructure. Virtualization enables you to see and manage your computing resources in ways that offer more flexibility because you are not restricted by implementation, location, or physical packaging. With virtualization, you have a *logical* rather than a physical view of data, computing power, storage capacity, and other resources. By gaining greater control of your infrastructure, you can improve cost management.

Cost savings is a primary driver for initial virtualization deployment. The full value of virtualization lies in its ability to:

- ▶ Reduce operating costs.
 - Consolidate via virtualization to fewer systems.
 - Simplify management of the infrastructure.
 - Recapture floor space through consolidation.
- ▶ Improve service responsiveness.
 - Improve system, network, and application performance.
 - Process more information in real-time to make better business decisions.
 - Bring new services online quickly.
- ▶ Manage availability in a 24/7 world.
 - Increase availability and improve resiliency.
 - Manage and secure data without affecting its availability.
- ▶ Dynamically adapt to the peaks of the business.
 - Dynamically deliver resources where needed most.
 - Make data available from anywhere, anytime.

By decreasing management costs and increasing asset utilization, you can experience a rapid return on investment (ROI) with virtualization. In addition, by virtualizing resources and making them easier to migrate or fail over to other physical devices or locations, you can enhance system availability and help lower the cost and complexity of disaster-recovery solutions.

Virtualization supports the pooling of resources that can be managed centrally through an enterprise hub to better support changing business requirements dynamically. Virtualization provides a resilient foundation and shared infrastructure that enables better access to infrastructure and information in support of business applications and service-oriented architectures (SOA).

Companies of all sizes are aggressively adopting IBM virtualization solutions to help with:

- ▶ Infrastructure simplification

Virtualization can help control infrastructure sprawl through the deployment of virtual servers and storage that run securely across a shared hardware environment.

Virtualization not only helps with server consolidation, but also server containment when deploying new systems. Consolidating to a virtual infrastructure can enable you to increase server utilization rates from 5% to 15% to over 70%, thus helping improve ROI. In addition, a simplified infrastructure can help lower management costs with a common management platform and tooling.

- ▶ Rapid application deployment

Virtualization can help enable rapid infrastructure provisioning (for example, minutes compared to days). It can help developers speed application test and deployment,

enhance collaboration, and improve access to the infrastructure. The ease and flexibility of creating and reconfiguring guest operating systems (OSs) means that development and test environments can realize significant benefits from virtualization. For example, you can use Dynamic Logical Partitions (LPARs) on Power in a shared development environment where applications can reside in logically separate operating system environments, but on shared hardware. Partitions can be expanded dynamically for load testing and contracted dynamically when testing is complete. Thus, you can maximize the investment in your environment and quickly make changes based on demands and business priorities.

- ▶ **Business resiliency**

Virtualization can help IT managers secure and isolate application workloads and data within virtual servers and storage devices for easier replication and restoration. This added resiliency can provide IT managers with greater flexibility to maintain a highly available infrastructure while performing planned maintenance, and to configure low-cost disaster-recovery solutions. Virtualization technologies solve many traditional backup issues because they decouple the bindings between the operating system (with the application and data) and the underlying hardware.

- ▶ **Managing a virtualized infrastructure**

IBM Systems Director and IBM Tivoli Service Management offer the right systems management platform and common tools to support both virtual and physical devices. IT managers can address configuration, deployment, monitoring, workload management, and additional management functions in a consistent and common way across their infrastructures. This can help simplify problem determination, increase productivity, and lower management costs.

IBM takes a holistic approach to virtualization by working across all resource types, taking advantage of decades of mainframe experience, embracing a diversity of resources, and integrating the virtual and physical worlds. We can help you virtualize not only your broad physical infrastructure, but your application workloads and information as well.

Virtualization allows you to freely mix and match technologies through common management tools for managing distributed heterogeneous resources. This added freedom offers capabilities to lower switching costs, add flexibility and freedom of choice, and mask complexity. Not having to manage each computer or resource separately—but instead managing them together virtually—allows for significant improvements in utilization and administrative costs.

Virtualization allows for easier maintenance, more reliability, and improved problem determination. Because you can now create virtual machines by simply copying a disk from a given template into a production disk, reliability and ease of maintenance of that guest operating system increase. In the past, administrators were used to installing operating systems on different hardware platforms with different disk controllers, different network cards, and so forth, thus increasing the complexity of software stack and drivers being installed. Because one of the key advantages of virtualization is that of shielding the real hardware being used, it provides a consistent set of virtual hardware interfaces that are exposed to the guest operating system.

Consolidation using virtualization

Businesses are pursuing financial savings through both server and storage consolidation, as well as looking at network and application consolidation. This consolidation is achieved using virtualization. The distributed computing environment in many data centers comprises numerous under-utilized servers. The ability to reduce floor space, power consumption, heat

generation, air conditioning costs, and the total number of physical servers that are managed easily supports the server and storage consolidation business plans.

Server consolidation

The process of server consolidation requires upfront planning to decide which physical servers along with their associated workloads can be consolidated together. The workload performance characteristics are considered for consolidation compatibility along with business requirements. The physical servers are transformed into virtual machines, and then compatible virtual server machines are consolidated onto a reduced number of physical servers hosting the virtual environment for consolidation. The utilization of the physical server hosting the consolidated virtual machines increases as additional virtual machines are hosted on it.

The need to discover and inventory the virtual machine assets in the virtual environment will emerge as the data center progresses forward with physical-to-virtual server conversions. Full visibility into the business services, including batch and online workloads, provided by the underlying IT infrastructure that supports these services, is important. To manage these services properly, it is critical to see and understand the makeup of these business services. This is where IBM Tivoli Service Management comes into play, which we discuss in “Systems and virtualization management” on page 30.

You must consider the capabilities of the platform that you have chosen for consolidation. Where possible, IBM takes advantage of proven investments in advanced server technologies and skills. This strategy allows greater capability across server lines without having to reinvent technologies and methods. By using the proven capabilities of other server families, IBM shortens development cycles, reduces development costs, and increases interoperability for your complex IT environments.

Running more of your applications on shared hardware makes reliability, availability, and serviceability (RAS) even more important. IBM uses skills and technologies from the mainframe and incorporates them across product lines to increase RAS. When IBM designs a server, the goal is always to get as close as possible to a platform that maintains continuous operation. Building highly available servers takes more than just using reliable components or redundant disk drives, fans, and power supplies. Naturally, these things are done. However, it is important to address both causes of downtime (scheduled and unscheduled outages) to truly improve operational efficiency. That is why serviceability (for example, performing real-time nondisruptive service actions such as installing and replacing components) is also an important factor.

Storage consolidation

The amount of data and information being generated by businesses continues to grow. The IT data center manager must deal with this high rate of growth, while at the same time look for ways to reduce costs. Storage consolidation helps the data center manager deal with rapid growth and cost concerns. Increasing the utilization of the storage hardware, similar to what was discussed for the server hardware, is cost-effective and helps meet the growing demand. Storage consolidation is the allocation or provisioning of shared storage resources.

Storage virtualization software, similar in concept to server virtualization, abstracts the storage hardware volumes of data into a logical or virtual view of the volume. Using SAN hardware with storage virtualization gives the data center a method to support storage provisioning in a manner that is independent of the underlying storage hardware. Storage virtualization can enable data sharing, data tiering, improved storage hardware utilization,

improved availability, and disaster recovery capabilities. Storage virtualization software separates the representation of the storage to the operating system from the physical device.

Network virtualization

If physical server farms are consolidated into virtual server farms, then parts of the physical network can be replaced by a virtual network, saving money and reducing management complexity. Network performance and bandwidth between the servers is increased, enabling new data-intensive applications. We do not discuss *network virtualization* in detail in this Redguide publication, but in this section, we provide a brief overview of the topic and highlight the various technologies within the platform-specific topics.

There are business-critical application requirements to manage and utilize network resources more efficiently with regard to performance, resource usage, people cost, availability, and security. Network virtualization includes the ability to manage and control portions of a network that can even be shared among different enterprises, as individual or virtual networks, while maintaining isolation of traffic and resource utilization.

Network virtualization includes technologies such as virtual private networks (VPNs), HiperSockets™, virtual networks, and virtual logical area networks (VLANs). It also includes the ability to prioritize traffic across the network to ensure the best performance for business-critical applications and processes.

Network virtualization technologies include:

- ▶ Virtual IP address (VIPA) takeover
Virtual addresses reduce the dependence on single physical connections of servers to networks. VIPA takeover allows for automatic recovery of network connections between different servers.
- ▶ HiperSockets
This is a mainframe-based technology that allows any-to-any TCP/IP network connection between virtual servers. This technology provides secure IP communication at memory speed between virtual servers, thus creating a base for closer integration of applications and the implementation of new data-intensive applications.
- ▶ Virtual Ethernet
This is power technology that enables internal TCP/IP communication between partitions.
- ▶ Virtual Fabric Architecture
In 2004, IBM and Cisco announced VFrame on BladeCenter®. VFrame virtualizes Fibre Channel SAN and Ethernet network on a single physical interface using InfiniBand® technology.
- ▶ Virtual LANs (VLANs)
This is a commonly used standards-based technique in which physical networks are shared in a secure way between multiple applications or user groups.
- ▶ Virtual private networks
This is a commonly used standards-based technique that encrypts data between two TCP/IP endpoints to provide end-to-end physical security for the transport.

It is important to note that much of the virtualization is at the platform layer, requiring support in the hypervisors and, in some cases, in the firmware, to enable sharing between different operating systems (in addition to the sharing that is provided in the operating system for functions, such as VLAN, QoS, and VPNs). Also note that integrating the management of

these networking resources in the context of the applications that they support and the servers on which the applications run begins to reduce the complexity of managing servers and networks separately. Examples include IBM Systems Director support for Cisco and Nortel blades and IBM Tivoli Provisioning Manager support for configuring server network resources, such as adapters, IP addresses, and VLANs.

Application virtualization

We do not discuss application virtualization in detail in this Redguide publication, but we provide a brief overview here of IBM WebSphere® Extended Deployment.¹

The need to apply the principles of virtualization to software management led IBM to create WebSphere Extended Deployment (WebSphere XD), a powerful tool rooted in application-focused virtualization. WebSphere XD works at the business application layer in an array of heterogeneous servers or a server farm of homogeneous servers and allows the user to view infrastructure resources as a single, consistent entity.

WebSphere XD reduces the potential for bottlenecks when various server types are in use and manages the workload at the application layer dynamically so that applications are started and stopped at the proper time and in the desired priority. In this way, the strong workload management capabilities of WebSphere XD enable the business to meet its established service policies.

From the business perspective, WebSphere XD presents a compelling value proposition by accomplishing three important goals:

- ▶ Business service-level objectives are met and workload throughput is increased.
- ▶ Utilization of hardware resources is maximized, often resulting in a consolidation of servers.
- ▶ The IT infrastructure can support new, innovative applications and types of workloads.

WebSphere Extended Deployment contains the following components, which can be purchased together as a single solution or as individual components. The WebSphere Extended Deployment Version 6.1 components include:

- ▶ WebSphere Virtual Enterprise
This provides application virtualization, centralized workload management, and administration for Java™ applications running on WebSphere and other middleware application servers.
- ▶ WebSphere eXtreme Scale
This contains high-performance features enabling applications to process massive data volumes efficiently.
- ▶ Compute Grid
This enables the scheduling, execution, and monitoring of batch type jobs with enhanced service policy and workload management.

¹ For more information about WebSphere XD 6.1, see Announcement Letter 207-088, "IBM WebSphere Extended Deployment V6.1 delivers workload management, application virtualization, and innovative application pattern support," available at http://www.ibm.com/ishource/cgi-bin/goto?it=usa_annred&on=207-088.

IBM server virtualization features and benefits

IBM server virtualization solutions are designed to provide flexible, dynamic, and secure virtualization capabilities while leveraging the underlying hardware. IBM has been able to utilize its 40+ year history starting with virtualization on the mainframe to bring enterprise class virtualization capabilities across its server lines. This section discusses many of those features and benefits.

For more information about specific technologies, refer to “Other resources for more information” on page 36 or go to:

<http://www-03.ibm.com/systems/virtualization/>

System z virtualization

From simple multitasking to logical partitions to complete simulation of virtual hardware, the virtualization capabilities of the IBM mainframe continue to represent some of the most mature and sophisticated virtualization technology in the industry today.

During spikes in demand, the IBM mainframe’s ability to redistribute system resources quickly and scale up or out can make the difference between flawless execution and the cost of slow response times or system crashes. For example, a single IBM System z® mainframe can scale up to millions of transactions per day or scale out to manage tens to thousands of virtual servers. It can also redistribute system resources dynamically to manage varying server demands on the system resources autonomically.

The System z platform is designed to handle the demanding requirements of business-critical core business systems. System z architecture is designed with a larger cache and more advanced reliability, availability, and serviceability features than other platforms in order to support these demanding high-volume or virtualized workloads. System z multi-dimensional virtualization technology consists of both hardware and software that work together seamlessly as part of the System z architecture. System z hardware provides a robust and reliable foundation that supports a powerful and flexible software layer.

IBM introduced the first virtualization technology, the virtual machine (VM) hypervisor, in 1968. Today’s version, z/VM®, provides the ability to create tens to hundreds of virtual machines or virtual systems and continues to evolve. In 1988, IBM introduced Processor Resource/System Manager (PR/SM™) technology, which lets you create multiple logical partitions, each of which, like z/VM, allows a full-scale OS to operate concurrently on the same physical mainframe footprint. PR/SM is fundamental to all System z mainframes, providing a highly stable and security-rich, firmware-encapsulated virtualization technology adjunct to z/VM, which is a full-scale hypervisor.

Mainframe virtualization technologies

System z advanced hardware lets you to:

- ▶ Logically partition the machine.
- ▶ Share CPU, memory, and I/O (channels and associated devices).
- ▶ Add or remove computing capacity on demand.
- ▶ Provide high-speed communications among partitions.

Collectively, System z hypervisor technologies provide the ability to support and dispatch multiple LPARs and virtual machines efficiently. The PR/SM layer supports an ever-growing number of LPARs. The latest System z technology can support up to 60 distinct partitions or servers. z/VM runs in an LPAR and provides a virtualization layer designed to allow the capability to run hundreds to thousands of virtual server images for larger deployments.

- ▶ Logical partitioning and PR/SM

Processor Resource/Systems Manager™ (PR/SM) is System z hardware technology that allows multiple operating systems to run on the same physical processor, with each operating system running in its own LPAR. System z PR/SM can currently support up to 60 of these logical partitions.

- ▶ Address spaces within LPARS

The z/OS® operating system employs address spaces and storage-protect keys to further protect key programs within an LPAR from corrupting each other's private storage or data areas. Storage-protect keys prevent programs from altering another's storage by matching the program's storage protect key against the storage protect key of the storage used by other programs in the LPAR. Additionally, extensive system locking and serialization techniques coordinate system events and actions. The combination of address spaces, storage protect keys, and system locking all help ensure that z/OS provides the maximum in data integrity and availability.

- ▶ HiperSockets

HiperSockets introduced the ability for virtual servers to communicate at near memory speed. This System z feature offers several advantages. From the hardware side, you can benefit from efficiency by eliminating much of the latency often associated with external physical networks. Implementing HiperSockets can also result in cost savings by reducing the amount of hardware (cabling, routers, switches, and hubs) that would otherwise be required if physical servers, rather than virtual ones, were connected together through an external network. HiperSockets can also provide a security advantage because inter-server communication is contained within the System z server and, therefore, eliminates exposures that might arise when separate physical servers communicate with each other.

- ▶ z/OS Workload Manager

System z Workload Manager (WLM) is the foundation for effective resource sharing on System z. Unlike other workload managers, System z Workload Manager is service-goal or service-level agreement oriented. Instead of telling the system how to manage its workloads (as in the UNIX environment), you simply tell System z what your service goals or SLAs are and WLM determines the optimum way to achieve those goals automatically.

- ▶ Intelligent Resource Director

The System z Intelligent Resource Director (IRD) complements System z Workload Manager. Where Workload Manager focuses on ensuring that the most important jobs and transactions get their required execution priorities, Intelligent Resource Director ensures that those tasks always get all the resources that they need to do the job.

For example, when IRD sees that a job is not getting the data as fast as it needs to, it can add additional data channels from a reserve pool of channels automatically or take away underutilized channels from lower priority jobs to meet the new need dynamically. IRD can also work with the logical channel subsystems to ensure that I/O requests from higher priority jobs always get put at the head of the queue so that they are serviced first. Similarly, IRD works with DS8000® Enterprise disk systems to ensure that the same kind of priority I/O queuing is done across different System z mainframes within a Parallel Sysplex®. System z Work Load Manager and Intelligent Resource Director work together to balance workload requirements against available resources in order to achieve service-level agreement requirements.

► z/VM

z/VM is key to the software side of virtualization on the mainframe. The z/VM hypervisor is designed to help clients extend the business value of mainframe technology across the enterprise by integrating applications and data while providing exceptional levels of availability, security, and operational ease. z/VM virtualization technology is designed to allow the capability for clients to run hundreds to thousands of Linux® servers on a single mainframe running with other System z operating systems, such as z/OS, or as a large-scale Linux-only enterprise server solution.

z/VM offers an ideal platform for consolidating select UNIX and Linux workloads on a single System z server. Running Linux as a guest of z/VM is designed to provide the capability of running hundreds to thousands of Linux images while benefiting from the reliability, availability, scalability, security, and serviceability characteristics of System z servers. At the same time, it allows customers to exploit the exceptional capabilities of z/VM virtualization.

► Capacity Upgrade on Demand

IBM provides the capability to quickly and nondisruptively activate *extra* processor capacity that is built directly into System z products. Capacity Upgrade on Demand is available for a permanent increase of processing capability. On/Off Capacity on Demand is available for a temporary capacity increase that lets you revert to your previous processing level whenever you want. There are also offerings for interim capacity for continued operation.

Linux on IBM System z

The rise of Linux in the IT world, from an interesting academic exercise to a popular platform for hosting enterprise applications, is changing the way enterprises think about their computing models. Linux on the IBM System z platform can help with infrastructure simplification and existing modernization by taking advantage of the outstanding IBM mainframe and z/VM capabilities. Linux can run on the mainframe natively in a logical partition, or as a virtual machine running under z/VM.

Linux on System z is an attractive platform that brings the strengths of the mainframe to new workloads, offering a higher level of uptake, integration with existing data and core applications available with z/OS and z/VSE™, less complex manageability, and dynamic workload management capabilities that can help to optimize your cost base. An effective way to grow your Linux workload capacity is to add more Linux guests to a VM system. By consolidating Linux servers onto one platform, hundreds or thousands of Linux instances on a single server require less energy, cooling, and floor space.

Integrated Facility for Linux

The Integrated Facility for Linux (IFL) is a central processor (CP) that is dedicated to Linux workloads. The attractively priced IFL processor enables you to purchase additional processing capacity exclusively for Linux workloads, without affecting the million service unit (MSU) rating or the IBM System z model designation. This means that an IFL will not increase charges for System z software running on general purpose (standard) processors in the server.

An IFL has the functionality of a general purpose System z processor and operates on full capacity. The consistent IFL price for the System z generations, besides the lower IFL price for z9® and z10 Business Class, can deliver price and performance gains with each successive generation of technology. z/VM V4/V5 and most IBM middleware products that run on Linux on System z are priced per processor, not per instance, and many software vendors have adopted the IBM pricing model for the traditional and Linux workloads.

Figure 1 shows that adding IFL capacity to your mainframe does not increase IBM software licensing costs for the traditional mainframe environment (for example, z/OS).

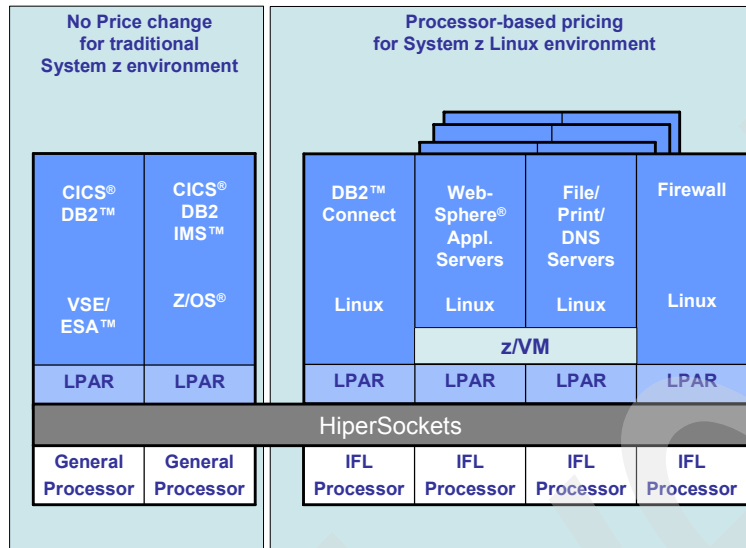


Figure 1 Adding IFL capacity to mainframe does not increase IBM software licensing costs

Benefits of running Linux on the mainframe

Linux running on the IBM System z platform can reduce costs and over time the savings can be considerable. Potential savings can be derived from several areas, such as:

- ▶ Unified IT infrastructures based on the consolidation of distributed servers to virtual Linux servers on System z can enable higher utilization rates and reduce software licensing costs, minimize complexity, reduce maintenance effort with intelligent workload management, streamline the network, and provide a more security-rich environment.
- ▶ Linux running on mainframes provides high qualities of service for your Linux applications utilizing the historical strengths of the System z environment and the established business processes and disciplines for disaster recovery and business resiliency.
- ▶ You can take advantage of your existing z/OS or z/VSE programs and data while deploying new applications rapidly with Linux on the mainframe.
- ▶ Linux-based solutions in the System z environment are easily deployed, extending the existing business applications and the open standards support of System z and enlarging the application developer and skill base for consistently high qualities of service to the user.
- ▶ Linux is platform agnostic, thereby allowing you to utilize the same tools and deploy across a range of architectures with a simple recompile. The mainframe with z/VM provides an excellent development environment. New virtual machines can be deployed in minutes on existing capacity, and if the virtual machine is not in use, its capacity is freed up for use by other virtual guests.

Project Big Green from IBM Spurs Global Shift to Linux on Mainframe^a

01 August 2007—In one of the most significant transformations of its worldwide data centers in a generation, IBM announced that it consolidated about 3900 computer servers onto about 30 System z mainframes running the Linux operating system. The company anticipates that the new server environment will consume approximately 80% less energy than the current set up and expects significant savings over five years in energy, software and system support costs.

At the same time, this transformation makes the IT infrastructure from IBM more flexible to evolving business needs. The initiative is part of *Project Big Green*, a broad commitment that IBM announced in May 2007 to sharply reduce data center energy consumption for IBM and its clients.

“The mainframe is the single most powerful instrument to drive better economics and energy conservation at the data center today,” said James Stallings, general manager, IBM System z mainframe. “By moving globally onto the mainframe platform, IBM is creating a technology platform that saves energy while positioning our IT assets for flexibility and growth.”

a. IBM press release 01 August 2007

Why IBM System z

System z is designed with a processor book architecture. The business-class systems have a one-book architecture, while the enterprise-class systems have a four-book architecture. The book architecture provides System z with uniquely flexible and dynamic configuration options. Of the multiple processor units (PUs) that come in each book (which varies depending on which generation of machine you have), only three to four have predefined roles. Two of these are defined as *system assist processors* (SAPs) and are devoted exclusively to supporting disk and tape I/O operations. Based upon the System z model, one or two of the processors are designated as hot spares that are invoked automatically to replace any failing processor.

The remaining units are defined as user characterizable, which means that you can individually define each processor unit to perform any of several specialized processing roles (for example, Linux, Java, and DB2®). As a result, you can tailor and optimize System z to meet the unique processing characteristics of your particular environment.

The System z book structure is also the basis for cost effectively tailoring System z in terms of the processing power that you require. This is because, while each book comes with all processors enabled, you can disable all but one of the user-characterizable processors if you initially do not require the full capacity. You only pay for the activated processors. Then, as your processing needs grow, you can simply activate any of the deactivated processors to meet the growing need.

The mainframe also provides the capability to run processors at subcapacity levels. This is controlled through microcode, and with today's increasingly powerful engines, enables customer to purchase hardware (and license software accordingly) in flexible increments.

System z processors are superscalar, meaning that they can execute multiple instructions on each processor cycle, resulting in more processing parallelism and higher performance. System z architecture means extremely high processing accuracy. Each processing unit contains dual processors, and each processor has its own instruction and execution units, as well as its own floating-point functions. This means that each instruction is executed twice, once on each processor, and the results are compared automatically to ensure simplified but highly accurate error detection.

Each System z PU also has a compression unit on the chip, providing excellent hardware compression performance. Similarly, each PU also has a CP Assist for Cryptographic Function (CPACF) on the chip to provide high-performance hardware encryption and decryption support for clear key operations. The compression and CPACF units are integrated and as a result both units benefit from combining their buffers and interfaces.

► Qualities of service

System z is built for high availability. For example, should a processor fail, the status of the application running on the processor will be preserved and the application will continue on a newly assigned spare processor without user intervention. If no spare processor exists, the application state and workload will be passed to another active processor, after which System z will recover the failing task and enable it to resume normal operations. System z also has redundant I/O interconnect, which means that it has dual connections to each I/O subsystem so that each book can get to each I/O device even if one of the I/O connections fails or the other book is offline for maintenance purposes.

► I/O capabilities

System z has a unique channel architecture that is designed to provide powerful and flexible support for the most demanding I/O performance and high-volume workloads. This is managed through the foundation technology called logical channel subsystems (LCSS). Each System z can have up to four of these logical channel subsystems, each capable of supporting 15 logical partitions, and each capable of addressing 256 data channels and 64,000 I/O devices. As a result, a single System z today can handle over 1,000 data channels and a quarter million I/O devices.

The logical channel subsystem's architecture is further enhanced by the System z Multiple Image Facility. This Multiple Image Facility allows all 15 logical partitions that share a common logical channel subsystem to directly access each I/O device without having to forward the request through an intermediate partition, as is the case with UNIX architectures. The direct result of a shorter path length is improved I/O performance.

System z channel spanning allows each device (disk or tape units attached using Fibre Channel technology) to appear to be on any logical channel subsystem. This means that it can be accessed by any partition on the mainframe. The direct result is greater I/O flexibility and simplified operational management.

► Specialty engines

System z offers the unique capability to add specialty processors to help users expand the use of the mainframe for new workloads, while helping to lower cost of ownership. The IBM System z specialty engines can run independently or complement each other. These specialty engines include:

- Integrated Facility for Linux: The attractively priced IFL processor enables you to purchase additional processing capacity exclusively for Linux workloads, without affecting the MSU rating or IBM System z model designation.
- Integrated Information Processor (zIIP): zIIP is designed to help free up general computing capacity and lower overall total cost of computing for select data and transaction processing workloads for business intelligence (BI), enterprise resource planning (ERP), and customer relationship management (CRM), and select network encryption workloads on the mainframe. IBM does not impose software charges on zIIP capacity.²

² Additional IBM software charges apply when additional general-purpose CP capacity is used. The amount of general-purpose processor savings varies based on the amount of workload executed by the zIIP, among other factors.

- Application Assist Processors (zAAPs): zAAPs are attractively priced specialized processing engines that provide a strategic z/OS Java execution and XML parsing environment. IBM does not impose software charges on zAAP capacity.
- Internal Coupling Facility (ICF): The coupling facility allows multiple z/OS LPARs to share, cache, update, and balance data access. There is no associated software cost for the ICF.
- System Assist Processor (SAP®): The SAP is standard on IBM System z servers and is a dedicated I/O processor to help improve efficiencies and reduce the overhead of I/O processing of every IBM System z logical partition regardless of the operating system (z/OS, z/VM, Linux, z/VSE, and z/TPF). There is no software cost for the SAP.

Macro 4 boosts speed-to-market with IBM System z9® Business Class^a

By implementing an IBM System z9 Business Class server with zAAP, zIIP and IFL engines, Macro 4 has improved its ability to run multiple independent virtual server environments simultaneously.

- ▶ **Business need:** Prepare for deployment of new mainframe technologies at customer sites; manage rapid growth in demand for processing resources; improve time-to-market for new products; keep total cost of ownership low
- ▶ **Solution:** Worked with IBM and Thesaurus to install a new IBM System z9 Business Class (z9 BC) platform with two standard engines, one Integrated Facility for Linux (IFL) engine, one IBM System z Application Assist Processor (zAAP) and one System z Integrated Information Processor (zIIP)
- ▶ **Benefits:** Ability to run dozens of virtual test and development environments side-by-side and to run multiple operating systems on a single physical server; ability to increase capacity 800 percent without requiring disruption to live systems; anticipated return on investment within 12 months

a. Case study available at <http://ibm.com/systems/z/advantages/virtualization>

IBM Power Systems virtualization

IBM Power Systems™ platforms (System i® and System p®) provide a virtualization feature named PowerVM™ (formerly Advanced POWER® Virtualization). The supported operating systems (AIX®, Linux, and i5/OS®) have been modified to support and optimize the underlying hardware virtualization capabilities. World-class POWER virtualization balances the need for flexible resource management and isolation within a dynamic environment.

Key benefits of deploying PowerVM Editions and IBM Power Systems include:

- ▶ Go green and save, by potentially cutting energy costs up to 65% through server consolidation³.
- ▶ Potentially reduce the cost of existing infrastructure by up to 72%⁴.
- ▶ Manage growth, complexity, and risk by potentially reducing server sprawl and administration while improving availability and application performance.
- ▶ Take advantage of 40 years of leadership in virtualization from IBM.

³ Based on an IBM study. Data is available at <http://www.ibm.com/systems/power/software/notices/index.html#1>.

⁴ From the paper "Impact of IBM System p Server Virtualization," Transforming the IT Value Equation with POWER6™ Architecture. International Technology Group, May 2007.

PowerVM virtualization features

PowerVM comes in three editions. You choose the right offering for your business needs:

▶ **PowerVM Express Edition**

PowerVM Express Edition is offered exclusively on the p550 and p520 Express servers and is designed for users looking for an introduction to more advanced virtualization features at a highly affordable price. With PowerVM Express Edition, users can create up to three partitions on the server, take advantage of virtualized disk and optical devices (Virtual I/O Server, or VIOS), and even try out the shared processor pool.

▶ **PowerVM Standard Edition**

For users ready to get the full value out of their server, IBM offers PowerVM Standard Edition, providing the most complete virtualization functionality for UNIX and Linux in the industry. PowerVM Standard Edition is available on all POWER5™ and POWER6 processor-based servers and includes features designed to allow businesses to increase system utilization, while helping applications continue to acquire the resources they need.

▶ **PowerVM Enterprise Edition**

PowerVM Enterprise Edition is offered exclusively on POWER6 processor-based servers and includes all the features of PowerVM Standard Edition plus an exciting new capability called Live Partition Mobility. Live Partition Mobility allows for the movement of a running partition from one POWER6 server to another with no application downtime, resulting in better system utilization, improved application availability, and energy savings. With Live Partition Mobility, planned application downtime due to regular server maintenance can be a thing of the past.

Table 1 IBM Power Systems PowerVM Editions

	Express	Standard	Enterprise
Maximum LPARs	3 per server	10 per core	10 per core
Management	IVM	IVM, HMC	IVM, HMC
Virtual I/O Server	✓	✓	✓
Lx86	✓	✓	✓
Shared Dedicated Capacity ^a	✓	✓	✓
Multiple Shared Processor Pools ^a		✓	✓
Live Partition Mobility ^a			✓

a. POWER6 processor-based models only

PowerVM technologies

The PowerVM technologies available are:

- ▶ **Micro-partitioning technology and shared processor LPARs**

Shared processor logical partitioning (LPAR) allows clients to *slice up* a machine into virtual partitions and provides the flexibility to change the allocation of system resources dynamically for those environments. The micro-partitioning feature provides the capability to create multiple virtual partitions within a processor to a granularity of 1/100th of a CPU, with a 1/10th of a CPU partition minimum.

- ▶ **Integrated Virtualization Manager**

The Integrated Virtualization Manager (IVM) literally allows you to point, click, and consolidate workloads with its easy-to-use, browser-based interface. The IVM lowers the cost of entry into power virtualization because it does not require the use of a hardware management console for single system partitioning.

With IVM, you can partition a single system, including the creation of LPARs and management of virtual storage and Ethernet. Best of all, IVM is included at no additional cost with the optional purchase of PowerVM on most IBM System p entry to mid-range models, as well as the BladeCenter JS21 and JS21, and select Power Systems servers. It is packaged as part of the Virtual I/O Server.

- ▶ **Virtual I/O Server**

The Virtual I/O Server is a special-purpose partition, called the *hosting partition*, which provides virtual I/O resources to client partitions. The Virtual I/O Server owns the resources that are shared with clients. A physical adapter that is assigned to a partition can be shared by one or more partitions, enabling administrators to minimize the number of physical adapters that they require for individual clients. The Virtual I/O Server is thus designed to reduce costs by eliminating the need for dedicated network adapters, disk adapters, and disk drives. Unlike other virtualization techniques, PowerVM does not require all devices to be virtualized.

- ▶ **Live Partition Mobility**

Part of the PowerVM Enterprise Edition offering, Live Partition Mobility allows clients to move a running partition from one physical System p POWER6 server to another System p POWER6 server without application downtime, helping clients to avoid application interruption for planned system maintenance, provisioning, and workload management. Live Partition Mobility is supported on IBM System p POWER6 servers.

The migration operation, which takes just a few seconds, maintains complete system transactional integrity.⁵ The migration transfers the entire system environment, including processor state, memory, attached virtual devices, and connected users.

Live Partition Mobility allows you to move partitions around so that you can perform previously disruptive operations on the machine when it best suits you, rather than when it causes the least inconvenience to the users. Live Partition Mobility helps you meet continuously increasingly stringent service-level agreements, because it allows you to move running partitions and applications proactively from one server to another.

- ▶ **Shared dedicated capacity**

A new feature for POWER6, shared dedicated capacity allows for the *donation* of spare CPU cycles for dedicated processor partitions to be utilized by the shared pool, thus increasing overall system performance. The dedicated partition maintains absolute priority for dedicated CPU cycles, and sharing only occurs when the dedicated partition has not consumed all its resources. Shared dedicated capacity is supported on IBM System p POWER6 servers.

⁵ For more information about Live Partition Mobility, see *IBM PowerVM Live Partition Mobility*, SG24-7460.

- ▶ AIX workload partitions

AIX 6.1 introduces a new mechanism for virtualization: *workload partitions* (WPARs). In contrast to LPARs, which are created and managed at the server's firmware level, AIX WPARs are software partitions that are created from, and share the resources of, a single instance of the AIX operating system. This means that you must have AIX 6.1 to create WPARs, but you can create WPARs on any System p hardware that supports AIX 6.1, including POWER4™, POWER5, and POWER6 hardware. You do not need an HMC or IVM to create or manage WPARs.

Figure 2 shows that LPARs and AIX workload partitions are complementary technologies and can be used together. Each square on this diagram represents a processor or micro-partitioned processor, while each dotted-line square represents a WPAR.

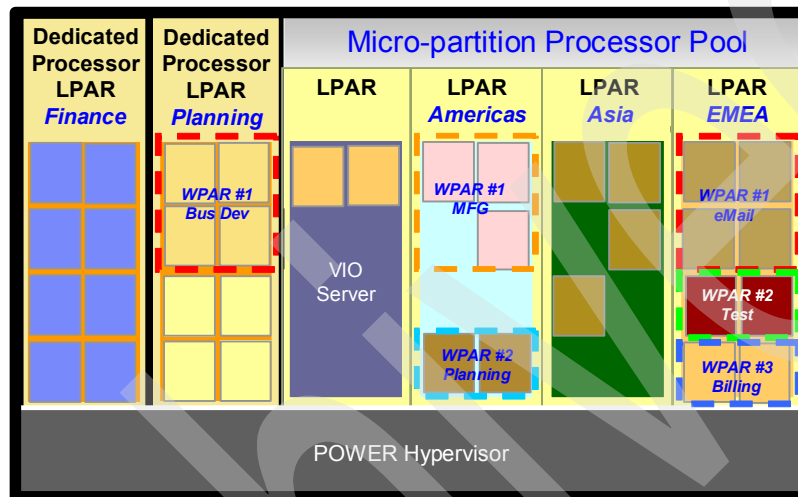


Figure 2 LPARs and workload partitions together on a system

- ▶ Multiple shared processor pools

Multiple shared processor pools allows for automatic nondisruptive balancing of processing power between partitions assigned to the shared pools, resulting in increased throughput and the potential to reduce processor-based software licensing costs.

- ▶ PowerVM Lx86

Run x86 Linux applications on POWER. This feature enables the dynamic execution of x86 Linux instructions by mapping them to instructions on a POWER processor-based system and caching the mapped instructions to optimize performance. PowerVM Lx86 software is designed with features that enable users to easily install and run a wide range of x86 Linux applications on Power Systems platforms with a Linux on POWER operating system.

Unique capabilities

Unlike other UNIX virtualization solutions:

- ▶ Virtualization capability is available on every model across the System p line.
- ▶ PowerVM provides Live Partition Mobility for UNIX systems
- ▶ PowerVM allows for far better granularity than hardware partitioning techniques, as your partitions do not have to be carved in increments of system boards.
- ▶ LPARs provide complete security isolation in both the kernel and application spaces. The kernel level is still exposed when you run in an application container type solution.

- ▶ PowerVM allows you to run multiple isolated OS instances on the hypervisor, so you are not tied to a host OS (such as you would be using an application container approach). This allows you to run different patches and OS levels in the same physical machine, as well as not cause an outage for the entire system if a partition must be rebooted.
- ▶ System p resources can be reconfigured dynamically between logical partitions. That is, no reboots are required for the changes to take effect.
- ▶ There is no limit to how large your logical partitions can be. LPARs can grow to the full size of the machine (which could be important for test LPARs, for example). Other solutions might allow you to have a partition of only four processors or less.
- ▶ System p memory can be reallocated dynamically.
- ▶ System p I/O can be virtualized, is reconfigurable, and a mix of dedicated and shared I/O is supported across partitions.

PowerVM is designed to enable you to aggregate and manage resources through a consolidated, logical view. (System p was awarded the Best Virtualization Solution at LinuxWorld 2006.) Key benefits of deploying System p virtualization include:

- ▶ Lowering the cost of existing infrastructure by up to 62%⁶
- ▶ Increasing business flexibility, allowing you to meet anticipated and unanticipated needs
- ▶ Reducing the complexity to grow your infrastructure

Dave Russo, Assistant Vice President, Web Infrastructure and Design of MetLife, said that, “By leveraging the advanced virtualization capabilities of our IBM infrastructure, we're able to squeeze every last dime out of the environment that's on the floor, with no impact on its stability. It gives us a powerful tool to maximize the efficiency of our IT spending.”

Abe Boersma, Product Manager System p/AIX, Rabobank, said that, “The business can now request the computing capacity that it needs for a new application, and we simply carve out a new virtual server in a partition on one of the System p5 servers.”

⁶ Business case for IBM System p5® Virtualization, Economic Benefits of IT Simplification. International Technology Group, 10 February 2006. Study methodology: Companies in financial services, manufacturing, and retail with \$15 billion+ revenues and 200,000+ employees focusing on UNIX large enterprise environments with multiple, broad-ranging applications.

Why IBM System p

When you must control costs while improving overall performance, client satisfaction, and the ability to respond quickly to changing business challenges, consider the IBM Power family of servers and the wide variety of solutions supported for AIX 6, AIX 5L™ (UNIX), and Linux operating system environments. The following capabilities and the stability of the IBM POWER architecture make System p servers the right platform for a UNIX and Linux migration that can support your infrastructure for years to come:

- ▶ System p servers set dramatic new industry performance records.

IBM System p servers, now with POWER6 processors, demonstrate continued commitment by IBM to organizations of all sizes. In addition to energy conservation and virtualization technologies, System p servers offer amazing performance. In fact, System p servers took the lead in over 70 key computing performance benchmarks⁷.

- ▶ IBM System p Virtualization technologies help make System p servers unique to the UNIX/Linux world.

You can achieve greater overall business value than server consolidation alone with the combination of unique advanced virtualization technologies (available on System p servers) that enable you to do more with a single system than ever before:

- Partition migration is enabled between physical UNIX servers through Live Partition Mobility.
- Dynamic logical partitioning increases the flexibility of partitioned systems by enabling administrators to add, remove, or move system resources (such as memory, PCI adapters, and processors) between partitions without the need to reboot each partition.
- Micro-partitioning technology supports both server consolidation and mixed workloads by allowing system resource allocation to be fine-tuned to changing business requirements through the activation of multiple partitions in each CPU in units as small as 1/10th of a processor.
- Virtual I/O enables the sharing of physical LAN adapters and disk storage devices on a system, which can reduce the number of physical devices needed and help achieve greater utilization of those already installed.
- Virtual LAN provides high-speed secure partition-to-partition communications-simplifying system configurations, helping to reduce costs.
- Cross-partition workload management allows dynamic workload adjustments to optimize throughput by continuously monitoring application workloads.
- IBM virtualization and Capacity on Demand technologies help increase flexibility and resource utilization while helping lower systems and administration costs.

- ▶ Proven IBM mainframe-inspired reliability features.

Leading-edge mainframe-inspired reliability, availability, and serviceability features contribute to ease of management and improved availability. IBM mainframes are the gold standard for reliability and availability. Many of these unique characteristics have been adapted for the System p family.

⁷ IBM performance benchmark information is available at <http://ibm.com/systems/p/hardware/benchmarks>.

- ▶ AIX is designed to automatically handle day-to-day activities and empower you to make better decisions.

Workload management features enable you to free staff from repetitive activities. Advanced accounting features are designed to give you key data necessary for improved resource utilization and planning. AIX Version 6.1 is designed with new features for virtualization, security, availability, and manageability designed to make AIX Version 6 even more flexible, secure, and available than previous versions.

- ▶ Use the right OS for your business, on the same system, on the same processor, at the same time.

You can simultaneously run AIX Version 6.1, AIX 5L V5.3, and AIX 5L V5.2, as well as multiple versions of Linux using logical partitioning. Also, System p servers offer a single binary compatible architecture, so this revolutionary technology is new and innovative, but not disruptive.

Why IBM System i

System i is virtualized to manage multiple applications and processes. One of the key factors of the i5/OS environment's efficiency is the ability to run multiple business processes and applications reliably and securely together. In a study of large enterprises using multiple operating systems, IBM found that utilization rates on i5/OS-based servers were over 10 times that of Intel®-processor-based servers and over twice as high as UNIX and other mid-range-based systems. The high rate of i5/OS utilization is achieved through the use of a variety of proven virtualization technologies, such as subsystems (multiple workloads managed in a single operating system image) and logical partitions (multiple workloads managed in independent operating system images).

Subsystems are independent operating environments within an i5/OS instance, through which the system coordinates and automatically manages work flow and resource use for jobs, processes, and applications. The system can contain many subsystems, each of which can be assigned defined system resources such as memory pools and processor priority. i5/OS subsystems are routinely used to separate multiple Web, batch, and transaction processing application components. Subsystems can be tuned manually for specific workloads, but most companies let i5/OS automatically handle routine subsystem prioritization and workload balancing.

Companies deploying i5/OS have routinely deployed their business applications using logical partitioning to optimize their IT operations over the past decade. System i integration with BladeCenter and System x® allows businesses to operate heterogeneous environments that include Intel-compatible servers running VMware® ESX Server in addition to core business applications on the System i platform. VMware ESX Server is supported on BladeCenter and System x models that are attached to the System i platform through the iSCSI host bus adapter (iSCSI HBA). Support varies by i5/OS release.

System x and BladeCenter virtualization

In addition to contributing to open source virtualization initiatives like Xen, IBM has chosen to work with IBM partners to provide virtualization in the x86 environment. For example, IBM is the number one reseller of VMware products.

Until recently, all virtualization on x86 architecture was implemented in software. However, Intel and AMD™ have developed hardware virtualization technology that is designed to:

- ▶ Allow guest operating systems, Virtual Machine Monitors (VMMs), and applications to run at their standard privilege levels.
- ▶ Eliminate the need for binary translation and paravirtualization.
- ▶ Provide more reliability and security.

The first phase of this iterative development endeavor was implemented in the processors. Intel named their hardware virtualization technology *VT-x*. AMD named their hardware virtualization technology *AMD-V™*. Additional phases of hardware virtualization technology are being developed for I/O and memory.

The end result of these virtualization hardware assists is to reduce the complexity of the hypervisor, which can reduce overhead and improve performance significantly. IBM System x servers support both Intel and AMD virtualization hardware assists.

VMware ESX Server and VirtualCenter

IBM and VMware can help optimize your IT environment with hardware and software designed for virtualization. With IBM System x, BladeCenter, and System Storage™ offerings running VMware software, applications and services can be deployed in highly reliable and secure virtual machines, which can be provisioned, consolidated, and managed centrally, simplifying the IT infrastructure and driving down total cost of ownership so that your business can realize innovation.

VMware Infrastructure Version 3.5 includes:

- ▶ Support for virtual machines with 64 GB of RAM and physical machines with up to 256 GB of memory.
- ▶ Storage VMotion® enables live migration of virtual machine disks from one data storage system to another without disruption or downtime.
- ▶ Update Manager automates patches and updates management for ESX Server hosts and virtual machines.

One of the benefits of virtualization is *stateless* hardware. State-full information and applications can be tied to a virtual machine. The hardware can run just the hypervisor. Therefore, if a system fails, the virtual machine can be migrated to a new hypervisor. VMware ESX 3i is a lightweight version of ESX and can be booted from flash memory or the network.⁸ This makes the hardware easier to maintain and deploy.

VMware comes in several editions including:

- ▶ VMware Infrastructure Enterprise Edition
- ▶ VMware Infrastructure Standard Edition
- ▶ VMware Infrastructure Foundation Edition

Features such as VMware High Availability (VMware HA, formerly known as Distributed Availability Services or DAS), Distributed Resource Scheduler (DRS), and consolidated backup will provide higher availability, guaranteed service-level agreements, and quicker recovery from failures than was possible before and comes close to the availability that you get from more expensive and complicated alternatives such as physically clustered servers. The System x3850 M2 and x3950 server with their scale-up abilities are uniquely positioned to take advantage of the larger workloads now available to be virtualized.

⁸ Linux-based hypervisors, such as XEN and KVM, can be run stateless as well.

VMware VirtualCenter

VirtualCenter allows you to rapidly provision virtual machines and monitor performance of physical servers and virtual machines. VirtualCenter intelligently optimizes resources, ensures high availability to all applications in virtual machines, and makes your IT environment more responsive with virtualization-based distributed services such as VMware DRS, VMware High Availability (HA), and VMware VMotion.

Case study

AISO.net generates big cost savings by harnessing the power of data center virtualization.⁹ As designed by Sirius, the new solution's key attributes included a marked consolidation in hardware (with nearly 100 of its stand-alone servers replaced by four System x servers), as well as a major improvement in the infrastructure's overall flexibility and resiliency. Four IBM x3650s utilizing VMware Infrastructure 3 with VMotion were used.

► Business need

While AISO.net had established itself as a leader among *green* service providers, its rapid growth forced it to confront the challenges of rising costs and maxed-out capacity. The company needed to transform its infrastructure strategy to have more control of its resources and maintain its superior performance.

► Solution

With the help of IBM Business Partner Sirius Computer Solutions, AISO.net achieved a massive consolidation of its data center resources through the use of advanced virtualization technologies deployed in an innovative fashion.

► Benefits

- 60% reduction in power and cooling costs through data center consolidation
- Reduced need to invest in server hardware to accommodate customer growth
- 99.9% availability through automated failover capabilities
- Estimated 50% increase in average server utilization levels

The benefits of choosing IBM System x and BladeCenter

You require easier ways to manage and optimize IT systems. A virtualized environment can help you save money, make IT staff more productive, and simplify system resource allocation. IBM System x and BladeCenter servers provide a robust and very affordable platform designed for virtualization, enabling you to run interactive applications by day and maintenance, inventory, or computational programs by night.

X-Architecture

These X-Architecture® technologies differentiate IBM System x from other Intel servers in many ways, including:

- Active Memory™ with features such as Memory ProteXion, hot-add memory, and Chipkill memory provide a level of reliability and availability that helps reduce downtime and maintain data integrity. Chipkill memory (based on memory used in the NASA Pathfinder's 1997 mission to Mars) helps keep the server up and running by tolerating a full chip failure.
- Two times the memory availability than previous generations with 32 DIMM slots, running DDR II PC2-5300 creates a more balanced total system design.
- Active PCI allows for installation or replacement of PCI Express adapters without taking the system down.

⁹ Case study available at <http://www.ibm.com/systems/x/solutions/infrastructure/virtualization/>.

- ▶ Light-path diagnostics provides rapid identification of failing or failed components, helping you minimize downtime.
- ▶ Extensive Predictive Failure Analysis (PFA) support helps predict failures on fans, VRM, and power supplies.

The ability of application servers to deliver high performance varies greatly, depending on the specifics of any given customer's workload. IBM raises the bar for scalable, high-performance application servers with the introduction of IBM eX4 Architecture, the ground-breaking fourth-generation of IBM Enterprise X-Architecture technology. Incorporating this chipset, the IBM System x3950 M2 and x3850 M2 deliver the performance, availability, expandability, and manageability required for the next generation of industry-standard servers. The outcome is demonstrated by recently published record-setting benchmark results.¹⁰ At the heart of IBM eX4 architecture is the *Hurricane 4* memory controller, with 60% front-side bus speed improvement and up to 60% faster memory.

IBM BladeCenter

IBM BladeCenter can be likened to physical partitioning. BladeCenter allows you to centralize computing power for physically separate environments while sharing infrastructure components like power and switches, and centralizing management. BladeCenter supports a variety of environments including Windows®, Linux, Solaris™, AIX, and other environments within the same chassis.

BladeCenter also supports virtualization. VMware support for BladeCenter can be found on ServerProven®.¹¹ BladeCenter is the best of both worlds, because it incorporates this physical partitioning along with traditional virtualization (using VMware, Microsoft® Virtual Server, Xen, and so forth), which contributes to its flexibility as a solution.

BladeCenter is innovative technology that can help reduce the cost of ownership with a more efficient use of valuable floor space due to its modular design. Its simplified management can help speed up tasks such as deploying, reprovisioning, updating, and troubleshooting hundreds of blade servers with relative ease. All this can be done remotely with one graphical console using IBM Systems Director systems management tools. In addition, blade servers can provide improved performance by potentially doubling current rack density, thereby permitting you to integrate your resources and share key components. This can result in cost reductions and increased availability.

The underlying hardware forms an important base for virtualization (for example, I/O bandwidth). Virtualization means more applications per server, which puts more demands on the system. The BladeCenter H and Cisco VFrame Solution offer fabric sharing and I/O consolidation. Other solutions do not necessarily offer fabric consolidation. The offering is simple to use and virtualizes the server, workload, and network connectivity, offering policy-driven automated blade failover.

Another offering, IBM BladeCenter Open Fabric Manager, allows for the I/O virtualization of Ethernet and Fibre Channel connections within a system by providing users with the option to assign Ethernet and Fibre Channel port addresses used by their server blades through software as an alternative to the addresses that are burned into the hardware during manufacturing.

¹⁰ See <http://www.ibm.com/systems/x/resources/benchmarks/>.

¹¹ See <http://www.ibm.com/servers/eserver/serverproven/compat/us/nos/vmwaree.html>.

IBM BladeCenter Open Fabric Manager benefits include:

- ▶ **Reduced deployment times**

BladeCenter Open Fabric Manager (BOFM) can help cut deployment times from days to hours or from hours to minutes, depending on the number of servers in your domain, allowing you to go into production much faster than in a rack environment. Simply plug the server into your chassis and it inherits the addresses that you preassigned.

- ▶ **Simplified management**

The Advanced Management Module (AMM) provides a Web-based interface to control the Open Fabric Manager functions. From the AMM the administrator can create addresses for the blades, save the addresses to a file, deploy the addresses to the blade slots in the same chassis or in up to 100 different chassis. This administration can all be done without any servers installed in the chassis.

- ▶ **Failover capability**

BOFM offers an advanced utility that provides automatic blade failover, allowing for the configuration of a standby blade pool. The standby blade pool can exist within the chassis or within another chassis in the 100-chassis domain. You are also able to create an event action plan for the individual blades that you want to monitor for failures. BOFM detects whether a blade has failed or has been removed automatically and without intervention.

Storage virtualization features and benefits

Storage area networks enable you to share homogeneous storage resources across the enterprise. For many companies, however, information resources are spread over various locations and storage environments with products from different vendors. The best solution takes advantage of the investment already made and provides growth when needed.

IBM SAN volume controller

IBM System Storage SAN Volume Controller (SVC) helps manage the complexity and costs of SAN-based storage. Based on virtualization technology, SVC supports a virtualized pool of storage from the storage systems attached to a SAN. This storage pool helps you tap unused storage capacity and makes your business more efficient and resilient. SVC helps simplify storage management by presenting a single view of storage volumes. Similarly, SVC is an integrated solution supporting high performance and continuous availability in open systems environments.

The solution runs on clustered storage engines, based on System x servers and open-standards-based technology. Industry-standard host bus adapters (HBAs) interface with the SAN fabric. SVC represents storage to applications as virtual disks, created from the pool of managed disks residing behind the storage engines. Your storage administrators can scale performance by adding storage engines and capacity by adding disks to the managed storage pool.

Features and benefits

The SAN Volume Controller has the following features and benefits:

- ▶ Manages storage volumes from your SANs and combines the capacity of multiple storage controllers, including storage controllers from other vendors, into a single resource with a single view of the volumes.
- ▶ Migrates data from one device to another without taking the storage offline and reallocates, scales, upgrades, and backs up storage capacity without disrupting applications.
- ▶ Increases storage capacity utilization and uptime, as well as administrator productivity and efficiency, while taking advantage of existing storage investments through virtualization and centralization of management.
- ▶ Supports advanced copy services across all attached storage, regardless of the intelligence of the underlying controllers.
- ▶ Supports local area network (LAN) free and server-free backups, IBM Subsystem Device Driver (SDD) multi-pathing software, and a variety of multi-pathing drivers.
- ▶ Applies copy services across disparate storage devices within the network because advanced copy services, such as FlashCopy® and Remote Mirror and Copy, are supported across the managed storage.
- ▶ Responds with flexibility and speed.

SVC is designed to deliver significant value to organizations facing the challenges of today's explosive growth in information. SVC helps combine capacity from different storage systems, helps provide common copy functions and enable data movement without server disruption, and is designed to support management of diverse storage from a single point, as seen in Figure 3.

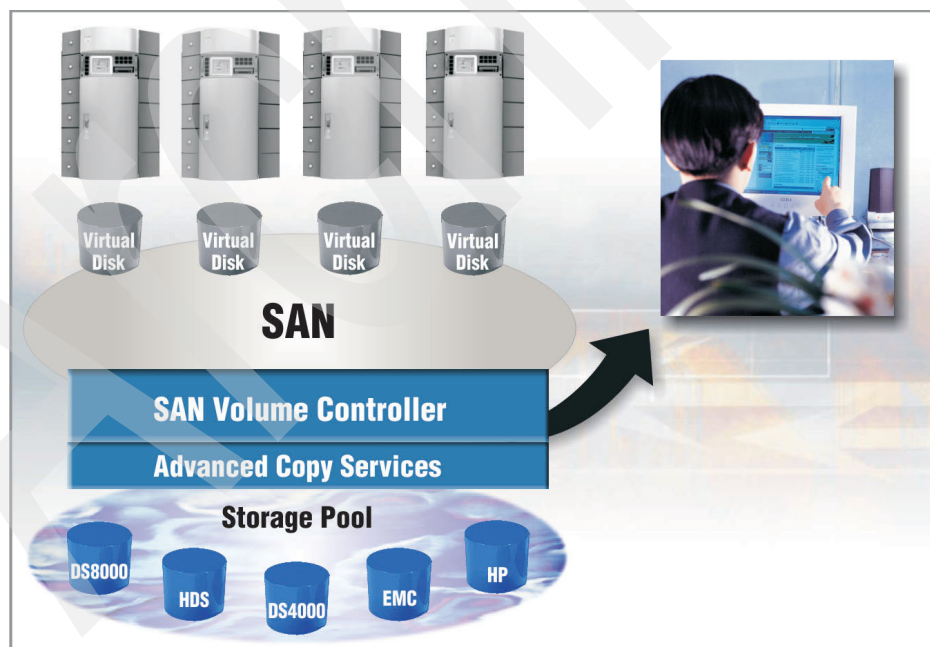


Figure 3 SAN Volume Controller

IBM has installed 10,000 SVC engines at more than 3,400 customer installations. IBM is the leader in the industry for block-level virtualization. SVC is designed to support up to world-class levels of availability and has one of the fastest industry-standard storage

performance benchmarks recorded for any disk controller.¹² SVC supports the virtualization of non-IBM as well as IBM storage (Including EMC, HP, HDS, Sun™, and Dell). It:

- ▶ Helps keep your applications running

SVC is designed to help you avoid the need to take your storage offline. SVC's data migration capabilities support continued access to data while data migration and storage infrastructure change is occurring. Continuous availability of data for applications can help you to avoid the cost and impact of downtime. In addition, SVC is designed to work with IBM TotalStorage Productivity Center to help automatically allocate more capacity to an application that needs it, again helping your business to run without interruption.

- ▶ Helps reduce the cost and complexity of the storage environment

SVC can help you take advantage of the cost savings of midrange storage while achieving the benefits of enterprise storage. Because the cost of midrange storage can be up to 50% less than enterprise storage, this can be a significant amount. SVC allows you to create tiered classes of storage to help you use the most efficient type of storage for the types of data you are storing. SVC is designed to provide robust attributes of enterprise storage across the entire virtualized environment.

SVC is designed to provide a single place to manage multiple, different disk systems. It also provides a common set of functions that are designed to work in the same way regardless of the disk system type. In this way, SVC can help avoid vendor lock-in and reduce management complexity, both of which can help you reduce storage costs.

Case study: CINECA, Italy's largest high-performance computing (HPC) research center used SVC and DS4500 storage to reduce their storage costs 10% in their first year.¹³

- ▶ Helps make people more productive

SVC creates a virtualized pool of your heterogeneous storage environment. By executing storage management tasks for the entire pool from a central point, SVC can help storage administrators become much more productive. They only have to learn one interface, and there are fewer tasks to execute because the action can be taken across the virtualized pool. Together, these can generate additional operational savings.

Case study: The Natural History Museum virtualized their data storage with IBM Business Partner Tectrade and IBM SAN Volume Controller. "SVC gives us a single interface through which we can manage the entire storage environment, however large it grows," says Paul Richards, Head of Information and Communication Technology. "We can expand easily and seamlessly without increasing the administrative workload, and even add other forms of storage like optical media if needed."¹⁴

- ▶ Helps utilize storage assets more efficiently

It is often estimated that many organizations are only using their storage assets at about 25% to 50% capacity. SVC is designed to help organizations significantly improve their utilization by combining the storage capacity from many disk arrays into a single storage resource, which storage administrators can manage from a central point. Administrators no longer need to keep spare space available for each individual server in case it is needed. Rather, they have a pool of space that is shared among all servers, so it can be smaller.

¹² See <http://www.storageperformance.org/results/>.

¹³ Case study available by searching <http://ibm.com/software/success> for CINECA.

¹⁴ Case study available by searching the following Web site for *Natural History Museum*:
<http://ibm.com/software/success>

Virtualization Engine TS7520: Virtualization for open systems

IBM Virtualization Engine TS7520 combines hardware and software into an integrated tiered solution designed to provide tape virtualization for open systems servers connecting over Fibre Channel and iSCSI physical connections. When combined with physical tape resources for longer term data storage, the TS7520 Virtualization Engine is designed to provide an increased level of operational simplicity and energy efficiency, support a low cost of ownership, and increase reliability to provide significant operational efficiencies.

One of the biggest issues with backup planning today is that the amount of data that is backed up is growing, but the time allotted for a backup (the backup window) is shrinking or remaining static.

With backup windows shrinking, tolerance for hardware failure has virtually disappeared. The TS7520 Virtualization Engine is designed to help address these issues by reducing tape mechanical delays and providing fault-tolerant architecture options supporting high availability.

Key functions of the TS7520

Key functional features of the TS7520 include:

- ▶ It is designed to manage growth to 1.3 PB.
- ▶ Enhanced caching provides the backup application with direct access to data whether in cache or on physical tape and a more intelligent policy-based data migration.
- ▶ It has encryption with network or backstore tape to help protect sensitive customer data.
- ▶ It has hardware-assisted compression designed to improve system performance with replication, compression, and encryption.
- ▶ Control path failover and data path failover can help provide higher availability over the control path and SAN.
- ▶ It has support for real-time compression of data, reducing disk storage requirements.
- ▶ It has on demand allocation of disk storage to help maximize storage use with virtual cartridges with static allocation, also supported for customized environments.
- ▶ It interacts with the TS7520 Cache Controllers to perform transparent failover/failback from path (HBA, port, switch, channel) or storage controller failure to minimize disruption to backup or restore activities.

TS7520 benefits

The TS7520 offers clients many benefits, including:

- ▶ Remote copy: Allows for the copied tape to reside on a remote TS7520 or vault
- ▶ Scalable configuration: Allows for extensive data growth, 9.75 TB to 1.3 PB uncompressed, depending on the configuration
- ▶ Hardware-assisted compression: Designed to provide increased performance during backup/restore, and helps alleviate CPU cycles in compression mode
- ▶ Active failover: Designed to provide automated policies for TS7520 node high availability
- ▶ Control path and data path failover: Allows the TS7520 to provide higher availability to the servers that it supports

- ▶ 4096 virtual drives: Allows for faster backup due to virtual resources allocated versus physical tape drives
- ▶ Encryption support: Designed to provide data security over the network and when the data is at rest on the tape cartridge using the IBM TS1120 Tape Drive

Virtualization Engine TS7700: Mainframe virtual-tape

IBM Virtualization Engine TS7700 is a mainframe virtual-tape solution that is designed to optimize tape processing. Through the implementation of a fully integrated tiered storage hierarchy of disk and tape, the benefits of both technologies can be used to help enhance performance and provide the capacity needed for today's tape-processing requirements. Deploying this innovative subsystem can help reduce batch processing time, total cost of ownership, and management overhead.

The TS7700 Virtualization Engine is designed to reduce or eliminate a number of bottlenecks that might be present in any given tape environment. Any reduction in bottlenecks will vary depending on the characteristics of installed equipment and workload, but reducing bottlenecks can help reduce batch processing time.

Key functions of the TS7700

Key functional features of the TS7700 include:

- ▶ Fewer *real* tape mounts, because most mount requests are satisfied from the Tape Volume Cache (TVC)
- ▶ Fewer physical tape cartridges required due to higher use of cartridge capacity
- ▶ Less floor space required to support the tape process as a result of fewer physical resources
- ▶ Improved performance due to the elimination of most of the physical movement of tape
- ▶ Reduced operating costs such as power, maintenance, operations, and support staff
- ▶ Enhanced reclamation policies to help migrate data between pools and provide efficient storage of long-term data
- ▶ Remote dual copy for use with disaster backup and recovery or remote tape vaulting

TS7700 benefits

The TS7700 offers clients many benefits, including:

- ▶ Tiered hierarchy of disk and tape storage: Helps improve performance and capacity to help achieve a low total cost of ownership for tape processing.
- ▶ Maximum of 768 virtual drives and 1,000,000 virtual volumes: Helps reduce or eliminate bottlenecks in your tape environment, supports the re-reference of volumes without the physical delays typical to tape I/O, and helps increase performance of tape processes.
- ▶ Advanced policy management: Cache management for volume retention and deletion, volume pooling that allows grouping of logical volumes on physically separate cartridges or cartridge pools.
- ▶ Grid capability: Two or three TS7700s can be configured to participate in a GRID environment. This configuration helps to support high-availability requirements; helps to enhance availability during planned maintenance, service, or system upgrades; and avoids the transportation of cartridges in the event of a disaster.

- ▶ Supports TS1120 tape-drive-based encryption: Helps secure sensitive at-rest data.
- ▶ Manageability: IBM TS3000 System Console allows IBM Technical Service to download new microcode and remotely monitor the installation and can automatically dispatch a service representative when required.

Systems and virtualization management

Management is key to the success of a virtualization solution. There are several tools that are available to help simplify and manage virtual systems. IBM Systems Director takes a hardware virtualization focus, whereas the IBM Tivoli suite of management products focuses more at the service level and from an enterprise view.

IBM Systems Director unifies its industry-leading server and storage management products, IBM Systems Director and IBM TotalStorage Productivity Center, with enhanced virtualization management support. The IBM Systems Director family provides a modular, open standards-based set of solutions that can be tailored easily to fit the requirements of any size business and can be integrated seamlessly into enterprise management solutions from IBM Tivoli.

IBM Tivoli Service Management enables clients to better manage their infrastructure, operations, and IT processes, to more effectively deliver services aligned to business goals. Systems Director can take information from various systems and platforms and feed it to the Tivoli Enterprise management products

Managing a virtualized IT infrastructure with IBM software

IBM IT management solutions deliver operational management products to visualize, control, and automate the management of the virtual environment. Together these technologies and products allow the business to increase workload velocity, increase utilizations, respond to changing market conditions faster, and adapt to customer requirements. IBM IT operational management products today provide significant management capabilities of virtual environments. The flexibility provided by IBM systems management products allows the IT infrastructure to be multi-vendor, heterogeneous, and still remain manageable by IBM.

One of the key values that IBM systems management software can provide is to mask the complexities that are introduced by virtualization. Businesses are embracing virtualization because it brings value and it enhances capabilities for business continuity and disaster recovery. The ability to use business policy-based process automation for orchestrating, provisioning, workload, and service-level management all in line with business goals will drive higher levels of virtualization adaptation. As the use of virtualization continues to be driven deeper into the data center, system management vendors must update existing tools to handle this dynamic infrastructure by adapting these tools to work with both virtual and non-virtual machines.

IBM Systems Director

IBM Systems Director is the platform management family that provides IT professionals with the tools that they need to better coordinate and manage virtual and physical resources in the data center.

The cost of managing the IT infrastructure has become the largest and fastest-growing component of overall IT spending for many organizations. Virtualization helps address this

cost through the consolidation of physical resources. However, it also adds complexity by creating a sharp increase in the number of managed virtual resources. IT professionals are seeking more advanced capabilities and tools for managing both their physical and virtual systems across multiple architectures and environments.

IBM Systems Director helps address these needs by unifying under one family its industry-leading server and storage management products, IBM Systems Director and IBM TotalStorage Productivity Center, with enhanced virtualization management support. With capabilities that include configuration, discovery, health and status monitoring, automated response, and power and virtualization management, the IBM Systems Director family gives IT professionals what they need for managing both physical and virtual systems across multiple IT environments.

IBM Systems Director is a cross-platform hardware management solution that is designed to deliver superior hardware manageability, enable maximum system availability, and help lower IT costs. IBM Systems Director helps you get started faster and be more productive. Its industry-standard foundation enables heterogeneous hardware support and works with a variety of operating systems and network protocols. Taking advantage of industry standards allows for easy integration with other systems' management tools and applications.

IBM Systems Director is included with the purchase of most IBM systems, and is offered for sale to help manage select non-IBM systems. Optional, fee-based extensions to IBM Systems Director are available if you want more advanced management capabilities.

You can use IBM Systems Director stand-alone or with existing enterprise or workgroup management environments (for example, Tivoli NetView®, HP OpenView, BMC Patrol, and many others) to access and manage physically dispersed IT assets more efficiently. Flexible capabilities help you realize maximum system availability and lower IT costs. With IBM Systems Director, IT administrators can view and track the hardware configuration of remote systems in detail and monitor the usage and performance of critical components, such as processors, disks, and memory.

In addition to the base IBM Systems Director, enhanced extensions are also available. These tools are tightly integrated with IBM Systems Director for consistent management from a single console.

These extensions allow you to:

- ▶ Discover, visualize, and manage both physical and virtual systems from a single console through IBM Virtualization Manager.
- ▶ Manage availability using IBM Systems Director Virtual Availability Management.
- ▶ Manage an image through IBM Systems Director Virtual Image Management to provide a single, unified view of all system templates and server images to help customers manage and deploy their systems.
- ▶ Know IT costs using IBM Usage and Accounting Manager to align IT costs with company priorities and account for individual department use of key applications, servers, and other IT resources by providing an extremely flexible, end-to-end tool that helps you improve IT cost management.
- ▶ Deploy mainframe virtual systems using the IBM Systems Director z/VM Center extension as a standardized way to deploy new z/VM virtual LINUX systems without requiring specific z/VM knowledge to operate it.
- ▶ Monitor and manage your energy utilization using Active Energy Manager Version 3.1, which is the next-generation product to IBM PowerExecutive™.

- ▶ Manage your capacity using capacity manager to track resource use, identify multiple levels of existing or potential bottlenecks, and make recommendations to improve performance.
- ▶ Deploy systems remotely using Remote Deployment Manager for remote, unattended installation of new and existing systems.
- ▶ Build, manage, and expand cluster environments efficiently using the IBM portfolio of cluster software for IBM Cluster System Management to help organizations using IBM System p servers running AIX or Linux, IBM System x servers running Linux, or a combination.

IBM unveils plan to combat data center energy crisis; Allocates \$1 Billion to advance *green* technology and services

IBM is going *green* and capabilities such as *Active Energy Manager* among many others support that goal. IBM plans to double computing capacity in its own data centers and will use new technologies to avoid five billion kilowatt hours of new energy use.

Called *Project Big Green*, the initiative from IBM is targeted at combating the energy crisis in data centers where energy demand and energy costs are dramatically increasing. The initiative includes new technologies and services designed to deliver energy savings which will be deployed by a new global *green team* of more than 850 energy efficiency specialists from across IBM. The savings are substantial—for an average 25 000 square foot data center, clients should be able to achieve 42% energy savings. This savings equates to 7439 tons of carbon emissions saved per year.

Energy efficiency in the data center has quickly become a critical issue as businesses rely increasingly more on IT innovation. Today, according to IDC, roughly 50 cents is spent on energy for every dollar of computer hardware. This is expected to increase by 54% over the next coming years.^a

a. Source: IDC, Worldwide Server Power and Cooling Expense 2006–2010 Forecast, Doc #203598, September 2006

IBM Tivoli Service Management

Systems management tools must be simple and intuitive to use, and must be able to be deployed in a straightforward manner. An easy-to-understand, high-level view of virtual and physical servers and the workloads running across those servers and their relationships is the first step to begin managing the environment.

The ability to monitor and drill down into the details for problem analysis and isolation is the next important aspect that the tools must provide. Problem analysis is aided by the comprehensive and cohesive view of the operation, along with the ability to seamlessly move between various tools that launch in context with single sign-on cross tool authentication.

Discovery

IBM Tivoli Application Dependency Discovery Manager (TADDM) provides visibility of interdependencies between applications, computer systems, and networking devices, using agent-less and credential-free discovery and automated application maps.

TADDM provides automatic discovery of the cross-tier infrastructure and creates a top-down tier map of components. TADDM can discover hosts and operating systems such as AIX, HP-UX, Linux, Solaris, and Windows, among others. TADDM helps the IT operations team

understand what they have and how the business services relate to the physical and virtual infrastructure.

Integrating data

Running an efficient IT infrastructure requires that the management tools provide data to the IT operations staff visually, and in an easy-to-understand manner. A comprehensive and cohesive view of the operational state of the heterogeneous, virtual, and physical IT data center is critical for rapid problem analysis and isolation.

IBM Tivoli Change and Configuration Management Database (CCMDB) is a data store that is used to track IT assets, their relationship, their configuration, and changes in the IT infrastructure. The CCMDB can be populated by TADDM automatically. Using the automated discovery with CCMDB enables an organization to maintain an accurate view of the infrastructure. TADDM's automated application map provides the visibility between physical host servers and the virtual machines running on them. This provides IT data center management with an understanding of the correlation between the business services and the IT infrastructure, including the virtual resources.

Virtual Machine monitoring

IBM Tivoli Monitoring for Virtual Servers is another important tool used by the data center staff after they have consolidated servers and are using virtual machines in addition to their physical servers. Tivoli Monitoring for Virtual Servers is able to drill down, identify, and resolve virtual server availability and performance issues.

Provisioning

IBM Tivoli Provisioning Manager (TPM) is adept at provisioning new servers. TPM provides a single integrated solution and includes an extensive set of inventory, OS provisioning, software distribution, and patch management capabilities on a service-oriented architecture.

In combination with the TPM task automation engine, the administrator can fully automate custom procedures that might require additional configuration changes to network, storage, or virtual server resources. Automating operational tasks helps optimize the efficiency and accuracy of deployments.

Workload scheduling and automation

IBM Tivoli Workload Automation, including IBM Tivoli Workload Scheduler, IBM Tivoli Dynamic Workload Broker, and IBM Enterprise Workload Manager™, provides visibility and control of composite workloads across mixed application and virtual and physical resource environments.

Through a single point of control, Tivoli Workload Automation can help automate key service execution steps such as planning and modeling event-driven and time-driven composite workloads across virtualized environments, dynamically brokering workloads to best available virtual resources while resolving cross-workload and physical resource dependencies, and dynamically adapting workload execution to incidences, problems, and configuration changes in the underlying virtual and physical IT infrastructure.

Cost management

IBM Tivoli Usage and Accounting Manager (ITUAM) is the tool needed to assist with this cost allocation problem. ITUAM helps solve this problem by collecting, analyzing, reporting, and billing based on usage and costs of shared computing resources.

Tivoli Usage and Accounting Manager helps you improve IT cost management. With it you can understand your costs and track, allocate, and invoice based on actual resource use by

department, user, and many additional criteria. The solutions enables you to consolidate a wide variety of usage data with data collectors associated with operating systems, databases, Internet infrastructure, e-mail systems, network and printing, and customized usage data import collection from any application or system.

Backup and recovery

The IT data center has many physical and virtual servers and associated information or data that must be protected against loss. The IBM Tivoli Storage Manager family of products is designed to help provide a comprehensive data protection solution focused on the key data protection activities of backup, archive, recovery, space management, and disaster recovery planning.

IBM Tivoli Storage Manager (TSM) minimizes the data needed for backup by only backing up new and changed files. TSM installed on a virtual server machine (guest machine) is used to provide file level restore and more granular restore for applications.

Consolidated storage management with IBM TotalStorage Productivity Center

IBM TotalStorage Productivity Center can manage all of your storage assets with a single, comprehensive management suite. TotalStorage Productivity Center brings together management of the SAN, storage devices, and host resources, including databases and file systems, into a single control point. It provides a modular, integrated set of products that can be purchased individually or in different combinations.

The IBM TotalStorage Productivity Center suite of products includes the products listed in Table 2.

Table 2 IBM TotalStorage Productivity Center suite of products

Component	Use
IBM TotalStorage Productivity Center for Fabric	To manage, monitor, and control your SAN fabric
IBM TotalStorage Productivity Center for Data	To manage the capacity utilization of storage systems, file systems, and databases and to automate file system capacity provisioning
IBM TotalStorage Productivity Center for Disk	To perform device configuration and management of multiple devices from a single user interface, tune and proactively manage the performance of storage devices on the storage area network
IBM TotalStorage Productivity Center for Replication	To control and monitor copy services operations (like FlashCopy, Metro Mirror, and Global Mirror capabilities) and use data replication for data protection and disaster recovery
IBM TotalStorage Productivity Center Basic Edition	To perform basic device management services for IBM System Storage DS4000®, DS5000, DS6000™, and DS8000 products, IBM SAN Volume Controller, and heterogeneous storage environments

Summary

Many customers report that energy efficiency and IT simplification are very important to them. Companies of all sizes are aggressively adopting IBM virtualization solutions to help with infrastructure simplification, rapid application deployment, business resiliency, and management of a virtualized infrastructure. When it is time to act on an emerging opportunity

or react to a competitive threat, the essence of an on demand business is getting the right information, to the right people, at the right time to create value or mitigate risk.

IBM virtualization enables you to:

- ▶ Address environmental concerns through more efficient shared infrastructure.
- ▶ Simplify your existing infrastructure while managing future growth.
- ▶ Improve the management of your infrastructure and your operators.
- ▶ Improve flexibility and responsiveness to business demands.
- ▶ Increase business resiliency.
- ▶ Improve total cost of ownership (TCO).

IBM takes a holistic approach to virtualization by working throughout all resource types, taking advantage of decades of mainframe experience, embracing diversity of resources, and integrating the virtual and physical worlds.

The goal is to be able carry out server consolidation, raise resource utilization rates, and leave the operations staff capable of dynamically provisioning capacity on demand. Companies are increasingly turning to virtualization as a way to simplify their infrastructure, improve their total cost of ownership, and increase their flexibility. Virtualization is available across the IBM hardware line, along with cross-platform tools to create a single view into your infrastructure.

IBM is uniquely positioned to offer both a breadth and depth of virtualization offerings. No other vendor can bring together the virtualization solutions (infrastructure simplification, rapid application deployment, and business resiliency), server, storage and application virtualization, and cross-platform systems management in a heterogeneous environment. IBM virtualization balances the needs for flexibility and isolation in a virtualized environment, while simplifying management so that customers are able to manage the ever-increasing server and storage requirements while maintaining or reducing current staff.

Next steps

IBM can help you build, plan, and execute your virtualization strategy. IBM has resources available to help with design, evaluation, testing, benchmarks, and proofs-of-concept featuring our virtualization solutions.

Potential next steps for leveraging virtualization could include:

- ▶ Reduce operating costs.
 - Start with a systems consolidation study.
 - Leverage IBM leadership server and storage products.
 - Increase utilization of servers through consolidated workloads.
 - Balance storage utilization with the SAN Volume Controller.
- ▶ Improve service responsiveness.
 - Leverage IBM IT optimization studies and business value assessment.
 - Implement virtualization to increase IT utilization and efficiency with improved flexibility and resilience.
 - Optimize network for new systems environment.

- ▶ Manage availability in a 24/7 world.
 - Implement virtualization to increase IT utilization and efficiency with improved flexibility and resilience.
 - Implement high-availability and disaster recovery infrastructure using virtualization as a base.
- ▶ Dynamically adapt to the peaks of the business.
 - Implement virtualization to increase IT utilization and efficiency with improved flexibility and resilience.
 - Leverage IBM IT optimization studies.
 - Leverage IBM Web infrastructure optimization and virtualization services.

IBM also has a comprehensive suite of virtualization services. Strategy and planning creates an approach that is aligned with business objectives. Design and implementation services are based on a proven approach and framework. We have proven reference architectures and leading practices that accelerate the design process.

Other resources for more information

For further information see the following sources:

- ▶ For information about z/VM see *Introduction to the New Mainframe: z/VM Basics*, SG24-7316-00.
- ▶ For information about using z/VM and Linux on IBM System z see *z/VM and Linux on IBM System z: The Virtualization Cookbook for SLES 10 SP2*, SG24-7493-00.
- ▶ For information about z/VM and Linux on IBM System z see *z/VM and Linux on IBM System z: The Virtualization Cookbook for Red Hat Enterprise Linux 5.2*, SG24-7492-00.
- ▶ For information about N_Port identifier virtualization for IBM System z9 see *Introducing N_Port Identifier Virtualization for IBM System z9*, REDP-4125.
- ▶ For information about PowerVM virtualization on IBM System p see *PowerVM Virtualization on IBM System p: Introduction and Configuration Fourth Edition*, SG24-7940-03.
- ▶ For information about IBM PowerVM Live Partition Mobility see *IBM PowerVM Live Partition Mobility*, SG24-7460-01.
- ▶ For information about IBM PowerVM virtualization managing and monitoring see *IBM PowerVM Virtualization Managing and Monitoring*, SG24-7590-01.
- ▶ For information about workload partition management in IBM AIX Version 6.1 see *Introduction to Workload Partition Management in IBM AIX Version 6.1*, SG24-7431-00.
- ▶ For information about PowerVM see *IBM System p Advanced POWER Virtualization (PowerVM) Best Practices*, REDP-4194.
- ▶ For information about POWER virtualization see *Advanced POWER Virtualization on IBM System p Virtual I/O Server Deployment Examples*, REDP-4224.
- ▶ For SAN Volume Controller best practices see *SAN Volume Controller Best Practices and Performance Guidelines*, SG24-7521-01.
- ▶ For information about SVC V4.3.0 Advanced Copy Services see *SVC V4.3.0 Advanced Copy Services*, SG24-7574-01.

- ▶ For information about IBM Virtualization Engines TS7740 R1.5 and TS7720 see *IBM Virtualization Engine TS7740 R1.5 and TS7720: New Virtualization Options for Mainframe Servers*, SG24-7712-00.
- ▶ For information about IBM Virtualization Engine TS7500 see *IBM Virtualization Engine TS7500: Planning, Implementation, and Usage Guide*, SG24-7520-01.
- ▶ For information about IBM System Storage N series with VMware ESX Server see *IBM System Storage N series with VMware ESX Server*, SG24-7636-00.
- ▶ For information about SAN storage performance management using TotalStorage Productivity Center see *SAN Storage Performance Management Using TotalStorage Productivity Center*, SG24-7364-01.
- ▶ For information about virtualization on IBM System x3950 Server see *Virtualization on the IBM System x3950 Server*, SG24-7190.
- ▶ For information about the TotalStorage Productivity Center for VMWare environments see *TotalStorage Productivity Center for VMWare Environments*, REDP-4471-00.
- ▶ For information about implementing IBM Systems Director 6.1 see *Implementing IBM Systems Director 6.1*, SG24-7694-00.
- ▶ For information about IBM Tivoli Provisioning Manager see *Deployment Guide Series: IBM Tivoli Provisioning Manager Version 5.1*, SG24-7261-00.
- ▶ For information about IBM Tivoli Usage Accounting Manager see *IBM Tivoli Usage Accounting Manager V7.1 Handbook*, SG24-7404-00.
- ▶ For information about WebSphere Virtual Enterprise see *WebSphere Virtual Enterprise Best Practices*, REDP-4461-00.
- ▶ For information about IBM system virtualization see *IBM Systems Virtualization: Servers, Storage, and Software*, REDP-4396-00.
- ▶ For information about virtualizing a worldwide grid implementation see *A Virtualization Experience: IBM Worldwide Grid Implementation*, SG24-7229.
- ▶ For the article IBM Virtualization: Optimize Your IT Infrastructure see:
<http://www.ibm.com/systems/virtualization>
- ▶ For the article Dynamic Infrastructure: Virtualization see:
<http://www.ibm.com/itsolutions/virtualization>
- ▶ For information about service management using Tivoli solutions see:
<http://www.ibm.com/software/tivoli>
- ▶ For information about Systems Director for physical and virtual environment management see:
<http://www.ibm.com/systems/virtualization/systemsdirector>
- ▶ For the article IBM System z: About Virtualization see:
<http://ibm.com/systems/z/advantages/virtualization>
- ▶ For information about AIX 6.1 workload partitions see:
<http://www.ibm.com/DeveloperWorks/aix/library/au-workload/>
- ▶ For tips and tricks for implementing infrastructure services on the ESX Server see:
<http://www.vmware.com/vmtn/resources/409>
- ▶ For information about IBM System x benchmarks see:
<http://www.ibm.com/systems/x/resources/benchmarks/>

- ▶ For the article ServerProven: Support for VMware ESX Server see:
<http://www.ibm.com/servers/eserver/serverproven/compat/us/nos/vmwaree.html>
- ▶ For IBM software success stories see:
<http://ibm.com/software/success>
- ▶ For information about Storage Performance Council benchmark results see:
<http://www.storageperformance.org/results/>

The team that wrote this Redguide publication

This Redguide publication was produced by a team of specialists from IBM.

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The original IBM Redpaper publication that this Redguide publication is based on, *IBM Systems Virtualization: Servers, Storage, and Software*, REDP-4396, contained contributions from the two following authors and also from the list of people that follows:

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