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Competitive Snapshot

Virtualization with IBM's POWER5: Empowering the Data Center

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March 18, 2005

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ABSTRACT

Virtualization is a state-of-the-art method to raise IT efficiency through the sharing of resources between many systems and applications. While virtualization has existed in mainframes for years, virtualization has been more difficult to bring to Open Systems because of the nature of distributed computing. In distributed systems, applications frequently run on one server and have little or no interaction with other servers. The result of this distributed approach is that over-provisioning and underutilization of resources is common and the inherent complexity stymies cost-effective growth. There are competing approaches to virtualization in the marketplace today, each with their own pros and cons. The ideal virtualization solution includes infrastructure simplification, cost containment, and improved utilization of IT resources within a heterogeneous environment to give organizations a sustainable competitive advantage. IBM's understanding of virtualization technology is driven by its experiences with the mainframe, which is a system designed to manage and allocate conflicting resource requests in compliance with business requirements within a controlled, enclosed environment. Nevertheless, IBM has driven much of its virtualization technology for mainframes into the Open Systems space. In this report, we discuss server virtualization and its potential for organizations of all stripes. We posit the ideal virtualization solution and review various competitive offerings from vendors in this market space. In addition, we examine the virtualization technologies available in the IBM eServer p5, as well as its capabilities and the benefits to business of implementing virtualization technologies.

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TABLE OF CONTENTS

The Case for Virtualization

Virtualization, while possessing the characteristics of a word not often used in polite company, is actually an idea whose time has finally arrived. It is no longer a set of arcane capabilities in search of a problem to solve but rather a set of advanced capabilities for addressing the business issues dogging IT managers today. Businesses increasingly want to drive benefit from their IT investments, and they have become ever more interested in virtualization as the way to make this possible. The way virtualization should make this possible is by leveraging existing IT resources for better business value. Until now, the dominant computing paradigm has been a model of one application per server. This was led by the availability of inexpensive and easy-to-use systems. Since utilization levels for any individual server remained low there was ample room for growth, which made it easy to justify continuing in this way. However, as the number of systems within the data center multiplied, system manageability became unwieldy and administration costs began to outweigh hardware costs. Clearly something had to change, and virtualization was increasingly viewed as the answer. The business benefits of virtualization mean that ever changing business cycles or unexpected surges in demand can be better matched to IT resources at a cost-effective price point.

Reducing Complexity While Enhancing Business Value

As with all movements of note within the computing industry, virtualization began with mountains of presentations dedicated to grandiose visions. Those visions gave vague directions to a nirvana of automated management, self-healing systems, and poetic financial equilibrium. While nirvana may not be quite within reach, virtualization technologies, if used effectively, do offer technical capabilities that can make managing and administering a data center easier, and can help the business's bottom line as well. At its core, virtualization is a way to share resources between systems and applications; virtualization was designed to tackle the most complex parts of the IT infrastructure, reducing that complexity and lowering overall infrastructure costs.

At the same time, it should improve the overall value that the IT infrastructure provides to the business and free up administrators for more interesting and value-generating tasks. Virtualization can apply to most any technology from a subsystem or a system to the entire IT infrastructure or business supply chain. Most IT managers, being frightfully pragmatic, concluded rightfully that they were not doing grandiose company-wide virtualization, and it was in danger of being relegated to the slideware of history. Fortunately, in tandem with these galactic ideas, some vendors were honing their cartographic expertise and began to create maps for how to get to virtualization from current data centers of all sorts.

The first step is usually virtualizing like resources. This can progress to virtualizing unlike resources and then data centers, and eventually business processes. All-out data center virtualization remains more fiction than fact today, but a host of real, useful, and innovative technologies have developed both independently and within existing products to make the foundational layers of virtualization possible, and these do provide immediate benefit to IT managers and users. Virtualization of like resources, particularly for servers, has become a common and well developed space as server management is one of the most expensive and least efficient areas of IT. From a strictly financial perspective, companies of all sizes would like to consolidate the many resources that exist across multiple servers, many of which are underutilized. From a business service perspective, recapturing the "lost" resource would allow IT to turn them to better use delivering new service to the organization or enhancing revenue opportunities.

Today's virtualization generally refers to management automation as well as automated interaction of system elements based on policy. The benefits of virtualization vary depending on the business and its environment, but they generally include:

- Greater automation of data center tasks, making it easier to scale architecture without scaling staff, and in some cases the ability to reduce the number of staff dedicated to administrative functions, freeing them for more advanced work;
- More effective use of IT resources leading to more efficient purchasing;
- The ability to provision IT resources more effectively and more quickly;
- Less planned or unplanned downtime due to automation and fewer instances of operator error; and
- Reduced complexity of IT architecture due to automation of management and processes.

This paper specifically assesses server virtualization, its benefits, competitive products, and who has the edge in server virtualization today.

Business Benefits

The business benefits of virtualization are hard to measure in a standardized form because of the range of possible uses for the technology and the varying IT department structures. On a theoretical level, understanding how virtualization affects server utilization rates illustrates where potential cost savings can be found. For example, IT managers can measure the percentage of system and resources utilization before and after virtualization. Several metrics have been calculated on the average utilization of systems. In addition, work has also been done that demonstrates how deploying capabilities such as multiple partitions with shared resources can be measured for savings.

Beyond lowering costs, there are other potential benefits derived from adopting virtualization technologies. Perhaps most important is the ability to improve service quality through enhanced technical capabilities with better availability, faster response times, and faster system recovery from failures. There are also potential benefits in quicker time-to-market where customers interact with systems by means of faster system provisioning capabilities.

Criteria for the Ideal Server Virtualization Solution

Many different products offer some form of server virtualization to eager IT managers looking for greater control and efficiency within their server infrastructure. While there is no one product that does all things for all people, an ideal virtualization solution should be able to do the following:

- *It must provide management automation as well as automated interaction of system elements*. Every vendor provides automation at some level. Differentiation is found in the degree and kind of automation. Some automation is focused on environments where implementation of additional like servers is important whereas other automation focuses on workload balancing within individual servers. The ideal solution should have both capabilities.
- *Resource provisioning must be automatic and granular to the sub-unit resource level (whether CPU, RAM, storage, etc.)* Again, most server virtualization offerings allow individual resources to be used in incremental fashion. The greater the degree of granularity, the more efficient the system will be.
- *Changes to resource allocations must happen in real time and not lead to either planned or unplanned downtime, and must not affect the applications running on*

them. Dynamic changes in allocation are one of the key differentiators between vendors' virtualization solutions. The ability to change resources without affecting applications is one of the keys to better availability and large potential business benefits.

- *Computational horsepower, data, applications, storage, network services, and other IT resources must be universally available to other heterogeneous solutions on the network in a shared resource pool.* This is another capability that differentiates vendor offerings. Vendors start with the ability to manage their own components and then expand to include heterogeneous components. Customers need solutions that ultimately treat all components equally and cooperate.
- *Service-level management capabilities must provide prioritization for classes of applications and users per corporate policy in an automated fashion.* This is another differentiator for vendors. Those vendors that focus on deployment generally are less capable of managing individual applications. Users benefit more from servers that can run multiple different applications simultaneously and manage those capabilities.
- *Use of virtualization technology must include process change options as the automation of business process generally goes hand-in-hand with automation of resource deployment.* Working with business process is something most technology partners leave to their consultancy partners. This capability may be done inhouse or through partnership, but business process and technology are increasingly interdependent.
- *Vendor-backed service and solution training is essential.*

Common Server Virtualization Approaches

Server virtualization in one form or another has existed for some time as witnessed by the abuse of the term in high-tech literature. Since virtualization can take place at various levels, product descriptions and capabilities can lead to confusion in understanding what truly is or is not virtualization. Additionally, vendors have taken different approaches based on their technology and proprietary value-adds, and with an emphasis that underlines their approach to systems and architectures. What follows is a review of five competitive solutions where we assess the vendor's approach to the server virtualization opportunity and how it compares with our ideal solution:

- Sun's Containers and Dynamic System Domains
- HP's NPARs/VPARs.
- Microsoft Virtual Server 2005
- EMC's VMware
- IBM's Virtualization Engine Suite for Servers

Sun's Containers and Dynamic System Domains

Sun's products consist of both logical and physical capabilities, and are designed to improve the system configuration and management burden. Since the focus is more on the initial configuration of many like systems than on the dynamic control of resources in play within a particular system, it takes a different approach to virtualization. Sun works with containers, which enable the creation of blueprints that detail the resource requirements for an application. Containers, which are software-based, may be built for and managed on servers within assigned pools of resources. The central console must run on either Solaris 8 or 9, Red Hat Linux AS 2.1 or Windows 2000 and 2000AS, but it can have agent containers running on Solaris versions 7 through 10, Red Hat Linux AS 2.1 and 3.0, IBM AIX 5.1 and 5.2, as well as

Windows 2000 and 2000AS. Software-based containers are built for one system but may be replicated to other systems through the central console to make copies of like systems. Sun's Dynamic System Domains are hard physical partitions within the server with separate instances of the operating system. They were Sun's first approach to partitioning.

Sun's strength is that it can run on multiple platforms including Sun's as well as Intel-based operating systems. On the other hand, Sun's focus is more on setting up environments of many servers with the same blueprint and controlling configurations and versions. Sun's Dynamic System Domains are not the optimal approach for a server used to consolidate diverse applications that use resources differently over time and require dynamic shifting of resources. Containers are much more appropriate. Sun's Dynamic System Domain allocations are not granular; that is, they must have four or eight CPUs per physical partition although Containers within Dynamic System Domains are more granular. Additionally Sun Containers cannot share I/O, and the underlying OS for each must be the same revision and release level.

HP's Virtualization Offerings (NPARs/VPARs)

HP views virtualization as a way to pool and share IT resources so utilization is optimized and supply automatically meets demand. HP approaches virtualization in a modular level, from individual elements of servers, storage, or networking and software, to integrated virtualization of applications and processes, to building up the entire data center as a virtual entity. The Virtual Server Environment combines many of these capabilities for HP-UX 11i and Linux systems and makes changes based upon a measurable system event, the time, or the date.

HP uses much of the right verbiage for describing virtualization, but its approach is focused on individual capabilities within servers. HP does not offer an overarching product that provides virtualization as its competitors do. For each server platform, HP offers specific capabilities such as workload management, partitioning, or clustering. HP's nPAR technology is not granular. Like Sun, it requires four or eight CPUs per partition. vPARs only run on HP-UX and PA-RISC. They require a minimum of one CPU, and they require a reboot (downtime) for configuration change. HP has many individual pieces but overall the offering is disjointed. Without an overarching program, HP's capabilities are limited to homogeneous environments rather than the total IT infrastructure. Additionally, customers are looking for the optimization inherent with better-integrated products and offerings. HP could lose out for some customers who need those capabilities.

Microsoft Virtual Server 2005

This product is Microsoft's virtual machine solution designed for Windows Server 2003. For other operating systems, customers need to run them as guest operating systems, and these include Windows NT 4.0 to Windows 2000 and 2000AS, Windows Small Business Server, and Windows 2003 Enterprise and Standard editions. According to Microsoft, the product enables customers to run multiple operating systems concurrently on a single physical server, where each of the operating systems runs as a self-contained computer. This is Microsoft's first real step into virtualization, with the focus on the Microsoft operating system, so heterogeneous environments require other products. Microsoft has a long way to go to catch up with other OS vendors in comparative virtualization capabilities. Because Microsoft only does server operating systems and not hardware, it is imperative that their products interact with other products once customers begin to integrate server virtualization with other system virtualization capabilities. They will also need to decide what their relationship with Linux will be, and how they will respond to the needs of environments with both operating systems.

EMC's VMware Virtual Infrastructure

VMware was acquired by EMC as part of its effort to enrich its Information Lifecycle Management (ILM) offerings. VMware's approach is different from that of the systems vendors in that it offers a virtual infrastructure that provides a layer of abstraction between the computing, storage, and networking hardware, and the operating system and additional software that runs on it. A uniform hardware image is implemented in software and operating systems and applications run on this image. VMware's products sit on top of this and provide management and provisioning of virtual machines, continuous workload consolidation across physical servers, and virtual machine mobility. The product works with Microsoft's Windows NT, Windows 2000, Windows 2003, Linux, and Netware servers.

The benefit of this approach is that it is holistic. As long as the product understands the hardware and the operating system, it can manage everything. The downside is that at present it is focused only on the x86 platform. While the majority of servers are Intel-based, they are generally smaller servers. Additionally, some virtualization capabilities function better at the operating system or chip level. Since VMware and EMC do not own either of these components, they are limited in how far into the system they can reach. At some level, they will always rely on the various hardware vendors to take advantage of capabilities and give them optimal performance. For VMware, the world is a pool of resources from which it creates virtual machines. The challenge is which resources VMware's products are cognizant of. Additionally, for some I/O-intensive applications, this can lead to higher overhead than IT managers may be comfortable with. At the same time, the product is the certainly the most comprehensive and advanced option for the x86 platform. It is also more advanced than many of the virtualization features found in the UNIX vendors, in that it offers hardware-independent templates for new virtual machines, it does not require minimum numbers of processors in systems, and it allows for dynamic logical partitioning.

IBM's Virtualization Engine Suite for Servers

IBM's Virtualization Engine is a set of offerings that span IBM's system products as well as its TotalStorage solutions. Typical of IBM, it began with a visionary articulation of how virtualization would be in an ideal world, but the work it has done architecting its systems from the chip forward has resulted in real, practical features that make many virtualization capabilities available today. IBM has a direction and road map of where it wants to help customers drive their data centers, but there are many features IT managers can begin to take advantage of now. IBM believes that its approach to virtualization provides a logical rather than physical view of data, computing power, storage capacity, and other resources, while simultaneously automating the management of these resources based on business goals. It makes basic systems management of multiple disparate systems possible and allows for real-time, dynamic deployment and optimization of these IT resources. IBM's products work with IBM operating systems and Microsoft operating systems for the iSeries, as well as with Solaris 8 and 9 and with Linux on the OpenPower systems.

One of the differences between IBM and EMC's VMware is that VMware provides only a software layer that sits between the hardware and OS. It has control of neither the OS nor the hardware itself. In contrast, IBM owns the Power architecture on which several operating systems run as well as the AIX operating system. IBM has much greater control of hardware capabilities and depending on the OS used, greater control there as well. While EMC uses virtual machines derived from shared pools of resources, IBM sees virtual systems including virtual servers, virtual networks, and the importance of how applications are managed within those virtual systems. This capability differentiates IBM's approach since it starts at the lowest levels of the core components and extends all the way to IBM's services business that

can provide business process solutions to tailor server virtualization environments to specific vertical industry needs.

POWER5 Virtualization and the IBM eServer p5

Four of the preceding products meet some of the criteria for the ideal virtualization solution, but only IBM's virtualization technology appears to meet all of the criteria for the full range and flexibility of a server virtualization solution with present products. IBM has had a degree of virtualization within the pSeries for some time; however, with the launch of the POWER5 processor, IBM now offers its greatest range of virtualization capabilities ever. These capabilities have been built into the core system making it much easier for customers to find the right breadth and depth of capability for their environment. Several capabilities in particular have direct business benefits when applied to the data center. Some of these include:

- Micro-Partitioning. Partitions are a way to divide a single server into numerous smaller servers. Using logical partitioning, IBM is able to make micro-partitions — that is using less than one unit of a component, such as a CPU — for very small workloads. Partitions can be defined as small as 1/10 of a processor, and increments as small as 1/100 of a processor may be added.
- Virtual LANs. This internal LAN connects a set of partitions. Virtual LANs provide fast communication between partitions, and look like Ethernet LANs to the operating systems. Shared Ethernet adapters connect virtual LANs to the external network.
- Virtual I/O. This feature set includes virtual SCSI for sharing Fibre Channel and SCSI adapters and their attached disk drives, as well as virtual networking to share Ethernet adapters.
- Users of eServer p5 systems with AIX v5.2 are able to implement the Partition Load Manager (PLM) as a complementary and synergistic capability. The PLM manages a partition's entitlements to resources based on predefined policies. It can manage both CPU and memory. It functions similarly to the Power Hypervisor firmware which runs with all Power-based virtualization, but PLM augments those capabilities for AIX-based systems.
- IBM provides resources on its Web site as well as help through IBM Global Services for help in designing and implementing advanced solutions.

The level of virtualization capability that IBM has now achieved should enable real progress in leading the Renaissance of the data center out of the Dark Ages of distributed computing and into the Enlightenment of demand-driven computing.

Scenarios for Server Virtualization

Because there are many ways in which server virtualization technologies can be deployed, it is useful to consider example scenarios to understand how this technology can be deployed to effect real change. When IT managers deploy virtualization, they are generally looking for one or more of the following: infrastructure simplification, cost containment, or improved utilization of IT resources.

Table 1 describes a variety of scenarios and their potential impact on the IT environment.

Table 1: Server Virtualization Scenarios

System Resource Optimization and Provisioning	This has been the market focus of server virtualization and is the common starting point in virtualization of like resources. With virtualization, users can pool or share resources within one or more larger systems. This is a relatively straightforward process requiring minimal strategic planning or resource commitment and is a good way for IT managers to get experience with the benefits of virtualization.
Virtual Blade Environments	This is an example of system resource optimization and provisioning. Through logical partitions, virtual blades can be created for Web applications or to provide extra capacity for Web traffic in the case of special events. The applications can share resources such as network and disk across partitions similar to a blade environment but also have access to spare CPU capacity and other system resources that are not available in a blade environment.
Distributed Resource Management	This is the next level of virtualization. At this stage, the ability to shift the balance of resources in a dynamic way is important. This requires a more strategic understanding of the resource distribution within the data center and the relative importance of systems.
Consolidating Batch and Production System Workloads	This is an example of distributed resource management. Batch workloads are usually scheduled for nighttimes or periods when production systems are less active. Through virtualization, resources can be shifted to a batch workload when production workloads dip below pre-specified thresholds. The benefit is that the length of dedicated batch windows can be decreased. Multiple production workloads can also be consolidated onto one server if they have different peak load times, so that resources can shift as one application reaches a peak and another dips into a valley.
Physical Consolidation of Multiple Older Technologies	This is a different take on distributed resource management. The workloads on aging servers due for a refresh are ideal for consolidating into a single state of the art solution supporting UNIX and/or Linux. This would also be an optimal time to implement the sharing of storage resources and network adapters. These servers may also be appropriate candidates for web, file, and print consolidation systems as well.
Development and Test Systems Consolidation	This is another example of distributed resource management. Since systems for application development and test could be quickly created and removed as individual partitions of a larger system the traditional allocation of resources for development and test could be changed. Rather than dedicating an entire system to a development application, developers can instead create partitions from a larger pool of resources in a single server as needed, thus enhancing overall utilization.
Multi-tier Service-Level Automation	This is the most advanced form of virtualization, the most complex, and requires the most strategic planning and familiarity with virtualization capabilities. At this level, pools of resources are dynamical assigned to services for various user groups within and between organizations.
Multi-tier Application Consolidation	This is one example of multi-tier service-level automation. Through capabilities such as IBM's VLAN for high-speed inter-partition communications, administrators can create different partitions within the same system to represent Web servers, application servers, and the back-end databases of multi-tier applications.

What Does It All Mean?

Business decision-makers have begun to realize the potential of virtualization to reduce IT costs and improve efficiencies through raising overall IT utilization and automating resource provisioning. Virtualization is a collection of technologies designed to share resources between systems and applications, reduce IT complexity, increase utilization, and lower overall IT infrastructure costs.

The benefits of virtualization include enhanced data center productivity, easier scaling, reduced operational staffing, and more effective use of existing as well as newly acquired IT resources. Virtualization can provide a sustainable competitive advantage when enterprises are able to release IT staff from repetitive reactive tasks and redirect them toward revenue-generating activities. Additionally the savings in downtime can lead to increased revenue and customer service response levels.

We believe that the time is right for organizations to start implementing virtualization within the data center to help IT evolve into a provider of business value within the enterprise. These capabilities can help to lower cost and improve business efficiency. While several vendors have good virtualization offerings on the market, only IBM appears capable of providing the full range of activities from technical capabilities to the business process management needed to help enterprises take full advantage of virtualization benefits. Organizations seeking to improve their operational efficiency and overall competitive standing are well advised to consider virtualization technologies, and specifically to review said offerings from IBM.