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EXECUTIVE SUMMARY

Red Hat Virtualization: Meeting the Challenges of Optimization

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IDC OPINION

Today a dramatic shift is taking place in the industry as virtual processing software — and specifically the virtual machine software layer — is causing significant changes in the way IT organizations look at configuring, provisioning, and deploying their server operating environments.

This shift has been enabled by the convergence of several key drivers, one of which is the significant growth in the processing performance available from x86 processor architecture, a direct benefit of multicore processors and the availability of x86-64 bit architectures.

Combined with this dramatic growth in processor capability is the emergence of new server form factors including rack optimized and blade servers, which enable the consolidation of large amounts of compute power in comparatively small amounts of floor space.

Red Hat's development effort for the next version of its Red Hat Enterprise Linux product is setting the stage for the company to dramatically improve its range of solutions for enterprise customers using enterprise virtualization software.

Red Hat has had some of its virtualization solutions in place for several years, but the company is arguably late to the game with a virtual machine solution for the x86 architecture. While non–open source products have already seen strong adoption in the x86 market segment, the open source community as a whole is only now poised to bring a solution to mainstream commercial Linux products. Accordingly, Linux vendors such as Red Hat face a market that, in some cases, has already adopted alternative (competitive) solutions from other vendors.

Still, the market is young; virtualized servers today represent less than 3% of total server volumes, indicating that mainstream customer adoption is yet to come. Red Hat has a reasonable opportunity to move those customers toward a Red Hat solution over the longer term, if its new products incorporating the capabilities that are currently under development by the company's engineers enter the market as scheduled this year.

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IN THIS EXECUTIVE SUMMARY

This IDC Executive Summary evaluates Red Hat's strategy and road map for the adoption and integration of virtualization software positioned for release in conjunction with the company's launch of its forthcoming Red Hat Enterprise Linux 5 release during 4Q06.

SITUATION OVERVIEW

Virtual Environment Software Background

A hot topic in the IT industry today, virtualization software is defined by IDC as a collection of six types of software that abstract operating systems, middleware, or application software away from physical resources. Called virtual environment software (VES), this software is an enabling technology that supports the concept described as adaptive environment, dynamic systems initiative, grid computing, matrix computing, on-demand computing, or utility computing by various suppliers of hardware, software, and services.

VES can break the link between a given function and the underlying systems. This means that functions may survive the loss of their original host systems. In case of a failure or slowdown, some forms of VES will either restart a given function on another system or pass the request to another instance of that application or function. The newest generation of VES increasingly allows organizations to see a system as a pool of shared resources that appear to be both self-healing and self-managing.

In the end, this software allows organizations not only to protect their investments in hardware and software but also to optimize those investments. A completely virtual environment allows established applications or functions to access features of newer systems and to be more reliable, more powerful, more scalable, or enhanced in some other way, and it allows users to fully utilize the IT resources for which they paid.

Today, customers commonly use VES for server consolidation, for hosting aging applications or operating systems on modern hardware, for application isolation and security, and for the benefit of increasing compute resource utilization.

The six layers of VES are virtual access software, virtual application environment software, virtual processing software, virtual storage software, server provisioning and management software, and security software. These six layers are described as follows:

- **Virtual access software.** This software allows applications to be accessed from nearly any intelligent access point device over just about any network, without the applications' having to be architected to support that device or network. Virtual user interface software and various types of portal software fit in this category.
- **Virtual application environment software.** This software creates an application development and deployment environment that allows properly developed applications to be more robust and reliable and also to be unaware of the underlying operating environments and hardware platforms. These benefits are available only to applications written for this environment. Application server software and parallel database software fit in this category.

- **Virtual processing software.** This category of software ranges from virtual machine software making a single system appear to be many systems, each supporting its own operating environment, to single-system image clustering software, which makes many systems appear to be a single computing resource running a single operating environment. This category also includes parallel processing software, load balancing software, and data and application availability software. The clustering and availability software (CLAS) market includes parallel processing software, load balancing software, data and application availability software, and single-system image clustering software.
- **Virtual storage software.** This software allows applications to be unaware of where and how application and data files are actually stored. This category includes storage replication and file system software. The software supports both storage area network (SAN) and network-attached software (NAS) hardware configurations.
- **Server provisioning and management software.** This software makes it possible for operators and administrators to load, manage, and operate multisystem configurations regardless of whether any of the other virtual environment software categories are present. This is a primary component of on-demand or adaptive environment approaches to application deployment.
- **Security software.** As applications are decomposed into components (sometimes called services), identity management and access control become increasingly important. Without a strong security layer, "black hats" could pick apart the distributed architecture and commandeer application components or functions to an organization's detriment.

Industry Trends Impacting VES

Shifts are taking place in the industry as virtual processing software — and specifically the virtual machine software layer — impacts the way IT organizations look at configuring, provisioning, and deploying their server operating environments.

The convergence of several key drivers has enabled this shift. One of these drivers is the significant growth in the processing performance available from x86 processor architectures, a direct benefit of multicore processors and the availability of x86-64 bit architectures.

Along with this dramatic growth in processor capability is the emergence of new server form factors including rack optimized and blade servers, which enable the consolidation of large amounts of compute power in comparatively small amounts of floor space.

Another driver, which is enabled by the processor performance and form factor advances described above, is the ability of the x86 processor family to support virtual machine software.

The extension of ongoing consolidation efforts, the need to bring better availability to more applications, the desire to utilize resources more effectively, the desire for easier capacity planning, and the need to streamline and simplify the management of highly complex IT environments are all drivers that are pushing customers to consider, test, and implement virtual machine technologies in their organizations.

A Brief History of Virtual Machine Software

The concept of abstracting physical system resources away from operating system software is not new. It has been utilized on mainframe systems from IBM running OS/390 and z/VM z/OS, as well as OS/400 and i5 for many years, and its roots trace back to technologies developed by IBM in the 1970s.

More recently, a number of companies attempted to sell virtual machine software for other processor architectures. In 1986, Insignia Solutions was founded and developed virtual machine technology that allowed non-Intel computers to run DOS and Windows applications, specifically aboard Motorola 68000 processors aboard Apple Macintosh computers. A second competitor entered the Mac OS market when Connectix Corp. built a modest business around virtual machine software for later Apple Macintosh systems, enabling the PowerPC processor to support a Microsoft Windows operating system and layered application software. Connectix subsequently launched an x86 workstation-oriented product and began work on a server-oriented product. A third competitor, VMware Inc., targeted PCs when it brought out its VMware Workstation product in 1999.

Many of those early versions of desktop and x86 virtual machine software attempted to emulate the underlying hardware architecture and, as such, added enough overhead to the system operations that the guest operating systems suffered from varying degrees of performance degradation.

A lot has changed since then, both with the efficiency of the virtualization algorithms and with the performance of the hardware available. In 2003, Microsoft acquired Connectix and updated Virtual PC and Virtual Server — products that were initially optimized to support Windows guests. Another competitor, SWsoft Inc., entered the market in 2001 with its Virtuozzo product. SWsoft focused on Linux and Unix initially and later expanded its list to include Windows.

Meanwhile, VMware was on a fast growth track; its virtual machine sales reached $172 million by 2004, largely driven by its two server-oriented products, VMware GSX Server and VMware ESX Server. VMware's products are generally regarded as being agnostic to the guest operating systems they support.

The most recent entry into the x86 virtual machine technology space comes from a GPL project that has generated the Xen hypervisor technology, a virtual machine for x86 architectures. Available in open source (GPL) form and as a commercially supported/packaged product from XenSource Inc., this technology is a strong candidate to see future integration into major Linux distributions. Xen virtual machine software is a paravirtualization technology that is being developed under the oversight of Ian Pratt, who, in addition to being a founder of XenSource, is a senior faculty member at the University of Cambridge Computer Laboratory.

Types of Hardware Virtualization

When it comes to virtual machine technology on x86 processors, several different types of virtualization schemes are relevant. Simply stated, the methods include providing a pure software layer that creates the illusion of a hardware architecture (a virtual machine software layer) and paravirtualization, which offers low-overhead virtualization capabilities but requires some alteration of the guest operating systems.

Examples of pure software solutions include VMware GSX Server, VMware ESX Server, and Windows Virtual Server. These products also illustrate another differentiation, that of a hosted solution versus a self-hosted solution. In the case of VMware GSX Server (being replaced by VMware Server) and Microsoft Virtual Server 2005, the virtual machine technology rides above the base or host server operating system. In this instance, the virtual machine technology is seen by the host operating system as an application. In contrast, VMware ESX Server is described as a "self-hosting" product because it is not required to have a host operating system installed aboard the hardware prior to the installation of VMware ESX Server. This is accomplished by integrating streamlined, thinned-down operating system functionality directly into the virtual machine product.

The alternative technology, referred to as paravirtualization, functions in a similar way to the hosted solution where the paravirtualization technology software is installed above an operating system layer. However, the paravirtualization software functions differently from the hosted operating system in that the paravirtualization software does not provide a pure emulation of the core hardware architecture; instead, it provides a similar, but nonidentical environment. In most cases, a paravirtualized solution requires some changes to the guest operating system layer to ensure compatibility with the interfaces of the paravirtualization layer that are not identical to the underlying hardware interfaces.

The key difference between software virtualization and paravirtualization has to do with the support for a limited number of privileged instructions that are used by an operating system to control hardware functions. Software virtualization traps these privileged instructions and handles them appropriately, whereas a paravirtualized environment mandates that the privileged instructions be replaced or trapped on a static basis, such that a specialized version of the operating system kernel must be used with a paravirtualized environment.

From a pure performance perspective, paravirtualization would offer a performance edge, whereas from an ease-of-configuration and compatibility perspective, pure software virtualization is easier to adopt. However, absolute performance issues aside, the specific type of virtual machine solution being used on a server will be invisible to users who are interacting with application software.

Hardware Innovations

A brief discussion of Intel's Virtualization Technology (VT) and AMD's Secure Virtual Machine (SVM) virtualization technology would help complete the discussion on virtual machine technology. Neither Intel's VT nor AMD's SVM virtualization technology eliminates the requirement for virtual machine technologies from XenSource, Microsoft, SWsoft, VMware, or other vendors; rather, each technology makes the virtualization enablement easier to accomplish without requiring paravirtualization. This is done by changing the relative privilege where the virtual machine software layer is installed, enabling the operating system layers to continue to use the privilege level normally utilized by the operating system.

It should be noted that Intel's VT-x (x86) and VT-I (Itanium) and AMD's SVM virtualization technologies will be, in general, solutions for customers moving forward — although, in some cases, customers with existing systems can enable these new virtualization solutions through a firmware upgrade. Nevertheless, until a critical mass of systems that incorporate Intel's VT or AMD's SVM virtualization technology–enabled processors are widespread through customers' organizations, there will not be a huge market for virtualization software that leverages these hardware technologies.

Linux and VES

A number of factors are driving the adoption and integration of VES elements into Linux operating environments. For example:

- The workloads being supported by Linux. Some elements of VES have a greater likelihood of deployment when the application workload calls for higher reliability. In that instance, CLAS can provide failover services to provide greater levels of application continuity.

- The existing infrastructure in use within an organization may dictate requirements for Linux server deployments. For instance, organizations with broad usage of Unix operating systems very often will have virtual storage software in use so that common storage resources can be used across multiple Unix servers. When such organizations add Linux operating systems to their infrastructures, the approach often includes attaching the new Linux server to the same centralized storage resources that are used by the existing installed base of Unix servers.

- Virtual machine software is increasingly becoming a critical element of an enterprise deployment, particularly aboard today's generation of multicore x86-64 systems. Early adopters of virtual machine software in x86 environments tend to first perform static many-to-fewer consolidations of older operating system installations as they move to state-of-the-art hardware. Interestingly, because Linux is a comparatively young player in the enterprise market space, the incidence of aging Linux server operating environments tends to be lower than that of, say, Windows or NetWare. This leads to a scenario where the most common consolidation activities are among platforms other than Linux. However, the second wave of virtual machine deployments tends to focus on deploying net-new static installations aboard new hardware, a scenario where Linux is well positioned to be a key player.

- Security and provisioning/management software will be a required element aboard the majority of enterprise servers. This requirement is a moving target: Today the emphasis is on systems management, patch management, and static provisioning, but tomorrow the emphasis will be on systems that can be provisioned and reprovisioned or deprovisioned on a dynamic basis.

This document next considers some of the technologies that Red Hat offers today and the road map that Red Hat is working toward to expand its set of solutions.

FUTURE OUTLOOK

Red Hat Enterprise Linux and VES

The open source development model has made it both possible and practical for many aspects of VES to be addressed by the community supporting Linux and related products. Many layers of VES technology exist or are being built today for use with Linux, and this technology can be expected to find its way into mainstream distributions of Linux server operating environment software.

However, IDC research finds that most customers tend to mix open source products with complementary solutions — solutions that may be licensed under proprietary terms and conditions rather than under GPL.

Within its product portfolio, Red Hat has a mixed scorecard of providing solutions to VES-layered product capabilities. In some categories, Red Hat has solutions that are already on the market and competitive in their market space, while in other segments, the company is working aggressively to deliver solutions that meet or exceed the functional attributes of products on the market today.

For instance, Red Hat proactively addressed the topic of storage software virtualization in 2003 when it acquired Sistina Software, a vendor of logical volume management and a global file system software. In 2004, Red Hat also acquired a number of software assets from Netscape, including its messaging server, directory server, and network security software products. Red Hat integrated those products into Red Hat Enterprise Linux 4 and released the resulting code under the GPL. The Sistina Software file system technologies were reintroduced as the Red Hat Global File System.

However, customers that have made significant investments in Unix servers may be using Symantec/VERITAS' file and storage virtualization software. Customers that fall into this category still have the option of using Symantec/VERITAS products in conjunction with Red Hat Enterprise Linux.

For several years, Red Hat has offered its Red Hat Cluster Suite, a layered software product that offers both failover and IP load balancing clustered configurations.

Conversely, Red Hat offers no virtual machine software today; instead, it relies on third-party solutions including VMware ESX Server and SWsoft Virtuozzo. Given customers' relative comfort with mixing open source solutions with non-GPL commercially licensed products, this approach is a reasonable way for customers to obtain the benefits of virtual machine software.

Red Hat Enterprise Linux 5 and VES

Red Hat has a product road map that will integrate open source Xen virtual machine technology into its next product, which is targeted for general release late in 2006. Customers seeking an early glimpse of Red Hat's implementation of the Xen virtual machine technology can obtain a copy of Fedora Core 5, which is expected to be available early in 2Q06.

Red Hat's integration plan for this technology is to incorporate a management domain of Red Hat Enterprise Linux 5, which should not be utilized for any general-purpose application deployment. Nevertheless, this installation, referred to as "Domain 0," will in fact be a general-purpose operating system, which means that existing software products certified against Red Hat Enterprise Linux will automatically be qualified to run on Domain 0. The rationale for this approach is that management software packages from partners such as BMC Software, CA, and others, which are already certified against Red Hat's software, can be supported in Domain 0 — where a virtual machine manager would need to reside.

As a paravirtualization technology, the Xen code being integrated into Red Hat's next release will enable the hosting of specific instances of Linux, including Red Hat Enterprise Linux versions 4 and 5. Red Hat has taken an interesting tack and is offering pure software virtualization in addition to paravirtualization. As with other pure software virtualization schemes, operating environments supported here will pay some performance penalty.

The modes of support are projected to be as follows:

- Red Hat Enterprise Linux AS v2.1 will be supported using software virtualization and can be run in its original, unmodified form.
- Red Hat Enterprise Linux 3 will be supported using software virtualization and can be run in its original, unmodified form.
- Red Hat Enterprise Linux 4 will be supported in two modes. Customers that are able to and willing to allow a kernel replacement on install can run Red Hat Enterprise Linux 4 in paravirtualized mode and experience the full performance benefits associated with paravirtualization. Customers that are uncomfortable with a kernel replacement, or that are using software that has specific kernel dependencies, can opt to use software virtual machine capabilities and retain the original kernel included in Red Hat Enterprise Linux 4.
- Red Hat Enterprise Linux 5 will always be paravirtualized when installed as a guest aboard Red Hat's own software. The paravirtualized kernel will be installed when the software is installed. Software virtualization through a product such as VMware ESX Server or SWsoft Virtuozzo would still be an option for customers, just as it is today — without requiring a kernel replacement on install.

An important aspect to Red Hat's approach with its virtual machine software is how the company has configured its support for hosted environments. The scheme allows the existing Anaconda installer to be used, which makes it possible for Red Hat Enterprise Linux 5 to host other Linux operating environments.

CHALLENGES/OPPORTUNITIES

Red Hat's strategy for Red Hat Enterprise Linux 5 fills some of the largest gaps in the company's virtualization competitive positioning compared with other solutions already on the market, but the following challenges and opportunities exist for Red Hat:

- **Displacing entrenched competitors.** With no virtual machine solution available from Red Hat today, customers that need a solution end up using alternative products, most likely either SWsoft Virtuozzo or VMware ESX Server. Solutions already in use will establish a comfort level among customers, making it harder to justify removing them for replacement by Red Hat's technology. **Opportunity:** Red Hat can establish itself in this space among its existing installed base — the largest installed base of Linux server operating environments among any of the major vendors. Given Red Hat's knowledge of its installed base, no vendor is in a better position to help that installed base begin the process of consolidating operating system images aboard fewer physical servers. Red Hat is realistic about potential market adoption of its virtual machine solution over the next 12–18 months and says it is not interested in trying to freeze the market in advance of its Xen-based solutions. Instead, the company steers customers in need of solutions today to one of the available commercial solutions.

- **Establishing credibility with a new solution.** Even with the product plan it has in place, Red Hat has some distance to go to prove its ability to deliver a solid solution that is reliable and scalable and that performs well. **Opportunity:** Red Hat has no reputation — positive or negative — in this space, not unlike its direct competitors in the commercial Linux distribution business. Thus, the company does not need to overcome any negative history, but it must come forward with a solid product that meets whatever promises the company makes for the product on release. Red Hat is relying on the collective effort of open source contributors to make the Xen technology successful. With contributions from individual contributors, developers from Linux distribution vendors, and the added boost from other key industry players such as Intel and AMD, it is likely that Xen will be successful. The differentiator for individual distribution vendors will be the completeness of the stack surrounding the virtual machine layer — including the related management layers, as well as other VES components.

- **Migrating customers forward onto Red Hat Enterprise Linux 5.** A classic challenge for every vendor of server operating environment software is moving customers from older releases to the most current release. With a current delivery targeted for late 2006, the real challenge of moving customers won't start for at least 6 to 12 months after the release of Red Hat Enterprise Linux 5. Red Hat plans to create an online virtualization resource center that will help customers with things such as readiness assessment, tools, and services to help prepare them to consume virtualization software capabilities. **Opportunity:** Red Hat is likely to have good customer retention regardless of how long it takes to start the movement to Red Hat Enterprise Linux 5 from older products. The likelihood of customers moving away from their existing investments in Red Hat software is low, but moving them quickly to Red Hat Enterprise Linux 5 will be the key challenge. However, an interesting alternative that is made possible by virtual machine technology is that customers can retain existing operating systems and layered software stacks and virtualize those stacks — either completely unchanged or paravirtualized — while deploying Red Hat Enterprise Linux 5 alongside those older software stacks.

CONCLUSION

The convergence of multiple industry drivers, including the high-performance capabilities of x86 architectures, multicore processors, and 64-bit capabilities, is greatly enhancing the ability of servers built on these technologies to support far more complex workloads. Additionally, virtual machine software is changing the nature of server deployments and is accelerating the requirements of operating systems from all vendors.

Red Hat's development effort for the next version of its Red Hat Enterprise Linux product is setting the stage for the company to dramatically improve its range of solutions for enterprise customers using enterprise virtualization software. As Red Hat brings to market its Red Hat Enterprise Linux product, the company will reduce the gap between capabilities that its products offer and those capabilities available on the market from a collection of third-party vendors.

Red Hat has a reasonable opportunity to move its customers toward a Red Hat solution over the longer term, if its new products incorporating the capabilities that are currently under development by the company's engineers enter the market as scheduled this year.